Design engineers are continually looking to meet the demand for increased speed, bandwidth, and port density in data communications, telecommunications, and medical equipment applications. For example, websites such as YouTube have created a demand for real-time video, resulting in the need for more bandwidth to support high-quality, streaming graphics content. As voice, video, and Internet capabilities become a novelty in wireless applications, the need for the supporting infrastructure continues to evolve. In the medical market, high resolution X-ray and MRI files are shared via the Internet and surgeries are hosted on video telecasts to enable global collaboration to enhance medical care. All of these market drivers are challenging design engineers to deliver high-performance solutions with more port density, while taking up less space and consuming less power, all at lower costs.

To keep pace, backplane connector manufacturers have begun offering innovative connector designs to support these IT infrastructure needs. While most original equipment manufacturers (OEMs) still employ the more traditional backplane and/or midplane architectures in their equipment, some are employing newly emerging architectures such as orthogonal systems, both hybrid and direct-connect (no midplane), to improve their channel performance and lower the overall costs associated with increasingly complex midplane designs.

**Backplane Interconnect and Architecture Options**

There are the traditional right-angle to vertical backplanes connectors, orthogonal midplane connectors, direct-connect orthogonal connectors, mezzanine connectors, and coplanar connectors. Following are some general electrical and mechanical features and benefit guidelines for each option.

**Right Angle to Vertical Backplane Connections**

Right angle-to-vertical backplane interconnect solutions facilitate a cross-connection between all system data points. These traditional backplane connector products are designed for use in industry standard rack sizes, making them a common choice in system design. Almost all backplane connector solutions allow for blind-mating of daughtercards into the chassis and are sequenced properly for gross alignment, keying, power, and signal delivery. All of which allow OEMs field upgradeability and scalability options for their systems. Most backplane connector solutions support the many different industry standard slot widths that allow for multiple daughtercard sizes. They also typically offer linear signal and power scalability via end-to-end stackable monoblocks and/or waferized systems to support the many different daughtercard applications. Overall, these traditional solutions support a wide range of applications, including data communications, telecommunications, military, and medical equipment.

*The Very High Density Metric (VHDM®) connector system is designed for applications that require increased interconnect density and high-speed signal integrity. Standard VHDM connectors support single-ended data rates of 2.5 Gbps with less than 5 percent crosstalk.*
the backplane. This drives a heightened potential for signal integrity degradation, spacing issues, and layer count increases, ultimately ending with additional costs. In turn, many connector manufacturers are challenged with delivering high-speed, high-performance connector solutions that occupy less space and have lower profiles to accommodate airflow requirements at a lower cost. With material costs continually on the rise, it is challenging for connector manufacturers to deliver increased capabilities at a lower price, particularly with traditional backplane interconnect solutions.

The Molex GbX® connector system is designed for leading-edge backplane applications that require speeds of 6 Gbps to 10 Gbps, and provides differential pair density up to 69 pairs per inch.

Orthogonal Midplane Solutions
Orthogonal backplane solutions are quickly emerging in a number of traditional server, switch, and storage applications. Orthogonal midplane connector solutions have been around since the early 1990s, primarily supporting single-ended architectures. Now that the industry has evolved into high-speed differential architectures, connector solutions were needed to facilitate the transition of differential pairs from daughtercard-to-daughtercard through the midplane, while still maintaining the channel’s signal integrity performance.

These solutions are unique because they eliminate the need for signal traces routed through the midplane, lowering cost, and improving signal integrity performance. The shorter channel lengths demonstrate less attenuation, and with the midplane via stubs removed, there is less opportunity for energy reflections that results in lower crosstalk. However, port density is the single largest benefit of a true orthogonal architecture. Some of the largest, densest switches on the market today are enabled by I-Trac orthogonal technology.

Airflow is the biggest challenge when working with orthogonal interconnects. It can be difficult to cool a system that has daughtercards rotated 90 degrees on one side of the midplane. One solution is direct-connect orthogonal connectors, which completely eliminate the midplane to further improve the system’s signal integrity performance and airflow. Additionally, transitioning from a traditional system to a pure orthogonal system can pose some backward compatibility and legacy obstacles. To address both issues, products such as the ones pictured are available to help ease this transition and provide a common footprint.

I-Trac Backplane System from Molex is a skew-equalized, broadside coupled orthogonal solution that eases the transition from a traditional system to a pure orthogonal system by allowing use of standard header and daughtercard components that can be routed traditionally or orthogonally through the midplane, allowing designers ultimate flexibility.
**Coplanar and Mezzanine Solutions**

Coplanar and mezzanine solutions are typically used for I/O expansion, personality cards, and memory expansion cards. In most backplane product families, these solutions feature the same mechanical and electrical properties found in traditional backplane connectors, including common separable interfaces, compliant pins, guidance, and power options.

In mezzanine solutions, airflow and heat sinks typically dictate the mated connector stack heights, posing some challenges for connector manufacturers. Due to the constantly changing thermal dynamics of systems, different stack heights are commonly required across different systems. Typical stack heights supported by existing high-speed connector solutions range from 5mm to 40mm. Validating the electrical (speed, density), mechanical (mating tolerances, guidance), and long-term reliability (solder joints) performance of the available connector solutions is critical. Because connector tooling flexibility is limited in supporting a wide range of stack heights, connector manufacturers are challenged with trying to reduce tooling costs and design times, while still providing a compelling mezzanine interconnect solution at competitive prices without the typical economies of scale seen from standard, off-the-shelf backplane connector solutions.

In coplanar solutions, the internal and external I/Os used on the daughtercards typically dictate signal performance requirements, as well as space available for coplanar connectors. Solutions such as the I-Trac backplane system offer an inverted RAM/RAF, allowing the two boards to connect in either a coplanar configuration or allowing one of the two cards to rotate 180° to adjust for the alternative I/O skylines and airflow requirements. Most backplane connector product families offer right-angle male options that leverage the mating interfaces; PCB footprint/attach methodology; and mating sequences to allow electrical and mechanical continuity across the entire system.

To ensure design engineers choose the best option for their high-speed applications, it is important to include connector and contract manufacturers, silicon vendors, and PCB fabricators early in the design process. This enables everyone to work together to address every challenge and limitation that might arise during the design process and determine which backplane interconnect solution meets the customer’s speed, density, cost, quality, and long-term reliability requirements.

**Standardizing Channel Performance**

Despite the care taken in optimizing a connector’s electrical parameters, system-level performance is determined by the entire channel. Printed circuit board interface (vias or surface mount attach); chip package and BGA attach; board traces; and DC blocking caps all influence channel performance. This results in a need to quantify the channel behavior. Several industry forums and standards committees have tackled this problem, and a couple of distinct solutions are available.

The Optical Internetworking Forum’s Common Electrical Interface (CEI) implementation agreements have chosen a methodology called StatEye (as in statistical eye) to specify channel compliance. StatEye is a mathematical algorithm currently implemented in Matlab that provides probability contours for eye diagram openings corresponding to different Bit Error Rate (BER) magnitudes. The software stimulates a given channel and uses a specified reference transmitter (with pre- or post-emphasis) and receiver models. If the resultant eye contours do not interfere with a given mask, then the channel is deemed compliant. An example of a StatEye diagram is shown below.

The IEEE 802.3 (Ethernet) working group took a different approach for its IEEE 802.3ap 10G Backplane Ethernet standard. This standard specifies limit lines for channel transfer functions (insertion loss), as well as parameters including insertion loss ripple and insertion-loss-to-crosstalk ratio (ICR). This collection of limit lines is called the Informative Channel Model, and while it is recommended that designers fall within the limits, this is not a formal restriction and flexibility is allowed for tradeoffs and specifics of a given system.

Whichever backplane design is chosen to meet ever-changing speed and performance requirements, design engineers ultimately need to consider what’s to come beyond current standards. To lower applied costs and extend the system’s lifecycle, a backplane’s infrastructure needs to have forward-compatibility that enables product use years down the road.

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