Test Methods for Key Specifications of $LiNbO_3$ Electro-Optic Intensity Modulator

(OE-EOM-FAM Series)

Contents

1. Insertion Loss (IL)

Definition:
Insertion loss is the total optical power loss caused by inserting a device into an optical fiber system. It is expressed as the ratio (in dB) of the output optical power with the device inserted to that without the device, under specified operating conditions.
Since the initial operating point of the intensity modulator is not necessarily at the maximum transmission point, the bias voltage must be adjusted to the maximum point before measurement.

1.1 Test Block Diagram

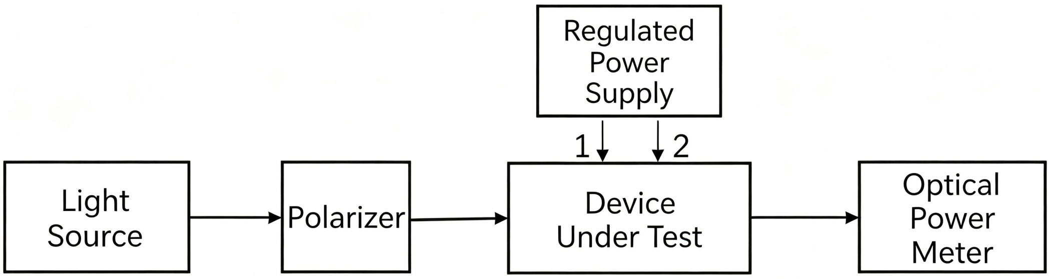

Figure 1 Block diagram of the test setup for insertion loss

1.2 Test Procedure

a) Connect the light source and polarizer, turn on the source, and measure the input optical power P_i to the DUT using an optical power meter.
b) Insert the DUT into the test system. Connect the output terminals of a DC power supply to the modulator pins: pin 1 (GND) and pin 2 (Bias).
c) Adjust the DC supply voltage until the optical power meter reading reaches its maximum. Record this reading as (P_{out})
d) Calculate the insertion loss using Equation (1):

$$IL=10lg(P_i/P_out) \tag{1}$$

1.3 Test Notes

- The test source should be a broadband depolarized source.
- The polarization direction of the input light must align with the operating axis of the modulator.
- A smaller voltage step on the DC supply gives higher measurement accuracy.

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2. Switch Extinction Ratio (ER@DC)

Definition:
The extinction ratio is the ratio of the maximum output optical power to the minimum output optical power when the modulator is driven by a voltage. It is expressed in dB.

2.1 Test Block Diagram

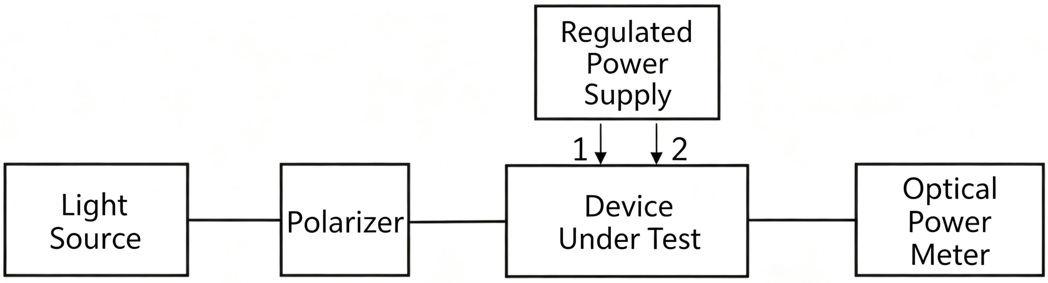

Figure 2 Block diagram of the test setup for polarization extinction ratio

2.2 Test Procedure

a) Connect the light source and polarizer, and turn on the source.
b) Insert the DUT and connect the DC supply to pins 1 (GND) and 2 (Bias).
c) Adjust the DC voltage and record the maximum power reading (P_{max}) and the minimum reading (P_{min}) on the optical power meter.
d) Calculate the extinction ratio using Equation (2):

$$ER=10\lg\left(\frac{P_{max}}{P_{min}}\right) \quad (2)$$

2.3 Test Notes

Same as Section 1.3 – broadband depolarized source, polarization alignment, and fine voltage steps are required.

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3. Half-wave Voltage (Vπ)

Definition:
The half-wave voltage is the applied modulation voltage required to produce a 180° phase shift of the optical signal at a specified wavelength and modulation frequency.

3.1 Test Block Diagram

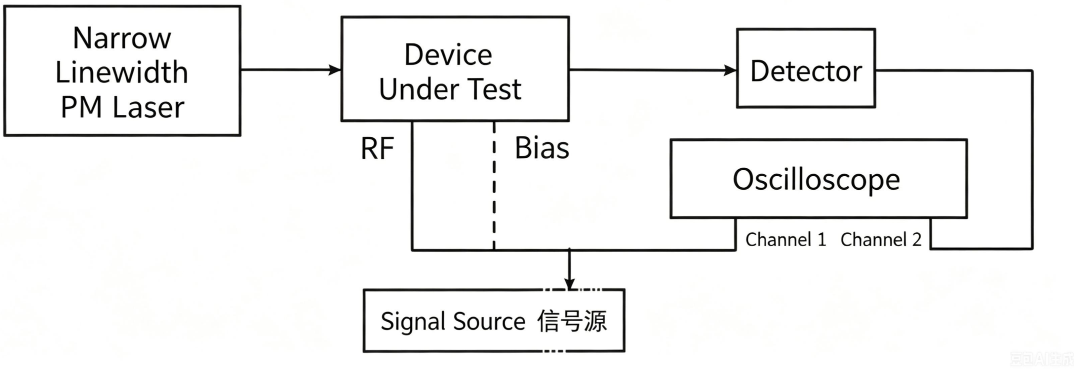

Figure 3-1 Block diagram of the test setup for half-wave voltage of the intensity modulator

3.2 Test Procedure

a) Take the RF-port Vπ as an example. Connect the system as shown in Figure 3: the signal generator, the DUT RF port, and oscilloscope Channel 1 are connected via a tee. For measuring the Bias-port Vπ, follow the dashed connection.

b) Turn on the light source and signal generator. Apply a sawtooth signal at a typical frequency of 1 kHz to the DUT. The sawtooth peak-to-peak voltage(V_{pp}) should be greater than twice the expected half-wave voltage, so that the detector output (cosine wave) shows at least one full period, as illustrated in Figure 3-2.

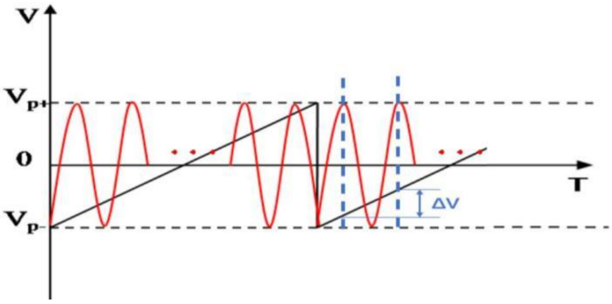

Figure 3-2 Schematic diagram of the detector output signal

c) Turn on the oscilloscope.

d) The detector output is a cosine waveform. Record the sawtooth voltage values(V_1) and(V_2) corresponding to two adjacent peaks of the cosine signal. The difference is (ΔV=$|V_1-V_2|$).

e) Calculate the half-wave voltage using Equation (3):

$$V_{pi}=\frac{|v_1-v_2|}{2} \tag{3}$$

3.3 Precautions

- Set the oscilloscope input to high impedance mode.

- The sawtooth(V_{pp})must not exceed the modulator's maximum allowable input voltage range.

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4. 3-dB Bandwidth (S21)

Definition:
The 3-dB bandwidth characterizes the operating frequency range of the device. It is the frequency range over which the device's frequency response curve drops by 3 dB from its maximum value.

4.1 Test Block Diagram

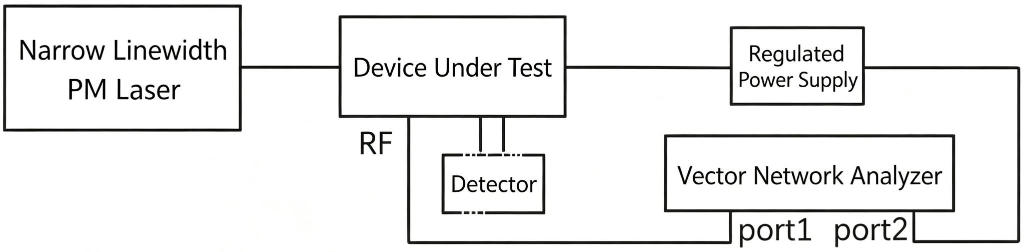

Figure 4 Block diagram of the test setup for bandwidth (S21)

4.2 Test Procedure

a) Connect the system as shown in Figure 4.
b) Preset and calibrate the Vector Network Analyzer (VNA).
c) Use the VNA to apply a modulated signal over the specified frequency range to the DUT.
d) Turn on the light source and adjust the bias voltage to stabilize the modulator at its linear operating point. Read the frequency range where the electrical signal power (S21) drops by 3 dB from its maximum value. Record the S21 curve.

4.3 Test Notes

- The modulation signal amplitude should generally not exceed 10% of the device's half-wave voltage.

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5. Electrical Return Loss (S11)

Definition:
Electrical return loss is the ratio (in dB) of the reflected signal power to the incident signal power at the RF electrical port of the device.

5.1 Test Block Diagram

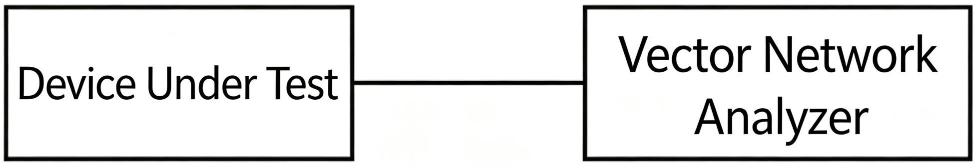

Figure 5 Block diagram of the test setup for electrical return loss (S11)

5.2 Test Procedure

a) Connect the test system as shown in Figure 5.
b) Enable the S11 measurement function on the VNA, set the frequency range, and sweep to obtain the S11 characteristic curve.
c) From the S11 curve, read the return loss value at the specified signal frequency.