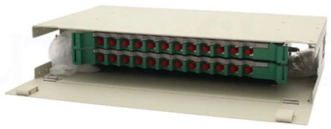
JEWELBLU OPTICAL SYSTEMS

Optical Module Structure and Manufacturing



Overview

An optical module is a typically hot-pluggable optical transceiver used in high-bandwidth data communications applications. Optical modules typically have an electrical interface on the side that connects to the inside of the system and an optical interface on the side that connects to the outside world through a fiber optic cable. The form factor and electrical interface are often specified by an interested group using a multi-source agreement (MSA).

Key Takeaways

Optical modules are compact transceivers that convert electrical signals to optical signals and vice versa, integrating TOSA/ROSA assemblies, functional circuits, and precision PCBs.Structure of Optical Modules

Core Components Optical modules consist of three main parts: optoelectronic devices, functional circuits, and optical interfaces . The key optoelectronic assemblies are:

• TOSA (Transmitter Optical Sub-Assembly): Converts electrical signals into optical signals using a laser diode (LD) or LED. It includes a light source, optical interface, monitoring photodiode, housing, and electrical interface. An automatic optical power control (APC) circuit ensures stable output power .

• ROSA (Receiver Optical Sub-Assembly): Converts incoming optical signals back into electrical signals using a photodetector diode and preamplifier, maintaining signal integrity at the required data rate . Functional Circuits These circuits manage signal processing, modulation, and monitoring. They include driver chips for the TOSA, transimpedance amplifiers (TIAs) for the ROSA, and digital diagnostic monitoring (DDM) circuits to track parameters like optical power, temperature, and voltage . Optical Interfaces The optical interface connects the module to fiber optic cables, ensuring precise alignment for minimal signal loss. High-precision mechanical tolerances are critical to maintain sub-micron alignment between the fiber and the optoelectronic components .
Optical Module PCB

The PCB serves as both the mechanical foundation and the electrical backbone of the module. It must handle extreme data rates, thermal loads, and mechanical precision:

• High-frequency signal integrity: Supports data rates up to 112 Gbps per lane with minimal signal distortion.

• Thermal management: Dissipates heat from densely packed components like DSPs, drivers, and TIAs.

• Mechanical precision: Ensures flatness and dimensional stability for accurate TOSA/ROSA alignment . Advanced PCBs use specialized materials and fabrication techniques to meet these stringent requirements.
Manufacturing Process
• Component Assembly: TOSA and ROSA assemblies are fabricated separately, integrating lasers, photodiodes, lenses, and monitoring circuits.

• PCB Integration: Functional circuits and sub-assemblies are mounted on the PCB with precise alignment.

• Optical Alignment: Fibers and lenses are aligned to the TOSA/ROSA with sub-micron accuracy to minimize insertion loss.

• Encapsulation and Packaging: The module is enclosed in a protective housing, often metal or high-grade plastic, to ensure durability and thermal stability.

• Testing and Calibration: Modules undergo rigorous testing for average optical power, extinction ratio, receiver sensitivity, and overload optical power to ensure compliance with standards .
Performance Considerations
• Transmission Distance: Limited by fiber loss and dispersion; optical modules are designed to optimize signal integrity over the intended range .

• Data Rate: Modules are engineered for specific interface rates, from 125 Mbit/s to over 400 Gbps, depending on application .

• Reliability: High-precision manufacturing and quality control are essential to prevent bit errors and ensure long-term stability . In summary, optical modules are highly integrated devices combining optoelectronic assemblies, functional circuits, and precision PCBs. Their manufacturing requires meticulous assembly, alignment, and testing to meet the demands of high-speed optical communication systems, data centers, and advanced AI-driven applications .

Article Content

Optical module

OverviewElectrical Interface TypesOptical modulation and multiplexing typesIn-module componentsElectrical cable equivalentFront panel optical module MSAsOn-Board Optical module MSAsUsers of Optical Modules

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