



# **PDFA100 O-Band Praseodymium Doped Fiber Amplifier**

## **Operating Manual**



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## 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



High voltage inside. To avoid electrical shock, before powering the unit on, 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.



### EXPLOSION WARNING



This instrument must not be operated in an explosion endangered environment.



### LASER WARNING



Avoid Exposure – Radiation Emitted from apertures. Do not look into the laser aperture while the laser is on. Injury to the eye may result. Laser should not be turned on unless there is an optical fiber connected to the laser output port. Caution – Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.



### CAUTION



Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: Reorient or relocate the receiving antenna.—Increase the separation between the equipment and receiver.—Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.—Consult the dealer or an experienced radio/TV technician for help.



### CAUTION



This instrument should be kept clear of environments where liquid spills or condensing moisture are likely. It is not water resistant. To avoid damage to the instrument, do not expose it to spray, liquids, or solvents.

The unit is supplied with a region-specific power cord. If using your own power cord, make sure it is IEC 320 compatible.

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 Section 4.2, Changing the Fuse). 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 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' Praseodymium-Doped Fiber Amplifier (PDFA) offers high gain, high saturation power, and a low noise figure, making it ideal for use within optical networks as either a booster amplifier or preamplifier. The fiber amplifier technology offers an alternative to semiconductor amplifiers (SOAs) with improved optical performance by eliminating the signal distortions typically associated with gain saturation in SOA devices. Each fiber amplifier is enclosed in a compact, turnkey benchtop package with FC/APC (2.0 mm narrow key) input and output connectors. The system integrates a pump laser and precision current driver to adjust the pump power in the amplifier. The current adjustment, done through an adjustment knob on the front panel, varies the amplifier gain. The amplifier includes input and output isolators to protect the input laser source from any amplified spontaneous emission or back reflections, as well as to prevent the pump light from exiting the amplifier.

The PDFA gain can be controlled in constant current control (ACC) mode via the front panel interface. The pump current of the amplifier is adjustable through the instrument's front panel, allowing the user to vary the gain and output power. The display screen shows the pump level, as well as the temperature and emission status. An indicator light is also included on the enable button to show when the internal laser is active. In addition to this mode of operation, the PDFA can be operated in constant power control (APC) and constant gain control (AGC) modes using a command-line interface via USB connection with a PC. These modes of operation allow the user to control the amplifier for a fixed output power level or a fixed gain value. The amplifier automatically adjusts the pump current in order to maintain the power or gain target values. For further information regarding all three modes of operation, please see Chapter 5.

For added safety, there is an interlock connector 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 doors to disable the fiber amplifier in unsafe conditions. An enable button must be set to activate the amplifier, and a green LED indicator displays the current state of the unit. There is a 3 second delay before the fiber amplifier turns on, and the user is warned by the rapidly blinking LED.

The amplifier includes a universal power supply allowing operation over 100 to 240 VAC without the need for selecting the line voltage. The fuse access is conveniently located on the rear panel.

### 3.1. Shipping List

The PDFA100 consists of the following components:

- O-Band Praseodymium-Doped Fiber Amplifier in Benchtop Package
- Interlock-Shorting BNC Connector
- Region-Specific Power Cord
- USB Cable
- FBC250 Connector and Bulkhead Cleaner

## Chapter 4 Setup



### CAUTION



**Prior to using the PDFA systems, it is highly recommended to clean the input and output bulkheads as well as the connector facets to be connected to the bulkheads. Failure to clean the connectors can result in damage to the internal connectors in the PDFA as well as the connectors on fiber patch cables connected to the PDFA.**

**When cleaning the connectors, ensure that the PDFA is powered off by turning off the push-button switch. Never inspect optical connectors unless all light sources in your setup have been switched off. Please refer to Section 9.2 for further instructions regarding connector cleaning.**

### 4.1. Setting the AC Line Voltage

The fiber amplifier has been shipped configured for 100 to 240 VAC operation. There is no end user adjustment of the line voltage for 110 or 220 VAC. The user needs to select the correct AC cord for their location.

### 4.2. Changing the Fuse

To change the power fuse, follow the following steps.

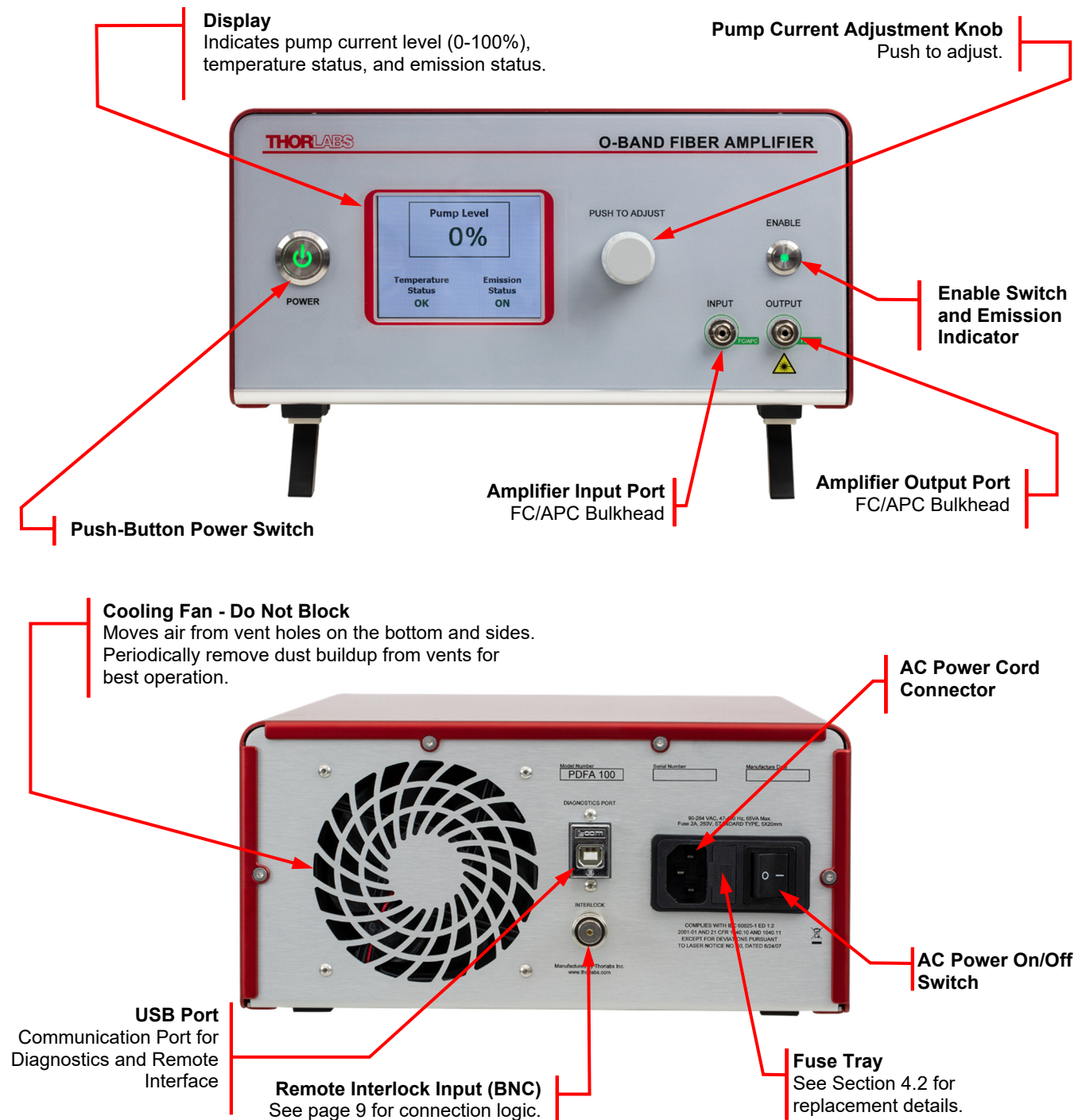
1. Remove the AC power cord if it is connected to the unit.
2. Locate the fuse tray directly adjacent to the AC power cord connection on the rear panel of the unit.
3. Carefully use a flat blade screwdriver to open the fuse tray.
4. Remove the existing fuses and install two fuses with the appropriate specifications. The replacement fuses must be 5 mm x 20 mm, 2 A, 250 VAC, slow-blow type.
5. Push the fuse tray back into place making sure that it snaps and sits correctly.
6. Connect the appropriate power cord into the AC receptacle and plug the unit in.

### 4.3. Initial Setup

1. Set the unit on a dry, level working surface.
2. Plug the female end of the provided AC line cord into the IEC input receptacle on the rear of the unit. Plug the male end into a properly grounded AC socket.
3. Install the interlock BNC connector. (See page 8 for details on the interlock circuitry.)
4. Connect the input to be amplified to the input fiber receptacle using a FC/APC fiber patch cable, carefully cleaning both the input FC bulkhead connector and the patch cable connector beforehand. Please note that a standard single mode (SM) cable should be used for the PDFA100, and that the input power entering the amplifier should not exceed 10 dBm (10 mW).
5. Carefully clean both the output FC bulkhead connector and the connectors on both ends of a second FC/APC patch cable. Connect one end of the cable to the output receptacle on the unit. Connect the other end to a power meter or another measurement instrument. The output power from the amplifier – when observing the 10 dBm (10 mW) input power limit – is guaranteed not to exceed 150 mW. Care should be taken to avoid damage to the measurement instrument connected to the output port. Also note that when the amplifier is enabled, it generates amplified spontaneous emission even when there is no input light entering the amplifier. This should be considered when connecting measurement instruments to the output port of the amplifier and when inspecting the fiber connectors.

## Chapter 5 Operation from Instrument Front Panel

### 5.1. Front and Back Panel Overview



**Figure 1 Front and Rear Panels of the Fiber Amplifier (PDFA100)**



## 5.2. Turning On the Amplifier

1. Please consult with your organization's laser safety officer regarding proper operation of the amplifier at your institution.



### LASER WARNING



**The amplifier generates invisible amplified spontaneous emission (ASE) even without any optical input. The power level of the ASE can be as high as 30 mW. Therefore, all laser safety measures should be followed even if the input light to the amplifier has been disconnected or switched off. Additionally, it should be noted that connecting a laser to the output port of the amplifier by mistake can cause damage to the laser due to the ASE light getting coupled into the laser source.**

2. Turn on the AC power switch on the back panel.
3. Press the POWER push-button switch. The display will turn on. The pump current set-point (in % of max) will be displayed in the middle of the screen.
4. Check the temperature status on the bottom left corner of the display. It should show "OK". If the temperature status shows "Stabilization" for more than 30 seconds or if it shows "Error", please turn the unit off and contact technical support.
5. Check the emission status of the device on the bottom right corner of the screen. It should show "Off" prior to enabling the amplifier.
6. Make sure the interlock input on the back panel is short-circuited. See Section 6 for detailed instructions.
7. Press and release the ENABLE switch to activate the fiber amplifier. There will be a 3 second delay before the fiber amplifier powers up. During this time, the ENABLE indicator will light up and blink.
8. Adjust the pump current set-point to the desired value by pressing the adjustment knob once. The "%" sign blinks in the adjustment mode and it times out after 5 seconds. The knob must be pressed again after the time-out in order to make additional adjustments to the pump current set-point.
9. Ensure that the temperature status still shows "OK" after the pump current has been increased to the desired level. The amplifier is now producing gain and is ready to use.

## 5.3. Adjusting the Fiber Amplifier Gain

The default operation mode of the amplifier is by controlling the pump current. This operation mode is referred to as the automatic current control (ACC). The fiber amplifier gain and output power are controlled by varying the pump current set-point. The system specifications represent the performance at max operating set-point (100%). Each unit is shipped with a test data sheet that shows the amplifier output power at two different input power levels (0 dBm and -30 dBm) as a function of the pump current set-point. The data can be used as a reference to adjust the pump current set-point for a desired gain level. In addition to the ACC mode of operation, it is possible to operate the PDFA in automatic power control (APC) and automatic gain control (AGC) modes. These modes of operation are only accessible through the command-line interface as explained in Chapter 6 of this manual.

## 5.4. Turning the Fiber Amplifier Off

- **Disabling the amplifier emission** - The amplifier output can be turned off by pressing and releasing the ENABLE switch. The pump diode temperature will be maintained even when the amplifier is disabled. The temperature status should show "OK" after the amplifier has been disabled.
- **Power Down** - When completely powering down an enabled unit, first press and release the ENABLE switch and then press the POWER push-button switch, which will turn OFF the entire unit. Anytime the unit is turned OFF and then turned back ON, the fiber amplifier will be disabled until the ENABLE switch is pressed. If the amplifier is not being used for an extended period of time, it is recommended to turn off the AC power using the switch located on the back panel of the instrument. Please note that the pump current set-point goes back to 0% after each AC power cycle.

## Chapter 6 Remote Operation from Command-Line Interface

The Command Line Interface (CLI) provides the user with a method of controlling the PDFA remotely over the USB interface that is emulating a serial port. A standard terminal program (such as Tera Term) can be used to send commands to the PDFA and receive responses. The following functions are available through the CLI:

- Enabling and disabling the amplifier emission.
- Reading status indicators
- Setting the current set-point value in the ACC operation mode.
- Operating the system in APC or AGC modes at user-defined power or gain values.

The list below shows the list of available commands along with a brief description and syntax:

<b><u>Command:</u></b>	<b><u>Command description:</u></b>
<b>Help</b>	DISPLAY COMMANDS – <i>Lists commands available to the user</i>
<b>le</b>	ENABLE LASER – <i>Turns the Pump LASER ON</i>
<b>ld</b>	DISABLE LASER – <i>Turns the Pump LASER OFF</i>
<b>sloc</b>	SET LASER DIODE OPERATING CURRENT – <i>Sets the Pump LASER output</i> sloc <current> Set current is between: 0 to 100 percent
<b>gloc</b>	GET LASER DIODE OPERATING CURRENT – <i>Returns the Pump LASER output</i>
<b>stat</b>	STATUS REGISTER – <i>Returns the following status info:</i> Interlock : Open or Closed Temp stable: Stable or Unstable Temp fault : No Fault or Fault LASER : ON or OFF
<b>runpwr</b>	RUN PID POWER CONTROL – <i>Enables the amplifier and starts the PID power control loop to keep output power constant</i> runpwr <power> <power> can be any positive value representing the output power in micro-Watts
<b>rungain</b>	RUN PID GAIN CONTROL – <i>Enables the amplifier and starts the PID gain control loop to keep the amplifier gain constant</i> rungain <gain> <gain> can be any positive value representing the gain value in linear scale.

Please note that the system default mode is the ACC mode. This mode is accessible by the front panel operation and the current set point is adjustable using the front panel knob as well as the CLI. The instrument enters this mode after every power cycle. Enabling the laser from the front panel switch or by executing the “le” command results in entering the ACC mode of operation. The APC and AGC modes of operation can be activated using the commands “runpwr” and “rungain”. These commands enable the amplifier and start control loops to maintain a constant level of output power or gain. The control loops can be interrupted by turning the laser off using the command “ld”. Alternatively, by setting the power or gain to zero, the control loop is interrupted and amplifier emission is turned off. If the control loop fails to reach its target under either APC or AGC modes, the closed-loop operation is automatically terminated and the amplifier id disabled. Upon exiting the control loop, the amplifier goes back to the default ACC mode.

## Chapter 7 Making Safety Interlock Connections

The PDFA100 is equipped with a remote interlock connector located on the rear panel. In order to enable the fiber amplifier, a short circuit must be applied across the terminals of the Remote Interlock connector. This connection is made available to allow the user to connect a remotely actuated switch to the connector (i.e. an open door indicator).

The switch that is connected to this interlock must be normally open (N.O.), meaning that it has to be closed in order for the unit to be enabled. If the switch is changed to an open state, the amplifier will automatically shut down. If the switch returns to a closed condition, the amplifier will not re-enable until the ENABLE switch is pressed.

All units shipped from Thorlabs are configured with a shorting BNC 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 throughout this manual. If you wish to make use of the interlock feature you will need to acquire the appropriate mating connector (BNC male) and wire it to your remote interlock switch.

## Chapter 8 Troubleshooting



### CAUTION



**Invisible Laser Radiation. Do not look directly into the fiber receptacle. Use a viewing card to help determine whether the fiber amplifier is generating an output.**



### WARNING



**Never open the amplifier housing cover for troubleshooting. Refer servicing to qualified personnel.**

The following table describes some typical problems that may be encountered while using the PDFA100 and possible solutions to these problems.

Problem	Solution
Unit does not turn on when pressing the power ON/OFF button on the front panel.	<ol style="list-style-type: none"> <li>1. Make sure the AC line cord is fully inserted into the AC Input receptacle and plugged into an outlet providing 100 to 240 VAC. Also ensure that the AC power switch on the back panel has been turned on.</li> <li>2. Fuse(s) may be open. Refer to Section 4.2 for information on replacing open fuses. If the problem persists, please return the unit to Thorlabs for evaluation.</li> </ol>
Unit powers on but does not enable when pressing the ENABLE button.	<ol style="list-style-type: none"> <li>1. Check to make sure the interlock connector is installed on the rear panel. See Chapter 7 for details.</li> <li>2. Check the temperature status on the front panel display. If temperature status is not OK for more than 30 seconds, turn the unit off and contact technical support.</li> </ol>
Unit is enabled but there is no output.	<ol style="list-style-type: none"> <li>1. Check to make sure you are using the correct type of fiber patch cable for the particular wavelength and FC/APC connector type.</li> <li>2. Check to make sure the input connector to the PDFA has power.</li> <li>3. Inspect the connectors on both cables connected to input and output ports to ensure they are clean and not damaged.</li> </ol>

## 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 in 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 onto the fiber end faces will degrade coupling efficiency and possibly damage the fiber patch cables, both inside and outside.

### 9.1. Cleaning

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

### 9.2. Connector Cleaning

Always clean the ferrule end of your fiber patch cables as well as the input and output FC bulkheads prior to inserting the fiber patch cables into the FC bulkheads. Thorlabs offers the FCC-7020 Fiber Cleaning Cloth Spool, which can be used for cleaning the ferrule ends of the patch cables.

Additionally, each unit is shipped with an FBC250 Bulkhead and Connector Cleaner for cleaning the input and output bulkheads.



**Figure 2** FBC250 Bulkhead and Connector Cleaner

To use the FBC250 Bulkhead and Connector Cleaner, please refer to the instructions shipped with the FBC250.

## Chapter 10 Specifications

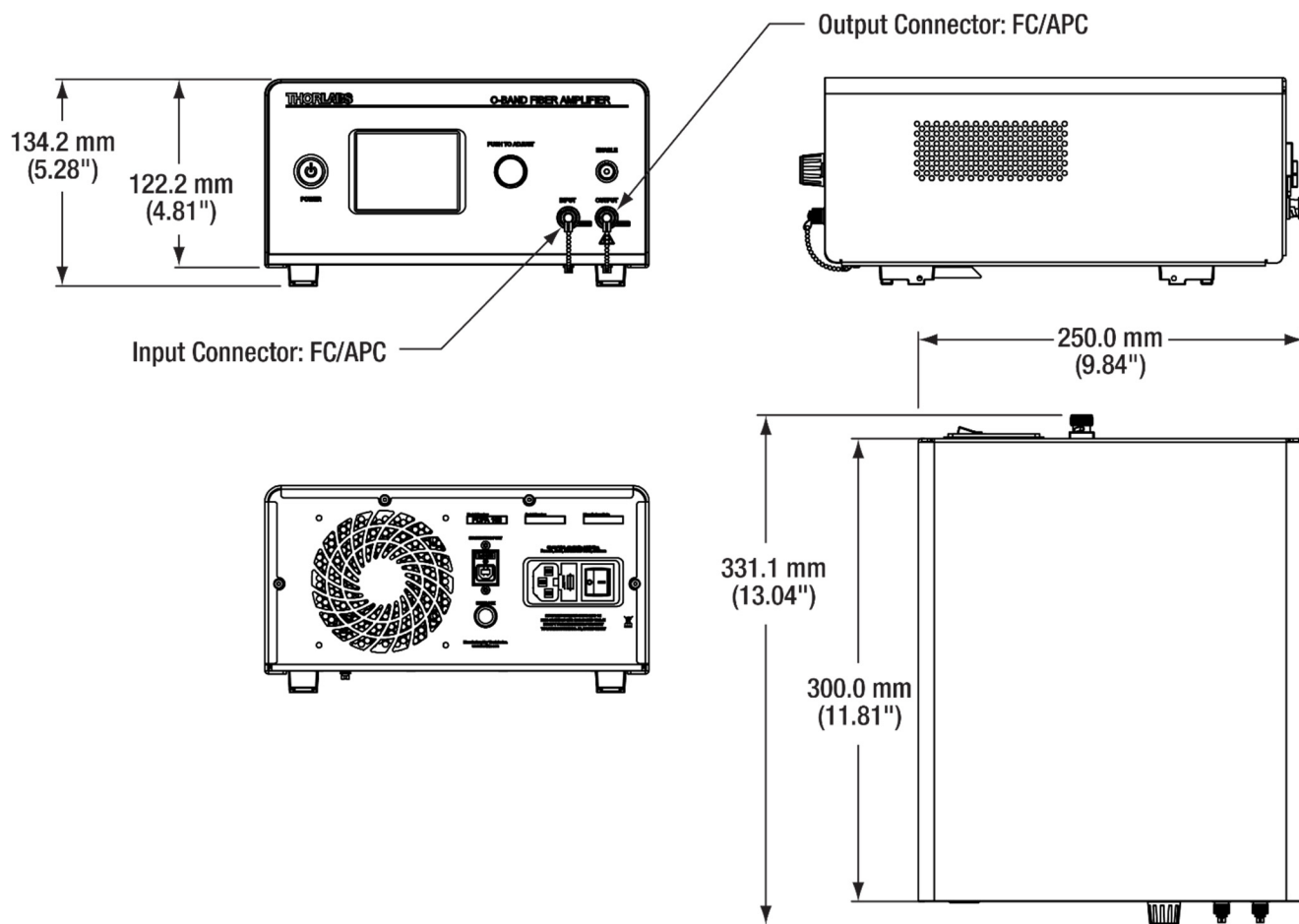
Item #	PDFA100
<b>Amplifier Specifications (Taken at 100% Pump Current Set-Point)<sup>a</sup></b>	
Operating Wavelength Range <sup>b</sup>	1280 nm - 1330 nm
Input Power Range	-30 - 10 dBm
Output Power (@ 3 dBm Input Power) <sup>c,d</sup>	>16 dBm
Small Signal Gain (@ -30 dBm Input Power) <sup>c</sup>	>20 dB
Noise Figure (@ -30 dBm Input Power) <sup>c</sup>	<8 dB
Laser Class	1M
<b>Fiber Specifications</b>	
Polarization-Dependent Gain	<0.5 dB
Return Loss at Input Port	>50 dB
Input / Output Isolation	>30 dB
Input / Output Fiber Type	Single Mode
Input / Output Fiber Connectors	FC/APC Compatible, 2.0 mm Narrow Key

- SMF-28 Ultra fiber patch cables with FC/APC connectors are used on the input and output.
- The wavelength range over which the small signal gain (at -30 dBm input power) does not fall below 10 dB.
- Specified at 1310 nm. Please refer to published data on the Thorlabs website for typical curves showing the variation of each parameter with wavelength.
- Please refer to published data on the Thorlabs website for the scaling of the output power vs. the input power.

<b>Absolute Maximum Ratings</b>	
Absolute Maximum Input Power	10 mW (10 dBm)
Absolute Maximum Output Power	150 mW (22 dBm)
Operating Temperature	15 to 30 °C
Storage Temperature	-10 to 40 °C

General Specifications	
Input Voltage	100 - 240 VAC, 50 - 60 Hz
Input Power	20 W (Max)
Fuse Rating	2 A, 250 V
Fuse Type	Time-Lag (Slow-Blow)
Fuse Size	5 mm x 20 mm
Dimensions (W x D x H)	250.0 mm x 300.0 mm x 122.2 mm (9.84" x 11.81" x 4.81")
Weight	7.5 lbs

## Chapter 11 Mechanical Drawings



**Figure 3** PDFA100 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.

### 12.1. 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.

### 12.2. 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: **PDFA100**

Equipment: **O-Band Praseodymium Doped Fiber Amplifier**

*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	2014-05

*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: 24 July 2019

Name: Ann Paterno

Position: Compliance Manager

EDC - PDFA100 -2019-07-24



## Chapter 14 Thorlabs Worldwide Contacts

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



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