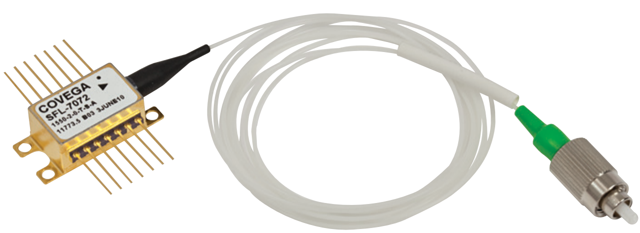
THORLABS

SFL1550S/SFL1550P
SFL1620S/SFL1620P

Single Frequency Laser

User Guide



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Chapter 1 Description

The SFL series lasers are single-frequency laser sources with spectral properties comparable to a DFB laser but with narrower linewidth and higher output power. Applying proprietary stabilization techniques, a single-frequency, external cavity, semiconductor laser is provided in a compact, 14-pin butterfly package. The single-frequency laser contains an integrated thermoelectric cooler, thermistor, and optical isolator with a single mode SMF-28 output fiber or polarization maintaining output fiber. FC/APC connectors are standard, but this laser can be supplied with any requested single-mode connector type.

Chapter 2 Laser Installation

The SFL laser series is compatible with any standard 14-pin laser diode mount, including Thorlabs' LM14S2 Universal 14-Pin Butterfly Laser Diode Mount. The laser unit should be installed in the zero insertion force socket of the LM14S2 using 2-56 screws, as described in the LM14S2 operating manual. The pin out of the SFL1550 series laser is compatible with the “Type 1” configuration card setting on the LM14S2.

Proper operation of the SFL laser series requires current and temperature control. These lasers are compatible with standard laser diode drivers and temperature controllers, including the following Thorlabs equipment:

- LDC205C: Benchtop LD Current Controller, ±500 mA
- TED200C: Benchtop Temperature Controller, ±2 A / 12 W
- ITC4001: Benchtop Laser Diode/TEC Controller, 1 A / 96 W
- LDC1300B: Laser Diode Controller for Butterfly Packages (includes 14-pin butterfly laser diode mount)

Chapter 3 Operation

3.1. Single Frequency Operation

The SFL series laser is an external cavity laser that enables narrower linewidth operation than a DFB laser. Unlike a DFB laser, however, the SFL series laser is not unconditionally single-frequency. Single-frequency operation is defined as having a side mode suppression ratio (SMSR) of ≥40 dB, as illustrated below in *Figure 1*. The SFL series laser is designed and manufactured to provide high-power, single-frequency operation over a range of operating currents and temperatures. There are, however, certain operating currents and temperature conditions where the SFL series laser exhibits multi-frequency operation as shown in *Figure 2*. To assist the user in selecting the proper operating conditions, a datasheet is supplied with each unit that provides the operating characteristics and single-frequency regimes of the laser.

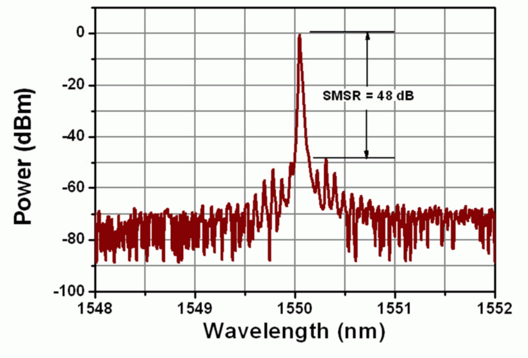

Figure 1 Typical Single Mode Lasing Spectrum

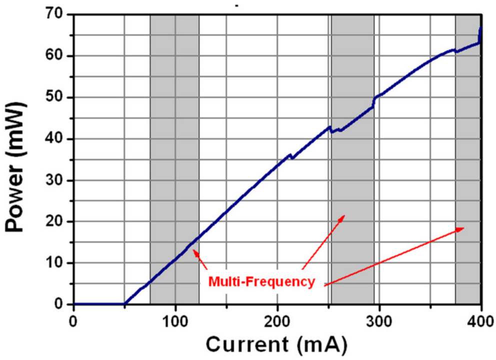

Figure 2 Light Output Curve Indicating Multi-Frequency Operating Regions

The test datasheet supplies a suggested operating current and temperature where the device meets all specifications (single-frequency, power, wavelength). The simplest way to verify single-frequency operation is to observe the output spectrum of the SFL series laser on an optical spectrum analyzer (OSA). If there is no OSA available, the output signal can be observed by connecting the laser output directly to the application setup. A large difference in the output signal will typically be seen when the laser changes between single-frequency and multi-frequency operation. In interferometric applications for example, single-frequency lasing output with high coherence (Lorentzian limited linewidth ≤50 kHz) will give a very clean interferometric signal, but multi-frequency lasing will degrade the signal dramatically. These two different behaviors can be observed by changing the driving current over a large range (typically >50 mA).

3.1.1. Setting the Laser for Single-Frequency Operation:

1. Set the TEC temperature (T) and operating current (I) as suggested in the test datasheet. The laser should have stable, single-frequency operation. However, due to different ambient temperatures (the settings on the datasheet are tested at a stabilized case temperature T_{CASE} = 25 °C) and temperature controller calibration accuracy, it is possible that the laser is outside of the single-frequency regime. A slight change in current will bring the laser back to single-frequency operation.

2. The laser performance is sensitive to TEC temperature. The datasheet gives a suggested operating temperature range (normally ±5 °C about a center temperature). By changing driving current, the laser will always be able to achieve good single-frequency lasing behavior over this temperature range.

3. The ambient temperature has a weak influence on laser performance. In most laboratory environments, single-frequency operation will always remain unchanged from the test datasheet. If the ambient temperature deviates greatly from 25 ℃, it may be necessary to reset the laser current and temperature to find single-frequency operation. In general, if the ambient temperature is between 10 and 60 ℃, it will always be possible to achieve single frequency operation of the laser by adjusting the current and chip temperature.

3.2. Center Wavelength Adjustment

The single frequency laser has a fixed wavelength, determined by the external cavity laser design that is within ±0.5 nm of the center wavelength. The center wavelength for the SFL1550 series is 1550 nm. The center wavelength for the SFL1620 series laser is 1620 nm. However, the lasing wavelength can still be changed over a small range (~0.3 nm) by adjusting the temperature and current.

When changing temperature and current to find a desired lasing wavelength, it is necessary to observe the lasting spectrum or detected signal to be sure that single-frequency lasing can be achieved at the same time.

3.3. Single-Frequency Continuous Tuning

Once a suitable center wavelength operating point has been established, the wavelength can be tuned without any longitudinal mode hops (continuously tuned) over a narrow range (~5 GHz). Test data show that the coefficient of lasing wavelength (λ) per temperature is ~0.042 nm/°C and that the coefficient of λ per current is approximately between 0.0005 and 0.0007 nm/mA. These numbers vary slightly corresponding to the operation conditions.

Current tuning is the most common approach for continuous tuning primarily because it scales easily to rapid tuning speeds (100-1000 Hz or higher). To demonstrate this, the outputs from two SFL1550 lasers were combined and the heterodyne beat frequency measured on an RF spectrum analyzer. The operating current on one of the unites was adjusted from 323.5 mA to 379.5 mA resulting in a 4.6 GHz tuning of the output frequency, as shown in *Figure 3*.

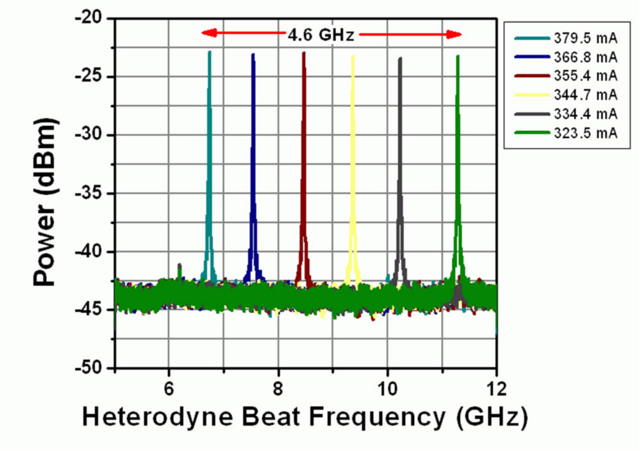

Figure 3 Single-Frequency Continuous Tuning with Current

3.4. Frequency Modulation Bandwidth

High-speed frequency modulation of the SFL series laser can be realized by current modulation. A typical modulation frequency response is shown in *Figure 4*. A continuous tuning range of 5 GHz is obtained at a 10 Hz rate for a peak-to-peak modulation current of 50 mA. This decreases to a 3 GHz tuning range at a 1 kHz scan rate. The reason for the decrease in modulation efficiency with frequency is due to the fact that the thermal component associated with a current change contributes less as the frequency increases.

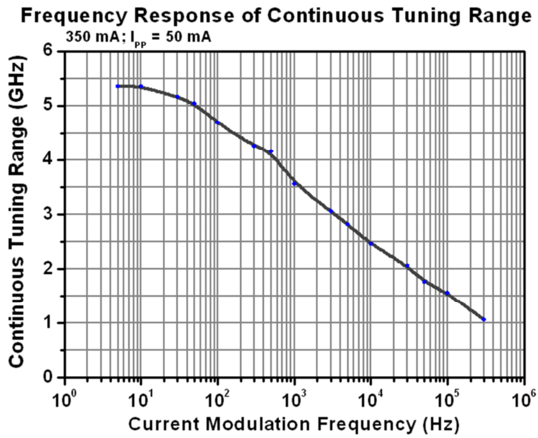

Figure 4 Frequency Modulation Response Curve (ΔI_{pp} = 50 mA)

3.5. Linewidth

The linewidth of the SFL series laser is approximately 50 kHz, as shown in *Figure 5* (note, for a Lorentzian line shape, the measured delayed self-homodyne linewidth is exactly double the laser linewidth[1]). In order to obtain this Lorentzian line shape, an ultra-low noise current driver (battery supply) and TEC controller must be used to avoid technical noise which appears as a distortion of the Lorentzian line shape. The linewidth observed using typical current/TEC controllers will be in the 200-500 kHz range.

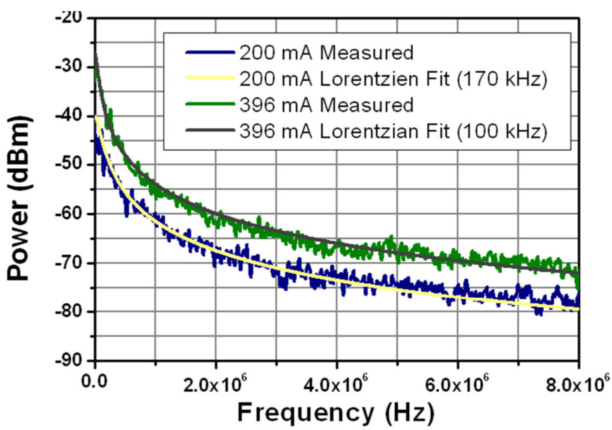

Figure 5 Homodyne Measure of Laser Linewidth (50 km fiber delay line)

[1] "Linewidth and Power Spectral Measurements of Single-Frequency Lasers," D.M.Baney and W.V. Sorin, *Hewlett-Packard Journal*, pp. 92-96, February 1990

Chapter 4 Specifications

CW; T_{CHIP} = 25 °C, T_{CASE} = 10 – 60 °C

SFL1550 Series	Symbol	Min	Typical	Max	Units
Operating Current	I_{OP}	-	300		mA
Center Wavelength	λ_C	1549.5	1550	1550.5	Nm
Optical Power @ I_{OP}	P_O	25	40		mW
Side Mode Suppression Ratio	SMSR	40	45	-	dB
Linewidth (Lorentzian Line Shape)	Δv	-	50	100	kHz
Threshold Current	I_{TH}	-	50	-	mA
Slope Efficiency	ΔP/ΔI	-	0.2	-	mW/mA
Relative Intensity Noise	RIN	-	-150	-	dB/Hz
Forward Voltage @ I_{OP}	V_F	-	1.5	1.8	V
Single-Frequency Continuous Tuning Range (1 kHz rate)	Δf	-	3	-	GHz
TEC Operation @ T_{CASE} =25 °C					
- TEC Current	I_{TEC}	-	0.3	-	A
- TEC Voltage	V_{TEC}	-	0.6	-	V
- Thermistor Resistance	R_{TH}	-	10	-	kΩ

SFL1620 Series	Symbol	Min	Typical	Max	Units
Operating Current	I_{OP}	-	300		mA
Center Wavelength	λ_C	1619.5	1620	1620.5	Nm
Optical Power @ I_{OP}	P_O	25	40		mW
Side Mode Suppression Ratio	SMSR	40	45	-	dB
Linewidth (Lorentzian Line Shape)	Δv	-	50	100	kHz
Threshold Current	I_{TH}	-	50	-	mA
Slope Efficiency	ΔP/ΔI	-	0.2	-	mW/mA
Relative Intensity Noise	RIN	-	-150	-	dB/Hz
Forward Voltage @ I_{OP}	V_F	-	1.5	1.8	V
Single-Frequency Continuous Tuning Range (1 kHz rate)	Δf	-	3	-	GHz
TEC Operation @ T_{CASE} =25 °C					
- TEC Current	I_{TEC}	-	0.3	-	A
- TEC Voltage	V_{TEC}	-	0.6	-	V
- Thermistor Resistance	R_{TH}	-	10	-	kΩ

Chapter 5 Mechanical Drawings

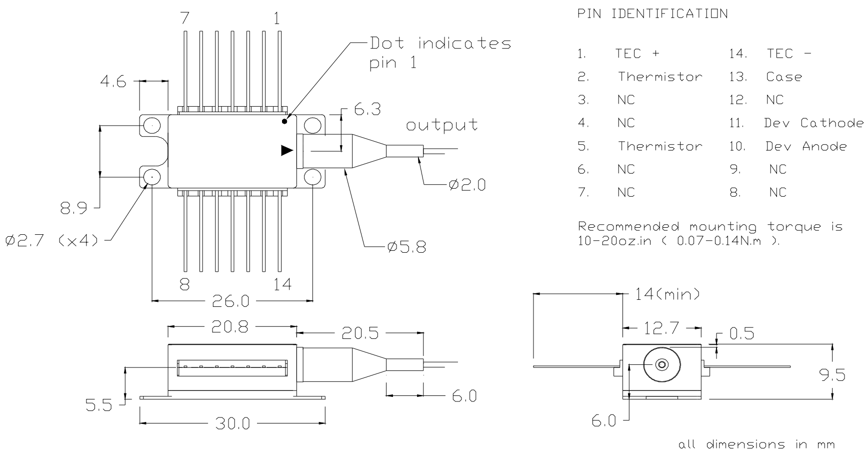

Figure 6 Mechanical Drawing of SFL Series Laser

Chapter 6 Regulatory

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

This offer is valid for Thorlabs electrical and electronic equipment:

- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated

Wheelie Bin Logo

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

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

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

6.1. Waste Treatment is Your Own Responsibility

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

6.2. Ecological Background

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

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

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