

High-speed optical module modulation method



Article Overview

High-speed optical modules use advanced modulation techniques such as PAM4, QAM, and Mach-Zehnder interferometer-based electro-optic modulation to achieve high data rates and bandwidth efficiency.

Modulation Principles

High-speed optical modulators convert electrical signals into optical signals by modulating the amplitude, phase, or polarization of light. The most common high-speed modulators rely on the Mach-Zehnder interferometer (MZM) or the electro-optic effect, where an input light beam is split into two arms, and an electrical signal applied to one arm changes the phase of the light, producing interference at the output to encode data. Materials like thin-film lithium niobate (TFLN) and silicon photonics are widely used due to their low loss, high bandwidth, and favorable electro-optic properties.

Advanced Modulation Formats

To increase data transmission rates, optical modules have evolved from NRZ (Non-Return-to-Zero) to PAM4 (4-level Pulse Amplitude Modulation) and higher-order QAM (Quadrature Amplitude Modulation). These formats allow multiple bits per symbol, effectively increasing the baud rate and overall data throughput without proportionally increasing the optical bandwidth. For example, PAM4 doubles the data rate compared to NRZ at the same symbol rate, while QAM can encode even more...

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