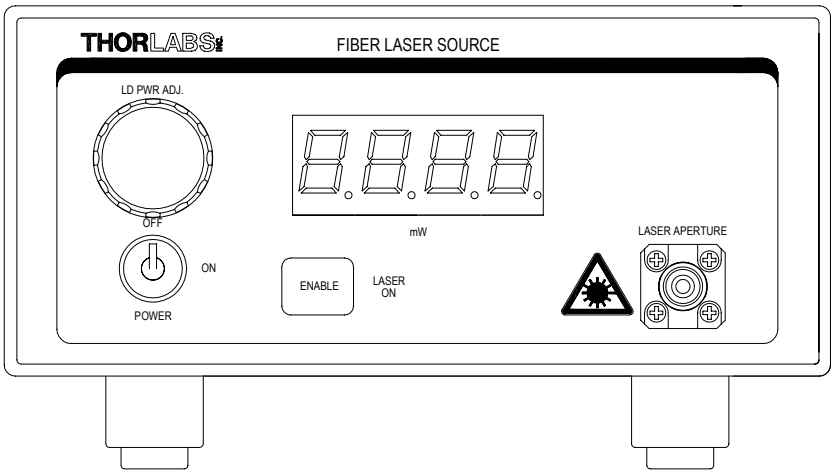
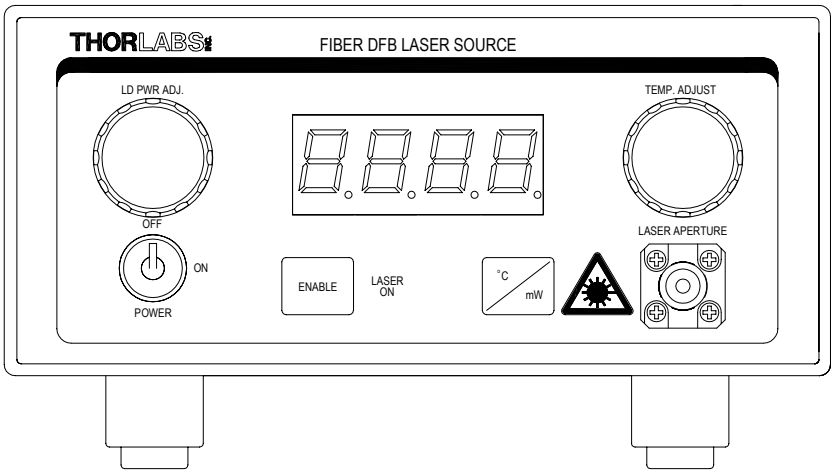
THORLABS INC

Fiber Coupled Laser Sources

Operating Manual





THORLABS, Inc.
435 Route 206N
Newton, NJ 07860 USA

Phone: (973) 579-7227
Fax: (973) 383-8406
Serial #:_____

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Description

The Thorlabs Fiber Coupled Laser Sources are fiber optic laser sources that provide ease of coupling and simple control of laser diode driven fiber optics. These laser sources are available in two versions, Fabry-Perot and Distributed Feed Back (DFB). The Fabry-Perot version comes in five available wavelength choices from 635nm up to 1550nm. The DFB version comes equipped with a thermo-electric cooler to stabilize the output wavelength, and a 40dB optical isolator to eliminate frequency jitter due to back-reflections. The DFB is available in 1310nm and 1550nm wavelengths.

Specifications

Electrical:

AC Input: 115VAC 50-60Hz @ 250mA Max
Switch selectable to 230VAC 50-60Hz @ 160mA (All Models)
Analog Modulation Input: 0 – 5V corresponds to 0mW to Max Power (max power varies per unit)
Bandwidth: 0 – 30kHz Sinewave ONLY – Do not apply TTL or squarewave.
50 Ω Input Impedance

Optical:

S1 Series Fabry-Perot

Item #	λ	Fiber	Power*	Actual λ**	Thorlabs Fiber Optic Cable
S1FC635	635nm	FS-SN-3224	mW	nm	P1-3224-FC-2
S1FC675	675nm	FS-SN-3224	mW	nm	P1-3224-FC-2
S1FC780	780nm	FS-SN-4224	mW	nm	P1-4224-FC-2
S1FC1310	1310nm	SMF-28	mW	nm	P1-6324-FC-2 or P1-SMF28-FC-2
S1FC1550	1550nm	SMF-28	mW	nm	P1-7324-FC-2 or P1-SMF28-FC-2

S3 Series DFB

Item #	λ	Fiber	Power*	Actual λ**
S3FC1310	1310nm	SMF-28	mW	nm
S3FC1550	1550nm	SMF-28	mW	nm

* Maximum power available at the output connector as determined during unit's final calibration.
** Actual wavelength of laser diode per manufacturer's spec. sheet.

Setpoint Resolution: +/- 0.01mW
Display Accuracy (mW): +/- 10% of actual power
Adjustment Range: 0mW to rated output power (units are power limited to specifications of Laser Diodes)
Stability: 15 min: +/-0.05dB, 24 hr: +/-0.1dB (After 1 hr. warm-up at 25°C +/-10°C ambient)
Refer to "Maximizing the Output Stability" for helpful advice on improving the performance of your S3 Series Laser Source.

Thermal:

Stability: .005°C / 1°C change in ambient
Setpoint Accuracy: +/- 0.25°C of actual temperature
Setpoint Resolution: +/-0.1°C
Adjustment Range: 20°C +/- 1°C to 30°C +/- 1°C

Mechanical:

Length: 11.5"
Width: 5.3"
Height: 2.5"

! IMPORTANT! PLEASE READ CAREFULLY!

Setting the AC Line Voltage and Installing Fuses

Your S1 or S3 Series Laser Source has been shipped from Thorlabs, Inc. configured for 115VAC operation. If you are planning to operate your unit using a 220 / 230VAC input, or need to replace an open fuse, you must perform the following procedure:

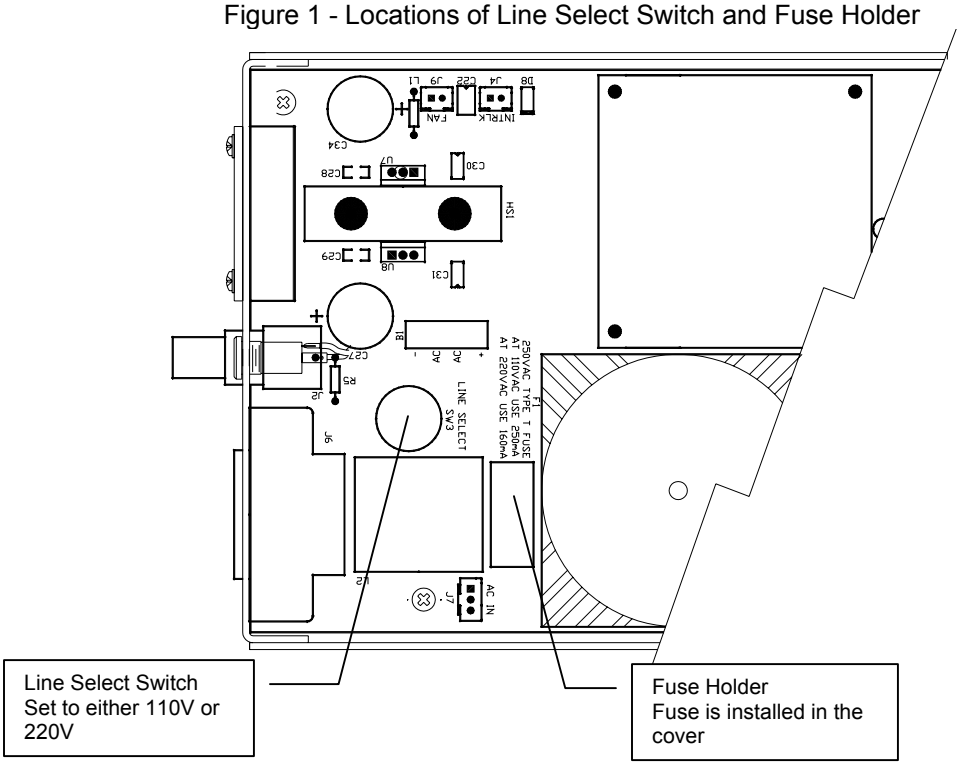
- Remove any AC Input cords that may be connected to the unit.
- Remove the cover of the unit by removing the two 4-40 Phillips head screws located on the bottom rear of the unit and sliding the cover off. Refer to Figure 2.
- Locate the AC Line Select Switch and Fuse Holder. They are located near the AC Input Module towards the back of the unit. Refer to Figure 1.
- Using a flat blade screwdriver turn the Line Select Switch to the appropriate setting to match the AC input voltage you will be using.
- Remove the cover to the fuse holder. The fuse is installed in the cover. Remove the existing fuse and install the appropriate fuse for the line voltage you will be using:

  For 115VAC operation use 250mA
  For 220 / 230VAC operation use 160mA

  In all cases use only 5mm x 20mm 250VAC Type T Fuses

- Reinstall the cover and replace the two 4-40 Phillips head screws.
- Remove the small label indicating the previous voltage configuration located on the rear panel, above the AC input housing. Place the label in the box indicating the new AC input configuration or fill in the appropriate box using a black permanent marker.

Figure 1 - Locations of Line Select Switch and Fuse Holder



OPERATION

S1 SERIES FABREY-PEROT

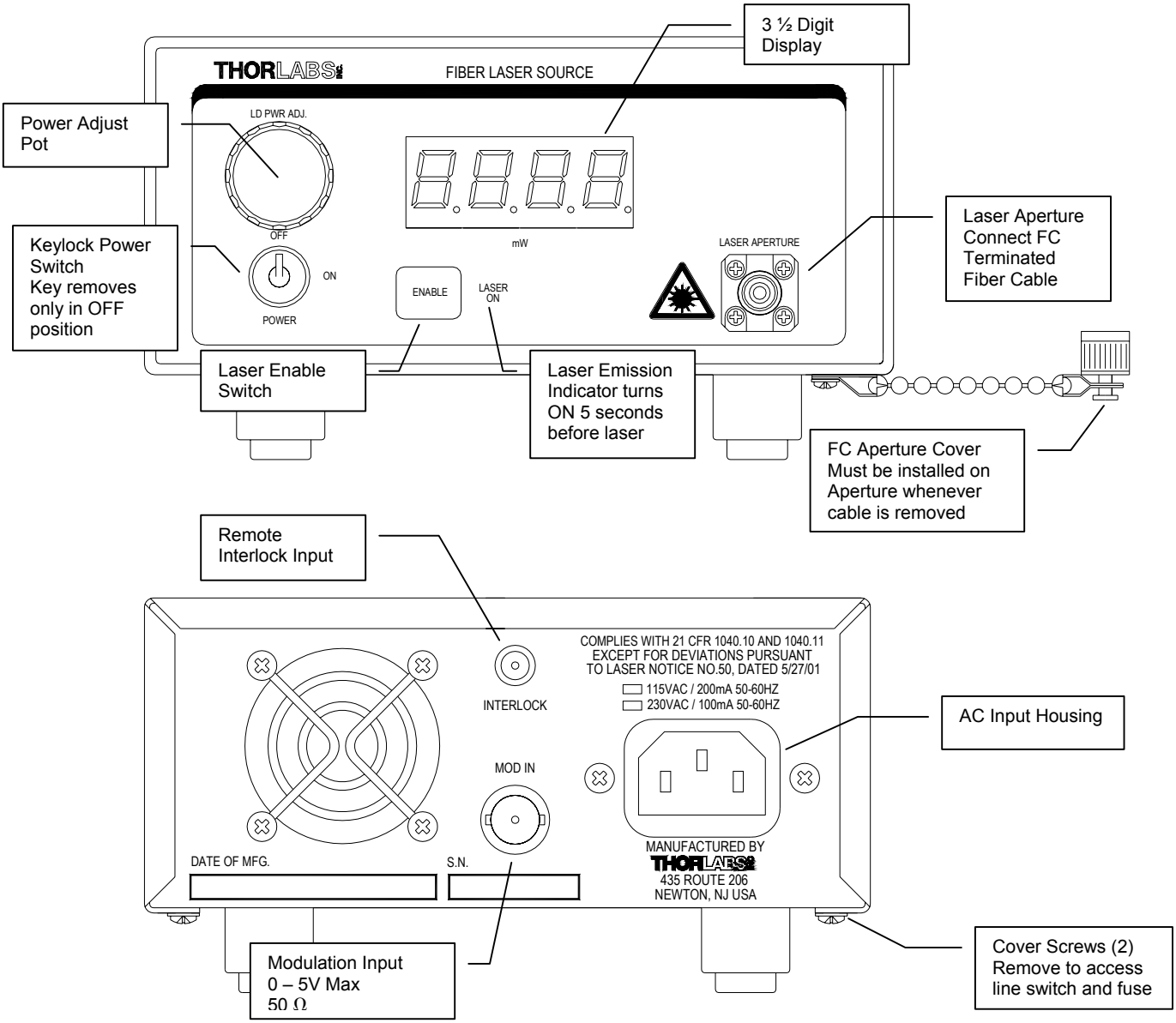


Figure 2 - Front and Rear Panels of Fabry-Perot Laser Source

1) Initial Set-up

- **Determine the AC line voltage the unit will be connected to (either 115VAC or 230VAC) and set the AC Line Voltage Selector Switch to the appropriate position and install the proper fuse. (Refer to "Setting the AC Line Voltage and Installing Fuses")**
- Locate the unit on a dry, level working surface.
- Make sure the **POWER** keyswitch on the front of the unit is in the OFF position (Key perpendicular to working surface).
- Plug the female end of the AC line cord provided into the AC Input Receptacle on the rear of the unit. Plug the male end into a properly grounded AC socket.
- Connect a Fiber Optic cable to the **LASER APERTURE** on the front panel of the unit.

2) Turning ON the Source

- Turn the **POWER** keyswitch clockwise. The unit is ON when the 3 ½ Digit Display lights up.
- Make sure the Interlock Input is short-circuited, refer to "Making the Safety Interlock Connections".
- Press and release the **ENABLE** switch to turn ON the laser. Immediately the LASER ON indicator will light up, after a "safety delay" of approximately 5 seconds the laser output will be available at the **LASER APERTURE**.

3) Adjusting the Laser Output Power

- Using the **LD PWR ADJ.** knob on the front of the unit, adjust the Output Power to the desired setting.
- The power shown on the 3 ½ digit display is the optical output at the **LASER APERTURE**. The actual power at the end of your fiber optic cable may be less, depending on the quality of the connections at the FC to FC adapter.
- Each unit is calibrated internally to limit the maximum operating power of the Laser Diode to a safe operating area.

4) Turning the Laser OFF

- The Laser output should be turned OFF by pressing and releasing the **ENABLE** switch.
- When completely powering down an enabled unit first press and release the **ENABLE** switch then turn the **POWER** keyswitch counterclockwise (which will turn OFF the entire unit). Anytime the unit is turned OFF and then turned back ON, the Laser will be disabled until the **ENABLE** switch is pressed.

5) Modulating the Laser Output

- The MOD IN input can be used to **sinusoidally** modulate the laser output, or set the laser output remotely using a 0 to 5V power source.
- The 5V maximum input corresponds to the maximum calibrated power of the laser source. Each unit is calibrated to achieve the maximum power output for the particular laser diode used in the internal fiber-coupling package. Due to variations in the coupling process no two units will have the same maximum power.
- Connect a signal generator or 0 – 5V power source to the unit using a BNC type connector.
- Set the LD PWR ADJ pot on the front panel to its full counter clockwise setting.
- Press the ENABLE switch to turn on the Laser, wait for the "safety delay" to time out.
- Apply the appropriate signal to the MOD IN input. Signals above approximately 5.5V will be clamped by internal circuits.
- Adjusting the LD PWR ADJ pot will allow for a DC offset on the modulated output. Adjust the input signal accordingly to avoid clipping the output waveform, which will occur if the unit is driven to its current or power limits.
- **DO NOT apply TTL or squarewave inputs to the MOD IN input. Due to response delays of the constant power control loop damage to the integrated fiber coupled laser may occur!**

S3 SERIES DFB MODELS

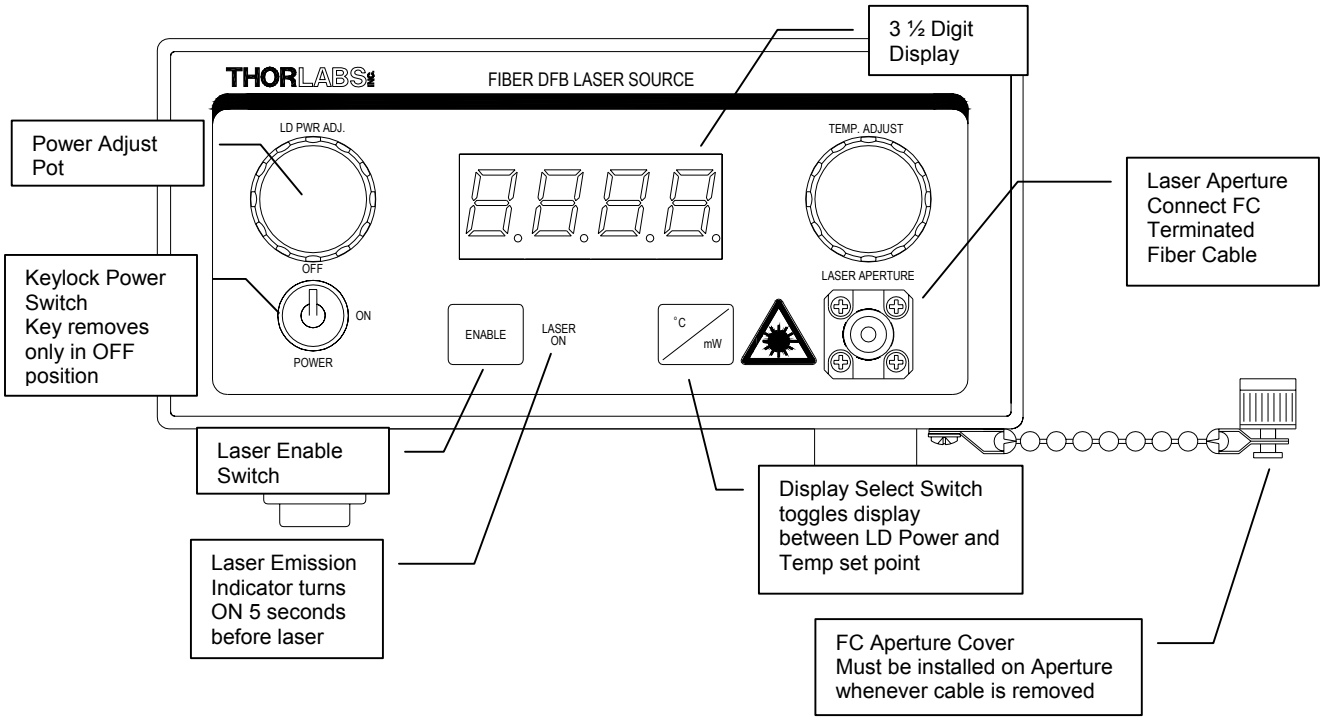


Figure 3 - Front Panel of DFB Laser Source

1) Initial Set-up

- **Determine the AC line voltage the unit will be connected to (either 115VAC or 230VAC) and set the AC Line Voltage Selector Switch to the appropriate position and install the proper fuse. (Refer to "Setting the AC Line Voltage and Installing Fuses")**
- Locate the unit on a dry, level working surface.
- Make sure the **POWER** keyswitch on the front of the unit is in the OFF position (perpendicular to the working surface).
- Plug the female end of the AC line cord provided into the AC Input Receptacle on the rear of the unit. Plug the male end into a properly grounded AC socket.
- Connect a Fiber Optic cable to the **LASER APERTURE** on the front panel of the unit.

2) Turning ON the Source

- Turn the **POWER** keyswitch clockwise. The unit is ON when the 3 ½ Digit Display lights up.
- Make sure the Interlock Input is short-circuited; refer to "Making the Safety Interlock Connections".
- Press and release the **ENABLE** switch to turn ON the laser. Immediately the LASER ON indicator will light up, after a "safety delay" of approximately 5 seconds the laser output will be available at the **LASER APERTURE**.
- The default display mode is Laser Power (**mW**), however the thermo-electric cooler is activated at turn on.

3) Adjusting the Laser Output Power

- Using the **LD PWR ADJ.** on the front of the unit, adjust the Output Power to the desired setting.
- The power shown on the 3 ½ digit display is the optical output at the **LASER APERTURE**. The actual power at the end of your fiber optic cable may be less, depending on the quality of the connections at the FC to FC adapter.
- Each unit is calibrated internally to limit the maximum operating power of the Laser Diode to a safe operating area. Allow a minimum of 5 minutes warm-up time for the unit to stabilize.
- Refer to "Maximizing the Output Stability" for helpful advice on improving the performance of your laser source.

4) Turning the Laser OFF

- The Laser output can be turned OFF by pressing and releasing the **ENABLE** switch.
- When completely powering down an enabled unit first press and release the **ENABLE** switch, then turn the **POWER** keyswitch counterclockwise (which will turn OFF the entire unit). Anytime the unit is turned OFF and then turned back ON, the Laser will be disabled until the **ENABLE** switch is pressed.

5) Adjusting the Temperature of the Laser Diode

- Pressing the **C°/mW** switch once will toggle the 3 ½ digit display from Laser Power (**mW**) to Laser Temperature (**C°**).
- The display indicates the temperature ***Set Point*** of the thermo-electric cooler system.
- Adjustments to the temperature are made with the **TEMP. ADJUST** knob on the front of the unit. Clockwise increases the set point, counter-clockwise decreases it.
- Depending on the magnitude of the change in temperature set point, it will take anywhere from a few seconds to a few minutes for the system to settle into the new operating temperature.
- Refer to "Maximizing the Output Stability" for helpful advice on improving the performance of your laser source.

6) Modulating the DFB Laser Output

- The MOD IN input can be used to **sinusoidally** modulate the laser output, or set the laser output remotely using a 0 to 5V power source.
- The 5V maximum input corresponds to the maximum calibrated power of the S1 Series Laser Source, which operates using a constant power drive technique. The S3 Series DFB Laser Sources operate using a constant current drive technique, which causes the actual output power to be dependent on the operating temperature as set using the TEMP ADJ pot. That is, for a MOD IN input of 5V the output power will vary depending on the operating temperature. Also, in order to eliminate a "dead zone" in the LD PWR ADJ pot, the output of the unit is offset to the threshold current of the coupled laser diode. That is, when the LD PWR ADJ pot is full counter clockwise the drive current is not zero but actually I threshold. Keep this in mind when using the MOD IN input.
- Connect a signal generator or 0 – 5V power source to the unit using a BNC type connector.
- Set the LD PWR ADJ pot on the front panel to its full counter clockwise setting.
- Press the ENABLE switch to turn on the Laser, wait for the "safety delay" to time out.
- Apply the appropriate signal to the MOD IN input. Signals above approximately 5.5V will be clamped by internal circuits.
- Adjusting the LD PWR ADJ pot will allow for a DC offset on the modulated output. Adjust the input signal accordingly to avoid clipping the output waveform, which will occur if the unit is driven to its current or power limits.
- **DO NOT apply TTL or squarewave inputs to the MOD IN input. Due to response delays of the constant current control loop damage to the integrated fiber coupled laser may occur!**

Making the Safety Interlock Connections

The S1 and S3 series Laser Sources are equipped with a Remote Interlock connector located on the rear panel (Refer to Figure 2). All units have this feature regardless of their FDA and IEC classifications. In order to enable the laser source, a short circuit must be applied across the terminals of the Remote Interlock connector. In practice this connection is made available to allow the user to connect a remote actuated switch to the connector (i.e. an open door indicator). The switch (which must be normally open) has to be closed in order for the unit to be enabled. Once the switch is in an open state the Laser Source will automatically shutdown. If the switch returns to a closed condition the Laser Source must be re-enabled at the unit by pressing the ENABLE switch.

All units shipped from Thorlabs are configured with a shorting device installed in the Interlock connector. If you are not going to use this feature then you can leave the shorting device installed and the unit will operate normally as described in the procedures above.

If you wish to make use of the Interlock feature you will need to acquire the appropriate connector mate and wire it your remote interlock switch. Next, remove the shorting device by pulling it out with a pair of needle nose pliers and install the connector into the Interlock input.

The Interlock input only accepts a **2.5mm mono phono jack**. This connector is readily available at most electronics stores (Radio Shack, Digikey, Mouser, Allied to name a few).

The electrical specifications for the Interlock input are as follows:

Type of Mating Connector: 2.5mm mono phono jack
Open Circuit Voltage: +5VDC with respect to Chassis ground
Short Circuit Current: 0.5mADC
Connector Polarity: Tip is +5V, Barrel is ground
Interlock Switch Requirements: Must be N.O. dry contacts (under no circumstances should any external voltages be applied to the Interlock input)

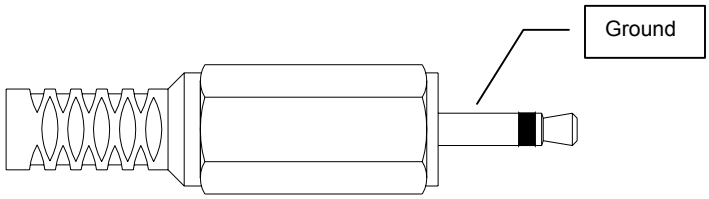
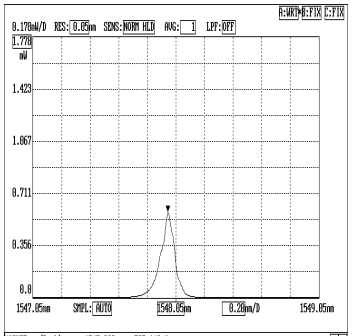
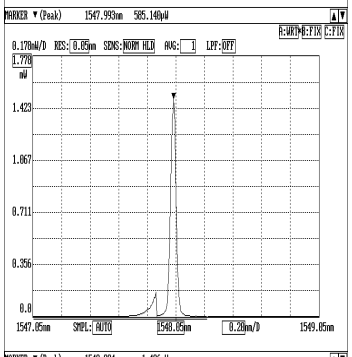


Figure 4 - Remote Interlock Connector

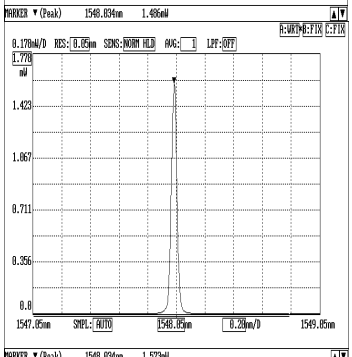
75% Current
1547.993nm



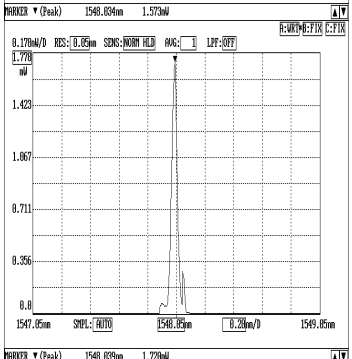
80% Current
1548.834nm



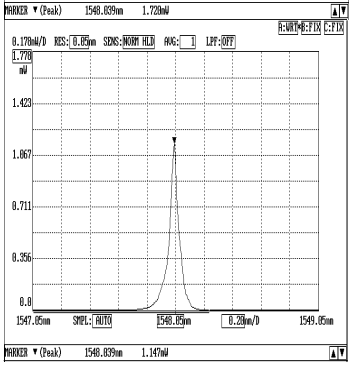
85% Current
1548.834nm



90% Current
1548.839nm



95% Current
1548.839nm



Maximizing the Stability of the S3 Series DFB Laser Source

The S3 Series DFB Laser Source provides the ability to control not only the output power of the fiber coupled laser diode, it also allows for the precise control of the temperature at which the laser is operating. These two controls can be used to "tune" the fiber coupled laser diode to an optimum operating point, providing as stable an output as possible.

To understand the relationship between the laser diode operating current, operating temperature, and stability refer to the optical spectrum analyzer plots of a typical S3FC1550 Laser Source provided on this page and the next.

To your left, reading from top to bottom is shown the effect of changing the operating current of the laser while maintaining a fixed operating temperature (in this case 24.5°C). The first plot corresponds to a drive current of 75% of maximum. Notice the broad line width, the laser is not optimized but the output will appear to be stable. The next plot is at 80% drive current. The laser is approaching a stable point but is not quite there yet as indicated by the second mode. At this point the laser will toggle between this mode and the previous mode, resulting in erratic performance. The power display of the unit will typically bounce between a number of different levels. The third plot down is at 85% current and is typical of an optimized DFB output; a single, very narrow line width and very stable power. The last two plots, taken at 90% and 95% currents shows the laser passing through the optimum point and starting to ebb again.

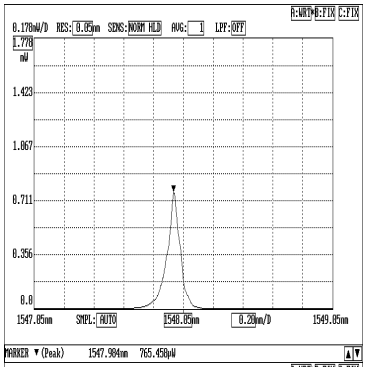
The five plots on the following page showing the relationship of temperature vs. stability. With the drive current fixed at 85% of maximum, the operating temperature was increased by 0.1°C per plot, starting at 24.3°C. Viewing the top most plot (24.3°C) the laser is once again not optimized but may appear to be stable. As the temperature is increased to 24.4°C the laser enters a transition point between modes. At this point the laser may toggle between these modes, resulting in erratic output. At 24.5°C the laser has reached a stable operating point, indicated by the single narrow line width. The last two plots (@ 24.7°C and 24.9°C) show the laser passing through the optimum point and ebbing again. The range of temperature that will yield favorable conditions at this drive current is therefore between 24.45°C and 24.65°C, ideally 24.50°C.

Some important points to add here are:

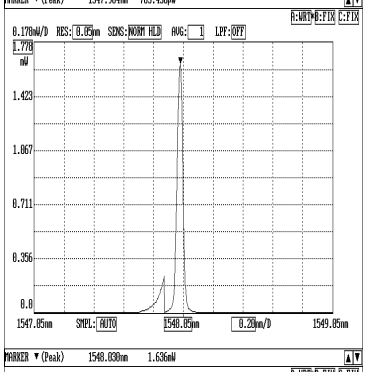
1) This is not the only setting capable of stable operation, there are many and,
2) This combination of temperature and current may not produce stable operation in a different unit.

In both of the above examples (fixed temp. or fixed current) the instabilities are a direct result of the effect that current or temperature has on the peak wavelength of the laser, shifting it ever so slightly into regions that don't support good lasing.

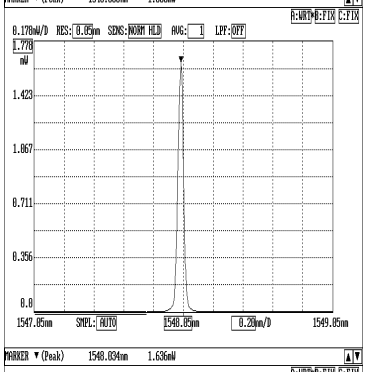
24.3°C
1547.994nm



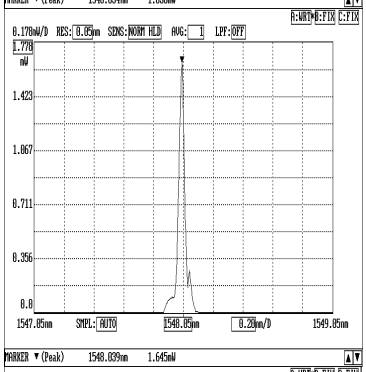
24.4°C
1548.830nm



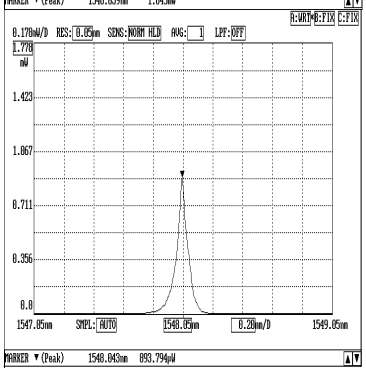
24.5°C
1548.834nm



24.7°C
1548.839nm



24.9°C
1548.839nm



How to tune your Laser Source to the most optimum power:

So what does all this mean? It means that through careful use of both the laser diode power control and laser diode temperature control you will be able to tune your unit to provide the most stable output. Ideally this procedure should be done using an Optical Spectrum Analyzer (OSA), however, lacking one you should be able to tune the unit using the power display on the front panel of the laser source.

Using an OSA:

Step 1 – Let the unit warm up for at least 5 minutes at approximately the target output power and temperature.
Step 2 – While monitoring the output on the OSA determine the quality of the output based on the samples shown in the plots to the left.
Step 3 – Adjust the temperature controller in 0.1°C steps until you have passed through an ideal operating point.
Step 4 – Determine the mid-point of the favorable temperature range and set the temperature to that point.
Step 5 – Do not change the power set point, doing so will affect the tuning.
Step 6 – Record the power and temperature set points. These settings are repeatable when used in an ambient temperature within +/-10 °C of the original tuning. To use recorded settings it is best to set the temperature and allow it to settle, then set the power.

Using the Power Display:

Step 1 - Let the unit warm up for at least 5 minutes at approximately the target output power and temperature.
Step 2 – Record the temperature set point and power set point.
Step 3 – Increase the temperature by 0.1°C, record the output power as displayed on the front panel meter.
Step 4 – Repeat Step 3 at least 8 to 10 more times, recording the output power after each step.
Step 5 – Looking at the changes in output power you should observe a trend of the power increasing-decreasing-increasing over the course of the temperature range (or visa-versa depending on the initial stability).
Step 6 – Determine the temperature that corresponds to a maximum power trend in Step 5 and set the unit to this point.
Step 7 – Do not change the power set point, doing so will affect the tuning.
Step 8 - Record the power and temperature set points. These settings are repeatable when used in an ambient temperature within +/-10 °C of the original tuning. To use recorded settings it is best to set the temperature and allow it to settle, then set the power.

CAUTION- use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

This product complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated May 27, 2001.