

### Introduction

Over the past 25 years, Ethernet standards have evolved from 10 Mbps and 100 Mbps to 1Gbps and now 10Gbps. The rapid growth of Internet use and bandwidth-intensive applications combined with routine transmission of large files is driving the need for 10 Gigabit Ethernet (10GigE) in many network backbone and Data Centre connections. Implementation is happening all around us. Sales of 10GigE switch ports are increasing dramatically, and will continue to grow over the next decade.

With increased network speeds comes a rise in the significance of fibre optic cabling and connectivity. Most Data Centres today have equal amounts of fibre and copper terminations, and fibre links are vital to carrying backbone traffic to and from a large number of sources. With many grades to choose from, selecting the right fibre type for your network can be an overwhelming task. Careful consideration of price, bandwidth, and distance is critical to choosing fibre today that will support requirements in the future. Laser optimised 50µm multimode fibre offers many benefits for both today's and tomorrow's network and Data Centre applications, and it may be the key to maximising your investment.

### An Inevitable Shift

Although 50µm multimode fibre was developed 10 years prior to 62.5µm, North America adopted fibre distributed data interface (FDDI)-grade 62.5µm fibre for Ethernet in the late 1980s. At that time, connectorisation and alignment were not as controlled as they are today, and the larger-core 62.5µm was ideal for use with larger light-emitting diode (LED) transmitters.

As backbone speeds increased to Gigabit Ethernet, LED signaling technology was no longer a viable solution. With a maximum modulation rate of 622 Mbps, LEDs could not be turned on and off quickly enough to support the higher bandwidth. This caused the industry to shift to low-cost vertical-cavity surface emitting laser (VCSEL) transmitters operating at 850nm (short wavelength). VCSELs have much faster rise and fall times than LEDs with more power and a smaller spot size.

Unfortunately, the use of VCSELs can cause differential mode delay (DMD), an effect that happens when the laser beam launched into a small area of the fibre's core splits into several modes of light traveling at different speeds. DMD ultimately causes the transmission pulse to spread out, which reduces the ability of the receiver to properly identify the signal and therefore reduces transmission capacity (see Figure 1).

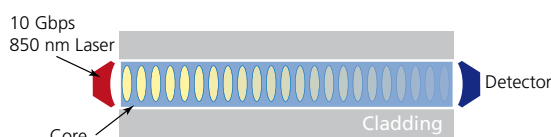


Figure 1. The Effect of DMD on Transmission

Because a larger fibre core has more modes of light excited and more modal dispersion, VCSELs do not perform as well with 62.5µm multimode fibre as they do with 50µm. So when low-cost 850nm VCSEL transmission technology was introduced for higher speeds, the industry moved away from 62.5µm fibre to 50µm. However, as the 10 Gigabit Ethernet standard developed, it became apparent that even 50µm multimode fibre could not take full advantage of the VCSEL point-like precision technology to run 10GigE over a 300-metre distance. As a result, fibre manufacturers began manufacturing laser optimised 50µm multimode fibre, which is now the most recommended fibre type for new installations and upgrades.

### Truly Advanced Technology

What exactly is laser optimised fibre and what does it mean? It's important to acknowledge that the term "laser optimised" is not a marketing ploy or misnomer. Also referred to as OM3 fibre, laser optimised fibre is specifically designed, developed, and tested for effective use with 850nm VCSELs.

With standard fibre, defects and variations in the fibre core can affect the angle and speed that a light pulse can travel. This can effect the refractive index profile of the material, which is calculated as the ratio of the speed of light in a vacuum to the speed of light through the material. For example, the refractive

# Technical Reference

## Laser Optimised Fibre

index of a vacuum is 1.0, while air is slightly higher than 1.0, and glass ranges from 1.45-1.48. The higher the refractive index, the slower the speed of light through that media.

In laser optimised multimode fibre, manufacturers have removed impurities and carefully graded the index of refraction of the fibre core to enhance VCSEL transmission. By carefully controlling the refractive index profile, DMD is reduced and the several modes of light are able to travel at similar speeds thus increasing the modal bandwidth. This prevents the transmission pulse from spreading out, and as a result, the receiver can accurately detect the signal over longer distances, therefore maximising bandwidth (see Figure 2).

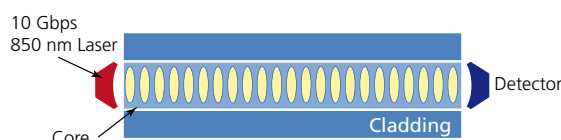


Figure 2. Laser Optimised Fibre Reduces DMD for Reliable Transmission

Laser optimised 50µm fibre provides a much higher modal bandwidth than standard 50µm or 62.5µm fibre. A 10GigE signal at a wavelength of 850nm is only guaranteed for 26 metres on standard 62.5µm fibre and for 86 metres on standard 50µm fibre. Standard laser optimised 50µm fibre can support 10GigE to 300m, which is the distance specified under TIA standards as the minimum distance for backbone cabling. Higher-grade laser optimised 50µm multimode fibre can even support 10GigE beyond the standard to distances up to 550 metres.

Laser optimised (OM3) 50µm fibre is now well accepted in the industry, and many cable and connectivity manufacturers offer a variety of 50µm fibre optic products. Laser optimised 50µm fibre has also been accepted and specified by all major standard bodies, most notably under IEEE 802.3 and ANSI/TIA/EIA 568-B. IEEE Gigabit Ethernet and 10Gigabit Ethernet standards with related fibre types and bandwidths/distances are shown in Table 1.

Channel	Gigabit Link @ 850nm Laser IEEE 802.3z 1000BASE-SX	Gigabit Link @ 1310nm Laser IEEE 802.3z 1000BASE-LX	10 Gigabit Link @ 850nm Laser IEEE 802.3ae 10GBASE-SR	10 Gigabit Link @ 1310 CWDM Laser IEEE 802.3ae 10GBASE-LX4*
62.5/125 µm multimode fibre				
OM1	300m	550m	35m	300m
50/125 µm multimode fibre				
OM2	750m	600m	80m	300m
OM3	970m	600m	300m	300m
OM3e	1040m	600m	550m	300m

\*LX4 standard uses Wide Wave Division Multiplexing scheme

Table 1. Fibre Type and Distance per IEEE Standards

As shown in Table 1, standard 62.5µm and 50µm only support 10GigE to 300m using Wavelength Division Multiplexing (WDM) electronics, which uses four laser sources at 2.5 Gigabit each and is cost prohibitive. With 62.5µm fibre making up much of the installed base, the IEEE is exploring ways to run 10 Gigabit Ethernet over 300 metres of 62.5µm fibre with the use of a singlemode laser source. The proposed standard, however, is slow to develop and does not currently appear as cost effective as upgrading to laser optimised 50µm multimode fibre, the benefits of which are many.

### Maximising Your Investment

With the same percentage of terminations as copper, fibre optic cabling and connectivity is a significant part of the Data Centre. Fibre backbone links are also the most critical links because they carry data to and from a large number of sources, including telecommunication rooms and the outside world. As emerging technologies continue to be layered onto the network, laser optimised 50µm fibre will be key to maximising your investment in all LAN applications.

Laser optimised 50µm multimode fibre is ideal for use in any LAN infrastructure or Data Centre application, including campus backbone, riser, storage, or horizontal connections. Laser optimised 50µm fibre is available in several grades and construction types to meet a variety of applications and cost benefits. For example, ADC KRONE's TrueNet® Structured Cabling solutions include three grades of laser optimised multimode fibre – OM2, OM3, and OM3e, which support 10GigE to 80m, 300m, and 550m respectively. Each of these laser optimised grades is also available in a variety of constructions including outside plant, indoor/outdoor and armoured.

Because fibre optic cabling is backwards compatible, but not forwards, it's critical to choose fibre today that will support current and future bandwidth requirements. Laser optimised 50µm fibre is compatible with legacy LED signalling technology while enabling migration to higher speeds. In other words, you can install laser optimised fibre today for use with slower data rates, and when the need for more bandwidth arises, you only need to upgrade electronics to VCSEL-based transceivers for GigE or 10GigE. As discussion begins surrounding next-generation Ethernet like 40Gbps or 100Gbps, it's expected that laser optimised 50µm multimode fibre will also support those speeds through higher-grade fibres or WDM schemes.

When you consider the total investment to upgrade or deploy a network or Data Centre, the cost difference between fibre types is minimal. Singlemode fibre electronics, however, can cost two to three times more than multimode electronics. In addition, it is anticipated that the cost per port of 10GigE over fibre will continue to decrease. So choosing laser optimised 50µm multimode fibre just makes sense – it's the one fibre type that allows for affordable electronics while reaching all areas of your LAN, providing the most flexibility and future growth for your Data Centre and backbone infrastructure.

### Conclusion

As you set out to choose a fibre type for your LAN infrastructure and Data Centre connections, it's important to recognise that within the rank of multimode fibre are higher performance grades known as laser optimised multimode fibre. Gigabit and 10 Gigabit Ethernet speeds in the backbone are a reality today, and so is this remarkable advanced fibre technology. Laser optimised 50µm multimode fibre offers the following benefits over other types of fibre:

- Offers the most bandwidth with cost-effective 850nm VCSELs
- Ensures reliable transmission through advanced technologies
- Thoroughly recognised and specified by standards bodies
- Enables easy migration to Gigabit and 10 Gigabit network speeds
- Ideal for use in any LAN or Data Centre fibre connection
- Available in several products, grades, and cable constructions

It is important to carefully examine your network and evaluate the distances and bandwidths required now and in the future. To maximise your investment, you must choose the correct type and grade of fibre to support future needs.

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