

Single-mode fiber optic module type



Overview

Unlike multi-mode optical fiber, single-mode fiber does not exhibit modal dispersion. This is due to the fiber having such a small cross section that only the first mode is transported. Single-mode fibers are therefore better at retaining the fidelity of each light pulse over longer distances than multi-mode fibers. For these reasons, single-mode fibers can have a higher bandwidth than multi-mode fibers.

Key Takeaways

Single-mode fiber optic modules, commonly SFP transceivers, are designed for long-distance, high-speed data transmission over single-mode fiber (SMF) and include types such as LR, ER, BiDi, CWDM, and DWDM. Overview of Single-Mode Fiber Modules

Single-mode fiber (SMF) uses a small core ($\sim 9 \mu\text{m}$) to carry a single light mode, minimizing modal dispersion and enabling long-distance transmission, often up to 100 km or more depending on the module type and optical power budget. SMF modules are optimized for high-speed networks, including 1G, 10G, 25G, 50G, and 100G links.

Common Single-Mode SFP Module Types

- LR (Long Reach) SFP
- Operates typically at 1310 nm wavelength
- Supports distances up to 10 km over OS2 single-mode fiber
- Ideal for campus backbones and metro networks

- ER (Extended Reach) SFP
- Operates at 1550 nm wavelength
- Supports distances up to 40–80 km
- Used for long-haul telecom and inter-city links
- BiDi (Bidirectional) SFP
- Uses a single fiber for both transmit and receive by employing two wavelengths
- Reduces fiber cabling requirements
- Suitable for 100 m to 2 km links in enterprise or metro networks
- CWDM (Coarse Wavelength Division Multiplexing) SFP
- Supports multiple wavelengths on a single fiber
- Enables cost-effective expansion of fiber capacity without laying new cables
- Typically used in metro and data center interconnects
- DWDM (Dense Wavelength Division Multiplexing) SFP
- Supports tightly spaced wavelengths for high-capacity long-distance links
- Often used in telecom backbones and high-speed metro networks
- Compatible with G.652.D fiber for future-proof upgrades
- Industrial-Grade SFP
- Designed for harsh environments with extended temperature ranges
- Used in outdoor APs, IIoT gateways, and industrial networks

Key Specifications

- Core Size: ~9/125 μm for SMF
- Wavelengths: 1310 nm (shorter reach), 1550 nm (longer reach), or specific CWDM/DWDM channels
- Distance: 10 km to 80+ km depending on module type
- Applications: Enterprise campus backbones, data center uplinks, metro networks, telecom, CCTV, and industrial networks

Considerations for Selection

- Fiber Type Matching: SMF modules must match OS2 fiber; mixing with multimode fiber causes link failure
- Insertion Loss and Dispersion: SMF minimizes modal dispersion, making it suitable for high-speed links above 25G

- Hot-Swappable: SFP modules can be replaced without powering down network devices
- Future-Proofing: G.652.D fiber and DWDM-compatible modules allow seamless upgrades for higher bandwidth needs Single-mode SFP modules provide long-distance, high-bandwidth, and reliable optical connectivity, making them essential for modern enterprise, data center, and telecom networks.

Article Content

Single-mode optical fiber

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