A NetClear® White Paper

Fiber in the Data Center

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A New Generation of Low-Loss, Modular Cassette-Based Systems Enhance 10-Gb/s Performance

Today's data centers (DC) present a challenge in meeting critical business needs in the face of burgeoning transactions and exploding amounts of information that must be stored and managed. With over five exabytes of new information being generated each year globally, even modest data centers must flexibly meet demands for growth in a high-reliability environment. While expansion can be accommodated by adding new servers and storage, it is also met by increasing bandwidth to allow more transmissions per second. Data rates have progressively moved from 10 Mb/s through 100 Mb/s and 1 Gb/s to today's 10 Gb/s and tomorrow's 40 or 100 Gb/s.

As data rates increase, the use of fiber-optic cabling in the DC is becoming more commonplace. Advances in optical technology make fiber more affordable, more practical, and easier to use in the data center. These improvements include:

- **50-micron laser-optimized multimode fiber** (LOMF) that allows cable runs of 300 meters at 10 Gb/s with traditional LOMF. Up to 600 meters is possible with a new generation of enhanced LOMF, exemplified by Berk-Tek GIGAlite™-XB cable. As will be shown, this second generation of LOMF gives even greater flexibility in meeting the needs of DCs.
- **Vertical-cavity surface-emitting lasers** (VCSELs) that lower the cost of optical transceivers. Since they are well matched to LOMF at a wavelength of 850 nm, they make the use of multimode fiber economically attractive.
- **Cassette-based interconnects** that speed the installation of fiber-based cabling systems and simplify the on-going management of the system. The Momentum® series of cassettes from Ortronics/Legrand offer improved performance over legacy cassettes of just a few years ago.

The Benefits of Cassette-Based Fiber Interconnects

Multi-fiber cables terminated with industry-standard MTP®/MPO array connectors simplify use of fiber in the DC. The cables significantly reduce congestion in pathways, provide the highest port densities (12 fibers in a 0.5 x 0.3-inch area), and simplify system design, installation, and management. While fiber ribbon cables are popular for array connections, new reduced-diameter cables, such as Berk-Tek's Micro Data Center Plenum (MDP) cable, are setting a new standard in DC cabling. As shown in Figure 1, the diameter of a 48-fiber MDP cable is less than half that of a stacked ribbon cable of the same capacity and only one-third of a similarly configured Loose-Tube Plenum (LTP) cable. When properly applied, reduced-diameter cables improve air flow and aid in dissipating heat in the computer room.

* MTP is a registered trademark of US Connec

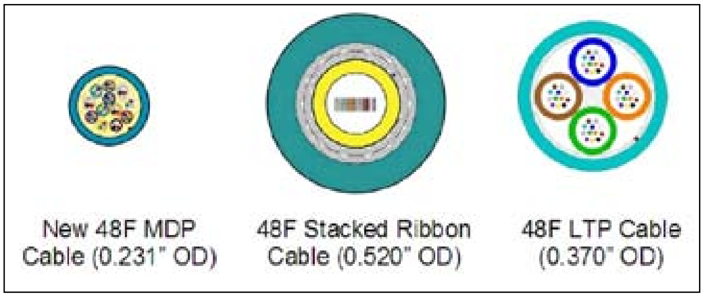


Figure 1. Reduced-diameter cables save space in crowded conduits.

The companion cassettes, as shown in Figure 2, perform the transition from the multi-fiber array to individual SC or LC patch cords. A single cassette can typically handle 12 or 24 fibers in a single unit and up to 12 cassettes fit in a standard 4U 19-inch rack-mount fiber patch panel. Installation of the cassette is simple (Figure 3). The cassettes are inserted into the fiber patch panel, and the array cable is plugged into the back of the cassette and patch cords connect to the front. This "plug-and-go" simplicity means extremely fast and reliable installation when compared to field installing fiber connectors.

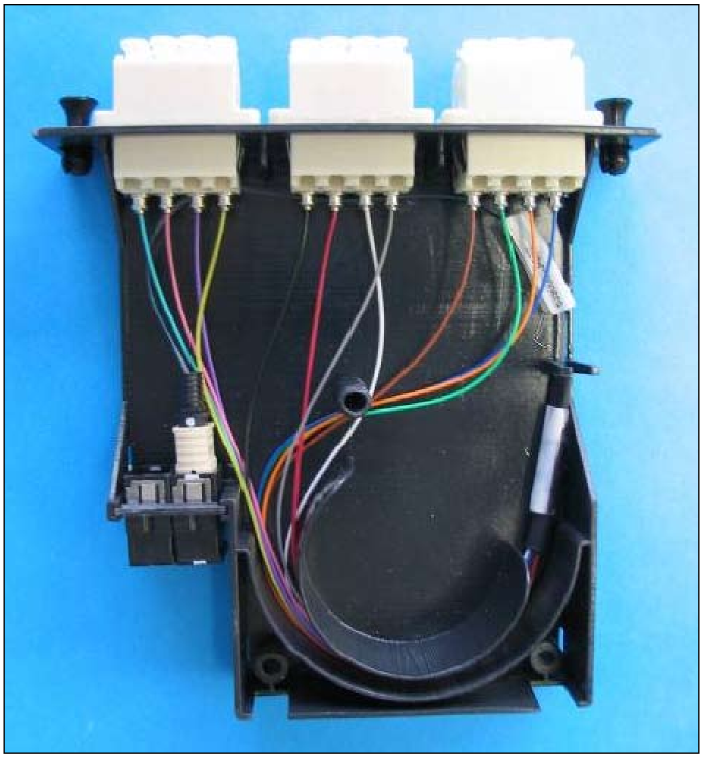


Figure 2. A fiber cassette acts as a transition between a MTP/ MPO-based multi-fiber backbone and LC- or SC-terminated patch cords (shown with cover removed for clarity).

Figure 3. Fiber cassettes offer the simplicity of "plug-and-go" application.

Cassettes can mount in standard 19-inch or 23-inch rack-mount cabinets, wall-mount enclosures, and under-floor boxes. All components—cable assemblies and cassettes—are factory terminated and tested so that there is no field preparation involved. And because the components are provided with the test data on a label conveniently affixed to the cassette housing, any field testing results can be verified quickly and easily.

Design Considerations

Using LOMF multi-fiber interconnect cables and cassettes is straightforward. A primary design consideration is ensuring that the system stays within the channel insertion loss budget for a particular application. This budget is simply predetermined by the application (such as 10GBASE-SR). Therefore, the attenuation of the patch cord and backbone cable, associated connector insertion loss, and the insertion loss value of the cassettes should not exceed the channel insertion loss budget. (A free link-loss calculator is available from NetClear at www.netclear-channel.com/calculator. It is an easy-to-use spreadsheet that automatically calculates loss based on component choices and link lengths.)

The sum of these individual losses must be less than the maximum channel insertion loss specified for the application running over the cabling system. As new higher-data-rate networking protocols enter the market, the link budget for the channel diminishes. One of the reasons for shrinking link budgets is that the standards groups, which defined new high-speed protocols conservatively, accounted for certain link penalties.

The **available** channel loss budget is what remains after these penalties are factored into the total loss budget. For example, intersymbol interference (ISI), which can cause bit errors when adjacent data pulses spread and overlap one another, is a major penalty in the overall power budget. As shown in Figure 4, the impact of ISI on overall loss budget is comparable to channel insertion loss, with over 75% of the total loss budget coming from these two factors

The ISI penalty in the 10G standard was calculated using a 50-micron LOMF (OM-3) with a modal bandwidth of 2000 MHz•km. The modal bandwidth is primarily limited by the fiber characteristic of differential model delay (DMD), which causes ISI due to pulse spreading. A new generation of LOMF improves the modal bandwidth to 4900 MHz•km at 850 nm using today's VCSELs. As we will discuss next, this has important consequences on the application of fiber cassettes in the data center.

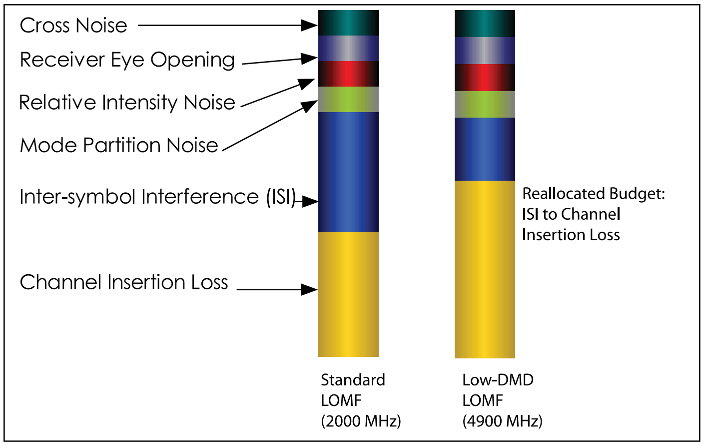


Figure 4. 75% of the total loss budget is allocated to ISI and channel insertion loss in IEEE 802.3ae.

Channel Insertion Loss

Assuming a fiber having an effective modal bandwidth of 2000 MHz•km at 850nm and a fixed link length of 300 meters, the budget for channel insertion loss for 10-Gb/s Ethernet is a tight 2.6 dB. With the new 4900 MHz•km LOMF, and conservatively compensating for connector modal noise, it becomes possible to reallocate up to 1.9 dB of the ISI penalty to the channel loss—yielding a more generous 4.5 dB budget of channel insertion loss.

At the same time, fiber cassettes, backbone cables, and patch cords have been improved to offer lower component insertion loss. Ortronics' Momentum cassettes are offered in two performance tiers, with progressively improved insertion loss: 0.75 dB for high-performance cassettes and 0.50 dB for premium-performance cassettes. This performance, which includes the loss of the rear panel MPO and front panel LC or SC connectors, represents an improvement over 1.25 dB or 1.5 dB for first-generation legacy cassettes.

The combination of enhanced low-DMD fiber and improved cassette performance significantly increases flexibility in deploying a cabling system in a DC. With traditional OM3 LOMF and first-generation cassettes, achieving the channel insertion-loss budget over a full 300 meters was pushing the limits: the cable loss at 1.05 dB and the insertion loss for 2 cassettes at 2.5 dB produced a total loss of 3.55 dB. This constrains the design flexibility. With improved fiber and cassettes, it is now possible (although not necessarily practical) to use as many as seven cassettes in the path. The extra system margin provides great flexibility for both the designer and installer. Figure 5 summarizes channel budgets and illustrates the maximum number of cassettes possible using different cassette grades.

Two things need to be noted about Figure 5:

1. The improved fiber has an attenuation of 3.0 dB/km (as opposed to 3.5 dB/km for OM-3 fiber), which yields a loss of 0.9 dB over 300 meters.
2. The graphic is for 300-meter channels. Most channels in DC applications are under 100 meters, which means additional power is reallocated to the budget. Figure 6 shows the distribution of real-world multi-fiber cable backbone lengths commonly used in the DC. Cable lengths over 25 meters are the exception: the vast majority of backbone cables are shorter.

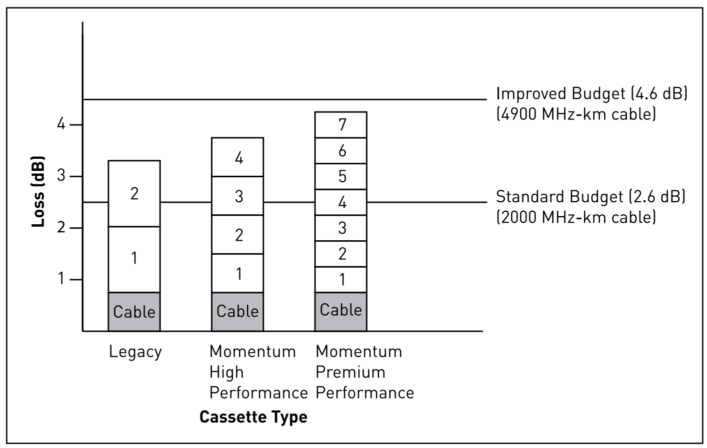


Figure 5. Low DMD cable and improved cassettes can allow more connections in the channel.

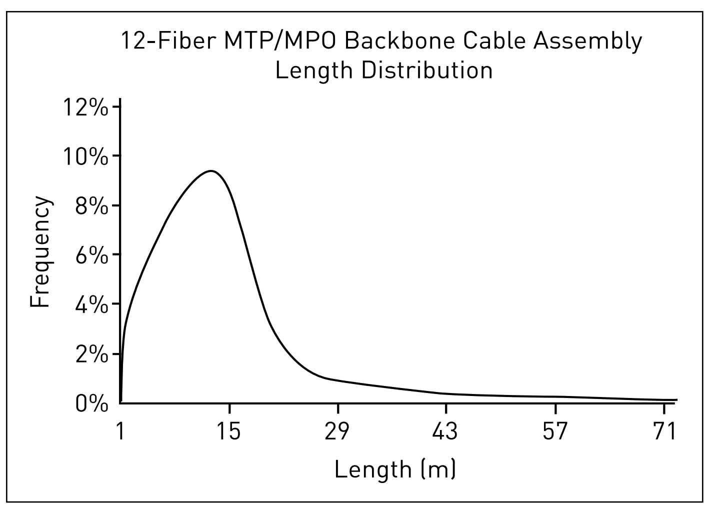


Figure 6. Most backbone cables in a DC are much shorter than the 300 meters maximum allowed by standards and the 600 meters possible with such cables as the GIGAlite-XB.

It's the System That Counts

The performance of a fiber-based cabling solution needs to be viewed at the system level and not just as an assembly of components. The newer high-performance and premium-performance fiber cassettes are perfect examples. Because the cassette's performance is primarily attributed to improved connector end-face polishing and connector end preparation at the factory, it is essential that the attached backbone cable and patch cords are prepared with the same high-quality process. Otherwise, the improved system-level insertion loss performance may not be realized. Simply put, to achieve improved performance you need high-performance or premium cassettes and matching cables. Similarly, to allow the ISI penalty to be reallocated to the channel budget, all fibers—backbone, patch, and fiber internal to the cassette—must use the improved high-performance, low-DMD cable.

The example in Figure 5 is based on worst-case performance at 300 meters. For other channel lengths, the calculations can be easily modified. Such systems will easily accommodate longer channels with fewer cassettes or shorter channels with the potential of additional cassettes. The important consideration is that, by using worst-case maximum numbers, real-world typical performance will provide an additional comfortable margin.

The increased flexibility in system configuration today translates to peace of mind knowing you will not be restricted tomorrow. The use of multi-fiber cable and cassettes, for example, will ease the transition to future parallel transmissions being considered for 40 Gb/s and 100 Gb/s systems now being defined. What's more, the easier installation, the simplified management, and the higher performance combine to offer a lower total cost of ownership.

Conclusion

Cassette/multi-fiber cabling systems in the DC have obvious advantages in space savings and simple installation. Low-DMD fiber, such as Berk-Tek's GIGAlite-XB, combined with improved connector performance in MOMENTUM 3 cassettes offer flexibility for longer runs or more connections. Gone are the severe limitations on the number of cassettes that you can use in a channel—which opens up the widest range of cabling and equipment topologies to keep the growth and evolution of DCs fluid and easily managed.

What to Look for in a Fiber Cassette

Low Insertion Loss. The lower the insertion loss, the more cassettes that can be used in the channel—and the greater flexibility you have in your DC topology

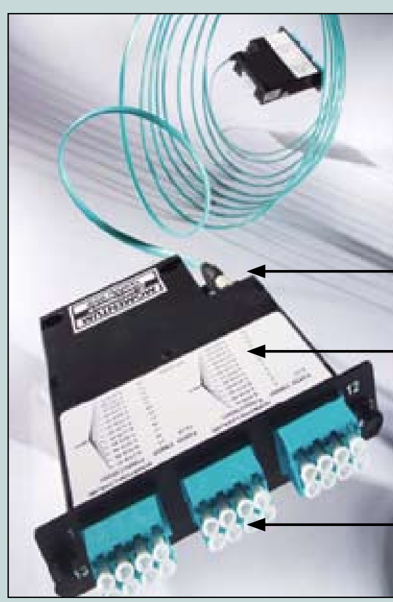
Compatibility with Low-DMD Fibers. A cassette using low-DMD fiber is already compatible with systems using low-DMD fiber. This allows the ISI penalty to be reallocated to the channel insertion loss.

Internal Fiber Management. The cassette should have internal guides to keep the fibers from bending too tightly.

Comprehensive Performance Documentation Conveniently Displayed. The cassettes should be supplied with factory test results. Because such data is often misfiled, lost, or located inside the cassettes, Ortronics/Legrand now affixes the performance data to a label on the outside of the housing.

Protected Array Connection. Many cassettes are designed so that the array connections stick out from the back of the cassette, increasing the chance they will be inadvertently bumped or damaged. Cassettes that have the connection located in a recess in the cassette housing provide better protection.

Choice of patchcord connectors. The LC interface is the most popular (and recommended) because it allows the best combination of high-density, low-loss, and compatibility with equipment vendors. Some users may prefer other options, such as the SC or MT-RJ.



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