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The Benefits of CommScope® TeraSPEED® ZWP™ Zero Water Peak Optical Fiber

White Paper

July 2008

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Introduction

Single-mode fiber has long been known for its high bandwidth at a few specific wavelengths. Today's applications, such as 40 and 100 gigabit Ethernet, as well as fiber-to-the-home, are pushing the limits of legacy fiber. One can use specialized fibers that are optimized for long haul systems, but these are costly, more difficult to engineer the network, and typically do not perform well in enterprise applications. Customers are looking for a standard single-mode fiber product that is versatile, capable of handling the network traffic of today and tomorrow, and backwards compatible with existing infrastructure, all at an economical price. Zero-water peak fiber meets all of these needs.

Legacy single-mode fiber has elevated attenuation in the E-band operating window (1360 – 1460 nm) due to what is called the "water peak". This peak occurs at 1385 nm and is caused by hydroxyl ions – essentially moisture – in the glass that absorbs and attenuates optical signals operating at, and near, 1385 nm. See Figure 1.

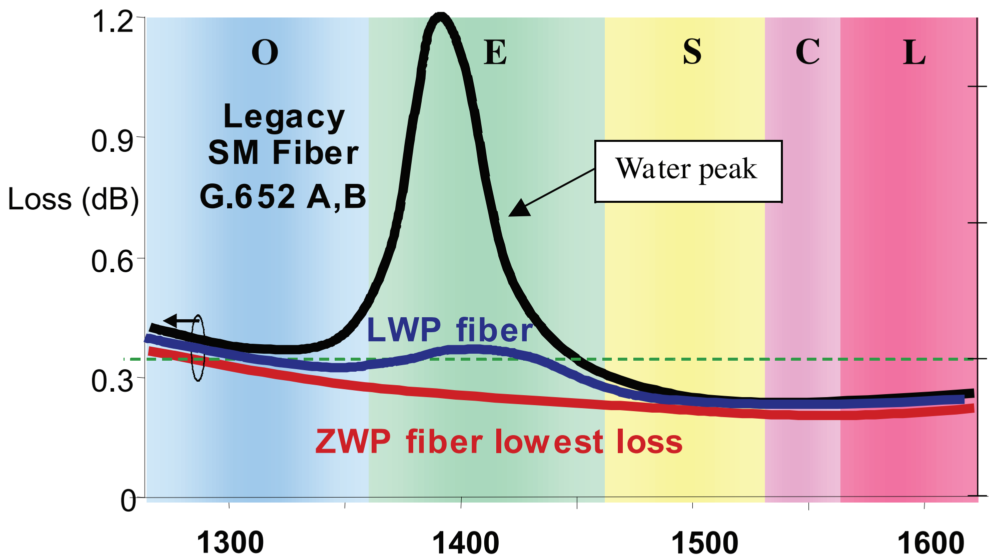

Figure 1: Spectral Attenuation Curve

Loss, or Attenuation, vs. Wavelength showing:

1) Legacy SM fiber with high attenuation at water peak (E-band region).

2) LWP (Low Water Peak) showing some elevated attenuation in E-band.

3) ZWP (Zero Water Peak) optical cable showing no elevated attenuation in E-band, and lower overall loss across entire spectrum from 1260 – 1625 nm.

Attenuation due to this water peak in legacy single-mode fiber can reach upwards of 1 dB/km or more (2.5 to 3 times the attenuation seen at 1310 nm). This renders the fiber practically inoperable in the E-band region. If the water peak attenuation is exceptionally high, this elevated loss can spill over into adjacent operating windows, like the 1490 nm S-band (used in FTTH systems) and even the 1310 nm O-band, which is the common wavelength used in most single-mode systems for the enterprise. In fact, the center wavelength tolerance allowed by IEEE 802.3 Ethernet standards is 1355 nm with a spectral width tolerance of up to 4 nm, which is very close to the 1383 nm water peak.

TeraSPEED zero water peak fiber is created by a process that eliminates all the moisture in the glass during the fiber manufacturing process. The process not only eliminates any added attenuation at the water peak and E-band region (zero additional attenuation due to moisture – hence the term ZWP), but it also lowers overall attenuation across the whole spectrum of operating wavelengths from 1260 to 1625 nm.

Eliminating attenuation due to the water peak opens up additional wavelengths for future bandwidth upgrades, or for secure, dedicated, revenue-enhancing services. By using a ZWP fiber, one can gain 50% more bandwidth compared to a legacy single-mode fiber. Wavelengths can be added as needed by utilizing Course Wavelength Division Multiplexing (CWDM) technology, an economical alternative to DWDM, which is typically used in high-bandwidth long haul systems. With a CWDM solution, multiple wavelengths are used to transmit data over a single fiber.

There are other optical fibers on the market that claim a lower attenuation compared to legacy single-mode fiber, but they are NOT a zero water peak product. The term "Low Water Peak" (LWP) was coined to describe this type of fiber, and it became standardized in the industry (ITU-T G.652 C & D, IEC 60793-2-50 Class B1.3). However, none of these optical fibers match the performance of a Zero Water Peak fiber.

Advantages of Zero Water Peak Fiber over Low Water Peak Fiber

Lower Attenuation

TeraSPEED ZWP not only has zero added attenuation in the water peak E-band, but it also has lower attenuation over a broader range of wavelengths compared to LWP fibers. The same process that eliminates the water peak also improves the overall purity of the light-carrying portion of the optical fiber, resulting in reduced losses across the full range of wavelengths. The advantages of lower attenuation are that network distances can be extended, or provide greater margin or headroom in terms of loss budgeting.

For every 0.01 dB/km reduction in cable attenuation, you can get about a 3% gain in reach. For example, let's look at a 10 gigabit Ethernet application that operates at the O and E bands, where IEEE standards designate a 10 KM minimum system length. Based on published specs, loose tube fiber cables with TeraSPEED ZWP have attenuation specified 0.06 dB/km lower at 1310 nm and 0.09 dB/km lower at 1385 nm compared to competitors' standard LWP fiber cable offerings.* At 1310 nm, you gain 1800 meters extra reach with TeraSPEED ZWP, and at 1385 nm you can actually go almost 2700 meters longer!**

* This article notes attenuation for cabled fiber, i.e. what is typically seen in the field. This attenuation value may be higher than specified for uncabled optical fiber, regardless of cable type or manufacture.

** Specifications of loose tube cable TeraSPEED ZWP fiber: 0.34 dB/km @ 1310 nm
0.31 dB/km @ 1385 nm
0.22 dB/km @ 1550 nm

Published specification of similar competitive offering: 0.40 dB/km @ 1310 nm
0.40 dB/km @ 1385 nm
0.30 dB/km @ 1550 nm

Comparing two systems, one with TeraSPEED ZWP and one with LWP fiber, there will be a noticeable decrease in the reach capability of the LWP fiber for a given amount of power or loss budget. And when it comes time to add future CWDM wavelengths, any runs that are near their loss budget limit may be cutting it too close for comfort in the water peak E-band region.

If you look at the benefit of lower attenuation in terms of margin, or headroom, every 0.01 dB/km reduction in attenuation offers 0.1 dB gain in headroom over 10 kms, or 0.2 dB over 20 kms. Again, using the published attenuation specs from the previous example, loose tube cable with TeraSPEED ZWP fiber provides 1.2 dB extra headroom at 1310 nm over 20 kms, and 1.8 dB at 1385 nm compared to similar cable offerings. The TeraSPEED ZWP advantage quickly becomes apparent.

Lower Insertion Loss

Coupled with the low attenuation benefit described above, TeraSPEED ZWP can provide for lower connection and splice loss to further minimize channel insertion loss.

Benchmark splicing studies have shown that TeraSPEED ZWP cable averages about 0.02 dB splice loss compared to about 0.04 dB for a competitor's LWP fiber. These results were obtained in a "best-case" pristine laboratory-like environment where such splicing studies are usually conducted. Note that actual field splicing losses are usually higher, and add up when there are numerous splices in a run.

TeraSPEED ZWP cable can provide lower splice and connection loss due to the superiority of its glass geometry characteristics, namely Core-to-Clad Concentricity Error and Mode Field Diameter (MFD) consistency. This allows for better alignment of the cores when splicing and connecting fibers and tighter geometry leads to lower connection and splice loss. Additional benefits of tight geometry include improved coupling/centering with the active equipment and more uniform coating for superior glass protection. To fully take advantage of these industry-leading specifications, patch cords should also contain TeraSPEED ZWP fiber.

Synthetic Glass vs. Natural Quartz

TeraSPEED ZWP fiber is manufactured using all synthetically produced glass. Such glass is extremely pure and free of any particulate or inclusions that can compromise fiber strength. Other fiber manufacturers may use natural glass that is mined and can contain potentially harmful particles, inclusions, and alkali contaminants. Benchmarking studies have shown that fibers made from natural glass typically have a lower Dynamic Fatigue Stress Corrosion Parameter ("n-value"), which affects the mechanical lifetime reliability of fiber. For example, if a fiber is subjected to a stress of about 25 kpsi (only a half a pound), a difference in a fiber's n-value between 21 and 20 can mean a reduction in predicted lifetime from 50 years to only 12 years.

Furthermore, alkali impurities found in natural quartz can react over time with hydrogen (present everywhere in air and water), causing attenuation to creep back up in the E-band water peak region.

Conclusions

Installation of optical fiber cable is a significant investment. It is expected to provide reliable service for 25 or more years, and be capable of handling ever-increasing bandwidth demands. ZWP key advantages include:

- Loose tube cables with TeraSPEED ZWP have a 0.06 dB/km attenuation advantage over other standard LWP cable offerings and an even greater advantage at 1385 nm.
- TeraSPEED ZWP offers:
  - Almost 2 km greater reach for 10 gigabit Ethernet at 1310 nm
  - 0.6 dB more headroom over 10 km @ 1310 nm
- Attenuation around the water peak may creep up long term on some cable suppliers' LWP fibers; ZWP will not.
- Some competitor's LWP uses low cost mined quartz and may risk earlier failure due to defects.

Not all fiber is created equal, or performs the same. TeraSPEED ZWP optical cable is produced with longevity in mind, as well as superior performance and future upgradeability. ZWP offers increased power margins, and the greatest potential for future bandwidth upgrades. These help preserve the integrity of the system and ensures maximum capacity for unknown future applications. Deploy fiber today that you know will meet whatever requirements develop over the next 20 years.

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