Performance Study

HD8^2

vs.

Traditional Plug-and-Play

Abstract

Insertion loss is the primary performance parameter that defines the ability of a fiber optic link to support a given application. As data transmission speeds have increased, insertion loss requirements have become more stringent, and staying within loss budgets is an increasing concern among data center designers. While traditional MPO-to-LC cassettes used in popular pre-terminated plug-and-play fiber connectivity systems facilitate a faster, easier deployment, both the MPO and the LC connection have associated insertion loss that can put a strain on loss budgets and limit the number of connections within a channel. This performance study compares the insertion loss results of fiber links using traditional plug-and-play cassettes to fiber links using HDReadyLink™ trunks that feature an integrated hard-wired cassette that eliminates the MPO connection and its associated insertion loss. By lowering insertion loss, data center designers have more headroom that ensures high-performance low-latency data transmission and enables reliability, flexibility and scalability.

Tactical Deployment Systems

Connect Anything.
Anywhere.

Background

Over the past decade, emerging technologies have been placing huge demands on today's data center infrastructure with more data than ever needing to transmit at faster speeds. Now the COVID-19 pandemic is changing the way people live and work and the way the world does business. Global Internet traffic has increased by nearly 70% with VPN usage, online gaming and video streaming spiking to never-before-seen levels. Businesses are reinventing themselves and shifting to a fully digital approach to achieve sufficient work-from-home functionality and business continuity, requiring low-latency, high-performance networking in on-premises, multi-tenant and cloud computing data centers.

For fiber optic networks, insertion loss is the primary performance parameter that determines if a channel will support a given application and is required for Tier 1 certification testing per TIA 568 and ISO 11801 standards. Expressed in decibels (dB), insertion loss is the loss of signal that occurs along any length of fiber and at every connection point within the channel. If the loss it too high, it will prevent the signal from properly reaching the receive end, resulting in network errors and non-functioning links. Industry standards specify the maximum insertion loss in a channel for each application and as data transmission speeds have increased, maximum distance and insertion loss requirements have become more stringent. For example, 10GBASE-SR (10 Gb/s) is supported over 400 meters (m) of OM4 multimode fiber with a total channel insertion loss of 2.9 dB, while 25GBASE-SR and 50GBASE-SR (25 and 50 Gb/s) is supported over only 100 m of OM4 multimode with a total channel loss of only 1.9 dB. Hence, loss budgets are an increasing concern among data center designers, often requiring shorter distances and fewer connection points that can ultimately limit flexibility, manageability and ease of deployment.

Within modern data centers, the use of pre-terminated plug-and-play fiber connectivity solutions has become the de facto practice for establishing connections between active equipment, including core routers, spine switches, leaf switches, servers and storage devices. These systems essentially replicate active equipment ports and allow for easy patching in either an interconnect or cross connect scenario. An interconnect patches directly between active equipment and a distribution panel, which requires less rack space and material. Preferred cross-connects use both an equipment panel and a distribution panel to easily make connections to any switch port at the panels without having to access the switch. In a cross-connect scenario, the expensive active equipment can therefore be located in a separate, secure location. This is especially ideal in multi-tenant, multi-service provider data centers as it allows for connecting tenant equipment to service provider equipment without having to access the active equipment, which is often prohibited. Figure 1 below shows the difference between an interconnect and a cross connect.

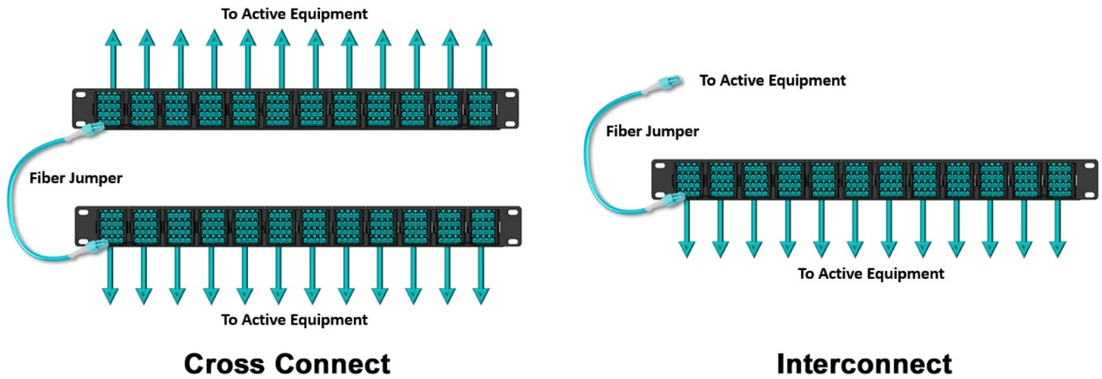


Figure 1: Cross Connect vs. Interconnect

Another key benefit of the cross connect is the flexibility to connect any switch port to any other switch port by simply repositioning fiber jumpers at the front of the panels. Scalability and speed of deployment is also enhanced as each panel can be connected by larger count fiber cabling to various locations within a data center and services brought on line by simply adding jumpers. The flexibility of the cross connect is also better suited for today's virtual server environments because it facilitates connecting distributed servers to the same switch.

Problem

For duplex applications, traditional plug-and-play systems deployed in a cross connect or interconnect typically use cassettes that feature 6 duplex connectors (i.e., 12 fibers) or 4 duplex connects (i.e., 8 fibers) on the front of the cassette with a 12-fiber or 8-fiber multi-fiber push-on (MPO) connector (e.g., MTP®) at the rear of the cassette. Cassettes located at active equipment connect using MPO trunk cables via the rear MPO connection. These solutions also facilitate link aggregation, which is becoming increasingly popular for optimizing switch port utilization, delivering higher bandwidth and saving cost. For example, in a 400GBASE-SR8 (i.e., 400 Gbps) application that transmits 50 Gbps per lane over eight lanes (16 fibers) of multimode fiber, link aggregation can allow a single 400GBASE-SR8 port on one switch to connect to up to eight 50 Gbps duplex ports (i.e., 8 X 50).

Duplex plug-and-play fiber deployments using traditional cassettes with an MPO connector at the rear and duplex fiber connections on the front must consider the insertion loss of both the MPO and the duplex connections. In other words, if the MPO connection at the rear of the cassette has an insertion loss of 0.2 dB and the LC connector has a 0.08 dB loss, a total loss is 0.28 dB for each cassette within the channel needs to be included in the loss budget, along with the loss of the fiber and loss of equipment connections. An example loss budget is shown below in Figure 2 for a 400-meter 10 Gb/s duplex multimode fiber application (i.e., 10GBASE-SR) with traditional cassettes at both ends.

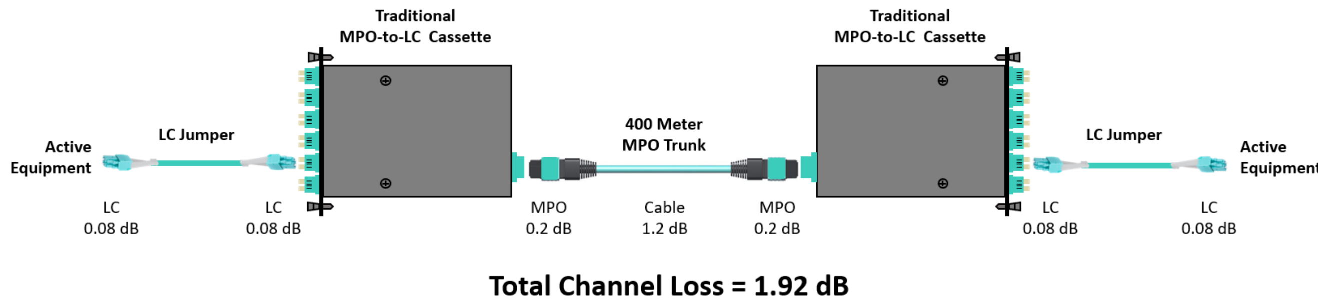


Figure 2: Channel loss for a 400m OM4 multimode fiber link using traditional cassettes

While a loss of 1.92 dB falls well within the maximum allowed channel loss of 2.6 dB for 10GBASE-SR, the example in Figure 1 does not include the preferred cross connect. Implementing a cross connect into the channel adds another 6 LC connections and 4 MPO connections, for a total loss of 2.48 dB. While this supports 10GBASE-SR, there is very little headroom to accommodate for any additional loss caused by a dirty fiber end face, macrobends in the fiber or other loss events. Furthermore, today's higher speed applications have more stringent insertion loss requirements. For example, 25 Gbps and 50 Gbps (i.e., 25GBASE-SR and 50GBASE-SR) applications that are becoming increasingly popular for horizontal switch-to-server links in the data center are supported by OM4 multimode fiber to 100 meters with a total channel insertion loss of just 1.9 dB. While the shorter 100-meter distance lowers the attributing insertion loss of the cable, these more stringent insertion loss requirements limit the number of connections and do not support the use of a cross connect.

Solution

While fiber cable and connectivity manufacturers have managed to significantly reduce insertion loss performance over the past decade, loss budgets still remain a number one concern among data center designers. As demonstrated, traditional MPO-to-LC cassettes encompass too much loss to provide headroom or to effectively enable the use of cross connects in 10, 25 and 50 Gbps duplex applications.

In 2019, Tactical Deployment Systems introduced the HD8² High Density Fiber System based on years of experience working with data center managers, understanding their needs and witnessing their frustrations with traditional high-density plug-and-play fiber connectivity. Rather than using a traditional cassette design with duplex connectors at the front of the cassette and an MPO connector at the rear, the HD8² system features HDReadyLink™ trunks that integrate the cassette and trunk cable into a single component as shown in Figure 3. This unique and innovative design eliminates the MPO connection at the rear of the cassette by hard wiring the trunk cable to the duplex connectors. With a maximum insertion loss of just 0.2 dB (0.08 dB typical) for the duplex port at the front of the cassette, this type of cassette-based trunk solution significantly decreases the overall channel insertion loss to allow for more connections points and/or more insertion loss headroom within a channel, enabling the use of cross connects and providing data centers with greater flexibility and manageability.

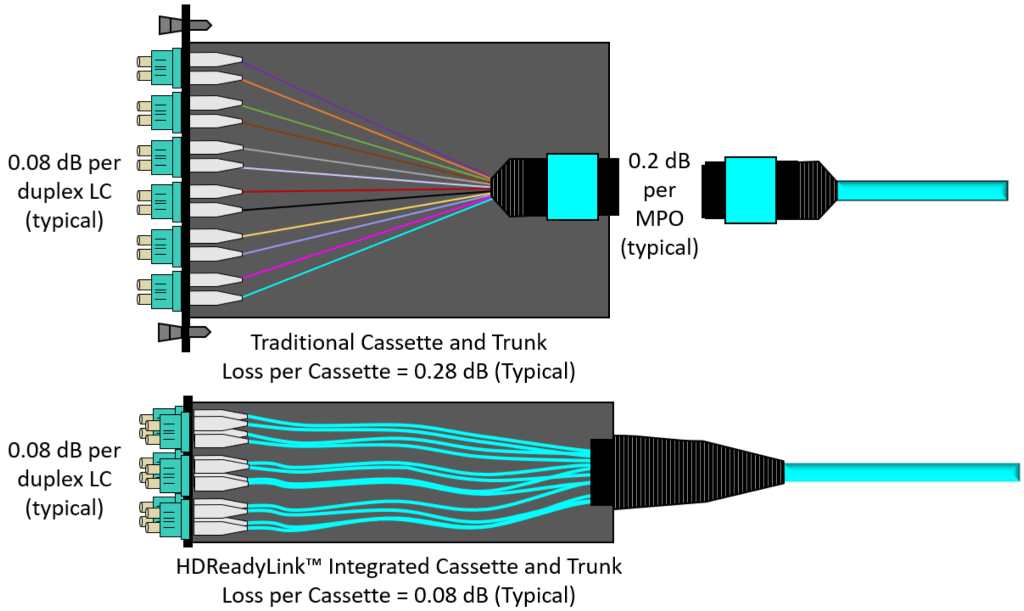
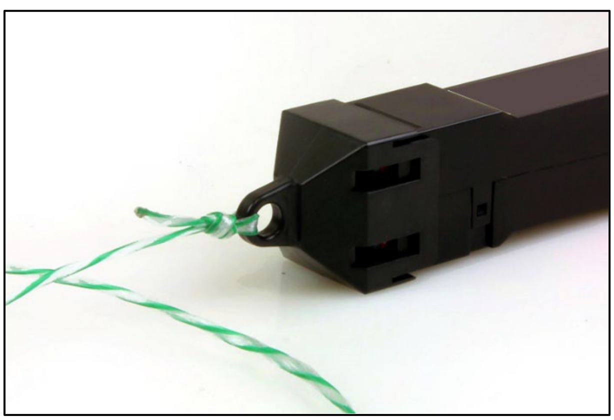


Figure 3: HDReadyLink™ integrated cassettes and trunks eliminate the rear MPO connection and associated loss

To accommodate deployment of the HDReadyLink™ trunks through pathways from fiber panel to panel, Tactical Deployment Systems innovated a smaller footprint square cassette design with a patented HDReadyPull™ snap-on pulling cap that protects the fiber ports while doubling as a removable pulling eye. Within the cassette, an integrated strain relief places the force on the strength members within the cable rather than the fibers themselves, enabling a 50 lbs. pulling force as shown in Figure 4.



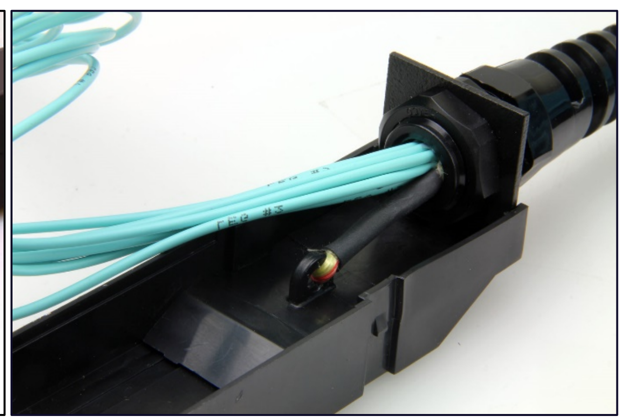


Figure 4: HDReadyLink™ trunks feature a patented HDReadyPull™ snap-on pulling cap and integrated strain relief that places the force on the strength members within the cable rather than the fibers

In addition to eliminating the MPO connector, the square design of the HDReadyLink™ supports a higher density of 8 duplex connectors (16 fibers) per cassette. With 12 HDReadyLink™ trunks per 1U, the HD8² system supports 96 duplex connections (192 fibers) for 33% more capacity than traditional plug-and-play fiber systems as shown in Figure 5.

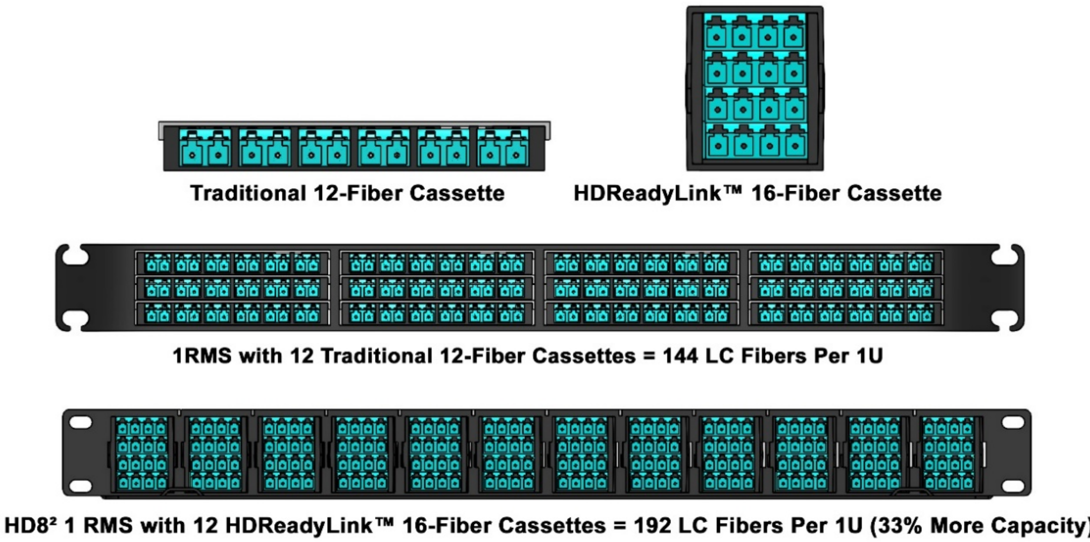


Figure 5: The square cassette design of the HDReadyLink™ trunks supports 16 LC fibers for 33% more capacity in 1U compared to traditional flat cassettes

The HDReadyLink™ trunks also enable easy deployment. In a traditional system, cassettes are installed separately within a fiber enclosure or chassis and trunk cables are then routed through pathways, the pulling eye is removed, and the cables are plugged into the back of the cassettes. Traditional cassettes also do not often securely lock into place within enclosures and chassis, causing them to come loose when plugging trunk cables into the rear or fiber jumpers into the front. With the cassette and trunk integrated into one component, HDReadyLink™ trunks can be easily pulled through pathways and then snapped into place within a chassis, eliminating the need to install and plug together separate components, remove pulling eyes and deal with loose cassettes.

Performance Study

To demonstrate the advantages of using HDReadyLink™ trunks over traditional cassette designs, a performance study was conducted that used Tier 1 testing to compare insertion loss of a leading manufacturer's traditional plug-and-play system to the HD8² system using HDReadyLink™ trunks. Published manufacturer typical and maximum insertion loss specifications were used for comparison, which includes:

- LC Connection: 0.08 dB typical (0.2 dB maximum)
- MPO Connection: 0.2 dB typical (0.6 dB maximum)

Actual link test results for the HD8² system were acquired via insertion loss testing performed using an Optotest OP710 multi-channel optical power meter with OP750 multi-channel LED source configured for at the 850nm wavelength.

Test Setup

Performance testing included the following setups with each channel (i.e., port) individually tested and insertion loss results averaged across all links:

Test 1: 6-Meter Duplex SFP-to-SFP Channel

- Side A Jumper: Eight (8) 1m duplex LC to LC SENKO Uniboot 50/125µm OM4 multimode jumpers
- Trunk: HDReadyLink™ 3m 50/125µm OM4 multimode trunk with integrated 8-port duplex LC cassette to 8-port duplex LC cassette (16 fiber)
- Side B Jumper: Eight (8) 2m duplex LC to LC SENKO Uniboot 50/125µm OM4 multimode jumpers

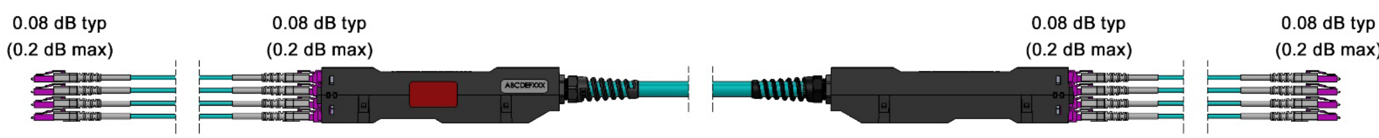


Figure 6: Test 1 utilized a 6-meter duplex channel with a total of 4 LC connections

Test 2: 95-Meter 10X4 Link Aggregation QSFP-to-SPF Channel

- Side A Jumper: Eight (8) 4m MTP-to-MTP (8-fiber) 50/125µm OM3 multimode jumpers
- Trunk: HDReadyLink™ 87m 50/125µm OM3 multimode trunk with integrated 8-port MTP (8-fiber) cassette to four (4) 8-port duplex LC cassettes (64 fiber)
- Side B Jumper: 32 (8) 4m duplex LC to LC SENKO Uniboot 50/125µm OM3 multimode jumpers

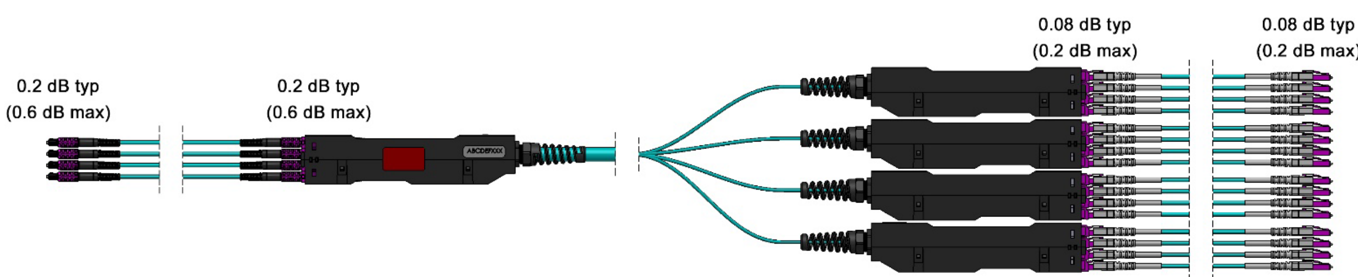


Figure 7: Test 2 utilized a 95-meter 10X4 aggregation channel with a total of 2 LC connections and 2 MPO connections

Test 3: 28-Meter Parallel Optic QSFP-to-QSFP Channel

- Side A Jumper: Eight (8) 2m MTP to MTP 50/125µm OM4 multimode jumpers
- Trunk: HDReadyLink™ 24m50/125µm OM4 multimode trunk with integrated 8-port MTP cassette to 8-port MTP Cassette (64 fiber)
- Side B Jumper: Eight (8) 2m MTP to MTP 50/125µm OM4 multimode jumpers

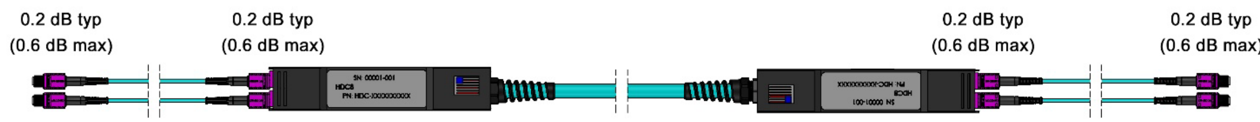


Figure 8: Test 3 utilized a 28-meter parallel optic channel with a total of 4 MPO connections

Results

In Test 1, performance testing for a 6-meter duplex channel demonstrated that the HD8² system with HDReadyLink™ offers a 56% improvement for typical channel insertion loss and a 60% improvement for maximum channel loss compared to using traditional MPO-to-LC cassettes. Actual insertion loss results for the HD8² system channel demonstrated a 83% improvement over maximum channel insertion loss for a traditional system, offering 1.66 dB of headroom. With the square design of the HDReadyLink™ cassette that can accommodate 8 LC duplex connections (16 fiber), the HD8² system offers 33% more density in a 1U space.

Test 1: 6-Meter Duplex SFP-to-SFP Channel	Traditional	HD8² with HDReadyLink™	HD8² % Improvement
LC Connections Per Channel	4	4	NA
MPO Connections Per Channel	2	0	NA
Typical Channel IL (dB)	0.72	0.32	**56%**
Max Channel IL (dB)	2.0	0.8	**60%**
Actual Average Channel IL (dB)	Not Tested	0.34	**83% over traditional max**
Density Per 1U (LC Fibers)	144	192	**33%**

Table 1: Performance testing of HD8² system with HDReadyLink™ Trunks in a 6-meter duplex application

In Test 2, performance testing for a 95-meter link aggregation channel (i.e., 10 X 4) demonstrated that the HD8² system with HDReadyLink™ trunks offers a 26% improvement for typical channel insertion loss and a 27% improvement for maximum channel loss compared to using traditional MPO-to-LC cassettes. Actual insertion loss results for the HD8² system channel demonstrated a 94% improvement over maximum channel insertion loss for a traditional system, offering 2.07 dB of headroom. With the square design of the HDReadyLink™ cassettes that can accommodate 8 MPO connections (64 fiber) to four (4) 8 LC duplex connections (64 fiber), the HD8² system offers 33% more density in a 1U space.

Test 2: 95-Meter 10X4 Link QSFP-to-SPF Channel	Traditional	HD8² with HDReadyLink™	HD8² % Improvement
LC Connections Per Channel	2	2	NA
MPO Connections Per Channel	3	2	NA
Typical Channel IL (dB)	0.76	0.56	**26%**
Max Channel IL (dB)	2.2	1.6	**27%**
Actual Average Channel IL (dB)	Not Tested	0.13	**94% over traditional max**
Density Per 1U (LC Fibers)	144	192	**33%**
Density Per 1U (MTP Fibers)	72	96	**33%**

Table 2: Performance testing of HD8² system with HDReadyLink™ Trunks in a 95-meter link aggregation application

In Test 3, performance testing for a 28-meter parallel optic channel demonstrates that the HD8² system with HDReadyLink™ trunks offers the same performance for both typical and maximum channel insertion loss compared to using traditional MPO-to-LC cassettes. The performance is the same because in a parallel optic application using MPO connectivity, there is no need to transition from the MPO connection to the duplex LC connection. Actual insertion loss results for the HD8² system channel demonstrated a 50% improvement over maximum channel insertion loss for a traditional system, offering 1.19 dB of headroom. With the square design of the HDReadyLink™ cassette that can accommodate 8 MPO connections (64 fiber), the HD8² system offers 33% more density in a 1U space.

Test 3: 28-Meter Parallel Optic QSFP-to-QSFP Channel	Traditional	HD8² with HDReadyLink™	HD8² % Improvement
LC Connections Per Channel	0	0	NA
MPO Connections Per Channel	4	4	NA
Typical Channel IL (dB)	0.8	0.8	**Same**
Max Channel IL (dB)	2.4	2.4	**Same**
Actual Average Channel IL (dB)	Not Tested	1.21	**50% over traditional max**
Density Per 1U (MTP Fibers)	72	96	**33%**

Table 3: Performance testing of HD8² system with HDReadyLink™ Trunks in a 28-meter parallel optic application

Conclusion

Due to the unique design of the HDReadyLink™ trunks that eliminates an MPO connection at the rear of the cassette, combined with overall superior performance and smaller footprint square cassette, testing clearly shows that the HD8² system offers significant improvement in both insertion loss performance and density. In duplex and aggregation deployments, HDReadyLink™ trunks demonstrate a 83% and 94% insertion loss performance improvement and 33% more density compared to maximum insertion loss values of traditional plug-and-play solutions. Even in a parallel optics application using only MPO connectivity where HDReadyLink™ trunks would be expected to offer equal insertion loss performance to traditional plug-and-play systems, HD8² demonstrated a 50% insertion loss improvement over published maximum insertion loss values, offering complete peace of mind that the solution performs as expected. Furthermore, in a parallel optics application, the HD8² still has the advantage of 33% more density.

It's important to note that while this study clearly demonstrated that the HD8² system offers 33% more density, the system also supports new small form-factor connector such as the Senko CS® dual fiber connector introduced in 2019, which is 40% smaller than a traditional LC connector. It also supports the latest Senko SN® and USCONEC ELiMENT™ MDC dual fiber connectors, which are 50% smaller than traditional LCs, thereby doubling the density. These small form connectors utilize the same 1.25mm ferule as the LC and are ideal for ultra-high-density patching environments, enabling four connectors (eight fibers) to fit into one transceiver to support 400-to-100 Gb/s or 200-to-50 Gb/s break-out applications that are becoming popular in large cloud and hyperscale deployments for server connections. As shown in Table 4, the HD8² offers significantly higher density when using these emerging small form-factor connectors.

Connector Type	Ports/Fibers per 1U	HD8² % Density Increase
LC connectors using traditional cassettes	72 duplex ports/144 fibers	N/A
LC connectors using square cassettes	96 duplex ports/192 fibers	33%
CS® connectors using square cassettes	144 duplex ports/288 fibers	100%
SN® connectors using square cassettes	192 duplex ports/384 fibers	266%
MDC connectors using square cassettes	216 duplex ports/432 fibers	300%

Table 4: The HD8² system with HDReadyLink™ Trunks Are Available with Emerging Small Form-Factor Connectors for Even Higher Density

In addition to insertion loss performance and density gains, the design of the HDReadyLink™ trunks with the cassette and trunk cable integrated into a single component, the patented HDReadyPull™ snap-on pulling cap and the integrated strain relief can offer fast, easy installation that is especially ideal for emergency response rapid expansion or disaster recovery scenarios. Unlike traditional plug-and-play systems where individual cassettes and/or adapters need to be removed from their packaging and mounted into a fiber panel, trunk cables routed, pulling eyes removed and cables plugged into the rear of the cassettes, HDReadyLink™ trunks are simply pulled through pathways and then snapped into place within a chassis. Furthermore, by eliminating the need to install and plug together separate components, HDReadyLink™ trunks prevent the common problem of cassettes and adapters coming loose when plugging components together that often requires installers to hold cassettes and modules in place.

To meet the requirements of any data application, the HDReadyLink™ trunks are available in OM3, OM4 and OM5 multimode and OS2 singlemode fiber and can be configured as a cassette-to-cassette trunk or multi-cassette fanout in lengths from 1 to 1000 meters and fiber counts from 2 to 32. Cassettes can be configured using premium-grade LC UPC and APC connectors, including shuttered connectors, as well as SC, ST, MTP, MDC, SN and CS connector types. All components are of the highest quality and made in the U.S.A. via quick-turn manufacturing that ensure fast lead times.

In conclusion, the HD8² High Density Fiber System with HDReadyLink™ trunks offers the following benefits over traditional plug-and-play systems:

- **Superior reliability** with up to 94% better insertion loss performance and premium-grade cables and connectors
- **Improved flexibility and scalability** by enabling more connection points per channel to support the use of cross connects
- **Maximum space savings** with 33% higher density in LC and MTP deployments and even higher density via support for new small form-factor connectors
- **Fast, easy deployments and capacity expansion** by eliminating the need to install separate components
- **Support for any data center application** via customized turnkey configurations
- **Reduced lead time** with quick-turn U.S.-based manufacturing

Customer Testimonial

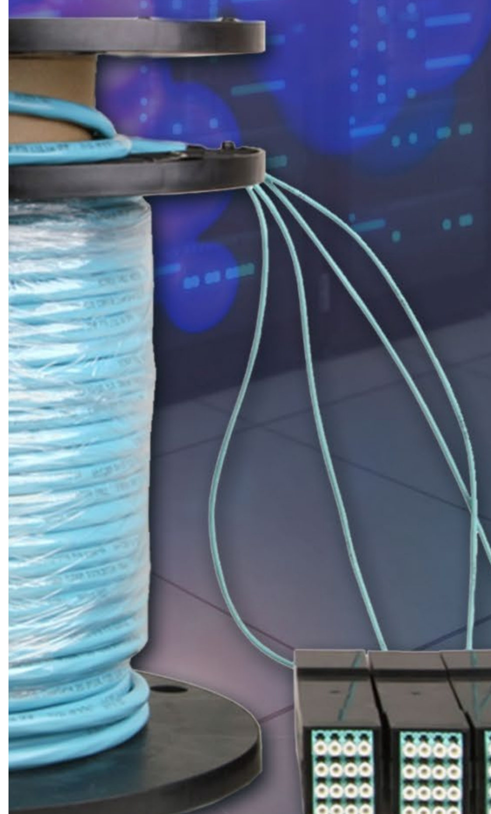
Adrian Ellsworth, Senior Application Engineer, Nokia

Nokia offers a comprehensive portfolio of network equipment that includes high-performance, high-density routers capable of supporting transceivers and applications from 10 to 400 Gigabit and beyond. Commonly deployed in data center, WAN and aggregation ISP networks, Nokia routers meet evolving service demands driven by emerging 5G and IoT technology. According to Adrian Ellsworth, senior application engineer for Nokia, the modularity, density and performance of Nokia's routers align well with the corresponding features of the HD8² High Density Fiber System and HDReadyLink™ trunks.

"Our high-density routers are designed to enable extremely high port counts in as least amount of space as possible. They are also modular to support virtually any mix of transceivers for a range of singlemode and multimode applications, including wave division multiplexing, parallel optics and duplex applications. For example, we could have 400GBASE-SR8 transceivers using MPO-16 connectivity, 100GBASE-SR4 using MPO-12 connectivity and 50GBASE-SR using LC connectivity all within a single chassis," says Ellsworth. "What's great about the HD8² System is that it can align with the density and connectivity needs of our routers by mixing and matching HDReadyLink trunks within a single rack unit. We really like the combination of connectivity the system supports, and we haven't seen anything else that offers that level of modularity and density."

When it comes to performance, Nokia also recognizes the benefit of using hard-wired cassettes. "Loss budgets are especially a concern among our customers who have very long runs and it will be even more of concern as speeds continue to increase. The fact that the HDReadyLink™ trunks eliminate the insertion loss of the MPO connection via hard-wired cassettes provides greater flexibility in design and deployment, which is important to our customer base," says Ellsworth. "We see a lot of aggregation where a 100 or 400 Gig port breaks out to multiple lower-speed duplex connections at the edge to maintain router density and cost savings, and the HD8² is an ideal way to passively support these breakouts while reducing insertion loss. Plus, it's all very plug and play with the integrated pulling eye that allows us to easily pull through cable tray."

According to Ellsworth, Tactical Deployment Systems customer-facing approach also adds value. "I have found TDS to be more innovative and willing to take the time to really understand our needs and build customized solutions."



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