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Data Network Optical Module Distance

Overview

How Is the Transmission Distance of Optical Modules Determined?

— In the era of high-speed interconnects and data-driven networks, the transmission distanc.

Key Takeaways

Optical module distance depends on fiber type, wavelength, and module design, ranging from a few meters for short-range multimode modules to tens of kilometers for long-range single-mode modules.Understanding Optical Module Distance

The distance an optical module can transmit data is determined by its optical design, not the data rate. Factors such as wavelength, optical power, and fiber type (single-mode vs. multimode) directly influence the maximum reach before signal degradation occurs. For example, short-range (SR) modules using 850nm wavelength over multimode fiber typically support distances up to 300 meters, while long-range (LR) modules using 1310nm or 1550nm over single-mode fiber can reach 10 kilometers or more. Extended-range (ER) and ZR modules can exceed 40 kilometers, suitable for backbone or long-haul networks .

Short-, Medium-, and Long-Range Modules
• Short-Range (SR/SX): Optimized for multimode fiber (MMF), 850nm wavelength, distances up to 100–300 meters. Common in data centers for intra-rack or intra-building connections .

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• Long-Range (LR/LX): Designed for single-mode fiber (SMF), 1310nm wavelength, distances up to 10 km, ideal for campus or metro networks .

• Extended-Range (ER/ZX): Single-mode fiber, 1550nm wavelength, distances beyond 10 km, often used in ISP or backbone networks .

• 400G Modules: High-speed modules like SR4, DR4, LR4, and FR4 use parallel optics and PAM4 modulation. SR4 modules over MMF typically reach 70–100 meters, while LR4 modules over SMF can reach 10 km, and ER4 modules up to 40 km .

Real-World Considerations

While datasheets provide theoretical maximum distances, real-world performance can vary due to fiber quality, connector cleanliness, modal dispersion, and environmental conditions. Network engineers often design with a safety margin of 3–5 dB to ensure stable connections. Short-range modules may fail on older multimode fiber, and long-range modules may overload receivers on very short links if not properly attenuated .

Key Selection Factors

When choosing an optical module, consider:

• Fiber Type: MMF for short distances, SMF for long distances.

• Wavelength: 850nm for SR, 1310nm for LR, 1550nm for ER.

• Data Rate: Ensure the module supports your network speed (1G, 10G, 25G, 100G, 400G).

• Connector Type: LC for single-mode/multimode, MPO/MTP for high-density 400G links.

• Power Budget and Optical Loss: Match Tx/Rx power to fiber attenuation to avoid signal errors .

Summary

Optical module distance is primarily determined by optical physics rather than Ethernet speed. Short-range modules serve intra-data center links, long-range modules support campus or metro networks, and extended-range modules enable backbone or long-haul connections. Proper selection requires evaluating fiber type, wavelength, power budget, and real-world deployment conditions to ensure reliable, scalable network performance .

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Standards-informed guidance on selecting data center optics by distance and fiber type, with practical advice for 400G and 800G AI

Fiber-optic communication

An optical fiber patching cabinet. The yellow cables are single-mode fibers; the orange and blue cables are multi-mode fibers:

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Are you planning a fiber optic installation and need to know maximum transmission distances? Understanding the

Wavelength and Transmission Distance of Optical Transceiver Modules

The price of the optical sources and signal converters that are paired with 850nm optical transceiver modules is far lower than the

Introduction to Optical Fibers, dB, Attenuation and Measurements

This document is a quick reference to some of the formulas and important information related to optical technologies.

Basic Knowledge Of Optical Module Transmission Distance

A: When selecting an optical module, consider the actual application requirements, transmission distance, network environment, and

What Is Optical Networking? Complete Explanation

Optical networking is a technology that uses light signals to transmit data through fiber-optic cables. It encompasses

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Calculating Fiber Loss and Distance Estimates

Assume that the primary communication devices at each center is a wide area network capable router with fiber optic communication

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Explore multimode fiber distance limits in data centers, including fiber types, performance, and solutions like WDM

Meaning of SR, LR, LRM, ER, and ZR in Transceiver Modules

What are the similarity and differences? Now let us make a comparison of the similarity and difference, it will help you

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