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A specially engineered optical trench can be used to trap the energy in the modes that propagate within the fiber core. Keeping the light in the core, even in the most challenging bending scenarios, significantly reduces the bend-induced attenuation.

The Evolution of Bend-Insensitive Multimode Optical Fiber

by Steve Swanson

Standards have played an important role in trade and commerce for a long time. A well-written product standard can often lead to widespread market acceptance. Markets grow faster if the user perceives less risk. In addition, a product standard can help position a product in a market of choice. Standards generally reflect what requirements the product should meet but do not define how one should design the product to meet those requirements. Standards are typically issued to achieve one or more of the following purposes:

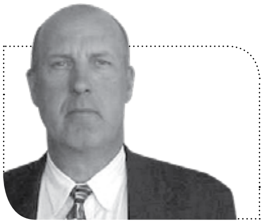
- Support an application need
- Promote interchangeability and interoperability of products
- Eliminate misunderstandings or confusion between manufacturers and buyers
- Provide assistance to the purchaser in selecting and obtaining the proper product for a particular need
- Improve the quality of products

Standards are usually developed by consensus, often defined by a lack of sustained opposition. Consensus is achieved through a process of discussion, correspondence, draft contributions and revision, all leading to a published standard. A recent example of this was the introduction of bend-insensitive singlemode optical fiber, which was introduced to solve the technical and physical challenges faced by telecommunications carriers installing fiber to the home (FTTH) networks, particularly in multi-dwelling units. Bend-insensitive singlemode optical fiber was standardized under the ITU-T G.657 standard.

A current example of the standards process is the ongoing discussion on bend-insensitive multimode fiber (BIMMF). While some differences of opinion exist among manufacturers, it may still be possible to reach a consensus that allows BIMMF to be standardized. This article provides an overview of the available multimode standards, examines the need for bend-insensitive optical fiber, and provides an update on the current standards activities related to bend-insensitive optical fiber.

Standards for Multimode Optical Fiber

Standards for multimode optical fiber are developed in several regional and



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international standards development organizations. Key applications include Fibre Channel, IEEE 802.3 Ethernet standards and Infiniband. All reference the Telecommunications Industry Association (TIA) or International Electrotechnical Commission (IEC) standards for multimode optical fiber. Tables 1, 2 and 3 provide a summary of the structured cabling standards, key testing standards and multimode optical fiber classifications, respectively.

The Need for Bend-Insensitive Multimode Optical Fiber

Multimode optical fiber is a cost-effective solution for high-bandwidth applications in the data center and local area network (LAN). For years, it has been the workhorse for LAN networks, supporting both intrabuilding and interbuilding backbone applications. Most of these applications were LED-based, supporting hundreds of megabits and hundreds of meters in length.

The escalating growth in high-bandwidth applications led to several advancements in the industry, including the development of cost-effective vertical cavity surface emitting laser (VCSEL) sources operating at 850 nanometers (nm) and the development of very high-bandwidth 50 micrometer (µm) laser-optimized multimode optical fiber. The combination of these two developments provides a cost-effective upgrade path for supporting future high-bandwidth applications.

As a result of the need to support higher speed applications, customers are facing other demands with their data center and enterprise networks, including power and cooling efficiencies, space constraints and density concerns. Using innovative designs in cable and hardware, BIMMF can help alleviate these problems by providing enhanced bend performance with all the existing performance inherent in legacy OM3 and OM4 cabled optical fiber types.

Standard	TIA	ISO/IEC
Commercial building	568	11801
Residential	570	15018
Data center	942	24764
Industrial	1005	24702

Table 1: Structured cabling standards

Standard	TIA	IEC
Fiber specification	492AAAx	60793-2-10
Attenuation of installed plant	526-14B (OFSTP-14)	61280-4-1
Attenuation coefficient	455-78B (FOTP-78)	60793-1-40
Bandwidth	455-204 (FOTP-204)	60793-1-41
Chromatic dispersion	455-175B (FOTP-175)	60793-1-42
Numerical aperture	455-177B (FOTP-177)	60793-1-43
Macrobending	455-62B (FOTP-62)	60793-1-47
DMD/EMBc	455-220A (FOTP-220)	60793-1-49

Table 2: Key testing standards

Core Diameter	Bandwidth		Standard		
	OFL (850/1300)	EMB (850)	IEC	TIA	ISO-11801
62.5 µm	200/500	N/A	60793-2-10 Type A1b	492AAAA	OM-1
50 µm	500/500	N/A	60793-2-10 Type A1a.1	492AAAB	OM-2
50 µm	1500/500	2000	60793-2-10 Type A1a.2	492AAAC	OM-3
50 µm	3500/500	4700	60793-2-10 Type A1a.3	492AAAD	OM-4

Table 3: Multimode optical fiber classification

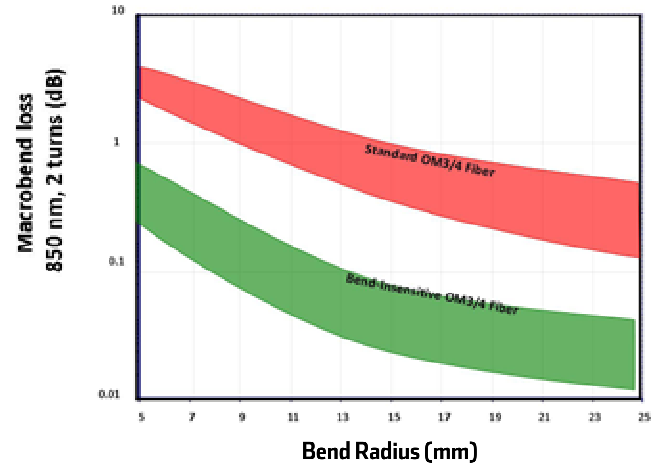

Figure 1: Comparison of bend performance

The improved macrobend performance allows operators and designers to use cost-effective multimode optical fiber solutions in more places in their enterprise network. BIMMF allows users to minimize the bend-induced attenuation, thereby creating more operating margin for system reliability and minimized downtime. Cable manufacturers and system integrators can also take advantage of the improved bend performance in innovative cable, hardware and equipment designs. Because bend sensitivity becomes less of an issue, smaller and lighter cable, hardware and equipment designs are possible. These new designs can provide additional cost savings by enabling smaller, denser, "greener" and easier-to-install data centers and enterprise networks.

What Is Different?

Multimode optical fiber has many modes of light traveling through the core. Each of these modes travels a different path—some near the center of the core (low order modes) and some near the edge of the core (high order modes). The modes near the edge of the core are more likely to escape, especially if the fiber is bent. In a traditional multimode optical fiber, as the bend radius is decreased, the amount of light that leaks out of the core increases.

BIMMF prevents much of the light from escaping. A specially engineered optical trench can be used to trap the energy in the modes that propagate within the fiber core. Keeping the light in the core—even in the most challenging bending scenarios—significantly reduces the bend-induced attenuation (see Figure 1). BIMMF can provide up to 10 times better bend performance than legacy 50 µm multimode optical fiber, and it is fully standards compliant and compatible with the installed base of OM2, OM3 and OM4 cabled optical fiber types.

Update on the Standardization of BIMMF

Discussion of bend-insensitive optical fiber standards started in IEC in April 2010, but most of the technical work is now being done in TIA. The objective is a revision to the fiber specifications TIA-492AAAC and TIA-492AAAD, as well as IEC 60793-2-10. Preliminary proposals would add a two-turn 15 millimeter (mm [0.590 inch (in)]) macrobend specification with improved bend loss, as well as a tighter two-turn 7.5 mm (0.295 in) bend specification as shown in Table 4.

The debate in standards is not in the proposed bend enhancements but on differences in manufacturers' designs, how to test certain optical attributes of the fiber and how to ensure interoperability and backwards compatibility with legacy 50 µm multimode optical fiber. To address these issues, TIA formed a task force that includes members from all interested parties and has a close liaison with IEC.

A checklist of items to be addressed is still in development but will cover, at a minimum, the issues mentioned above. An important aspect in the discussions will be to establish ties to actual system performance, such as concatenated link performance and bit error rate (BER) testing.

ISO/IEC Nomenclature			OM2	OM3	OM4
Maximum Macrobending Loss	Radius	Number of turns	A1a.1	A1a.2	A1a.3
			Max at 850 nm/1300 nm		
	37.5 mm	100	0.5/0.5 dB		
	15 mm	2	1/1 dB		
	Radius	Number of turns	A1a.1BI	A1a.2BI	A1a.3BI
			Max at 850 nm/1300 nm		
	15 mm	2	0.1/0.3 dB		
	7.5 mm	2	0.2/0.5 dB		

Table 4: Improved bend performance proposal

Summary

Standardization often occurs after new designs have been developed. The standardization process frequently involves performance and testing tradeoffs that must be accommodated in the standard before all parties can approve the standard. This is not unusual and, in most cases, consensus can be achieved and the new product idea can be supported by a standard that is acceptable to all parties involved. Discussion of BIMMF is ongoing in standards. While differences exist among manufacturers, it is believed that these optical fibers will be standardized. ■