AMP NETCONNECT
XG OPTICAL FIBER SYSTEM

The Complete High-Performance, Cost-Effective Optical Fiber Premises Cabling Solution for Supporting Ten Gigabit Networks

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INTRODUCTION

If history is any indication, network applications will continue to demand higher data transfer rates. New applications such as high-resolution graphics and complex scientific modeling continue to pressure bandwidth requirements at the desktop and backbone. Increases in the number of high bandwidth applications, the number of users and the volume of network traffic dictate that old 10 Mb/s Ethernet and 100 Mb/s Fast Ethernet LANs will be replaced with even higher-speed LAN and data center connections. Fibre Channel networks, too, are migrating to faster data rates, and LAN applications are evolving to cover the WAN and even access applications like fiber to the home (FTTH). Conclusion: network managers have to look for even higher data rates than the 10/100 Mbit/s or even one gigabit per second.

Many network owners have turned to Gigabit Ethernet (1000 Mb/s or 1 Gb/s) to maintain acceptable performance levels. While the need for a gigabit "pipe" to the desktop may seem like overkill today, it is a logical progression and cabling installed today should be capable of at least gigabit data rates. The rapidly decreasing price differentials between Fast Ethernet and Gigabit Ethernet also make an effective argument for installing Gigabit Ethernet electronics today as an inexpensive insurance policy against future upgrades to the electronic end equipment. However, just as the growing number of Fast Ethernet connections created the need for Gigabit Ethernet connections, so too has Gigabit Ethernet created the need for Ten Gigabit Ethernet (10000 Mb/s or 10 Gb/s).

Ten Gigabit Ethernet (10GBASE-X) provides the solution for high-speed backbone connections as a natural upgrade for extending the existing network investment to ten gigabit per second speeds at a reasonable cost without the need to re-educate support staff. The IEEE 802.3ae task group spent over two years developing the Ten Gigabit Ethernet Standard, which was published in 2002. This Standard provides the opportunity to significantly increase the system bandwidth while maintaining compatibility of the installed base of Ethernet.

The convenience of a one-fiber-fits-all solution is inestimable, and this convenience did not escape notice during the development of the 10-gigabit applications. This convenience is evident in **The AMP NETCONNECT XG Optical Fiber System**, which provides a migration path from 10 Mb/s all the way to 10 Gb/s on the same fiber, using the lowest-cost wavelength (850nm) for the complete

horizontal and building backbone (or “riser”) network. The XG Optical Fiber System offers the high bandwidth ‘850nm laser-optimized 50/125µm’ fiber, cables and connector components capable of running 10-gigabit applications, such as Ethernet and Fibre Channel, for distances of 2 to 300 meters at a wavelength of 850nm. This same fiber supports legacy applications just as well or even better than the standard laser certified 50/125µm fibers. Install the XG fiber today, use it today, and use it for future equipment upgrades to 1 and 10 Gb/s without re-cabling.

HISTORY

Gigabit Ethernet, and now 10 Gigabit Ethernet, demand fast optical sources to support the rapid modulation rates necessary for intelligible bit streams, yet still need the low-cost advantages that propelled Ethernet to become the most popular LAN application. The traditional and inexpensive light-emitting diode (LED) can be utilized only for applications running up to 622 Mb/s - the output is unreadable at faster data rates. Single-mode lasers, capable of higher speeds, have been available for many years, but are much more expensive than the common LEDs. Fortunately, the industry developed and refined a cost-effective laser technology called the VCSEL (Vertical Cavity Surface Emitting Laser) for short wavelength (850nm), high-speed data applications.

Of course, a source is only as good as its coupled fiber. The standard 62.5/125µm and 50/125µm fibers were fine for use with LED sources and their overfilled launches. The newer laser certified multimode fibers are generally sufficient to support VCSELs used for Gigabit Ethernet and similar data rates for LAN networks for distances to 300 meters. However, to take advantage of 10Gb/s VCSEL technology, a higher bandwidth fiber had to be developed to reach the same distances.

Physical limitations prevent a 62.5/125µm multimode fiber from providing bandwidth this high in the 850nm window, except in rare cases. A 50/125µm fiber typically offers higher bandwidth, but is designed with an index of refraction profile that provides optimum bandwidth near 980nm, providing good bandwidth at both the 850nm and at 1300nm wavelengths – the two operating wavelengths for premises optical networks (this explains why standard 50/125µm fiber offers equal bandwidth for both wavelengths, typically 500 MHz·km). However, the models show that 500 MHz·km is not sufficient for 300 meters of 10 Gb/s. In fact, neither is 1000 MHz·km, nor even 1500 MHz·km. To

support 10 Gigabit Ethernet and 10 Gigabit Fibre Channel to the full 300 meters, 2000 MHz·km bandwidth is needed at 850 nm. Unfortunately, the normal production of 50/125µm fiber is unlikely to produce a fiber of this bandwidth, so a change was needed.

The result was the "850nm laser-optimized 50/125µm fiber" – fiber produced by making small changes in the index of refraction profile (the fiber core's index of refraction vs. core position) of a 50/125µm fiber to provide the maximum bandwidth at 850nm, rather than 980nm. With this change, it became possible to produce fibers with the minimum bandwidth needed to support 10Gb/s applications to the full 300m distance of structured cabling building backbones. This fiber, specifically designed to work with the 850nm VCSELs was optimized for these sources – 850nm laser optimized.

Even that was not enough to ensure the necessary operation. The traditional overfilled launch (OFL) bandwidth measurement could not assure that a 2000MHz·km fiber would support a 10Gb/s application. Because VCSEL sources only partially fill the multimode fiber core with light, it is much more susceptible to perturbations in the optical fiber's index of refraction profile. These perturbations, a consequence of the manufacturing process, are most pronounced in the centerline of the fiber - at the point where the VCSEL launches. Instead of OFL, a new measurement method was developed that approximates a laser launch and compensates for the light power distribution in the core. Now, it is easy to determine the ability of a fiber to support 10Gb/s data rates for the 300-meter distance.

This fiber, called 850nm Laser-Optimized 50/125µm Multimode Fiber or OM-3 fiber in the industry standards, is available for the networks of today and tomorrow. At AMP NETCONNECT, this fiber is our standard XG Fiber.

WHY 850NM LASER-OPTIMIZED 50/125 µM MMF?

In a word, the answer is "compatibility". This fiber, with a laser bandwidth of 2000 MHz·km @ 850nm complies with the optical fiber performance requirements of laser-based applications. This fiber is also verified to have an LED bandwidth of at least 1500/500 MHz·km, so it can still support all legacy

systems using LED sources. Thus, this one fiber type will support the network needs of today (Ethernet, Token Ring, Fibre Channel, FDDI, Fast Ethernet, etc.), of tomorrow (Gigabit Ethernet, 2-Gigabit Fibre Channel, etc.) and beyond (10 Gigabit Ethernet and 10 Gigabit Fibre Channel). Further, this fiber type supports the use of 850nm optical sources – the lowest cost sources – and the electronics that use them (see Table 1). Now, there is no need to buy higher-cost electronics to compensate for lower-performance fiber or to re-cable a facility with single-mode fiber in order to migrate to faster data rates.

Table 1: IEEE Distances for 850nm Serial 10 Gigabit Ethernet (10GBASE-SR)

	OFL Minimum Bandwidth (MHz•km) @850/1300nm	10GBASE-SR Serial 850nm (meters)
TIA 62.5/125 µm	160/500	2 - 26
ISO 62.5/125 µm	200/500	2 - 33
50/125 µm	400/400	2 - 66
50/125 µm	500/500	2 - 82
XG 50/125 µm	**2000*/500** (* Laser Bandwidth)	**2 - 300**

The fibers in the XG Fiber System are screened to ensure clean laser light transmission, while still providing clean LED light transmission. This clean laser light transmission has an additional benefit for lower-speed applications. The fiber performs as a “laser-certified” or “Gigabit Enhanced” 50-micron fiber, which means extended operating distances for Gigabit Ethernet – up to 1 kilometer (see Table 2)!

Table 2: Distance Capability of Gigabit Ethernet

	Minimum OFL Bandwidth (MHz•km) @850/1300nm	1000BASE-SX Serial 850nm (meters)	1000BASE-LX Serial 1300nm (meters)
TIA 62.5/125 µm	160/500	2 - 220	2 - 550
ISO 62.5/125 µm	200/500	2 - 275	2 - 550
TIA 50/125 µm	500/500	2 - 550	2 - 550
AMP NETCONNECT 62.5/125 µm	200/500	2 - 300	2 - 500
AMP NETCONNECT 50/125 µm	500/500	2 - 600	2 - 600
XG 50/125 µm	**1500/500**	**2 - 1000**	**2 - 600**

In Table 1, the 10 Gigabit Ethernet distances of 62.5/125µm and 50/125µm at 850nm are too short for a 300-meter riser or for a centralized optical fiber network. Standard 50/125 optical fiber can support Gigabit Ethernet on a majority of the horizontal, centralized and riser network links installed today, but distance limitations for 10 Gigabit speeds mean either deploying single-mode fibers and the associated high-cost electronics to cover a 300m distance, or deploying the 850nm laser-optimized 50/125µm. The **AMP NETCONNECT XG Optical Fiber System** will support 10 Gigabit applications for TIA-568 horizontal cabling (100 meters maximum), centralized LAN and data center cabling (300 meters maximum), and building backbone cabling (300 meters maximum), as well as short campus backbones to distances of 300 meters. The high data rate capabilities and flexibility of supported applications also make this fiber the recommended fiber type in TIA-942, *Telecommunications Infrastructure Standard for Data Centers*, the standard for data center cabling.

WHY NOT JUST BUY HIGHER BANDWIDTH FIBER?

The bandwidth provided on specification sheets for standard fibers is LED, or overfilled, bandwidth. For applications where only LED sources will be used, a higher bandwidth may, depending on the application, support higher performance levels. However, LED bandwidth is not a good predictor of performance with laser sources. Because the overfilled measurement minimizes the impact of any index of refraction profile centerline defect, this measurement may not indicate a problem that

underfilled launches from laser sources will experience. Accordingly, high LED bandwidth does not mean better laser performance. In fact, some fibers installed today have lower laser bandwidth than LED bandwidth!

Another factor to consider is cost. Fiber with higher LED bandwidth is selected from the manufacturing distribution and carries a cost premium. Thus, these fibers may result in a higher-priced cable that will not provide any better laser performance than standard optical fiber. This is why the industry standards do not guarantee any better performance than that shown in Tables 1 and 2, even for a higher LED bandwidth fiber.

The best way to ensure fiber will support the legacy LED applications of yesterday and today, while supporting the higher data rate laser-based applications of today and tomorrow, is to purchase and install 850nm laser optimized 50/125µm fiber. The fiber bandwidth of this fiber is certified using a laser measurement test procedure, ensuring its compatibility with VCSEL transceivers, and was designed in cooperation with VCSEL manufacturers to ensure an operational 10Gb/s network.

CONCLUSION

Advances in optical source technology and optical fiber have resulted in higher data rate applications than ever imagined. The fastest, short wavelength (850nm), laser-based, enterprise fiber technology today is 10 gigabit. These data rates impose severe limitations on the application distances of standard 62.5/125 µm fiber, which cannot fully support the requirements of centralized and building backbones. Similarly, while standard 50/125µm fiber can be used for gigabit data rates in horizontal, centralized, and intra-building backbone networks, distance limitations prevent their use in maximum length centralized and building backbone links at 10 Gigabit speeds.

The **AMP NETCONNECT XG Optical Fiber System** provides the best choice for LAN and data center cabling infrastructure. This new fiber system not only works well with today's readily available LED-based components, but also provides an effortless migration path into laser-based technology, making it the best choice for applications from 10 Megabits to 10 Gigabits.

AMP NETCONNECT XG OPTICAL FIBER SYSTEM

COMPONENTS

The XG optical fiber can be substituted in any optical fiber cable construction. That's why Tyco Electronics can offer a complete line of AMP NETCONNECT XG Optical Fiber Cables.

- Interconnect and Distribution (OFNR and OFNP) Cables with XG Optical Fiber
- Indoor/Outdoor (OFNR and OFNP) Cables with XG Optical Fiber
- Outdoor (All-dielectric and Armored) Cables with XG Optical Fiber
- Low-smoke, Zero-halogen (LSZH) Cables with XG Optical Fiber
- Hybrid Optical Fiber Cables (Single-mode and XG optical fibers in one cable)

The XG fiber can be used as the fiber stub in no-epoxy/no-polish optical fiber connectors. That's why Tyco Electronics can offer a complete line of the quickly-installed AMP NETCONNECT XG Optical Fiber No-epoxy/no-polish Terminations.

- No-epoxy/No-polish SC LightCrimp Plus XG Optical Fiber Connectors
- No-epoxy/No-polish LC LightCrimp Plus XG Optical Fiber Connectors
- No-epoxy/No-polish MT-RJ XG Jacks

No-epoxy/polish and epoxy/polish optical fiber connectors can also be used in these networks, as they preserve the end-to-end continuity of XG optical fiber. That's why Tyco Electronics offers the complete line of AMP NETCONNECT No-epoxy/polish Terminations and AMP NETCONNECT Epoxy/polish Terminations for use in XG Optical Fiber Systems.

- No-epoxy/Polish SC LightCrimp Connectors
- No-epoxy, Polish ST LightCrimp Connectors
- Epoxy/Polish SC Connectors
- Epoxy/Polish LC Connectors
- Epoxy/Polish ST Connectors

XG Optical Fiber Connectors are compatible with all AMP NETCONNECT optical fiber enclosures and faceplates – there is no need for special hardware or adapters.

- Snap-in Adapter Plates (multimode)
- Rack-mounted Enclosures
- Wall-mounted Enclosures
- Faceplates, including SL Series

XG Optical Fiber Cables Assemblies are made with XG Optical Fiber, again to ensure the continuity of the end-to-end XG optical fiber. That's why Tyco Electronics offers a complete line of AMP NETCONNECT XG Optical Fiber Cable Assemblies in standard and custom lengths.

- MT-RJ and Hybrid Cable Assemblies
- LC and Hybrid Cable Assemblies
- SC and Hybrid Cable Assemblies
- ST and Hybrid Cable Assemblies
- MPO Trunk Cables and Cassettes