Application Notes

Zero Water Peak Single Mode Optical Fiber for Metro and Access Networks

Author
Sudipta Bhaumik

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Abstract

Coarse Wavelength Division Multiplexed (CWDM) systems are often used in metro area networks as a lower cost option to Dense Wavelength Division Multiplexed (DWDM) systems. Metro CWDM systems use un-cooled DFB lasers with wide channel spacing of 20nm, wide band optical filters, and operate over a broad range of operating wavelengths. Zero water peak single mode fiber (ITU-T G.652.D)[1] has been designed for CWDM systems due to its low attenuation over wide range of operating wavelengths including water peak at 1383 ± 3 nm. This paper compares conventional and reduced water peak single mode fibers in metro and access networks.

Keywords
Optical fiber, Water peak attenuation

Introduction

Optical fiber due to its superior transmission capacity forms the foundation of today's optical networks. As bandwidth demand from end users increases, their needs are met both by increasing the number of deployed optical fibers, and the throughput on those fibers using technologies such DWDM. In DWDM systems multiple wavelengths are placed in very close proximity with typical wavelength spacing of 0.4nm. This requires expensive electronic and optical components such as cooled lasers with external modulators, wavelength locking, and arrayed waveguide gratings for wavelength selection. While DWDM technology has been widely adopted in long-haul and trunk networks, other options like CWDM are preferred in metro networks where transmission distances are more modest and lower costs are imperative. CWDM systems typically use less expensive uncooled lasers with 20nm channel spacing, directly modulated transmitters, and less expensive optical filters reducing total system costs, but with the disadvantage of lower network throughput. Fig 1 shows how a network is dimensioned and served by different technologies.

Ideal Fiber For CWDM Metro Networks

Optical fiber cable deployment is expensive because it requires complete geographical audit, digging and trenching of city streets, and right of way access to network points of presence. It is therefore important to deploy the right fiber, which not only meets today's network requirements, but also future-proofs the network. A key point in fiber selection for metro networks is to maximize bandwidth capacity, thereby avoiding the high installation expenses of continually adding more and more fiber. Operating wavelength of CWDM system covers several wavelength bands like O, E, S, C and L bands i.e. from 1310nm to 1610nm. As per ITU G.694.2 [2] 16 channels are available for transmission with CWDM channel spacing of 20nm, and each channel has transmission capacity of 2.5Gb/s with repeater less transmission distance of 70 – 100km.

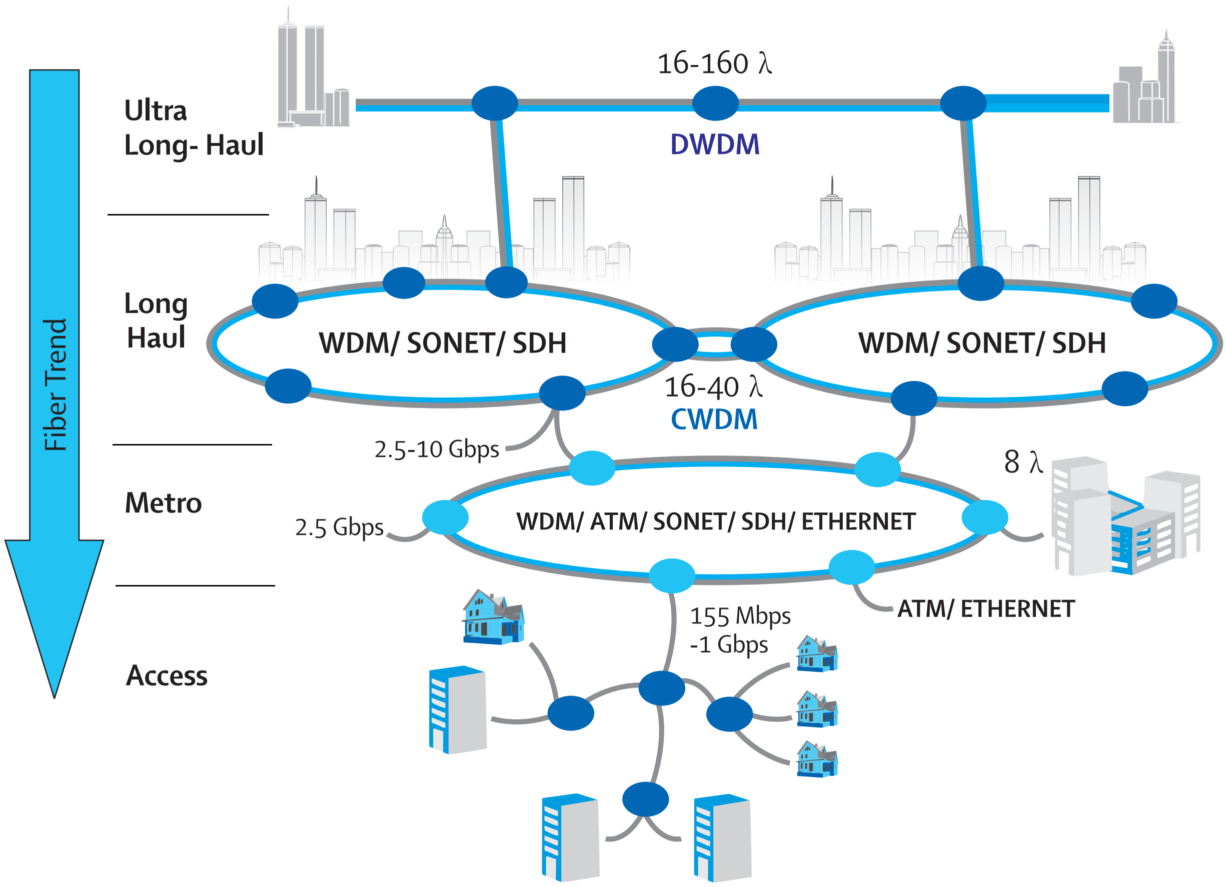

Figure 1 Fiber trend vis-à-vis network system and bandwidth demand

The most challenging fiber requirement is full spectrum coverage of 16 channels. This is extremely difficult with conventional single mode fiber (ITU-T G.652.B), where the loss peak due to hydroxyl ion (OH) virtually eliminates E-band 1400nm region for use in metropolitan networks. The hydroxyl ion is a residue from moisture or water incorporated in glass during manufacturing process. Figure 2 shows comparison of attenuation curve between ITU-T G.652.B & G.652.D where dispersion curve remains the same for both types of fibers. A fiber with reduced water peak (G.652.D) meets all requirements for an ideal fiber in metro networks, including 16 channel full-spectrum CWDM capabilities. Table 1 shows comparison between various categories of ITU-T G.652 fibers and Sterlite OH-LITE® (E) G.652.D fiber. Water peak (1383±3 nm) attenuation of Sterlite's OH-LITE® (E) G.652.D fiber is considerably reduced to ≤0.31 dB/km, similar to zero-water peak fiber[3,4]. As no optical amplifiers are used in CWDM systems, reduction in attenuation provides direct benefit in power budget and subsequently increases transmission distance. Water peak attenuation for commercially available low water peak fiber (for example Sterlite OH-LITE®) typically is ≤ 0.34 dB/km. Therefore, a reduction in water peak attenuation by 0.03dB/km provides 3dB gain in power budget in a 100km CWDM route. Similar attenuation benefit can be achieved with Sterlite's bend insensitive zero water peak G.657.A1 category BOW-LITE™ PLUS optical fiber[5].

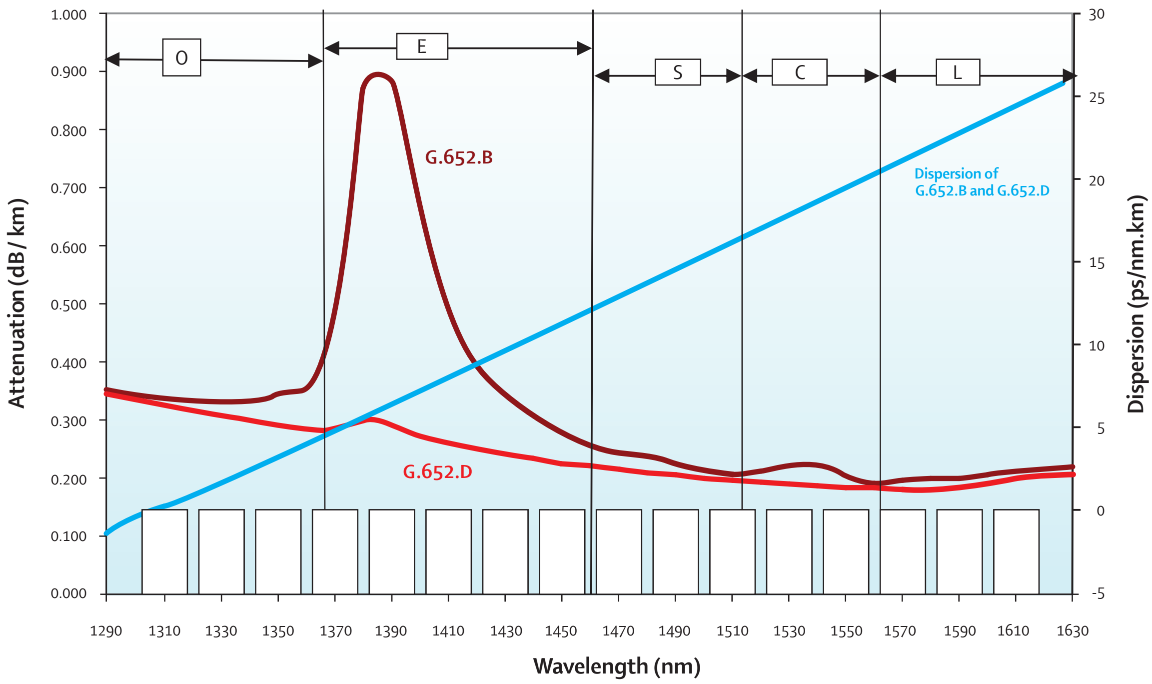

Figure 2 Attenuation and Dispersion curve of ITU-T G.652.B & D

Characteristics of ITU-T G.652.D Fiber

ITU-T G.652.D fiber is fully compatible with G.652.B fiber, and it meets all requirements for an ideal fiber in metro local networks. Like G.652.B, it supports all standards protocol and major access solutions. It fully supports 1310nm and 1550nm system specifications such as SONET, SDH etc. It is compatible for splicing with G.652.B fiber as there is no difference in Mode Field Diameter (MFD). G.652.D combines previously untouched 1400nm region (E- band) where water peak loss renders G.652.B fiber useless. This ability opens an extra 100nm of bandwidth, which can support at least four more CWDM channels as compared to G.652.B fiber, representing a channel gain of at least 33%. At higher data rates (10Gb/s), PMD associated with optical fiber and network components can add to system penalty. G.652.D fiber with tight PMD_Q specifications of $0.2ps/\sqrt{km}$ ensures network upgradability to higher data rates.

Table 1 Comparison between different types of ITU-T G.652and Sterlite's OH-LITE® (E) fibers [1,4]

Attribute	ITU- T G. 652. A	ITU- T G. 652. B	ITU- T G. 652. C	ITU- T G. 652. D	Sterlite's OH LITE® (E)
Mode field diameter at 1310nm	8.6-9.5 (± 0.6) µm	8.6-9.5 (± 0.6) µm	8.6-9.5 (± 0.6) µm	8.6-9.5 (± 0.6) µm	9.1 (± 0.4) µm
Cladding diameter	125±1 µm	125±1 µm	125±1 µm	125±1 µm	125±0.7 µm
Maximum Core Clad concentricity error	0.6 µm	0.6 µm	0.6 µm	0.6 µm	0.5 µm
Maximum Cladding non circularity	1 %	1 %	1 %	1 %	0.8 %
Maximum Attenuation at 1310nm	0.5 dB/km	0.4 dB/km	0.4 dB/km	0.4 dB/km	0.33 dB/km
Maximum Attenuation at 1550nm	0.4 dB/km	0.35 dB/km	0.3 dB/km	0.3 dB/km	0.19 dB/km
Maximum Attenuation at 1625nm	–	0.4 dB/km	0.4 dB/km	0.4 dB/km	0.21 dB/km
Maximum Attenuation at 1383 nm ± 3 nm Note*	–	–	0.4 dB/km	0.4 dB/km	0.31 dB/km
Zero Dispersion Wavelength	1300-1324 nm	1300-1324 nm	1300-1324 nm	1300-1324 nm	1300-1324 nm
Maximum Zero Dispersion Slope	0.092 ps/nm^2. km	0.092 ps/nm^2. km	0.092 ps/nm^2. km	0.092 ps/nm^2. km	0.090 ps/nm^2. km
Cable Cutoff Wavelength	≤1260nm	≤1260nm	≤1260nm	≤1260nm	≤1260nm
Minimum Proof test	0.69 GPa	0.69 GPa	0.69 GPa	0.69 GPa	0.69 GPa
Maximum Macro bend Loss (100 Turns) on 30 ±1mm radius mandrel	0.1 dB at 1550 nm	0.1 dB at 1625 nm	0.1 dB at 1625 nm	0.1 dB at 1625 nm	0.03 dB at 1625 nm
Maximum PMD_Q	0.5 ps/$\sqrt{km}$	0.2 ps/$\sqrt{km}$	0.5 ps/$\sqrt{km}$	0.2 ps/$\sqrt{km}$	0.06 ps/$\sqrt{km}$

* The average attenuation coefficient at this wavelength shall be less than or equal to the maximum value specified for the range of 1310 nm to 1625 nm, after hydrogen ageing. The hydrogen ageing is a type test that shall be done to a sampled fiber, according to [IEC 60793-2-50] regarding the B1.3 fiber category.

Stability Performance against Hydrogen ageing

The chemical reaction between hydrogen molecule and defects in optical fiber causes attenuation to increase at around 1383 nm, 1240 nm and 1440 nm. The increases in attenuation at 1383nm due to hydrogen molecule makes it impossible to transmit optical signal in E- band, if the fiber is in a hydrogen atmosphere for long time. It is therefore important to understand hydrogen-induced attenuation in G.652.D fiber to assure the long-term reliability of field-installed optical fiber. In order to prevent hydrogen induced losses fiber is exposed to a deuterium- nitrogen mixture. The purpose of this treatment is to exchange the hydrogen atom of –OH groups to –OD groups, which absorbs light at different wavelengths than –OH groups. Hence deuterium aging is necessary for G.652.D fiber.

Figure 3 shows a typical performance of Sterlite's G.652.D fiber in a hydrogen aging test in accordance with IEC60793-2-50[6]. Attenuation at 1383 nm has to be less than 1310 nm after hydrogen aging for G.652.D fiber and thus it shows excellent performance even in hydrogen-induced environment.

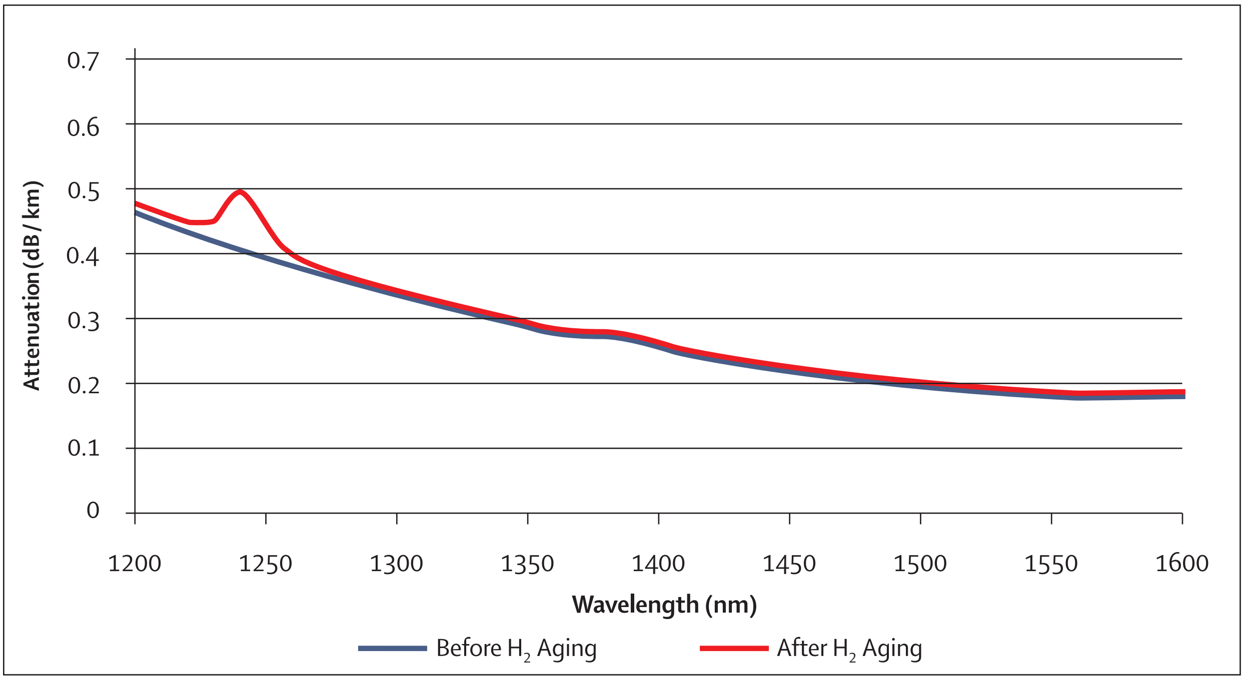

Figure 3 Spectral attenuation curve of G.652.D fiber in hydrogen aging test

Fiber for premises network

For the deployment of broadband access technology called Fiber to the Premises/Home (FTTP/H), a question arises which optical fiber should be used? Keeping in mind the long-term view of deployed FTTP/H system, it must support voice, video and data transmission. Passive Optical Network (PON) is an important type of FTTP/H system, consisting of central office to serve multiple subscribers through optical splitters. The split ratio can vary from 2 to 64 depending upon the number of subscribers. PON uses WDM to enable multiple data stream at different wavelengths over single fiber. Different kinds of PON networks like EPON, GPON and BPON have transmission data rates from 155Mbps to 2.45Gbps to a reach of 20km to 60km.

Multimode fiber can support 10Mbps to 10Gbps but only for 2km and 100m distances respectively. Therefore, PON exclusively needs single mode fiber to support the distance required in access networks. There are two choices of single mode fiber according to PON requirements

1) Conventional standard single mode fiber ITU-T G.652.B

2) Reduced water peak standard and/or bend insensitive single mode fiber ITU-T G.652.C,G.652.D & G.657.A1 or G.657.A2.[7]

Reduced water peak fiber enables services in 1360 – 1480nm band (E Band), which is not available with G.652.B fiber because of high attenuation loss at 1383 ± 3 nm due to water peak. G.652.D and G.657.A1/G.657.A2 provide potential upgrade path to PON networks, with little or no added cost to the overall FTTP/H network cost. Therefore, G.652.D or G.657.A1 or G.657.A2 are the best choice for PON FTTP/H networks. The selection between these 3 categories of fibers is dependent on macro bend loss requirement and as one goes deeper into the access part (so near the home), the macro-bend loss requirement increases and bend insensitive G.657.A1 or G.657.A2 fibers are needed. Fiber used in cables inside the home is generally of an even higher grade with better bend sensitivity,and G.657.B3 fiber is generally used for inside home cabling.

Conclusion

Fiber optics cable installation and deployment is a long-term investment in optical networks. Fiber installed today must be extremely versatile and support network needs for 20 –25 years in the future, and also provide compatibility with any already installed standard single mode fiber. Due to its reduced water peak characteristics, its stability against H_2 aging, its enhanced bend sensitivity, its low attenuation over a large wavelength band (O, E, S, C, and L) and its low PMD, ITU-T G.652.D compliant fiber such as Sterlite's OH-LITE®(E) G.652.D zero water peak fiber with industry leading specification is an ideal candidate for metro networks. Additionally, Sterlite OH-LITE® (E) fiber combined with Sterlite's enhanced bend insensitive series of G.657 BOW-LITE™ fibers will be ideal for FTTH/P networks, especially as network connectivity goes closer to the home.

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