WHITE PAPER SERIES

50μm vs. 62.5μm FIBER
WHICH ONE WORKS BEST FOR YOUR APPLICATION?

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Multimode fiber has come a long way since its creation in the 1970s. When optical transmission made the move from laboratory to the real world, multimode fiber was the original fiber and light emitting diodes (LEDs) were the original light source. The reasons were both economic and technical. Multimode fiber (with cores in a range of sizes from 50 to 100 microns [µm] in diameter) could be easily manufactured, connectorization was simple and 850 nanometer (nm) LED transmitters were readily available. Local area fiber networks became possible.

Singlemode fiber (with a core of 10 µm or less) became commercially available in the early 1980s and quickly became the preferred fiber for long-distance transmission. While singlemode fiber was more cost effective than multimode, the limiting factor for singlemode systems was the very high cost of the transmitters. Instead of LEDs, fast and powerful (but expensive) lasers were required for long-distance operation. As a result, singlemode fiber systems were too expensive for use on the local network level.

Until recently, that was how fiber was used. Laser-powered singlemode was for high-speed long-distance transmission and multimode (in either the 50 µm or 62.5 µm core diameters) was used for lower speed short-distance applications. However, major advances in transmission electronics have brought higher speeds and increased operating distances to multimode fiber systems. The question is: Which multimode fiber works best for these faster systems?

Core Size, Light Wavelength and Bandwidth - A History of Compromise

Optical fiber and equipment manufacturers eventually standardized on two sizes of multimode fiber: 50 µm and 62.5 µm. Japan embraced 50 µm fiber, North America transitioned to 62.5 µm while Europe was split between the two sizes.

Each size had its advantages. The larger 62.5 µm core was easier to couple to a light source and was less bend-sensitive than 50 µm core fiber by a factor of 3. However, 50 µm fiber had a lower cost and higher theoretical modal bandwidth than 62.5 µm core fiber.

Bandwidth is a measurement of the data-carrying capacity of the fiber. A higher bandwidth fiber carries more data. Bandwidth is derived from a fiber's modal dispersion and is expressed in megahertz • kilometers (MHz•km). Modal dispersion is when the pulses of light 'spread out' and become unrecognizable by the receiver as individual pulses. Bandwidth is determined by using an OverFilled Launch (OFL) test, where the entire core was filled with light to excite all of the possible pathways (or modes) in the fiber. A 62.5 µm core has about 1,100 possible modes at 850 nm; a 50 µm core has around 300. The higher the number of modes, the greater the chance for the modal dispersion. (Modal dispersion can also be controlled by the composition and construction of the fiber core.) A fiber with low modal dispersion has high bandwidth.

As multimode fiber found its way into commercial applications, ANSI and ISO standards defined a Fiber Distributed Data Interface (FDDI) grade of fiber. The FDDI specification was somewhat influenced by the installed base of fiber and the electronics available at that time. FDDI fiber had a core of 62.5 µm and delivered 160 MHz•km of bandwidth at 850 nm and 500 MHz•km at 1300 nm. (This was commonly called 160/500 fiber.) FDDI fiber could carry 100 Mb/s traffic for up to 300 meters using 850 nm LEDs and up to 2000 meters (2 km) with 1300 nm LEDs. While 50 µm fiber was not abandoned, it was not as popular as 62.5 µm fiber in North America.

Rising Performance with a Smaller Core Fiber

Fiber manufacturers found that the fiber core profile could be altered to optimize bandwidth at one or both wavelengths. Because 1300 nm LEDs were the more widely used transmitters, 62.5 µm fiber was tweaked to deliver bandwidth of up to 1000 MHz•km for that wavelength. Transmission speeds and distances began to greatly exceed the FDDI standard.

Network speeds are increasing by ten-fold jumps. Gigabit Ethernet (1000 Mb/s or 1 Gb/s) has become the de facto standard for campus networks; 10 Gb/s networks are coming online. LED-powered multimode systems cannot operate at 10 Gb/s. Until recently, the only system that could deliver 10 Gb/s was laser-driven singlemode fiber.

Fortunately, advances in laser design are bringing down the cost of high-speed fiber networks. New and economical Vertical Cavity Surface Emitting Lasers (VCSELs) make 10 Gb/s networks possible over high-bandwidth laser-optimized multimode fibers. Currently, VCSELs are available for transmission only in the 850 nm window. This puts new emphasis on 50 µm fiber and its inherently higher bandwidth at that wavelength.

Laser-optimization is mandatory for multimode fiber if it is to operate at 10 Gb/s. This is because lasers put light into fiber differently than LEDs. Instead of an overfilled launch, an 850 nm VCSEL uses only a small portion of the core . The laser light is greatly affected by minor differences in the index of refraction in the core. These differences cause Differential Mode Delay (DMD) which lowers the effective bandwidth of the fiber.

DMD is the difference in time between the first and last pulses measured at the receiver and is expressed in picoseconds per meter; it replaces modal dispersion as the key determinant of bandwidth when using a laser. Different bandwidth measurement techniques (such as FOTP-220) were developed for laser bandwidth. And in order for a fiber to be certified for 10 Gb/s networks, it must pass DMD laser testing as described in TIA/EIA-492aaac-rev.a.*

Today's 50 µm fiber is a vastly improved waveguide. Greatly reduced variations in the index of refraction of the core significantly improves laser bandwidth. The IEEE 802.3ae standard for 10 Gb/s Ethernet specifies a 2000 MHz•km bandwidth for 50 µm fiber operating with 850 nm VCSELs. These bandwidths and application speeds are just not possible with the current generation of 62.5 µm fibers.

New Installations vs. Installed Base

Unfortunately, pure performance is not the only criteria for choosing a particular type of fiber. While the onset of 10 Gb/s networks clearly favors laser-certified 50 µm multimode fiber and makes it the overwhelming choice for new installations, other issues may take precedence. CommScope does not recommend mixing 50 and 62.5 µm fibers at a patch panel. Mistakenly using a 50 µm jumper on a 62.5 link could result in crippling attenuation.

A good migration strategy is to first introduce 50 µm fiber in the system backbone, then (as permitted or demanded by budget and need) re-cable segments of the horizontal network. In anticipation of even faster networks, it's a good idea to install singlemode fiber alongside the 50 µm multimode fiber in the backbones. The minor additional cost of the extra fiber is far smaller than the labor cost of replacing or adding cable later on.

Summary

Faster network speeds are inevitable. The challenge is being prepared for them when they occur. Cabling new backbone segments of networks with laser-certified 50 µm multimode fiber (and parallel installations of singlemode fiber) offer the most secure and least-cost upgrade path to higher-speed networks.

1 Gb/s fiber options

CommScope Fiber Name/Description	Bandwidth (MHz-km) 850/1300 nm	1 Gb/s Range with 850 nm LED	1 Gb/s Range with 1300 nm LED
6F/62.5 µm	200 /500	300 m	600 m
5M/50 µm LaserCore™ 150	950*/500	700 m	600 m
5L/50 µm LaserCore™ 300	2000**/500	900 m	600 m
8W/8.3 µm LightScope™ ZWP singlemode	NA	2 km and up***	2 km and up***

**using 850 nm VCSEL lasers*
***effective modal bandwidth per FOTP-220*
****using 1310 & 1550 nm lasers*

10 Gb/s fiber options

CommScope Fiber Name/Description	Bandwidth (MHz-km) 850/1300 nm	10 Gb/s Range with 850 nm VCSEL laser
6F/62.5 µm	200 /500	26 m - not recommended
5M/50 µm LaserCore™ 150	950*/500	150 m
5L/50 µm LaserCore™ 300	2000**/500	300 m
8W/8.3 µm LightScope™ ZWP singlemode	NA	2 km and up***

**using 850 nm VCSEL lasers*
***effective modal bandwidth per FOTP-220*
****using 1310 & 1550 nm lasers*

**CommScope's LaserCore fiber [see Appendix] is tested to a tighter standard than indicated in TIA 492 to further minimize DMD. This is because VCSELs from various manufactures differ in their launch characteristics. Fiber that passes the bandwidth testing with one VCSEL could conceivably fail when used with another VCSEL. DMD testing to this tighter standard means that LaserCore fibers will support 10 Gb/s at specified distances even with a VCSEL that may not exactly meet specified launch characteristics.*

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