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Usage Models for Multi-Gigabit Serial Transceivers

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This document provides an overview of the various usage models for high-speed, point-to-point, serial transceiver technology. While not intending to represent all the applications of this technology, it provides a basic categorization and description of some of the most common uses.

Overview

To highlight the basic usage categories, a representative communications system is shown in Figure 1. Within this system, communication takes place at various levels and distances, including within a PCB or card, between PCBs within a chassis, and between equipment or chassis. For the most part, these categories are based on the distance to which each is targeted. The four basic categories discussed in detail in later sections are as follows:

- Chip-to-Chip
- Backplane
- Copper Cable
- Optical Cable

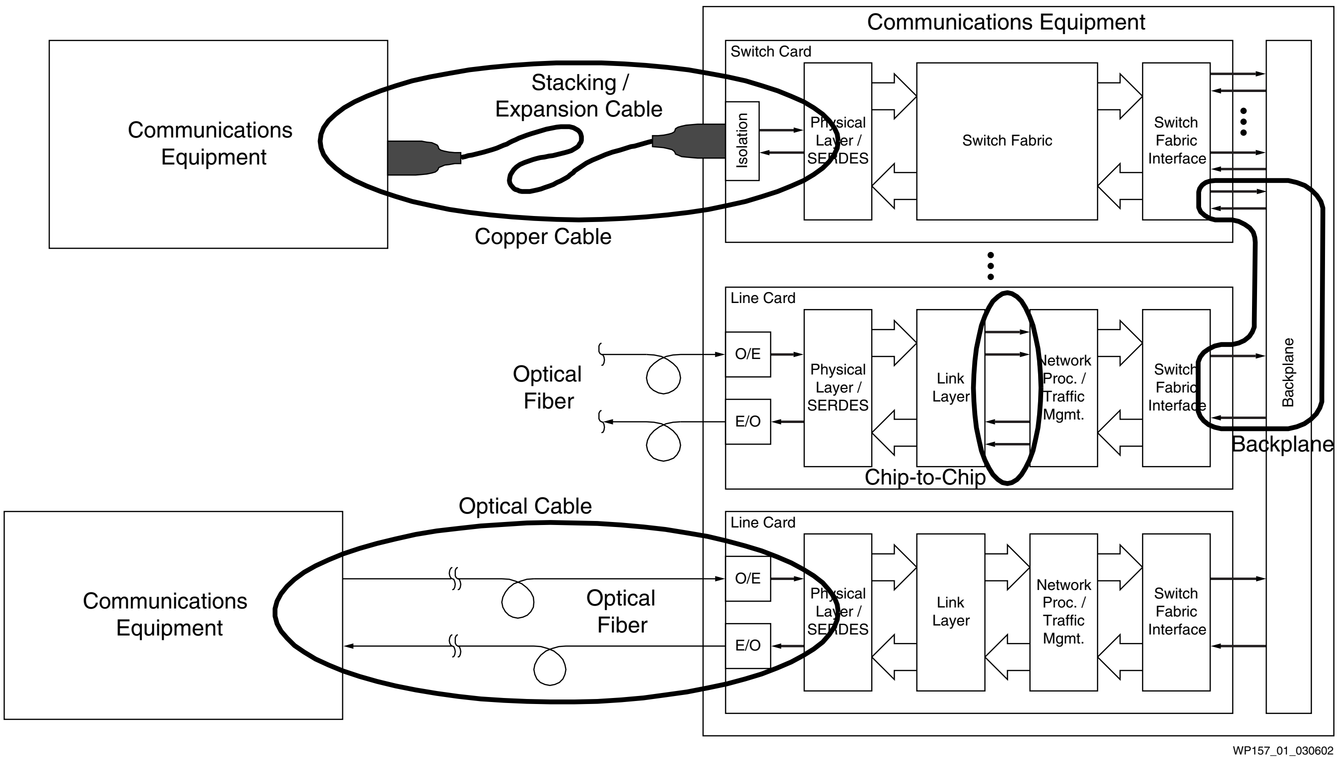

Figure 1: **Communications System Example**

To successfully design and deploy products using multi-gigabit serial links, the signaling channel must be carefully designed with the aid of high-accuracy simulation and channel simulation models. Since each of these applications utilizes different elements, the models should be appropriate to the environment and components used. Many manufacturers provide models for their active and passive components.

Notes:

1. In the basic channel models described throughout this document, on-chip termination (as is provided in the Rocket I/O serial interfaces of the Xilinx Virtex-II Pro™ FPGA family) is assumed as part of the driver and receiver integrated circuits. If termination is done off chip, it must be accounted for in the appropriate location in the signaling channel and model.

Chip-to-Chip Applications

A chip-to-chip application is the simplest and most basic application for high-speed, serial transceivers. It can include single channel, multiple channel (independent), or multiple channel (bonded) configurations. Only the IC package and printed circuit board (PCB) elements are between the driver and receiver.

Some examples of high-speed serial interconnect standards supporting chip-to-chip interfacing include the 10G Attachment Unit Interface (XAUI)[1], Serial Rapid I/O, and 3GIO. Proprietary interfaces are also common, where maximum data rate and pin limitations demand this level of performance.

A basic model for this medium includes the driver, driver termination, driver package, PCB elements (traces, vias, etc.), receiver package, receiver termination, and receiver. An example is illustrated in Figure 2.

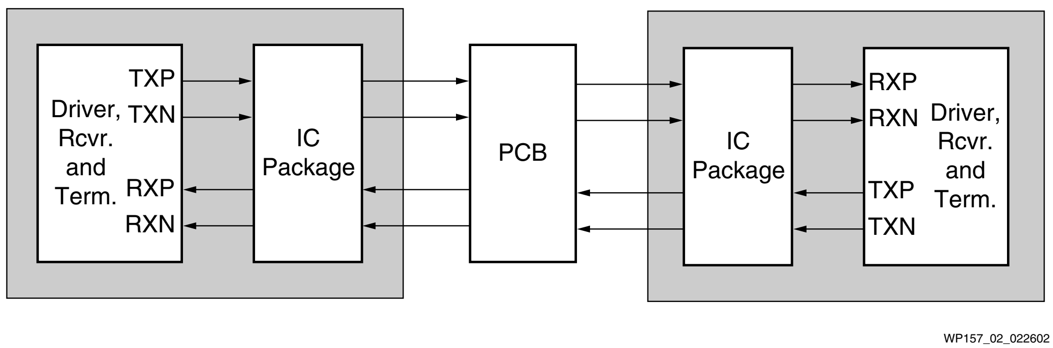

Figure 2: **Basic Channel Model for Chip-to-Chip Applications**

XAUI

XAUI is defined in the 10G Ethernet standard[1] for extending the useful reach of the XGMII interface between the link and physical layer. It consists of four channel bonded 3.125 Gb/s interfaces with an aggregate bandwidth of 12.5 Gb/s (10 Gb/s useful payload with 8B/10B encoding overhead). The standard defines chip-to-chip connectivity up to 20" of FR4 PCB trace. XAUI can also be used in backplane applications.

Backplane Applications

A backplane application is similar to chip-to-chip, but adds at least one electrical connector and additional PCB assemblies between the driver and receiver. Some applications include daughter (or mezzanine) cards, chassis and switch fabrics. It can include single channel, multiple channel (independent), or multiple channel (bonded) configurations.

Some examples of high-speed serial interconnect standards supporting backplane interfacing include XAUI[1], Serial RapidIO, InfiniBand[2], and 3GIO. Proprietary interfaces are also common, where highest data rate with the fewest pins demand this level of performance.

A generic model for the backplane medium includes the driver, driver termination, driver package, at least one connector, PCB elements (traces, vias, etc.), receiver package, receiver termination, and receiver. An example with two connectors and backplane PCB is illustrated in Figure 3.

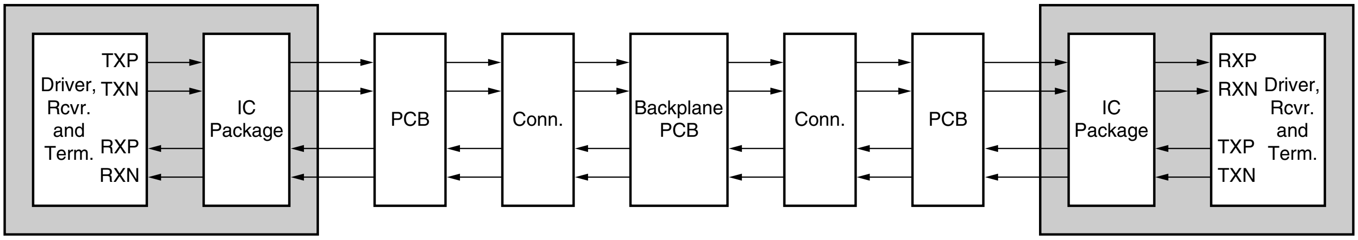

Figure 3: **Basic Channel Model for Backplane Applications**

XAUI

In addition to chip-to-chip applications, the XAUI can support communication to mezzanine cards or across a backplane and up to a total 20 inches of FR4 PCB trace. Two examples of high-speed connectors supporting XAUI (and other) backplane links include the Teradyne VHDM-HSD™[3] and the Tyco / AMP Z-PACK HM-Zd[4]. These are illustrated in Figure 4 and Figure 5, respectively. For more information on these products, go to **http://www.teradyne.com** and **http://www.amp.com**.

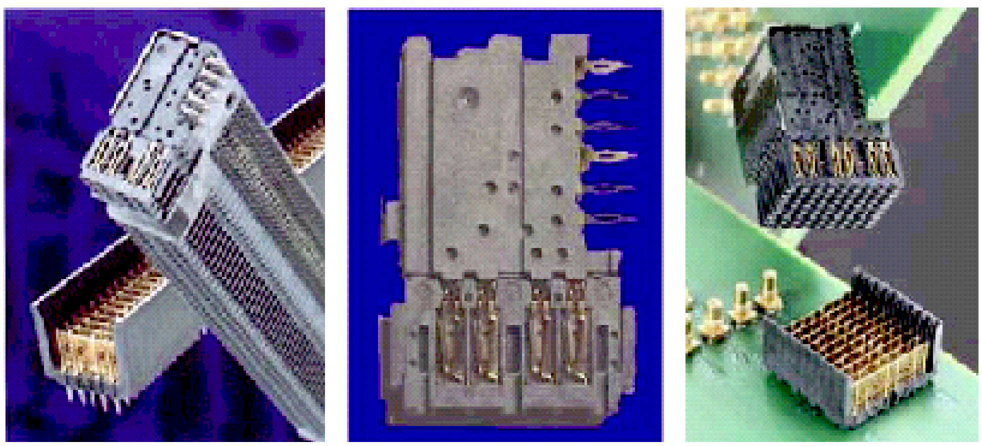

Figure 4: **Teradyne VHDM-HSD™ Backplane Connector**

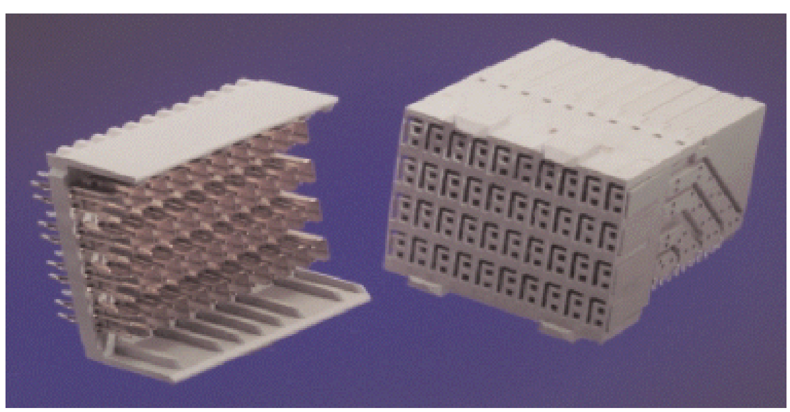

Figure 5: **Tyco/AMP Z-PACK HM-Zd Backplane Connector**

InfiniBand

The backplane connector specified by the InfiniBand™ standard is shown in Figure 6. It is based on the SpeedPac technology from Tyco / AMP and supports 1x, 4x, and 12x serial channel configurations. The connector consists of a card edge "paddle" (with paddle guard) and backplane socket combination.

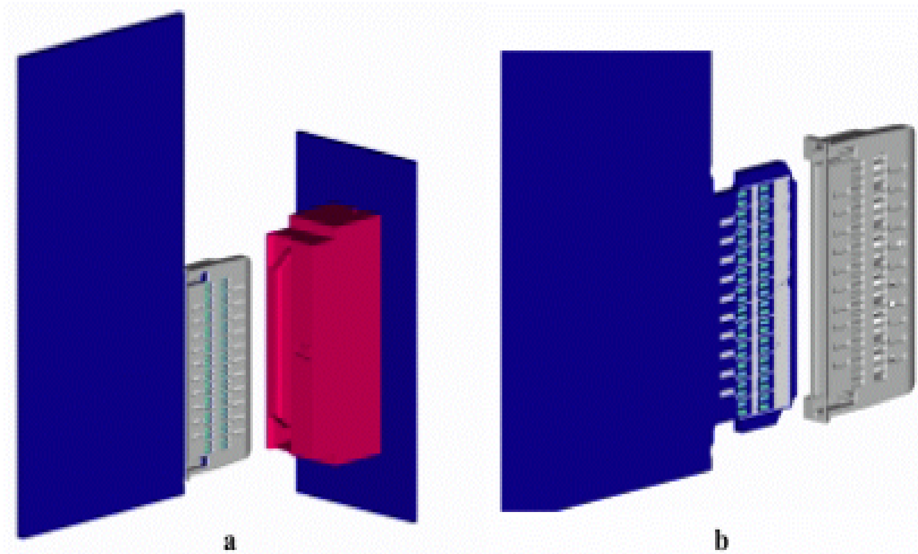

Figure 6: **(a) InfiniBand Backplane Connector and Board Paddle and (b) Paddle Guard Assembly**

Copper Cable Applications

Copper cabling can be used to interconnect system components over short to medium distances (generally up to about 20m) at data rates up to about 3.125 Gb / s. These cables are generally based upon shielded twisted pair (STP), coaxial, twin-axial, or other similar technologies. Copper cabling has the advantage of utilizing familiar electrical signaling technology rather than more exotic (and generally more expensive) optical technology. There is a tradeoff between data rate and distance, with greater distances coming at the expense of lower data rates. Some type of galvanic isolation (blocking capacitors, transformers, etc.) is typically required. While single channel, dual simplex configurations (single differential pair in each direction) are the most common, multiple channel configurations can also be used.

Some examples of high-speed serial interconnect standards supporting copper cabling include Fibre Channel[5], Gigabit Ethernet (1000Base-CX)[6], and InfiniBand[2].

A generic model for this medium typically includes the driver, driver termination, driver package, electrical connector, cable, electrical connector, receiver package, receiver termination, and receiver. Any PCB elements (traces, vias, etc.) and source or destination isolation (caps, transformers, etc.) would also be included, where appropriate. An example is illustrated in Figure 7.

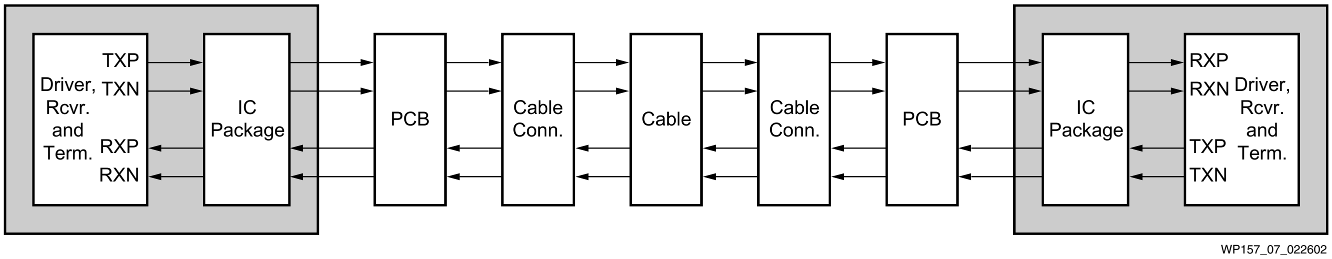

Figure 7: **Basic Channel Model for Copper Cable Applications**

InfiniBand

An example of a high-speed cabled solution can be found in the InfiniBand standard. This standard supports communication at 2.5 Gb/s per differential signal pair over 1, 4, and 12 channels in each direction. Examples of the connector technology adopted by this standard are shown in Figure 8 and Figure 9. The 1x connector is based upon the HSSDC2 technology from Tyco/AMP[7]. More information on InfiniBand and the copper cabling standard can be found in reference [2].

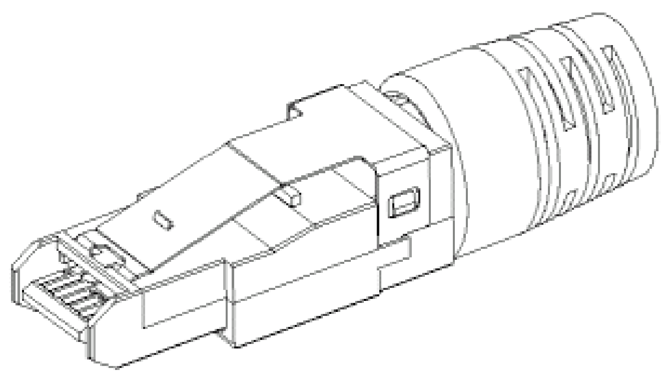

Figure 8: **InfiniBand Connector Example (1x)**

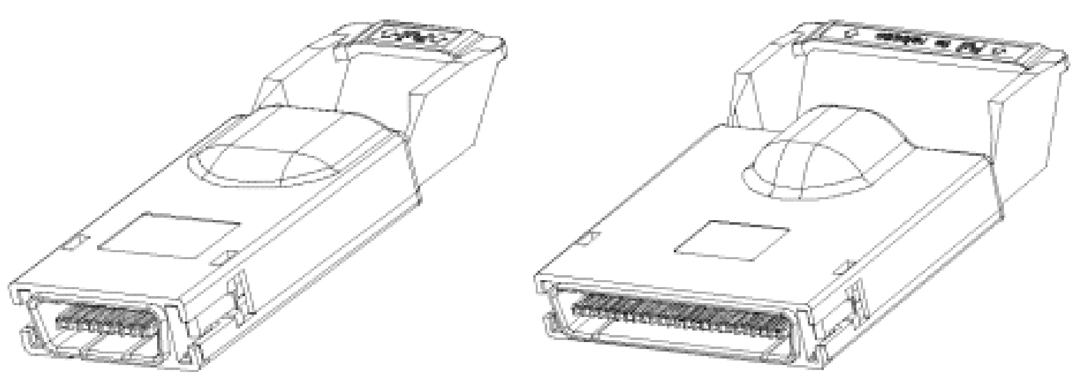

Figure 9: **InfiniBand Connector Examples (4x, 12x)**

Optical Cable Applications

Optical cable solutions can provide the highest combination of data rate and transmission distance. Solutions are now available over a wide range of cost / performance tradeoffs, from very short reach, shortwave, multimode fiber to long-haul, long-wave, single-mode fiber supporting distances of over 40 km. In addition to single channel serial implementations, other options include aggregating multiple channels via parallel optical ribbon cable or wave division multiplexing (WDM).

Some examples of high-speed serial interconnect standards supporting optical cabling include Fibre Channel[5], Gigabit Ethernet (1000Base-SX / LX)[6], 10 Gigabit Ethernet[1], InfiniBand[2] and the OIF Very Short Reach (VSR) standards[8][9][10][11]. In addition, there are several optical transceiver form-factor definitions available, including Gigabit Interface Converter (GBIC), Small Form-Factor (SFF), Small Form-factor Pluggable (SFP)[12], XENPAK[13], and XGP[14], to name a few. Paroli® and MPO are common parallel optical ribbon cable and connector solutions.

A generic model for this medium typically includes the driver, driver termination, driver package, electro-optical (E / O) converter, optical media (fiber, patch panels, and connectors), electro-optical (O / E) converter, receiver package, receiver termination, and receiver. Any PCB elements (traces, vias, etc.) and multi-channel optical components (parallel fiber, WDM, etc.) would also be included, where appropriate. An example is illustrated in Figure 10.

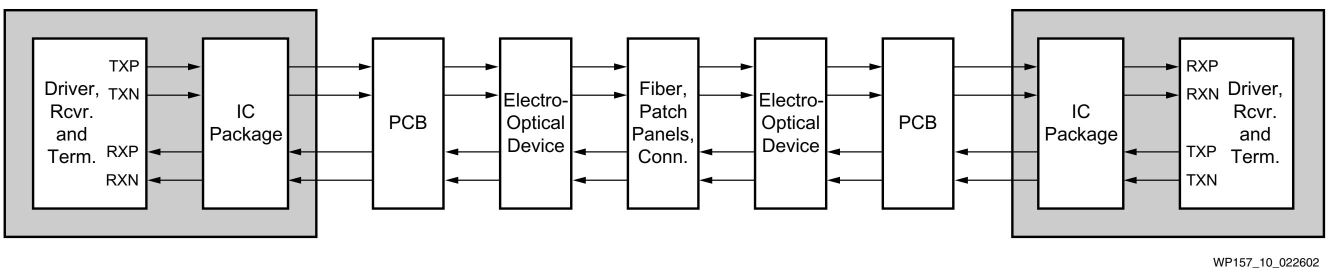

Figure 10: **Basic Channel Model for Optical Cable Applications**

XENPAK

An example optical transceiver standard is the XENPAK Multi-Source Agreement (MSA)[12]. These provide a pluggable form-factor with an SC Duplex optical receptacle, as illustrated in Figure 11. These modules utilize the XAUI interface on the system (electrical) side, while the external (optical) interface can be any of the various line standards defined in 10 Gigabit Ethernet[1]. These include 10GBase-SR / W, 10GBase-LR / W, 10GBase-ER / W, and 10GBase-LX4.

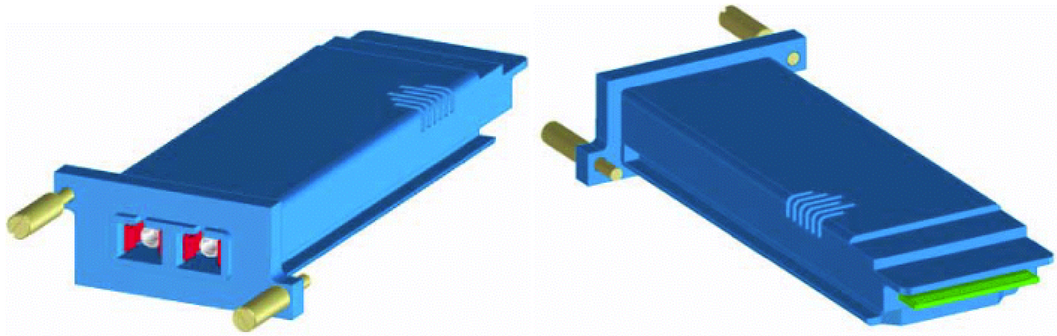

Figure 11: **XENPAK MSA Optical Module Assembly**

InfiniBand

In addition to backplane and copper cable options, the InfiniBand standard supports 1x, 4x, and 12x optical interconnect options at 2.5 Gb/s per fiber. Although the optical module form-factor is not specified, the connector technology is defined. The 1x standard is based on an LC duplex connector, while the 4x and 12x standards utilize the 12-fiber MPO connector, as illustrated in Figure 12. The fiber connections can be seen as dark row of holes between the alignment holes on the cable and alignment pins on the socket. The 4x channel requires 8 fibers (4 each direction), leaving 4 of the 12 channels unused. The 12x channel requires two such cables, each carrying 12 fibers in each direction. See Figure 12.

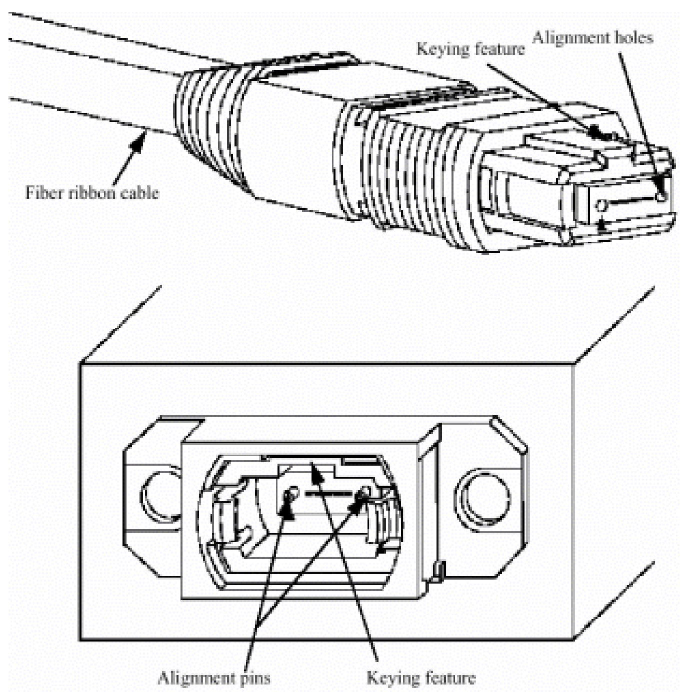

Figure 12: **InfiniBand™ MPO Fiber Optic Connector (4x, 12x)**

Optical Internetworking Forum (OIF)

Several standards have been defined within the Optical Internetworking Forum (OIF) to support Very Short Reach (VSR) optical communication channels. The following four OIF implementation agreements support the OC-192 (~10 Gb/s) generation of SONET equipment:

- **VSR4-01.0**[8]**:** Aggregated link of 12 fibers operating at 1.244 Gb/s per fiber using 8b/10b encoding. Utilizes multi-mode, parallel optical ribbon cable with MTP™ (MPO) connector (each direction) and shortwave (850 nm) optoelectronics, supporting distances up to 300m.
- **VSR4-02.0**[9]**:** Single fiber operating at 9.953 Gb/s (OC-192). Utilizes single-mode fiber and longwave (1310 nm) optoelectronics, supporting distances up to 600m.
- **VSR4-03.0**[10]**:** Aggregated link of four fibers operating at 2.5 Gb/s per fiber. Utilizes multi-mode, parallel optical ribbon cable with MTP (MPO) connector (one 12 fiber ribbon with 4 fibers each direction and middle four unused) and shortwave (850 nm) optoelectronics, supporting distances up to 300m.
- **VSR4-04.0**[11]**:** Single fiber operating at 9.953 Gb/s (OC-192). Utilizes multi-mode fiber and shortwave (850 nm) optoelectronics, supporting distances to 85m-300m.

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14. **http://www.xgpmsa.com**

Revision History

The following table shows the revision history for this document.

Date	Version	Revision
03/15/02	1.0	Initial Xilinx release.