How to Measure $V_{\pi}$ at High Frequencies

**Description**

The voltage $V_{\pi}$ needed for a phase shift of $\pi$ is an important figure of merit for the performance of an optical modulator. One method to measure $V_{\pi}$ is by analyzing the optical spectrum of the modulated. This way, one can determine $V_{\pi}$ from low to high frequencies characterizing a modulator’s bandwidth and modulation speed.

**Schematic Setup**

DUT: Device Under Test  
HF: High Frequency  
OSA: Optical Spectrum Analyzer  
TLS: Tunable Laser Source

**Working Principle**

Modulation of the optical carrier leads to a transfer of energy from the carrier to sidebands. The modulation can be calculated as the power ratio between carrier and sideband. From this, one can calculate the modulation index or phase modulation amplitude $\eta$. One can then calculate $V_{\pi}$ for a PPM, respectively a MZM as follows:

$$V_{\pi} = \frac{V_D}{\eta \pi}, \quad V_{\pi} = \frac{V_D}{2\eta \pi}$$

An ideal MZM in push-pull mode only needs half the voltage for a shift of $\pi$. Furthermore, MZM must be driven at its 3 dB point which is done by applying a constant bias voltage for a balanced MZM or by shifting the wavelength for an imbalanced MZM.

**References**


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