PDFA100 and PDFA100P
O-Band Praseodymium Doped Fiber Amplifiers

User Guide



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Chapter 1 Introduction

1.1 Intended Use

The PDFA100 and PDFA100P can be used by general production personnel for O-band amplification or as ASE broadband light sources. The units are intended to be operated in controlled environmental conditions.

The product may only be used in accordance with the instructions described in this manual. Any other use will invalidate the warranty.

1.2 Explanation of Safety Warnings

⚠WARNING Warning indicates a hazard with a medium level of risk that, if not avoided, could result in death or serious injury.

NOTICE Indicates information considered important, but not hazard-related, such as possible damage to the product.

 Danger, Warning, or Caution

 Laser Radiation Warning

 Shock Warning

 ESD Component Caution

CE The CE markings on the product are the manufacturer's declaration that the product complies with the essential requirements of the relevant European health, safety, and environmental protection legislation.

 The wheelie bin symbol on the product, the accessories or packaging indicates that this device must not be treated as unsorted municipal waste but must be collected separately.

1.3 Description

Thorlabs' Praseodymium-Doped Fiber Amplifiers (PDFAs) offer high gain, high saturation power, and a low noise figure, making them ideal for use within optical networks as either booster amplifiers or preamplifiers. 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 automatic 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 automatic power control (APC) and automatic 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 4.

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.

1.4 Technical Data

1.4.1 Amplifier and Fiber Specifications

Item #	PDFA100	PDFA100P
Amplifier Specifications (Taken at 100% Pump Current Set-Point)[a]		
Operating Wavelength Range[b]	1280 nm - 1330 nm (O-Band)	
Input Power Range	-30 to 10 dBm	
Output Power (@ 3 dBm Input Power)[c,d]	>16 dBm	>15 dBm
Small Signal Gain (@ -30 dBm Input Power)[c]	>24 dB	
Noise Figure (@ -30 dBm Input Power)[c]	<7 dB (6 dB Typ.)	<8 dB (7 dB Typ.)
ASE Output Power[e]	2 mW (Typ.)	
Signal Latency (Input- Output)	<100 ns	
Pump Laser	980 nm	
Laser Class	1M	

a. SMF-28 Ultra fiber patch cables with FC/APC connectors are used on the input and output of PDFA100. Fujikura SM13-PS-U25A cables are used with FC/APC connectors on the input and output of PDFA100P.

b. The wavelength range over which the small signal gain (at -30 dBm input power) does not fall below 10 dB.

c. Specified at 1310 nm. Please refer to published data on the Thorlabs website for typical curves showing the variation of each parameter with wavelength.

d. Please refer to published data on the Thorlabs website for the scaling of the output power vs. the input power.

e. The PDFAs will function as Amplified Spontaneous Emission (ASE) sources when operating without a seed laser at 100% pump current. The ASE power varies from unit to unit; this number represents typical performance.

1.4.2 Fiber Specifications

Item #	PDFA100	PDFA100P
Fiber Specifications		
Output Polarization	Random	Linear, Aligned to Slow Axis
Polarization Extinction Ratio	N/A	>20 dB
Polarization-Dependent Gain	<0.5 dB	N/A
Return Loss at Input Port	>50 dB	
Input / Output Isolation	>30 dB	
Input / Output Fiber Type	SMF-28-J9	Fujikura SM13-PS-U25A
Input / Output Fiber Connectors	FC/APC Compatible, 2.0 mm Narrow Key	

1.4.3 Absolute Maximum Ratings

Absolute Maximum Ratings	
Absolute Maximum Input Power	10 mW (10 dBm)
Absolute Maximum Output Power	150 mW (22 dBm)
Operating Temperature	5 to 45 °C
Storage Temperature	-10 to 40 °C

1.4.4 General Specifications

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 (3.4 kg)

1.4.5 Mechanical Drawings

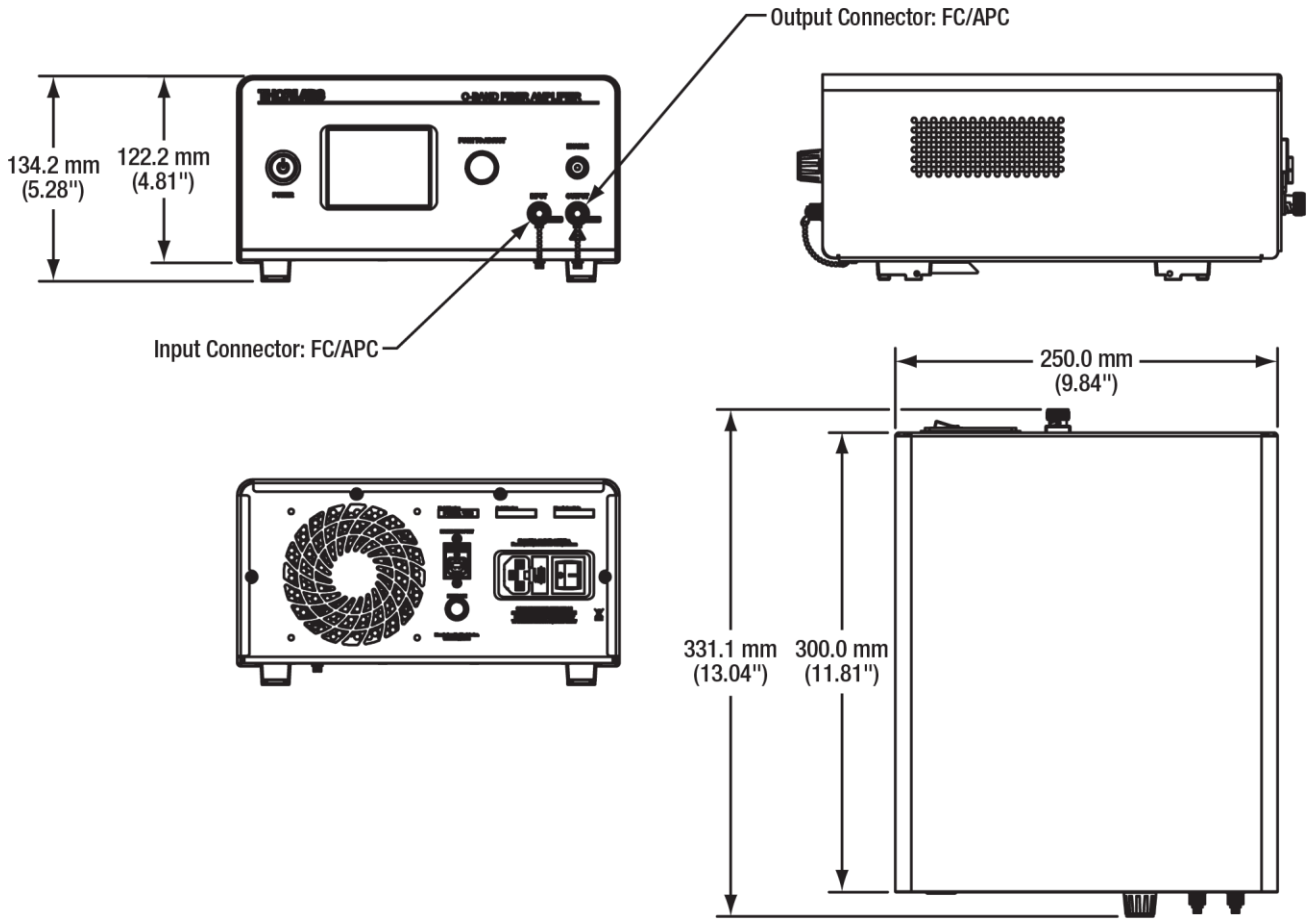


Figure 1 PDFA100 Mechanical Drawing

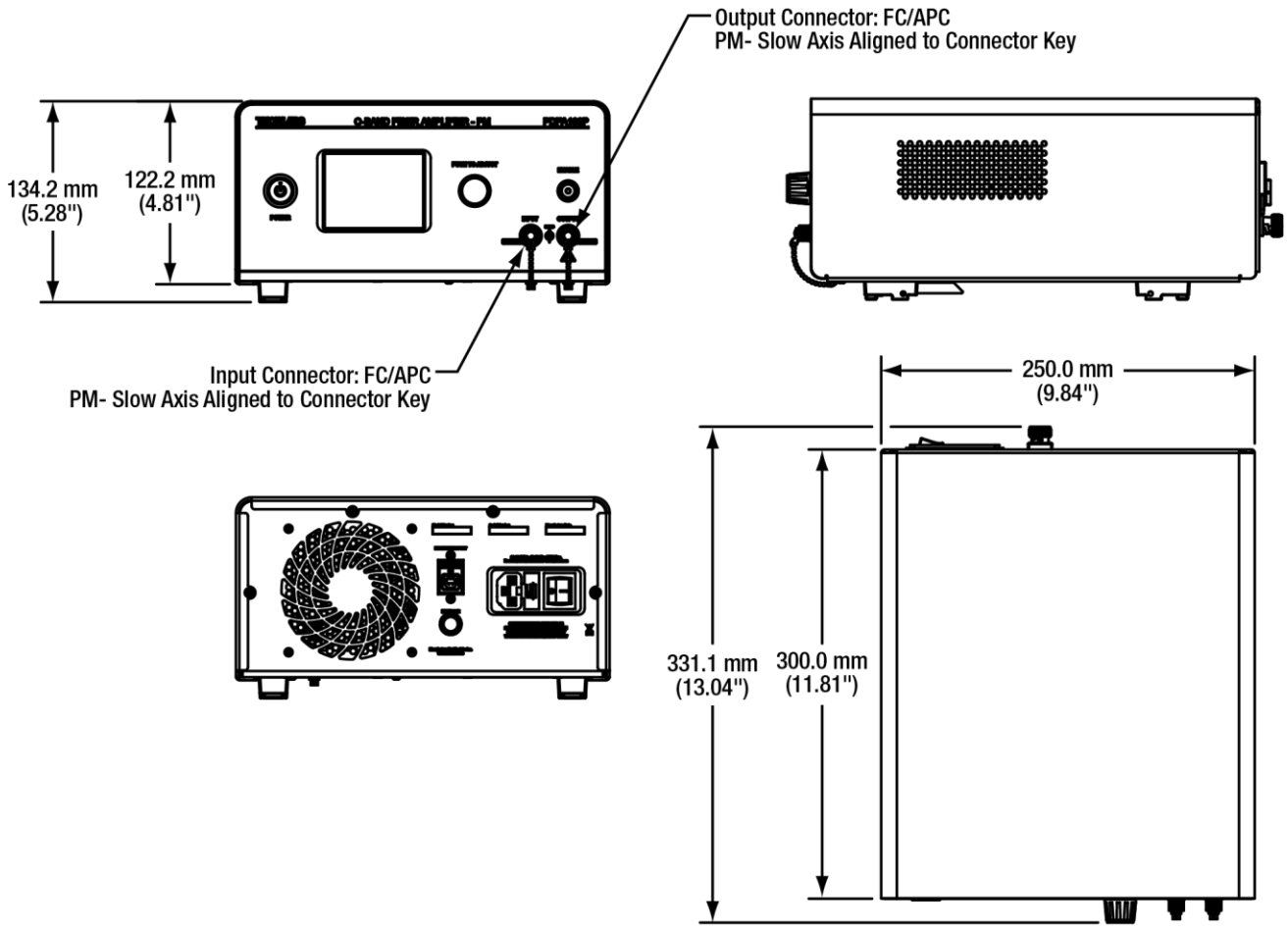


Figure 2 PDFA100P Mechanical Drawing

1.5 Components

1.5.1 Front and Back Panel Overview

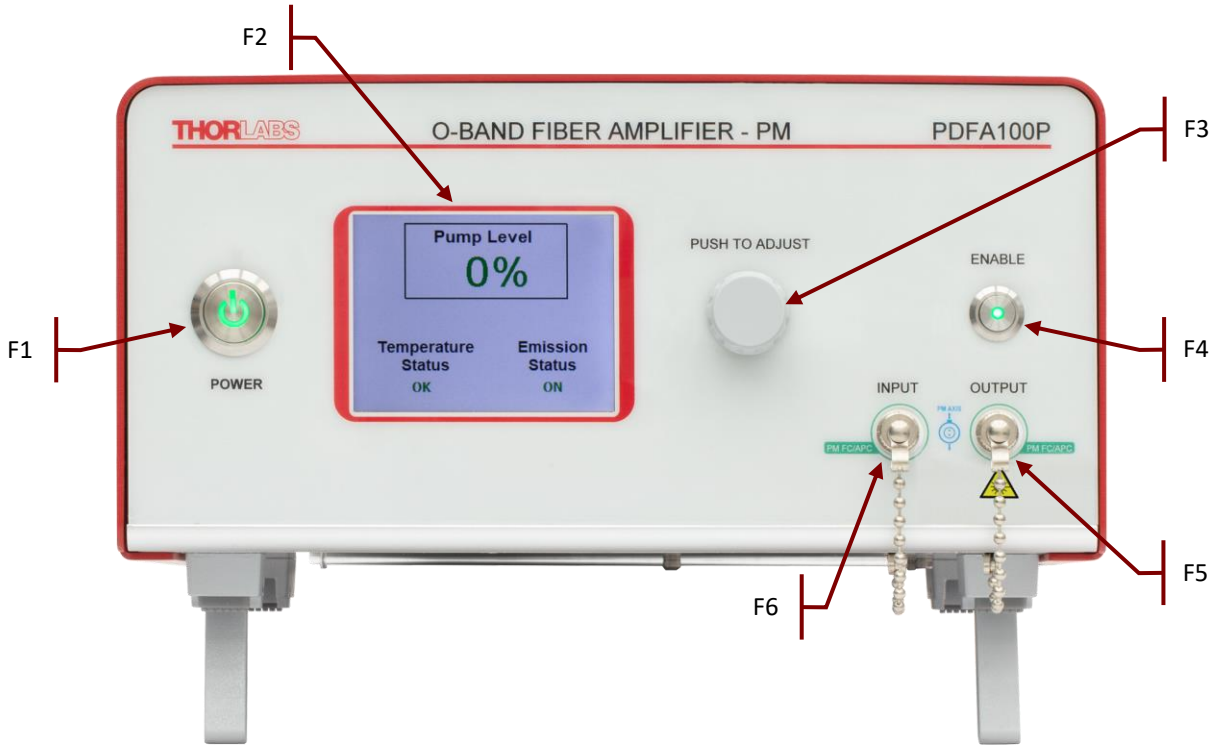


Figure 3 Front Panel

Callout	Description
F1	Push-Button Power Switch
F2	Display (Indicates Pump Current Level from 0 to 100%, Temperature Status, and Emission Status)
F3	Pump Current Adjustment Knob (Push to Adjust)
F4	Amplifier Enable Switch and Emission Indicator
F5[a]	Amplifier Optical Output Port (FC/APC Bulkhead)
F6[a]	Amplifier Optical Input Port (FC/APC Bulkhead)

a. The optical Output/Input is single mode for Item # PDFA100 and polarization-maintaining for Item # PDFA100P.

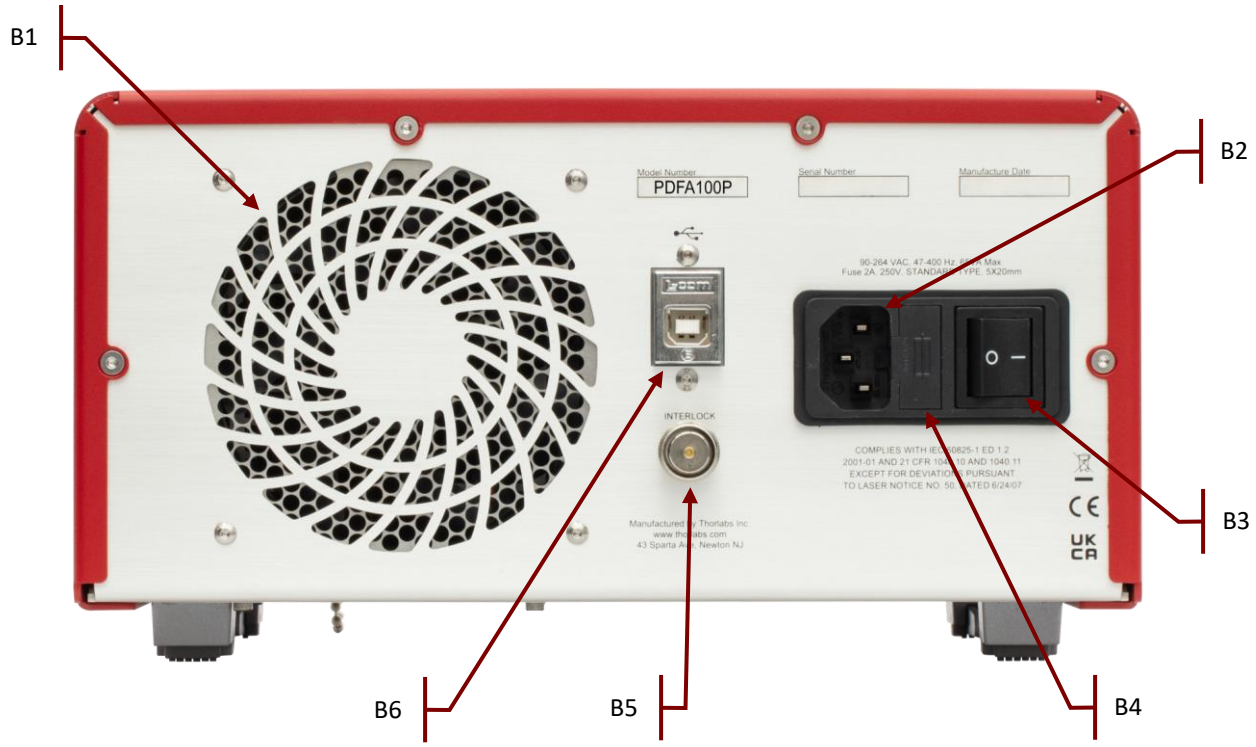


Figure 4 Back Panel

Callout	Description
B1	Cooling Fan – Do Not Block (Fan moves air from vent holes on the bottom and sides. Periodically remove dust buildup from vents for best operation.)
B2	AC Power Cord Connector
B3	AC Power On/Off Switch
B4	Fuse Tray (See Section 3.4.2 for Replacement Details)
B5	Remote Interlock Input (BNC) – See Section 4.3 for Connection Logic
B6	USB 2.0 Type B Port (Communication Port for Diagnostics and Remote Interface)

1.6 Simplified Declaration of Conformity

The full text of the EU declaration of conformity is available at the following internet address:

https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=12403

1.7 FCC Designation

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.

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.

⚠WARNING



Risk of Electrical Shock

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.



Risk of Explosion

The instrument must not be operated in explosion endangered environments.



Laser Radiation

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.



NOTICE

Components not Water Resistant
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.

Follow Intended Usage Guidelines
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 3.4.2, 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 Installation

3.1 Warranty Information

This device is under warranty for 1 year and is only serviceable if returned and properly packed into the complete original packaging including the complete shipment plus the cardboard insert that holds the enclosed devices. If necessary, ask for replacement packaging. Refer servicing to qualified personnel.

3.2 Packing List

Inspect the shipping container for damage. If the shipping container seems to be damaged, retain it until all contents have been inspected and the unit has been mechanically and electrically tested. Verify receipt of the following items:

- O-Band Praseodymium-Doped Fiber Amplifier in Benchtop Package
- Interlock-Shorting BNC Connector
- Region-Specific Power Cord
- USB-A-79 High Speed USB 2.0 Type-A to Type-B Cable, 79" (2 m) Long
- FBC250 Connector and Bulkhead Cleaner

3.3 Unpacking Instructions

Exercise caution when unpacking the instrument as it contains sensitive electronic and optical components. A simple shipping inventory should be performed when unpacking to ensure all parts mentioned in Section 3.2 are present and accounted for before beginning the installation process.

3.4 Installation Instructions

NOTICE

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.



Warning: Laser Radiation

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 5.2 for further instructions regarding connector cleaning.

3.4.1 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.

3.4.2 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.

3.4.3 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 Section 4.3 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, a standard polarization maintaining (PM) cable should be used for PDFA100P, 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 4 Operating Instructions

4.1 Operation from Instrument Front Panel

4.1.1 Turning on the Amplifier

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



Warning: Laser Radiation
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 4.3 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.

4.1.2 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 Section 4.2 of this manual.

4.1.3 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.

4.2 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:

Command:	**Command description:**
Help	DISPLAY COMMANDS – *Lists commands available to the user*
le	ENABLE LASER – *Turns the Pump LASER ON*
ld	DISABLE LASER - *Turns the Pump LASER OFF*
sloc	SET LASER DIODE OPERATING CURRENT – *Sets the Pump LASER output* sloc <current> Set current is between: 0 to 100 percent
gloc	GET LASER DIODE OPERATING CURRENT – Returns *the Pump LASER output*
stat	STATUS REGISTER – *Returns the following status info:* Interlock : Open *or* Closed Temp stable: Stable *or* Unstable Temp fault : No Fault *or* Fault LASER : ON *or* OFF

runpwr RUN PID POWER CONTROL – *Enables the amplifier and starts the PID power control loop to keep output power constant*
runpwr <power>
<power> can be any positive value representing the output power in micro-Watts

rungain RUN PID GAIN CONTROL – *Enables the amplifier and starts the PID gain control loop to keep the amplifier gain constant*
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.

4.3 Making the Safety Interlock Connections

The PDFA100 and PDFA100P are 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 5 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.

5.1 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.

5.2 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 5 FBC250 Bulkhead and Connector Cleaner

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

Chapter 6 Troubleshooting

Warning: Laser Radiation
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: Risk of Electric Shock
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 or PDFA100P and possible solutions to these problems.

Problem	Solution
Unit does not turn on when pressing the power ON/OFF button on the front panel.	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. 2. Fuse(s) may be open. Refer to Section 3.4.2 for information on replacing open fuses. If the problem persists, please return the unit to Thorlabs for evaluation.
Unit powers on but does not enable when pressing the ENABLE button.	1. Check to make sure the interlock connector is installed on the rear panel. See Section 4.3 for details. 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.
Unit is enabled but there is no output.	1. Check to make sure you are using the correct type of fiber patch cable for the particular wavelength and FC/APC connector type. 2. Check to make sure the input connector to the PDFA has power. 3. Inspect the connectors on both cables connected to input and output ports to ensure they are clean and not damaged.

Chapter 7 Disposal



Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out "wheelie bin" logo (see right), were sold to and are currently owned by a company or institute within the EC and are not dissembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. "End of life" units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site. It is the user's responsibility to delete all private data stored on the device prior to disposal.

Chapter 8 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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