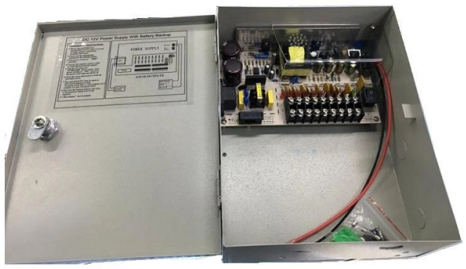
COETZER OPTICAL SYSTEMS (Pty) Ltd

AI Optical Module Structure



Overview

The Application of Optical Modules in AI TechnologyOptical modules convert electrical signals into light to move data quickly and reliably in AI XPO: Redef.

Key Takeaways

AI optical modules are compact optoelectronic devices that convert electrical signals into optical signals, integrating transmitters, receivers, driver circuits, and high-performance PCBs to support high-bandwidth, low-latency AI data center interconnects.Core Components

Optoelectronic Components: AI optical modules include transmitters (laser diodes or VCSELs) and receivers (photodetectors) that handle the conversion between electrical and optical signals, enabling high-speed data transfer across fiber optics ( ). Driver and Amplifier Circuits: Internal driver chips modulate the laser or LED based on incoming electrical signals, while transimpedance amplifiers (TIA) convert received optical signals back into electrical form ( ). Optical Interfaces: These provide the physical connection to fiber optic cables, supporting various standards such as OSFP, QSFP-DD, and emerging XPO modules for AI workloads ( ).

PCB and Substrate Design

AI optical modules require precision PCB substrates to maintain signal integrity at extremely high data rates (e.g., 56 GBaud per lane). Key design features include:

• Low-loss laminates (Dk < 3.5, Df < 0.003 at 28 GHz) for high-speed signal layers

• Hybrid stackups combining Megtron 6 or Rogers for signal layers with FR-4 or metal-core for power and thermal management

• Embedded thermal solutions like copper coin inserts to dissipate 10–15W per optical engine

• Ultra-tight impedance control (+/-5%) and precision fiducial placement (+/-10 microns) for fiber alignment ( ) These design choices ensure minimal signal loss, low crosstalk, and efficient photon coupling between silicon and fiber.

Advanced Module Architectures

Pluggable Modules: Standards like OSFP, QSFP-DD, and XPO provide high-density, field-replaceable modules. XPO modules, for example, deliver up to 12.8 Tbps per module with integrated liquid cooling and high-voltage power input to reduce current requirements ( ). Linear-drive Pluggable Optics (LPO): LPO modules remove DSPs, relying on analog drivers and TIAs to reduce latency and power consumption by 30–50%, though they require precise host-side SerDes processing ( ). Near-Packaged Optics (NPO) and Co-Packaged Optics (CPO): These architectures place optical engines close to GPUs or NPUs, minimizing electrical path length, reducing signal loss, and improving thermal management ( ).

Performance Considerations

AI optical modules are designed for:

• Extreme bandwidth (400G, 800G, 1.6T) to support GPU-to-GPU communication

• Low latency for synchronized parallel computation

• High density to optimize rack space

• Power efficiency with better watts-per-gigabit ratios than copper interconnects ( )

Thermal management, precise PCB engineering, and high-quality optical components are critical to maintain performance under the high data loads typical in AI training and inference workloads.

Summary

The structure of AI optical modules integrates optoelectronic components, driver circuits, precision PCBs, and advanced cooling/power architectures to meet the demands of modern AI data centers. Innovations like XPO, LPO, and NPO/CPO architectures enhance bandwidth, reduce latency, and improve energy efficiency, making these modules essential for scalable, high-performance AI infrastructure ( ).

Article Content

XPO: Redefining Pluggable Optics for AI Networking

This paper outlines the new requirements imposed by this AI-driven transformation and introduces a purpose-built optical

AI-Embedded Optical Modules With Millisecond-Granularity Power

To address this need, we propose an intelligent optical module for edge deployment featuring millisecond-granularity power sampling

AI Optical Module Market Size & Growth Outlook 2035

AI Optical Module Market Overview: The AI Optical Module Market Size was valued at 1,700 USD Million in 2024. The AI Optical

Emerging Optical Interconnects for AI Systems

1. Introduction Large-scale AI systems are the foundation of modern online services. As the world is recovering from COVID-19, there

Related Video Reference

This video was associated with the source search result. Verify technical details against current product documentation and project requirements.

Contact Us

Continue your research online:

Website: https://coetzerinvestments.co.za
Technical inquiry: https://coetzerinvestments.co.za/contact.html

This document is for preliminary research. Verify specifications against current standards, product documentation and project requirements.