Zero Water Peak Fiber – Margin for Today and Extra Bandwidth for Tomorrow

By David Mazzarese

Even to those of us in the communications industry, the explosive demand for bandwidth is striking. With the adoption of video applications such as on-demand HDTV and YouTube®, more bits are traveling over the global network than ever before. Furthermore, as we look out a few years into the future, it's not hard to imagine applications that will demand even more capacity. Think what will be required, for example, by improving the resolution of on-demand video applications to high definition, or by an increase in real-time videoconferencing as the cost of traveling to off-site meetings continues to soar.

Optical fiber, with its high bandwidth and low attenuation (signal loss), is the medium of choice to carry these vast quantities of data, and single-mode fiber is the product type best suited to carry that information in long haul, metro, campus, and FTTH/FTTP applications. Therefore, as more data is pushed across the core network and to individual homes and businesses, the demands on single-mode fiber are more stringent than ever before.

Choosing the best single-mode fiber for a given network means looking beyond current standards towards the latest technologies that will enable full utilization of the fiber's inherent transmission capacity. One of these technologies is zero water peak fiber, which offers the lowest loss in the 1310nm O-Band and the Extended E-Band of any single-mode fiber.

This article will describe the benefits of this fiber type and offer suggestions on going beyond the standards for even greater network performance.

ATTENUATION: THE KEY FIBER PARAMETER

As discussed, today's video age requires more bandwidth than simple broadband connections can supply; therefore, the industry is taking optical fiber closer to the home. As data rates continue to surge, there is little doubt that the network of the future will have optical fiber running from the head end to the end user. Given this massive change in network demands, one needs to carefully consider the choice of optical fiber that is at the core of the information superhighway.

Like any transmission medium, single-mode fiber has four critical attributes:

- Attenuation (how far can I transmit a signal and still receive it?);
- Bandwidth (can I make sense out of the received signal?);
- Reliability (how long can I expect to receive this signal?);
- Cost (what will be the initial capital costs as well as operating costs?).

While today's fibers are designed to provide value in all of these areas, attenuation is the most critical factor, for one simple reason: If the signal does not reach the detector, none of the other parameters will even come into play. Low attenuation has long been sought-after for both electronic and optical transmission. Because optical fiber has much lower attenuation than copper wiring, this parameter is one of the key factors driving the switch from electronic to optical transmission.

Attenuation is measured in decibels per kilometers (dB/km). The lower the attenuation, the further a signal can be transmitted, and the lower the system power requirements. Lower power improves reliability and cost. "Full spectrum" fibers (those with zero water peak) allow for more useable wavelengths, which, in turn, provides more usable bandwidth. Thus, full spectrum single-mode fibers with zero water peak have become an important part of both today's and tomorrow's networks.

WHAT IS "ZERO WATER PEAK" FIBER?

Zero water peak, or ZWP, fibers can accommodate even greater amounts of information over longer distances compared to conventional single-mode fiber, and as such, are an excellent choice for your network.

The difference, as the name implies, has to do with the "water peak." Because they absorb OH ions (moisture) during manufacturing, traditional single-mode fibers have very high loss in the 1360-1460nm band (the so-called water peak), as shown in Figure 1. The loss may continue to increase even after cable installation. The high attenuation makes transmission in this spectral region impractical for these single-mode fibers.

What exactly causes the problem? Transmission of light is impaired at around 1385nm because the OH hydroxyl impurities incorporate in the glass matrix, causing the light signal to be absorbed rather than propagate down the optical fiber.

With OFS' development of zero water peak fiber in 1998, the 1360-1460m region (called the E-Band) that was previously unavailable for long distance transmission was opened up. This enabled many new paths for system upgrades.

As can be seen in Figure 1, lowered attenuation in zero water peak fiber is not confined to just the E-Band. Once the water peak was removed, lower attenuation was observed across the full spectrum from 1260-1625nm. For example, networks transmitting near the water peak – such as the 1490nm wavelength used for downstream transmission in many FTTx deployments – benefit from this lower attenuation, as well.

There is another class of fibers called Low Water Peak (LWP) fibers, developed after ZWP fibers. LWP fibers simply lower the loss at the water (unlike Zero Water Peak fibers, which eliminates loss due to moisture at the water peak) and further lowers the loss across the entire spectrum. While both types meet the International Telecommunications Union (ITU-T) G.652D specification, the differences in network support between the two are significant.

ZWP FIBER AND CWDM APPLICATIONS

With the advent of ZWP and LWP fibers, the ITU developed and standardized a grid of wavelengths for course wave-

Figure 1 - Zero Water Peak fibers eliminate loss due to moisture found in conventional single-mode fiber.

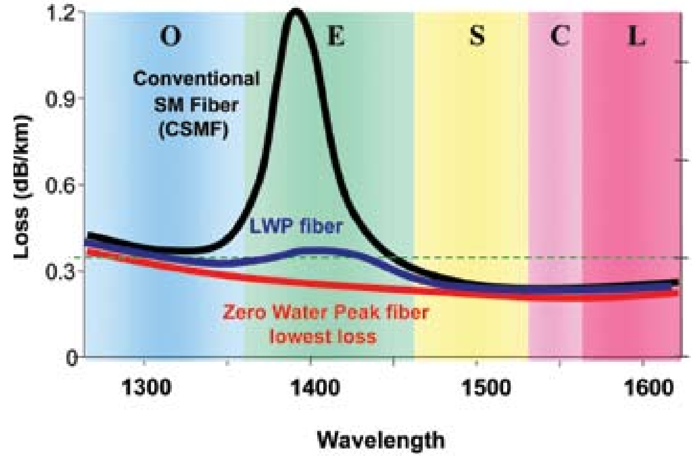

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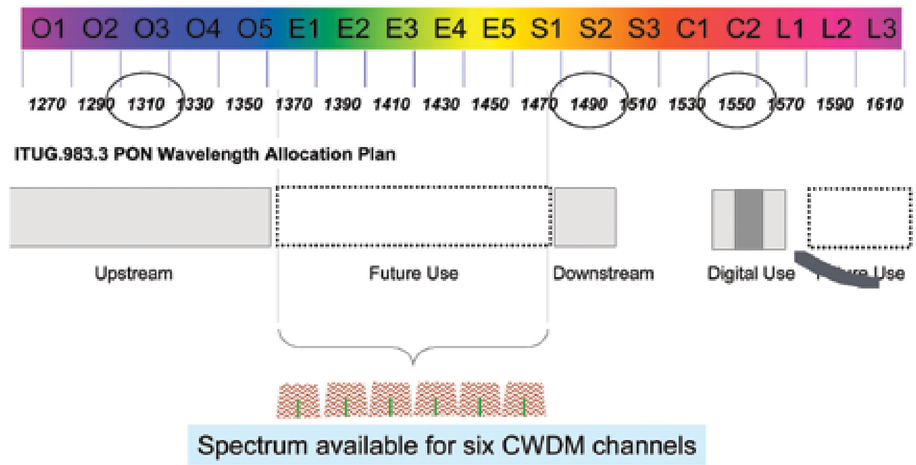
Figure 2 - ITU developed a grid of CWDM wavelengths to take advantage of added spectrum provided by ZWP fiber.



length division multiplexing (CWDM) that took advantage of this added spectrum.

This is important because service requirements of metropolitan networks demand that multiple service platforms be available over network architectures at low cost. CWDM is now an economically viable choice as it allows the use of low-cost, un-cooled lasers with direct modulation technology and lower cost multiplexers. ZWP fiber provides 50 percent more usable wavelengths than conventional single-mode fiber (G.652.A or G.652.B).

Deploying CWDM over ZWP fiber using commercially available equipment from multiple system vendors can reduce system costs by 35 percent or more compared to DWDM systems over conventional single-mode fiber.

CHOOSING A ZERO WATER PEAK FIBER

As with any discussion about selecting a high-performance fiber, we must recognize that, first and foremost, the fiber you choose must be compatible and compliant with the installed base of optical fiber if it is going to provide the greatest value to the end user. Currently, the most stringent conventional single-mode specification presented by the ITU-T is the G.652D standard. Many optical fiber products meet this standard. But for the most demanding applications, you may want performance beyond what is outlined in the standards, to provide extra margin for such things as additional connections, higher loss connectors or greater reliability.

The processes used to manufacture ZWP fiber yield significantly lower loss at the water peak compared to other LWP fibers, and provides lower overall loss across the whole wavelength spectrum. Manufacturing optical fiber and simply selecting the lowest attenuation spools (as is done with LWP fibers) will not provide the same quality and performance as a process specifically designed to produce a ZWP fiber with typical attenuations in the 1385nm region that are significantly lower.

In addition, different fiber manufacturing processes can affect fiber performance. Fibers made using 100 percent synthetic quartz offer added reliability, mechanical strength and stable attenuation over time compared to fibers made from natural quartz, which may contain foreign particulates and impurities. Optical fiber should have a lifetime of 25 or more years, so long-term reliability is important. What's more, the added bandwidth capability and lower attenuations of ZWP fiber will be enabling features that will provide more options for future networks.

When selecting a ZWP fiber, look for the following:

- Fiber manufactured using a process that ensures the full-spectrum attenuation will remain stable throughout the life of the cable, even when exposed to hydrogen;
- A manufacturing process that uses high purity synthetic silica glass, minimizing alkali impurities and guarding against long-wavelength hydrogen aging loss;
- A high-performance coating for excellent environmental performance and long-term reliability;
- Proof testing of each fiber to at least 0.7 GPa (100 kpsi) for durability;
- Ultra-low and stable PMD performance to support future high-speed upgrades.

Removing the water peak from single-mode fiber provides 50 percent more channels for a CWDM network, thereby greatly increasing the bandwidth potential of zero water peak fiber. Excess bandwidth capacity is very important to accommodate future communications needs.

The G.652D standard defines low water peak fiber for full spectrum performance, but zero water peak fiber provides benefits beyond that. Zero water peak fiber provides attenuation that is lower than what is standardized at many wavelengths deployed in today's networks. Lower attenuation allows either greater distances between the transmitter and receiver or allows for greater margins to help ensure system reliability (either way, a great advantage for a deployed system). ■

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