

Article Overview

A 400G optical module integrates a DSP chip, optical transmitter and receiver units, monitoring circuitry, PCB, and housing to achieve high-speed 400G data transmission using PAM4 modulation.

Core Components

Digital Signal Processor (DSP): The DSP is the "core brain" of the module, responsible for converting input electrical signals into four 100G PAM4 signals for transmission and decoding received optical signals back into digital data. It also compensates for fiber impairments such as chromatic dispersion and polarization mode dispersion, performs carrier recovery, and ensures signal integrity . **Optical Transmitter Unit:** Typically consists of a 4-channel electro-absorption modulated laser (EML) driver, a 4-channel Transmitter Optical Sub-Assembly (TOSA), a thermoelectric cooler (TEC) for temperature stabilization, and a multiplexer (MUX) to combine signals for fiber output . In some designs, InP lasers driven by GaAs dies are used for precise modulation . **Optical Receiver Unit:** Includes photodiode dies (often InP), a TransImpedance Amplifier (TIA) circuit, and optical couplers with focusing lenses to convert incoming optical signals into electrical signals for the DSP . **Monitoring Unit:** Provides real-time monitoring of module parameters such as temperature, voltage, and optical power to ensure reliable operation. **PCB and Housing:** The printed circuit board interconnects all components, while the housing provides mechanical protection and standard form factor compliance, such as QSFP-DD or OSFP .

Transmission Architecture

Lane Configuration: 400G modules often use multiple lanes, such as 4x100G or 8x50G, depending on the design. Each lane carries a portion of the total 400G bandwidth . **Modulation Technique:** PAM4 (4-level Pulse Amplitude Modulation) is widely used, allowing each symbol to encode two bits, effectively doubling the data rate per lane compared to NRZ modulation . **Parallel and Coherent Transmission:** Short-reach modules (SR4) use parallel optics with multiple fiber pairs, while long-reach coherent modules (e.g., QSFP-DD ZR) employ advanced modulation schemes like QPSK, 8-QAM, or 16-QAM with digital coherent optics to achieve distances up to 120 km .

Form Factors

QSFP-DD and OSFP: These are the most common 400G module form factors. While the external packaging differs, the internal functional components and working principles are largely the same . QSFP-DD modules can support breakout modes, such as 4x100G, providing flexibility for different network configurations .

Summary

400G Optical Module Architecture

A 400G optical module is a highly integrated system combining DSP signal processing, multi-channel optical transmitters and receivers, monitoring circuits, and standardized form factors. Its architecture leverages PAM4 modulation, multi-lane parallelism, and sometimes coherent optics to deliver reliable 400G data transmission across short or long distances, depending on the module type and application scenario .

The definitive guide to selecting, deploying, and maximizing 400G optical transceivers for network architects,

Key differences between SR4, DR4, FR4, and LR4 400G optical modules. Expert advice from Asterfusion engineers

Learn how to select 400G optical modules and 100G/400G DAC and AOC cables for Spine-Leaf architectures. This

Explore the influence of AI development on data center network architecture, the evolution of network speed

The 400G OSFP SR4 optical module, with its innovative design, is redefining the performance limits of short-reach

Introduction With increasing demand for higher bandwidth, lower latency, and efficient data center interconnects,

Nowadays, the progress of 400G optical module development and mass production is relatively satisfactory. In the

400G Coherent Optics is a complex system that integrates key photonic and electronic components to enable high

Definition of 400G QSFP-DD LR4 The 400G QSFP-DD LR4 module combines high-speed electrical interfaces and wavelength

Comprehensive Product Portfolio In addition to 400G OSFP Ethernet transceivers,

Learn how Cisco 400G QSFP-DD High-Power (Bright) Optical module's small size and low power make it an optimal

A clear, engineer-friendly overview of 400G optical modules, including standards, packaging formats, functions, and

The article traces the evolution of optical transceivers from 400G to 800G to 1.6T, examining the core

400G Optical Module Architecture

architectures and key

Building upon its first-to-market 400G EML and PD debuted at OFC 2025, Broadcom is launching the Taurus

400 Gigabit Ethernet (400G) optical transceivers commonly feature an eight-lane architecture, with each lane operating at 50 Gbps.

For organizations planning high-capacity optical deployments, understanding the specifications, architecture, and deployment

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