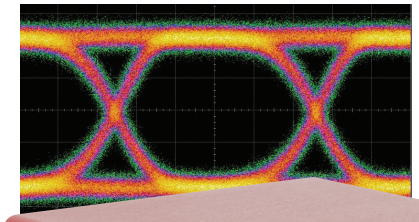
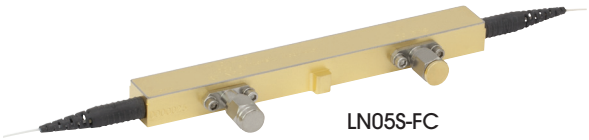
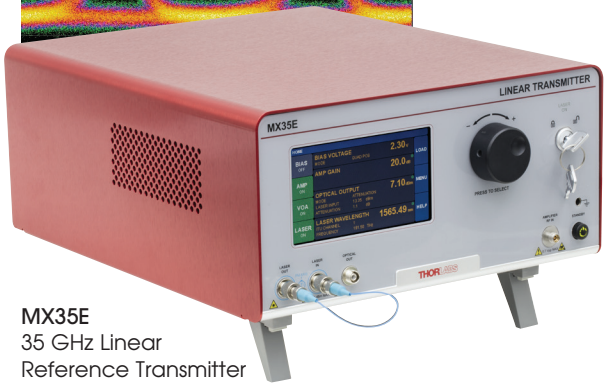
Ultrafast Optoelectronics





LN05S-FC
40 GHz $LiNbO_3$ Modulator

PDA015C
380 MHz Amplified Detector



MX35E
35 GHz Linear Reference Transmitter

DXM20AF
20 GHz Fiber-Coupled Detector

MX40G
40 GHz Calibrated Electrical-To-Optical Converter

Thorlabs designs and manufactures a wide variety of optoelectronic instrumentation for high-speed test and measurement applications. These instruments and components are ideal for use in R&D laboratories for performing experiments requiring high-speed transmitters or receivers, as well as in manufacturing environments for automated testing of high-speed components with reference instrumentation.

Thorlabs has a long history of providing OEM and custom solutions. We welcome the opportunity to work with you to meet your ultrafast optoelectronic application needs, whether at the level of hermetic modules or fully integrated instruments.

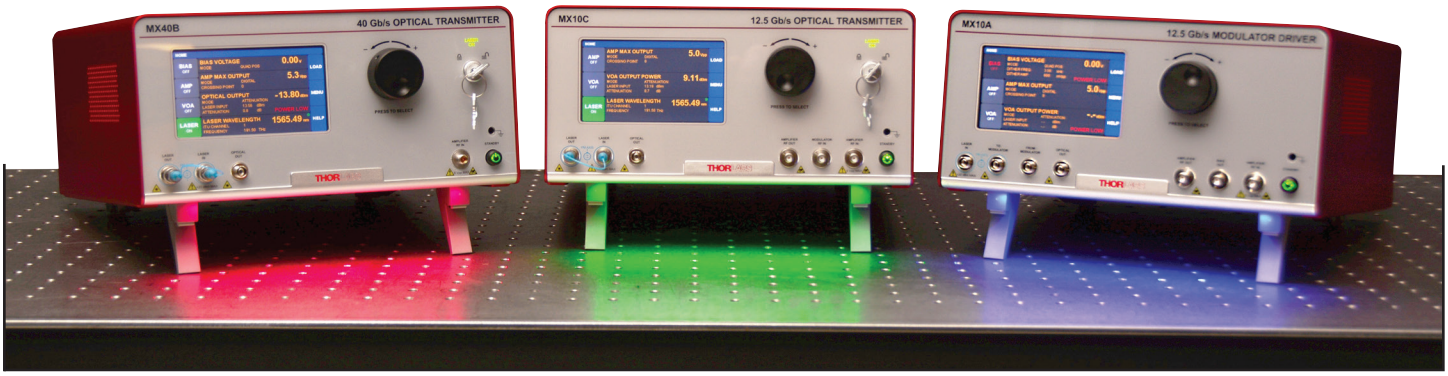
Fully Integrated Solutions

- 40 Gb/s Digital and 35 GHz Linear Reference Transmitters
- 40 GHz Electrical-to-Optical Converter for Optical VNA Applications
- Drivers and Bias Controllers for Lithium Niobate ($LiNbO_3$) Modulators
- C-Band and L-Band Narrow Linewidth and Telecom-Grade Laser Sources
- High-Fidelity Ultrafast Biased Detectors with Current Monitors
- 380 MHz High-Gain Amplified Detectors
- Nanosecond Pulsed Lasers

THORLABS

Product Overview

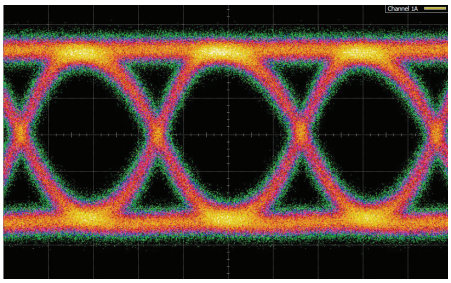
Thorlabs' ultrafast optoelectronics instruments and components include lasers, transmitters, $LiNbO_3$ modulators, modulator drivers, bias controllers, detectors, receivers, and electronic variable optical attenuators (EVOAs). We provide standard configurations as well as custom and OEM solutions.



Optical Transmitters and a Modulator Driver

Optical Transmitters

Thorlabs' High-Speed Optical Transmitters are fully integrated and user-configurable solutions based on proven $LiNbO_3$ electro-optic (EO) modulator technology driven by high-fidelity RF amplifiers. The modulated optical output is fiber coupled, and the only required external input is the signal source coupled to the RF amplifier port.



MX35E 32 Gb/s Eye Diagram

Linear Reference Transmitters

Based on the use of EO intensity modulators and an RF amplifier with user-adjustable gain that provides a linear relationship between the input and output voltages, the MX35E linear reference transmitter is designed for linear applications and multi-level modulation schemes, like four level pulse amplitude modulation (PAM4), that require frequency response up to 35 GHz.

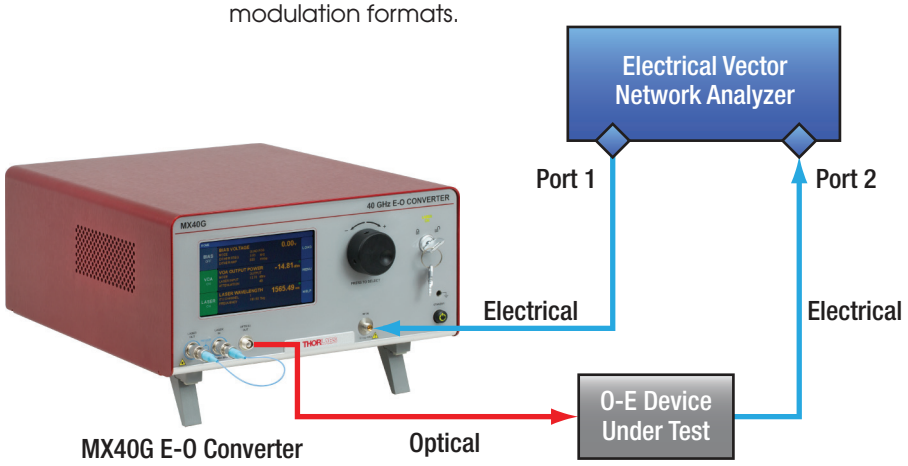
Digital Reference Transmitters

Both the MX10B and MX40B reference transmitters are based on EO intensity modulators and high-gain, limiting amplifiers with user-adjustable output voltage swing. They are well-suited to many binary modulation formats. The MX10B supports bit rates up to 12.5 Gb/s and the MX40B operates up to 40 Gb/s.

Thorlabs also offers Digital Transmitters with phase modulators, with the MX10C operating up to 12.5 Gb/s and the MX40C up to 40 Gb/s. Both are well-suited to phase-shift keying binary modulation formats.

Calibrated E-O Converter

Our MX40G Electrical-to-Optical (E-O) Converter is a general purpose electrical-to-optical converter with frequency response up to 40 GHz. The MX40G is ideal for use as an accessory that provides optical test capability for an all-electrical vector network analyzer, which allows measurement of optical-to-electrical (O-E) devices.



The MX40G enables an all-electrical vector network analyzer (VNA) to test an O-E device.

Tunable Telecom-Grade Lasers

With linewidths of 10 kHz and telecom-grade stability and reliability, our TLX Series of Tunable Laser Sources emit in the C-Band or L-Band. They are tunable on the ITU 50 GHz frequency grid and provide optical power levels up to +13.5 dBm. Using remote serial control via USB or RS-232 enables tuning resolution capability to 1 MHz. A frequency dither option aids in stabilizing the laser wavelength, and the integrated variable optical attenuator (VOA) provides optical output power control.

MX10A
EO Modulator Driver

Modulator Drivers

Our MX10A and MX40A Modulation Drivers provide control for an external fiber-coupled $LiNbO_3$ EO modulator and have operating wavelength ranges from 1250 nm to 1610 nm. Each driver includes an RF amplifier with amplitude and eye-crossing controls and accepts an external drive signal source.

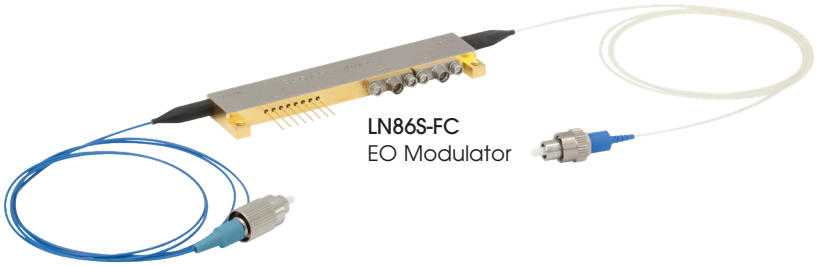
Automatic Bias Controller and VOA

Thorlabs' fully featured MBX Modulator Bias Controller provides complete, precise, and automated control of DC bias and optical output power for any fiber-coupled $LiNbO_3$ EO intensity modulator, regardless of signal speed. The MBX is ideal for use within a customized setup that uses an external laser, intensity modulator, signal source, and RF amplifier.

Complementary Components

Thorlabs' ultrafast optoelectronics product line includes a number of components complementary to our instruments. These include ultrafast biased detectors, PDA015 series 380 MHz InGaAs and Si detectors, lithium niobate phase and intensity modulators, premium microwave cables, microwave cable adapters, and electronic variable optical attenuators (EVOAs).

DXM20AF
20 GHz Detector



LN86S-FC
EO Modulator

V450A
Compact EVOA
for System Integration

EVOA1550F
1250 - 1625 nm EVOA
with Power Lock

PDA015A
380 MHz Amplified
Detector

Microwave Cable and Adapter

Linear Reference Transmitter

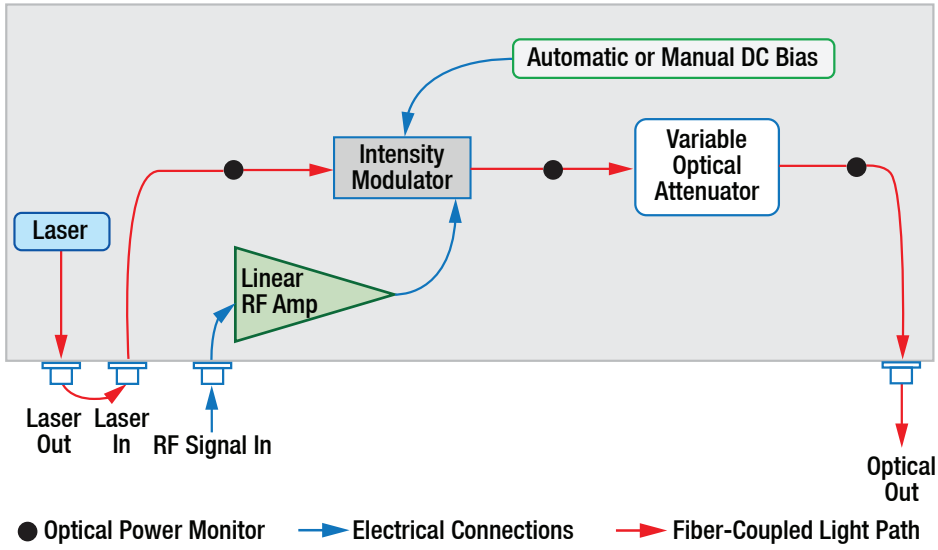
MX35E

Features

- Fully Integrated Transmitter
- 1250 to 1610 nm Operating Range
- Linear RF Amplifier with User-Adjustable Gain
- Built-In VOA for Power Control
- 35 GHz Maximum Frequency
- C- or L-Band Tunable Laser

Thorlabs' MX35E Linear Reference Transmitter is a fully integrated solution driven by a high-fidelity linear amplifier and featuring a built-in $LiNbO_3$ intensity EO modulator, telecom-grade tunable laser, fully featured modulator bias control, and a variable optical attenuator (VOA) for automatic output power control and stabilization. The MX35E is designed for linear applications that require frequency response up to 35 GHz, which makes it compatible with high-bit-rate modulation schemes that rely on multi-level encoding, such as four level pulse amplitude modulation (PAM4).

MX35E Internal Setup and External Connections



Specifications

Amplifier Type	Linear (Analog)
Internal Laser Type	C- or L-Band[a]
Operating Wavelength Range[b]	1250 nm - 1610 nm
Internal Laser Output Power (Maximum)	+13.5 dBm (Typical)
Maximum Frequency	35 GHz
Low Frequency Cutoff	200 kHz
Amplifier Linearity	<3.5% THD at 1 GHz
Amplifier Gain	10 dB to 23 dB
Optical Extinction Ratio	13 dB (Typical Maximum)

a. L-Band Laser Available Upon Request
b. Exceeds range of internal laser. Accessible with user-supplied laser.

The MX35E transmitter is based on the use of an RF amplifier that provides a linear relationship between the input and output voltages. The user-adjustable gain control allows the output of the amplifier to remain linear across a broad range of input signal levels.

The internal C-band laser is tunable over a range of 1527.6 nm to 1565.5 nm on the ITU 50 GHz grid. Serial control via USB or RS-232 enables laser tuning resolution capability to 1 MHz, as well as offering remote control capability for all our reference transmitters. Please contact us to discuss custom options, including systems operating over different wavelength ranges.

LASER RADIATION
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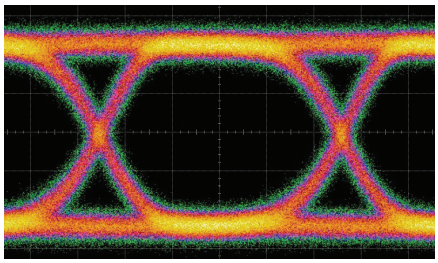
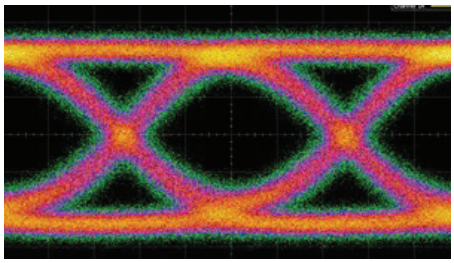
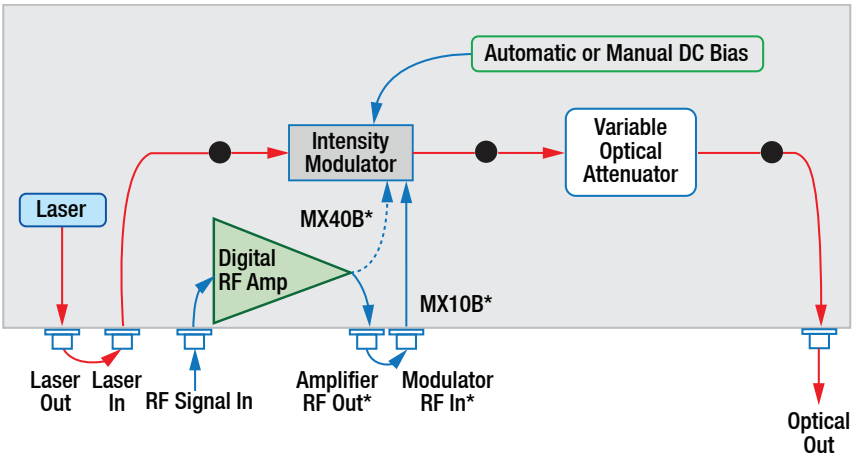
CLASS 1M LASER PRODUCT


MX35E 20 Gb/s PAM4 Eye Diagram


MX35E 40 Gb/s Eye Diagram

Digital Reference Transmitters

MX10B and MX40B Internal Setup and External Connections



*The external loop-back between Amplifier RF Out and Modulator RF In is only available on the MX10B. For the MX40B, the connection between the RF Amp and the modulator is made directly inside of the housing.

Optical Power Monitor
Electrical Connections
Fiber-Coupled Light Path

MX10B

The fully integrated MX10B and MX40B Digital Reference Transmitters are well suited to many binary modulation formats, including return-to-zero (RZ), non-return to zero (NRZ), and on-off keying (OOK) in high-speed fiber optic test applications. These digital reference transmitters include an internal laser, $LiNbO_3$ intensity modulator with bias control and driven by a high-fidelity limiting amplifier, and a variable optical attenuator (VOA). They may be controlled using the touchscreen or via USB or RS-232 connectors on the back panel for remote serial control.

Designed for digital applications, the MX10B and MX40B operate at bit rates up to 12.5 Gb/s and 40 Gb/s, respectively. Because of their high gain, they can accommodate a wide range of input voltages. The maximum output voltage swing of their limiting RF amplifiers is user adjustable, while their gain is held constant, allowing the user to control the optical extinction ratio of the signal from the modulator. Both models also offer user-adjustable eye-crossing points, which enable fine control of the eye transitions.

Related products are the MX10C and MX40C, which are based on phase modulators and operate at bit rates up to 12.5 Gb/s and 40 Gb/s, respectively. They include the same limiting RF amplifier as the MX10B and MX40B but do not include the bias controller.

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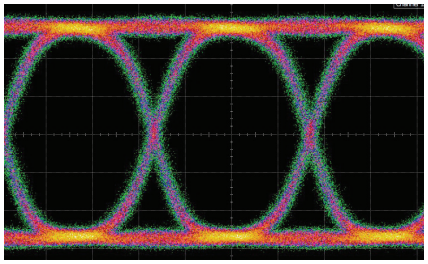
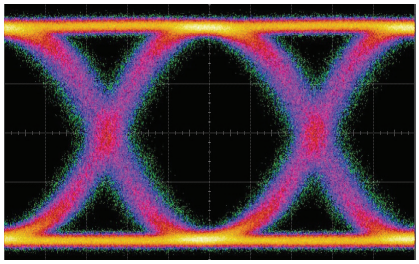


MX10B 15 Gb/s Eye Diagram



MX40B 40 Gb/s Eye Diagram

Features

- Fully Integrated Transmitter
- Operating Range: 1250 to 1610 nm
- High-Fidelity Digital RF Amplifier with User-Adjustable Extinction Ratio
- Maximum Bit Rates
  - MX10B: 12.5 Gb/s
  - MX40B: 40 Gb/s
- C- or L-Band Tunable Laser

Specifications

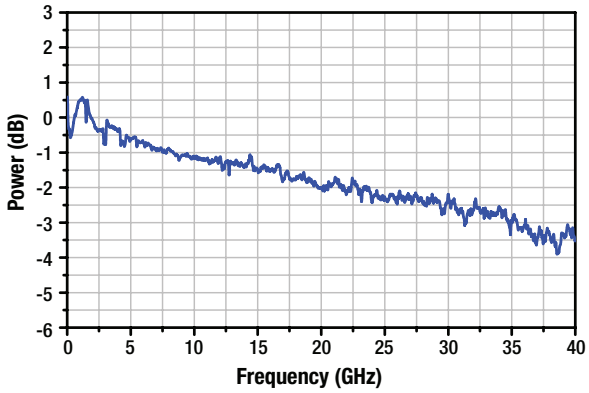
Item #	MX10B[a] MX10C[b]	MX40B[a] MX40C[b]
Amplifier Type	Digital (Limiting)	
Internal Laser Type	C- or L-Band[c]	
Operating Wavelength Range[d]	1250 nm - 1610 nm	
Internal Laser Output Power (Maximum)	+13.5 dBm (Typical)	
Maximum Bit Rate	12.5 Gb/s	40 Gb/s
Low Frequency Cutoff	100 kHz	
Amplifier Gain	34 dB	30 dB
Optical Extinction Ratio	13 dB (Typical Maximum)	

a. Intensity modulator
b. Phase modulatior
c. L-Band Laser Available Upon Request
d. Exceeds range of internal laser. Accessible with user-supplied laser.

Calibrated E-O Converter

MX40G

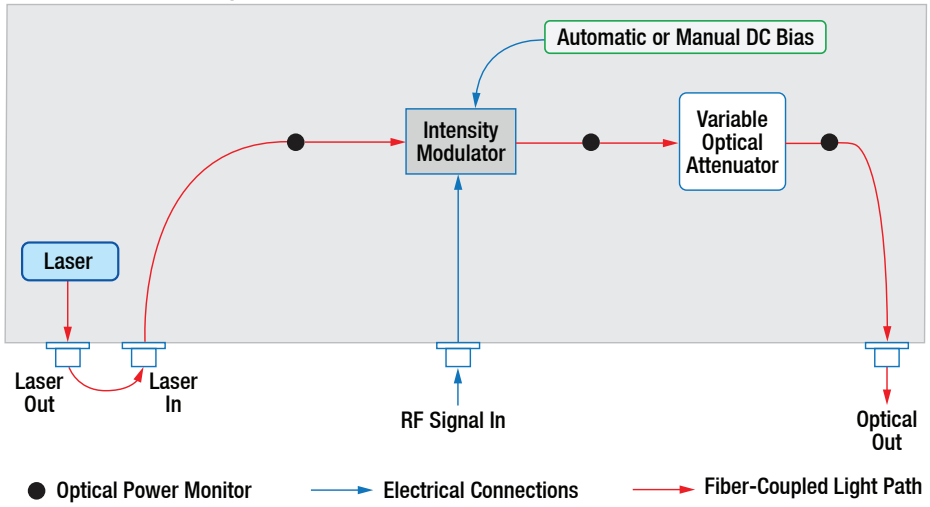
Typical Frequency Response



Features

- Calibrated E-O Conversion
- Operating Range: 1250 to 1610 nm
- Optical Accessory for Electrical VNA
- S_{21} De-Embedding Parameters Supplied
- Bulit-In C- or L-Band Tunable Laser

MX40G Internal Setup and External Connections



Specifications

Internal Laser Type	C- or L-Band[a]
Optical Wavelength Range[b]	1250 nm - 1610 nm
Internal Laser Output Power	+13.5 dBm (Maximum)
Frequency Response	DC - 40 GHz
Optical Extinction Ratio	13 dB (Typical Maximum)
Modulator RF Input	±1 V (Maximum)[c] ±5 V (Absolute Maximum)
RF Drive Voltage (V_π)	5.5 V_{pp} (@1 GHz)

a. L-Band Laser Available Upon Request
b. Exceeds range of internal laser, accessible with user-supplied laser.
c. For linear response, with bias point at quadrature.

LASER RADIATION
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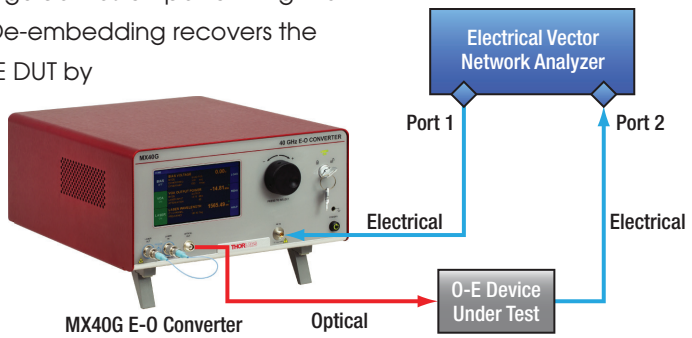
The MX40G is a calibrated, 40 GHz Electrical-to-Optical (E-O) Converter with built-in tunable laser and variable optical attenuator (VOA). Its telecom-grade $LiNbO_3$ modulator is stabilized by a fully automatic bias controller. Use the internal tunable laser source or couple an external laser operating from 1250 nm to 1610 nm to the PM FC/PC fiber optic connector on the input panel. Control the instrument using the intuitive GUI touchscreen or serial commands delivered via USB or RS-232 connectors on the rear panel.

The MX40G is ideal for use as an accessory that provides optical test capability for an all-electrical vector network analyzer (VNA). This pairing enables an optical-to-electrical (O-E) device under test (DUT) to be accurately measured.

The MX40G is supplied with a calibrated response file (*.s2p) containing S_{21} de-embedding parameters and guidelines on performing the de-embedding procedure. De-embedding recovers the accurate response of the O-E DUT by removing the response of the MX40G from the system response measured by the VNA. Please contact us to discuss custom options, such as systems with different frequency ranges.



The MX40G enables an all-electrical VNA to test an O-E device.

Features

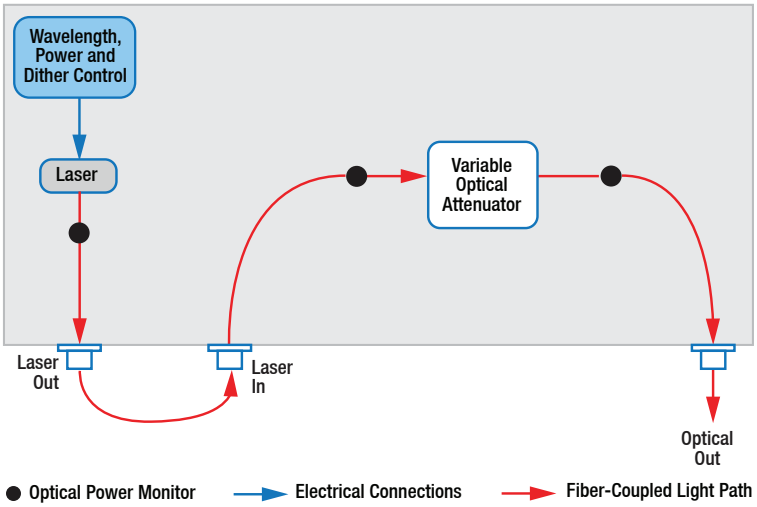
- Telecom-Grade Tunable Lasers for C-Band (TLX1) or L-Band (TLX2)
- Tunable on ITU 50 kHz Frequency Grid
- Narrow 10 kHz Typical Linewidth
- VOA for Output Power Control
- Wavelength Dither Option for Frequency Accuracy

TLX1

The TLX Series of Tunable Laser Sources supplies highly stable and narrow-linewidth C- or L-band optical emission, which can be tuned on the ITU 50 GHz frequency grid. Each source includes a laser source and a variable optical attenuator (VOA), whose settings can be controlled using the touchscreen interface or serial commands delivered via USB or RS-232 connectors on the rear panel. This allows the user to tune the emission wavelength, choose whether to enable the frequency dither option to improve wavelength stability, and control the optical output power. The specified operating conditions are maintained using internal power monitors and microprocessor-controlled feedback loops.

For added flexibility, the connection between the laser source and the VOA is established via an external loop-back fiber patch cable, which allows the VOA to be used with other laser sources if desired.

TLX1 and TLX2 Internal Setup and External Connections



Dither Function: The user can enable the dither function to stablize the wavelength at the expense of increased noise. The noise performance of the laser with and without dither can be seen in the plot to the right.

LASER RADIATION
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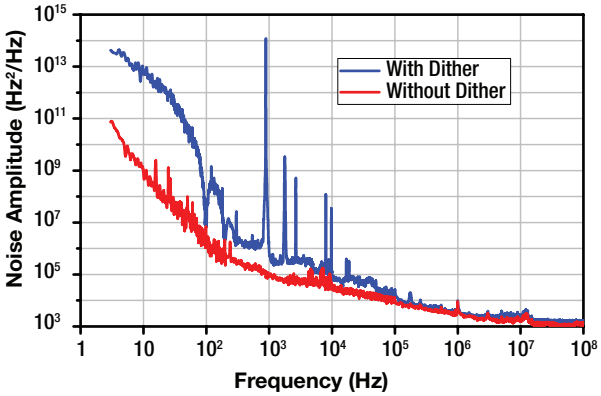
Specifications

Item #	TLX1	TLX2
Frequency Range	191.50 - 196.25 THz	186.35 - 190.95 THz
Wavelength Range	1528 - 1566 nm	1570 - 1609 nm
Optical Output Power	+13.5 dBm (Typical)	
Side Mode Suppression Ratio	55 dB (Typical)	
Intrinsic Linewidth	10 kHz (Typical)	
Relative Intensity Noise (RIN)	-145 dB/Hz (Maximum)	
Polarization Extinction Ratio	18 dB (Minimum)	
Optical Insertion Loss[a]	0.7 dB (Typical)	
Tuning Resolution	50 GHz (Typical)	
VOA Response Time	≤1 s	

a. Laser In to Optical Out

Power Spectral Density of Frequency Noise



EO Modulator Driver

MX10A

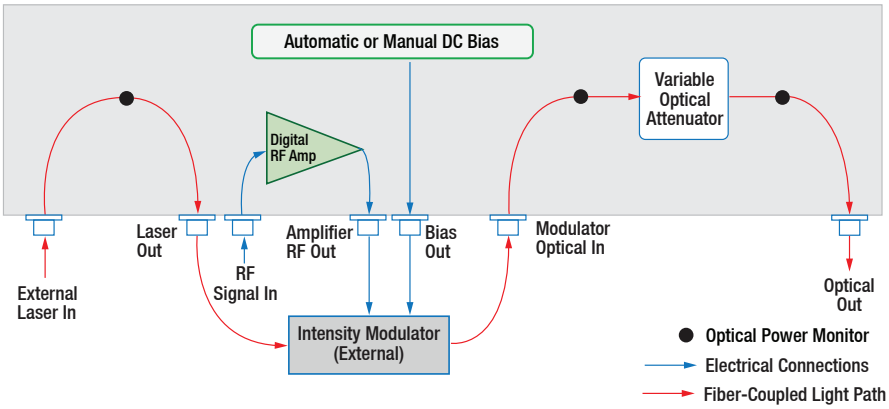
Specifications

Item #	MX10A	MX40A
Optical Input Power	20 dBm (Max)	
Operating Wavelength Range[a]	1250 nm - 1610 nm	
Maximum Bit Rate	12.5 Gb/s	40 Gb/s
Low Frequency Cutoff	100 kHz	
Amplifier RF Input (Digital Mode)[b]	400 mV (Typical) 3.5 V (Maximum)	400 mV (Typical) 4 V (Maximum)
Maximum Amplifier DC Input	±15 V	±10 V
Maximum Bias to Modulator	±10 V (≥50 Ω Input Impedance)	

a. Laser Not Included b. Peak to Peak

Thorlabs' MX10A and MX40A High-Speed Drivers for fiber-coupled $LiNbO_3$ modulators provide digital operation up to 12.5 Gb/s or 40 Gb/s, respectively. The drivers also have analog (linear) operation with up to 7 GHz small signal bandwidth for the MX10A and up to 20 GHz small signal bandwidth for the MX40A.

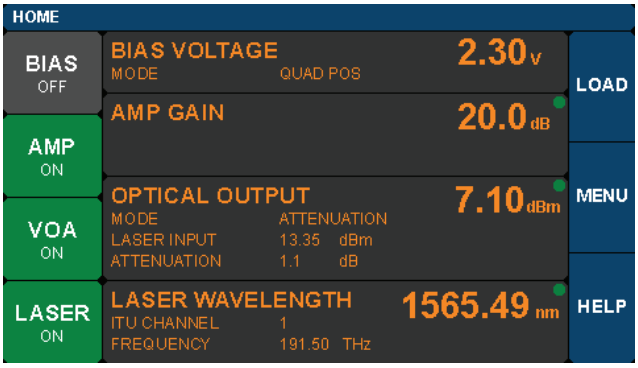
MX10A and MX40A Internal Setup and External Connections



They include RF driver electronics and fully functional bias and power control. The bias controller includes automatic modes with peak, null, and quadrature setpoints as well as manual modes. The drivers also include a series of power monitors at the laser input, modulator output, and final optical output, as well as a VOA. These enable fully automatic monitoring and control of optical power along the entire optical path.

The touchscreen interface allows for the selection of power calibration points at 1310, 1550, and 1590 nm. These modulators are ideal for use either in a lab or in a manufacturing environment for creating optical links, performing experiments requiring fast optical modulation, or testing modulators or other components.

Intuitive Touchscreen Interface



Home Screen of the MX35E Linear Reference Transmitter

Our transmitters, modulator drivers, bias controller, and E-O converter each include a native graphical user interface (GUI) that gives the user complete control over all instrument functionality, in addition to providing information on function stability and operating values.

Use the touchscreen exclusively or in conjunction with the knob on the front panel, which enables set point values to be quickly changed.

For those applications benefitting from remote control capability, these instruments also offer serial control via USB or RS-232 connectors on the rear panel.

Bias Controller for EO Intensity Modulators

Thorlabs' MBX Bias Controller provides complete control of DC bias and optical output power for any fiber-coupled $LiNbO_3$ EO intensity modulator, regardless of signal speed. The MBX offers manual and fully automatic modes, which use a dither tone to bias the modulator at the null, peak, or quadrature (positive or negative slope) setpoints. Another option is ditherless control of the bias point, which holds the output/input optical power ratio at a constant value.

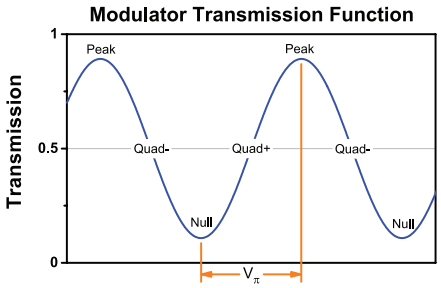
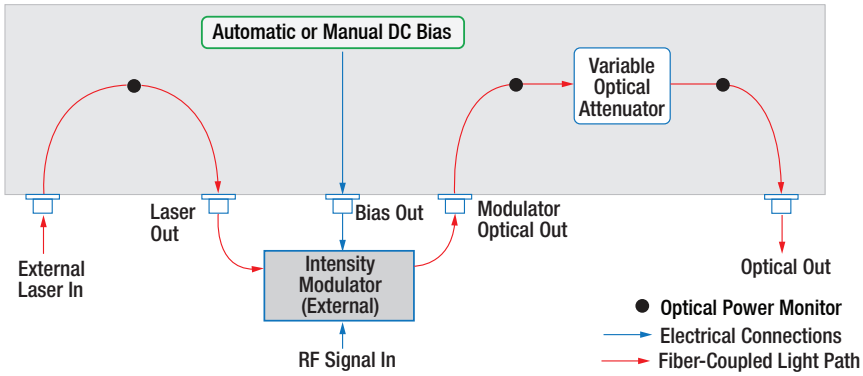


Illustration of Modulator Bias Points

MBX

MBX Internal Setup and External Connections



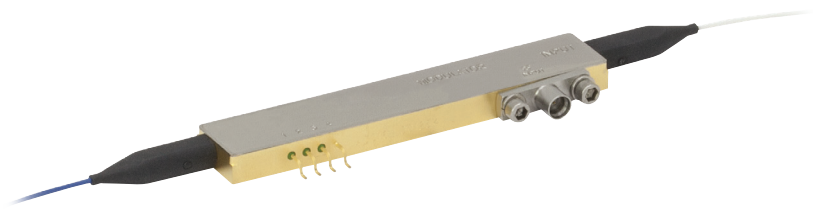
Specifications[a]

Optical Input Power (From External Laser)	20 dBm (Maximum)
Wavelength Range	1250 nm - 1610 nm
Bias Voltage Range	±10 V
Bias Modes	Quadrature, Peak, Null, Manual
Dither Frequency Range[b]	1 kHz to 10 kHz
Dither Amplitude Range[b]	20 mV to 2 V

a. All values are typical unless noted otherwise.
b. Adjustable

$LiNbO_3$ Intensity and Phase Modulators

Thorlabs offers a selection of $LiNbO_3$ intensity and phase modulators fabricated from titanium-indiffused $LiNbO_3$ and based on the Mach-Zehnder interferometric architecture. They are designed for RF-over-fiber and microwave photonics applications as well as simple integration into systems. Single mode or polorization maintaining optical fiber pigtails are available. They operate over the C- and L-bands and are Telcordia GR-468 compliant. Drivers for these modulators include the MX10A and MX40A, and the MBX is designed to provide bias control for the intensity modulators.


LN82S-FC
10 GHz Analog Modulator

LN82S-FC Intensity Modulator

- Analog Operation from DC to 15 GHz
- 5.2 V Typical RF Drive Voltage
- Low 4.0 dB Typical Optical Insertion Loss

LN05S-FC Intensity Modulator*

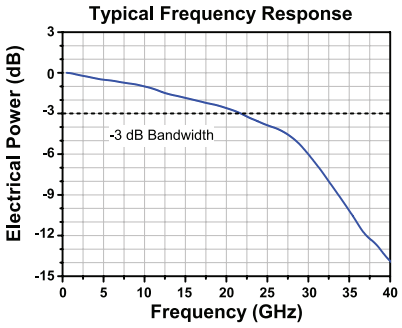
- 40 Gb/s Bit Rate
- 20 dB Optical Extinction Ratio
- Low 5.5 V Typical RF Drive Voltage
- Low 4.5 dB Typical Optical Insertion Loss

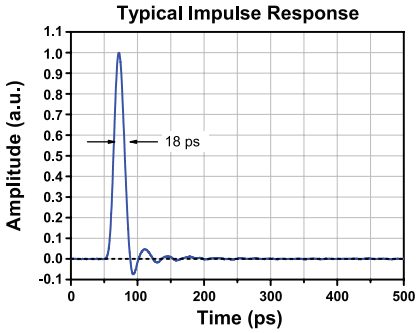
LN27S-FC and LN66S-FC Phase Modulators*

- 35 GHz Bandwidth
- 7.5 V Typical RF Drive Voltage
- Low 4.0 dB Typical Optical Insertion Loss

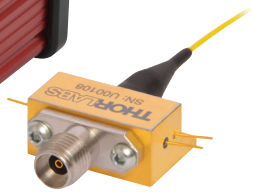
*Includes an optical polarizer.

Ultrafast Fiber Optic Photodetectors





DXM20AF
Input Panel



These detectors are also available in three-pin packages for OEM applications.

Specifications

Item#	DXM12CF	DXM12DF	DXM25CF	DXM25DF	DXM30AF	DXM30BF	DXM20AF
Wavelength Range	700 nm - 870 nm				750 nm - 1650 nm		1250 nm - 1650 nm
Photodiode	GaAs				InGaAs		
Impulse Response[a] (FWHM)	29 ps		19 p		15 ps		18 ps
Frequency Response	DC - 12 GHz		DC - 25 GHz		DC - 30 GHz		DC - 20 GHz
Conversion Gain[a, b]	15 V/W	14 V/W	12.5 V/W	11 V/W	19 V/W	16.5 V/W	22.5 V/W
Responsitivity[c]	0.6 A/W		0.5 A/W		0.7 A/W		0.9 A/W
Optical Input Power	75 mW		100 mW		50 mW		

a. Typical Values at 780 nm for the DXM12CF, DXM12DF, DXM25CF, and DXM25DF, and at 1560 nm for the DXM20AF, DXM30AF, and DXM30BF.
b. Into External 50 Ω Load
c. For Single Mode Input, Typical Values at 1550 nm given for DXM30AF, DXM30BF, and DXM20AF

The DXM series of Ultrafast Detectors include single-mode and multimode fiber-coupled photodetectors with wide wavelength ranges. Each provides a high-fidelity electrical output pulse in response to an optical input pulse, and their clean impulse responses have full width half maxima (FWHM) down to 15 ps. Each detector features a fiber-coupled, hermetically sealed microwave detector module. For convenience and simplicity of use, the module is mounted inside a rugged aluminum housing that includes a rechargeable battery, current monitor circuitry, and a digital display of the DC photocurrent.

380 MHz Amplified Detectors

PDA015A

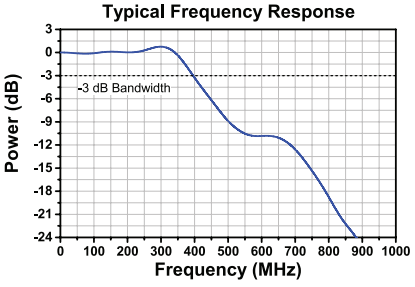
PDA015C

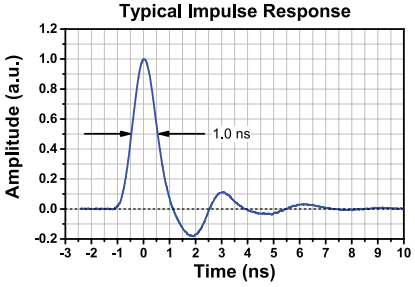
Thorlabs' PDA015 Series Amplified Detectors are the most sensitive free-space nanosecond receivers available. All models have a frequency response from DC to 380 MHz, which produces an impulse response and rise time of 1 ns. The output is DC coupled and provides a transimpedance gain of up to 50 kV/A into a high impedance load.

Specifications

Item #	PDA015A(/M)	PDA015C(/M)
Photodiode Type	Si PIN	InGaAs PIN
Incident Power, Max[a]	350 µW	180 µW
Wavelength Range	400 - 1000 nm	800 - 1700 nm
Peak Responsitivity	0.47 A/W (at 740 nm)	0.95 A/W (at 1550 nm)
Frequency Response	DC to 380 MHz	
Impulse Response (FWHM)	1 ns	
Transimpedance Gain	50 kV/A (High Z); 25 kV/A (50 Ω)	
NEP[b] (DC to 380 MHz)	36 pW/√Hz	20 pW/√Hz

a. Free Space Optical Input, Spec is for Linear Operation
b. Measured with a 50 Ω Load





Nanosecond Pulsed Laser Systems

Features

- Center Wavelengths: 405, 450, 488, 520, or 640 nm
- Adjustable and Fixed Pulse Width Options
- Peak Pulse Output Powers from 13 mW to 50 mW

NPL64B

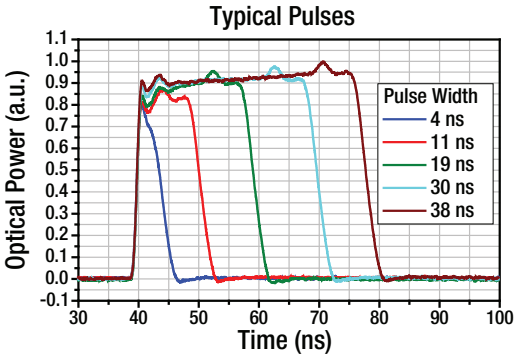
Thorlabs' NPL Series Pulsed Laser Diode Systems generate trains of nanosecond pulses at repetition frequencies up to 10 MHz. These compact turnkey insturments consist of a laser head and an external 15 V power supply. Drive electronics and temperature stabilization circuits for the laser diode are all integrated into the laser head. An adjustable lens controls beam divergence, and a safety shutter can be rotated to cover the optical output port. Adapters are included for post mounting. Please ask us about custom wavelength and power level options.

The NPL64A model offers a 10 ns pulse width, triggered at rates up to 10 MHz by a user-supplied input to an SMA connector on the back panel. Models with item numbers ending in B include controls for adjusting the pulse width to 16 settings between 5 and 39 ns, depending on the model. Additionally, the repetition frequency for these lasers can be varied from 1 MHz to 10 MHz. These units also accept a user-supplied input for triggering pulses at rates of up to 10 MHz.

A power supply and two ECM225 mounting clamps that accept either 8-32 or M4 cap screws for post mounting are included with each laser system.

Back Panel of the NPL41B, NPL45B, NPL49B, NPL52B, and NPL64B

Back Panel of the NPL64A



Typical Pulses for the NPL52B and NPL64B

Specifications

Item #	Center Wavelength[b]	Pulse Width[a]	Pulse Energy	Peak Power	Average Power	Max Rep. Rate	Internal Trigger
NPL64A	640 nm	10 ns	0.12 nJ	13 mW	1.2 mW	10 MHz	No
NPL41B	405 nm	6 to 38 ns	1.5 nJ	38 mW	15 mW	10 MHz	Yes
NPL45B	450 nm	5 to 39 ns	3 nJ	75 mW	30 mW		
NPL49B	488 nm	6 to 39 ns	2 nJ	50 mW	20 mW		
NPL52B	520 nm	5 to 39 ns	1.2 nJ	30 mW	12 mW		
NPL64B	640 nm	5 to 39 ns	2 nJ	50 mW	20 mW		
NPL41C	405 nm	6 to 129 ns	128 nJ	1000 mW	6.4 mW	50 kHz	No
NPL45C	450 nm		204 nJ	1600 mW	10.2 mW		
NPL52C	520 nm		186 nJ	1500 mW	9.3 mW		
NPL64C	640 nm		126 nJ	1000 mW	6.3 mW		

a. The maximum supported edge transition time is 1 ms.
b. Average power depends on repetition rate, pulse width, and the diode's peak pulse output power. Some short duration pulses do not reach maximum peak pulse power and therefore have reduced average output powers.
c. Typical maxima for pulses that reach maximum output power; some short duration pulses will not reach the maximum peak power.

Variable Optical Attenuators

Electronic VOAs with Power Monitoring

Thorlabs' in-line, fiber-coupled Variable Optical Attenuators (VOAs) provide up to 25 dB attenuation for wavelengths from 1250 to 1610 nm. These units accept input powers up to 200 mW, and the output power, reported on the digital display, can be continuously tuned using the large rotary knob or modulated up to 1kHz via external voltage control. The Power Monitoring feature automatically stabilizes the optical output power when the Lock button is pressed. This mode has a bandwidth of 1 Hz, making it ideal for correcting slow drifts that occur over long-term measurements.

Our EVOAs are powered by a Li-ion battery that typically lasts up to 300 hours from a full charge. This battery can be recharged using a mini-USB connector or the included 5 V power adapter. The EVOAs ship factory calibrated at two wavelengths, and the user can also calibrate them at any wavelength over the operating range. They are available with either FC/PC or FC/APC connectors.

EVOA1550F
1250 - 1625 nm, FC/PC

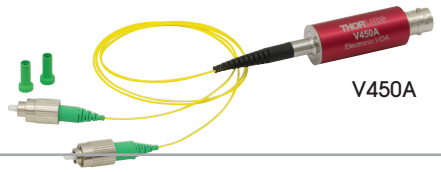
Specifications

Item #	Fiber Connectors	Wavelength Range	Attenuation	Input Power	Return Loss	External Modulation Frequency	Battery Life	Operating Temperature
EVOA800A	FC/APC	780 nm - 980 nm	1.5 dB (Typical Min) >25 dB (Max)	200 mW (Max)	≥40 dB	DC to 1 kHz	300 h (Typical) from Full Charge	10 to 40 °C
EVOA800F	FC/PC							
EVOA1550A	FC/APC	1250 nm - 1625 nm						
ECOA1550F	FC/PC							

Voltage-Controlled Electronic VOAs for Systems

- MEMS-Based Control of Optical Power
- Control Voltage Range: 0 to 5 V
- Modulation up to 1 kHz
- Input Protected from Electrostatic Discharge
- Input Optical Power up to 100 mW
- Units with Single Mode or Polarization Maintaining Fiber Available

Thorlabs' Fiber-Coupled Electronic VOAs are Micro-Electro-Mechanical System (MEMS) based devices that provide attenuation up to >30 dB or >25 dB, depending on the model. Driving voltages of 0 to 5 V control optical transmission, which decreases with applied voltage. These electronic VOAs use a BNC cable to connect with most voltage sources, including power supplies, function generators, and digital-to-analog converters.



V450A

Specifications

Item #	Fiber Type	Wavelength Range	Attenuation		Bandwidth	Optical Return Loss	Connectors
			Max	Min			
V450A	SM	450 - 600 nm	>30 dB	2.5 dB	DC - 1 kHz	>30 dB	FC/APC
V450F							FC/PC
V600A		600 - 780 nm					FC/APC
V600F							FC/PC
V800A		780 - 980 nm		2.0 dB			FC/APC
V800F							FC/PC
V1000A		980 - 1250 nm					FC/APC
V1000F							FC/PC
V1550A		1250 - 1650 nm	>25 dB	1.5 dB			FC/APC
V1550F							FC/PC
V450PA	PM	450 - 635 nm	>30 dB	2.5 dB	DC - 1 kHz	>30 dB	FC/APC
V600PA		620 - 850 nm					
V800PA		770 - 1100 nm		2.0 dB			
V1000PA		970 - 1550 nm					
V1550PA		1450 - 1610 nm	>25 dB	1.5 dB			

Complementary Components

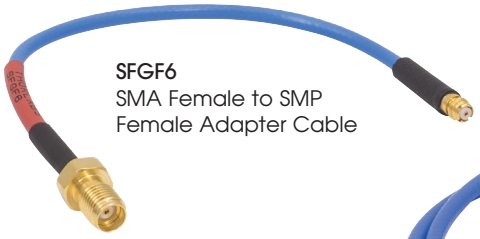
Premium Microwave Cables

Thorlabs' flexible and high-performance microwave cables include a variety of connector types and are designed to serve applications up to 50 GHz. They exhibit low voltage standing wave ratios (VSWR) and low insertion loss over the usable frequency range.

TMKM4
2.92 mm Male to 2.4 mm Male Adapter Cable

Cables with Male Connectors

- SMA Cable Lengths from 3" to 120"
- 2.4 mm Cable Lengths from 4" to 36"
- 2.92 mm Cable Lengths from 4" to 72"
- SMP Cables of 3" or 6"



SFGF6
SMA Female to SMP Female Adapter Cable

Adapter Cables 3" to 6" in Length

- Female SMP Connectors to Any-Gender SMA Connectors
- 2.92 mm and 2.4 mm Connectors: All Gender Combinations

KMM24
2.92 mm Male Cable

Microwave Adapters

Our Microwave Cable Adapters include in-series as well as between-series adapters for all gender combinations of 2.92 mm and 2.4 mm connectors.

TMKM
2.4 mm Male to 2.92 mm Male

TMM
2.4 mm Male to Male

TFKM
2.4 mm Female to 2.92 mm Male

KMF
2.92 mm Male to Female

KFF
2.92 mm Female to Female

Calibrated Torque Wrench

Ideal for mating two coaxial connectors, our 5/16" torque wrenches use a break-over design to apply the preset torque.

TQW8A:
8 in-lbs Preset Torque

- 3.5 mm Connectors
- 2.92 mm Connectors
- 2.4 mm Connectors
- 1.85 mm Connectors
- K and V Connectors

TQW5A:
5 in-lbs Preset Torque

- Most SMA Connectors

The break-over design of the callibrated torque wrench applies preset torque.

Fiber Index Matching Block

Our FOBH Fiber Index Matching Block uses a dry optical gel that is index matched (n = 1.46) to the core of standard optical fiber. Reflections from the end of single mode fiber are reduced to at least -50 dB (@ 1550 nm) in most cases .

Custom Capabilities and OEM Applications

Design, Manufacturing, and Testing Capabilities

Key Capabilities

- Detector and Receiver Design up to 70 GHz
- Fiber Optic Transmitter Design up to 70 GHz
- RF & Microwave Design and Simulation
- High-Speed Testing up to 70 GHz
- Micro-Assembly and Wire Bonding
- Hermetic Sealing of Microwave Modules
- Custom Laser Engraving
- Qualification Testing

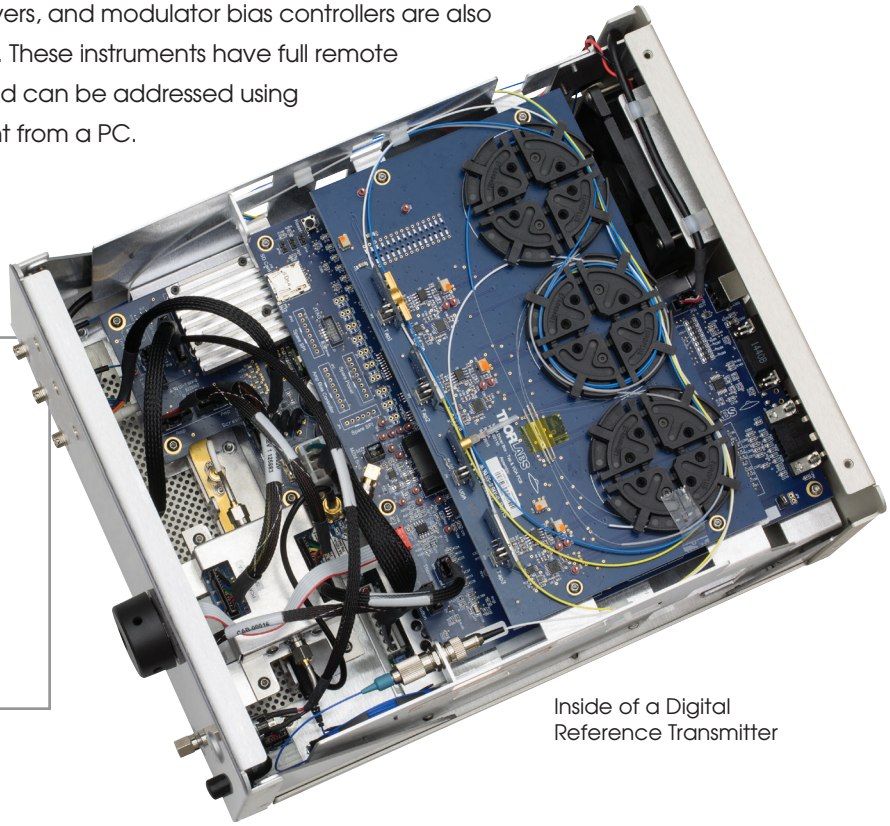
Thorlabs' Ultrafast Optoelectronics Team designs, develops, and manufactures high-speed components and instrumentation for a variety of photonics applications having frequency responses up to 70 GHz. Our extensive experience in high-speed photonics is supported by core expertise in RF/microwave design, optics, fiber optics, optomechanical design, and mixed-signal electronics. Our catalog and custom products include a range of integrated fiber-optic transmitters, modulator drivers and controllers, detectors, receivers, pulsed lasers, variable optical attenuators, and a variety of accessories. Beyond these products, we welcome opportunities to design and produce custom and OEM products that fall within our range of capabilities and expertise.

Electronic VOA with Power Lock

Fiber Optic Instruments

Fiber optic instruments incorporate a variety of optical components integrated with electrical, mechanical, and firmware features necessary to produce a complete system suitable for laboratory use. Complexity ranges from simpler devices like the electronic variable optical attenuator (EVOA) product line, to fully integrated, high-speed transmitters that offer both analog and digital versions operating out to 40 GHz.

Our complete transmitters each include a tunable laser, a modulator with driver amplifier and bias controller, full control of optical output power, and an intuitive touchscreen interface. Tunable lasers, modulator drivers, and modulator bias controllers are also available separately. These instruments have full remote control capability and can be addressed using serial commands sent from a PC.



Inside of a Digital Reference Transmitter

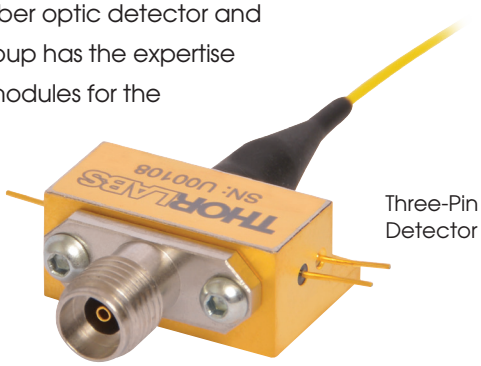
Options

- Fixed and Tunable Laser Sources
- Modulator Drivers and Bias Controllers
- Variety of Operating Wavelengths and Fiber Types
- Digital and Analog Amplifiers at Various Bandwidths

Fiber Optic Detector and Receiver Components

At the component level, we specialize in hermetically sealed, high-speed, fiber optic detector and receiver modules with performance currently ranging out to 50 GHz. Our group has the expertise and capability to design, develop, qualify, and produce a wide variety of modules for the instrumentation market.

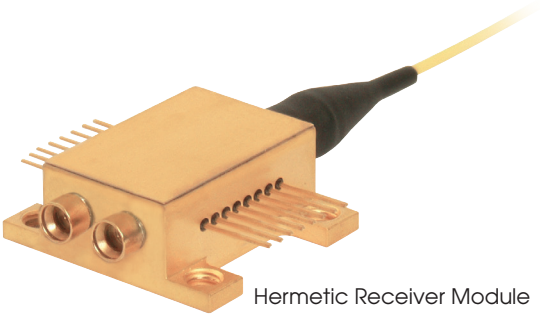
Detectors (photodiode only) are currently offered in the industry standard 3-pin module with coaxial output. Receivers (photodiode plus transimpedance amplifier) are available in our standard 16-pin, dual GPPO output package. A large variety of photodiodes and amplifiers are available to create many standard and custom products. Other types of packages are also available on a custom basis.



Three-Pin Hermetic Detector Module

Options

- Photodiodes and Amplifiers up to 50 GHz
- Custom Packages and Connectors
- Single Mode and Multimode Fibers
- Time or Frequency Domain Response


Hermetic Receiver Module

Free-Space Products

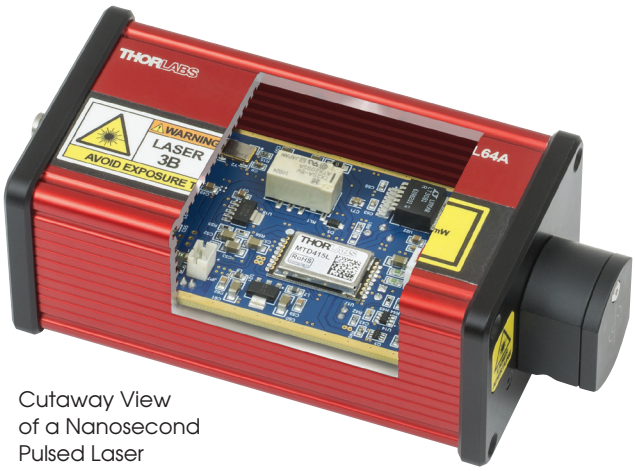
Free-space products include devices such as nanosecond pulsed lasers (NPL series) and amplified photodetectors (PDA series) operating in the sub-GHz regime. These items are designed for use with free-space optical beams where fiber optic coupling is not required.

Nanosecond Pulsed Lasers typically generate pulses in the 5 - 35 ns range with a range of models at different wavelengths and optical output powers. User-adjustable repetition rates and trigger in/out signals provide additional flexibility, and electronic delay-line products enable experimental synchronization of multiple lasers. Gain-switching capability is also possible for the generation of pulses in the 100 ps range.

Our amplified photodetectors are based on the use of a hermetically sealed photodiode coupled to a very high gain linear amplifer for the most sensitive applications at these speeds. The user has complete flexibility in how the optical signal is focused into the photodiode.

Options

- Nanosecond Pulsed Lasers
  - Pulse Duration and Repetition Rate
  - Power and Wavelength
  - Electronic Delay Lines for Synchronization
- Amplified Photodetectors
  - Bandwidth
  - Wavelength
  - Gain



Cutaway View of a Nanosecond Pulsed Laser

Amplified Detector

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