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Design considerations for PICMG 3.0 AdvancedTCA backplanes

By Melissa Heckman and Mihai Savu

As PICMG 3.0 Rev. 1.0 for AdvancedTCA (ATCA) is a new and detailed specification, there are many questions for designers, particularly on the backplane. Issues such as hub placement, topology, FR-4 material's reliability, and routing are common questions for ATCA. This article will study the design of a 14-slot Dual Star AdvancedTCA backplane. The simulation and measurement results will provide some insight on many ATCA backplane elements. We'll provide design tips and answer many of the questions surrounding the backplane.

Background

The AdvancedTCA (PICMG 3.x) specifications are a collaboration of more than 100 participating companies in PICMG. The PICMG community created AdvancedTCA (Advanced Telecom Computing Architecture) as an open solution geared for central office applications. The 8U form factor and 280mm depth are based on Eurocard. The larger cards and wider slot spacing allow more components (and taller ones) to be used on the blades, maximizing performance. Using various fabrics for the traffic engine, the performance can hit Gigabit/Terabit levels and offer high availability and scalability. There are currently four sub-specifications, PICMG 3.1 for Ethernet, PICMG 3.2 for InfiniBand, PICMG 3.3 for StarFabric, and PICMG 3.4 for PCI Express. System management, dual-redundant 48V DC power distribution, and cooling capacity of 200 watts per board are other requirements of the specification.

Backplane

The backplane is approximately 5U tall to allow for the rear transition module interface. If the rear transition module interface is added to the backplane, the overall height becomes 8U. The slot pitch is 1.2 inches so a 14-slot backplane will fit in a 19-inch rack. The specification allows for a 16-slot backplane for ETSI rack mounting.

The backplane is broken up into zones. Zone 1 contains the power connector. Zone 2 is made up of the signal connectors carrying the base interface, clocks, update channel interface and the fabric interface. The base interface uses an Ethernet Dual Star topology. The power connector was specially designed by Positronic Industries for the PICMG 3.0 application. It is a 34-pin press fit connector, with two redundant 48V DC feeds. Signals on the power connector are tip and ring, redundant ringing generators, hardware address bits and redundant IPMB buses. The signal connectors in Zone 2 are ZD connectors manufactured by ERNI and Tyco. Horizontally the connector columns have five differential pairs and vertically there are 10 rows. The ZD connector is specifically designed for high speed differential signaling, and is capable of speeds up to 5 Gbits/sec.

At the top of the backplane above the Zone 2 connectors, there is provision for an alignment key to enable proper insertion of the front card. If a rear transition module is called for, the alignment key continues out the rear of the backplane.

Topology

The topologies of the specification are Dual Star, Dual-Dual Star, and Mesh (including Replicated Mesh). All of these configurations can go up to 14 slots (in a 19-inch rack). However, Replicated Mesh is limited to eight slots.

The topology can greatly affect the overall system cost as the cards, backplane, etc., will be affected. Focusing on the backplane, a Mesh topology can demand significantly more layers than a Dual Star topology. With more point-to-point links, more layers need to be added to achieve the signal routing. Going from a Mesh to a Replicated Mesh is not expected to change the layer counts to any significant degree.

Dual Star topology – A design overview

In the AdvancedTCA specification, the trace width, separation, and dielectric thickness have recommended values (see Figure 1). They need to be considered in the PCB design to ensure the functionality for a FR4, with a maximum backplane thickness of 6.35mm with no more than a 533mm trace length. Using a stripline design method, the ATCA backplane design should stay within recommended values for trace width, separation, etc.

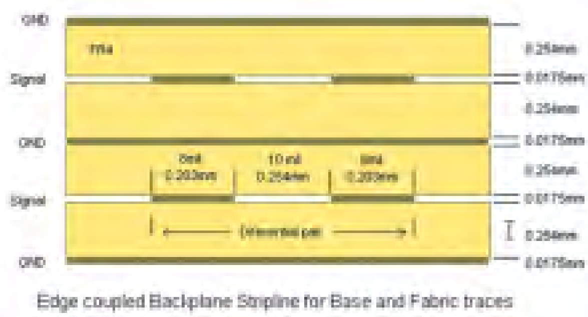

Figure 1

In a Dual Star or Dual-Dual Star configuration, the physical position of the hub slots on the backplane is not restricted. They can be placed in any slot. But the position of the hub slots is a very important design factor because this will determine the maximum trace length on the backplane. The positioning will allow the implementation of intelligent routing, which help the design engineer to minimize the backplane layer count. These benefits are highlighted by the Bustronic/Elma TreNew Dual Star AdvancedTCA Backplane (Figure 2) where the hub slots are placed in the middle of the backplane.

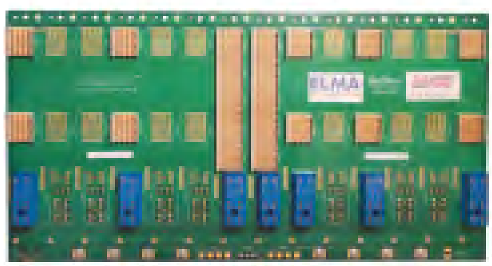

Figure 2

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The 14-slot AdvancedTCA backplane in Figure 2 shows a Dual Star design with the hub slots in the center of the backplane. Simulation results show favorable results with careful hub placement and precise routing strategies.

The TDR profile in Figure 3 shows a trace situated in the first signal layer. Using the worst case stub, the measured backplane impedance was about 102W, only a 2W tolerance from 100W.

The Eye Diagram in Figure 4 shows strong values for the longest trace in the worst-case layer on the backplane. In a real-case scenario, performance for the 14-slot Dual Star ATCA backplane is expected to be even better.

By placing the hub slots in the center of the backplane, the maximum trace length will be reduced by half. The result is a big improvement in signal quality because the losses due to dielectric and skin-effect will be considerably smaller. The maximum trace length would be about 270mm. Further, by placing the hub slots in the middle, special routing strategy can be implemented which can minimize the layers from 18 layers to only 12 layers. Besides effective cost savings, the small number of layers leads to a PCB thickness of 3.2mm only. That will minimize the stub influence and will improve the signal quality. Figure 3 shows a TDR profile for the worst case stub. It represents a trace situated in the first signal layer under the connectors. The minimum differential impedance is only 85W. One may also notice that the measured backplane impedance is about 102W. This very small tolerance, only 2W, is the result of the strict conditions worked out with the PCB manufacturers. To prove these benefits, measurements were performed using passive and active cards with real drivers that operate at 3.125 Gbits/sec. The traces on the cards have 5-mil width and are 115mm long. Figure 4 shows the eye diagram for the longest trace on the backplane situated in the worst-case layer. The eye opening is about 509mV, which represents a good value considering that the driver used for measurement requires a minimum opening of 200mV. In a live system, performance is expected to be even better because additional noise introduced by measurement cables and SMA contacts would be eliminated. Using standard FR-4 material was not a problem. Using various transceivers and SerDes devices, simulation and performance measuring showed speeds of over 5 Gbits/sec were reliable using FR-4.

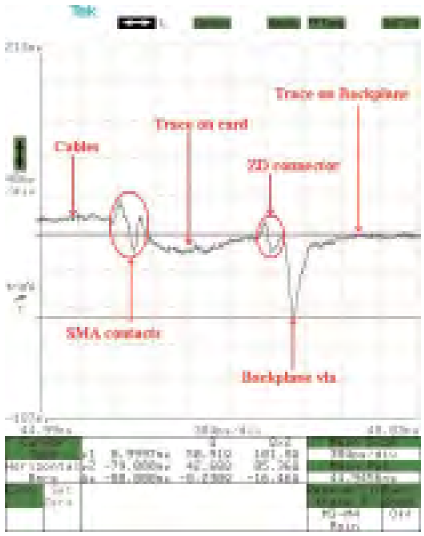

Figure 3

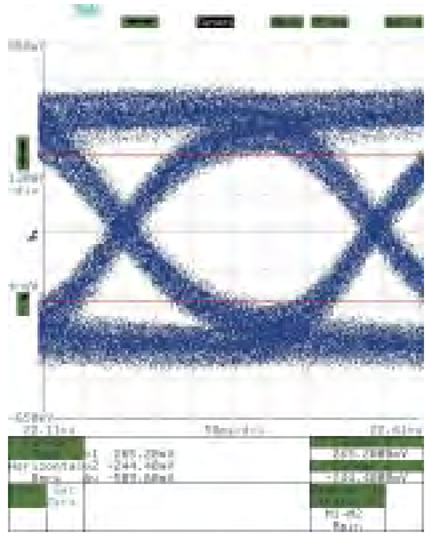

Figure 4

So, by placing the hub slots in the middle of backplane for a Dual Star or Dual-Dual Star configuration and by applying intelligent routing solutions, the result is reduced costs and improved signal quality. ATCA versions designed this way are more tolerant to external noise, and will be able to operate at higher data rates compared to similar backplanes where these improvements were not implemented.

More on ATCA

AdvancedTCA has some intriguing products coming down the road. System management is a key element in intelligent platform design. Our parent company Elma Electronic is working with Pigeon Point Systems on shelf management infrastructure based on the IPM Sentry hardware and software building blocks. The IPM Sentry products enable cost-effective, interoperable management of open modular platforms based on the Intelligent Platform Management Interface (IPMI), the chosen foundation for platform management for PICMG specifications. Using IPM Sentry components, developers of AdvancedTCA shelf and board products can quickly and cost-effectively incorporate compliant, competitive management subsystems (see *Management building blocks speed AdvancedTCA product development* on page 52 for more background).

There are also ideas for PMC modules for ATCA and participation for PICMG should be under way by the time this article is published. Although a sheet metal packaging design was approved for the specifications, some are choosing to also develop modular versions. The modular packaging makes prototyping for specific chassis sizes and designs quicker and more affordable.

For more information on AdvancedTCA or other packaging products, visit www.bustronic.com, www.elma.com, or www.nextgenbackplanes.com

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