High Data Rate Optimized Multimode Fiber for 100G/lane Based VCSEL Transmission

WP8350
Issued: June 2023

Authors: Xin Chen, Corning Incorporated
Hao Dong, Corning Optical Communications

Evolution of VCSEL Transceiver Technology

Global Internet traffic continues to skyrocket in cloud and enterprise data centers (DCs), driven by a 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 emerged as one of the most dynamic, fastest-growing market segments driving innovation across many technical fronts. Data center operators are striving to build faster, denser, cost-effective, power-efficient, and easier to install data centers designed to be sustainable, renewable, and resilient.

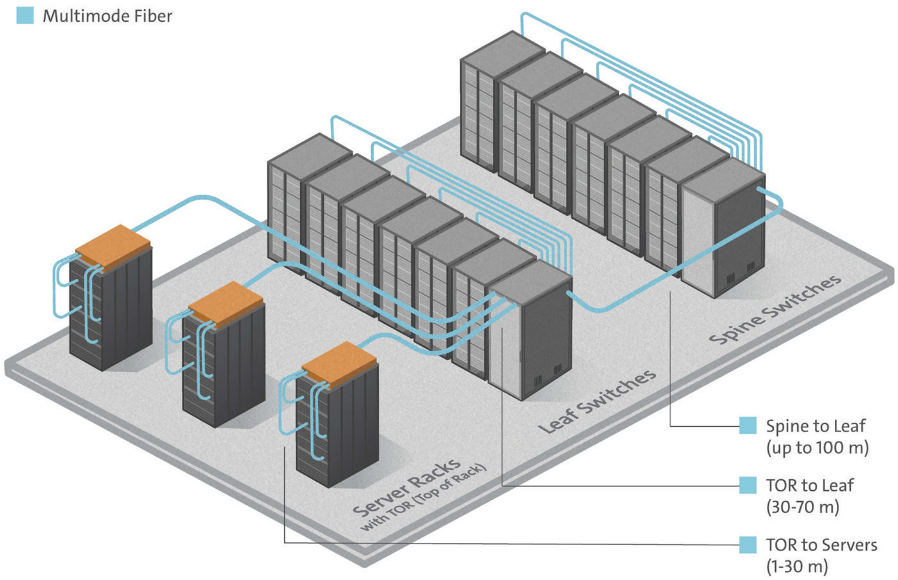

Figure 1. Standard OM3 and OM4 multimode fibers deployed for up to 70 m or 100 m data center links.

For short distance communications, multimode fibers (MMFs) have been widely deployed in data centers using VCSEL-based transceivers to form a cost-effective eco-system. Existing 50-micron core MMFs are categorized in IEC 60793-2-10 standards as Type A1 OM2, OM3, OM4, and OM5. For 25 Gbaud-based transmission (i.e. 25G NRZ or 50G PAM-4), OM3 and OM4 are the two primary MMF types covering 70 m to 100 m distance links. The reach details for various 25 Gbaud-based VCSEL transceivers are listed in Table 1. Today, as data centers evolve to higher speeds, the industry is moving toward 100G/lane for VCSEL-based transceivers using only an 850 nm wavelength or using multiple wavelengths including 850 nm and longer for wavelength-division-multiplexing (WDM) transmission. There are two types of VCSEL transceivers using WDM technology: a BiDi transceiver using two wavelengths, 850 nm and 910 nm [1,2]; and a SWDM transceiver that utilizes four wavelengths, for example 850 nm, 880 nm, 910 nm and 940 nm [3].

Table 1. System reach for 25 Gbaud-based VCSEL transceivers

	25G SR	100G SR4	100G BiDi	100G SWDM4	400G SR8	400G SR4.2
MSA/Standard	IEEE 802.3by	IEEE 802.3bm	IEEE 802.3cm*	MSA	IEEE 802.3cm	MSA/IEEE 802.3cm
OM3 Reach	70 m	70 m	70 m	75 m	70 m	70 m
OM4 Reach	100 m	100 m	100 m	100 m	100 m	100 m
Fiber Count	2	8	2	2	16	8

*100G BiDi follows the same fiber optical bandwidth specs as IEEE 802.3cm.

Existing Transmission Reaches: 70 m with OM3 and 100 m with OM4

The industry is accustomed to 70 m OM3 and 100 m OM4 multimode fiber transmission reaches for several generations of transceivers based on the 25 Gbaud data rate, as illustrated in Figure 2. Some customers and some regions prefer a 70 m reach using OM3 fiber as it is more cost-effective and meets their specific application requirements, while others use both OM3 and OM4 fibers to address their needs.

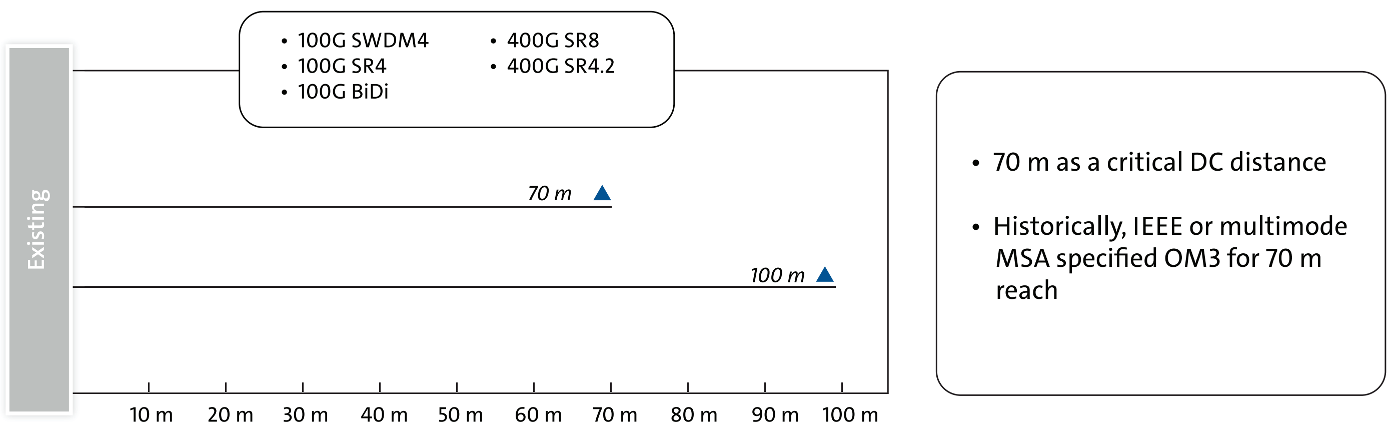

Figure 2. Reach capabilities of legacy multimode OM3 and OM4 fibers for typical IEEE standards or MSAs.

However, when 100G/lane is introduced, the system reach is reduced in some cases due to a bandwidth limitation at 850 nm and/or at longer wavelengths. This limitation is particularly evident in applications defined in IEEE Std.802.3db [4]. This standard specifies that transceivers operating solely at 850 nm (including 100G SR, 200G SR2, and 400G SR4) can only transmit up to 60 m over OM3 fiber, due to its modal bandwidth limitation around 850 nm wavelength. While 100 m length transmission over OM4 fiber remains the same as that for 25 Gbaud-based transceivers, the restricted reach of 60 m for OM3 fiber poses challenges for customers who designed their applications around a 70 m distance. It is worth noting that this bandwidth limitation also applies to other 100G/lane VCSEL transceiver technologies, including applications like BiDi and SWDM transmissions that utilize WDM wavelengths [5].

Multimode Fiber Solution for 100G/lane Based Applications

100G/lane based VCSEL transmission can occur either at 850 nm wavelength only or over multiple WDM wavelengths including 850 nm and additional longer wavelengths. To address the needs of high data rate transmission covering these applications, we propose a high data rate optimized multimode fiber ("HDR MMF") concept for future-ready 100G/lane multimode applications [5]. Essentially, "HDR MMF" is defined based on re-categorizing a specific subset of OM3 and OM4 fibers. The effective modal bandwidth (EMB) values of "HDR MMF" required to meet 80 m and 100 m transmission reaches are specified in Table 2. They are defined at two wavelengths, 850 nm and 910 nm, enabling optimal performance of VCSEL transceivers operating at either an 850 nm wavelength only or at both 850 nm and 910 nm wavelengths.

Table 2. “HDR MMF” EMBs for 100G/lane VCSEL applications.

MMF Solution	EMB at 850 nm	EMB at 910 nm	Reach for IEEE Std. 802.3db
“HDR OM3”	2,890 MHz•km	2,220 MHz•km	80 m
“HDR OM4”	4,700 MHz•km	3,100 MHz•km	100 m

The IEEE 802.3db specifications, which mandate transmission only at 850 nm wavelength, are of particular interest for “HDR OM3” fiber. Although the EMB value of “HDR OM3” at 850 nm is only moderately higher than that of the standard OM3 fiber (2890 MHz.km vs. 2000 MHz.km), the improvement in reach capability from 60 m to 80 m is quite significant. It can not only support traditional 70 m OM3 fiber based applications but also transmits up to an 80 m length, which is particulary beneficial for customers requiring 70-80 m distances for a majority of their links.

The 80 m reach capability of “HDR OM3” fiber also backward applies to 25 Gbaud-based VCSEL transceivers operating at an 850 nm wavelength. Since the EMB value of 2890 MHz.km falls within the middle-low range of OM3 EMBs (ranging from 2000 MHz.km to 4700 MHz.km), fibers with such specifications are widely available at large volumes and can enable economic deployments of VCSEL-MMF ecosystems. “HDR OM3” fiber offers customers an additional option to achieve the most cost-effective solution suitable for their distance and bandwidth requirements. Further, IEEE Std.802.3db specifies the use of 8-fiber cable for 400G SR4. This means that the proposed “HDR MMF” is highly compatible with existing structured cabling, enabling incremental cable additionsto current infrastructures as needed.

The proposed EMB values for “HDR MMFs” also support transceivers that operate at both 850 nm and 910 nm wavelengths, enabling longer reach compared to legacy OM3 or OM4 fibers while meeting the same link bandwidth requirements set by IEEE 802.3db for 100G/lane VCSEL transmission. Specifically, “HDR OM4” fiber, which has EMB values of 4700 MHz·km at 850 nm and 3100 MHz·km at 910 nm wavelengths, is capable of achieving a 100 m transmission reach. Similarly, “HDR OM3” fiber, which has EMB values of 2890 MHz·km at 850 nm and 2220 MHz·km at 910 nm wavelengths, can reach up to 80 meters.

Conclusion

In this white paper, we have illustrated the innovative “HDR MMF” concept with compelling benefits. It shares similarities with legacy standard OM3 and OM4 multimode fibers in terms of availability and compatibility with existing infrastructure. For VCSEL-MMF transceivers that only use an 850 nm wavelength, we highlighted that “HDR OM3” fiber can offer a remarkable reach improvement of up to 80 m. As a result, it is an attractive option for VCSEL-MMF transmission that is based on 100G/lane, aligning with IEEE-defined transceiver solutions including 400G SR4 (IEEE Std.802.3db) and 800G SR8 (IEEE P802.3df). In addition, “HDR MMF” can be used for broader WDM applications, making it a versatile choice. As demand for higher data rates and bandwidth continues to escalate, the implementation of “HDR MMF” ensures that structured cabling can meet evolving data center requirements while providing the most cost-effective and sustainable solution for link lengths up to 100 m.

References

[1] https://www.cisco.com/c/en/us/products/collateral/interfaces-modules/transceiver-modules/at-a-glance-c45-740242.html

[2] https://www.ieee802.org/3/cm/

[3] https://www.swdm.org/

[4] https://standards.ieee.org/ieee/802.3db/10283/

[5] Hao Dong and Xin Chen, “The Road to 800G with Multimode Fiber,” https://www.corning.com/catalog/coc/documents/articles/CO8000_Article_Road%20to%20800G%20multimode%20fiber.pdf

Corning Incorporated
www.corning.com/opticalfiber

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