The Road to 800G with Multimode Fiber

by Hao Dong and Xin Chen

CORNING

Skyrocketing bandwidth demand in cloud services

The demand for cloud-based services continues to skyrocket, driven by the growing number of internet users and connected devices, faster broadband access, high-quality video streaming, metaverse connectivity, and ubiquitous social networking. Over the past two decades, data center applications have become one of the most dynamic, fastest-growing market segments driving innovation in many technical fronts. To keep up with and ahead of this growth, data center operators are striving to build faster, denser, more cost-effective, and more power-efficient data centers that are sustainable and resilient.

Optical fiber enables rapid communications in data centers

Consumers expect a virtually instant response to their browser searches and uninterrupted streaming of their video content. Data centers must therefore contain a large variety of connectivity equipment and technology to quickly transmit the correct stored data to the right place. Optical fiber, with its tremendous transmission capacity and strength, enables the rapid communications data centers need to meet and outpace consumer demands for decades to come.

Multimode fiber is the ideal solution for short link lengths in data centers

Multimode optical fibers can support high data rates with transmission reach typically below 100 m. Predominantly VCSEL-based transceivers are used with multimode fibers to transmit and receive data. VCSEL-based transceivers exhibit lower power consumption than single-mode transceivers, delivering more than 20% power savings and reduced greenhouse gas emissions [1]. The high data rate and energy-efficient transmission makes multimode fiber solutions very beneficial for deployment in short links between switches inside data centers.

IEC standard 60793-2-10 establishes multimode fiber types OM1, OM2, OM3, OM4, and OM5. For VCSEL-based multimode transceivers, OM3 and OM4 multimode fibers are the two primary types covering 70 m to 100 m link lengths, respectively.

Multimode fiber transceiver considerations for 800G

VCSEL-based transceivers currently offer maximum data rate speeds of 400G with optical lane speeds of 50G utilizing PAM-4 modulation. There are two commercially available 400G multimode options: 400G SR8 and 400G SR4.2. The 400G SR8 transceivers operate at a single wavelength of 850 nm and require the use of 16 multimode fibers. The 400G SR4.2 transceivers, on the other hand, utilize bidirectional (BiDi) transmission across two wavelengths, typically 850 nm and 910 nm, and only require the use of 8 multimode fibers.

Data centers, however, need even higher speeds, specifically 800Gbps, to keep up with the demand. More multimode fibers could be added, but that is both expensive and inefficient. As a result, the industry is moving toward multimode transceivers with 100G/lane speeds, doubling the current 50G/lane rates.

In late 2021, the Terabit BiDi Multi-Source Agreement (MSA) group announced its formation as an industry consortium to develop interoperable 800 Gb/s and 1.6 Tb/s optical interface specifications for parallel multimode fiber. Terabit BiDi is based on 100G/lane transmission at both 850 nm and 910 nm wavelengths, delivering the benefits of high data rate (and high capacity) with minimal structured fiber cabling requirements.

However, when 100G/lane transmission is introduced, the system reach is dramatically reduced in some cases due to modal bandwidth limitations at 850 nm and/or 910 nm. The industry typically expects a 70 m reach for OM3 multimode fiber and a 100 m reach for OM4 multimode fiber. For the Terabit BiDi MSA, however, these specifications are compromised, with the transmission reaches for OM3 and OM4 multimode fiber reduced to 45 m and 70 m, respectively [2].

The transmission capability reduction is not exclusive to Terabit BiDi; similar reductions also apply to other 100G/lane-based applications. IEEE Std.802.3db, for instance, defines that for transceivers that transmit solely at 850 nm wavelength (100G SR, 200G SR2, and 400G SR4), the OM3 multimode fiber reach is limited to 60 m.

Multimode fiber solutions for TeraBit BiDi and other 100G/lane applications

To address the reach reduction caused by bandwidth limitations of OM3 and OM4 multimode fibers, Terabit BiDi MSA has included OM5 multimode fiber as a solution to achieve 100 m reach [2]. OM5 has defined effective modal bandwidth (EMB) values of 4700 MHz·km at 850 nm and 2470 MHz·km at 953 nm wavelengths. For Terabit BiDi transmission, the highest operational wavelength is 915 nm, so OM5 is not technically required.

To address the EMB requirements of Terabit BiDi applications while meeting longer reaches, we propose two new cost-effective high data rate (HDR) multimode fibers engineered for BiDi applications. These fibers have specified EMB values at both 850 nm and 910 nm, enabling transmission distances of 80 m and 100 m. Table 1 shows the comparative data. The proposed EMB values for these new fibers align with the link bandwidth requirements derived from Terabit BiDi and the IEEE Std.802.3db specifications.

Table 1. Fiber selection criteria for 100 m and 80 m applications.

MMF Solution	EMB at 850 nm	EMB at 910 nm	Reach for 800G BiDi	Reach for IEEE 802.3db
"HDR OM3"	**2,890 MHz·km**	**2,220 MHz·km**	**80 m**	**80 m**
"HDR OM4"	**4,700 MHz·km**	**3,100 MHz·km**	**100 m**	**100 m**
Standard OM3	2,000 MHz·km	1,260 MHz·km	45 m	60 m
Standard OM4	4,700 MHz·km	1,980 MHz·km	70 m	100 m

For the new fiber with 100 m reach, the EMB values for 850 nm and 910 nm wavelengths are specified as 4700 MHz·km and 3100 MHz·km, respectively. These are effectively the same values for OM5 at these two wavelengths, making it a viable, cost-effective option for higher data rate applications such as 100G/lane BiDi transmission.

In addition to the 100m fiber option, we also define an 80 m length multimode fiber option to address broader market needs for some customers using 70-80 m distances to cover a majority of their links. At 80 m reach, the EMB values for 850 nm and 910 nm are 2890 MHz·km and 2220 MHz·km, respectively.

While these EMB values are lower than those for the 100 m fiber option, they are sufficient to cover link bandwidth requirements for many data center applications. Thus, this new fiber option offers an additional option to achieve the most cost-effective solution suitable for their distance and bandwidth requirements.

In the end, these fibers offer the benefits of legacy standard OM3 and OM4 multimode fibers, such as availability and compatibility with existing infrastructure, while providing the improved reach and performance needed for 100G/lane data applications.

Conclusion

As demand for higher data rates and bandwidth continues to grow, new multimode fibers optimized for 100G/lane applications will help to ensure that structured cabling can keep up with the evolving data center requirements and provide the most cost-effective and sustainable solutions for links up to 100 m.

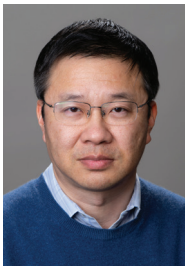
Reference

[1] Dong, Hao. "Multimode Fiber for High Data Transmission and Energy Efficient Next-Generation Data Center." *White Paper*. Corning Incorporated, March 2022, https://www.corning.com/media/worldwide/coc/documents/Fiber/white-paper/WP8300.pdf

[2] Terabit BiDi MSA specifications, https://terabit-bidi-msa.com

The Authors

Hao Dong is a market and technology development manager at Corning



Xin Chen is a senior research associate in optics at Corning

Corning Incorporated
www.corning.com/opticalfiber

One Riverfront Plaza
Corning, New York
USA
Phone: (607) 248-2000
Email: cofic@corning.com