

Increase Network Flexibility Through Proper Fiber Selection

Andrew Oliviero, Senior Product Manager

Data center designers and managers must be sure that the optical fiber products they specify can provide the performance and reliability they need.

Specifically, you may want your network to provide power "headroom" to accommodate additional connections and higher loss connectors, and to improve overall reliability. This is especially critical in 10 Gigabit Ethernet applications at 850 nm, since loss budgets for these systems are lower than previous applications.

Be sure the cable you purchase has been DMD-controlled to the very center of the fiber.

There are two ways to achieve greater power headroom (also known as power margin): first, by reducing Channel Insertion Loss (CIL), the end-to-end loss resulting from all connections and splices in the link, plus the attenuation of the cable itself; second, by using a higher bandwidth fiber to reduce Inter-symbol Interference (ISI), which occurs when bits of data run together.

Reducing CIL

When IEEE created 10GBASE-SR, the standard for 10 Gb/s transmission to 300 meters, they made certain assumptions about network configuration and connections to establish the power budgets (right, column A).

According to the link model, 77 percent of the total link power penalty of 7.3 dB is caused by a combination of CIL (accounting for 36 percent, at 2.6 dB) and by ISI (41 percent, 3.0 dB). Therefore, the easiest way to create

power headroom is by reducing CIL and/or ISI power penalties.

One strategy for reducing CIL directly is to improve cable attenuation and connection loss. This involves the use of:

- Small form factor (SFF) connectors (e.g., LC connectors).
- Fiber with improved core centering tolerances to improve core-to-core alignment:
 - Low core/clad concentricity error (< 1.0 μm)
 - Tight clad diameter tolerance (125 +/- 1 μm)
 - Tight core diameter tolerance (+/- 2.5 μm)
 - Low 850 nm fiber attenuation (< 2.3 dB/km)
 - A bend-insensitive coating
 - Low 850 nm cable attenuation (< 3.0 dB/km)

Reducing the ISI Penalty

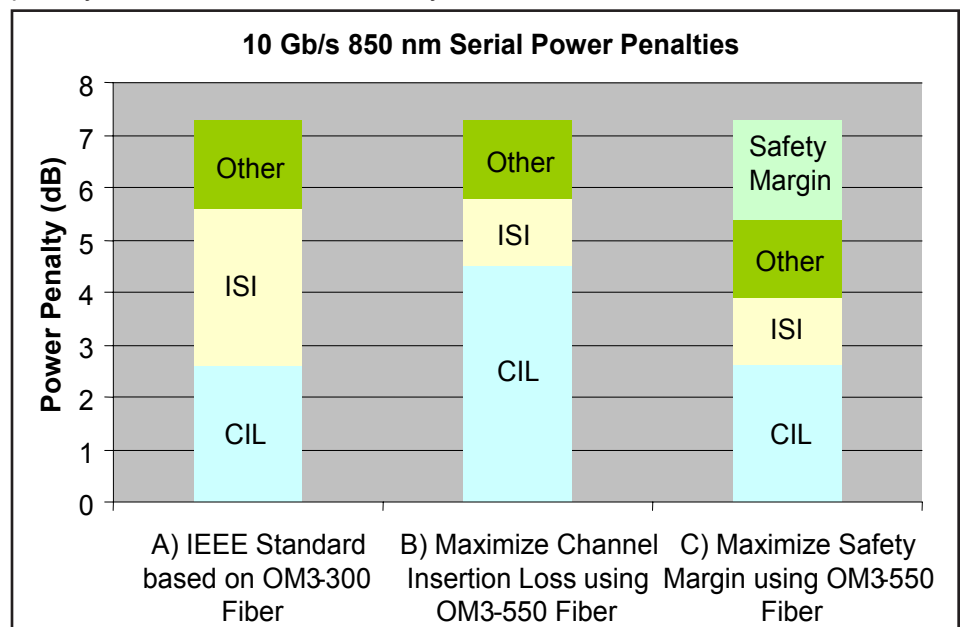
The most effective way to increase power headroom is to reduce the ISI penalty of the link. ISI is lowered by

reducing Differential Mode Delay (DMD), the "pulse spreading" that causes ISI, and increasing the bandwidth of a fiber for a given distance.

To understand DMD, let's look at how a multimode fiber works. Multimode fiber is so named because it has hundreds of light pathways, or modes, in which light can travel along the core of the fiber. Imperfections in fiber design and manufacturing can result in large differences in modal speed.

When a laser transmits light into such a fiber, different parts of each light pulse will travel along the fiber at different speeds. The pulse may spread into adjacent bit slots, causing the system to fail. However, if the fiber is precisely manufactured, all modes arrive at the transceiver at the same time and result in a clear signal. Such a fiber has low DMD.

Controlling DMD minimizes the ISI and maximizes the bandwidth of the fiber system. Using a fiber with low



DMD can dramatically improve performance while preserving the cost benefits of multimode fiber systems.

Be sure that the fiber contained in the cable you purchase has been DMD-controlled to the very center of the fiber. Choosing a multimode fiber whose DMD is specified in the 0 - 5 μm range can double the bandwidth for lasers that launch power in the fiber's center. This, along with higher resolution DMD measurements, will help ensure that the fiber cable can withstand deviations in laser characteristics over time.

High Bandwidth, High Performance

By specifying a high-bandwidth fiber, you can "trade off" bandwidth headroom to increase Channel Insertion Loss budgets. For example, many designers are specifying the use of 850 nm laser-optimized 10 Gb/s multimode fibers in data centers.

For 10 Gigabit Ethernet applications, the most cost-effective solution is OM3 fibers.

If this fiber is used at distances shorter than its maximum rating, the ISI penalty is reduced, and the "liberated" power (i.e., bandwidth headroom) can be devoted to increasing the Channel Insertion Loss budget.

That extra headroom allows you to use "plug and play" connectivity solutions, and to support the high loss of some of these systems, while meeting

bandwidth and reach requirements. For example, consider a 10 Gb/s cable solution using 850 nm laser-optimized multimode (OM3) fiber.

This system is rated to 550 meters under standard conditions. If this fiber is used to shorter distances (e.g., 300 meters), the extra bandwidth gives you 1.9 dB of power headroom. This can be added to the 2.6 dB of budgeted channel insertion loss to allow a total of 4.5 dB of CIL (column B).

This extra margin can be devoted to the higher-loss connections of some MTP/MPO cassettes used with a plug-and-play design in data centers.

Conclusion

Because network downtime can be very expensive, reliability is a key requirement for high performance networks. For greater flexibility in network design and, ultimately, greater reliability, follow these strategies.

First, specify lower loss cables and connectors, which provide more power margin. Second, specify a fiber rated for a longer distance than what it will be used for. Third, don't assume that all products that meet a particular standard are equal. It's possible to find higher performing products that exceed the standards.

This is especially true in demanding 10 Gigabit Ethernet optical fiber applications. Here, the most cost-effective solution is OM3 fibers that have been designed and manufactured specifically for laser transmission. They are

available in various performance grades, all featuring a DMD-controlled core that helps ensure 10 Gb/s support with low-cost 850 nm serial applications up to their rated distances.

What to look for in DMD testing

DMD testing provides such a clear picture of how individual mode groups carry light down the fiber, and which mode groups are causing DMD, that the standards require fiber to be DMD-tested to ensure adequate bandwidth for the rated distances for 10 Gb/s applications.

DMD testing involves transmitting short-duration, high-powered laser pulses in small steps across the entire core of the fiber. Each pulse excites only a few modes at each step, and the individual pulse shapes and arrival times are captured at the other end of the fiber. The DMD of the fiber is the difference between the earliest and latest arrival times of all pulses at all steps.

From this information, the manufacturer can adjust his process to produce low DMD (high bandwidth) fiber. With a highly advanced process for making fiber, DMD testing is a powerful process control tool to maintain a precise refractive index profile, even to the center region of the fiber.

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North America

Telephone: 508-347-8590
Toll Free: 800-799-7732
Fax: 508-347-1211
E-mail: fibersalesna@ofsoptics.com

Caribbean, Latin America

Telephone: 508-347-8590
Fax: 508-347-1211
E-mail: fibersalescala@ofsoptics.com

Europe, Middle East, Africa

Telephone: +45-43 48 3736
Fax: +45 4348 3444
E-mail: fibersalesemea@ofsoptics.com

Asia Pacific

Telephone: +852 2836 7102
Fax: +852 2836 7101
E-mail: fibersalesap@ofsoptics.com

Japan

Telephone: +81-3-3286-3424
Fax: +81-3-3286-3708 or 3190
E-mail: fibersalesjapan@ofsoptics.com

China

Telephone: +86 10 6505 3660
Fax: +86 10 65059515
E-mail: fibersaleschina@ofsoptics.com



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