

Taking Rugged I/O Cabling and Connectors to Higher Speeds

You now have the option to take copper cabling and connectors to 12.8 Gbps and beyond.

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Today's transceivers and chip sets are demanding better performance at higher data rates from the cables and connectors being used to carry serial data. Future systems promise to operate at even higher data rates. This performance is measured in terms of attenuation, crosstalk, and impedance control. The need for greater port density leads to that eternal conundrum: How can I package more signals in less space and at higher speeds without degrading performance?

Connector design is reaching a point where signal density requirements are severely limiting the ability to use interstitial ground planes to isolate single-ended or differential pair signals from one another. This same density requirement also makes the extensive use of ground pins problematic. Higher data speeds – and their correspondingly shorter signal wave lengths – also contribute to design problems by making which termination techniques you use and the number of terminations in a signal path critical.

Engineers are also encountering another problem caused by the need for increased density and the constraints imposed by signal integrity requirements. Increasing density and reducing the physical size of terminations leads to connectors and individual connections that are too fragile for many applications.

In this article, we'll describe some cutting-edge approaches that hold promise for taking copper to the speeds and densities that tomorrow's designs will require, and discuss how your designs can accomplish these goals while still providing a robust and reliable connection.

Faster and Farther

The speeds used today – and those proposed for the near future – were almost unthinkable just a few years ago. We can attribute this progress to significant developments in the understanding of (and ability to simulate) the conditions that high-speed signals encounter.

Advanced connector designs and manufacturing techniques allow connectors to approach transparency, enabling you to take advantage of the signal conditioning now embedded in many transceivers to design serial links between boards, racks, and cabinet bays. This enables copper cabling to be a feasible option for data center distances that exceed 15 meters at 6 Gbps – for example, T10 SAS-2 cabling.

Using software to simulate 2D, 2.5D, and 3D fields has allowed engineers to design for signal integrity before a part is molded or stamped. This has led to the use of different combinations of signal and ground pin size and placement. You can now optimize the placement of signal and ground pins to match the particular requirements of a given application, or use pins of different widths and thickness to increase the shielding available in an interconnect to control crosstalk.

Additionally, you must consider impedance control – and its direct impact on insertion loss and return loss – in the design phase. Signal and ground pins can have their size and shape contoured within the connector to minimize any changes in impedance. The physical shape of mating contacts at the

point(s) of contact also plays a role in defining the quality of the transmission line.

Using automated welded contact to wire terminations creates predictable and repeatable signal paths. You should take great care in establishing these contact weld programs to ensure that the termination zone size is kept to an absolute minimum.

Impedance control is also aided by bringing the shielding right up to the termination zone whenever possible. Tight manufacturing tolerances ensure a consistent physical geometry, which leads to consistent eye diagrams.

You can address all of these concerns in the design of a connector from its inception with simulation software. Figure 1 compares a next-generation differential contact with Meritec's current 4X cable.

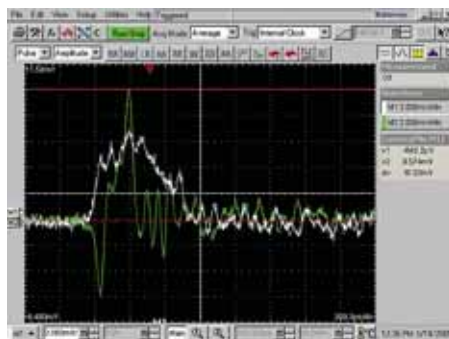


Figure 1 – Near-end crosstalk (NEXT) at a 40 psec (20-80%) risetime: green = Meritec's current 4X with two nearest neighbors added together, crosstalk = 2%; white = Meritec's high-speed differential contact with six nearest neighbors added together, crosstalk = 1.4%.

I/O cabling offers unit-distance losses within the cable that are significantly less than those within the printed circuit board. For example, according to test report #335, conducted by co-author John Sawdy, the losses in a 3 meter, 26 AWG (American Wire Gauge) cable are roughly equivalent to a 12 inch, 4.5 mil trace in a low-loss substrate.

The silicon you choose can also help. Using signal conditioning techniques such as pre-emphasis, post-emphasis, and adaptive equalization can allow copper to meet the needs of the multi-gigabit data transmission community. The semiconductor industry continues to explore other, more advanced signaling techniques for the future, addressed in "Beyond 10 Gbps," presented at DesignCon 2005 by Tom Palkert of Xilinx.

Ten Pounds in a Five-Pound Bag

Two approaches spring immediately to mind when addressing the need for increased data density: increased signal density and increased data rate. The industry has chosen to attack the problem on both fronts simultaneously.

Increasing signal density is not as simple as putting more pins in a tighter grid. As the pins get closer, their fields encroach on each other and interact. This interaction can lead to substantial reductions in signal integrity.

Meritec has successfully designed and tested a co-planar board-to-board connector that allows for densities on the order of 44 differential pairs or 66 single-ended signals per square inch. We have also simulated designs for mezzanine connectors and I/O cables, which show great promise. This contact design should also be suitable for many zero insertion force (ZIF) applications.

Bolstered by this testing and simulation, Meritec is developing new higher density mezzanine connectors, co-planar board-to-board connectors, and 16X-48X rugged I/O cable assemblies that will meet current and future needs for data transmission at speeds from 2.5 Gbps per lane through 12.8 Gbps per lane and beyond. Figure 2 represents one proposed, stackable cable assembly configuration.

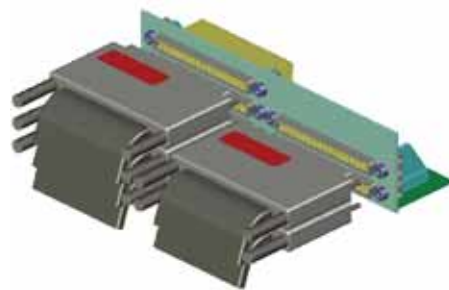


Figure 2 – High-speed differential cable assembly and mating board connector

Increasing the data rate requires you to use many of the techniques we have described. These techniques allow the connectors and cable assemblies to accommodate the data rate increases called for in such current and proposed standards and applications as PCIe, RapidIO, HyperTransport, custom Xilinx® RocketIO™ transceivers,

CX4, Qnet, NUMA, Myrinet, OIF CEI, Infiniband, SAS, Fibre Channel, or SONET extenders.

Rugged Construction is a Must

Engineers designing for high density and faster data rates will quickly encounter another serious obstacle. As pins become smaller and more tightly spaced, the possibilities of physical damage increase. Contact and connector designs that look great in a CAD program or signal integrity simulation can begin to show serious

As pin counts increase, so do mating forces. These forces can reach the point where they prohibit hand mating and require special mechanisms to engage. Standard pin and socket contacts typically have very high insertion forces; you should take steps to reduce these to manageable levels for high-pin-count connectors. The hermaphroditic contact design allows for extremely low insertion forces, despite high pin counts, while maintaining high normal force because of dual contact.

You must also offer protection from



Figure 3 – Edge view – individual row of mated contact pairs

flaws in the field. Fragile construction becomes an issue when connectors are subjected to use in uncontrolled environments and expected to perform.

Smaller contacts are a clear requirement of higher densities, so you must utilize another means of physical protection. One approach is to use a hermaphroditic contact. In a standard male/female interconnect, the female end occupies far more space than the male. Meritec's hermaphroditic contact eliminates the need for the female. Two identical contacts are used to mate with each other.

This contact design has been used in numerous applications, and we have developed a new version for higher data rate applications. The contact is extremely robust. Each mating pair provides two points of contact; these contacts are also more tolerant of minor contact misalignments that become more consequential as pitch decreases. To our knowledge, there has never been a single failure of our hermaphroditic contact. Figure 3 shows how one row of these contacts is mated.

stray tools, corners, and edges. One way to accomplish this is to recess the contacts in a unique honeycomb-like housing that surrounds the contacts to protect them in the unmated state. Aside from intentional damage, the contacts are well protected from physical damage during handling, mating, and un-mating.

Conclusion

It is clear that the demand for higher data rates and signal density will continue to grow. It is also clear that a fundamental understanding of signal integrity; the ability to accurately simulate electrical and magnetic fields; advances in semiconductor technology; innovative contact design; and progressive manufacturing techniques will allow copper to remain a viable signal conductor for the foreseeable future.

For more information, contact Meritec Customer Service at (440) 354-3148, e-mail info@meritec.com, or visit www.meritec.com.

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