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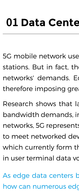
OM5 Optical Fibre

Is Becoming an Important Choice for Data Centers



As 5G networks are constructed and their use grows widespread, the data accessible to us during our daily lives will exponentially increase, placing new demands on society's capacity for computing and storing data. Cloud service providers will ultimately find themselves in competition over many dimensions, including computing capacity, server scale and number of end customers.

Cloud computing, virtualization, streaming media, Internet of Things... almost all of these IT technologies depend on high-speed network transmission to develop further. Network service capability, driven by demand for high-speed network transmission, is gradually becoming an increasingly important yardstick during Data Center planning and construction. And during data center construction standards formulation, cabling system requirements on planning are gradually becoming increasingly forward-looking.

01 Data Center Development Trends

5G mobile network users may need to access network services via local data centers close to their mobile network's base stations. But in fact, the capabilities of existing centers for edge data processing are wholly unable to meet 5G mobile networks' demands. Edge computing and micro data centers are in the earliest stage of explosive growth, and are therefore imposing greater requirements on cloud data centers.

Research shows that large-scale deployment of 5G mobile networks has further intensified cellular operators' network bandwidth demands, in order to meet customers' growing demands for WAN capacity. Compared with existing 4G mobile networks, 5G represents a 10-fold increase in data throughput, and a 100-fold increase in communication capacity. In order to meet networkedge device users' needs, the scale of 5G cloud data centers must continually increase. Existing 100G ports, which currently form the backbone of 5G network cloud data centers, are incapable of supporting exponential increases in user terminal data volumes, making the application of 400G/800G in these settings increasingly urgent.

As edge data centers bring services closer to people and applications, and take on increased data processing burdens, how can numerous edge data centers and cloud data centers handle the exponential growth in network data volumes?

How Can Faster Network Connections be Achieved?

1. Increase Baud Rate
- Increase baud rate
- Adopt more advanced modes of encoding (e.g PAM4)

2. Increase Number of Fibre Cores
- Use MPO/MTP connectors (MPO-12, MPO-24, MPO-16 or MPO-32)

3. Increase Number of Wavelengths.
Use Improved Optical Fibres
- Wavelength division multiplexing (WDM), CWDM/DWDM/SWDM
- Use improved optical fibres

02 OM5 Solves the Distance Limitation of OM3 and OM4 in Data Center

In the latest cabling standards, ISO 11801 3rd and TIA-568.0-D, released in 2017 by the International Organization for Standardization (ISO) and the Telecom Industries Association (TIA), respectively, OM5 fibre's compatibility with VCSEL laser light sources is noted, and the bandwidth characteristics for WDM are specified. This new optical fibre classification method supports a variety of "short" (850 - 950 nm) wavelengths, in a range suitable for high-bandwidth applications after polymerization.

OM5 broadband multi-mode optical cables' attenuation rate has been reduced to 3.0 dB/km from existing OM3 and OM4 optical cables' 3.5 dB/km, while increasing their bandwidth requirement at 953 nm wavelength.

Category of ISO Standard	Maximum Cable Attenuation (dB/km)			Minimum Modal Bandwidth (MHz·km)				
				Overfilled Launch Bandwidth			Effective Modal Bandwidth	
	850nm	953nm	1300nm	850nm	953nm	1300nm	850nm	953nm
OM3	3.5	--	1.5	1500	--	500	2000	--
OM4	3.5	--	1.5	3500	--	500	4700	--
OM5	3.5	--	1.5	3500	1850	500	4700	2470

Table 1 ISO/IEC 11801-1 Technical Parameters for Multi-mode Optical Cable

While supporting the 400G Ethernet of the future, OM5 fibre offers increased transmission ranges for applications such as 400GBase-SR4.2 (4 pairs of optical fibres, 2 wavelengths, with each channel using 50G PAM4) or 400G Base-SR4.4 (4 pairs of optical fibres, 4 wavelengths, with each channel using 25 GNRZ).

Rate (Gb/s)	Standard	Wavelength (nm)	Fibre Number	Maximum Transmission Distance (m)		
				OM3	OM4	OM5
10	10GCBase-SR	850	2	300	550	550
25	25GBase-SR	850	2	70	100	100
40	40GBase-SR4	850	4	100	150	150
100	100CBase-SR4	850	4	70	100	100
	100CBase-SR10	850	20	100	150	150
400	400GBase-SR16	850	32	70	100	100
	400GBase-SR8	850	16	70	100	100
	400GBase-SR4.2	850/910	8	70	100	100

Table 2 List of Transmission Ranges for Parallel Multi-mode

Multi-mode Link Distance 400G BiDi MSA		
OM3 Operating Range	OM3 Operating Range	OM5 Operating Range
0.5m to 70m	0.5m to 100m	0.5m to 150m

Table 3 List of Transmission Ranges for Multi-mode Link Media Supporting 400G BiDi MSA

Rate (Gb/s)	Duplex Application	Parallel Application	Maximum Transmission Distance(m)			Number of Fibre Core
			OM3	OM4	OM5	
40	--	40GCBase-SR4	100	150	150	8
100	--	100CBASE-SR2	70	100	100	4
	--	100CBASE-SR4	70	100	100	8
	--	100CBASE-SR10	100	150	150	20
40	40G-SWDM4	--	240	350	440	2
100	100C-BiDi	--	70	100	150	2
	100G-SWDM4	--	70	100	150	2
200	--	200GBASE-SR4	70	100	100	8
400	--	400C-BiDi	70	100	150	4

Table 4 List of Multi-mode Application and Transmission Ranges for Data Centers

Over the last few years, various optical fibres and module manufacturers have reported their latest transmission results for OM5 and "ultra wideband multi-mode fibre" using PAM4 modulation and WDM technology. The experimental results reported reveal that OM5 fibre is capable of supporting 100 Gb/s, 200 Gb/s and 400 Gb/s multi-wavelength transmission systems over ranges in excess of 150 m, giving this fibre a clear transmission range advantage over OM3 and OM4 under various transmission standards. OM5 should therefore remain the leading multi-mode fibre in data center cabling.

03 OM5 Solves the problem of need for Rapid Optical fiber Cable Growth Due to the demanded of Increasing Bandwidth and Latency

OM5 fibre has the same physical dimensions (50 μm core, 125 μm cladding) as OM3 and OM4, maintaining backward compatibility with these fibre classes that makes for smooth upgrades from 10G to 400G or even higher transmission rates - an indication of its flexibility and scalability in application. OM5 fibre can support higher-speed network transmission with fewer multi-mode fibre cores at far lower cost and power consumption than single-mode fibre. At present, large data centers' transmission rates are constantly increasing, with 100G/200G/400G super-large data centers under construction or on the drawing board. Use of existing OM3/OM4 multi-mode fibre would require huge numbers of fibre uplinks, putting great pressure on data center cabling and impacting air circulation, thereby leading to long-term increases in data center power requirements.

IEEE 802.3, published November 2017, established the Next-generation 200 Gb/s and 400 Gb/s Multi-mode Fibre Physical-layer Research Group (the "NGMMF Research Group"). This aims to develop methods for reducing the number of multi-mode fibres necessary for 200 Gb/s and 400 Gb/s transmission relative to existing Ethernet systems. At the NGMMF Research Group's first formal meeting, in January 2018, the replacement of 400GBASE-SR16 with 400GBASE-SR8 or 400GBASE-SR4.2 solutions was proposed, in order to permit support of 400G Ethernet. The 400GBASE-SR8 solution uses 8 pairs of optical fibres, and makes excellent use of the strengths of existing technology (eg by adopting more VCSEL-friendly PAM4), at an 850 nm target wavelength. Currently, several optical-module packaging techniques including QSFP-DD, OSFP and COBO 8-Lane are available. The 400GBASE-SR4.2 solution uses 4 pairs of optical fibres (each of 2 wavelengths), and maintains the cabling mode adopted by existing 100 GBASE-SR4 solutions. It also adopts PAM4 modulation technology, with an 850 nm target wavelength and one longer-wavelength light source. The 400GBASE-SR4.2 solution under PAM4 modulation is best suited to use of multiple wavelength OM5 fibre cabling. This can reduce pressure due to 400G networking's increasing cable counts, via increasing the number of wavelengths.

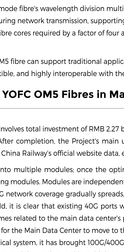


Figure 1 Transmission on 4 Different Multiplexed Wavelengths on an OM5 Fibre Sample

04 OM5 Remains the Dominant as Multi-mode Fibre in Data Center

- **Standards association approvals**: At present, OM5 fibre is compliant with the Communications Industry Association's TIA 492AAAE, and the sixth edition of the IEC's 60793-2-10 specifications. The OM5 and TIA 492AAAE specifications are recognized in the third edition of IEC/ISO 11801, and ANSI cabling standard ANSI/TIA 568.3-D.
- **Strong scalability**: In the future, OM5 fibre will be capable of combining short wavelength division multiplexing (SWDM) and parallel transmission technology, only requiring 8-core broadband multi-mode fibre (WBMMF) to support 200/400G Ethernet applications.
- **Reduce the costs**: Drawing on single-mode fibre's wavelength division multiplexing (WDM) technology, OM5 fibre extends the wavelength range available during network transmission, supporting up to 4 wavelengths on a single-core multi-mode fibre, cutting the number of fibre cores required by a factor of four and greatly reducing the cost of cabling a network.
- **Compatibility and interoperability**: OM5 fibre can support traditional applications in just the same way as OM3 and OM4 fibres, and thus remains fully compatible, and highly interoperable with these.

05 China Railway Deploys YOFC OM5 Fibres in Main Data Center

China Railway's Main Data Center Project involves total investment of RMB 2.27 billion, in premises covering about 70 mu and a total built-up area of 46,000 m². After completion, the Project's main uses will include storage of core railway industry data, storage and transmission of China Railway's official website data, etc.

Cabinets in the data center are divided into multiple modules; once the optimal scheme within a module has been discovered, it can be copied to the remaining modules. Modules are independent from one another, allowing "some to be active while others are being set up". As 5G network coverage gradually spreads, increasing data throughput capacity to 10 fold, and communication capacity 100 fold, it is clear that existing 40G ports will become incapable of supporting the rapid increases in user terminal data volumes related to the main data center's provision of railway, big data application, ticketing system, etc., making it necessary for the Main Data Center to move to the forefront of networking. By becoming the first data center to apply the OM5 optical system, it has brought 100G/400G or even 800G systems within the realm of possibility. The OM5 fibre products are mainly used to achieve high-speed transmission between ToR-leaf and leaf-spine.

24-core MTP pre-terminated optical cables can be extended to provide 12 100G channels, upgradable to 2 400G channels through alternative adapter units. The Project has mainly adopted a C4 high-density fibre distribution frame, MTP-LC adapters and 24-core MTP OM5 pre-terminated optical cables.

06 OM5 Fibre Is Becoming an Important Choice for Data Centers

Multi-mode fibre has always been an efficient, flexible transmission medium, capable of continuous adaptation to higher speed network transmission via the development of new potential applications. Multi-mode fibre with VCSEL offers advantages in terms of low link cost, low power consumption and high availability, which have made it the most cost-effective data center solution for the majority of enterprise customers. Continuous, stable growth in demand from cloud data centers and enterprise local data centers also provides cost-effective multi-mode fibre solutions with broad market prospects.

Yangtze Optical Fibre and Cable Joint Stock Limited Company (YOFC) has conducted experiments testing 400G SR8 transmission and 100G SWDM4 transmission at 850 nm and 908 nm wavelengths over samples of YOFC OM5 fibre. These indicate that this OM5 fibre can support error-free transmission at 50 Gbps over at least 500 m at 850 nm wavelength under PAM4 signaling, and at least 300 m at 908 nm wavelength. Under the 100G SWDM4 transmission system, moreover, the OM5 fibre sample could support link transmission at ranges of over 400 m. In conclusion, these results demonstrate the advantages of OM5 fibre in high-speed data center interconnection applications, at transmission rates of 100 Gbps, 400 Gbps, etc.

Scalable and flexible OM5 fibre can support higher-speed network transmission over fewer multi-mode fibre cores via improved transmission rates and an increased number of wavelengths, reducing its cost and power consumption to far lower levels than for single-mode fibre. OM5 fibre thus has broad scope for future application in hyper-scale data center of 200G/400G/IT networking.