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Bend-insensitive vs. standard multimode in the enterprise

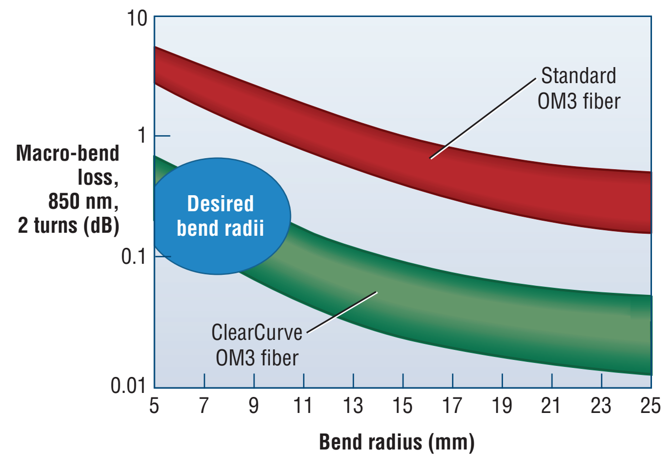
Ultra-bendable 50-µm fiber can mitigate the risks of increased attenuation loss caused by macro-bending while accommodating space constraints and tight bends.

The optical network market has seen a flurry of introductions of various grades of single-mode fiber with enhanced macro-bending performance down to a 5-mm bend radius. These fibers have been primarily used in multi-dwelling unit (MDU) applications to feed individual apartments in challenging installation environments.

Recently, a 50-µm multimode fiber with enhanced macro-bending performance was introduced, designed to reduce and, in some cases, eliminate the challengesencountered in installations in local area network (LAN) data center and other enterprise applications. This article reviews bend-insensitive multimode fiber performance in real world conditions when compared to standard bend-performance multimode fiber.

Historically, fiber optimization for targeted performance benefits meant significant compromise in other performance factors. Through precise engineering, these new bend-insensitive multimode fibers are able to maintain an equivalent level of bandwidth performance, attenuation per length, and temperature performance in conjunction with the added benefit of improved bend.

Macro-bend loss/bend radius



New bend-insensitive fibers are designed to maintain an equivalent level of bandwidth performance, attenuation per length, and temperature performance.

Termination, splicing similarities

These bend-insensitive multimode fibers were designed to be fully compatible with existing OM2/OM3 fibers, eliminating concerns about integration into existing networks. Handling and installation testing has confirmed that no differences exist between standard 50-µm fiber and the bend-insensitive 50-µm fiber in terms of termination and splicing methods. Therefore, new products enabled with the bend-insensitive fiber are able to provide the standard performance that network designers expect and the added benefit of enhanced bend performance without sacrifices.

Customers face continual demands in their data centers and enterprise networks as a result of the increasing growth in high-bandwidth applications. The figure "Historical speed re- ➤

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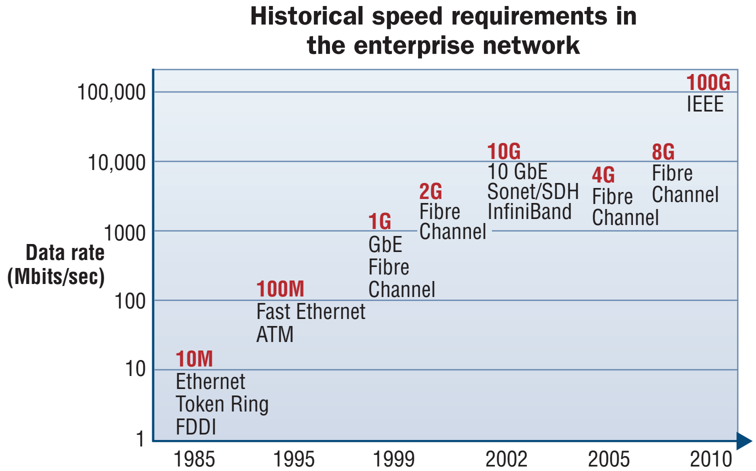
quirements in the enterprise network" (this page) shows how quickly speed requirements have continued to increase in the enterprise network. 40G deployments are beginning, and we expect to see the first 100G deployments in 2010. As networks migrate to 10 Gbits/sec and higher, and transceiver specifications tighten, available margins begin to shrink. In other words, there is very little room for bend-induced attenuation, which can trigger slow system responses and even outages.

To increase efficiency, a comprehensive network design strategy can optimize the margin headroom from the onset and also increase the network's ability to cope with unintended loss issues.

The first step in the strategy is to deploy low-loss-enabled products in the network. Factory-terminated solutions, such as plug-and-play, are available with insertion loss values as low as 0.10 dB for single connectors and 0.35 dB for multi-fiber connectors. The gains in headroom margin act as a safety net in the system for other areas where the loss may be more than expected.

It is important to remember that the gains achieved by using low-loss connectors are eliminated if mated with standard loss connectors. This can happen especially at interconnect points in the network where lower performance interconnect cables are used to patch a system together. As a network is brought online, and transitions from initial installation to move, add and change (MAC) management, interconnect cables may come from varying sources and suppliers. Maintenance of performance consistency at all times is important in this most fundamental link in the system.



As speed requirements increase for high-bandwidth applications, there is little room for bend-induced attenuation that can result in slow system response and outages.

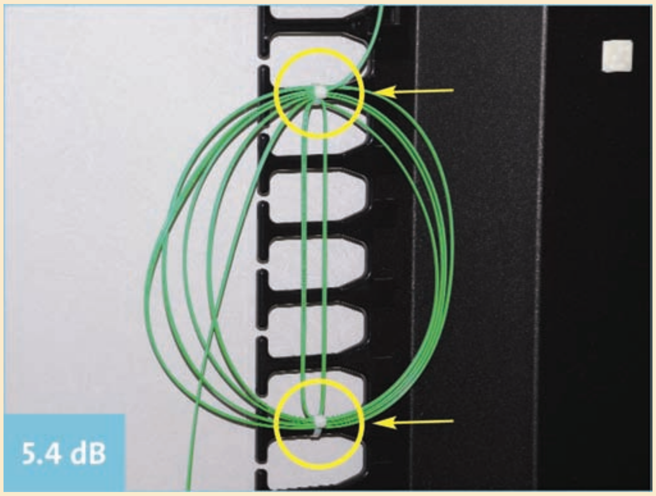
Reducing system disruptions

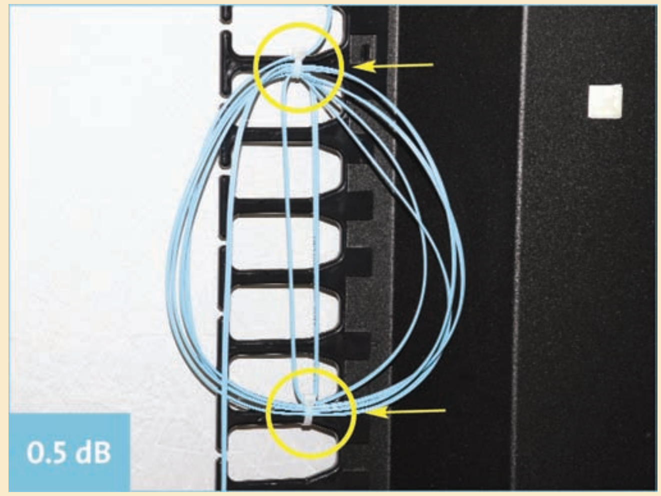
The second step is to deploy risk management strategies to reduce the risk of system disruptions associated with acci-dental adverse events. Although system downtime originates from many different sources, and there are as many different strategies to reduce risk, we will focus on failure due to cabling and connectors.

Current studies estimate that cable and connectors account for 5% to 10% of the downtime companies experience during a year.[1] Loss degradation accounts for roughly 50% of total downtime, while complete outages account for the remaining 50%. The negative impact of these outages is either directly in terms of revenue or indirectly through lost productivity.

The absolute cost of downtime is difficult to measure and varies widely by application and network usage; however, as networks migrate to 10 Gbits/sec and now to 40 and 100 Gbits/sec, the amount of traffic flowing over these high-speed networks becomes increasingly critical, and the potential cost exposure for the end-user increases dramatically. Therefore, it is advantageous for users to actively deploy risk management strategies, such as robust optical connectivity solutions with bend-optimized fibers in their networks.

In tests simulating common accidental bend events, a simple pressure point can result in a loss of 3.4 dB for a standard OM3 jumper (left), while a jumper enabled with bend-insensitive multimode fiber had a loss of 1.5 dB.





In this test of a typical move, add, and change, a typical 50-µm jumper saw greater than 5.0 dB loss (left), while an ultra-bendable jumper experienced a 0.5 dB loss.

Even when best practices are employed, mistakes can occur that result in kinked cables and cables bent beyond the recommended minimum bend radius. Examples include jumpers closed in housing doors, jumpers pulled too tightly against tie wraps in slack loops, fibers caught in drawers as they are pulled from the housing, cables pinched on edges of cable trays because of tension or heavy loading on top from other cables, and congestion in trays or raceways causing tight crossover points. At times, these problems are blackout events resulting in an immediate outage.

As margins have tightened, the amount of unintended loss to reach such an outage event has decreased. Tighter margins have also increased the risk that an event will cause degradation in the network. These inadvertent events may result in unnoticed attenuation that causes a live system running close to its link-loss budget to degrade to levels higher than the desired bit error rate (BER) of 10^{-12}. This leads to reductions in network throughput. As the system sees more errors and must retransmit the signal, network efficiency is diminished and the net effect is that network throughput decreases.

Avoiding system outages

A series of comparative tests were performed that simulated the common accidental bend events described previously. The tests determined to what level system outages can be avoided by using products enabled with bend-insensitive multimode fiber. Because fiber density deployed in networks is increasing at such a rapid rate, and housings are often densely packed, the testing included the effect of a jumper accidentally closed in a housing door. This simple pressure point, which produced both macro- and micro-bend effects, resulted in a loss of 3.4 dB for a standard OM3 jumper. While the standard OM3 jumper was subjected to the pinching event, the BER increased to 10^{-6}. For a system with tight margin headroom, a likely outcome of the event described using standard OM3 assemblies would be system outage.

When an interconnect jumper enabled with bend-insensitive multimode fiber was subjected to the same conditions, the comparative loss impact was 55% less or 1.5 dB. Compared with the standard OM3 jumper, the BER for the ultrabendable jumper was maintained at 10^{-12}. Low-loss jumpers with ultra-bendable performance provide an insurance policy to protect against these types of degradation events.

A second test simulated a common MAC event in which a jumper is moved to another port, and the cable is pulled too tightly in the slack loop. The insertion loss and impact on BER were evaluated for a standard multimode jumper and an ultra-bendable OM3 jumper.

It is often difficult to assess exactly how tight a jumper is bent around a tie wrap until it is pulled—and it is too late. Testing showed that in a tight loop, the traditional 50-µm jumper suffered greater than 5.0 dB of loss. Under the same conditions, a 50-µm ultra-bendable jumper only experienced 0.5 dB of loss—a 10x loss performance improvement. As before, utilization of bend-insensitive 50-µm fiber-enabled products can provide the difference between a downtime event and no event at all.

Lowering attenuation risks

With the advent of the new higher performance multimode fibers, it will take time to determine all possible and newly-enabled applications that they bring. For now, however, it is certain that new 50-µm products with ultra-bendable performance can mitigate the risks of increased attenuation loss caused by macro-bending.

They will also allow system designers to accommodate space constraints and tight bends like never before.

1. Infonetics, "The Cost of Network Downtime in Medium Businesses," 2006.

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