LIGHTWAVE

Technology

Advances in research, development, engineering, and standards

Bend-insensitive multimode fiber improves enterprise networks

By Sharon Bois

OVERVIEW

Multimode fiber has appealed to enterprise network managers because of its lower overall system cost versus singlemode fiber. New bend-insensitive multimode fiber extends these benefits to high-speed networks by improving system margins.

Premises optical networks running on multimode fiber have always been significantly less expensive than singlemode fiber systems because they enable lower-cost 850-nm VCSEL transceivers. As a result, multimode fibers are quite popular in data centers and intra-building backbones. In addition, multimode fiber is starting to penetrate into the horizontal with the increasing use of fiber-to-the-zone (FTTZ) architectures. The FTTZ architecture offers significant material and electronics cost savings compared to traditional copper home-run architectures.

Despite the significant cost savings, some end users are still choosing singlemode fiber over multimode fiber for campus backbones and other enterprise network installations. The majority of enterprise network links—including campus backbones—are less than 100 m in length and more than 95% are less than 250 m in length. Both of these distances are achievable with existing laser-optimized 50-µm (OM3) and proposed OM4-grade multimode fibers for transmission of 40-Gbps and 100-Gbps Ethernet.

Therefore, it is not necessary to use singlemode fiber to ensure future-proofed operations. You can get the performance you need at a significantly lower cost by choosing multimode fiber for enterprise network applications. And new technology advances that enable bend-insensitive performance now make multimode fiber even more appealing.

Source: Corning Inc.

Today's data centers and telecom closets require significantly tighter bend radii than those established in existing standards.

Speeds continue to increase

As the need for information transfer continues to grow, data transmission rates are increasing rapidly. The market is shifting to 50-µm multimode fiber as a result. The biggest growth segment for multimode fiber over the past few years has been the high-bandwidth OM3 and the proposed OM4 multimode fibers.

Each new incremental speed increase places more demands on the quality and performance of link components. When using OM3 fiber, a 1-Gbps Ethernet transmission system requires very little of the overall 7.5-dB system power budget at short distances (≤600 m). Therefore, there is ample margin available for the fiber/cable/connector system. This means that it is possible to extend the link distance or accommodate additional splices, connectors, or bends without compromising system performance.

However, the world is now shifting to 10 Gbps and faster transmission speeds. At these higher speeds, the transceiver specifications are significantly tighter than for 1 Gbps and the available margin starts to shrink. For a typical OM3 10GBase-SR 300-m link, the channel length loss budget is 2.59 dB. With worst case transceiver specifications and the basic cable and connector attenuation, 0 dB of spare margin remains. Even for a system with better transceiver specifications, there is very little margin available for bend-induced attenuation; exceeding the

Table 1. Multimode bend standards

	IEC 60793-2-10	ITU-G.651.1
Bend radius	37.5 mm	15 mm
Number of turns	100	2
Max attn at 850 nm	0.5 dB	1 dB

allowable margin creates the potential for a significantly slowed system response or even failure.

Bend's critical role

Newly created bend-insensitive multimode fiber minimizes bend-induced attenuation, thereby freeing spare operating margin. This helps maximize system reliability and minimize downtime. Less attenuation (including bend-induced attenuation) means more assurance that the information you send gets where it is going every time without delay.

In this era of increased connectivity, reducing stress on the physical power budget becomes more critical. It also provides insurance against the unplanned attenuation that can be induced into the system as a result of tighter-than-expected cable bends.

Bend performance standards related to multimode fiber are not representative of actual enterprise network requirements. Until recently, the only international standard that called out a specific bend-induced attenuation limit for multimode was IEC 60793-2-10, and it specified bend at a 37.5-mm radius. That's approximately the radius of a baseball.

In 2007, ITU-T G 651.1 introduced a new bend standard with a tighter bend radius requirement. This new standard specifies performance at a 15-mm radius, which is slightly smaller than the radius of a ping-pong ball. The maximum attenuation allowed for these multimode bend standards is shown in Table 1.

Consider the 300-m 10-Gbps link mentioned previously—if two turns at a 15-mm radius introduces an additional 1 dB of loss into the system, then the potential for failure can become quite high.

Now take a look at the photo and see if you can count the number of cables that are bent tighter than the radius of a baseball. How about a ping-pong ball? And then look at your own telecommunications closet or data center rack, and see if you can beat that number!

It's not hard to understand why there is a need to accommodate tighter bends than those specified in the current standards. Bend radii between 5 and 15 mm are quite common.

The bend challenge

Light naturally wants to travel in a straight line. When you bend a traditional optical fiber, the tendency is for the light to keep going straight and escape from the fiber. As the bend radius decreases, the amount of light that leaks out of the core increases. This escaped light causes signal degradation and increases the potential for transmission errors.

Multimode fibers have many modes of light traveling down the core. The behavior of these different modes and the impact of the larger core diameter for multimode fiber (as compared to singlemode fiber) require a unique approach to enhance bend performance.

Another complicating factor for improving bend in multimode fiber is the fact that trapping all of the light into the core of the fiber can adversely affect fiber bandwidth if not properly executed. It is relatively easy to make a bend-improved multimode fiber with low bandwidth. However, incorporating bend with high bandwidth is a significant challenge.

Previous attempts to address bend in multimode fiber were not able to support information- and bandwidth-intensive applications with the bend radii they require. This would have forced IT managers to choose between the superior bandwidth performance required for high-speed applications and the superior bend performance that would enable increased reliability and reduced cost. New bend-insensitive multimode fibers are able to deliver superior bandwidth performance in an ultrabendable package without requiring any adjustments to standard field installation, termination monitoring, or maintenance procedures.

Bend improvement in these new multimode fibers is achieved through the use of a specially engineered optical trench that traps the many modes within the fiber core. This optical trench ensures that the outer modes, which traditionally have a tendency to "leak" out of a multimode fiber when it is subjected to bends, stay put. By keeping these modes within the core of the fiber, much less of the information-carrying signal is lost and more information gets to the end user without dropped packets or corrupted data.

Consider this simple analogy: Think of the core of your multimode fiber as a road and the

Table 2. The benefits of bend-insensitive multimode fiber

Goals	Network impacts from using bend-insensitive multimode fiber
Greater network reliability and less downtime	• Lower total system loss • Significantly less impact due to tight bends
Futureproofed systems	• Longer reach and more flexibility • Accommodates more connectors and more moves, adds, and changes
Reduced time and cost for network installation	• Enables easier and cheaper installations • More efficient use of space
Reduced operating costs	• Greater cooling efficiency, reduced power, and lower energy costs • Easier moves, adds, and changes • Lower IT support costs • Less downtime

mode groups as a convoy of trucks traveling in parallel down a multilane highway. The goal is to get as many of them to their final destination at the same time, which corresponds to high bandwidth and low loss in a multimode fiber.

The drivers in the center lanes tend to stay in their lanes, even when there are sharp turns in the road. On the other hand, the trucks in the outer lanes must travel farther during a turn if they want to keep up with the rest of the convoy. As a result, they must accelerate around each curve, and in the process some of them lose traction and slip off the shoulder of the highway and fail to reach their final destination.

More bends in the road mean more chances of losing the trucks in the outside lanes. With traditional 50-µm multimode fiber, each bend means more light escapes from the outer modes and more of the signal is lost.

The mechanism behind the new bend-insensitive multimode fiber is analogous to putting guard rails on the shoulder of the highway. These barriers help prevent the trucks in the outer lanes from drifting off the road. As a result, they arrive at their destination at the same time as the other trucks, with their payloads intact.

Addressing the issues

Bend-insensitive multimode fiber can help solve many of the problems that are faced by managers of LANs, data centers, and other enterprise networks. Table 2 shows some of the key benefits that are enabled by bend-insensitive multimode fiber and their effects on the network.

Bend-insensitive multimode fiber maximizes system reliability, minimizes system downtime, and provides opportunities for cost reduction. In addition, cablers and system integrators can take advantage of the improved bend in smaller and lighter cable, hardware, and equipment designs. These new designs will enable smaller, denser, more "green," and easier-to-install data centers and enterprise networks.

By withstanding tight bends and challenging cabling routes with substantially less signal loss than traditional multimode fiber, a bend-insensitive multimode fiber enables optical fiber to be used in more places by delivering all of the bandwidth benefits of laser-optimized multimode optical fiber in a package that is easier to handle and install and offers more robust system performance than copper cabling.

Multimode fiber continues to be the fiber of choice for enterprise networks as compared to singlemode fiber. A bend-insensitive multimode fiber makes the choice even clearer.

Sharon Bois *is product line manager, multimode fiber, at Corning Inc. (www.corning.com).*