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Practical Multimode Fiber Considerations

Application Note

Overview

With all the innovations being discussed to enhance IP infrastructure bandwidth and speed capacities, one technology continues to be brought up in conversation – fiber optics. In fact, the use of 50µm fiber is actually gaining in popularity, and multimode fiber designations OM1, OM2, OM3, and OM4 have been specified by the ISO/IEC 11801 international standard. The key is determining which of these highly efficient multimode fibers is appropriate for the system installations you are designing and/or implementing.

The following overview identifies some of the key features and benefits of utilizing OM3 and OM4 fiber, and addresses the potential side effects if the OM3 and OM4 fibers are added as part of an extension to an existing system where OM1 (62um) fiber and legacy equipment are also being utilized.

A little background on fiber

The OM2 (50µm) fiber was initially deployed in the 1970s for both short and long reach (distance) applications. During the 1980s, singlemode replaced the OM2 (50µm) fiber in long reach applications. Around this time, OM1 (62.5µm) soon became the de-facto multimode fiber in North America because it was capable of carrying 10Mb/s Ethernet signals over 2 km. The larger 62.5µm core enabled coupling more power into the fiber.

Today, data rates of 1Gb/sec and 10Gb/sec are becoming common infrastructure transmission requirements. OM3 and OM4 laser optimized (50µm) multimode fibers have been developed to support these data rates over longer distances than OM1 (62.5µm) and OM2 (50µm) fibers. OM3 and OM4 fibers are capable of supporting data rates 10Mb/sec through 10Gb/sec utilizing cost-effective 850nm Vertical Cavity Surface Emitting Laser (VCSEL) technology. These extended distances are made possible by optimizing the fiber's modal bandwidth performance specification for applications using VCSEL lasers at 850nm.

Table 1 identifies the distance improvement for a 1Gb/sec link and a 10Gb/sec link. As shown in the table, the distance improvement is more dramatic at the 10Gb/sec data rate. Since the benefit of OM3 and OM4 fibers are mainly utilized to transport higher data rates, they are primarily utilized in data center applications.

Note that the benefit only exists when using 850nm VCSEL optics. There is no extended distance benefit if utilizing 1300nm optics and 850nm LEDs cannot operate at the 1Gb/sec data rates.

OM Designation	OFL 850/1300nm (MHz*km)	EMB 850nm (MHz*km)	1 Gb/sec Link Length meters, (ft)	10 Gb/sec Link Length meters, (ft)
OM1 (62.5µm)	200/500	-	*300, (985)	*33, (108)
OM2 (50µm)	500/500	-	*750, (2460)	*82, (269)
OM3 (50µm)	1500/500	2000	1000, (3280)	300, (984)
OM4 (50µm)	3500/500	4700	1100, (3608)	550, (1804)

OFL: Over Filled Modal Bandwidth (Legacy/LED Bandwidth Measurement Technique)
EMB: Effective Modal Bandwidth (Laser Bandwidth Measurement Technique)
*Estimated by OFL, OM1 & OM2 is not certified over these distances.

Nevertheless some common lower bandwidth / lower data rate security installation requirements are also choosing OM3 and OM4 (50µm) fiber. The rational most likely being that the fiber will be capable of handling future equipment upgrades. Or perhaps the fiber installation will support both data and security applications and the customer prefers to standardize on one type of fiber.

<u>Connecting OM3, OM4 50µm fiber to OM 62.5µm optimized equipment</u>

Since OM1 (62.5µm) was the de-facto standard North American fiber for a long time, there are a significant number of fiber links already in place that are optimized for this type of fiber. For example, analog cameras (PTZ or fixed) have commonly utilized 850nm LED optics using 62.5µm OM1 in fiber applications.

What is the impact of using 50µm OM2, OM3, or OM4 with this equipment?

The major effect is that the optical loss budget is reduced by 4 to 5 dB. Typical optical loss budgets are 12 to 15 dB. Therefore, this is a substantial reduction (~33%) in the optical loss budget. This is primarily due to coupling less light from the optical source into the 50µm fiber. The optical receiver which expected to connect to a 62.5µm fiber will have no adverse effect in coupling from the smaller 50µm fiber into the optical detector. Typically, there is also no advantage since the optical detector area is generally large enough to capture most of the light from either the 50µm or 62.5µm fibers.

Mixing 50µm and 62.5µm fibers

Some applications arise where the newly installed 50µm fiber may be added as an extension to an existing 62.5µm infrastructure. Connecting 50um fiber directly to 62.5µm fiber is generally not recommended since the difference in core sizes could cause a high optical loss when transmitting from the 62.5µm fiber into the 50µm fiber.

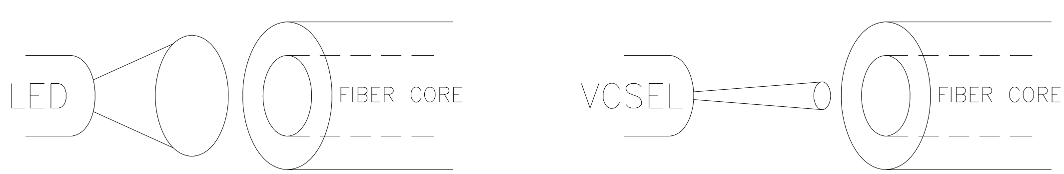
The amount of connection loss will depend upon whether the optical source is an LED or VCSEL laser. The amount of connection loss is about 4 dB for an LED based system since the LED source generally fills the entire 62.5µm core of the fiber. The connection loss for a VCSEL source could be anywhere between 0 and 4 dB due to the optical power density in the core of the fiber known as Encircled Flux. The VCSEL, being a more focused source will generally illuminate a smaller portion of the fiber core. Transmission from the 50µm fiber into the 62.5µm fiber will not incur any significant loss since the smaller 50µm core easily couples the light into the larger 62.5µm fiber.

Even though not recommended, if the link can tolerate the 4dB of additional optical loss, it is feasible to mix and match 50µm and 62.5µm fibers in a system.

What is "Encircled Flux"?

Encircled Flux is a standard that was initiated to address the issue of having "inconsistent light source launch conditions" when calculating multimode optical loss measurements. The intention of the Encircled Flux standard is to ensure that regardless of the light source used in a light-source/power-meter test setup, the test results on any given multimode link will be consistent.

Inconsistencies result from the optics used in the light source. Many light sources using light-emitting diodes (LED) emit what is called an over filled launch because the LED source emits more light than the fiber core can capture. When certain VCSELs are used as the light source, a slightly under filled launch is created. The VCSEL source almost but not completely fills that multimode core with light. An under filled launch is created by some VCSELs or by an edge-emitting LEDs.



This situation with light sources is nothing new. It has been known for some time, and the idea that insertion loss results can vary by as much as 1 full dB, depending on the light source used, was simply tolerated. Generally speaking, it was tolerated because for many users a 1 dB margin of error in insertion-loss performance was not going to make or break the network's performance.

This is not the case when operating high speed Ethernet links at 1Gb/sec and 10Gb/sec. As transmission speeds increased, optical loss budgets have gone down (see Table below). For 1Gb transmission in the short-wave, 850nm operating window, the loss limit is 4.5dB over OM3 and 4.8dB over OM4. When you move up to 10Gb, it's 2.6dB over OM3 and 3.1dB over OM4.

Optical Loss and Distance Limits (850nm)				
Fiber Type	1 Gb/sec		10 Gb/sec	
	Loss (dB)	Distance m, (ft)	Loss (dB)	Distance m, (ft)
OM3	4.5	1000, (3280)	2.6	300, (984)
OM4	4.8	1100, (3608)	3.1	550, (1804)

Lab and field test equipment is currently available to perform "Encircled Flux" optical loss measurements on installed multimode fiber. "Encircled Flux" may become a more common requirement to verify that the fiber optic solution you are working with provides the performance you need.