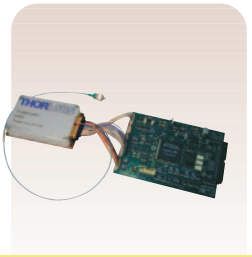
TUNABLE LASERS: OVERVIEW



Benchtop Systems • TXP Modules • OEM Modules

Thorlabs' tunable lasers are all based on external cavity tunable laser technology with tuning ranges up to 150nm. Since they are able to continuously tune or step between ITU grid wavelengths, Thorlabs' tunable lasers are ideal for both test and measurement as well as for research and development. Using our proprietary technology, all models exhibit mode-hop free tuning with wavelength resolution of 0.1pm and absolute wavelength accuracy within ±10pm. The highly stable output and quick tuning speed of our continuous tuning models allow the units to tune over their entire range in less than a second. The low source spontaneous emission (SSE) makes them an ideal source for testing fiber-optic components, spectroscopy, or basic research applications. Our tunable lasers cover wavelengths ranging from 770nm to 1650nm and are available with fiber output or with free-space collimated beams. The various models offer different features from benchtop units to OEM modules for integrating into larger applications.

ECL Technology

Thorlabs' models are based on external cavity lasers (ECL), which are capable of delivering very high output powers in combination with a wide tuning range.

In addition, ECL technology has the advantage of continuous, mode-hop free, tuning. ECL lasers are comprised of a laser diode with high gain and a separate grating that is mounted on a pivoting arm to form the cavity (see figure 1). To tune the laser's wavelength, the angle of the grating is changed by turning the arm with an actuator. The positioning and alignment of the grating assembly and the actuator design are critical to optimal scanning performance.

Scanning Capabilities

The patented inductive motor design of our continuously tunable models enables a smooth and quick sweep over the full wavelength range in both directions with perfect repeatability. Optional step mode operation and true continuous linear tuning without any ripple result from this unique design.

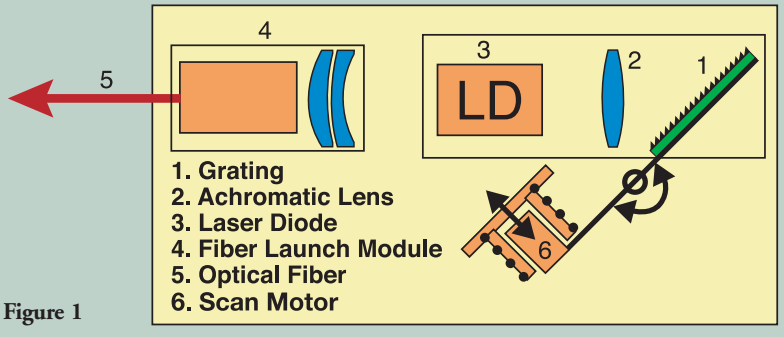
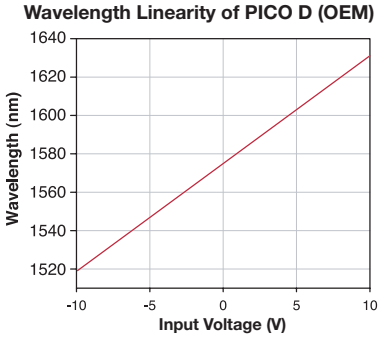
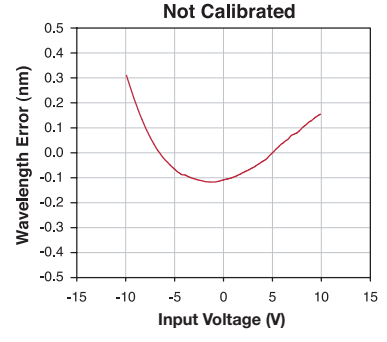


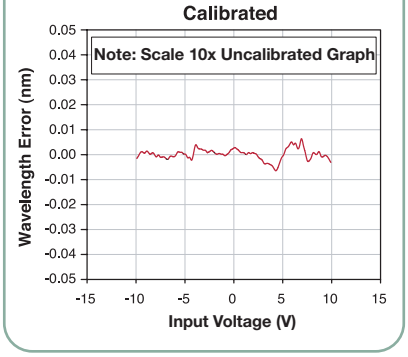
Figure 1

These lasers provide an excellent sweep performance while being robust and reliable at the same time.

The waveforms below show the excellent linearity of the ECL across the entire tuning range.







Applications

Heterodyne Interferometry

Optical Heterodyne Interferometry is an important measurement technique that benefit from Thorlabs' continuously tunable lasers.

Laser requirements for this high-precision measurement include smooth continuous tuning, high accuracy measurement, control of the wavelength, low noise, and narrow linewidth.

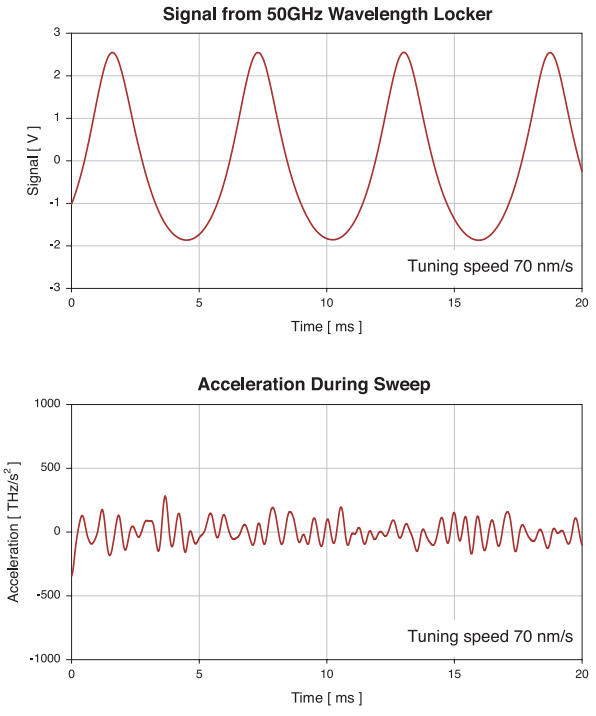
Our patented motor design enables a highly constant tuning speed. The constant sweep speed (low acceleration) makes these lasers suitable for interferometric and heterodyne measurements.

The acceleration during sweep (variation in the tuning speed) is measured using a wavelength locker (low finesse Etalon). The wavelength locker signal provides evenly spaced peaks (clock) in the frequency space (k-space). There are several methods to acquire data, which enables the calculation of the tuning speed and the acceleration. One method is to use the k-space clock to determine the tuning speed, and the time fluctuations of the k-space clock to determine the tuning speed variations (acceleration). In the figure to the right, we have used (in addition to the k-space clock) the knowledge of the finesse of the Etalon to improve the time resolution of the measurement. When using the knowledge of the finesse, the time resolution of the tuning speeds and the measurement of the acceleration is limited to the sampling frequency rather than the k-space clock.

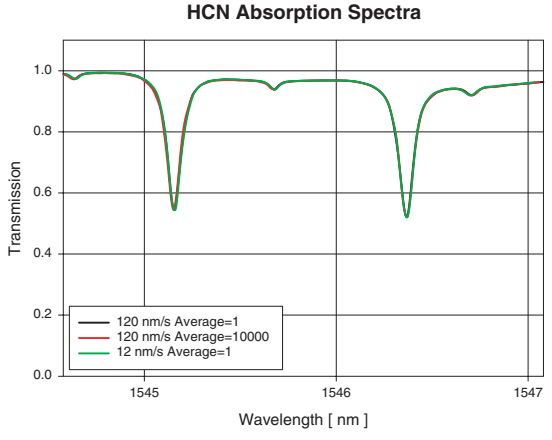
Spectral Monitoring

The ECL tunable lasers provide an outstanding building block in spectral measuring and monitoring. The waveform shows an HCN (Hydrogen Cyanide) scan using Thorlabs' ECL technology. See pages 851-857 for our gas cell products.

The impressive scan-to-scan repeatability allows the user to average spectral features without smearing (see figure to the right).



Plot of the Fluctuation of the Tuning Velocity (PICO D)



WAVELENGTH (nm)	TUNING RANGE (nm)	POWER (mW)	FIBER OUTPUT	MODEL
780	15	>5	–	INTUN
980	25	20	–	INTUN
1320	>110	>5* to >20	Yes	INTUN. PICO D ECL5000
1560	>130	>5* to >20	Yes	INTUN. PICO D ELC5000, µECL

* For the fiber coupled versions

LASER SELECTION TABLE	PICO D	ELC5000DT	INTUN-T	INTUN-B	ELC1525
Mode-Hop Free Tuning	***	***	***	***	***
Fiber Output	***	***	**	**	***
Swept Wavelength Applications	***	***	***	*	*
Step and Measurement	*	*	*	***	***
Digital Interface		***		***	***
ITU References					***

Legend *** Best **Selected Models Only *Standard

ECL5000-Continuously Tunable, PC-Controlled Laser 1519-1630nm

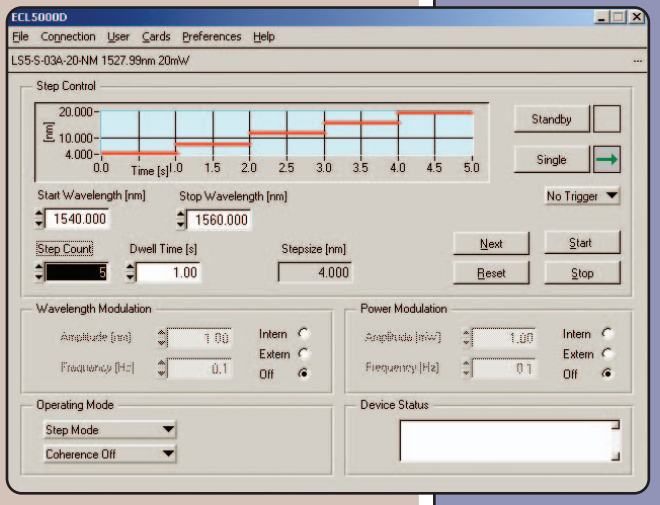
COMES COMPLETE WITH LAPTOP AND INSTALLED SOFTWARE!

Specifications

Parameter	Typical Data
Wavelength Range	1519-1630nm*
Mode Hops	0
Tuning Speed Continuous	0-130nm/s
Tuning Speed Step (Includes Settling Time)	1nm: <50ms 10nm: <100ms 100nm: <800ms
Wavelength Resolution	1pm
Wavelength Repeatability	±5pm (1 Hour)
Wavelength Accuracy	±15pm
Wavelength Stability	±5pm** (1 Hour)
Wavelength Modulation Bandwidth	100Hz
Power Repeatability	±0.1dB (1 hour)
Optical Power Modulation Bandwidth	100kHz
Optical Peak Power	>6dBm
Optical Power Over Tuning Range	>2dBm (typ.) (0dBm min.)
Spectral Linewidth FWHM	<150kHz***
SMSR	>50dBc
STSSER	>65dB
Optical Isolation	60dB
RIN	-140dB/Hz
Optical Interface	FC/APC****
Analog Input Voltage Range	±10V
Input Power	100-240VAC 50-60 Hz
Dimensions ECL5000DT	168 x 133 x 315mm
Dimensions ECL5000D	101 x 129 x 270mm

* Standard product, other wavelengths available upon request.
** ΔT ±0.5°C
***Measurement time 1ns.
****Peak isolation

The ECL5000DT benchtop tunable laser utilizes Thorlabs' patented ECL technology, providing high stability, high output power, and smooth continuous tuning over the 110nm tuning range. The benchtop unit is comprised of a Thorlabs PICO D series tunable laser packaged in a rugged TXP5004 chassis. The microprocessor controlled unit provides both digital and analog modes of controlling the unit. In the analog mode, the wavelength and power can be controlled by applying a voltage to the front input jacks. This can be a DC voltage for step control or a modulated signal for sweeping either the wavelength, the power, or both. The digital control is achieved through the USB interface. The easy-to-use interactive GUI (Graphical User Interface) allows direct tuning, step tuning, and selectable sweep operation. The laser is ready for use as soon as the USB cable, included with the unit, is plugged in. LabVIEW™ and LabWindows™/CVI drivers are provided for those who need to integrate the programming of the tunable laser with other equipment. These two methods of tuning provide a powerful and flexible control capability to meet the most demanding testing applications to synchronize with external events.



The ECL5000DT also provides a trigger-in and a trigger-out jack. The output voltage at the analog out jack is proportional to the optical wavelength.

THE PMD5000, a versatile PMD and polarization analysis system, is an application example of an ECL5000D in a complex TXP-based test and measurement system (see pages 984-987).

Highlights

- Mode-Hop Free Tuning
- Internal and External Wavelength and Power Modulation
- Smooth and Continuous Tuning
- 1519-1630nm Tuning Range
- Continuous Sweep and Step Mode Operation
- High Output Power
- USB with Intuitive Graphical Interface

ITEM#	$	£	€	RMB	DESCRIPTION
ECL5000D	$22,500.00	£ 14,175.00	€ 20.925,00	¥ 214,875.00	TXP Linear Tunable Laser Module
ECL5000DT	$25,000.00	£ 15,750.00	€ 23.250,00	¥ 238,750.00	Complete Benchtop Linear Tunable Laser Including Laptop

Using the PICO D Tunable Laser for Polarization Measurement

PMD5000 SERIES
Complete PMD/PDL Analyzation System
(Laptop Included)

The PMD5000 measurement system consists of three parts: the tunable laser source ECL5000D, the fast deterministic polarization controller, and either our fast or our high dynamic range polarimeter. This system provides extensive measurement and analysis of Polarization Mode Dispersion on components, optical fibers, and installed optical systems that are either active or passive, or broadband or narrow band. The PMD5000 is also capable of determining Polarization Dependent Loss (PDL) and Polarization Dependent Gain (PDG).

The system uses the Jones Matrix Eigenanalysis (JME) method to ensure accuracy when making measurements on a large variety of optical elements. Key components of the JME are the tunable laser detector, ministic polarization controller, and the DPC5500. (Refer to page 979 for more information).

Clean and Fast

The core of the ECL5000D is the PICO D tunable laser. The PICO D, with low noise and fast linear tuning characteristics, is a natural choice for integration into optical parameter measurement instruments such as the PMD5000 System.

High demands on fiber optic equipment require reliable testing, and the source must not impose limits on the subject being measured.

Range and Power

The tunable laser provides continuous, mode-hop free tuning. It is available in several models spanning the 1260-1630nm range and each model has more than 110nm of tuning range. With a Signal on Total Source Spontaneous Emission Ratio (STSSER) specification of >65dB, the PICO D provides plenty of margin when measuring PMD and PDL, for example.

Accurate and Adaptable

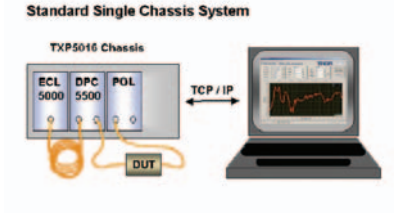
The tunable laser provides outstanding performance with a wavelength resolution and repeatability of 1pm each and a one-hour wavelength stability of ±2pm. This is important for demanding applications such as polarization measurement (JME) where the PMD5000 System measures the optical transfer function.

PMD and PDL analysis of fibers and broadband components can be performed with this model. This includes the PMD measurement of passive components (couplers, isolators, and narrow bandwidth components such as optical filters, Bragg gratings, and OADM), and active components (EDFAs and PDFAs).

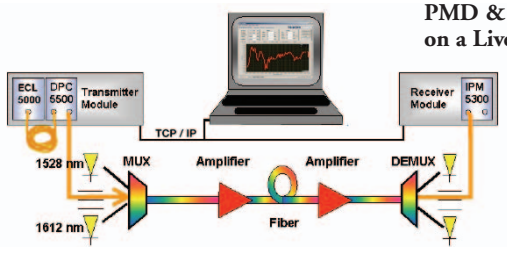
The OEM Solution

Cost effectiveness and quality of light are equally important. When selecting a Tunable Laser Source (TLS), one must consider the following:

- **Wavelength Range:** The Wider the Range, the Lower the Risk For Needing More Than One Source
- **Tuning Speed:** The Faster the Sweep, the More Units That Can Be Tested Over Time
- **Power:** High Output Means the Ability to Test High-Power Components and the Possibility of Light Sharing Among Multiple Devices Simultaneously
- **Price:** The TLS Must Have a Modular Design to be Easily Integrated Into the Test Equipment, Which Would Avoid the Need for Separate Benchtop Tunable Lasers



PMD & PDL Measurements of Broadband and Narrow Bandwidth Devices



PMD & PDL Monitoring on a Live Fiber With Traffic