OM5 and SWDM: Are We Ready?

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Application Note

Data centers are constantly moving toward faster speeds and tighter densities – operators want higher performance, but we don't want to take up a lot of physical space to achieve it.

In the past few years, 25G and 100G Ethernet have become mainstream in hyperscale data centers. As a result, the industry is working collaboratively on next-generation network development, such as 200G and 400G Ethernet. As I/O speed increases on active equipment, fiber infrastructure will also need to be upgraded to support higher port density and higher bandwidth with lower channel insertion loss.

Recently, a new multimode fiber (MMF) standard was developed to support a wide range of wavelength multiplexing (from 840 nm to 953 nm), targeting next-generation network applications such as 100G and 400G Ethernet. ANSI/TIA-492AAAE, the new wideband multimode fiber standard, was approved for publication in June 2016. In October 2016, the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) determined the nomenclature for wideband multimode fiber cable: OM5.

To understand the potential impact of OM5, it's important review the new MMF market requirements and applications, the development and technical specifications of OM5 fiber cable, its dedicated shortwave wavelength division multiplexing (SWDM) applications, its technical benefits and limitations, and new technology directions and the market potentials of OM5 and SWDM.

Multimode Fiber Development and Classification

MMF specifications have been developed by the ANSI-affiliated Telecommunications Industry Association (TIA). MMF supports interconnects between servers and switches, primarily in the datacom and local area network (LAN) environments. The system of classification for MMF is determined by the ISO/IEC 11801 standard and is primarily based on the model bandwidth of the MMF type.

With a light-guiding core size significantly larger than singlemode fiber (SMF), MMF is a cost-effective solution for datacom thanks to a high tolerance to fiber misalignment and relatively lower connection loss at each connector interface. MMF cabling systems, combined with LED-based optical transceivers (light-emitting diodes) and

VCSEL-based optical transceivers (vertical-cavity surface-emitting lasers), are an ideal solution for short-reach optical interconnects.

The original MMF standard, ANSI/TIA-492AAAA (OM1, 62.5/125 µm), was released in 1989 to support Fast Ethernet 100BASE-FX and 1000BASE-SX Ethernet, with a high numerical aperture (NA) of 0.275 and light capture from 1300 nm LED sources. The ANSI/TIA-492AAAB standard for OM2 (50/125 µm) was released in 1998, with an improved modal bandwidth and a reduced NA of 0.2 to support higher data transmission, such as 1 Gbps VCSEL with longer reach.

Although OM1 and OM2 have been widely deployed in the past, they are no longer suitable for new Ethernet infrastructure deployment. In the new ANSI/TIA-568.3-D standard, OM1 and OM2 MMF types are “grandfathered in” and are not recommended for new greenfield installation.

To meet growing bandwidth requirements, laser-optimized multimode fiber (LOMMF) standards OM3 and OM4 were developed in 2002 and 2009, respectively, with effective modal bandwidths (EMBs) of 2000 MHz·km and 4700 MHz·km to support 10G, 40G and 100G Ethernet applications, as well as InfiniBand and the Fibre Channel protocols.

While bandwidth requirements are specified at 850 nm and 1300 nm wavelengths, 850 nm VCSEL-based transceivers are dominant in the market thanks to low cost, high yield and improved modal bandwidth of OM3 and OM4 MMF; however, as a multimode laser source, the VCSEL spectral width is a limiting factor to the fiber link reach. To avoid individual wafer-level testing on each GaAs VCSEL laser, the spectral-width specifications have been relaxed for 10 Gbps and 25 Gbps VCSELs at the expense of the reduced transceiver nominal reach.

In ANSI/TIA-568.3-C, the over-filled launch condition was a characterization of LED-based systems in which the light was launched over the entire core of the fiber and measured at 850 nm and 1300 nm. In the ANSI/TIA-568.3-D revision, the encircled flux launch condition, which is a characterization of VCSEL-based systems, has been specified for testing multimode connector performance at 850 nm but eliminates the requirements for testing multimode connector performance at 1300 nm.

Table 1 shows the different MMF standard specifications and their supported link distances for IEEE 802.3 Ethernet applications.

Fiber cable type ISO/IEC 11801	Glass fiber specification TIA-492AAAx	Core diameters (µm)	Max refractive index difference Δn	Mimimum modal bandwitdh (MHz·km)					Maximum glass fiber attenuation (dB/km) TIA-492AAAx IEC 60793-2-10			Maximum fiber cable attnuation (dB/km) TIA 568-3-D ISO/IEC 11801			IEEE 802.3 link distance				
				Overfilled launch (OFL) bandwidth			Effective modal bandwidth								1000-SR	10G-SR	40G-SR4 & 100G-SR10	100G-SR4 & 400G-SR16	50G-SR & 200G-SR4*
				850nm	953nm	1300nm	850nm	953nm	850nm	953nm	1300nm	850nm	953nm	1300nm					
OM1	TIA-492AAAA	62.5	0.02	200		500			3.2		0.9	3.5		1.5	275 m	33 m			
OM2	TIA-492AAAB	50	0.01	500		500			3		1	3.5		1.5	550 m	82 m			
OM3	TIA-492AAAC	50	0.01	1500		500	2000		2.5		0.8	3.0		1.5		300 m	100 m	70 m	70 m
OM4	TIA-492AAAD	50	0.01	3500		500	4700		2.5		0.8	3.0		1.5		400 m	150 m	100 m	100 m
OM5	TIA-492AAAE (WBMMF)	50	0.01	3500	1850	500	4700	2470	2.5	1.8	0.8	3.0	2.3	1.5	no spec	400 m	150 m	100 m	100 m

Table 1: Multimode fiber standard specifications (*standard in progress)

New Applications with Multimode Fiber

Each new fiber type is developed to support higher speed I/O in accordance with new physical medium dependent (PMD) interfaces developed by standards bodies, such as in IEEE 802.3.

Today, 100G Ethernet has become the mainstream speed in access and top-of-rack (ToR) switches in cloud data centers, and they are deployed in the core network in enterprise and multi-tenant data centers; however, as shown in Table 1, due to limited bandwidth of OM4 and other signal-transmission impairments, the nominal reach specification has dropped from 150 m with 40GBASE-SR4 transceivers to 100 m with 100GBASE-SR4 transceivers. Both 40GBASE-SR4 and 100GBASE-SR4 are four-lane solutions, each fiber will carry 10G or 25G serial data, and the eight-fiber connectors (four for Transmit Tx and four for Receive Rx) will be used for -SR4 transceivers.

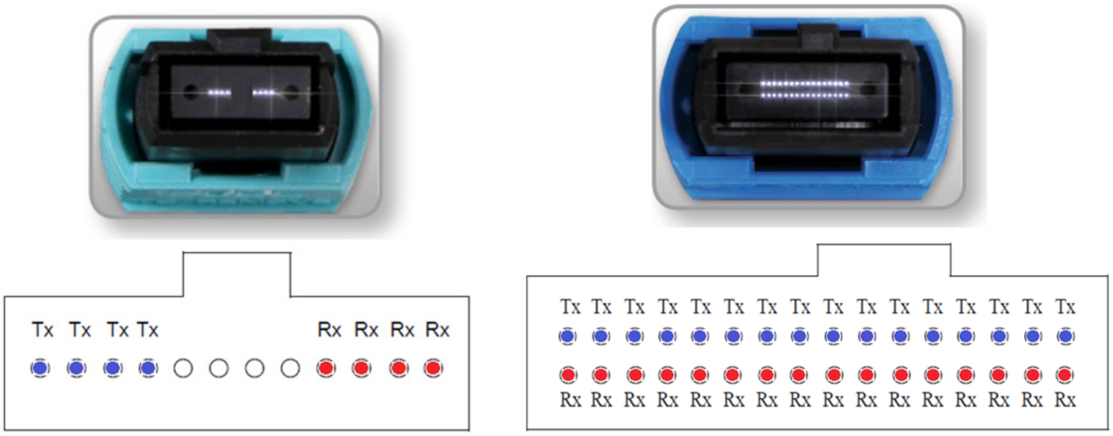

Figure 1: MPO-12 fiber connector and MPO-32 fiber connector

At 25G, the physical channel is subject to much higher loss and more signal integrity impairment than at 10G. Typically, 100GBASE-SR4 transceivers implement the integrated clock-data-recovery (CDR) ASIC for signal recovery and regeneration. Recently, the IEEE 802.3bs 400G Ethernet taskforce adopted the 400GBASE-SR16 PMD with a newly defined MPO-32 connector that supports duplex 25G serial data transmission. Although the 400GBASE-SR16 solution helps considerably increase faceplate density, it increases the number of fibers in each connector, as well as fiber cable assembly complexity. The MPO-32 connector is not compatible with the most popular MPO-12 single-row connector, which raises concerns about the adoption of the MPO-32 connector and the 400GBASE-SR16 form factor.

An Introduction to OM5 Wideband Multimode Fiber

To maintain the appeal of the MMF cabling systems (speed, reach, density and cost), the TIA TR-42.11 and TR-42.12 working groups have developed a new type of MMF. This new fiber type can support wavelength multiplexing between 840 nm and 953 nm, and is backward compatible with OM4 at the 850 nm wavelength.

The EMB is defined to not only support a bit rate of 25.78125 Gbps, as specified in the IEEE 802.3bm 100GBASE-SR4 standard, but to also support a bit rate of 28.05 Gbps as specified in the 32G Fibre Channel (32GFC) standard across the whole wavelength range.

In a multimode fiber link, data rates and maximum reach are limited by:

1. Fiber cable attenuation and connection loss
2. Chromatic dispersion in the fiber
3. Modal bandwidth of the fiber

There are also other factors, including:

- VCSEL rise-fall time
- Transmitter emission power
- Optical modulation amplitude
- Signal-to-noise ratio
- Sensitivity and bandwidth of photo-detectors
- Crosstalk from adjacent channels

These specifications are typically developed by IEEE 802.3 to ensure a technically feasible product with enough margin in mass production.

Now let's take a look at the nominal fiber properties as specified for new OM5 fiber in the ANSI/TIA standard, and elaborate on its improvements over OM4.

OM5 Attenuation and Dispersion Improvement

The IEEE 100GBASE-SR4[1] and the Fibre Channel 32G link model[2] assumptions are used to develop fiber specifications for ANSI/TIA-492AAAE, as a raw glass fiber standard for OM5 fiber cable.

Figure 2a shows the dependence of the fiber attenuation (dB/km) on the wavelength; the attenuation coefficient at 950 nm is ~0.9 dB/km lower than that at 850 nm.

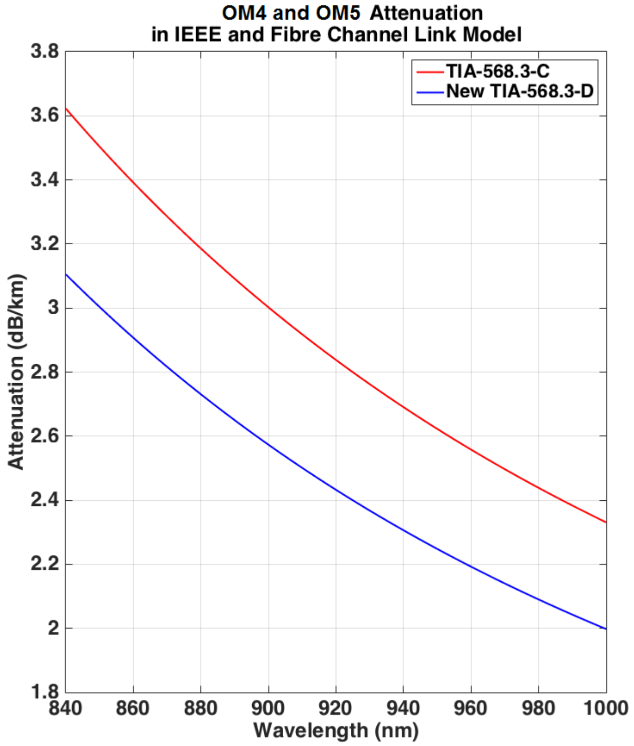

Figure 2a: OM4/OM5 attenuation specification in ANSI/TIA-568.3-C and ANSI/TIA-568.3-D.

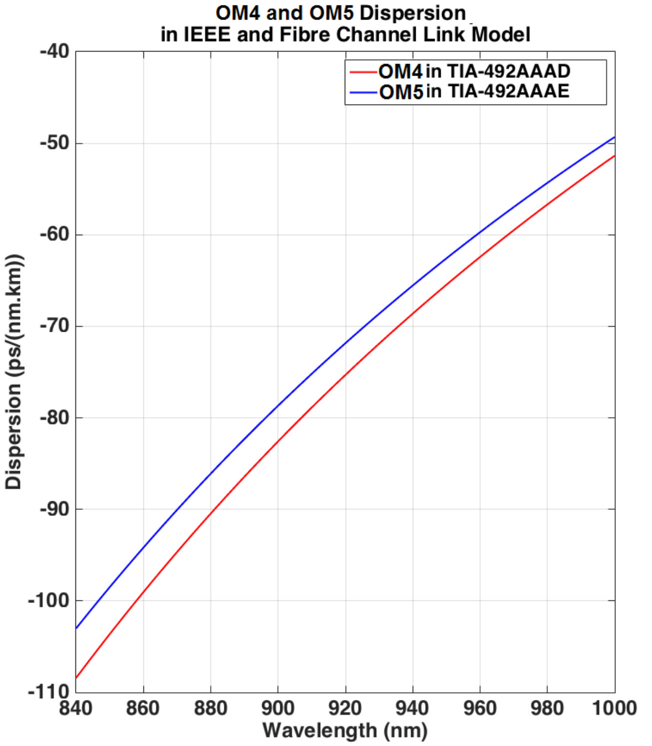

Figure 2b: OM4 dispersion vs. OM5 dispersion in ANSI/TIA-492AAAD and ANSI/TIA-492AAAE.

In the new draft of ANSI/TIA-568.3-D Optical Fiber Cabling and Components Standard, the fiber cable attenuation for OM3/OM4/OM5 has been ratified to 3.0 dB/km at 850 nm. This also lowers fiber cable attenuation at higher wavelengths. Cabled fiber has a slightly higher loss compared to raw glass fiber due to stress from the coating and jacket. With improved fiber-loss specification, it enables a longer reach and allocates more link-loss margin to MMF cabling systems.

Figure 2b shows the dependence of the chromatic dispersion on wavelength. As the wavelength shifts from 850 nm to 950 nm, the value of the chromatic dispersion decreases by 40%. After the round-robin MMF sample tests conducted by different glass fiber manufacturers in 2015, the TIA TR-42.12 community agreed on improved chromatic dispersion minimum requirements as a result of the improved estimates of fiber glass material properties. This also allows attaining a longer reach with OM5, as specified in ANSI/TIA-492AAAE, particularly in the longer wavelength.

Effective Modal Bandwidth

Actual fiber bandwidth is determined by EMB and chromatic bandwidth in the fiber. The minimum EMB of OM4 is specified as 4700 MHz·km at 850 nm only. With current glass fiber manufacturing technology and processes, it's very challenging to provide a flat modal bandwidth profile for OM5 across a range of 840 nm to 953 nm because the material absorption loss in silica glass is wavelength dependent. On the other hand, chromatic dispersion decreases as the wavelength shifts toward 953 nm; as a result, chromatic bandwidth increases with wavelength.

As fiber insertion loss (Figure 2a) and chromatic dispersion (Figure 2b) both decrease as the wavelength shifts from 840 nm to 953 nm, the required EMB to support Ethernet 100GBASE-SR4 and 32GFC operation can therefore be relaxed at higher wavelengths.

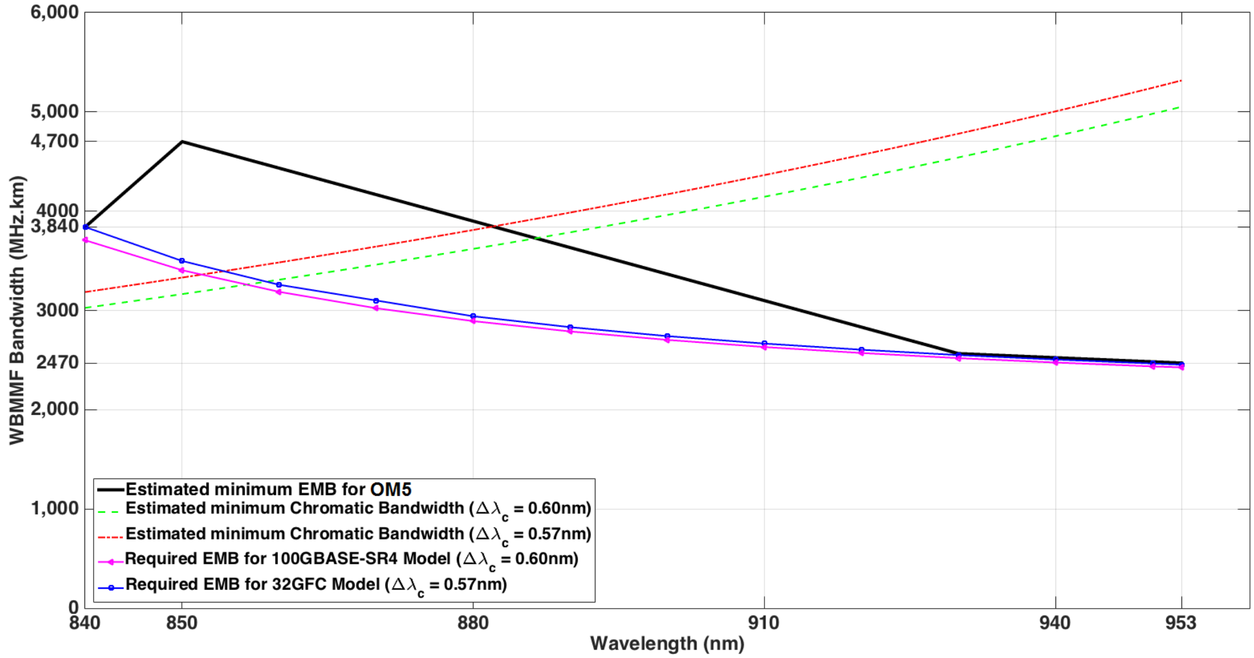

Figure 3: OM5 effective modal bandwidth (EMB) specifications in ANSI/TIA-492AAAE.

Figure 3 shows that the estimated chromatic bandwidth (green and red dashed lines) improves as the wavelength increases from 840 nm to 953 nm, using the IEEE Ethernet and Fibre Channel link model [1, 2] and the enhanced chromatic dispersion specifications in ANSI/TIA-492AAAE for OM5.

Chromatic bandwidth depends on the VCSEL spectral width; hence, the actual chromatic bandwidth using IEEE 100GBASE-SR4 ($\Delta\lambda$ = 0.6 nm) is slightly lower than that of 32GFC ($\Delta\lambda$ = 0.57 nm). The magenta and blue curves indicate the minimum required EMB to support at least 100 m reach for 100GBASE-SR4 and 32GFC in OM5.

As the operation data rate is higher in 32GFC (28.05 Gbps), the link model requires a slightly higher minimum EMB as compared to 100GBASE-SR4 (25.78125 Gbps); therefore, a 32GFC link model is used as a baseline to determine the minimum EMB specification for OM5 where the cable loss specification still conforms to ANSI/TIA-568.3-C. On the other hand, the backward compatibility with OM4 specification also requires OM5 to have a minimum EMB of 4700 MHz·km at 850 nm wavelength.

In Figure 3, the black three-section curve is the specified minimum EMB of OM5 in the ANSI/TIA-492AAAE, which is defined by the following equation:

$$\begin{cases} EMB \geq 3840 + (4700 - 3840) \times (\lambda_c - 840)/(850 - 840) \;\; for \;\; 840nm \leq \lambda_c \leq 850nm \\ EMB \geq 4700 + (2565 - 4700) \times (\lambda_c - 850)/(930 - 850) \;\; for \;\; 850nm \leq \lambda_c \leq 930nm \\ EMB \geq 2565 + (2470 - 2565) \times (\lambda_c - 930)/(953 - 930) \;\; for \;\; 930nm \leq \lambda_c \leq 953nm \end{cases}$$

Note that OM5 potentially has very high EMB at an 850 nm to 900 nm wavelength range to comply with minimum EMB requirements across the 840 nm to 953 nm range.

Toward Shortwave Wavelength Division Multiplexing

Quad small form-factor pluggable (QSFP) is the dominant form factor for 40G and 100G Ethernet transceivers. The MMF cable assembly that connects 100G QSFP28 SR4 transceivers is the same as the 40G QSFP+ SR4 (it uses the MPO-12 [Base-12 or Base-8] fiber interface as specified in the IEEE 802.3bm and 802.3ba standards).

Parallel multimode fiber cabling systems are flexible and can also support the breakout configuration. For example, a 40G port on a top-of-rack switch can be configured as 4× 10G Ethernet ports and connected to four servers with the 10G Ethernet interface.

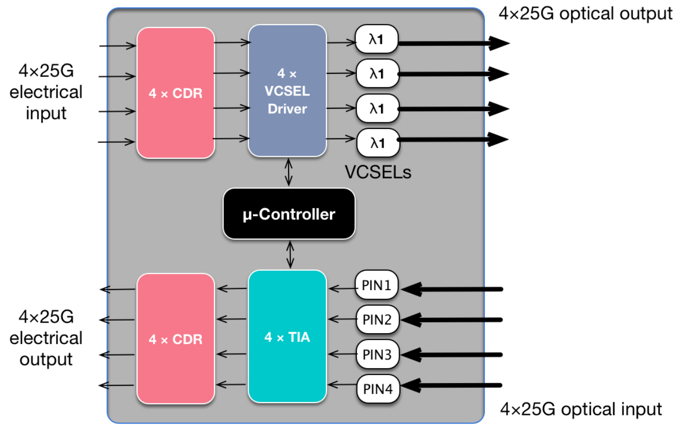

Figure 4: 100G QSFP28-SR4 transceiver with MPO-12 fiber interface

Short-Reach Transceivers Using Duplex Cabling

Parallel MMF MPO cabling is considerably more costly than LC-duplex fiber cable. For a direct 40G port connection, it is more desirable to use a single pair of fiber cable instead of an MPO trunk for cost reduction.

To support smooth migration from 10G to 40G Ethernet with the installed permanent fiber link, Cisco released a proprietary 40G bi-directional (BiDi) transceiver solution that allows the reuse of duplex multimode fiber pair for 40G connection. The BiDi transceiver employs two wavelengths (850 nm and 900 nm) transmitting in the same fiber on opposite directions, with an actual bit rate of 20 Gbps. With the integrated CDR, the 40G-SR BiDi transceiver can support 40G data transmission of 100 m over OM3 fiber or 150 m over OM4 fiber.

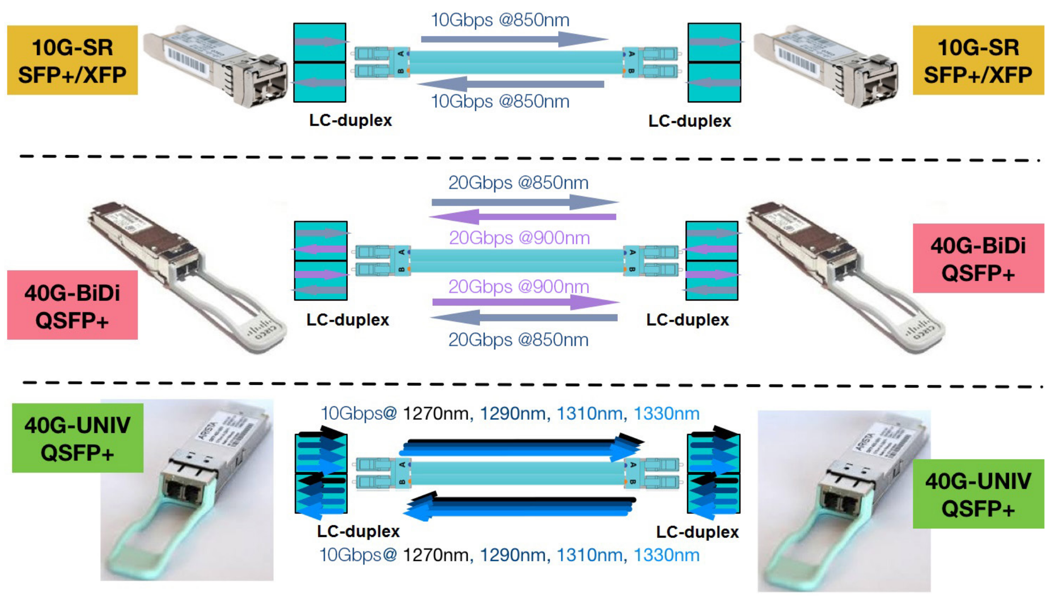

Figure 5: 10G SFP+, Cisco 40G QSFP+ BiDi and Arista 40G QSFP+ Universal transceivers

Arista's 40G universal transceiver is another solution that supports LC-duplex fiber pair instead of MPO cabling. It is interoperable with 40GBASE-LR4 transceivers; the DFB singlemode laser with the same wavelengths (1270 nm, 1290 nm, 1310 nm and 1330 nm) are used in both. The 40GBASE-UNIV module allows the use of an SMF pair for a reach of 500 m, and supports 150 m reach with OM3 or OM4 MMF.

Juniper's proprietary 40G-LX4 transceiver and Finisar's 40G-LM4 transceiver also use similar technology that supports 40G data transmission over single pair of OS1/OS2 SMF or OM3/OM4 MMF.

The rationale of using a single fiber to carry multiple wavelengths (wavelength division multiplexing [WDM]) is not a new concept and has been widely used in the telecom world to reduce the total number of singlemode fibers.

In short-reach datacom applications, BiDi and Universal transceiver solutions that use two and four wavelengths have also proven to be market successes.

Shortwave Wavelength Division Multiplexing

In 2015, the SWDM Alliance was formed by a group of transceiver, fiber and system vendors to develop a multi-source agreement (MSA) for SWDM transceivers. As OM5 permits the use of a much wider wavelength range, it is now desirable to reduce fiber count by transmitting multiple VCSEL wavelengths in the same multimode fiber.

The potential wavelength grids { λ_1, λ_2, λ_3 and λ_4 } are defined as {850 nm, 880 nm, 910 nm and 940 nm}, with a spacing of 30 nm. New SWDM-based QSFP multimode transceivers, including 40G-SWDM4, 100G-SWDM4 and 100G-SWDM2, have already been demonstrated by a few vendors, as shown in Figure 7.

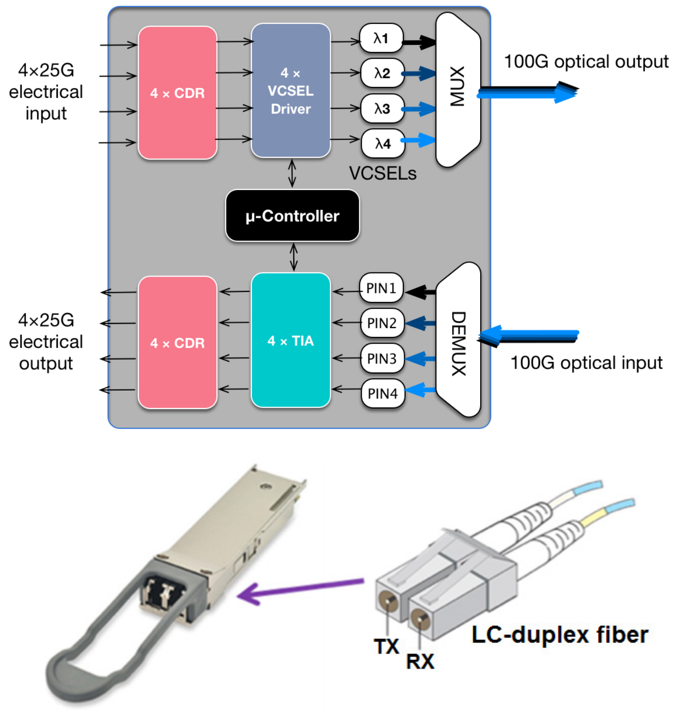

Figure 6: 100G QSFP28-SWDM4 with LC-duplex fiber

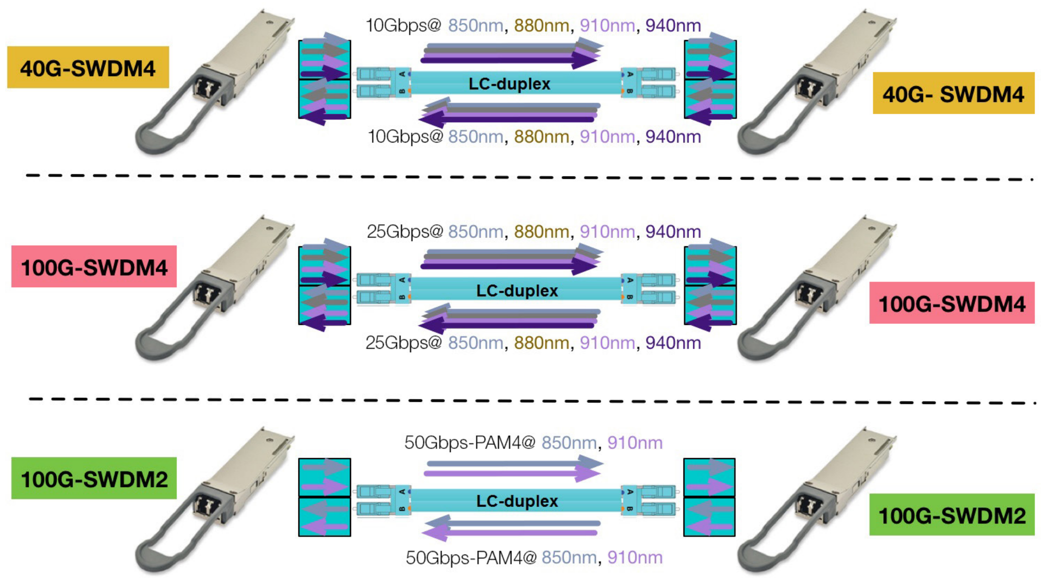

Figure 7: SWDM transceivers with LC-duplex MMF

Limitations of SWDM with OM5

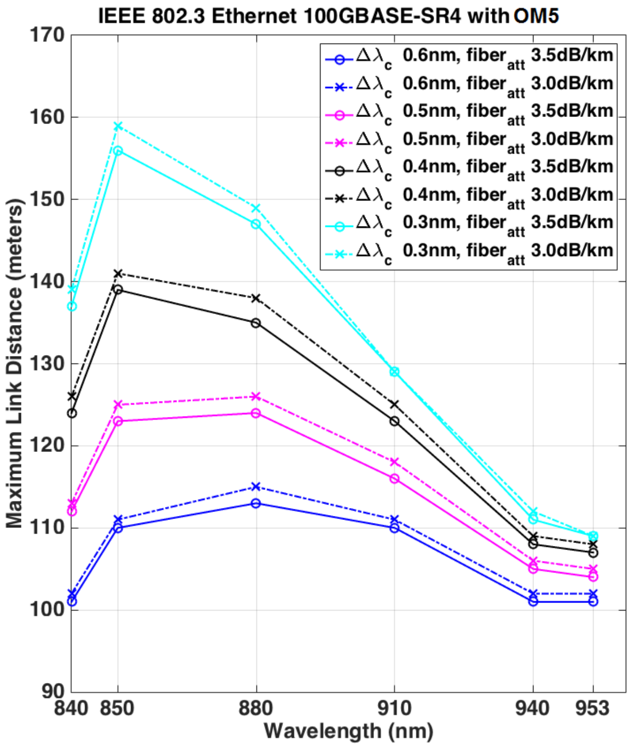

Figure 8: Reach limits in OM5 vs. VCSEL spectral width Δλ (100GBASE-SR4 link model and Fibre Channel 32G link model).

100GBASE-SR4 and 32GFC specify the maximum spectral width Δλ to be 0.6 nm and 0.57 nm, respectively. OM5 was developed to guarantee the 100 m reach operation with zero-dB margin model in IEEE 802.3bm 100GBASE-SR4 and 32GFC standards.

The chromatic dispersion penalty increases as the VCSEL spectral width Δλ becomes larger and decreases actual link reach. In the other words, reducing the Δλ of the VCSEL can extend the maximum link distance.

Comparing Δλ = 0.6 nm to Δλ = 0.3 nm at 850 nm, reach can be extended from 100 m to over 155 m in the same OM5 fiber; however, this improvement shrinks at the longer wavelength end. At 940 nm, there is only a small increment from 100 m to 110 m.

According to some VCSEL manufacturers, it's technically feasible to achieve lower spectral width at the cost of additional wafer-level testing and decreased yield. Nevertheless, as shown in Figure 3, both chromatic dispersion and modal dispersion are limiting factors in wideband VCSEL applications. At 850 nm, the dominant factor is chromatic dispersion; at 940 nm, the dominant factor is the EMB.

The improved MMF cable specification of 3.0 dB/km (in ANSI/TIA-568.3-D) offers another direction to extend MMF reach for higher data rates; however, Figure 7 (page 7) shows that only 1 m to 3 m of additional reach can be attained as compared to the fiber with 3.5 dB/km (as in ANSI/TIA-568.3-C) loss coefficient specification. Instead of allowing a marginal extended reach, it will allocate more link budget to the fiber link for connections.

The EMB of OM5 specified in ANSI/TIA-492AAAE is the minimum glass fiber requirement; some manufacturers can produce OM4 MMF with much higher EMB at 850 nm (e.g. EMB > 10,000 MHz·km); however, high EMB alone cannot allow the equal reach extension across the whole wavelength range.

Figure 9 shows the maximum link distance of 100GBASE-SR4 and 32GFC at different wavelengths as a function of the EMB, using the link model [1, 2]. The improved EMB does not extend the maximum link distance equally over the 840 nm to 953 nm wavelength range. Especially at short wavelengths, the gain is very marginal.

In the 100GBASE-SR4 model, the maximum link distance is bounded by the chromatic dispersion penalty at 850 nm. Even with the EMB = 50,000 MHz·km assumption, the link distance cannot exceed 121 m. At 940 nm, it's possible to attain 150 m reach with EMB = 5000 MHz·km, and its chromatic dispersion bounded reach is 187 m.

From the above analyses, we can conclude that OM5 is beneficial to support SWDM across the 840 nm to 953 nm wavelength range for 100 m maximum reach, and for bit rates of up to 28.05 Gbps as specified in the 32GFC standard.

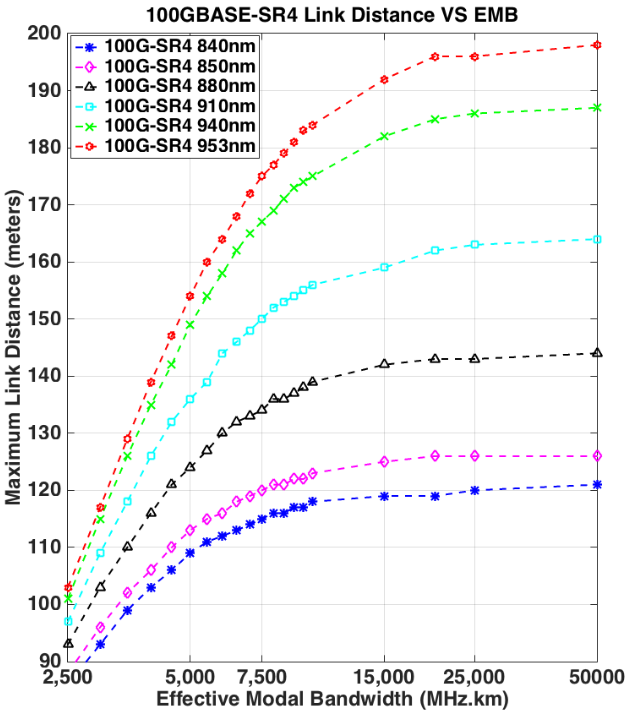

Figure 9a: Maximum reach vs. EMB with 100GBASE-SR4 (Δλ = 0.6 nm, fiber cable 3.0 dB/km).

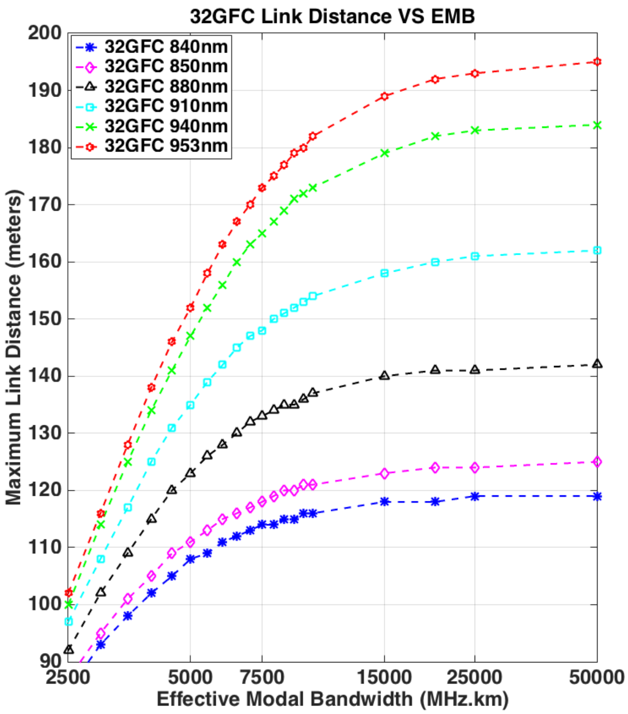

Figure 9b: Maximum reach vs. EMB with 32GFC (Δλ = 0.57 nm, fiber cable 3.0 dB/km).

The interplay of VCSEL spectral width, fiber chromatic dispersion and fiber EMB limits the support of higher signal symbol rate and further reach. To attain more than 100 m reach for all wavelength elements, the VCSEL spectral width has to be reduced significantly at the 850 nm end; the EMB has to be improved at the 953 nm end.

With digital signal processing (DSP), equalization and forward-error correction (FEC) encoding, OM5 has the potential to support between 200 m and 300 m reach. Nevertheless, this potential improvement comes at the expense of more complicated and costly electronics, and higher power consumption. It's still too early to predict whether such costs will negate the appeal of low-cost multimode optics.

From a technology perspective, it makes more sense to move to longer wavelengths beyond 980 nm, where chromatic dispersion and fiber loss are both lower, and an improved EMB can be very efficient in reach extension.

On the other hand, most of the installed base MMF infrastructure is optimized for 850 nm optics; 850 nm VCSELs have been proven by the market as a reliable, cost-effective datacom solution. Furthermore, most of the test gears in production and in field installation are designed for 850 nm optics. This makes the change to higher wavelengths very challenging for market adoption. Meanwhile, singlemode optics have already been established as the best solution for 500 m and 2 km reach in large-footprint data centers.

New Directions and Market Potentials

After the development of the IEEE 802.3 100G Ethernet standard, the industry agrees that the next-generation 50G SerDes interface is no longer economically feasible with the non-return-to-zero (NRZ) modulation format because of various signal integrity issues and power penalty.

This statement also applies to MMF cable and multimode optics. The IEEE 802.3cd taskforce was recently founded to work on next-generation 50G, 100G and 200G Ethernet solutions. Moving from 25G- to 50G-per-lane serial data transmission, if still operating with the NRZ or pulse-amplitude-modulation with 2-level (PAM2), the electronics would encounter significantly higher loss at high frequency.

The VCSEL would be subject to high power and laser safety issues, and the laser spectral width and MMF modal bandwidth would also set a fundamental limit for the reach. As a result, the taskforce decided to use PAM4 modulation with four-level signaling to increase bandwidth efficiency by a factor of two (i.e. each symbol will carry two bits of information instead of one).

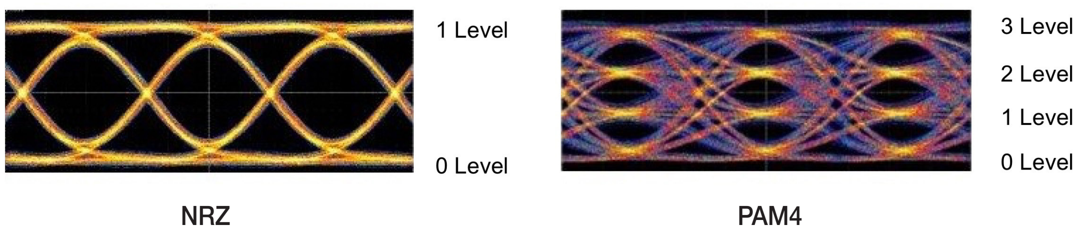

Figure 10: NRZ (PAM2) and PAM4 signaling (source: http://globaltek.us.com/awg6010/)

With the PAM4 modulation, the next-generation 50G per lane can be implemented with the same 25G VCSEL components, with a signaling rate of 26.5625 GBaud (as adopted in IEEE 802.3cd), at the cost of an additional power penalty on optical signal-noise-ratio (SNR) of 4.8 dB [4]. The 50G VCSEL is still in the research and development phase, and will probably be commercialized in the next two or three years.

The advanced modulation format PAM4 is not sufficient to support growing bandwidth requirements. A combination of five technical directions is proposed to support next-generation 100G, 200G and 400G applications:

1. **Faster active optical components** – i.e. optical transceivers with higher bandwidth
2. **Parallel optics** – i.e. high-density optical I/O, high-density array connector and high fiber count
3. **Wavelength multiplexing** – i.e. more wavelengths in one fiber
4. **Advanced modulation formats, such as PAM4** – i.e. higher data rates with the same bandwidth
5. **DSP and FEC encoding** – i.e. higher tolerance to signal transmission penalty

As Table 2 shows, using WDM technology, fiber count can be significantly reduced, and more cost-effective fiber cable, such as LC-duplex, can be used instead of MPO-12/24 trunk cable; MPO-12 can be used instead of MPO-24 or MPO-32. With OM5, it will be possible to transmit two, four or up to eight wavelengths in the same fiber.

Symbole rate / Data rate		10G NRZ		25G NRZ		50G PAM4			
		Parallel (1λ)	WDM(4λ)	Parallel (1λ)	WDM(4λ) & Parallel	Parallel (1λ)	WDM(2λ)	WDM(4λ)	WDM(8λ)
40G Ethernet	Fiber Count	8	2						
	Connector	MPO-12	LC-Duplex						
100G Ethernet	Fiber Count	20		8	2	4	2		
	Connector	MPO-24		MPO-12	LC-Duplex	MPO-12	LC-Duplex		
200G Ethernet	Fiber Count					8	4	2	
	Connector					MPO-12	MPO-12	LC-Duplex	
400G Ethernet	Fiber Count			32	8	16	8	4	2
	Connector			MPO-32	MPO-12	MPO-16/24	MPO-12	MPO-12	LC-Duplex

Table 2: Fiber count and connector type for next-generation Ethernet speeds (grey italic font are assumptions only)

SWDM Challenges and Potentials

Despite the potential advantages of the OM5 and SWDM solution, there are some important considerations:

1. The SWDM ecosystem is not mature; currently, the IEEE 802.3 Ethernet working group has only considered the CWDM and LAN-WDM with singlemode fiber solutions. The SWDM Alliance is independent of other standards bodies. As of today, there are a limited number of vendors that have demonstrated 40G and 100G SWDM-SR4 samples.
2. OM5 doesn't support higher EMB, so the bandwidth gain over OM4 is still unclear. Some 40G and 100G SWDM4 transceiver vendors claim that, with DSP and FEC integration, OM4 fiber can support up to 100 m reach while OM5 can potentially support a longer reach of up to 200 m. Meanwhile, another vendor demonstrated that its 100G BiDi transceiver with 50G PAM4 modulation could support up to 100 m reach in OM4 fiber.
3. To support 40G/100G migration with the installed base fiber cabling system, network equipment vendors are working closely with OEM transceiver suppliers. Transceiver solutions, such as BiDi and Universal, would allow customers to reuse installed OM3 and OM4 fiber for smooth speed upgrades. Currently, OM5 is taking steps toward being recognized as a general cabling solution; the market is expecting a small incremental increase from OM4 costs.
4. Transceiver complexity and power consumption can be potential hurdles for SWDM transceiver adoption; the network equipment and line card may not support high-power transceivers and provide efficient cooling.
5. Compared to parallel fiber solutions, the SWDM solution is less flexible and does not support breakout configuration, which has been used extensively in data center applications.

Conclusion

As an exciting new fiber type with wide wavelength coverage, OM5 is a good addition to the multimode fiber product family, and opens the door for SWDM at a range of between 840 nm and 953 nm. The direct benefit is the reduction in fiber count and fiber cabling costs for next-generation speed migration; however, unlike the upgrade path from OM3 to OM4, which is a simple decision that leads to higher speed and longer reach, OM5 could only be beneficial with transceivers that use multiple wavelengths.

In combination with parallel optics and advanced modulation techniques, OM5 and SWDM will eventually benefit the industry by combining the advantages of high-volume, low-cost VCSEL and high-density, low-loss multimode fiber cabling systems.

From the application standpoint, emerging SWDM transceivers are competing with existing BiDi and Universal transceivers as the new low-cost, middle-reach (500 m to 2 km) singlemode transceivers, such as PSM4, CWDM4 and CLR4. Today, singlemode fiber has gained great traction in hyperscale data centers thanks to its boundless bandwidth and the possibility to support a new generation of speed upgrades.

Singlemode optics and multimode optics both have sweet spots to support different data center applications and interconnect architecture. When evaluating your new fiber infrastructure installation options, it’s essential to understand current applications and the future migration path and scale-out plan to minimize operational risks and reduce total cost of ownership. Product availability, deployment complexity, maintenance and upgrade costs, and backward/forward compatibility also need to be taken into careful consideration – there is no simple or single answer in the new data center ecosystem.

No matter which technology and migration path you choose, a trusted data center infrastructure partner can help determine the most sustainable, cost-effective solutions for you.

To learn more about Belden’s data center solutions
call 800.BELDEN.1 (800.235.3361) or visit
info.belden.com/data-center

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