Challenges in Developing I/O Systems for Today's Telecom and Datacom Needs

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Today's world craves real-time, information-rich data within very short periods of time. Whether it is transmission of video on sites like YouTube, communication through social networks like Facebook, or retrieving real-time information and updates from smart meters, these activities that are now part of everyday life were not around just five years ago.

This seemingly insatiable need for more data and commensurate network bandwidth will continue unabated for the foreseeable future.

Given this projected growth in demand, leading companies, industry organizations and trade associations have been diligently working to ensure specifications and products are ready to address these anticipated capacity needs. A number of industry specifications have been developed to assure commonality, compatibility and networking functionality of hardware connections, signaling and software communications. These industry standards include those for data center interconnect technologies such as Infiniband, Fibre Channel, Ethernet, Serial Attach SCSI (SAS), and Serial ATA (SATA). Meanwhile, organizations like the Infiniband Trade Association and various IEEE 802.3 sub-committees are in the process of finalizing specifications that address the industry's desire for 40 Gb/s and 100 Gb/s bandwidth-capable systems and I/O links. Further reinforcing these expected trends are published developmental roadmaps that point to link bandwidths that extend well beyond100 Gb/s into the 400 Gb/s bandwidth range.

Satisfying these bandwidth needs isn't always easy as service providers must balance customer demands for timely, reliable and cost-effective delivery of services against equipment and energy costs, equipment utilization and overall data center productivity and efficiency. It is clear that these challenges will continue to affect virtually all data center and communication equipment platforms whether switches, routers, servers or storage systems.

The growth and proliferation in the number of 10 Gb/s server connections over the next five to six years will be followed by a similar growth cycle for the 40 Gb/s connections beginning around 2015. To connect these servers to the network, industry analysts expect 10G Ethernet switch ports to experience 143% CAGR from 2008 to 2012 and high-end router demand for 10G ports to see a CAGR of 31% during the same time period.

Enabling this industry progression are new and evolving cable link and I/O interface specifications such as SFP+, QSFP+, CXP, mini-SAS HD and CFP which will provide the high-speed external and internal cable links needed to handle this explosive growth.

So where does this product evolution and technical advancement leave suppliers of today's copper-based I/O link solutions? The short answer is that making a cable assembly for these systems isn't as simple as it used to be. There are a number of

challenges that any viable cable assembly supplier must address in order to assure a high quality, compliant interconnect link is supplied to their customers.

Equipment and System Design

Equipment and system designers are challenged in numerous ways as they attempt to adapt to the rapidly growing bandwidth demands. Technologies such as multi-core processors, virtualization, consolidation, increased host bus speeds and memory performance have certainly helped increase the available capability a designer can integrate into a system design but these technologies strain bandwidth capacity, power consumption and power and thermal management. The migration to increased signal speeds while preserving adequate signal integrity makes the continued use of commonly used, cost effective printed circuit board materials like FR-4 and cables with commonly employed insulations and manufacturing processes an increasingly difficult task.

As an example of the power management challenge, let's consider a Google search. Given today's chip technologies and capabilities, it has been estimated that a single Google search requires 3 watts of power to complete the inquiry. But for proper cooling and dissipation of the heat generated by the search, an additional 3 watts of power is required. These power needs are driving designers to employ "green" techniques such as port power management functionality that directs the port to automatically go into a "sleep" mode when not being utilized. The intent is to reduce the power consumption with better power management. This is just one example of the multiple and sometimes conflicting considerations that system designers and users must balance in next-generation equipment designs.

Signal integrity at increased signal speeds and power consumption aren't the only things designers and users must consider. Other factors like proper system heat dissipation and management, sufficient air flow, cable routing and EMC / EMI shielding, port density and cable assembly installation, removal, and attachment, also require careful design consideration.

Equipment manufacturers and users are looking for flexible, future-proofed interconnect systems that are easy to install, easy to maintain and provide performance headroom to support future system upgrades. While the minimum requirement is to maintain existing system port density the preference is to achieve an increase in the I/O port bandwidth density along the edge of a line card to provide increased capacity. The capability to freely designate or configure any available system port with either copper or fiber-based cabling as dictated by the specific installation environment with minimal issues and cost implications is desirable.

All of these needs have helped to necessitate a closer working relationship between system designers and high-speed I/O system suppliers. In the past, there wasn't a lot of collaboration between these two disciplines but with the advent of higher signaling speeds, it became apparent that a higher level working relationship between system designers and the I/O system designer was necessary in order to meet all of the goals

outlined above. It also requires that both parties have a deeper appreciation and understanding of the specific functional and design capabilities each party can bring to the overall system design without adding excessive costs and overhead. This new dynamic is best illustrated by the collaboration within and among industry standard organizations, committees and sub-committees as well as industry ad hoc groups, such as the Small Form Factor committee (SFF), where a great deal of discussion and collaboration takes place. This interaction has become an absolute must for equipment suppliers to ultimately give their customers what they are asking for. The I/O system supplier must give the equipment designer as much flexibility and functionality as possible.

I/O system solutions

The good news is that I/O systems have been developed which address many of the requirements. XFP and SFP copper- and fiber optic-based I/O systems have been on the market for some time now. They have been instrumental in bringing I/O port bandwidths to the 5 to 6+ Gb/s per channel capability level. These systems are also more compact in order to minimize the linear board "shoreline" required. The SFP system significantly reduced the module outlines and shoreline required from earlier GBIC and XENPAK systems.

One need that the SFP system failed to address was 10 Gb/s channel capability, which is being demanded today. This need led to the development of the SFP+ system with capability to properly support 10 Gb/s channel capability. While the SFP and SFP+ systems share the same board space, connector and cages, only the SFP+ systems support 10 Gb/s channel bandwidth.

The I/O product development progression is continuing with the recent developments of industry standard interfaces such as QSFP+, mini-SAS/SATA, mini-SAS HD, CXP and CFP.

The QSFP+ system has been developed to address the need for an I/O system capable of supporting a 40 Gb/s total bandwidth in each port. Similarly the CXP system is being developed to support systems that are looking for 100 to 120 Gb/s total bandwidth per port. Both of these systems are being developed, offered and aligned with a number of interconnect technologies such as Infiniband and Ethernet, and are being adopted in multiple industry specifications. Both systems offer connector and cage products that support either a passive copper-based cable solution generally used for relatively short length cables (5 to 7 meters or longer depending on the acceptance criteria); an actively equalized copper-based cable solution for longer lengths (up to 15 meters or longer depending on the acceptance criteria); a plug-in optical transceiver module with an optical-based I/O connector on the back side of the module; or an active optical cable assembly (AOC) with the optical fiber terminated inside the cable backshell. This architectural approach gives the system installer and system user the flexibility to define and change the port configuration and capabilities as required.

The CFP system, which was announced in early 2009 as a multi-source agreement (MSA), takes a similar approach to the CXP interface in that it has capability to support 100 Gb/s bandwidth. The CFP system, as it's currently configured, will always have the transceiver embedded in the module and utilizes a standardized two-piece connector interface between the module and equipment port. The I/O side of the module allows for multiple port configuration options (SFP+, QSFP+, CXP or optical simplex or multi-fiber interface combinations) that can be customized depending on the customer-desired I/O interface and data distribution. In contrast to the more compact CXP module, the larger CFP transceiver module is optimized for longer reach, single-mode fiber applications.

Signal transmission speeds and bandwidth demand are being driven by the video-rich and social networking applications with significant growth forecast for the future. There is a significantly higher level of collaboration between equipment designers, raw cable suppliers, component suppliers, and high-speed I/O system suppliers that is necessary to properly address these market demands, and it will be reflected in products that offer higher port density and flexibility in port configuration. In light of the added functionality and increased signal speeds, manufacturing of these cable assemblies is a more challenging proposition than ever before. The quality considerations for raw cable, PCB design, wire management, wire stripping, wire termination, and wire strain relief all must be carefully addressed and properly controlled as development of these systems and components evolves.

MINI SAS / SATA Connectors, Cages & Cable Assemblies

For High-Speed Serial Mini SAS or Mini SATA 4x Links

DESCRIPTION

FCI's external mini-SAS / SATA connector, cage and cable assembly system solution addresses the storage industry's demand for more compact, high-speed serial I/O interfaces that also support evolving signal speed requirements. Increasing numbers of drives within a system demand additional I/O ports along a card edge, dictating more densely packaged serial I/O solutions. The mini-SAS / SATA I/O system provides a cost-effective, high-speed solution that meets the bandwidth requirements of current and future applications in servers and external storage systems. FCI's connectors and cable assemblies meet Serial Attached SCSI (SAS) or Serial ATA (SATA) requirements for mini-multilane external systems thus assuring inter-mateability with standardized port interfaces. Specifically, FCI's mini-SAS / SATA solutions satisfy the applicable requirements of the INCITS T10 SAS 2.0 & SAS 2.1 specification or the SATA-IO Serial ATA specification and conform to the mechanical requirements described in the associated SFF-8086 and SFF-8088 documents. The availability of both mini-SAS and mini-SATA compatible connectors, cages and cable assemblies gives the user the option to choose the most appropriate and cost-effective link for their respective application.

FEATURES & BENEFITS

Cable Assemblies

- Ruggedized 26-position cabling interconnect system is SFF-8088 (shielded – external) and SFF-8086 compatible
- Available options support Mini SAS (SAS 2.0 & 2.1) and Mini SATA 4x external I/O requirements
- Cable assembly paddle card design is optimized for signal integrity and mechanical performance
- Low profile "pull-to-release" latching system provides secure connection and allows stacking
- Adaptive, robust EMI Gasket and die-cast backshell assure proper EMI shielding
- Robust cable strain relief system isolates cable termination from mechanical stress
- Reduced backshell protrusion provides short cable exit
- Fully compliant with all SAS and SATA defined keying options
- Controlled wire management and termination process assures consistent high-speed electrical performance
- RoHs compliant

TARGET MARKETS / APPLICATIONS

- Data
  - Servers
  - RAID systems
  - Storage racks
  - External storage systems
  - SAS/SATA HBA interfaces
  - Direct-attached storage (DAS)
- Communications
  - Switches
- Industry Standards
  - SATA-IO Serial ATA (SATA) Specification
  - INCITS/ANSI Serial-Attached SCSI (SAS) specification
  - SFF-8088 and SFF-8086

QSFP Copper Cable Assemblies

For 40Gb/s aggregate bandwidth applications – IEEE802.3ba & Infiniband QDR

DESCRIPTION

FCI's QSFP (Quad Small Form-factor Pluggable) connector, cage and cable assemblies are designed to meet emerging data center and high performance computing application needs for a high density cabling interconnect system capable of delivering an aggregate data bandwidth of 40Gb/s. This interconnect system is fully compliant with existing industry standard specifications such as the QSFP MSA and IBTA (InfiniBand Trade Association). The QSFP cables support the bandwidth transmission requirements as defined by IEEE 802.3ba (40 Gb/s) and Infiniband QDR (4x10 Gb/s per channel) specifications.

The 38 position SMT mounted edge card connector and the cable assembly's mating printed circuit card has been designed for the higher-bandwidth signal integrity requirements associated with 10Gb/s per channel transmission. The metal EMI cage along with the rugged diecast covers on the cable assembly assure proper EMI shielding effectiveness and termination. FCI offers both passive as well as actively equalized cable assemblies that enables the use of a copper based interconnect system for applications with cable lengths up to 12 meters. The cage offering also includes a heat sink and mounting clip to address applications where module heat dissipation is required.

FEATURES & BENEFITS

- Fully compatible with IEEE802.3ba and Infiniband QDR specifications
- 100 ohm differential impedance system
- Allows for 10Gb/s per channel transmission; aggregate of 40 Gb/s total bandwidth
- Optimized PCB interface board to minimize crosstalk and insertion loss
- Robust diecast covers for superior EMI shielding effectiveness
- EEPROM for cable signature & system communications
- Actively equalized cables enable longer cable lengths or the use of smaller cable diameters for shorter cable lengths
- 32 AWG to 24 AWG cable sizes available
- RoHS compliant

TARGET MARKETS / APPLICATIONS

- Data
  - Servers
  - Networked storage systems
  - Routers
  - External storage systems
  - High Performance Computing (HPC) applications
  - Data Center networking
- Communications
  - Switches
  - Routers
- Industry Standards
  - InfiniBand Trade Association (IBTA)
  - IEEE802.3ba
  - 40Gigabit Ethernet (40G BASE – CR4)

SFP+ Connectors, Cages and Copper Cable Assemblies

For 10Gigabit-Ethernet (10GbE), 8G Fibre Channel and 10G Fibre Channel over Ethernet applications

DESCRIPTION

FCI's SFP+ connector, cage and cable assembly I/O system offerings are designed to meet data center, networking and high performance computing application needs for a high density cabling interconnect system capable of 10Gb/s per channel transmission rates. This interconnect system is designed to meet the requirements of Small Form Factor industry standards SFF-8431 and 8461. FCI offers both passive & actively equalized cable assemblies each tailored to meet specific cable lengths while meeting all performance requirements. Multiple cage configurations are offered to allow customers the ability to maximize useable linear board real estate. The pick-n-place compatible 20 position SMT terminated connector meets all interface and standard requirements. The SFP+ I/O system supports the bandwidth transmission requirements as defined by 10Gigabit-Ethernet (10G Base-CU), 8G Fibre Channel (FC) and 10G Fibre Channel over Ethernet (FCoE) specifications.

FEATURES & BENEFITS

- Fully compatible with all SFP+ interfaces & mechanical backwards compatibility with SFP
- Designed to be compliant with SFF-8431 and SFF-8461 industry standards
- 100 ohm differential impedance
- Allows for 10Gb/s per channel transmission up to 7 meters (passive cable assembly)
- Allows for 10Gb/s per channel transmission up to 15 meters (actively equalized cable assembly)
- Optimized PCB interface board to minimize crosstalk and insertion loss
- Stamped EMI girdle to assure superior EMI shielding effectiveness
- EEPROM for cable signature & system communications
- Actively equalized cables will enable longer cable lengths or can enable the use of smaller cable diameters for shorter cable lengths
- Lower cost and lower power solution when compared to fiber optic links
- 32 AWG to 24 AWG cable sizes available
- RoHS compliant

TARGET MARKETS / APPLICATIONS

- Data
  - Servers
  - Networked storage systems
  - External storage systems
  - High Performance Computing (HPC) applications
  - Data Center networking
- Communications
  - Switches
  - Routers
- Industry Standards
  - 10 Gigabit-Ethernet (10 GBASE-CU)
  - Gigabit-Ethernet (IEEE 802.3ae)
  - 8G FC and 10G FCoE
  - SFF-8431 & SFF-8461