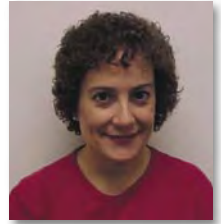


Design considerations for PICMG 3.0 AdvancedTCA backplanes

By Melissa Heckman



Many designers have questions, particularly backplane design questions, concerning a relatively new and detailed specification, PICMG 3.0 Rev. 1.0 for AdvancedTCA. Issues regarding hub placement, topology, FR-4 material reliability and high frequency characteristics, and routing concern designers. This article discusses the design of a 14-slot Dual Star AdvancedTCA backplane. In addition to presenting simulation and measurement results to provide some insight on AdvancedTCA backplane elements, this article offers design tips, answers many backplane questions, and updates recent developments.

AdvancedTCA update

A few recent events point to AdvancedTCA's forward migration. Over the course of 2003 and into 2004, PICMG has been conducting a series of AdvancedTCA Interoperability Workshops. Workshop members have been testing specific 3.0 Rev 1.0 sections to ensure interoperability among different vendors' equipment. Workshop #6 was held before the Bus and Board 2004 conference in the third week of January 2004. This Workshop demonstrated the interoperability of various vendors' cards and shelf managers with different AdvancedTCA chassis platforms. Answering the question of whether the various vendors' fabric interfaces would communicate effectively with each other comprised another Workshop objective. As the live demo at Bus and Board illustrated, the products were fully interoperable, and the demos went off without a hitch.

Vendors introduced new 5U AdvancedTCA development units at Bus and Board. These units' AC-to-DC converters allow them to plug into a conventional wall outlet (the AdvancedTCA specification calls for -48V input to shelves). These chassis also feature a standard plug-in shelf manager card. These features play an important role in demos, portability, prototyping, and similar applications. Other recently announced AdvancedTCA products are a 13U chassis, handles, front panels, and ESD clips.

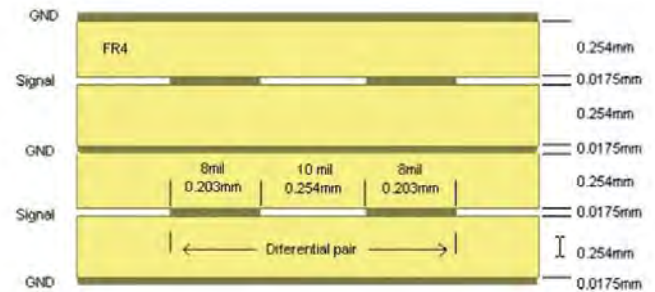
Work has begun on the PICMG 3.5 specification for RapidIO, joining the already completed PICMG 3.1 for Ethernet, PICMG 3.2 for Infiniband, PICMG 3.3 for StarFabric, and PICMG 3.4 for PCI Express. These subsidiary specifications map specific link technologies onto the AdvancedTCA backplane.

The several backplane configurations on the market include AdvancedTCA versions in 2, 5, 6, and 14 slots that use both Dual Star and Mesh topologies. Placement of the hub slots in a Dual Star configuration gives rise to one interesting issue, as the following study shows.

Dual Star topology: A design overview

The AdvancedTCA specification recommends trace width, separation, and dielectric thickness values (Figure 1). PCB designers must consider these values to ensure functionality when using FR-4 material, by using a maximum backplane thickness of 6.35mm and a trace length of no more than 533mm.

Using a stripline design method should result in an AdvancedTCA backplane design that is within recommended values for trace width, length, and separation.



Edge-coupled Backplane Stripline for Base and Fabric Traces

Figure 1

Dual Star or Dual-Dual Star configurations do not restrict the physical position of the hub slots on the backplane; they can be placed in any slot. However, hub slot positioning plays an important role because this placement determines the backplane's maximum trace length. By enabling intelligent routing, positioning the hub slots helps design engineers minimize the backplane layer count. The Bustronic/Elma TreNew Dual Star AdvancedTCA Backplane (Figure 2), in which the hub slots reside in the middle of the backplane, highlights the benefits of reduced backplane layers.



Figure 2

Careful hub placement and precise routing strategies for the 14-slot AdvancedTCA backplane shown in Figure 2 have produced favorable results during simulation.

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 AdvancedTCA backplane is expected to be better.

Placing the hub slots in the center of the backplane can reduce the maximum trace length by half. Signal quality experiences a large improvement because the losses due to dielectric and skin effect will be considerably smaller. The maximum trace length is about 270mm. Further, placing the hub slots in the middle makes possible a special routing strategy that will shrink the layer count from 18 to 12. In addition to delivering cost savings, the lower number of layers leads to a PCB thickness of just 3.2mm, minimizing the stub influence and improving 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. Also note that the measured backplane impedance is about 102W. This deviates only 2W from nominal, the result of the strict conditions worked out with the PCB manufacturers.

To prove these benefits, Bustronic/Elma took measurements using passive and active cards with real drivers that operate at 3.125 Gbits/sec. The traces on the cards are 5mm wide and 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 will be eliminated. Using various transceivers and SERDES devices, simulation and performance measurements showed speeds of over 5 Gbits/sec using FR-4, evidence that standard FR-4 material use posed no problem.

Positioning the hub slots in the middle of backplane for a Dual Star or Dual-Dual Star configuration and applying intelligent routing solutions reduces cost and improves signal quality. AdvancedTCA backplanes designed this way are more tolerant to external noise, and will be able to operate at higher data rates compared to similar backplanes not incorporating these improvements. Later this year, Bustronic/Elma will perform S-parameter studies on different AdvancedTCA backplane designs.

From development to deployment

As we move from development to deployment, look for new AdvancedTCA configurations. The 3U, 4U, and 5U systems built for development have been handy, as have the full 14-slot (in a 19-inch rack) 12U systems for fully loaded performance evaluations. However, full deployment will require integrated shelf management, a flexible backplane design, and a wider selection for various customers' needs.

A five-slot Mesh PICMG 3.0-compliant backplane works well because it fits in both 4U and 5U horizontal chassis, and design engineers can use these backplanes with either Mesh or Dual Star topologies. If it has connectors for a shelf manager plug-in, it has even more advantages (See Figure 5).

Some AdvancedTCA systems will require enhanced airflow, as mentioned, and will demand more powerful system management modules. To resolve these issues, designers can use a 13U



Figure 3

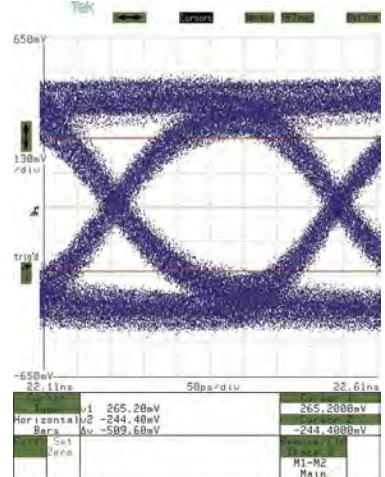


Figure 4

(577mm) shelf solution. The extra 1U of shelf space (44.45mm) is valuable for air intake and exhaust plenums or for incorporating redundancy in cooling and shelf management. Existing AdvancedTCA products have already done a pretty good job of addressing deployment concerns such as hot swap for the fan trays, cable management, and meeting NEBS criteria.



Figure 5

On the development side, the industry still has room to improve the process. For example, additional AdvancedTCA load boards, extender boards, and adapter boards would significantly further development. These boards are beginning to appear. AC-to-DC power supplies present additional development possibilities. As mentioned above, the Elma 5U AdvancedTCA Development chassis works well for the AC-to-DC conversion that AC plugging requires, providing *anywhere* access.

Conclusion

The market research presented at the January 2004 Bus and Board conference showed positive expectations for AdvancedTCA, with a multi-billion dollar market only a few years away. The backplane will continue to be an integral part of the system design to ensure optimum performance. More simulation studies are underway to further improve the signal integrity in various design configurations. For more information on AdvancedTCA backplanes and systems, visit www.nextgenbackplanes.com or www.picmg.org.

Melissa Heckman is an electrical engineer with more than fifteen years of experience in electronics. Melissa has been with Bustronic for more than three years and received her degree in Electrical Engineering from California Polytechnic State University. Melissa has been heavily involved in organizations such as VITA, PICMG, and the StarFabric Trade Association.

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