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

(OE-EOM-FPM 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.

1.1 Test Block Diagram

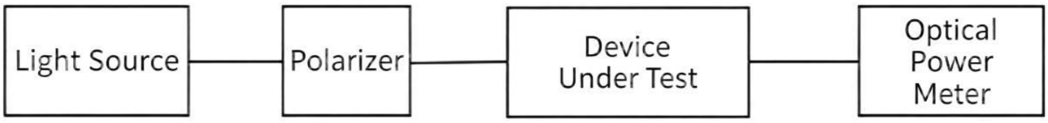

Figure 1 Block Diagram of the Test Setup for Insertion Loss

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.
c) Record the optical power reading as P_{out}.
d) Calculate the insertion loss using Equation (1):

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

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.

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2. Polarization Extinction Ratio (PER)

Definition:
The polarization extinction ratio characterizes the polarization-maintaining capability of the device. It is the ratio (in dB) of the optical power in the operating mode (typically TE mode) to that in the non-operating mode (typically TM mode) at the device output.

2.1 Test Block Diagram

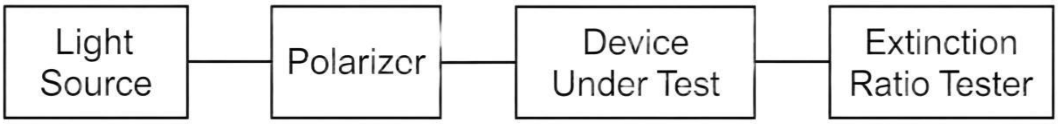

Figure 2 Block Diagram of the Test Setup for Polarization Extinction Ratio

2.2 Test Procedure

a) Connect the test system as shown in Figure 2.
b) Turn on the light source and record the PER value and angle displayed on the PER meter.

2.3 Test Notes

- The quality of the output fiber end face of the DUT significantly affects the measurement. The fiber end face should be kept perpendicular, clean, and free from bending or squeezing.

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3. Half-wave Voltage (Vπ)

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

3.1 Test Block Diagram

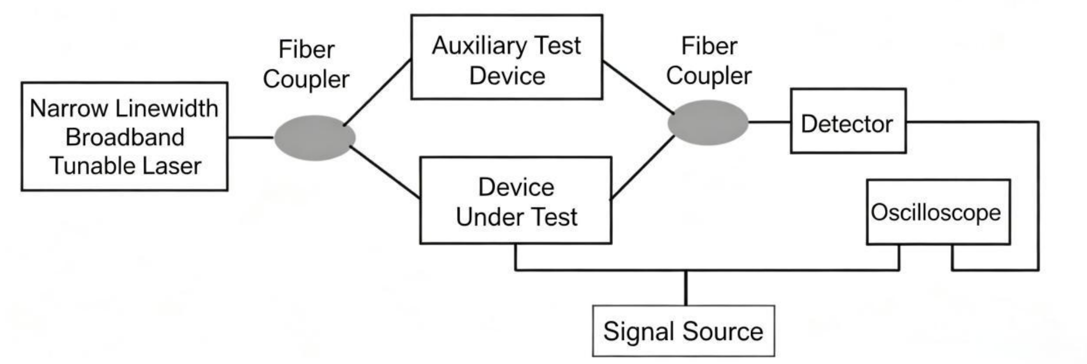

Figure 3-1 Block Diagram of the Test Setup for Half-Wave Voltage of the Phase Modulator

3.2 Test Procedure

a) Connect the test system as shown in Figure 3-1 to form an optical interferometer. The optical path difference between the two arms must be within the coherence length. Connect the signal generator, the DUT RF port, and oscilloscope Channel 1 through a tee.
b) Turn on the light source and signal generator. Apply a sawtooth signal (typical frequency: 50 kHz) to the DUT. The sawtooth peak-to-peak voltage V_{pp}, must be greater than twice the half-wave voltage, so that the detector output (cosine waveform) shows at least one full period, as illustrated in Figure 3-2.

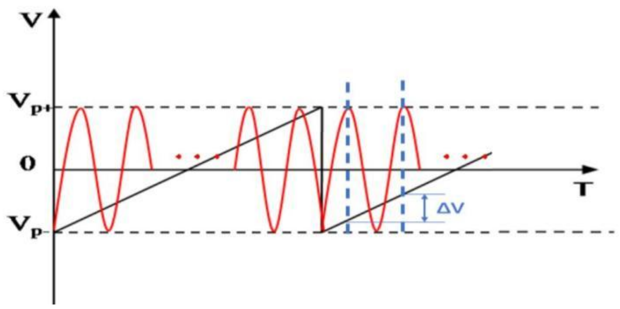

Figure 3-2 Schematic Diagram of the Detector Output Signal

c) Turn on the oscilloscope.
d) The detector output is a cosine waveform. Record the sawtooth voltage values $V_1$and V_2corresponding to two adjacent peaks of the cosine signal.
e) Calculate the half-wave voltage using Equation (2):

$$V_{pi}=\frac{|v_1-v_2|}{2} \qquad (2)$$

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 (S21) drops by 3 dB from its maximum value.

4.1 Test Block Diagram

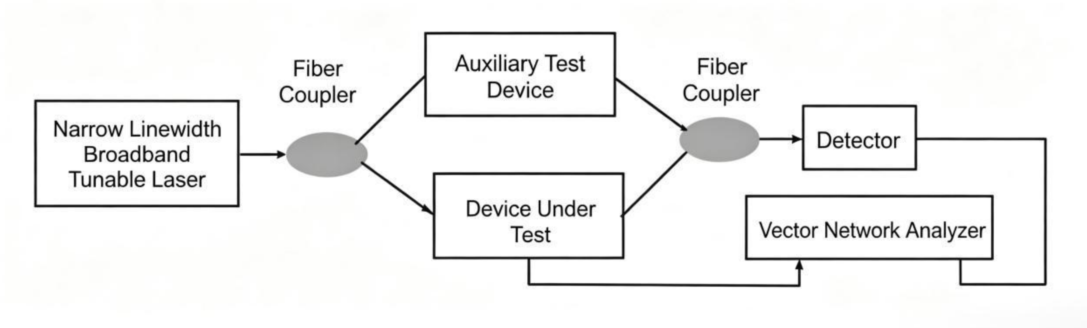

Figure 4 Block Diagram of the Test Setup for Bandwidth (S21)

4.2 Test Procedure

a) Connect the system as shown in Figure 4.
b) Turn on the light source. 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) Adjust the auxiliary phase shifter to stabilize the interferometer 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.
- The optical path difference between the two arms of the interferometer must be within the coherence length.
- If the output optical power after the interferometer is too low or cannot be stabilized at the operating point, adjust the auxiliary phase shifter to bring the interferometer to its linear operating point.

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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

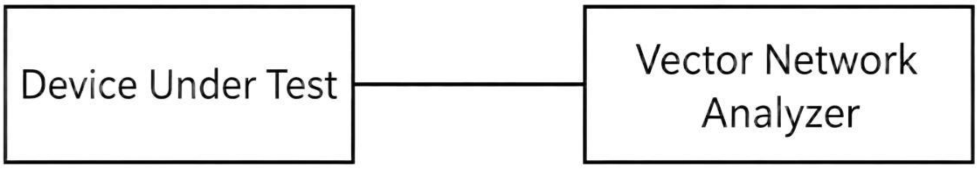

Figure 5 Block Diagram of the Test Setup for Electrical Return Loss (S11)

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.