

## Next Generation AdvancedTCA



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## **1. Introduction: the PICMG 3.0 "AdvancedTCA" standard**

Advanced Telecommunication Computer Architecture (AdvancedTCA) is the first cross-manufacturer and cross-user standard for very high data traffic and new communications services in the telecommunications sector. AdvancedTCA was first established by PICMG (the *PCI Industrial Computer Manufacturers Group*) as PICMG 3.0 Rev. 1 in late 2002. AdvancedTCA boards are capable of transporting, processing and analyzing large volumes of data in real time.

AdvancedTCA systems are typically used in large data volume applications that require high data throughput and a 99.999% availability (carrier grade). High data volumes occur, for example, in media gateway servers when multimedia content such as digitally encoded speech, audio or image data is processed or transmitted. Carrier-grade systems, such as servers that operate with very high reliability levels, are used primarily by telecommunications and internet service providers who have very high failure safety standards. Scientific applications that involve carrying out and reporting on special research projects in real time are also increasing.

The main features of AdvancedTCA systems are:

- Scalable architecture and bandwidth of up to 2.5 Tb/s
- Redundancy and hot-swap capability of all important system components
- 99.999% ( $9^5$ ) system availability
- Modularity and wide range of configurations
- Different protocols for fast interfaces  
(e.g. Ethernet, InfiniBand, Star Fabric, PCI Express and Rapid I/O)

## **2. Market requirements determining future developments**

Thanks to regular workshops and close contact with customers, the AdvancedTCA standard has quickly become industry practice; the first AdvancedTCA systems have been operating in the field since 2005. With the use of these systems for core networks and backbones, however, maximum system data throughput requirements have steadily increased. Multimedia applications such as video on demand, mobile internet applications, Web 2.0, webinars, etc., have contributed to this demand. Since increasing the data throughput by adding extra hardware is very costly, it is common practice to seek improvements by raising the data transfer rate.

The bottleneck in an AdvancedTCA system, currently 25 Gb/s, is not caused only by the backplane. If high data rates are to be processed, the AdvancedTCA boards must be provided with more powerful chipsets, such as quad-core processors. However, using such powerful chipsets together with AdvancedMC carriers containing up to four AdvancedMC boards results in higher power consumption and also higher system dissipation loss.

### **3. Market requirements implementation**

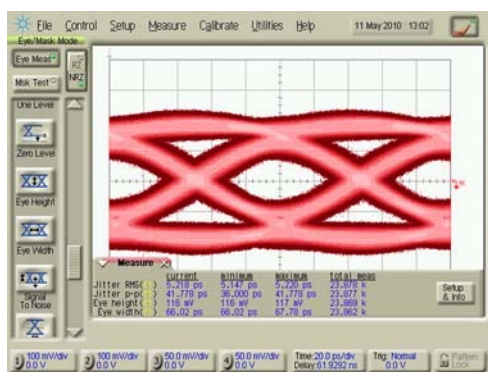
Schroff is one of the first manufacturers to bring a new series of standard AdvancedTCA systems with 40 G backplanes, 4 parallel lanes of 10 Gb/s and almost double the data transfer rate of the current AdvancedTCA generation to the market. This technology change consists of AdvancedTCA boards with faster chipsets (10 Gb/s Ethernet) and higher transmission rates to meet the previously mentioned demand for ever-higher data throughput. At the October 2009 AdvancedTCA Summit, manufacturers announced the 40 Gb/s (4 lanes of 10 Gb/s) data transfer rate increase for 2010, which new standard AdvancedTCA systems provide.

#### **3.1 Backplane: improved efficiency and simultaneous cost reductions**

When the AdvancedTCA standard was defined in 2002, the backplane high-speed data transfer rate was about 10 Gb/s (4 lanes of 3.125 Gb/s, with 8/10 coding). Today, however, backplanes typically transmit at 20 Gb/s (effective bandwidth 4 lanes of 6.25 Gb/s) with the newest transmitting at 40 Gb/s.

The first generation of Schroff full-mesh backplanes had a transmission rate of 10 Gb/s (4 x 3.125 Gb/s) and 38 layers. Today's 40 Gb/s backplanes contain only 22 layers.

Despite the higher transmission rate, it is still possible to use low-cost FR4 material. Costlier materials such as Nelco, etc., are not required for standard backplanes, although they can be used at the customer's request. Material test reports are also available at [www.schroff.co.uk/testreports](http://www.schroff.co.uk/testreports).



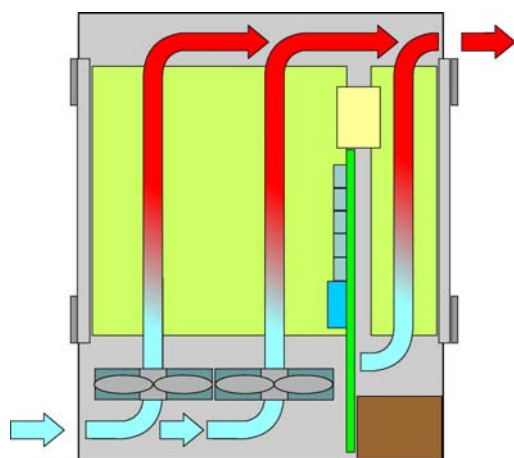
Eye diagram



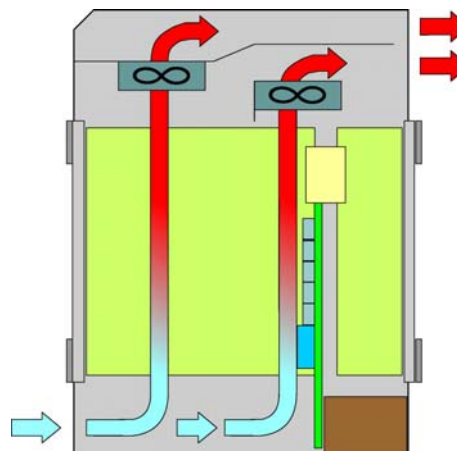
Backplane simulation measurement

### 3.2 Cooling capacity: 300 watts required per front board and 30 W for RTM boards

Apart from the high-speed characteristic, dissipating board heat is an increasingly important issue in AdvancedTCA system development. With 14- and 16-slot systems that contain vertically mounted boards, a distinction is made between push cooling and pull cooling, while in 2- to 6-slot systems with horizontally mounted boards, a combined push/pull approach is used. In push cooling, fans are positioned under the boards to be cooled and push air toward and past the hot components. In pull cooling, fans are mounted above the boards to pull air through the board cage.



Push cooling

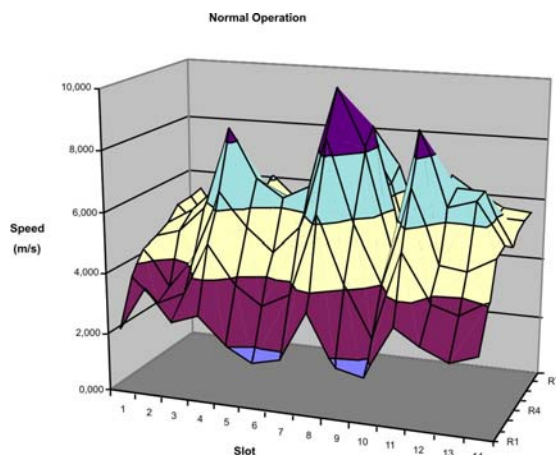


Pull cooling

The AdvancedTCA specification originally specified a cooling capacity of 200 W per front board plus 5 W for RTM boards, and first generation 14- and 16-slot systems were fitted with diagonal fans, the most powerful available. In contrast, today's systems require a cooling capacity of 300 W per front board and 30 W for RTM boards. With a target  $\Delta T$  of 10 K, cooling becomes a new challenge as diagonal fans have been replaced with more powerful axial or radial fans, but the space available for fitting fans cannot be increased at will.

Chassis height is limited to 13 U to fit three systems into a 42 U cabinet. Additionally, a 3 U power distribution box must be installed. Fan capacity can therefore only be further increased via higher fan speeds and more powerful fan motors. The fans originally employed drew approx. 140 W, but those used today require 420 W, which represents 10 to 15% of a 16-slot system's power consumption. The present generation of fans in 14-slot AdvancedTCA systems allows an airflow volume of 1170 m<sup>3</sup>/h (~ 695 cfm) through the system and 4.5 kW of heat dissipation, and these numbers will continue to increase. While it is still possible for waste heat from individual systems to be dissipated using air as the cooling medium, cabinets containing three systems are today cooled with an air/water heat exchanger capable of removing up to 40 kW of heat.

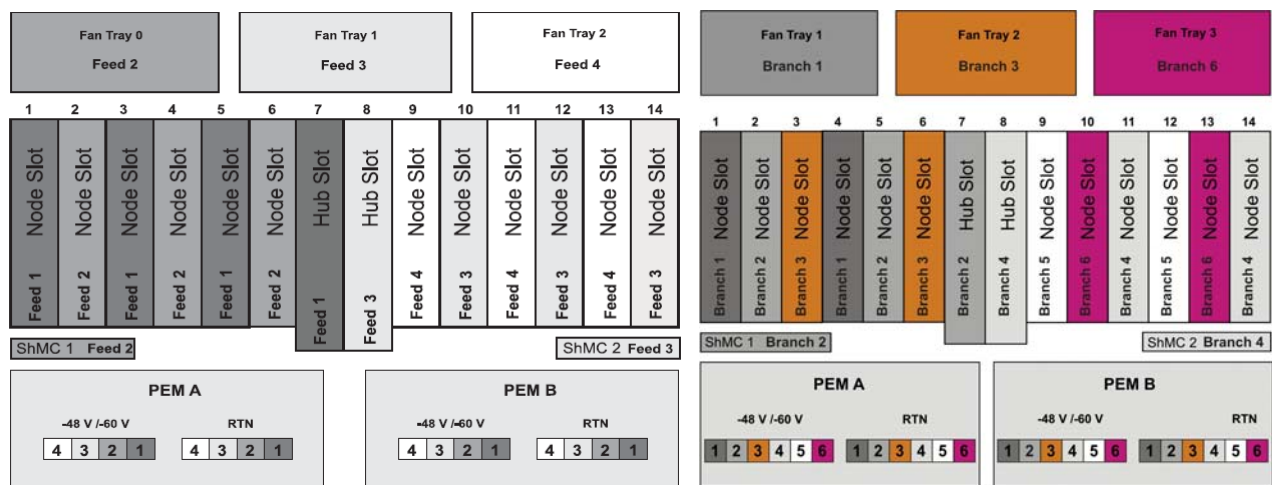
Fan noise level is likewise defined for a variety of scenarios, such as fan failure, for which no limit is placed on the noise generated. The speed of all remaining functioning boards is increased to level 15 to protect the boards, and it is possible, if necessary, to perform a controlled system shutdown. During normal operation, fans run at level 5 or 6, corresponding to a 67 dB (A) noise level.



Air speed per slot during normal operation

### 3.3 Power Consumption - power supply to the boards

Because AdvancedTCA boards consume more power, the power supply units (PSUs) originally developed for first generation AdvancedTCA systems have reached their performance limits. For redundancy and security purposes, each system is now divided into four branches, each protected by a fuse. The  $-48V_{DC}$  supply had been secured via two redundant power entry modules (PEMs). To accommodate increased power requirements, however, fuses have been replaced by magnetic-hydraulic circuit breakers which can be loaded to their rated current. Increasing the number of branches to six from today's usual four makes it possible to keep the current per branch at 30 A.



Power Entry Module (PEM) with 4 (left) resp. 6 (right) power branches

### 3.4 The next generation of AdvancedTCA systems

The next generation of AdvancedTCA systems is now being developed to meet the growing transmission rate and cooling capacity demands of the telecommunications industry.



Increasing interest in the AdvancedTCA specification is also being shown by new user groups from sectors including general electronics (instrumentation and control systems), medical technology, defense and research. Potential users in nuclear research have meanwhile established a new working group at PICMG, the Physics Group (WG1), to create a specification for their particular requirements, full-size boards in the RTM area and boards requiring more than 400 W cooling capacity.

The AdvancedTCA Extension group has also been recently formed to represent the datacom industry and server manufacturers, whose cooling and up to 400 W per board power supply requirements are largely the same as those of WG1. This group's objectives additionally include uniformly sized front and RTM boards and two backplanes in one chassis.

#### **4. Shelf management**

The PICMG 3.0 specification (AdvancedTCA) represents the first open standard for electronics packaging systems that describes management functions in the chassis as a fixed component. Every aspect of this shelf management is described in detail on some 130 pages, with references made to further reference standards. In creating this specification particular focus has been placed on standardizing the most important functions necessary to assure the interoperability of the chassis components. The actual physical implementation is left, however, to the discretion of the chassis manufacturer or system integrator.

The most frequently encountered implementation is one in which the shelf manager is accommodated on a plug-in board inserted into a separate slot in the system. In another version the shelf manager is contained on the two hub boards. Since the hub boards act as the 'switchboard' of the system, this implementation is recommended.



Shelf manager with PPS ShMM module



## **5. Tests**

For all the components of a system to work smoothly together, it is vital to ensure they are matched to one another and tested under real operating conditions. This design is highly complex. In particular, communications and management within such a system are substantially more sophisticated than in, say, VMEbus or CompactPCI.

This complexity requires very close collaboration within the development team. From as early as the conception stage, new system parameters such as heat development are examined using special simulation software so any weak points or hotspots can be pinpointed and eliminated prior to the CAD design stage or prototype construction.

Prototypes must pass a wide range of design verification tests (DVTs). Before serial production begins, all system components are tested in an in-house development, EMC and heat dissipation laboratory under worst-case conditions. The results of this extensive testing help form a highly targeted course of action for the next development stage.

## **6. Summary**

Rapidly changing technological developments result in rapidly changing customer requirements. Companies must quickly recognize and respond to these trends to meet customers' needs. A further advantage is obtained by combining all development areas (mechanical construction, board design, electronics development), manufacturing and component integration into a single location. Having a worldwide sales network with local product specialists completes this overall competence.

## **7. Company portrait and notes on the authors**

Schroff ([www.schroff.biz](http://www.schroff.biz)) is a leading developer and manufacturer of Schroff brand packaging systems for electronics, automation, IT and communications technologies. The company's standard products range from cabinets, enclosures and subracks through power supply solutions and backplanes to microcomputer assembly systems. Schroff's comprehensive product integration service provides complete plug-and-play systems for 19" technology.

Pentair Technical Products, a Pentair global business unit, is the leading provider of worldwide product and service solutions for enclosing, protecting and cooling electrical and electronic systems. Its industry-leading brands — Hoffman®, Schroff®, McLean® Cooling Technology, Calmark®, Birtcher®, Aspen Motion Technologies™ and Taunus™ — provide a broad variety of standard, modified and engineered solutions to the commercial, communications, energy, general electronics, industrial, infrastructure, medical, and security and defense markets.

Oliver Kistner, Dipl.-Ing., studied telecommunications at Fachhochschule Wiesbaden, Germany. In 1992 he began working for Schroff / Technical Products, Straubenhardt, as a development engineer for power supply systems and today is principal engineer for power electronics, responsible for developing sub-assemblies in the areas of PSUs, AdvancedTCA power entry and fan electronics.

Andreas Lenkisch, Dipl.-Ing., is principal engineer for backplanes at Schroff / Technical Products, Straubenhardt. He has been active for over 20 years in the initial and subsequent development of backplanes. His special interests include questions of signal and power integrity in high-speed designs. Andreas Lenkisch has submitted a number of patents and is a member of various standards committees including VITA, PICMG and IEEE802.3.

Dietmar Mann, Dipl.-Ing., studied mechatronics at Fachhochschule Karlsruhe. He has worked for Schroff GmbH, Straubenhardt since 1995 in various positions, including three years as a technical coordinator at a Japanese subsidiary. Today he works at Schroff in Straubenhardt as principal engineer for system development in the area of system management.

Martin Traut, Dipl. Wirt. Ing., studied industrial engineering at Fachhochschule Karlsruhe. Since 1990, he has been product manager for various Schroff products. In 2004 he became product manager for the Integrated Systems division (CompactPCI, VME, AdvancedTCA) and has subsequently exerted considerable influence on the design of the integrated systems product platform.