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## Multimode or Single-Mode Optical Fiber?

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Cloud computing and web services continue to drive increased bandwidth demand, pushing data communications rates from 1 and 10G to 40 and 100G and beyond in enterprise and data center networks.

These higher speeds might lead system designers to believe that single-mode optical fiber enjoys an increasing advantage over multimode optical fiber in premises applications. However, higher Ethernet speeds do not automatically mean that single-mode optical fiber is the right choice.

Although single-mode optical fiber holds advantages in terms of bandwidth and reach for longer distances, multimode optical fiber easily supports most distances required for enterprise and data center networks, at a cost significantly less than single-mode.

### In the Enterprise

In enterprise Local Area Networks (LANs) and shorter campus runs, OFS' LaserWave® *FLEX* 300 (OM3) and LaserWave *FLEX* 550 (OM4) Multimode Optical Fibers can easily support reaches up to 500 - 600 meters for the 10 Gb/s maximum speeds typically required these days. Looking to possible future needs of 40 and even 100 Gb/s data rates, OFS' LaserWave *FLEX* Multimode Optical Fibers can support these same reaches when coupled with available (40G) or soon to be available (100G) extended reach multimode transceivers.

### In the Data Center

For the increasingly diverse needs of today's wide variety of data centers, LaserWave *FLEX* OM3 and OM4 Optical Fibers support the typical 100 - 150 meter maximum distances seen in all but the largest mega data centers. Even the largest warehouse-scale data centers contain thousands of shorter server-to-server, server-to-top-of-rack or end-of-row connections that are well suited for multimode optical fiber and its associated economic benefits. And again, with extended reach multimode transceivers, even longer distances are achievable where needed.

As data rates increase in the data center, a new multimode optical fiber called wide band (OM5) fiber will allow use of Short Wavelength Division Multiplexing (SWDM) technology to transmit multiple signals (wavelengths) on one fiber, increasing the bandwidth of a single fiber by a factor of at least four. This minimizes the number of fibers required to achieve greater speeds, and preserves the economic benefit of using multimode optical fiber.

As SWDM applications are developed and standardized, OFS' LaserWave *FLEX* WideBand (OM5) Multimode Optical Fiber will support longer distances than OM4 fiber. Completely OM4 compatible, LaserWave *FLEX* WideBand Multimode Optical Fiber can be installed now to support today's OM4 applications, and be ready for tomorrow's SWDM applications.

### **Total Cost – Multimode wins for short reach**

Multimode optical fiber continues to be the more cost-effective choice over single-mode optical fiber for these shorter reach applications. While the actual cost of multimode *cable* is greater than that of single-mode fiber optic cable, it is the optics that dominates the total cost of a network system, dwarfing variation in cable costs.

On average, single-mode transceivers continue to cost from 1.5 to 4 - 5 times more than multimode transceivers, depending on data rate. As faster optoelectronic technology matures and volumes increase, prices come down for both, and the cost gap between multimode and single-mode decreases. However, single-mode optics have always been more expensive than their equivalent multimode counterparts. This fact is supported by the difference in multimode vs. single-mode 10G optics, a common Ethernet speed used today.

Multimode transceivers also consume less power than single-mode transceivers, an important consideration especially when assessing the cost of powering and cooling a data center. In a large data center with thousands of links, a multimode solution can provide substantial cost savings, from both a transceiver and power/cooling perspective.

Finally, the fact that multimode optical fiber is easier to install and terminate in the field is an important consideration for enterprise environments, with their frequent moves, adds and changes.

### **Multimode and Single-Mode – What's the Difference?**

The way in which these two fiber types transmit light eventually led to their separate names. Generally designed for systems of moderate to long distance (e.g., metro, access and long-haul networks), single-mode optical fibers have a small core size (< 10  $\mu\text{m}$ ) that permits only one mode or ray of light to be transmitted. This tiny core requires precision alignment to inject light from the transceiver into the core, significantly driving up transceiver costs.

By comparison, multimode optical fibers have larger cores that guide many modes simultaneously. The larger core makes it much easier to capture light from a transceiver, allowing source costs to be controlled. Similarly, multimode connectors cost less than single-mode connectors as a result of the more stringent alignment requirements of single-mode optical fiber. Single-mode connections require greater care and skill to terminate, which is why components are often pre-terminated at the factory. On the other hand, multimode connections can be easily performed in the field, offering installation flexibility, cost savings and peace of mind.

For these reasons, multimode optical fiber systems continue to be the most cost-effective fiber choice for enterprise and data center applications up to 500 - 600 meter range.

Beyond the reach of multimode optical fibers, it becomes necessary to use single-mode optical fiber. However, when assessing single-mode optical fibers, be sure to consider newer options. A bend-insensitive, full-spectrum single-mode optical fiber provides more transceiver options, greater bandwidth and is less sensitive to handling of the cables and patch cords than is conventional single-mode optical fiber.

### **Which Multimode Fiber Type and Why?**

At one time, the network designer or end user who specified multimode optical fiber for short reach systems had to choose from two fiber types defined by their core size, namely, 50 micron ( $\mu\text{m}$ ) or 62.5  $\mu\text{m}$ . Now, that choice is slightly different: choose from OM3, OM4, or the new OM5 grade of 50  $\mu\text{m}$  multimode optical fibers. Today, 62.5  $\mu\text{m}$  OM1 multimode optical fiber is virtually obsolete and is relegated for use with extensions or repairs of legacy, low bandwidth systems. 62.5  $\mu\text{m}$  OM1 fiber supports only 33 meters at 10G, and is not even recognized as an option for faster speeds.

50  $\mu\text{m}$  multimode optical fibers were first deployed in the 1970s for both short and long reach applications. But as data rates increased, 50  $\mu\text{m}$ 's reach became limited with the LED light sources used at the time. To resolve this, 62.5  $\mu\text{m}$  multimode optical fiber was developed and introduced in the 1980's. With its larger core, 62.5  $\mu\text{m}$  optical fiber coupled more signal power than 50  $\mu\text{m}$  optical fiber. This allowed for longer reach (2 kms) at 10 Mb/s to support campus applications. That was the only time when 62.5  $\mu\text{m}$  fiber offered an advantage over 50  $\mu\text{m}$  optical fiber.

With the advent of gigabit (1 Gb/s) speeds and introduction of the 850 nm VCSEL laser light source in the mid-1990s, we saw a shift back to 50  $\mu\text{m}$  optical fiber, with its inherently higher bandwidth. Today, 50  $\mu\text{m}$  laser-optimized multimode (OM3, OM4, and OM5) optical fibers offer significant bandwidth and reach advantages for short reach applications, while preserving the low system cost advantages of multimode optical fiber.

### **Planning for the Future**

Industry standards groups including IEEE (Ethernet), INCITS (Fibre Channel), TIA, ISO/IEC and others continue to include multimode optical fiber as the short reach solution for next generation speeds. This reinforces multimode optical fiber's continued economic advantage for these applications.

IEEE includes multimode optical fiber in its 40G and 100G Ethernet standards as well as its pending 50G, 200G, and 400G standards. In addition, TIA issued a new standard for the next generation of multimode optical fiber called wide band (OM5) multimode optical fiber. This new version of 50  $\mu\text{m}$  optical fiber can transmit multiple wavelengths using Short Wavelength Division Multiplexing (SWDM) technology, while maintaining OM4 backward compatibility. In this way, end users can obtain greater bandwidth and higher speeds from a single fiber by simply adding wavelengths. OFS' version of this fiber is

called LaserWave® *FLEX* WideBand Optical Fiber. This new fiber allows for continued economic benefit in deploying short reach optics using multimode optical fiber – as opposed to more expensive single-mode optics.

### **Conclusion**

In general, multimode optical fiber continues to be the most cost-effective choice for enterprise and data center applications up to the 500 - 600 meter range. Beyond that, single-mode optical fiber is necessary.

For multimode optical fiber, 50 µm should be used, specifically the higher bandwidth OM3, OM4 or new wide band OM5 grades. OFS' family of LaserWave *FLEX* Multimode Optical Fibers offers the full performance range and have better optical and geometry specifications than required by the standards. This can allow for reduced connection / insertion loss and greater systems margin, which in turn enables longer reach, additional connections, and greater systems reliability.

If the network's transmission distances dictate the use of single-mode optical fiber, consider specifying bend-insensitive, zero water peak (ZWP), full spectrum fibers, such as the OFS family of AllWave® Optical Fibers. Depending on the application, these optical fibers offer various options for bend performance, attenuation and spliceability.