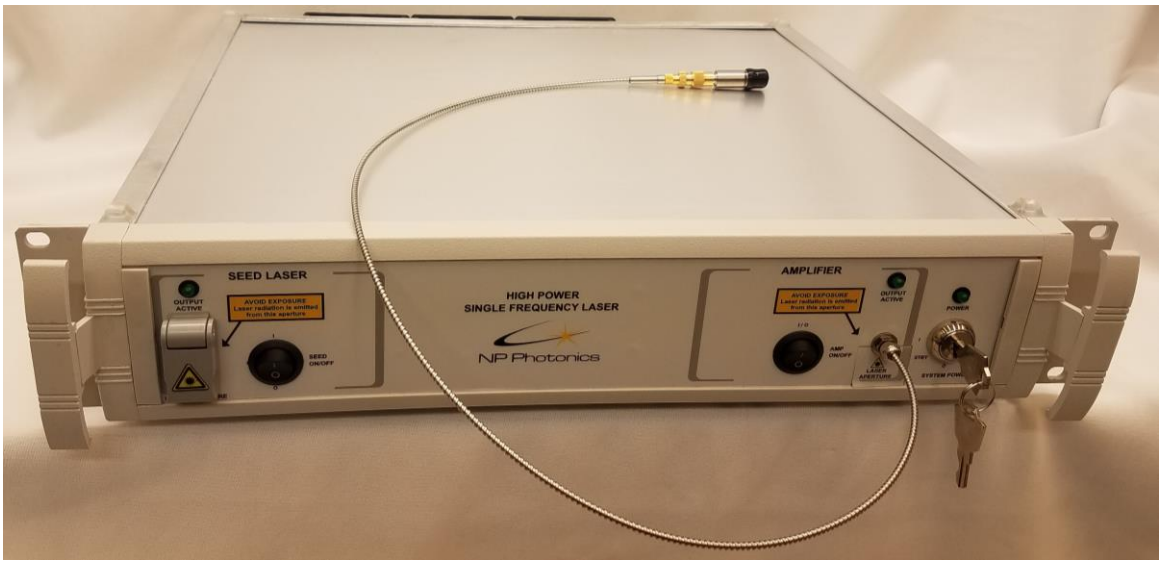
Identifier:	Revision:	Effective Date:	HIGH POWER SINGLE FREQUENCY FIBER LASER SOURCE
RFLPXA (GEN V)	**2**	**12/10/18**	
Document Catalog Number: M600-419			**CLASS IV DEVICE**



Product User Manual

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Visit our Website at www.npphotonics.com

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1 Safety Information

Dear Customer,

Thank you for choosing NP PHOTONICS!

You have purchased one of the most sophisticated and reliable products on the market today.

The serial number is located on the Benchtop Fiber Laser Source:

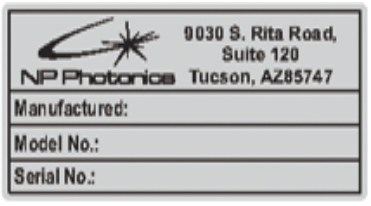


Figure 1.1 Serial Number Label

Caution

Mechanical housing of the laser module may become hot. Avoid handling during operation. Use proper heat sinking.

Caution

Laser modules may emit a small amount of laser radiation at 976nm and 1550/1060nm from any surface.

Caution

Avoid eye exposure to laser radiation emitted from connectors. It is always good practice to USE LASER GOGGLES! Avoid irradiation on eye or skin by direct or scattered light.

OD 6+@900nm-1020nm, OD 6+@1020nm-1100nm, OD 6+@1500nm-1600nm

Caution

Any modification of the product may result in dangerous laser radiation.

Caution

Laser Warning: Invisible Laser Radiation emitting from optical connector. Avoid direct exposure to beam. Dangerous laser radiation leakage may occur near damaged splice joints.

Caution

Attention! 25W max. @ 1550/1060/976nm. Class IV by ANSI Z136.1.

Caution

Single Mode Connector

Maximum emission 976nm: 25W

Maximum emission 1064nm: 25W

Maximum emission 1550nm: 25W

Caution

The connector between power supply and laser module is not suited for connection or disconnection while operating the laser.

Caution

Use of controls, adjustments, and procedures other than those specified in this manual may result in hazardous laser radiation exposure.

Caution

Guarantee expires with intervention in device. NP Photonics refuses any liability for damage caused by non-compliance with safety requirements.

1.1 Class IV Laser Product

Declaration of Conformity

Trade Name: NP Photonics, Inc.

Model No. RFLPXA

Responsible party: NP Photonics, Inc., 9030 S. Rita Road, Suite 120, Tucson, AZ 85747

Support Contact: NP Photonics, Inc. Phone: 1-520-799-7400 email: info@npphotonics.com

NP Photonics, Inc. complies with the following standards:

The following symbols/labels that might appear on your RFLS product:

- EN 61326-1 (IEC)

- EN 61010-1

- EN 60825-1

The High Power Laser Source Gen IV, Model: RFLPXA, meets the Class B specification limits defined by C.I.S.P.R. Publication 22 for Information Technology Equipment for radiated emissions, and the Class B specification limits defined by CFR Title 47, Part 15, Subpart B for conducted emissions. Under paragraph G of section 15.109 of the Code of Federal Regulations Title 47, Part 15 of the FCC rules, FCC accepts the international standards set forth in C.I.S.P.R. Publication 22.

The following symbols/labels that might appear on your RFLS product:

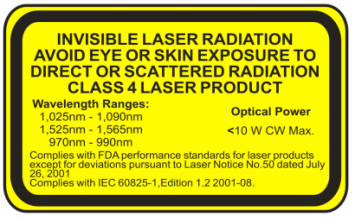
	Laser Aperture Warning Label – Laser radiation is emitted from this port!
	Laser radiation warning and classification – Avoid exposure label, and class 4 laser radiation warning.
	ESD warning label - Electrostatic Sensitive Connections – observe precautions for handling electrostatic sensitive devices - Do not connect anything to these inputs when the system is powered on. All connections should be made when the system power is off.

Figure 1.2 Laser Warning Labels

2 Maintenance and Care Instructions

Maintenance and Care Instructions: Other than keeping the optical connector(s) extremely clean at all times, there is no other maintenance to be performed by the operator. The laser has no serviceable parts. In case of a failure or malfunction please contact an NP Photonics, Inc. representative @ 520-799-7400.

-Do not shake, bump or drop the laser

-Do not install this unit in confined spaces and ensure that the unit is well ventilated

-To prevent risk of electric shock or fire hazard due to overheating, ensure that curtains and any other materials do not obstruct the ventilation vents.

- The socket outlet shall be installed near the equipment and shall be easily accessible

WARNING:

To reduce the risk of fire, electric shock, explosion, burns or product damage:

- Do not expose this unit to rain, moisture, dripping or splashing and ensure that no objects filled with liquids such as vases, shall be placed on the unit

- Use only the recommended accessories

- Do not remove the cover (or back); there are no user serviceable parts inside. Refer to servicing to qualified service personnel.

- Do not disassemble

- Do not heat above 60° C or incinerate

WARNING:

- DO NOT CONNECT THE MAIN AMP STAGE 2 OUTPUT FIBER WITH MORE THAN 1 WATT OF OUTPUT POWER TO ANY OTHER FIBER, ONLY CONNECT TO FREE-SPACE COLLIMATOR. IF THE SYSTEM COMES WITH A COLLIMATOR ALREADY ATTACHED, DO NOT REMOVE THE COLLIMATOR. DO NOT CLEAN THESE CONNECTORS WITH STANDARD FIBER CONNECTOR CLEANERS, CONTACT NP PHOTONICS FOR ASSISTANCE.

- If applicable, Output Fibers with less than 1 Watt of Output Power can be connected to matching fiber connectors while the laser is turned off.

- DO NOT INSTALL COLLIMATOR OR CONNECT TO ANOTHER FIBER WHEN LASER IS ACTIVE

- REMOVE DUST CAPS FROM FIBER CONNECTORS AND POINT FIBER ENDS TO A SUITABLE POWER METER OR EQUAIVALENT BEAM DUMP BEFORE ACTIVATING LASER OUTPUT

- MAKE SURE THAT THERE IS AT LEAST 0.5" CLEARANCE AROUND THE LASER IN ALL DIRECTIONS, AND ADEQUATE AIR FLOW FOR STABLE OPERATION

3 Introduction to the High Power Erbium Micro Fiber Laser

The High Power Fiber Laser Source is an all fiber-based single frequency laser. It is an amplified version of NP Photonics' Rock Laser Module – an ultra-narrow line width laser for sensing, LIDAR, test and measurement, R&D, and telecommunication applications. Incorporating proprietary Erbium Micro Fiber EMF technology developed at NP Photonics, the Rock laser provides up to 150mW of optical power over the telecommunications C-band (1530-1565nm) or in the (1030-1075nm) band. The clean optical power from the seed module ensures good saturation in the subsequent amplification stages, and ensures large signal to amplified spontaneous emission (ASE) noise ratio and low relative intensity noise. High power (up to 25W) is achieved by using a master oscillator power amplifier (MOPA) configuration consisting of the seed fiber laser as the oscillator, and one or two stages of high power fiber amplifiers optimized for single frequency operation. For >2W systems, there are two stages of amplifiers, whereas for ≤2W systems, there is only a single amplifier stage. By design the output from the MOPA maintains the narrow linewidth and low noise from the seed, while delivering many watts of optical power.

3.1 The Laser Cavity: Single Mode Operation and Wavelength Tuning

The cavity is established by two fiber Bragg gratings (FBG) that are fusion spliced to a short piece of active material (see Figure 3.2). A spectrally narrow grating (NB-FBG) selects a single longitudinal mode of the laser cavity and acts as the output coupler for the laser signal. The laser is excited through the second, spectrally much wider, high-reflector grating (WB-FBG), using the output of a single mode pump diode. The temperature of the fiber laser cavity is well controlled to keep the laser frequency stable within its thermal tuning range.

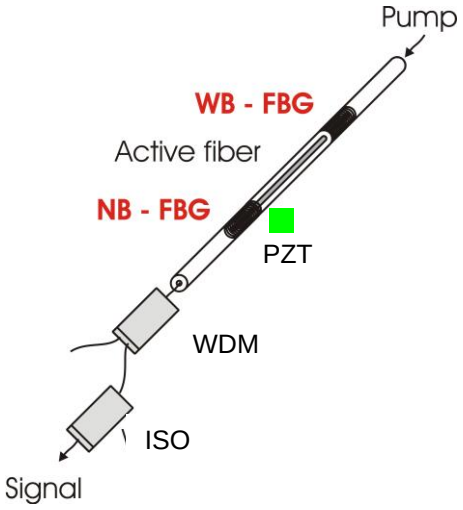


Figure 3.2 Laser Schematic

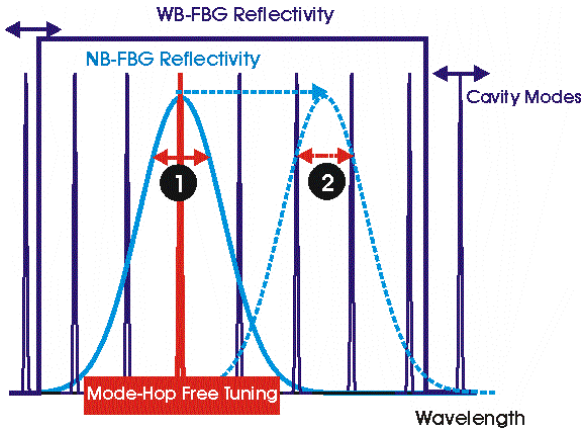


Figure 3.1 Wavelength Tuning

A small piezo actuator (PZT in Figure 3.2) is attached to the fiber laser to allow for fast frequency tuning as well as to avoid occasional mode hop regions that can occur within the thermal tuning range.

The effective total cavity has a length of ~ 4 cm and a free spectral range on the order of 2.5 GHz. When the laser temperature is changed, the mode selector and the cavity modes are tuned together and the laser wavelength changes within about 1 GHz/K. However, due to slightly different expansion coefficients of the fibers used in the Rock laser, the longitudinal modes will move somewhat less than the center wavelength of the NB grating and eventually a situation occurs where 2 longitudinal modes experience the same output coupler reflectivity. This is illustrated as situation in Figure 3.1. and typically occurs less than 3 times over the whole thermal tuning range. Figure 3.3 shows the laser frequency as a function of the laser temperature. Two mode hop regions are observed over a thermal tuning range of more than 30 °C or > 0.3 nm. These regions

are very narrow (< 0.1 °C) and can automatically be avoided by internally applying a DC voltage to the piezoelectric actuator. This is schematially illustrated in Figure 3.3.

The laser has been calibrated at the factory and any wavelength inside the 30 GHz wide thermal tuning range can be easily accessed through the software interface.

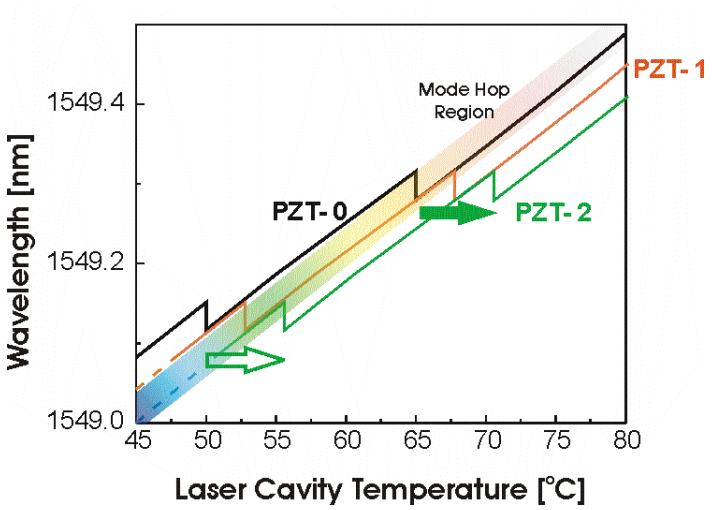


Figure 3.3 Example of Tuning Curves

4 High Power Single Frequency Fiber Laser Source Features

Features of the High Power Single Frequency Fiber Laser Source include:

- Very Narrow linewidth (long coherent length) down to 700Hz (corresponding to a coherence length of many kms)
- Center wavelength selectable over 1550nm C-band or between 1030 and 1075nm
- Output isolation standard
- Up to 25W of output power
- Adjustable output power
- Dual output (seed laser port and high power output port) and multi-fiber output options
- Linearly polarized or randomly polarized output available
- High wavelength stability
- Thermal tuning of wavelength
- Fast piezo tuning of wavelength
- Microprocessor control
- RIN suppression
- Automatic Power Control loops (APC Constant Power Mode)
- Software supported

The High Power Single Frequency Fiber Laser Source combines a narrow linewidth Seed fiber laser and an optimized high power fiber amplifier in a 19” rack mountable enclosure.

The Seed laser is integrated in a compact, acoustically damped package with controls for wavelength tuning, RIN suppression, and a constant Seed power or Seed current mode.

The fiber amplifier can be operated in a constant current as well as a constant power mode by varying the pump diode current to the final amplifier stage. This can be done either through the software or through a potentiometer from the front panel. The output power is adjustable over a wide range.

5 RFLPXA Operation

Figure 5.1 Front Panel of the RFLPXA (multiple output options shown)

5.1 System Power Key Switch

This is a two-position switch.

Position 0	System is powered down
Position 1	System is powered up, laser can be turned on

5.2 Status LEDs

The *SYSTEM POWER* LED is on (green) when the system is powered up.

The *SEED OUTPUT ACTIVE* LED is on (green) when the Seed laser output is active and light is emitted from the Seed port

The *AMPLIFIER OUTPUT ACTIVE* LED is on (green) when the Amplifier outputs are active and light is emitted from the Amplifier output fiber

5.3 SEED OUTPUT Enable Switch

This switch is used to turn the Seed laser output on (1) or off (0). When the switch is turned to the on (1) position the green output active LED will come on to indicate that the Seed laser is emitting light. There is a delay of approximately five seconds between the LED coming on and an optical output being present. The Seed laser output typically takes 10 minutes to stabilize to a narrow linewidth emission after the Seed is enabled.

5.4 Seed Laser Optical Port

This port is used for seed laser monitoring (before the optical amplifier), and optical mixing for Lidar/sensing applications. The connector is PM-1550 FC/APC, key aligned to slow axis.

A mechanical shutter in front of the Seed laser optical port acts as a beam stop and will automatically block the laser. The shutter is marked with a laser warning. The SEED Output active LED above the aperture is on when an optical signal is present. See 6.1

For safety reasons the mating connector should be fitted only when the laser is inactive.

5.5 AMP OUTPUT (Amplifiers Output) Enable Switch

This switch is used to turn the Amplifiers' outputs on (1) or off (0). When the switch is turned to the on (1) position the green output active LED will come on to indicate that the Amplifier is emitting light. There is a delay of approximately five seconds between the LED coming on and an optical output being present.

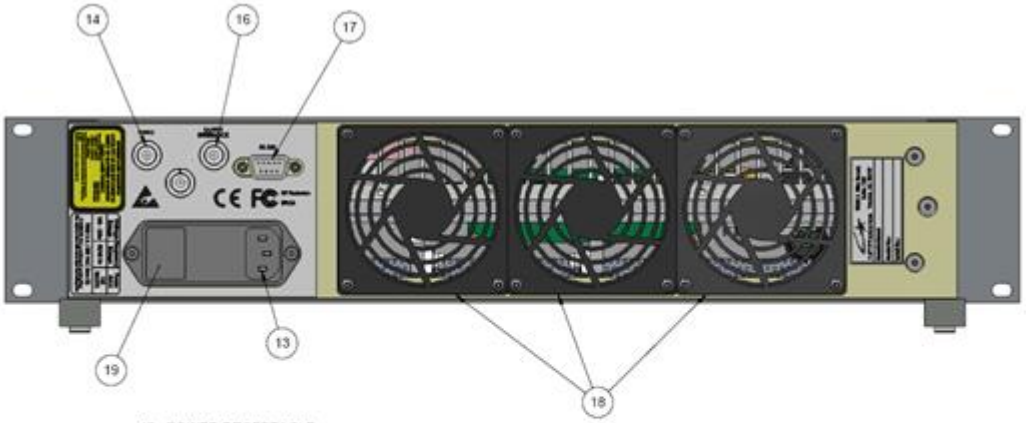
Note that Amplifiers will be held in a disabled state, regardless of the switch, unless the Seed laser has stabilized, which typically takes 10 minutes after the Seed is enabled.

5.6 Amplifier Output Fiber

This port nominally houses a special fiber cable exiting the front panel with a FC/APC (key aligned to slow axis) connector at the end. There could be a collimator attached to the fiber, or multiple fiber coming out of the front panel depending on the configuration of the system.

For RFLPXA systems with greater than 1W output power output, if the output fiber is attached to a collimator, do not remove the fiber from the collimator. If the collimator has a plastic cover, remove it before turning on the laser. If the fiber has a metal cap but no collimator, then this fiber needs to be coupled to a free-space collimator or other free-space setup, and not connected to another fiber patchcord. Do not clean these fiber connectors with standard fiber optic connector cleaners. Contact NP Photonics for assistance.

For RFLPXA systems with less than 1W output power output (or multi fiber output with less than 1W per fiber), the fiber can either be coupled to a free-space collimator or connected to another fiber patchcord. Make sure that the laser is turned off before making any connections.



13. POWER RECEPTACLE W/FUSE DRAWER
* 14. PIEZO
* 16. SAFETY INTERLOCK
* 17. RS 232
18. COOLING FANS
19. AC POWER ENTRY ROCKER SWITCH

* These components are ESD sensitive, DO NOT CONNECT anything to these inputs when the system is powered on. All connections should be made when the system power is off.

Figure 5.2 Rear Panel of the Fiber Laser Source

5.7 RS232 Connector

For connections to a PC an RS-232 extension cable should be used. This is a DB-9 male to female cable assembly with one-to-one pin connections. There should be no crossover of the transmit and receive signals. Note that a null modem cable is not suitable. The serial port uses the transmit (TXD), receive (RXD) and signal ground (GND) lines only; the pins normally used for hardware handshaking (Pin 7 - CTS and Pin 8 - RTS) are not connected.

Pin	Function
1	no connection
2	TXD, transmit data (output from laser)
3	RXD, receive data (input to laser)
4	no connection
5	GND, signal ground
6	no connection
7	no connection
8	no connection
9	no connection

5.8 Interlock Connector

The safety interlock BNC is required to be shorted together for normal operation. When the terminals are open circuit the laser will automatically be in a shutdown state. A 50 Ω terminator can be used to bypass this feature.

5.9 AC Power Entry Connector

The line input power connector requires an input voltage of 90-264Vac at 50-60Hz and is internally grounded.

5.10 Piezo Connector & Fast Wavelength Modulation

The Piezo BNC connector allows the user to apply a signal to modulate the wavelength of the laser using the piezo actuator inside the laser. To use this option the Fast Piezo Modulation option must have been chosen at the time of ordering the laser.

The piezo allows users to have a means (faster than via temperature) to change or modulate the laser frequency. Using the internal piezo amplifier the typical piezo response is ~ 30 MHz/V at dc and the 3dB bandwidth (speed) is typically around 14 kHz.

5.11 Cooling Fans

The laser requires a flow of air to keep it cool. Fans are provided for this purpose. When installing the laser, ensure that there is adequate access for airflow. **Make sure that there is at least 0.5" clearance around the laser in all directions.**

6 Setup Procedures

THIS IS A CLASS IV LASER PRODUCT: requiring proper eye and skin protection as specified by the Center for Devices and Radiological Health (CDRH) of the United States Food and Drug Administration.

Dangerous laser radiation leakage may occur.

PLEASE USE APPROPRIATELY SPECIFIED LASER SAFETY GOGGLES.

6.1 Optical Connections

The high power output from the laser can come in several output formats depending on the customer preference. The output power is generally accessed from (1) an FC/APC connector at the end of a fiber cable exiting the front panel, or from (2) a collimator assembly attached to the output fiber exiting the front panel. The seed port output is always via an FC/APC bulkhead connector on front panel.

The FC/APC connectors (2mm narrow key type) nominally contain polarization maintaining (PM) single mode fiber. The single mode APC connectors are used to avoid back reflections from returning to the laser system. The polarization axis of the seed laser and amplified outputs are aligned parallel to the slow axis as indicated in Fig. 4.1

For Type (1) delivery option:

RFLPXA systems with greater than 1W output power output, the output fiber needs to be coupled to a free-space collimator or other setup, and not connected to another fiber patchcord. Do not clean these connectors with standard fiber optic connector cleaners. Contact NP Photonics for assistance. It is important to always use appropriately high power rated and AR-coated free-space optics with the output of the laser system. Consult with NP Photonics if there are any questions on the output connections.

RFLPXA systems with less than 1W output power output (or multi fiber output with less than 1W per fiber), the fiber can either be coupled to a free-space collimator or connected to another fiber patchcord. Make sure that the laser is turned off before making any connections.

For type (2) delivery option:

RFLPXA systems contain collimating assemblies as the output format and deliver a collimated output beam. The collimator has been attached to the fiber cable at the factory, and it is not adjustable and should not be removed! If the collimator has a plastic cover, remove it before turning on the laser.

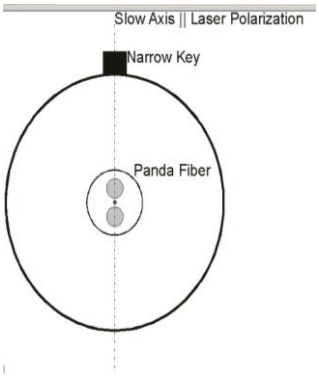


Figure 6.1 Laser Polarization Alignment with Fiber Axis and Connector Key

6.1.1 Cautions

1. The ferrule of your optical fiber connector must be absolutely clean before being mated with the Rock High Power Fiber Laser. Dust, lint, oil (from touching the fiber end face), and other foreign particles will not only obscure the face of a fiber but – owing to the high light intensities that occur in single mode fiber lasers – may also permanently "burn" the fiber. The fiber optic ferrule must be cleaned and inspected every time it is mated and unmated.

   For RFLPXA systems with greater than 1W output power output, if the output fiber is attached to a collimator, do not remove the fiber from the collimator. If the collimator has a plastic cover, remove it before turning on the laser. If the fiber has a metal cap but no collimator, then this fiber needs to be coupled to a free-space collimator or other free-space setup, and not connected to another fiber patchcord. Do not clean these fiber connectors with standard fiber optic connector cleaners. Contact NP Photonics for assistance.

2. Unprotected connector ends are most often damaged by impact, such as from hitting the floor.

   Most connector manufacturers provide some sort of protection boot. The best protectors cover the entire connector end, but most often protectors are simple closed-end plastic tubes that fit snugly over the ferrule only. These boots will protect the connector's polished ferrule end from impact damage that might crack or chip the polished surface. However, many of the tight fitting plastic tubes contain jelly-like contamination (a byproduct of making the protection boot) that adheres to the sides of the ferrule. A blast of cleaning air or a quick dunk in alcohol will not remove this residue and a more thorough cleaning will be needed.

   Never turn on the laser when the protection boot is still attached; the fiber optic connector may be damaged by the high power output.

3. Never touch the fiber end face of the connector.
4. Never touch the collimator lens (if applicable). When in use, cover collimator head to avoid accumulation of dust.
5. Never move or swing the output fiber cable when the laser is on.
6. Do not bend or curl the output fiber with radius less than 10 cm.
7. Securely attach the output fiber cable so that it does not move while the laser is running. Motion of the fiber cable can affect the stability of the laser.
8. The laser system is sensitive to back reflections. Back reflections can cause instabilities and even damage in some cases. It is strongly recommended that back reflections be kept to a minimum and certainly below the values listed in the table.

Power output rating		Maximum power back (Max ORL, dB)	Maximum power back	Isolation level (output isolation, typical)
1064nm	1550nm			
0.5W	0.5W	-3	250 mW	30dB
1W	1W	-6	250 mW	30dB
2W	2W	-9	250 mW	25dB
	3W	-11	250 mW	25dB
≥ 5W	≥ 5W	-13	250 mW	25dB

6.1.2 Cleaning Technique

For RFLPXA systems with greater than 1W output power output, if the output fiber is attached to a collimator, do not remove the fiber from the collimator. If the fiber has a cap but no collimator, then this fiber needs to be coupled to a free-space collimator or other free-space setup, and not connected to another fiber patchcord. Do not clean these fiber connectors with standard fiber optic connector cleaners. Contact NP Photonics for assistance.

For regular cleaning of the ferrule, use a high quality commercially available optical fiber connector cleaner; follow the manufacturer's instructions to remove all contaminations.

- Air can be used to remove lint or loose dust from the fiber port to be mated with the connector.

- Always inspect the end of the fiber with a fiber scope after cleaning to ensure the connector end is cleaned.

- Never insert any liquid into the port.

⚠ Ensure no optical power is present at time of inspection

6.2 Electrical Connections

Note: Safety concerns require the following steps to be performed in the order indicated.

1. Make sure the AC power entry is set to the off position.
2. Make sure the system power key switch is in the O (Off)
3. Plug the power supply into a 100-230VAC, 50-60Hz electrical outlet.
4. If you plan to run and monitor the laser from a computer, connect the provided RS232 cable to the computer and to the RFLPXA RS-232 connector.
5. Make sure that the remote interlock connector is short circuit or a 50 ohm terminator is fitted if an interlock is not in use.
6. Make a connection to the fast piezo modulation BNC on the rear panel - if it is to be used.

6.3 Startup Procedures

1. Verify that the system power key switch is in the OFF (0) position.

2. Turn the AC power entry rocker switch on the back of the unit from O (OFF) to 1 (ON)

4. Turn the key switch that is located on the front panel from OFF (0) to ON (1). A green indicator LED will light up and verify that the electrical power is supplied to the system.

5. Wait for ~10 minutes for the seed laser temperature to stabilize. Turn the SEED OUTPUT key switch to ON (1). This enables the seed laser to emit light. The green indicator LED located above the seed laser' optical output ports will light up to show that the seed laser is emitting optical power.

6. Once seed laser is turned on, it will take some time (about 15-20 minutes) for its temperature to re-stabilize. During this time the seed laser will not yet operate to all specifications. The laser may temporarily emit two longitudinal modes – indicated by the red indicator labeled 2ND MODE in the software program. Once the Seed has stabilized, the Amplifiers can be turned on.

7. Make sure the Amplifier output fiber (or fibers) is directed to a high power optical power meter, or to your free-space experiment setup.

8. To energize the high power output, set the AMP OUTPUT enable rocker switch to ON (1). The Amplifier Enable LED will come on. Note that if the Amplifiers are turned on before the Seed is stable, the software will hold the Amplifiers in a disabled state until the Seed Laser is ready.

9. For >2W systems, there are two stages of amplifiers, whereas for ≤2W systems, there is only a single amplifier stage.

10. If your system is designated to be >2W, the Amplifier Stage1 will turn on, and the AMP Stage1 current/power will rise to the preset value that is fixed at the factory. This level is not adjustable by the user. At this point, the GUI software can be used to make adjustments to the Amplifier Stage 2 current/power. See Section 7 for details.

11. If your system is designated to be ≤2W, the Amplifier Stage1 will turn on at a predetermined current level (nominally zero current). At this point, the GUI software can be used to make adjustments to the Amplifier Stage 1 current/power. See Section 7 for details.

Important Notes on Operation

1. **When increasing or decreasing the Amplifier current and/or power either using the GUI, or through the RS232 command line, avoid large step increases in the current or power settings.**

   A rate of no more than 0.05Amps/second (ACC mode) , or 0.1W/sec (APC mode) is recommended in both positive and negative direction.

2. If the Seed laser destabilizes either because the wavelength is adjusted or because the optimization routine is avoiding a Seed 2nd mode region, the Amplifier may temporarily turn off until the seed stabilizes.

3. **It is important to not change any seed laser settings including wavelength tuning while the amplifier is operational. First turn off the amplifier, change the seed laser settings, and turn back on the amplifier.**

6.4 Shut Down Procedures

To shut down the system follow these steps:

1. Use the GUI, or the RS232 command line to slowly reduce the Amplifier output to the minimum setting as described in the notes above.
2. Disable the Amplifier Output by setting the AMP OUTPUT rocker switch to OFF (0).
3. Disable the Seed Laser Output by setting the SEED OUTPUT rocker switch to OFF (0).
4. Turn the system power's key switch to OFF (0) position.
5. Set the AC power entry switch on the back of the unit to the OFF position.

7 Computer Interface and Fiber Laser Control Panel Program

7.1 Software Installation

The delivered CD contains a SETUP.EXE file in a directory similar to that shown in Figure 7.1. Run SETUP.EXE to install. Select the default settings or make changes as desired.

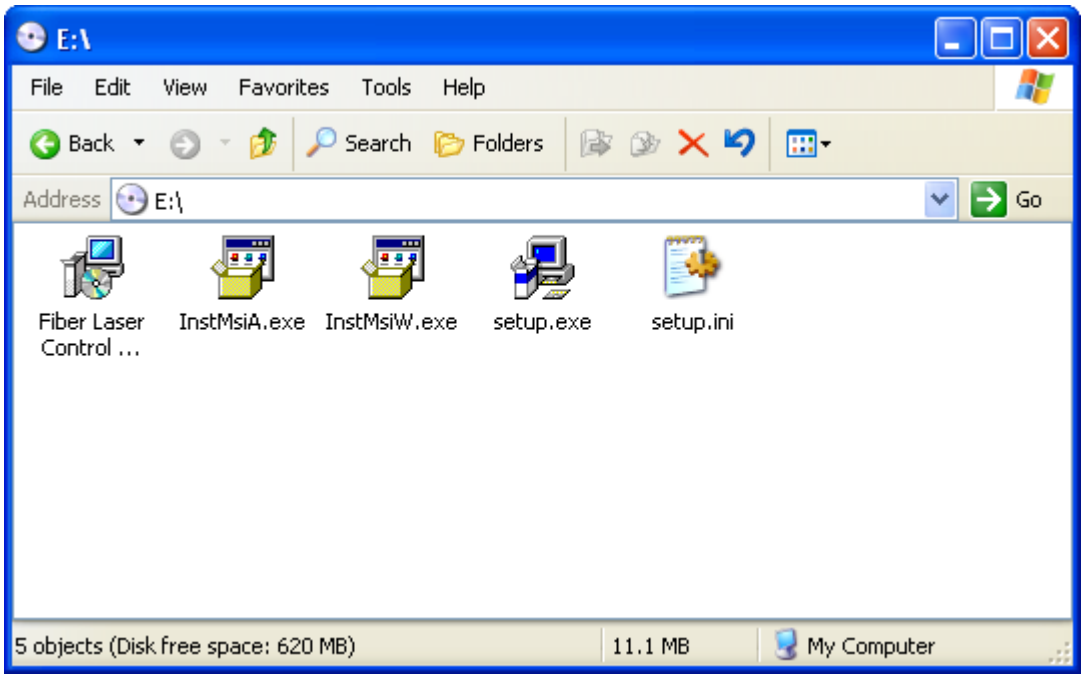


Figure 7.1 Installation Disc

7.2 Running the Software

1. Connect the RS232 to the PC before turning on the power to the unit. Turn on the power to the laser (key switch in I (On) position).

2. Start the Fiber Laser Control Panel (FLCP) program using the desktop icon or click *Start – Programs – Fiber Laser Control Panel – Fiber Laser Control Panel*.

7.3 The Startup Window

The startup window allows you to specify the device type and associated COM port number or IP address before opening communications with the laser.

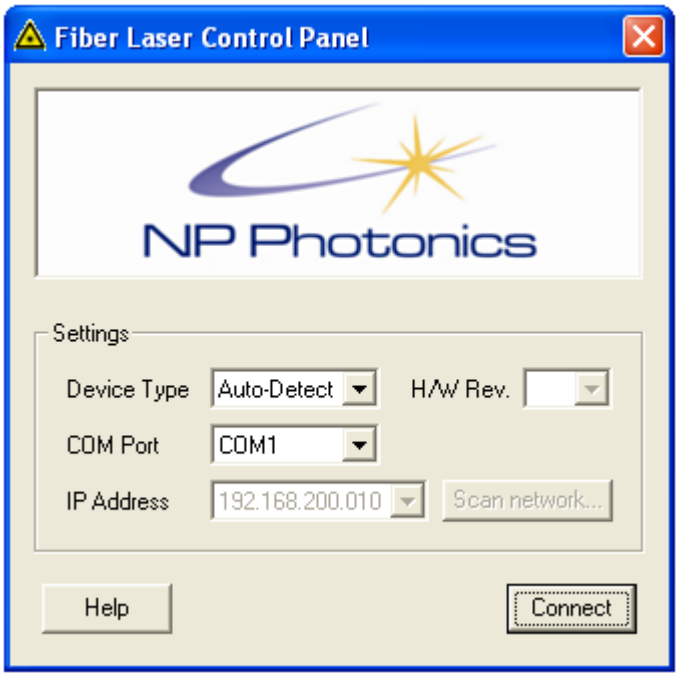


Figure 7.2 Start-Up Window

For the RFLPXA module the **Device Type** drop down box can be left as *Auto-Detect*.

For the **COM Port** drop down box select the correct COM port number. This is usually COM1 for computers with a built in COM port, but where a USB to RS232 converter is used the correct port number for the COM port must be determined by looking in the computers device manager screen.

To start communicating with the laser, click the **Connect** button. The startup window will then close and the main window will appear.

To view context-sensitive help, click the **Help** button or press the **F1** key.

7.4 The Main Window

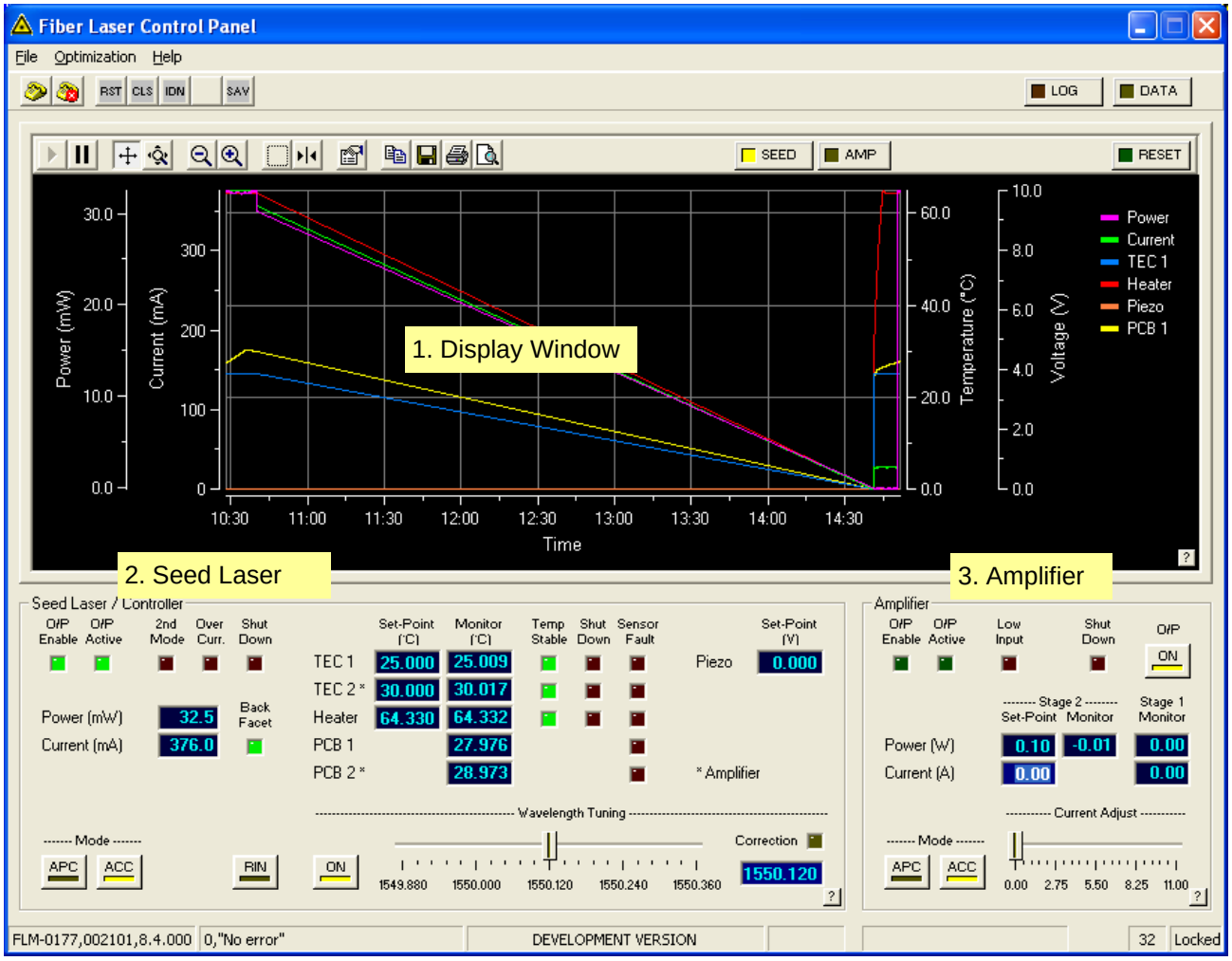


Figure 7.3 The Main Window

The main window of the program is shown in Figure 7.3

It has 3 main sections:

1. Display Window
2. Seed Laser
3. Amplifier

A description of each section is given below.

Help Button

? Displays context sensitive help for each of the sections

7.4.1 Display Window Section

The Display window is the largest part of the main program window. The graph can display parameters for the Seed laser or the Amplifier.

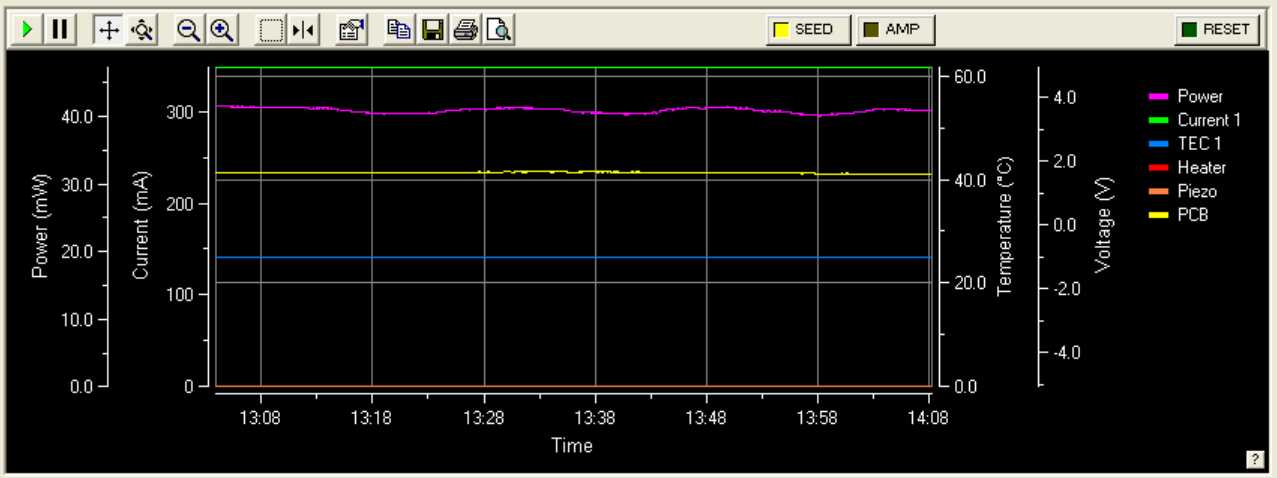


Figure 7.4 Display Window – Seed Laser Parameters

For the Seed laser the graph displays the laser output power, the pump diode current(s), the pump diode TEC temperature(s), the heater temperature, the Piezo voltage and the internal Seed PCB temperature.

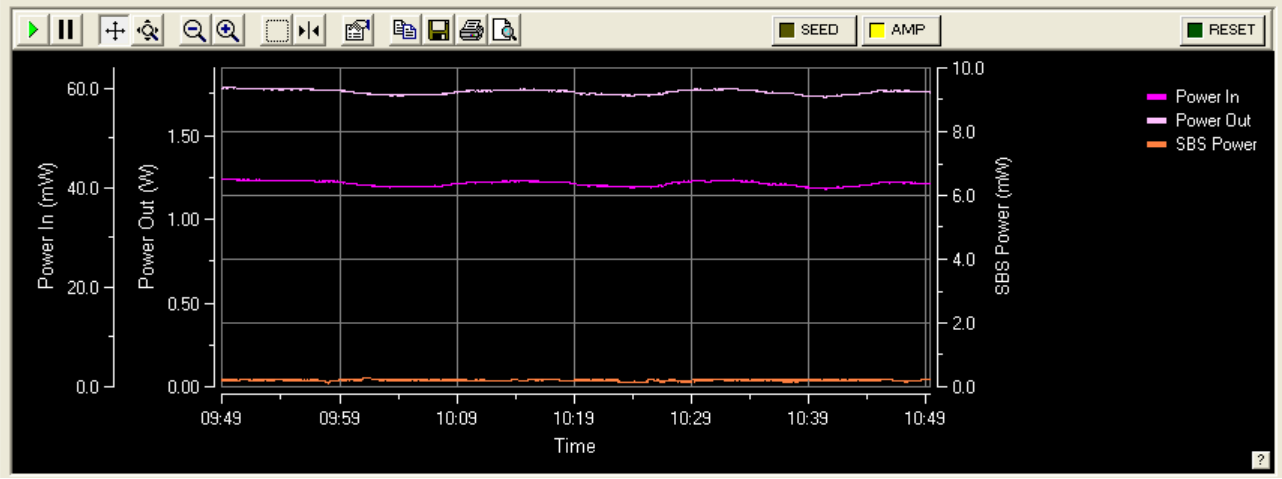


Figure 7.5 Display Window - Amplifier Parameters

For the Amplifier the graph displays the power input from the Seed laser, the power output from the Amplifier and the SBS power monitor

	Resume	This button enables tracking on all axes.
	Pause	This button turns off tracking on all axes. When tracking is off, the axes will remain stationary while data is being added.
	Axes Scroll Mode	When this button is active, you can drag the axis and scroll the view. When the button is selected, the Axes Zoom Mode button is unselected.
	Axes Zoom Mode	When this button is active, you can drag the axis and zoom the view. When the button is selected, the Axes Scroll Mode button is unselected.
	Zoom In	When this button is clicked, all axes are zoomed in by a factor of 2. When the button is clicked, tracking on all axes will be disabled to pause the view.
	Zoom Out	When this button is clicked, all axes are zoomed out by a factor of 2. When the button is clicked, tracking on all axes will be disabled to pause the view.

	Zoom Box	This button allows you to zoom in on any region of the plot area. The zoom box can start at any point, but you must drag from the upper left to the lower right. The zoom action will affect all axes and will cause tracking to be disabled.
	Cursor	This button shows or hides all data cursors.
	Properties	This button displays the property editor.
	Copy	This button copies an image of the graph to the clipboard.
	Save	This button saves an image of the graph to file. You can select Bitmap, Metafile or JPEG as the file type.
	Print	This button sends an image of the graph to your printer.
	Preview	This button displays a print preview of the graph.
		These buttons select the Seed Laser or Amplifier parameters for Graphical display
		This button allows the graph display to be cleared of all existing data and re-started from the current time.

7.4.2 Seed Laser Section

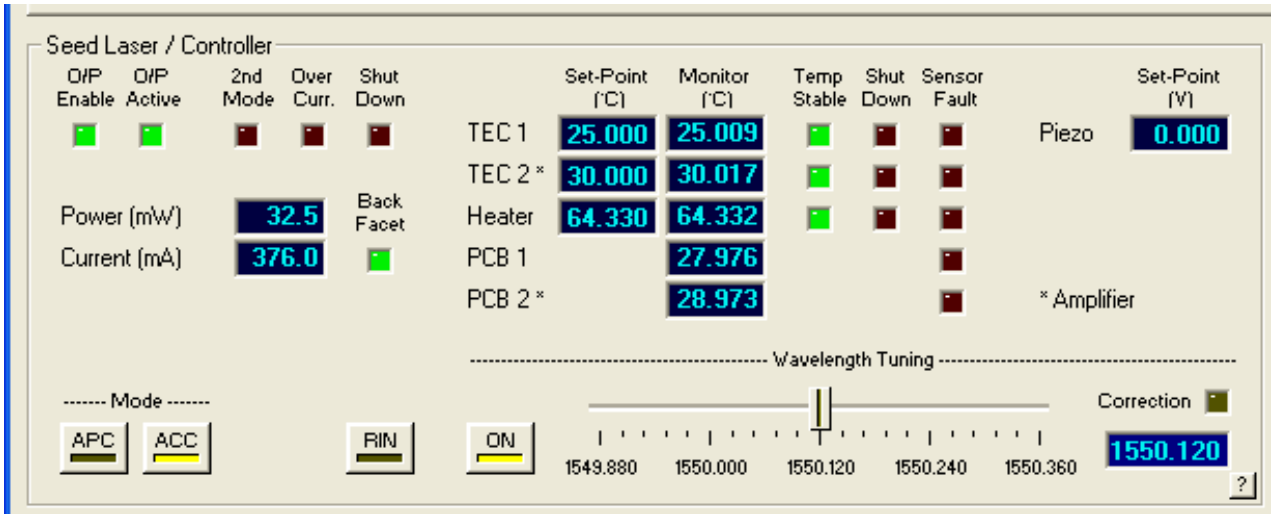
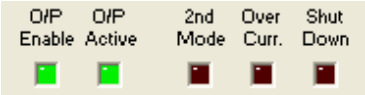


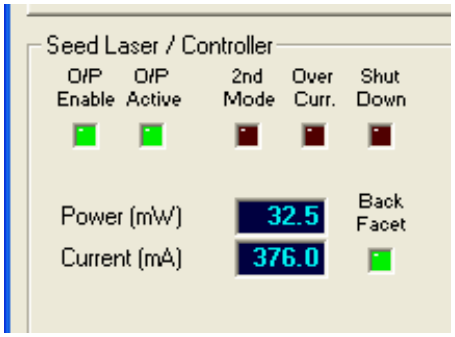
Figure 7.6 Seed Laser Window

Status Indicators



O/P Enable	Indicates that the Seed laser output is hardware-enabled.
O/P Active	Indicates that the Seed laser output is on.
2nd Mode	Indicates the presence of 2nd longitudinal mode in the output spectrum.
Over Curr.	Indicates an over-current fault condition in the pump diode(s).
Shut Down	Indicates that the laser has shut down due to current or temperature error.

Numerical Readouts



Power (mW)	The Seed laser output power monitor.
Pump 1 (mA)	The monitored current for Pump 1.
Back Facet	The indicator to the right of the pump diode current is a back facet monitor. When it is on it indicates that the pump diode is generating light.

Mode Buttons

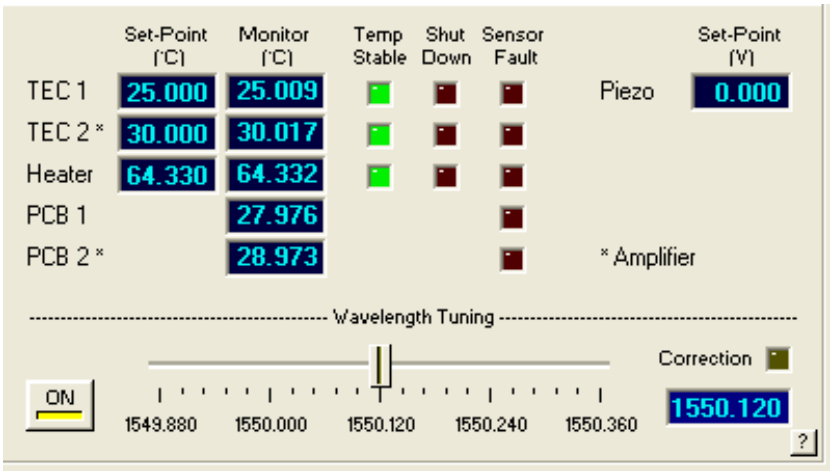
Automatic Power Control mode (constant Seed power).

Automatic Current Control mode (constant Seed current).

Rin Button

Turns the Seed laser Rin suppression control on or off.

Temperature Controls



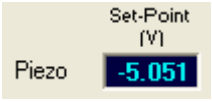
The Temperature Control section comprises a series of numerical readouts and status indicators associated with the Seed laser's temperature control and monitoring functions.

Set-Point (°C)	The temperature set-point for the referenced control loop.
Monitor (°C)	The monitored temperature for the referenced control loop or PCB.
Temp Stable	Indicates that the referenced control loop is settled and stable.
Shut Down	Indicates that the referenced control loop has shut down.
Sensor Fault	Indicates a sensor fault on the referenced control loop or PCB.

The temperature of the heater within the laser is automatically set by tuning the wavelength of the laser. The "Temp Stable" LEDs will turn green when the temperatures are stable. Stabilization of the heater temperature takes on the order of 5-10 minutes.

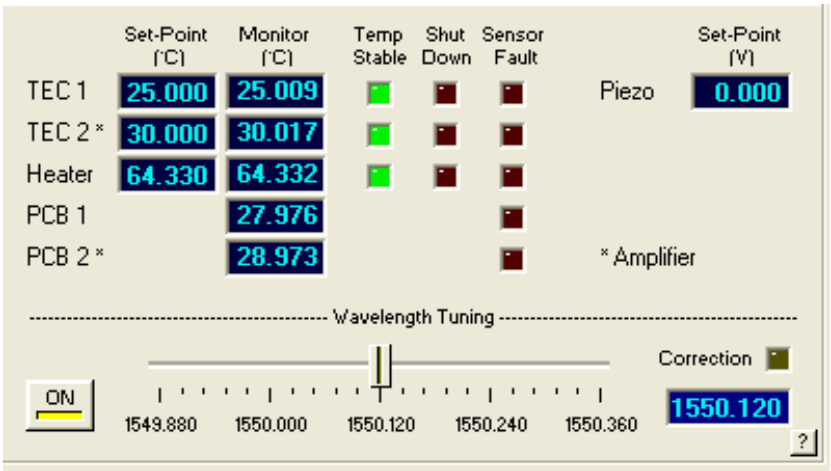
If the heater temperature is stabilized and the second mode status indicator is still on, it may be that more time is needed to come to total thermal equilibrium. If the 2nd mode persists the laser is configured to automatically remove the 2nd mode, after a delay, by performing an optimization.

Piezo Voltage Monitor

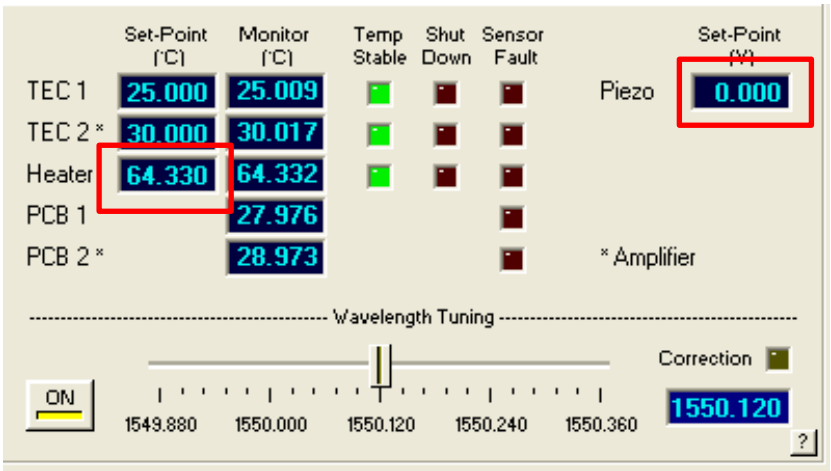


This section displays the piezo drive voltage applied by the internal amplifier for 2nd mode avoidance. It **does not** include any additional voltage applied to the piezo modulation input for fast piezo tuning.

Wavelength Tuning

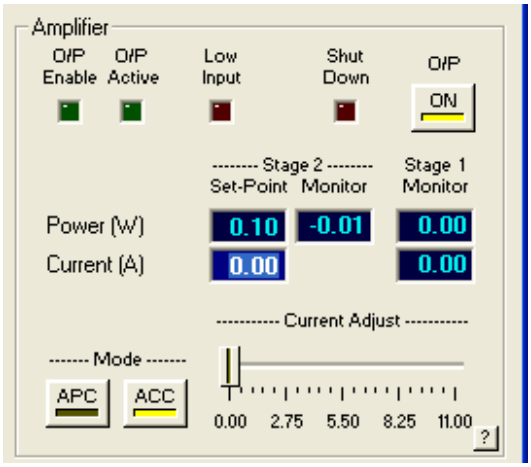


When Wavelength Tuning is switched ON the slider can be used to control the Seed laser wavelength. When the slider is moved the Seed Heater temperature and Piezo voltage are tuned according to an internal calibration to avoid second mode regions and reach the calibrated wavelength.

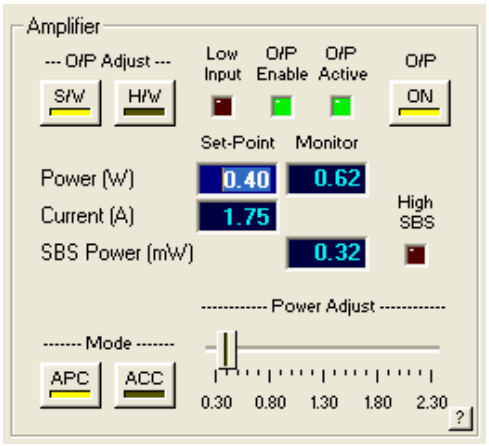


With the wavelength tuning turned off, it is possible to type in values in the *Heater* set point box and the *Piezo Drive* set point box and press the return key. The numerical wavelength display is invalid.

7.4.3 Amplifier Section



Two Stage Amplifier (>2W System), ACC mode



One Stage Amplifier (≤2W System), APC mode

Figure 7.7 Amplifier Window – multiple system configuration examples shown

Mode Buttons

Power Control mode. The Amplifier output power is controlled using the *Power Adjust* slider or by directly typing a power level into the *Power (W)* Set-Point box.

Current Control mode. The Amplifier current is controlled using the *Current Adjust* slider or by directly typing a power level into the *Current (A)* Set-Point box.

O/P Adjust Buttons

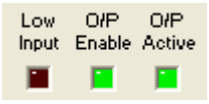
Software Control. The Amplifier output current or power is controlled via software.

Hardware Control. The Amplifier output current or power is controlled via the front panel potentiometer.

O/P Button

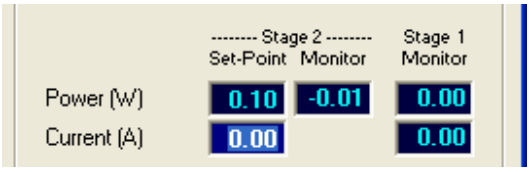
The amplifier output, when enabled by the hardware controls, can be turned on and off via this software switch.

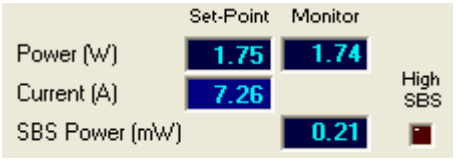
Status Indicators



Low Input	Indicates that the Seed power into the Amplifier is too low. Amplifier will shut down.
O/P Enable	Indicates that the Amplifier outputs are hardware-enabled.
O/P Active	Indicates that the Amplifier outputs are on.

Numerical Readouts





Power (W)	The Amplifier power set-point and corresponding power monitor read back. For >2W systems, this controls the AMP Stage 2 (left figure). For ≤2W systems this controls the AMP Stage1 (right figure)
Current (A)	The Amplifier current set-point. For >2W systems, this controls the AMP Stage 2 (left figure). For ≤2W systems this controls the AMP Stage1 (right figure)
SBS Power (mW)	The monitored SBS power (only applicable for ≤2W systems)
High SBS Indicator	The indicator to the right of the SBS power monitor. When it is on it indicates that the SBS power level reached a high enough level for the Amplifier to perform an automatic shutdown. To clear this, turn the Amplifier off and on again using the front panel Amplifier enable toggle switch. (only applicable for ≤2W systems)
Stage1 Monitor	This section shows the current and power levels of AMP Stage 1. It is a read-only section, not adjustable by the user (only applicable for >2W systems)

7.4.4 Toolbar Buttons

The toolbar is located just below the window's menu bar.

Toolbar Buttons

 Connect	This button is used to open communications with the controller. For most applications, communications start automatically when the main window is first displayed, but you can choose to stop communications using the Disconnect button (see below) and to re-start using this button.
 Disconnect	This button is used to close communications with the controller. Although communications stop automatically when the main window is closed, you can choose to stop communications using this button and to re-start using the Connect button (see above).
 Reset	This button resets the controller using the *RST command. This causes the laser's firmware to reset to its boot-up state.
 Clear Status	This button clears the laser's status using the *CLS command. This essentially clears its internal error queue.
 Query Identification	This button requests the laser's identification string using the *IDN? command. The identification string comprises the manufacturer, model number, serial number and firmware version number. It is displayed in the Status Bar.
 Query Option	This button requests the laser's option information using the *OPT? command. This option information is used to report any hardware or firmware options fitted. If there are no options fitted, "0" is reported. The option information is displayed in the Status Bar.
 Save	This button saves the laser's settings into non-volatile memory using the *SAV command.
	This button is used to open or close a data log file. It will log all of the data which is used in the graphical display to file; for analysis with a program such as Excel. Only data from the time the LOG button is pressed is saved.
	This button indicates when status information is being read from the laser. It can also be used to request status updates manually. See *Preferences* under the File menu for further details.

Note that the Seed laser *RIN* and *Wavelength* controls plus the Amplifier *O/P Adjust*, *Mode* and *Current (or Power)* controls and set points are all affected by the SAV button.

If any settings are changed they will be lost when the laser is power cycled or reset, unless the SAV button has been pressed to save them in non-volatile memory.

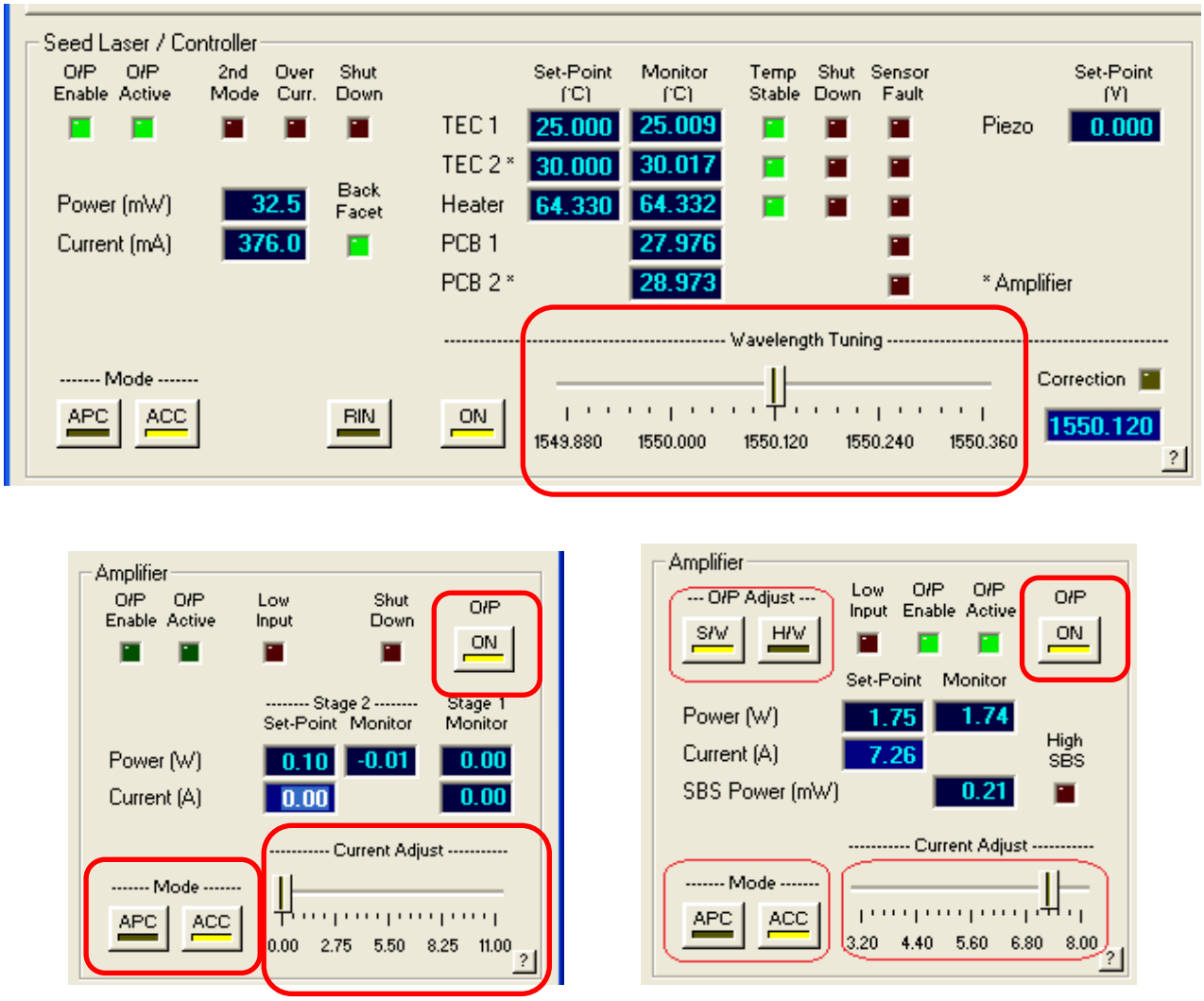


Figure 7.8 Controls affected by the SAV button

7.4.5 Menu Bar

The menu bar is located just below the window's title bar. It provides the following menus:

- The File menu includes commands for setting the program preferences and exiting the program:

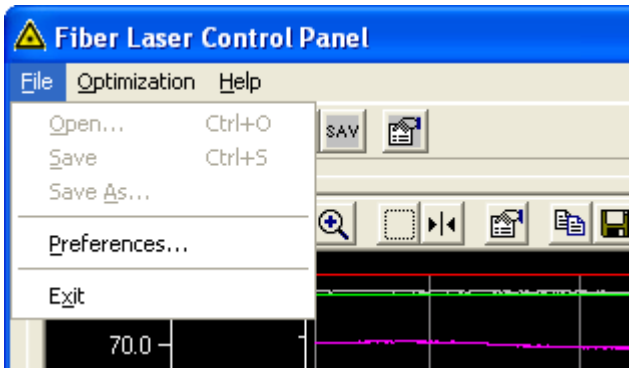


Figure 7.9 File Menu

- The Optimization menu includes commands for optimizing the laser, viewing the results and setting the optimization options:

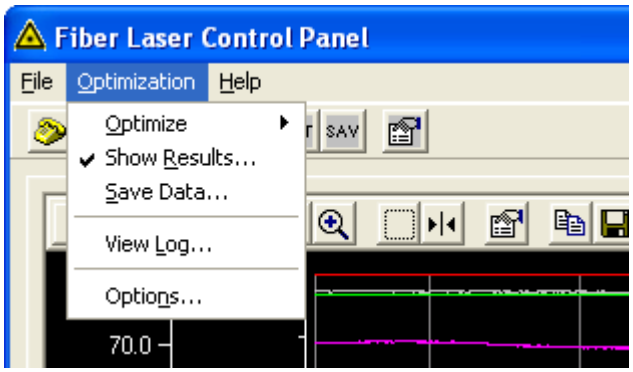


Figure 7.10 Optimization Window

- The Help menu includes commands for accessing the program's help file, requesting technical support and checking the program version:

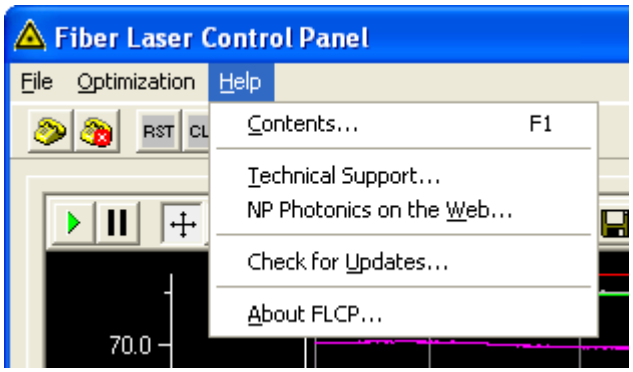


Figure 7.11 Help Menu

8 The Optimization Process

Often the laser is used in an environment where there are temperature changes or where customers use the laser in a way that moves it outside the "factory-calibration" conditions. These lasers are conservatively specified and can be exercised to operate in these more challenging environments. Under such conditions it is possible for the laser to enter a regime where it has two longitudinal modes at the same time. This is a *second mode* region. To enable this extension of capabilities we have developed an optimization routine to be initiated by the user to recover from this condition.

The aim of the optimization process is to adjust the laser's operational point within a single mode region, so as to minimize the likelihood of drifting into any bordering second mode regions. The technique involves monitoring the laser's output power and second mode level whilst scanning the piezo voltage through its operating range.

The data is analyzed to find the optimum point of operation for the piezo voltage. Constraints are imposed during the process to ensure a reliable result, and a confidence level is employed to determine whether or not to set the laser to the predicted operating point. A confidence level of 2 or higher indicates a good prediction.

An optimization takes approximately 35 seconds to complete.

An optimization is only valid once the laser has been allowed to operate and stabilize at a particular wavelength. If the laser wavelength is altered, then a new optimization should be performed, if required as a result of the presence of a second mode.

As a default, the results of the optimization process are not automatically saved. To save the results manually the SAV button on the toolbar should be used. This will return the laser to the known good operating point when the laser is power cycled.

The optimization facilities have been designed to be as easy to operate as possible. Use of the optimization facility is simply a matter of initiating the process, as and when needed, and waiting for it to complete.

Note that lasers should be operating in ACC (constant current) mode and temperature-stable before initiating an optimization. It is also recommended that RIN suppression be enabled.

It is important to make sure that the Amplifiers are turned off before initiating the optimization process.

8.1 Using Fiber Laser Control Panel to control the Optimization process

8.1.1 Optimization Menu

The Optimization menu is located on the menu bar of FLCP's main window, as shown below. The individual commands are summarized below.

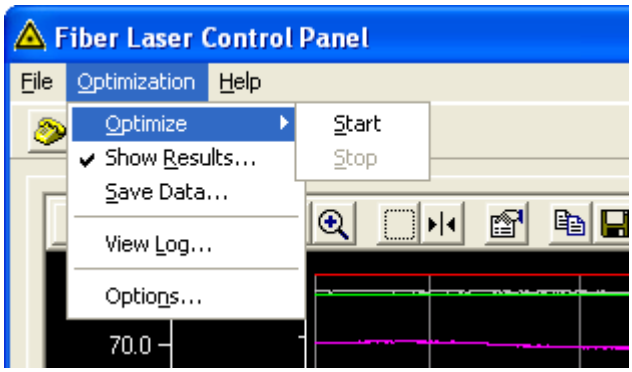


Figure 8.1 Optimization menu

Optimize

This command and its sub-commands allow an optimization to be started and, if necessary, aborted.

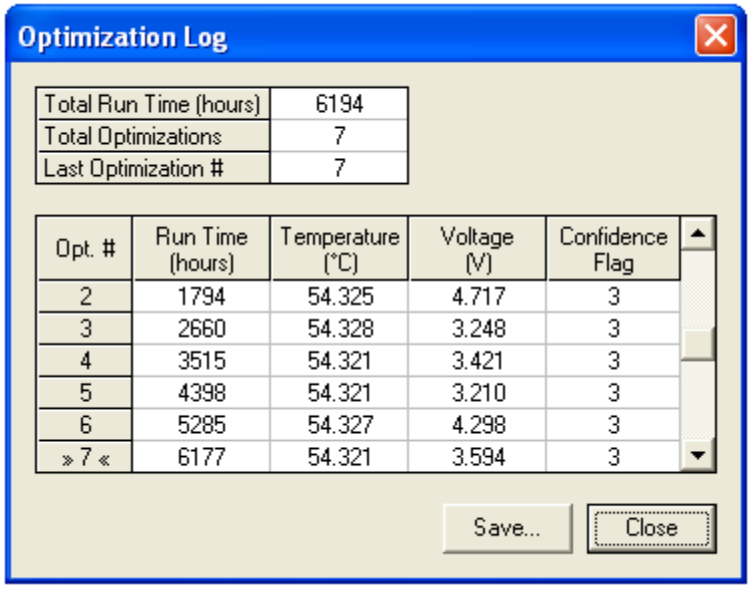
Show Results…

This command displays the results of the most recent optimization. If the command is checked, then the results will be displayed automatically at the end of each optimization. This feature can be disabled through the Optimization Results window (see Section 8.1.2).

Save Data…

This command saves the results of the most recent optimization to file. The facility to save the data is also available through the Optimization Results window (see Section 8.1.2).

View Log



The Optimization Log window will appear, showing the laser's total run time and optimization history

Figure 8.2 Optimization Log

Options

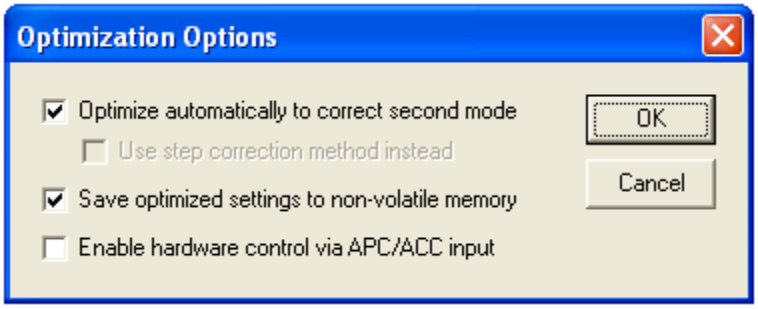


Figure 8.3 Optimization Options

When **Optimize automatically to correct second mode** is checked, the laser will optimize automatically if it detects a second mode condition. If this option is not selected, then **Use step correction method instead** can be set as an alternative means to move the laser out of a second mode region.

The laser will automatically call the optimization process if certain conditions are met. These are

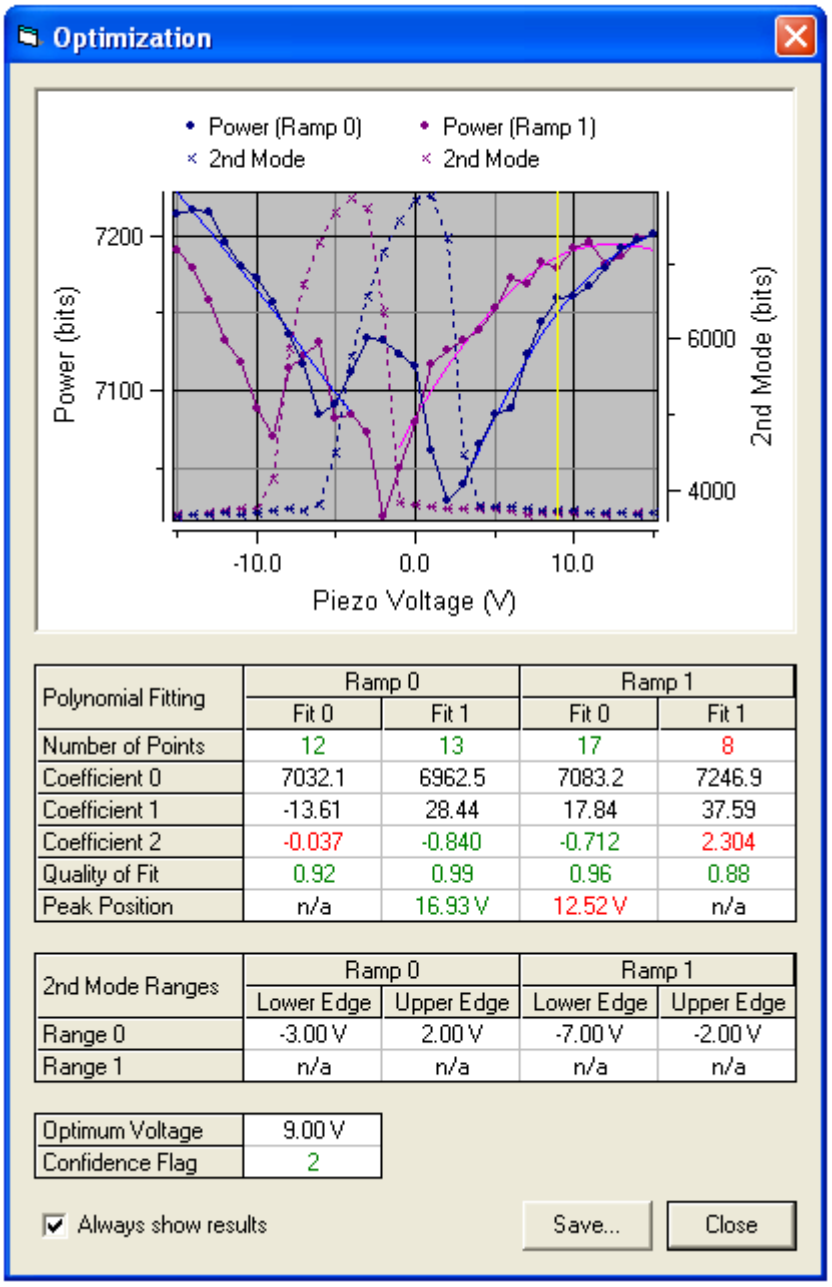
- The laser has been warmed up and active for at least 15 minutes.
- The temperature must have been stable for at least 32 seconds
- A second mode condition is consistently present

When **Save optimized settings to non-volatile memory** is checked, the laser will save its optimized settings to non-volatile memory, so they will be remembered after the laser is reset or power cycled.

When **Enable hardware control via APC/ACC input** is checked, optimizations can be initiated using the APC/ACC (pump mode) input. In this mode, the laser remains permanently in ACC (constant current) mode.

8.1.2 Optimization Results

To view the results of the latest optimization, click on the **Optimization** menu and select the **Show Results…** command:



Polynomial Fitting	Ramp 0		Ramp 1	
	Fit 0	Fit 1	Fit 0	Fit 1
Number of Points	12	13	17	8
Coefficient 0	7032.1	6962.5	7083.2	7246.9
Coefficient 1	-13.61	28.44	17.84	37.59
Coefficient 2	-0.037	-0.840	-0.712	2.304
Quality of Fit	0.92	0.99	0.96	0.88
Peak Position	n/a	16.93 V	12.52 V	n/a

2nd Mode Ranges	Ramp 0		Ramp 1	
	Lower Edge	Upper Edge	Lower Edge	Upper Edge
Range 0	-3.00 V	2.00 V	-7.00 V	-2.00 V
Range 1	n/a	n/a	n/a	n/a

Optimum Voltage	9.00 V
Confidence Flag	2

Figure 8.4 Optimization Results

The various features of the window are summarized below.

Ramp Data Graph

The graph shows the accumulated power (solid lines) and second mode level (dotted lines) readings plotted against piezo voltage. The quadratic fits to the power data are also shown. The upward and downward ramps are indicated using blue and magenta traces, respectively. The yellow cursor denotes the predicted optimum voltage.

Ramp Results Table

The results of the ramp data analysis are tabulated immediately below the graph. Generally, there are two quadratic fits for each ramp, giving two peaks per ramp. Each set of fit results comprises the number of points, the three quadratic coefficients, the quality of fit (coefficient of determination) and the peak voltage calculated from the fit. Where appropriate, the values are displayed in green or red to indicate whether or not they met their respective assessment criteria.

Second Mode Ranges Table

This table shows the positions of the lower and upper edge of each second mode range identified. Up to two ranges can be identified on both the upward and downward ramps.

Final Results Table

The last table summarizes the final results of the optimization. It shows the predicted optimum voltage and the confidence flag value. The latter is displayed in green or red to indicate whether or not it met the required confidence level.

Miscellaneous Controls

There are three controls at the bottom of the window:

- When **Always show results** is checked, the results will be displayed automatically each time an optimization completes. To disable this feature, uncheck the box. This setting also controls the check mark on the **Show Results…** command on the Optimization menu.
- The **Save…** button is used to save the optimization data to file. It performs the same function as the **Save Data…** command on the Optimization menu.
- The **Close** button is used to close the results window and return to the main window.

9 Operating Conditions

Please be aware that the grating temperatures are controlled via a resistive heater loop. The grating temperature can be changed between about 40 and 70°C leading to a (thermal) frequency tuning range of >30GHz. When mounting the laser, keep in mind that the temperature of the laser module needs to be lower than the grating temperatures, i.e., lower than ~35°C.

The grating temperatures and, therefore, the laser frequency cannot be controlled for grating set temperatures that are lower than the enclosure temperature.

This laser is designed to operate in a normal laboratory environment with ambient temperatures between about 15 and 30°C. Please contact us if you wish to run the laser in a warmer or colder environment.

Note: The laser will be most stable when the whole enclosure has reached thermal equilibrium. This can take several hours.

10 Polarization Maintaining Fibers Handling

In fiber optics, a **polarization-maintaining optical fiber** (**PMF** or **PM fiber**) is an optical fiber in which the polarization of linearly-polarized light waves launched into the fiber is maintained during propagation, with little or no cross-coupling of optical power between the polarization modes. Such fiber is used in special applications where preserving polarization is essential.

Several different designs of PM fiber are used. Most work by inducing stress in the core via a non-circular cladding cross-section, or via rods of another material included within the cladding. Several different shapes of rod are used, and the resulting fiber is sold under brand names such as "Panda" and "Bow-tie". NP Photonics is mainly using PANDA PM Fibers for its products.

Polarization-maintaining fiber will not polarize light like a polarizer does. Rather, PM fiber maintains the existing polarization of linearly-polarized light that is launched into the fiber with the correct orientation. If the polarization of the input light is not aligned with the stress direction in the fiber (PM Fiber axis), the output will vary between linear and circular polarization (and generally will be elliptically polarized). The exact polarization will then be sensitive to variations in temperature and stress in the fiber.
The output of a PM fiber is typically characterized by its polarization extinction ratio (PER)—the ratio of correctly to incorrectly polarized light, expressed in decibels (dB) measured with a PER meter. Common values for PER out of a polarized laser source is >20dB.

NP Photonics do not recommend fibers bending diameter lower than 4” (100mm). Our standards products are equipped with FC/APC connectors. “FC” stands for Fiber Connector and “APC” stands for Angled Physical Contact. There is a contact between fibers being connected, therefore it is really important to check the fiber tip cleanliness before any connection with a fiber scope (make sure the laser is off if the inspection is being done on the laser source side) and to clean if needed. A connection using standard FC/PC connector on one side and FC/APC on the other side will be loser and can potentially provide undesirable optical feedback.

Furthermore, the standard FC/APC connectors used on our products line are narrow key connectors (2.00mm)/ narrow key ways adaptors (2.05mm) to provide the best alignment possible between the PM fiber axis when connecting PM fibers together. A connector with a wide key (2.12mm) will not fit into a narrow key way adaptor (2.05mm) and forcing the parts in will likely damage the connector and the adaptor. A connector with a narrow key (2.00mm) will fit into a wide key way adaptor (2.17mm); nevertheless, the PM fiber axis will be misaligned due to the loose tolerance through the connection resulting into a poor PER.

11 Shipping Contents and Accessories

Included:

- NP High Power Single Frequency Fiber Laser Source (RFLPXA)
- Software on CD/USB Drive
- RS-232 Extension Cable
- Power Cord

You will need:

- A 100-240 VAC, 47-63 Hz, (25 W max.) voltage outlet
- FC/APC optical connectors or adapters
- A personal computer with Windows2000, XP or Windows 7 operating system and RS-232 port IF the laser is to be monitored and controlled through the software (Note suitable USB to RS232 adaptors can be used if no RS232 port is available)

Keep the shipping container. If you file a damage claim, you may need it to demonstrate that the damage occurred as a result of shipping. If you need to return the unit for service at a later date, the specially designed container assures adequate protection.

12 Product Specifications

Mechanical Outline:

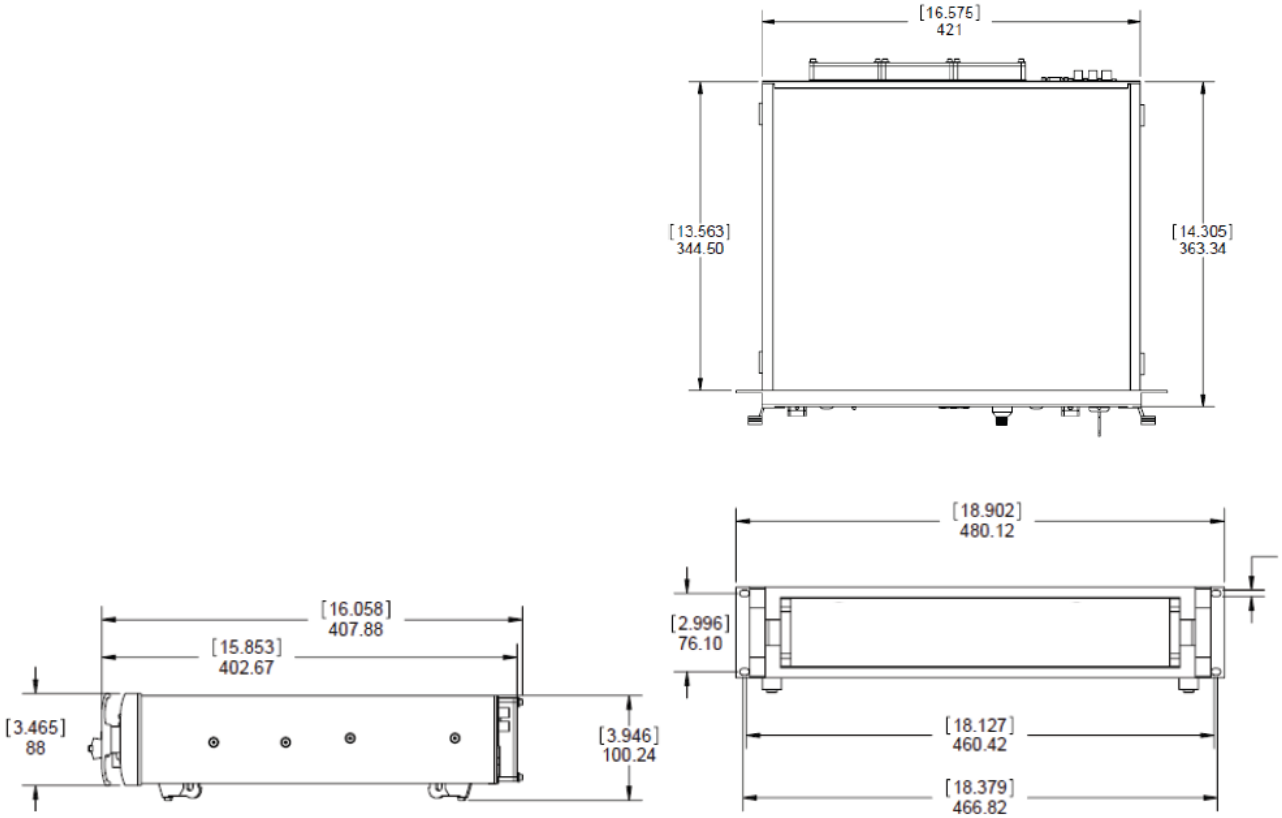


Figure 12.1 Mechanical Outline

RFLPXA

Power	Code
500mW	0.5K
1000mW	1K
2000mW	2K
3000mW	3K
5000mW	5K
10 W	10k
20 W	20k

Tunability	Code
None	0
Tuning	1
Modulation	2
Tuning & Modulation	3

Wavelength	Code
Standard	15xx.xx
Or ITU Grid	Hxx/Cxx
Generic C-Band	C

Polarization	Code
Non-PM	N
PM	P

S seed beam	**A*** – Armored cable	**O** No Collimator
N – no seed beam	**S** – Standard Fiber	**1** – 0.9-1.6mm collimator
		2 3-5mm collimator
*Armored cable only available with collimator option		

Linewidth	Code
<700Hz	U
Standard	S

Figure 12.2 Ordering Code

13 High Power Fiber Laser Optical Interface

The RFLPXA High Power Single Frequency Fiber Laser Source has different optical interface and terminations depending of the product configuration. A detailed summary of the most common configurations is given in section 6.1. If you have any question about the optical interface of your laser system, please contact NP Photonics for assistance.

14 Warranty

NP Photonics Rock Laser Modules are protected by a 12-month warranty. All components and assemblies are unconditionally warranted to be free of defects in workmanship and materials for the warranty period, beginning from the date of shipment. This warranty is in lieu of all other warranties, expressed or implied, and does not cover incidental or consequential loss. This warranty does not apply to devices damaged due to operating conditions outside of the specified parameters. Modified warranties for OEM customers are available.

Warranty Limitations

This warranty excludes products, parts (including fiber connectors) or equipment which have been tampered with, disassembled, opened, or modified by persons other than NP Photonics personnel, misused, neglected, or damaged by accident, used in applications which exceeds their specifications or ratings, used outside of environmental specifications for the product, used with buyer software or interfacing, improperly installed, maintained or otherwise abused or used other than in accordance with the information and precautions contained in this User's Manual. It is the customer's responsibility to understand and follow operating instructions in this Manual and specifications prior to operation—failure to do so may result in voiding this warranty. Accessories and fiber connectors are not covered by this warranty.

15 Services and Repair

CAUTION: No operator serviceable parts inside. Refer all servicing to qualified personnel at NP Photonics. All requests for repair or replacement under this warranty must be made as soon as possible after the defect has been noticed and must be directed to NP Photonics or its representative in your area. Items authorized for return by us must be returned in a suitable container.

Any damage noted upon receipt of the unit must be documented for appropriate claim against the carrier.

IMPORTANT: Never send any product back to NP photonics without a Return Merchandise Authorization (RMA). The customer will be charged for the cost of repairing the product if the product is not under warranty or if the repair is not covered under the warranty.

1. NP Photonics will only accept returns for which an approved Return Material Authorization (RMA) has been issued by NP Photonics. You must return defective products freight prepaid and insured to NP Photonics. All products which have been returned to NP Photonics but which are found to meet all previously applicable specifications for such products or which indicate damage to the fiber connectors not resulting from defect manufacturing, shall be subject to NP Photonics' standard examination charge in effect at the time and these costs shall be charged to the Buyer. NP Photonics warrants to Buyer that its services, labor and replacement parts, assemblies and modules will be free of defects in material and workmanship for ninety (90) days from the date of shipment or performance of services.

2. Warranty Returns - Domestic & *International Buyers should pay for **one-way** freight costs to NP Photonics. NP Photonics will reimburse Buyers for applicable reasonable third-party freight costs and NP Photonics will pay for freight return cost back to the Buyer.

3. Non-Warranty Returns - Domestic & *International Buyers are responsible for **two-way** freight costs. If shipment consists of returns that are both warranty and non-warranty, the shipment will be considered as non-warranty. Any UNAUTHORIZED shipments billed to NP photonics without authorization will be reinvoiced to the Buyer. Confirming purchase orders are required for non-warranty returns.

4. *International Returns **must** include applicable DUTIES AND TAXES, and you must mark air bills with “RETURNED FOR REPAIR”. In any event, where NP Photonics accepts a shipment, NP Photonics will invoice to the Buyer for any charges as stated above.
Please be sure the shipping documents clearly state that this unit is for evaluation and repair only to avoid unnecessary customs duties or taxes, please use HTS code 9801.00.1012.PLEASE USE FEDEX as shipper, DO NOT USE DHL. Any charges as a result of incorrect paperwork or your "preferred" shipper’s extra charges will be billed back to the sender.

5. Returns for credit will not be accepted unless authorized in advance, in writing by NP Photonics, in accordance with NP Photonics' Terms and Condition, including the warranty provisions. In most cases, restocking fees will apply.

6. All returns must be packaged adequately to avoid damage during shipment.

SHIPPING ADDRESS:

NP PHOTONICS, Inc.

9030 S Rita Road, Suite 120

Tucson, Arizona 85747

USA
Phone: 1-520-799-7423

Fax: 1-520-799-7403

16 Services Parts

NP Product	P/N	Description
RFLPXA	620384	CD/USB (Software & Manual)
	500411	RS232 Cable
	500215	Power Cord, North America
	500230	Power Cord, UK/Hong Kong/Jordan
	500293	Power Cord, Europe
	500423	Power Cord, Japan
	500442	Power Cord, Australia
	500504	Power Cord, Israel
	600419	Manual (Hard copy)
	501138	Key
	210016	Fiber Cleaner replacement spool
	210137	Fiber Cleaner
	500793	Plug, 50 ohm terminator

Notes: