

Lithium Niobate Fiber Optical Modulator

(25 GHz, 3.5V, bias control option)



DATASHEET

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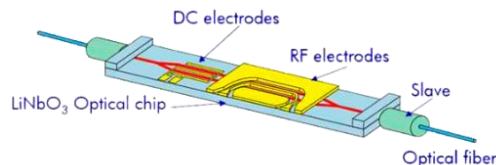
Features

- Low Voltage
- Bias Control
- Feedback

Applications

- Laboratory Uses
- Concept Proving
- Instrumentation

This series of Lithium Niobate (LiNbO₃) fiber optic modulators employs a Mach-Zehnder interferometer structure for optical power modulation with low drive voltage, utilizing a traveling push-pull waveguide electrode design. Each Z-cut device integrates a bias control section featuring a built-in micro-heater and an optical power monitor, enabling precise bias adjustment while monitoring output intensity for optimal performance. To compensate for DC drift and maintain the optimal bias point, an optional automatic bias control (ABC) version is available; when selected, the modulator is mounted on a PCB and fully tested prior to delivery. Additionally, a push-pull configuration is available that features two RF driving inputs to achieve zero-chirp operation when driven at a 180° phase difference.



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

Note: Without a 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	1520		1605	nm
Insertion Loss	4	4.5	7 [2]	dB
Return Loss	40			dB
Extinction Ratio [1]	16 (H frequency)	20 (H-F)	27 (L frequency)	dB
Optical Input Power			20	mW
RF V _π Voltage	1 kHz	3.5		V
	12 GHz	5		
	22 GHz	8		
Bandwidth	DC	25	40	GHz
S21 (Electro-Optic Bandwidth-3dB)	23	25	30	GHz
S11 (130MHz to 10 GHz)			-10	dB
RF Port Resistance (DC)		50		Ω
RF Input Power			24	dBm
Bias Port Resistance (DC)			1	MΩ
Bias Voltage Range	-15		15	V
Photodetector Responsivity	1			mA/W
Photodetector Extinction Ratio			6	dB
Photodetector Bandwidth		100		kHz
Operating Temperature	-1		70	°C
Storage Temperature	-45		85	°C

Notes:

- [1]. With bias control
- [2]. Without connectors

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



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Rev 07/09/26

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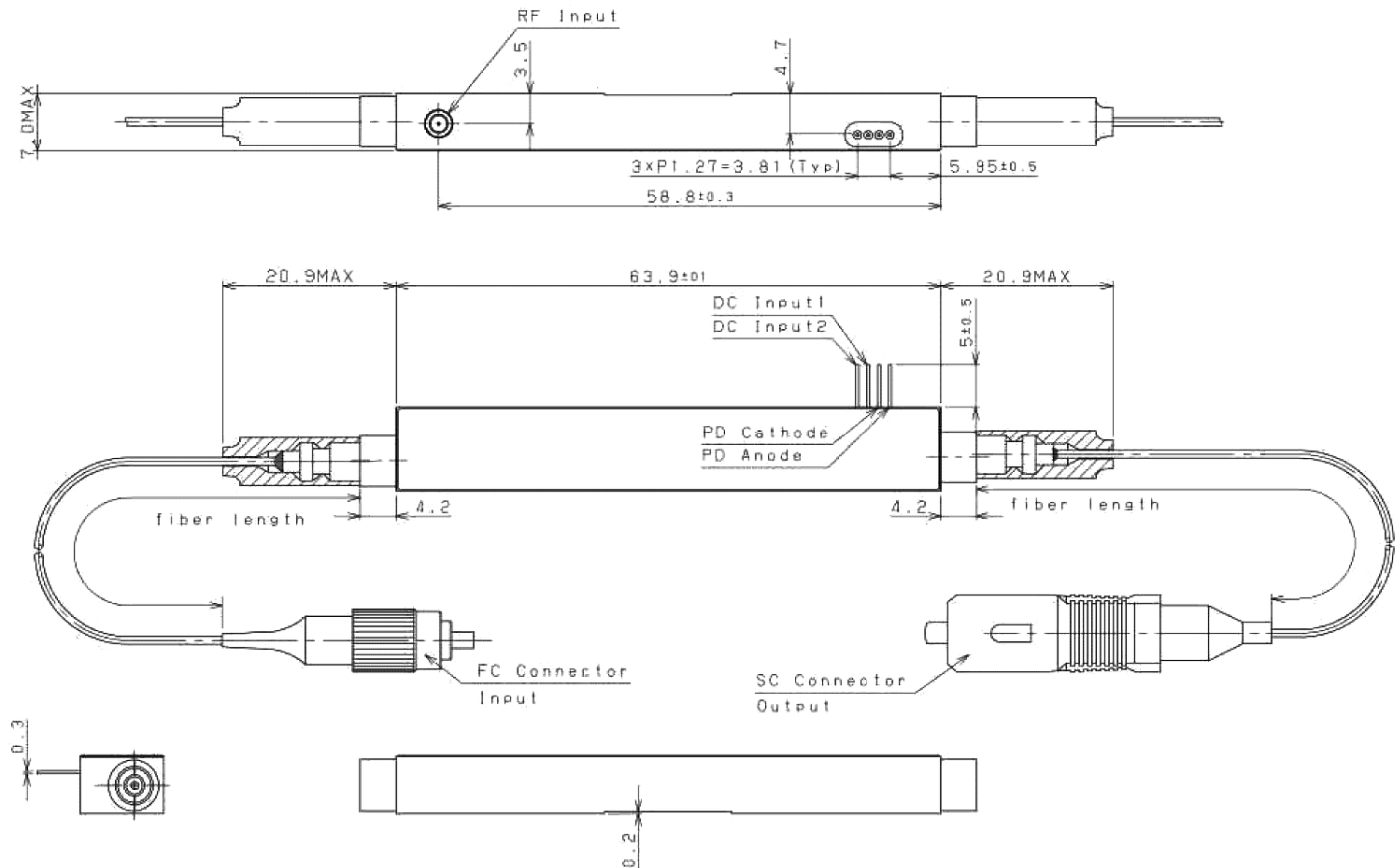
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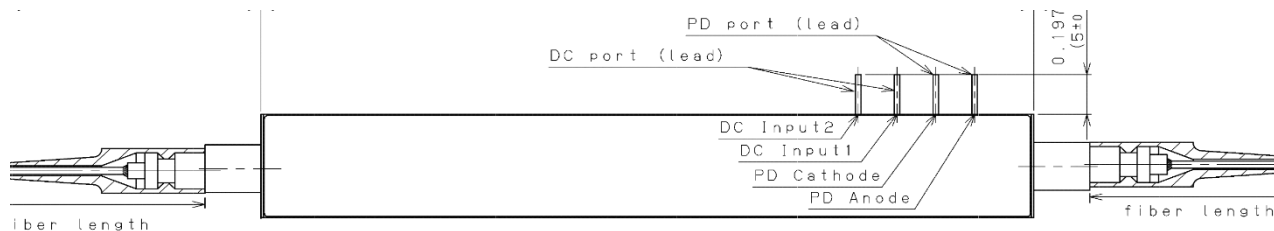
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Dimensions (unit: mm – tolerance: 0.2)



*Product dimensions may change without notice. This is sometimes required for non-standard specifications.

Electrical Connection (RF Input via SMA)



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Instruction for Comprehensive Characterization Procedure for LiNbO₃ 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 = $10 \cdot \log(P_{in} / P_{out})$
(Typical LiNbO₃ insertion loss: 3–7 dB).

b. Extinction Ratio (for MZIs)

- Apply DC voltage sweep to modulation electrodes.
- Record maximum and minimum output powers.
- $ER = 10 \cdot \log(P_{max} / P_{min})$
(Good ER: >20 dB for analog, >30 dB for digital).

c. V π Measurement (Half-wave voltage)

- Apply a slowly varying triangular or sinusoidal voltage.
- Measure output optical power vs. voltage.
- Determine V π = voltage required to induce a π phase shift (first null).
- Also check **V π -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 **V π , 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
 - V π vs. temperature
 - Drift vs. time
- Include tables for:
 - Insertion loss
 - ER
 - V π 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**

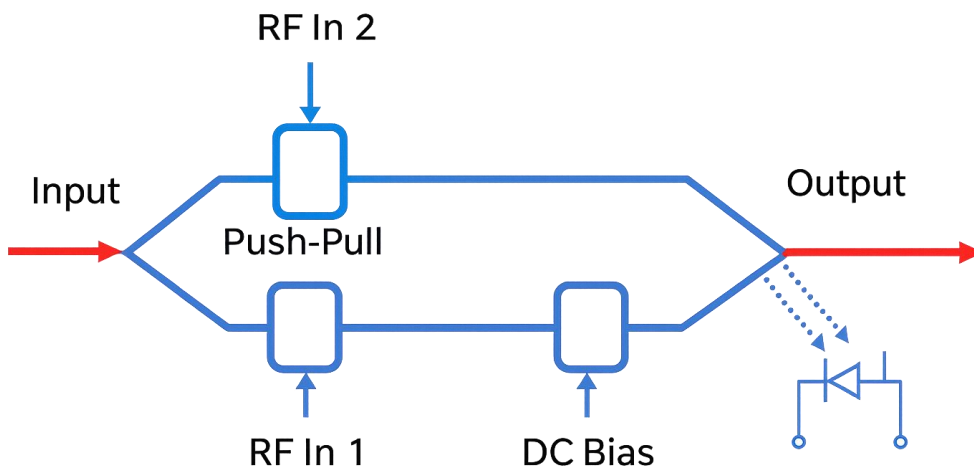
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Push –Pull Function Diagram



Device Mounted On Automatic Bias Controller



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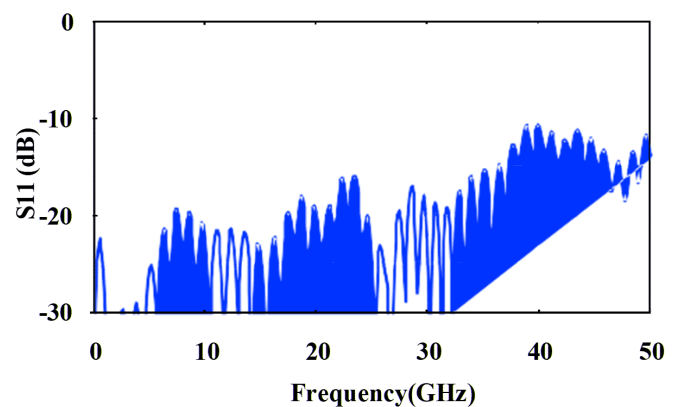
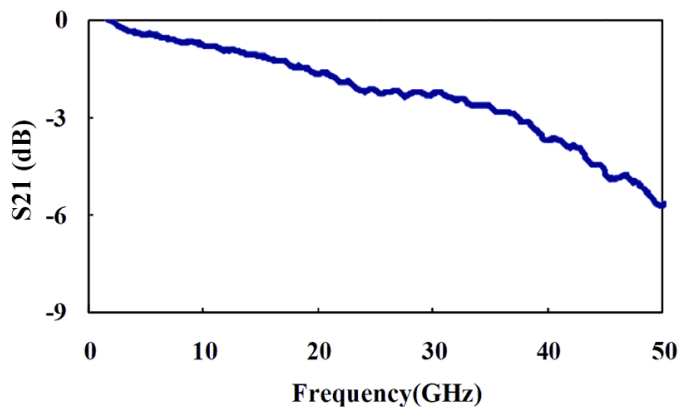
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Ordering Information (Part Number)

	☐	☐	☐	☐	☐	3	5	5	☐	☐	☐	☐
Prefix	Type	RF Input	Bias Controller	RF Driver	Wavelength	Frequency	Input Fiber	Output Fiber	Fiber Cover	Fiber Length	Connector ^[1]	RF Connector
LNML-	Amplitude = 1	Single = 1 Dual = 2	Non = 1 Yes = 2	Non = 1 4V = 2 8V = 3	1520-1620nm = 2	25GHz = 3	PM1550 = 5	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.

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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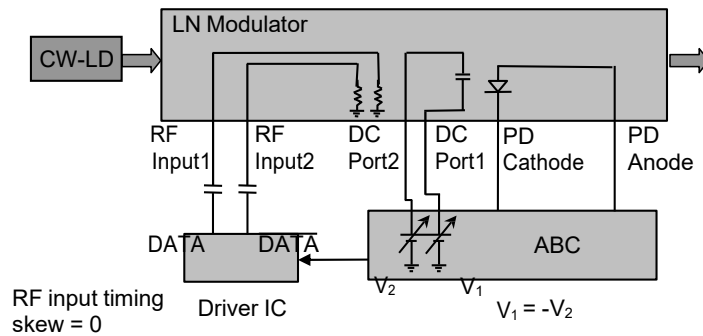
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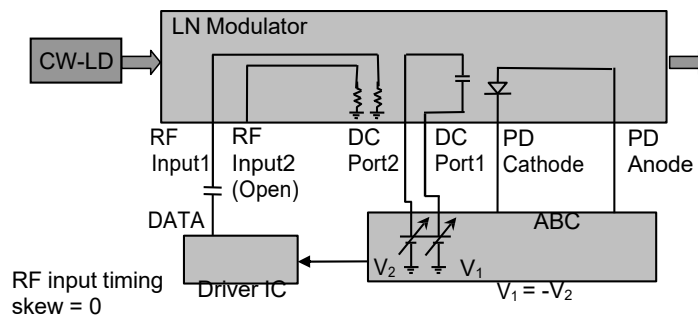
Typical Circuit

Typical Circuit for Dual-drive



ABC: Automatic Bias Control

Typical Circuit for Single-drive



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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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