Lithium Niobate Fiber Optical Modulator

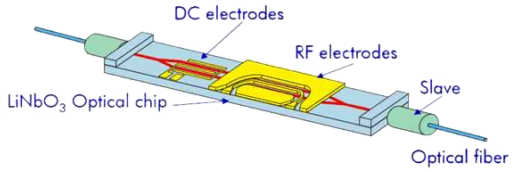
40 GHz, 7V, bias control option

DATASHEET | Return to the Webpage



The LNML is a Lithium Niobate Mach–Zehnder optical intensity modulator that uses a push-pull, traveling-wave electrode structure to provide high-speed, low-drive-voltage modulation in the C-band, and it incorporates an internal bias control section with a micro-heater and built-in optical power monitor photodiode for precise bias point adjustment and long-term stability; an optional automatic bias control (ABC) version is available in which the device is mounted on a PCB and delivered fully tested with a slow-feedback stabilization circuit to eliminate DC drift, and compatible single-stage 17 dB (5 V) or dual-stage 40 dB (8 V) RF driver amplifiers can be used to achieve the required modulation voltage for >20GHz for telecom-grade performance.

The device is based on traveling push-pull waveguide electrode design. We offer mounting the device on an automatic bias control PCB option for convenient application.



Features

- Low Voltage
- Bias Control
- Feedback

Applications

- Laboratory Uses
- Concept Proving
- Instrumentation

Warning: The photodetector pins are highly sensitive to electrostatic discharge (ESD). Extreme caution must be exercised during handling to prevent permanent damage.

Note: Without bias controller, the device will not function properly.

Note: This component is intended for OEM system integration and is not designed for standalone laboratory use. Units supplied without a protective benchtop enclosure are provided without warranty, as they are susceptible to damage from improper handling, installation, or operation.

Specifications

Parameter		Min	Typical	Max	Unit
Operation Wavelength	C band	1530		1570	nm
	L band	1570		1610	
Insertion Loss				8.0	dB
Return Loss		30			dB
Extinction Ratio [1]		20			dB
Optical Input Power				50	mW
Driver Voltage (Vπ)	At low frequency			3.5	V
	At 43 Gb/s			7	
Vπ at DC port				10	V
Bandwidth (3dB down relative to 1.5GHz, Small-signal 5% smoothing)		25			GHz
S11 (130MHz to 10 GHz)	130MHz < f < 30GHz	10			dB
	30GHz < f < 40GHz	6			
RF Port Resistance (DC)			50		Ω
RF Voltage at RF Inputs				10	V
Bias Voltage Range		-30		30	V
Responsivity (RmAC) (Monitor PD)		1			mA/W
Bias Shift (Monitor PD)				6	dB
Photodetector Bandwidth			100		kHz
Operating Temperature		-5		75	°C
Storage Temperature		-40		85	°C

Note: Applying over the maximum RF control voltage or optical power will burn the device. Only the protected benchtop package has warranty.

RoHS COMPLIANT

ATTENTION
OBSERVE PRECAUTIONS FOR HANDLING ELECTROSTATIC SENSITIVE DEVICES

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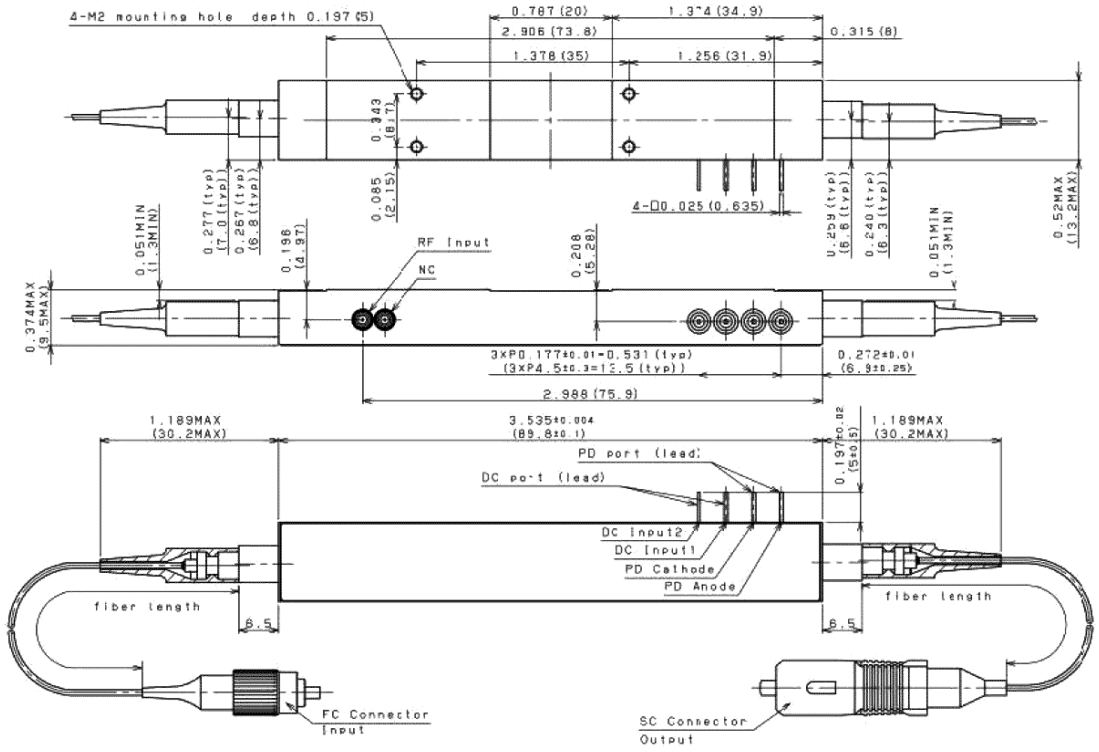
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Dimensions (unit: mm – tolerance: 0.2)



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Instruction for Comprehensive Characterization Procedure for $LiNbO_3$ Modulator

1. Initial Setup and Inspection

- **Visual inspection**: Check for fiber integrity, waveguide cleanness, electrode contacts.
- **Connector integrity**: Inspect RF and optical connectors for damage or debris.
- **Polish & clean fibers**: Use fiber scope and fiber wipes if necessary.
- **Thermal stabilization**: Place the device on a temperature-controlled stage (if needed).

2. Electrical & RF Interface Check

- Measure **RF return loss (S11)** using a VNA.
- Confirm **50 Ω impedance matching** across the modulator's bandwidth.
- Verify the **bias-T (if present)** does not short or distort the signal.
- Check for **electrode continuity** and isolation between electrodes.

3. Optical Characterization

a. Insertion Loss

- Use a narrow-linewidth laser (e.g., at 1550 nm).
- Launch light into input fiber and measure output power.
- Insertion Loss = 10·log(Pin / Pout)
  (Typical $LiNbO_3$ insertion loss: 3–7 dB)s.

b. Extinction Ratio (for MZIs)

- Apply DC voltage sweep to modulation electrodes.
- Record maximum and minimum output powers.
- ER = 10·log(Pmax / Pmin)
  (Good ER: >20 dB for analog, >30 dB for digital).

c. Vπ Measurement (Half-wave voltage)

- Apply a slowly varying triangular or sinusoidal voltage.
- Measure output optical power vs. voltage.
- Determine Vπ = voltage required to induce a π phase shift (first null).
- Also check **Vπ·L** product (performance metric).

4. Electrical & RF Interface Check

- Connect modulator RF input to a signal generator or VNA (S21 test).
- Bias the MZI at quadrature (linear point of transfer curve).
- Apply RF sweep from 100 kHz to >20 GHz (or device limit).
- Use a fast photodiode and spectrum analyzer or VNA.
- Record **modulation response (S21)**:
  - Bandwidth = −3 dB point from peak response.
  - Watch for peaking or drop-offs due to impedance mismatch or piezoelectric resonances.

5. Linearity Tests (for Analog Applications)

- Use two-tone RF input (e.g., f1 = 10 GHz, f2 = 10.01 GHz).
- Measure intermodulation distortion (IMD3).
- Calculate **Spurious-Free Dynamic Range (SFDR).**

6. Bias Drift / Stability Testing

- Apply DC bias and monitor optical output over time.
- Check for **DC drift**, typically caused by photorefractive or charge trapping effects.
- Test under light-on and light-off conditions.
- Optional: Integrate **auto-bias control loop**.

7. Thermal Response (Optional)

- Vary modulator temperature (e.g., from 20°C to 70°C).
- Track **Vπ, insertion loss, and ER** as a function of temperature.
- Identify thermal sensitivity and hysteresis.
- Important for packaged systems or field deployments.

8. High-Power Handling & Backreflection

- Gradually increase optical input power (with isolator).
- Watch for power-induced drift or photorefractive effects.
- Check backreflections using an **optical return loss meter (ORL).**

9. Data Logging and Reporting

- Capture all test data in a structured format.
- Plot:
  - Optical power vs. voltage (transfer function)
  - S21 vs. frequency
  - Vπ vs. temperature
  - Drift vs. time
- Include tables for:
  - Insertion loss
  - ER
  - Vπ and bandwidth
  - Bias stability
  - RF return loss

Optional Advanced Tests:

- **Jitter analysis** (for digital modulators)
- **Bit Error Rate Testing (BERT)** for NRZ or PAM signals
- **Eye diagram measurements**
- **Pulse response and rise/fall time**
- **Photorefractive damage threshold test**

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Device Mounted On Automatic Bias Controller



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Ordering Information (Part Number)

	☐	☐	☐	☐	4	5	☐	☐	☐	☐	☐
Prefix	**Configuration**	**Bias Control**	**RF Driver**	**Wavelength**	**Frequency**	**Input Fiber**	**Output Fiber**	**Fiber Cover**	**Fiber Length**	**Connector [1]**	**RF Connector**
LNML-	Amplitude = 1	No = 1 Yes = 2	No = 1 7 V = 2 4.5V = 3	1530-1570nm = 1 1570-1610nm = 2	40GHz = 4	PM1550 = 5	SMF28e = 1 PM1550 = 5	0.9mm tube = 1 Special = 0	0.5m = 1 Special = 0	None = 1 FC/PC = 2 FC/APC = 3 SC/PC = 4 SC/APC = 5 ST/PC = 6 LC/APC = E LC/UPC = F FC/UPC = U Special = 0	GPPO = 1 SMA = 2

[1]. The default connector configuration uses fiber with 0.9 mm buffer protection. The connector cannot be installed directly onto bare fiber because the bare fiber is prone to damage during shipping. However, the connector can be assembled on bare fiber if a 3 cm protective loose tube is added for reinforcement. The customer may remove this protective tube after testing. The optical power handling of a standard connector is less than 0.5 W for SMF-28 fiber and decreases further for smaller-core fibers.
The default PM fiber connector is **2.0 mm narrow key, with the fiber slow axis aligned to the key**.

Performances

Application Notes

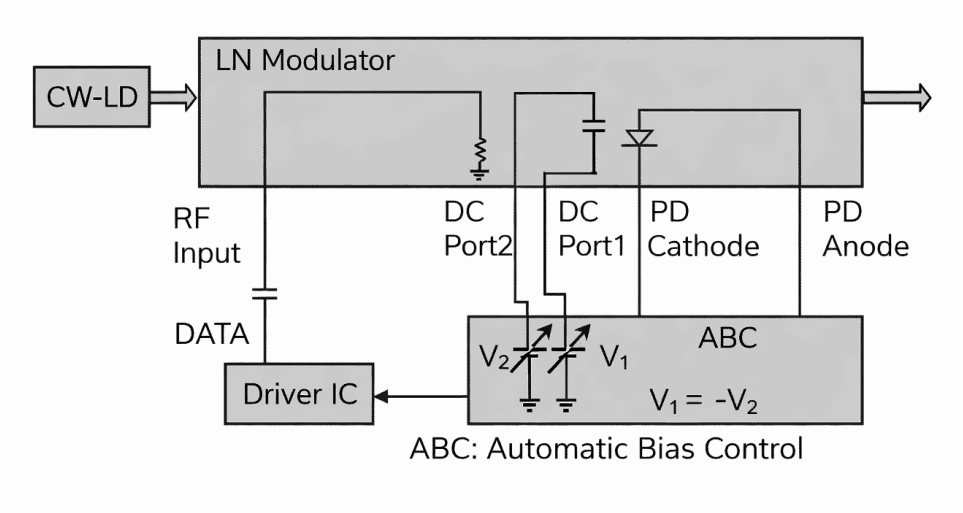
Fiber Core Alignment
Note that the minimum attenuation for these devices depends on excellent core-to-core alignment when the connectors are mated. This is crucial for shorter wavelengths with smaller fiber core diameters that can increase the loss of many decibels above the specification if they are not perfectly aligned. Different vendors' connectors may not mate well with each other, especially for angled APC.

Fiber Cleanliness
Fibers with smaller core diameters (<5 μm) must be kept extremely clean, contamination at fiber-fiber interfaces, combined with the high optical power density, can lead to significant optical damage. This type of damage usually requires re-polishing or replacement of the connector.

Maximum Optical Input Power
Due to their small fiber core diameters for short wavelength and high photon energies, the damage thresholds for device is substantially reduced than the common 1550nm fiber. To avoid damage to the exposed fiber end faces and internal components, the optical input power should never exceed 20 mW for wavelengths shorter 650nm. We produce a special version to increase the how handling by expanding the core side at the fiber ends.

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Typical Circuit



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Benchtop Integration



The EOCV Series Fiber Optical Transmitters (Electrical-to-Optical converters) deliver high-fidelity analog and digital optical signals from electrical inputs, supporting a wide operating frequency range from DC to 100 GHz. These user-friendly, turnkey benchtop modules integrate a Lithium Niobate fiber-optic modulator, a DFB laser with driver, an automatic bias controller, high-performance control electronics, and an internal DC power supply into a convenient plug-and-play unit. The front panel includes a selector switch for three modulator bias modes: Peak and Null for high on/off contrast, and Quadrature for superior linearity in electro-optic conversion. A front-panel rotary control also provides adjustable laser output power, enabling precise output optimization. A tunable laser aligned to the ITU grid is available for DWDM transmission over a single fiber. Designed for RF-over-Fiber applications and for the testing and characterization of optical-to-electrical (O-E) devices, the EOCV Series offers a versatile, stable, and reliable solution for advanced optical communication and signal-processing requirements.

Ordering Information (Part Number)

	☐	☐☐☐☐☐	☐	3	☐	☐
Prefix	**RF Frequency**	**Laser Wavelength***	**Tunable Laser****	**Package**	**RF Amplifier**	**Fiber Connector** [1]
EOCV-	10GHz = 1 20GHz = 2 35GHz = 3 40GHz = 4 50GHz = 5 70GHz = 7 90GHz = 9	1550 nm = 15500 1551.11 nm = 55111 1562.22 nm = 56222 Special = 00000	None = 1 Yes = 2	Benchtop = 3 Special = 0	14dBm gain = 1 Non = 2 Special = 0	FC/APC = 2 FC/UPC = U Special = 0

Note:

* Laser on the ITU grid can be selected

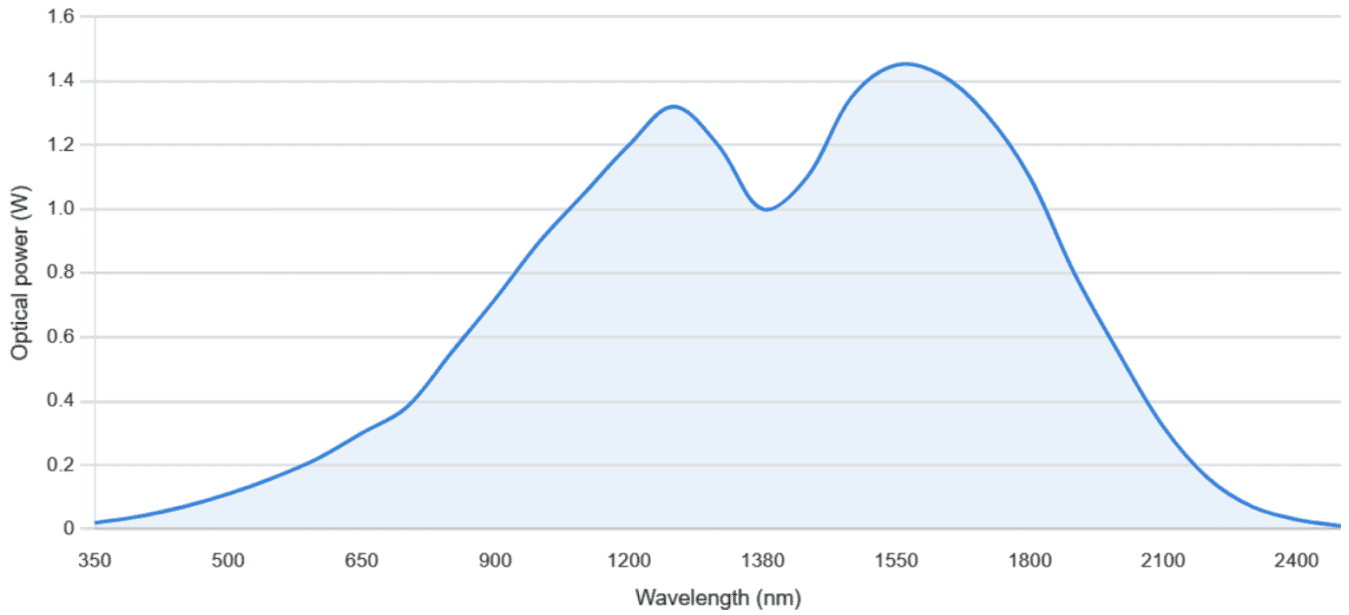
** Tunable laser with locking on ITU capability

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Regular Single Mode / Polarization Maintaining Fiber Optical Power Handing vs Wavelength



Single mode fiber optical power is limited by nonlinear effects in addition to absorption that increase loss and generate heat. The curve shows the approximate safe CW power envelope for standard single-mode fiber. Actual limits depend on fiber design, core size, length, and laser characteristics. Specialty fibers can significantly increase the power limit.

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