

Standard Single-Mode Fiber Upgrades to Full-Spectrum and G.652.D

White Paper

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Abstract

Telecommunications network technology continues to evolve, with today's networks providing faster, more reliable and more ubiquitous connections at lower costs than ever before. Optical fiber, due to its superior transmission capability, forms the foundation for today's optical networks. As network complexity, flexibility and cost-sensitivity have evolved, single-mode fiber has undergone significant change since its inception in telecommunication networks in the 1980s. Corning Optical Fiber and the world's other leading optical fiber manufacturers continue to innovate to ensure that fiber attributes meet these changing network demands. In order to unleash the vast potential of optical fiber, it has become increasingly critical for network designers and operators to select the appropriate optical fibers to support existing and emerging system technologies.

ITU-T G.652.D defines a full-spectrum, low water peak fiber with low PMD and represents the most comprehensive standard for standard single-mode fibers. Corning Optical Fiber's standard single-mode fiber product, SMF-28e+™ optical fiber, is fully compliant with ITU-T G.652.D.

We discuss the benefits and increasing worldwide demand for full-spectrum ITU-T G.652.D-compliant single-mode fibers such as SMF-28e+ fiber and define why network operators are best served by specifying this classification of fibers in order to ensure network capabilities now and in the future.

Introduction

Standard single-mode optical fiber has a long history of evolutionary change. Consequently, today's products are now far superior to their original ancestors. Corning® SMF-28e+ optical fiber is a low water peak standard single-mode fiber with low Polarization Mode Dispersion (PMD). The advent of such fibers has changed the face of the standard single-mode fiber market and raised the performance expectations. Previously, transmission around the water peak region centered at 1383 nm was not possible due to the elevated attenuation. Low water peak standard single-mode fiber is produced using an advanced manufacturing process which reduces the OH- contaminants to a level where it can be used to transmit high data rate signals across the full optical spectrum from 1260 nm to 1625 nm. The standard also requires that the 1383 nm attenuation be post-hydrogen aging, which guarantees both short and long-term attenuation performance. Figure 1 illustrates the difference in fiber attenuation in legacy fiber and current-generation full-spectrum fiber.

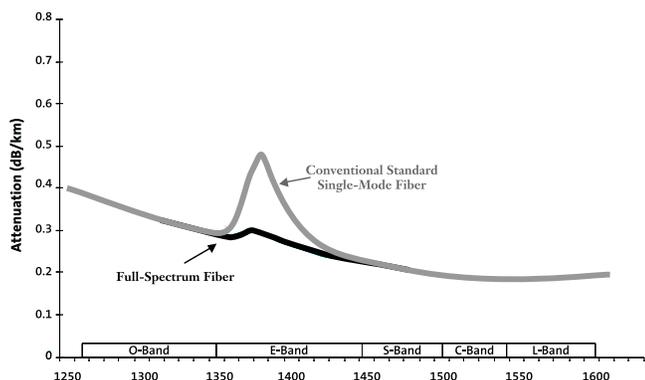
The ultra-low PMD specification of Corning's SMF-28e+ fiber enables optical transmission over longer distances using the next generation high data rate systems without signal distortion related to PMD.

Industry Standards Lead Network Evolution

Standards keep pace with fiber and system development, to ensure interoperability among competing vendors and facilitate the specification process for network operators. The two leading international fiber and cable standards organizations are the International Electrotechnical Commission (IEC) and the International Telecommunications Union (ITU).

The logo for Corning, featuring the word "CORNING" in white, uppercase, serif font, centered within a solid blue square.

To address the significant changes in standard single-mode fiber manifested by low water peak and low PMD products like SMF-28e+ fiber, the ITU and the IEC updated their requirements for standard single-mode fiber to include new classifications for current-generation versions of this fiber known interchangeably as “reduced-water-peak”, “low-water-peak” or “full-spectrum fiber.” This resulted in the introduction of the ITU-T G.652.D and IEC 60793-2-50 B1.3 standards.



Mode in Comparison of Conventional and Full-Spectrum Standard Single-mode Fiber

Figure 1

ITU-T G.652.D-compliant fibers are backwards compatible with all previous single-mode fiber designations. There is no operational impact (such as splicing) if full-spectrum fibers are combined in a network with legacy fiber types.

The ITU-T G.652.D standard represents the most comprehensive standard single-mode fiber specification. While some manufacturers still produce fibers compliant with only the outdated lower-level designations (such as ITU-T G.652.A or B1.1) due to the difficulty in producing low water peak fiber, Corning® Optical Fiber and several other leading optical fiber manufacturers are now compliant with the up-to-date ITU-T G.652.D standard.

Full-Spectrum Fiber Enables Advanced Optical Transmission Systems

By opening up the full-spectrum from 1260 nm to 1625 nm for optical transmission, full-spectrum fibers like SMF-28e+ fiber have extended the capability of CWDM systems and have enhanced the viability of emerging technologies like Raman amplified systems. Furthermore, the reduced PMD specification of full-spectrum fiber extends the transmission reach of high data rate (>10Gbps) systems.

Full-Spectrum Fiber and CWDM

CWDM systems use un-cooled distributed feedback lasers and wideband optical filters, providing lower power consumption and reduced capital and operating cost relative their DWDM counterparts. Various system manufacturers suggest that CWDM allows for total system cost reductions on the order of 40% below conventional metro DWDM equipment, according to a 2003 report from Wintergreen Research. The ease of use and low cost of CWDM has made it a popular networking option where the larger capacity of metro DWDM is not required.

CWDM technology is now standardized in two international specifications. ITU-T recommendation G.694.2 specifies the CWDM operating wavelength grid, extending from 1271 nm to 1611 nm in 20 nm increments, including values within the water-peak region around 1383 nm. ITU-T G.695 provides detailed specifications for CWDM optical interfaces. These rigorous standards have promoted a high level of general industry interest in CWDM, with more than 20 leading system manufacturers currently incorporating standardized CWDM interfaces into at least one of their product offerings.

Carriers who embrace full-spectrum fiber, like Corning’s SMF-28e+ fiber, will position themselves strategically in a CAPEX sensitive market to take full advantage of the cost savings offered by CWDM.

Full-Spectrum Fiber and High Data Rates

At higher data rates (10 Gb/s and above), especially at longer distances, PMD associated with optical fiber and network components can severely limit system capability. Both the IEC and the ITU specify a maximum allowable value of PMD in cabled fiber for the various fiber designations, in the form of “PMD_Q.” ITU-T G.652.D specifies a full-spectrum fiber with the tightest requirement for PMD_Q, at 0.20 ps/√km. The ITU recommends this as the maximum level of allowable PMD for STM-256 (40 Gb/s) transmission. In advance of full-spectrum fiber, non-zero dispersion shifted fibers (NZ-DSF) were developed with very low PMD and reduced chromatic dispersion to enhance the performance of high data rate, long reach systems. Where such systems are encountered and NZ-DSF is not the preferred option, G.652.D-compliant fibers become the obvious next-best choice due to superior PMD characteristics as compared to other standard single-mode fibers.

Full-Spectrum Fiber and Emerging Technologies

Beyond today’s applications for full-spectrum fiber, there are also potential future opportunities. Raman amplification, already a viable technology in certain applications, utilizes pump lasers in the 1400 nm region to amplify signals in the C and L bands. In conventional legacy fibers, the high water-peak region can degrade the capability of pump wavelengths due to excessive loss, whereas full-spectrum fiber minimizes loss and maximizes amplification efficiency.

Full-spectrum fiber is a necessity for the future viability of ultra-wide band systems in which a continuous spectrum spanning a large wavelength range is generated and then a simple passive filter is used to selectively transmit individual wavelengths.

Conclusion

Fiber is a long term investment that forms the foundation for today’s network infrastructure. Hence it must be considered that fiber deployed today must support network needs that will arise 15 to 20 years from now while also providing full backward compatibility with previously installed standard single-mode fiber. ITU G.652.D-compliant full-spectrum fiber, such as Corning® SMF-28e+ fiber, accomplishes this important balance between capability and compatibility.

Network operators around the world are now specifying full-spectrum fiber as a requirement in both new network builds and extensions of existing infrastructure. These operators have made the decision to adopt optical fibers compliant with the most stringent standards, rather than risk limiting the future capability of their long-term infrastructure investment.

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