OVERCOMING CHALLENGES IN
100 GBPS BACKPLANE DESIGN

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Since ATCA was introduced in 2002, demand for higher data transfer rates across the backplane have continually risen. This is particularly evident in the Telecommunications and Industrial sectors where high data transfer rates are typically required. Today's processor technologies with Multicores, GPGPUs (General purpose computing on Graphics Processing Unit) and powerful co-processors can satisfy the demands of full HD video on demand, increasing data hungry services for smart phones and other services. In addition to the data services required for these applications the infrastructure must support these large traffic volumes. High transfer rates therefore provide new challenges in the design and application of connectors and materials, as well as the conductor path structures of backplanes.

FROM 1 TO 100 GBPS IN THE SPAN OF A FEW YEARS

Starting several years ago with packet-switching-backplanes and a data transfer rate of 1 Gbps, today's ATCA technology supports a data transfer rate of 40Gbps. This speed is achieved by pooling of four 10 Gbps ports, but that is not sufficient for the requirements of high-performance processor blades today. Dual-Dual Star backplanes are often used where two switches work in parallel to increase the data traffic between transmitter and receiver to 80 Gbps. This method will not support the demand for ever-increasing data transfer rates for long, especially considering that the IEEE specification for 100 Gb Ethernet over copper was released at the end of 2014. This specification describes all of the requirements for 100 Gbps data transmission. Today, the PICMG working group is defining 100G Ethernet for AdvancedTCA based on the IEEE spec.

100 Gbps data rates create many new challenges for backplane design. The following graphs show the thresholds for insertion and return loss of the IEEE802.3ap specification which defined 40G Ethernet and the new standard IEEE802.3bj, which defines 100G. At 100G, the IEEE defined two coding methods, 100GBASE-KR4 and 100GBASE-KP4. The thresholds for both new methods of 100G are defined for much higher frequencies as shown in Figure 1 and Figure 2. This means that all backplane components such as connectors, the bare board and the copper trace structures have to be designed for those high frequencies.

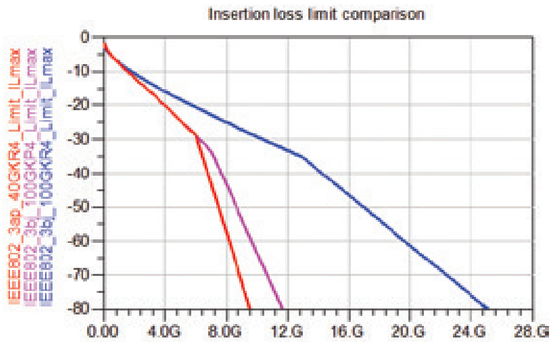

Figure 1. Insertion loss comparison

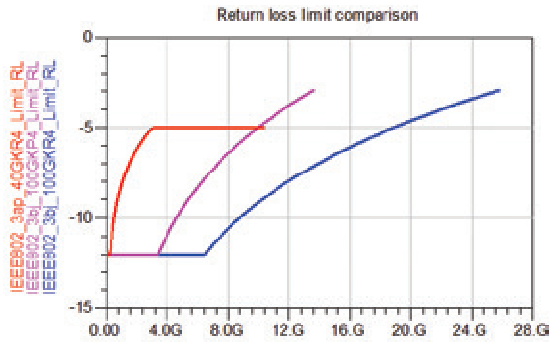

Figure 2. Return loss comparison

CONNECTER DEVELOPMENT

The current connectors defined currently in the AdvancedTCA specification are completely sufficient for the previous 40 Gbps data transfer rates, however, they are not designed for the high frequencies of 100Gbps data transmission. For this reason, two connector manufacturers have independently developed "ZD compatible" plug connectors for 100 Gbps. If one considers impedance in the ZD and ZDplus connector pair, as well as one of two new ZD100G connectors (Figure 3), it can be seen that impedance is reduced in the newly developed connectors. This leads to less reflection and thus a better signal transmission.

Figure 3 shows the isolated impedance characteristics of a plugged connector pair which means without the influence of the through holes of the bare board. The characteristics from surface to surface within the bare board is not considered. The diameter of the vias were also reduced in further connector development to achieve a more homogeneous impedance curve. Taking into account the vias, the difference is even clearer.

Overcoming Challenges in 100 GBPS Backplane Design

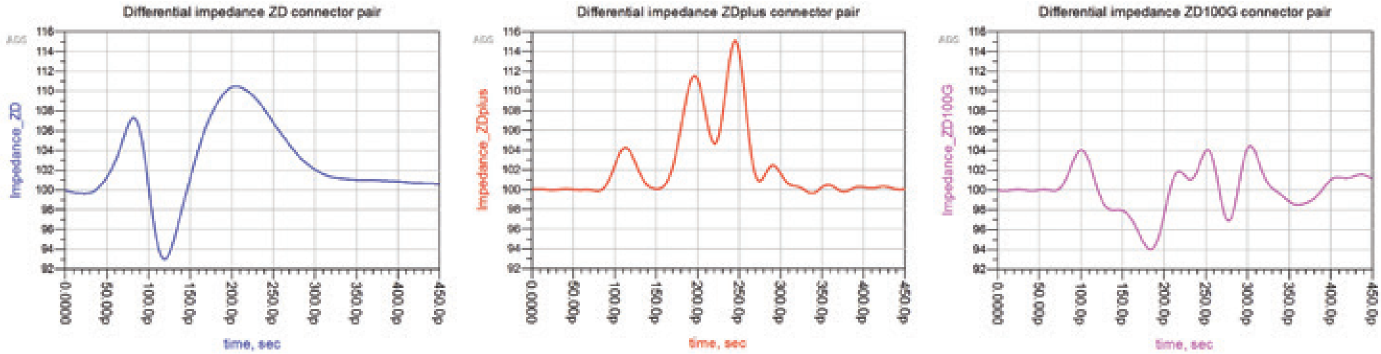

Figure 3. Impedance curves in the inserted connector pair (ZD, ZDplus and ZD100G)

To ensure backwards compatibility, the two new connector types are able to mate with ZD or ZDplus connectors. The two ZD100G connectors can be combined also with the other manufacturer's versions. Unfortunately, the two manufacturers have used different footprints on the printed circuit board, making second-sourcing of backplanes and boards a challenge. A backplane or board manufacturer must choose a connector type and is therefore bound to that manufacturer. To change connector types a redesign of the board and backplane is required.

Clearly different strategies were pursued in the development of the two new 100 Gbps connectors. This is reflected in slightly different mechanical properties of the connector, which has led to slightly different high-speed characteristics. These are all factors to be considered when selecting which connector type to use. At the moment, PICMG has no plans to restrict the type of connector that may be used.

BOARD MATERIALS

PICMG also has no plans to restrict material selection for boards or backplanes. Each manufacturer can decide which material is to be used in their design. A wide range of materials for high speed circuit boards are offered on the market. The differences based on material selection can be very large. Material selection depends on not only loss factors, but you must take account of all of the properties to make an optimal choice of material. The price/performance ratio may also vary widely. There is no guarantee that the best currently used material will function for 100 Gbps transmission. Design of transmission lines also plays an important role in performance. nVent has avoided using the highest cost materials in the 40 Gbps series of ATCA backplanes. The most important factor is optimized design of transmission lines.

PCB DESIGN

Not all differential pairs have the same properties. For example, comparing two differential pairs both with 100 Ohm impedance yet different trace widths, they have different behavior in terms of loss and crosstalk (emissions and immissions). Here, it is the task of the backplane or Board developer to create an optimized design. This is hardly possible without an elaborate 3D simulation of the conductor path structures (Figure 4). It is important to carry out a simulation of the entire transmission channel before the completion of a design. This process allows analysis of potential weaknesses in the design, leading to optimization and ultimately, certainty of functioning 100 Gbps transmission. nVent has used the 3D-Solver simulation software HFSS and ADS for years.

DESIGN VERIFICATION

Simulation alone is not enough in practice. The PCB manufacturer may make some small design adjustments for manufacturability. Additionally, there may be fluctuations in substrate material of the backplane resulting slight variations in end results. These effects can increase loss and crosstalk on the transmission path. After completing the backplane or board design, the properties need to be verified by measurement. For DVT (design verification testing) a high frequency Network Analyzer is necessary in addition to validated measuring adapters. nVent uses a Keysight (formerly Agilent) 67Ghz N5227A PNA microwave network analyzer for these DVT tests. This equipment is supported by a TDR and various oscilloscopes when needed.

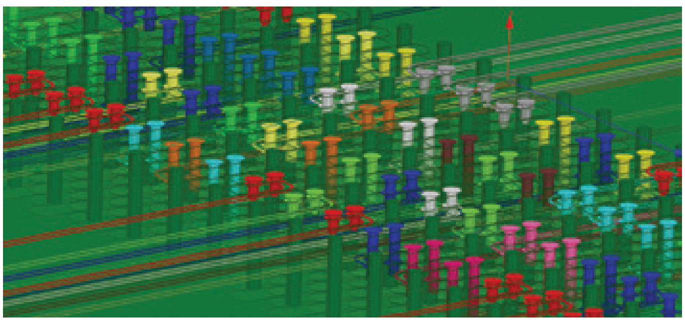

Figure 4. Example: signal lines in an ATCA backplane

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IEEE SPECIFICATION FOR THE ADVANCEDTCA STANDARD

The IEEE specification 802 3bj for 100 Gbps defines parameters for the entire Ethernet channel, located between the two Transceiver chips (between points A and D in the Figure 5). An AdvancedTCA backplane transmission line is only part of the entire transmission channel (Point B to C in Figure 5). The two AdvancedTCA boards are located in the transmission channel before and after the backplane (Point A to B and C to D in Figure 5). For this reason the parameters of the IEEE specification 802 3bj cannot be used one on one for AdvancedTCA backplane or Board validation. The parameter limits of the IEEE specification 802 3bj must be divided between these three parts (two AdvancedTCA cards and the backplane) in a way that makes sense. Then, independent validation on the backplane and the Board parameters is possible. The PICMG working group for 100 Gbps and companies such as nVent exactly participate are actively working on the definition of this important new standard. Once PICMG 100 Gbps AdvancedTCA standard is defined, adopted, or at least the limits for the backplane are fixed (probably beginning 2016), nVent will bring a 100 Gbps AdvancedTCA backplane to the market which meets all of these requirements.

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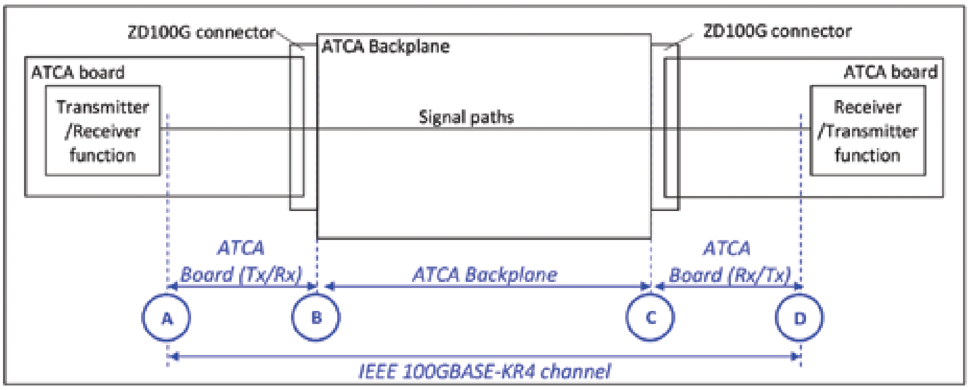

Figure 5. Overview of a 100 Gbps transmission channel

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Electrical systems come in all shapes and sizes, from massive industrial controls to single components. nVent offers a comprehensive range of enclosures that house these vital assets. Marketed under the nVent HOFFMAN and SCHROFF brands, our enclosures offer two-pronged protection: safeguarding electrical equipment from the operating environment and people from electrical hazards.

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