WHITE PAPER

Optical Backplane Connectors

Dense and Highly Engineered Interface Technology

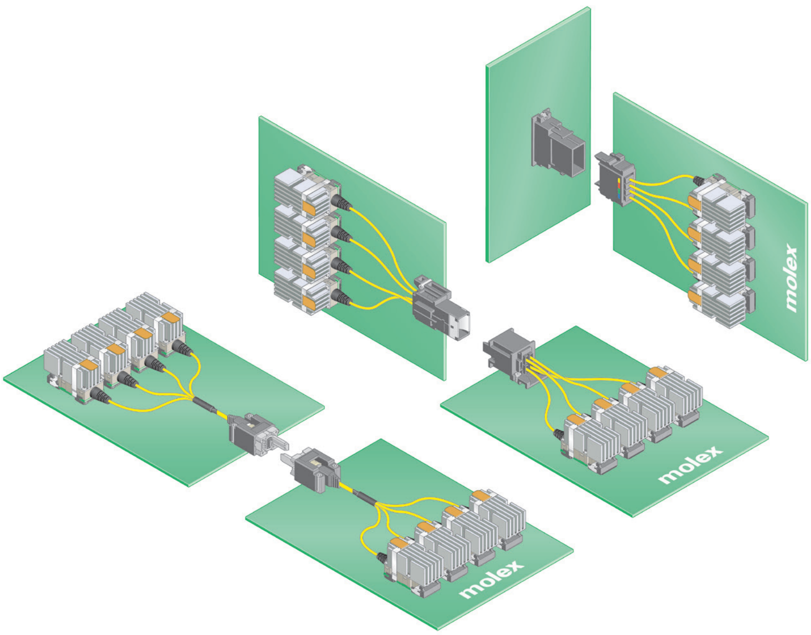
Optical backplane connectors allow the connection of optical fibers through blind mating interfaces in similar fashion to electrical backplane connectors. These dense and highly engineered interfaces have been utilized successfully for decades to enable scalable capacity systems for applications in core routing, optical switching and telecommunications.

In this paper we will examine what attracts system architects and mechanical designers to the use of blind mating optical interconnects as well as design requirements, fiber density drivers, maintenance, industry dynamics and our views towards future needs and challenges.

As with front panel optical connections, OBO (On Board Optic) modules are easily interfaced to optical backplane connectors through standard multi-fiber round jacketed cables, ribbon fiber or pre-shaped routed ribbon fiber technology attached to OBO modules.

Optical FlexPlane can also be utilized with optical backplane specific connection elements on one end of the FlexPlane and OBOs attached on the other. In this manner very dense and highly complex fiber port mapping can be accomplished within the system elements. Hardware designers and system architects are attracted to these interface technologies for a variety of aspects:

- Freeing up front panel space for increased airflow and client or networking ports
- Enabling faster system deployments, upgrades and repairs by eliminating manual installation of front panel cabling connections
- Increasing interconnect density and easing cable management beyond traditional front panel optical connectors and transceivers
- Allowing for greater modularization of system components via built in system specific connectivity configurations such as optical shuffling which standardizes line cards and drawers thus enabling use of standard structured cabling external to the chassis



COPLANAR, ORTHOGONAL AND STANDARD OPTICAL BACKPLANE CONNECTOR CONFIGURATIONS

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Types of Optical Backplane Connectors

Ceramic ferrule based optical backplane connectors were first to market decades ago and for the most part based on industry standard connectors for the user side such as the MU, SC and LC along with custom termini based versions for vendor specific applications. Ceramic single fiber ferrule interconnects utilize a cylindrical ferrule on each side of the interface aligned within a ceramic split sleeve held in a mating housing normally mounted on the backplane. The board side of the interface is a customized housing mounted to the PCB holding the ferrules designed for proper mating alignment into the backplane housing.

Optical performance and density mimic the standards-based connector with additional dimensional overhead for latching and mounting features. Port counts typically range from 2 to 8 connectors utilizing either 1.25 or 2.50mm ferrules. Cleaning and inspection is more standardized and well supported due to wide adoption of the standards-based connectors. Today the LC blind mating interface is most predominant in 2, 4, and 8 port counts supporting multimode and single mode fiber.

Multi-fiber MT ferrule based optical backplane interfaces are most common and achieve vastly higher fiber density than ceramic single fiber ferrules by incorporating multiple fibers per ferrule and multiple ferrule ports per connector. Port counts typically range from one 1 to 8 MT type ferrules enabling up to 384 fibers per connector in a 16x55mm area when using 48 fiber ferrules. These interfaces are available from several manufacturers in a number of configurations and mounting styles addressing card cage styles and system specific mechanical and packaging needs.

MT type ferrules utilize precision molded polymer ferrules aligned via metal guide pins in a male/female configuration. Their incorporation within an optical backplane connector housing requires detailed consideration for mechanical alignment and containment for proper operation.

Optical Backplane Connector Mechanical Overview

Early engagement between system architects and optical backplane connector engineers is critical as needs of the system architecture, mechanical enclosure, connector interface and system fiber connectivity scheme are tightly coupled. The number of fibers connected throughout the system can be immense numbering in the thousands making for a complex set of mechanical, optical device, cable management, thermal and usage needs. It is nearly impossible to add optical backplane connectors to a system design after the fact or to even change across different types of interfaces due to mechanical mounting, card pitch and chassis design requirements. One aspect that is very flexible is fiber count per connector due to the many options available in multi-fiber MT ferrules and optical connectors supporting multiple MT ferrule ports. The trade-off becomes optical performance which decreases with an increase in the number of fibers per ferrule and fiber management where a single optical backplane connector can have hundreds of fiber connections.

Mechanical design and mounting needs of optical backplane connectors greatly influences chassis design due to mating geometries and nuances in latching and holding force required dependant on the type of connector. As ferrules are individually spring loaded, these forces must either be accounted for in the optical backplane connector or card front panel latches. Spring forces per MT ferrule ranging from 10N for 12 fiber ferules to 20N for 24+ fibers per ferrule is multiplied for each ferrule port of the connector. Considering an optical backplane connector with eight 24 fiber MT ferrule ports and 4 connectors per card builds up to a required holding force of 640N per card. Optical backplane connectors come in two types, self-latching or non-latching, which in the case of the latter card latches and chassis/backplane structure must compress the ferrule springs and hold the cards and connectors in a mated condition.

Self-latching optical backplane connectors offer additional Z axis travel or float easing card to backplane design tolerances. The trade-off between the two versions is somewhat dependent on individual connector design and affects density, connector complexity and cost as latches add additional size, design complexity and component count. This is one of the reasons expanded beam and alternate ferrule interfaces are attractive as they greatly reduce spring forces required to hold the ferrules in contact often by a factor of 5 to 10x less force independent of fiber count.

Optical backplane connectors are typically mounted to a back panel which has cut-outs for the connector to mount within letting the fibers pass through to the backside of the chassis. As with electrical backplane connectors there are versions of optical backplane connectors supporting coplanar, orthogonal and standard card cage designs as well as newer rack scale drawers/sled architectures all having unique mounting methods and mechanical requirements. Mounting methods include screws, rivets, clips or snap fits and require mechanical float of the connector housing to accommodate mating tolerances of the card or drawer assembly to the backplane / chassis.

If mechanical tolerances of the card cage or rack are not within a range supported by the connector, guide pins are often utilized to increase mating precision. Because optical connectors are typically longer or first to mate in the mating sequence, electrical connectors cannot be utilized as guidance features. AAdditionally, board mounted electrical connectors have no float therefore the optical connector must have float to eliminate binding of the multiple interfaces. These aspects must be carefully considered by mechanical designers and considered in connector selection.

Testing and qualification criteria for mechanical and environmental performance is established within Telcordia GR-1435-CORE covering multi-fiber connectors. Durability and performance of these connectors is primarily governed by the ferrule performance where optimal optical performance can be maintained well over the defined 50 mating cycle requirements. System specific mechanical and cable management validation is key throughout the development process.

One unique aspect to optical backplane connectors is there are very few industry standards driving harmonization or interoperability across vendors. Limited standardization efforts primarily within VITA and ARINC organizations focused mainly on rugged and aerospace applications with a few vendors being interoperable but not harmonized fully in design. Across optical backplane connector manufacturers design approaches taken to protect and secure ferrules on the cable and within connector housings differs greatly with each trying to achieve a trade-off between density, robustness and usability. Some low-density versions utilize industry standard MPO/MTP connectors as the mating interface while most use proprietary clips and connectors making vendor interoperability non-existent. For system designers and users, it is important to understand how optical ferrules are held within mounting clips, their installation and removal process from the main connector housing during manufacturing and maintenance and how potential inspection or cleaning processes will be implemented in the intended system.

Alternative multi-fiber ferrule solutions are in development to address end user robustness and usability aspects with a goal of reducing total cost of ownership. These ferrules also provide benefits as to reduced sensitivity to dust / debris, lower spring forces, different mechanical mating and alignment benefits. As with any physical mating interface maintaining cleanliness for unabated fiber to fiber contact at the ferrule surface is critical to optical performance and preventing fiber surface damage. This is especially critical in optical backplane connectors where access to the ferrule interface for cleaning and inspection is more difficult. Ferrule and fiber debris drive interest to ferrule interfaces that do not require fiber to fiber physical mating such as expanded beam and fiber gap ferrules. When alternative multi-fiber ferrules are based on the industry standard MT ferrule footprint they can be implemented in any MT ferrule-based backplane connector broadening the connectors application space and reducing total cost of ownership.

Cleaning and Inspection

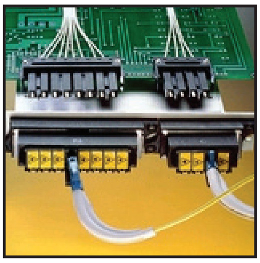
As optical backplane connectors are often seated deep within a chassis or rack or on narrowly spaced cards, inspection and cleaning aspects of fiber optic interfaces are greatly aggravated due to restricted access to the interfaces. Additionally, safety shutters are a method often utilized on optical backplane connectors to keep ferrule interfaces protected and while helpful for eye safety, complete dust prevention is often not possible making cleaning and inspection products necessary accessories to be considered for factory and field usage. Cleaning and inspection apparatus available from industry suppliers can be implemented with connector specific fixtures on system dummy cards properly mounted and positioned for the specific chassis and optical backplane connector implementation. Due to these complexities much care is taken to ship system elements with factory inspected, cleaned and protected interfaces enabling first time installed system bring up rates to very high levels where long-term repair and inspection takes more effort. These challenges are strong drivers to increased interest in expanded beam and alternate ferrule technologies (e.g. air gap) as they ease many aspects of inspection, cleaning and end user cost of ownership.

Future Needs and Challenges

Roadmaps for optical backplane connectors should include several aspects:

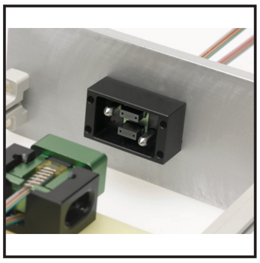
- Versions supporting new application such as rack scale architectures incorporating greater mechanical tolerances and robustness for large heavy drawers and / or sleds
- Versions with lower mating forces per ferrule or fiber for economical card and backplane designs
- Incorporation of alternative multi-fiber ferrule technologies easing deployments and usage while reducing cleaning and inspection burdens thus reducing total cost of ownership
- Improvements in cleaning and inspection technologies
- Support for new fiber types to increase density, reduce fiber bulk
- Potential standardization efforts providing supply side security and increasing volumes through wider adoption

Molex offers a wide selection of optical backplane interconnects, some examples are shown here.

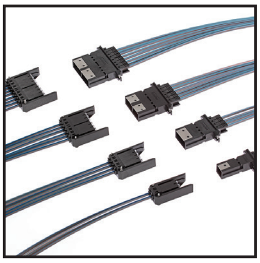


BLC, 2, 4, 8 LC ports

HBMT - 4 MT ports

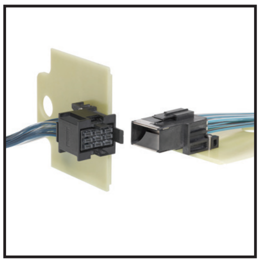


Vita 66.1 - 2 MT ports

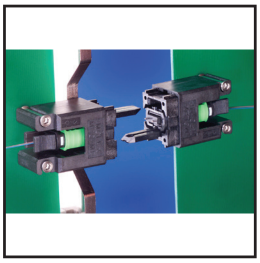


VFI Family - 2, 4, 6, 8 MT ports

FlexPlane Optical Circuitry



Orthogonal Optical - 9 MT ports



MTP-CPI - 1 MTP connector ports

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