Can MicroTCA® Replace 3U CompactPCI® for Industrial Applications?

Chris Eckert, Chief Technologist
SBS Technologies
05.16.2006

Introduction

When the MicroTCA® specification is published, it will create a very interesting potential migration path from 3U CompactPCI® to MicroTCA for industrial users. Physically, a standard MicroTCA chassis has a low profile which appears similar to a 3U cPCI card rack, and for space-constrained industrial applications, this is an appealing feature. There are, however, very definite differences between the two technologies, and based on these differences it looks as though MicroTCA will find a place in applications with higher traffic capacities, engineered interconnect, and more controlled environments, while 3U CompactPCI will continue to serve applications with lower traffic needs which must survive in harsh and/or mobile environments.

Parameters of Comparison

As with any platform evolution, the idea of migrating to new infrastructure requires a detailed scrutiny of key system parameters. A comparison of the 3U CompactPCI and AdvancedMC™ and MicroTCA technologies based on the parameters below should produce some rules-of-thumb when evaluating a low-profile system controller application:

- Differences in the plug-in unit form factor geometries;
- Maximum power and thermal load characteristics for the plug-in units;
- System management and hot-swap resources on the plug-in units;
- System interconnect architectures and associated failure modes in the host system;
- Host system mechanical packaging and backplane connector attributes; and
- Local front and rear I/O resources for the plug-in units.

Plug-In Unit Form Factor Geometry

The 3U CompactPCI assembly conforms to the IEEE 1101 Eurocard form factor, with a PCB outline of 100 mm x 160 mm. The IEEE specification document family includes specifications for both air-cooled and conduction-cooled assemblies built around the PCB. The majority of 3U CompactPCI assemblies (including the CV-1 single board computer pictured below) are single slot assemblies with a height of 20.48 mm (4 HP). The 3U assembly is capable of hosting an IEEE 1386/.1 PMC assembly or VITA 42 XMC assembly as a daughtercard to provide additional hardware functionality if sufficient board space and/or thermal relief resources are available.

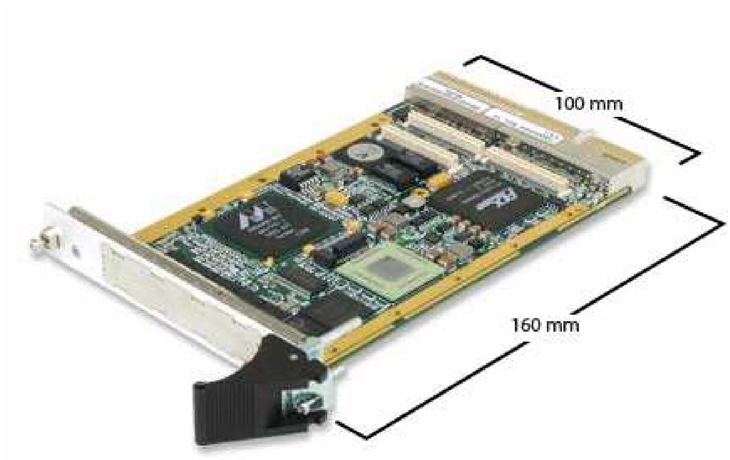

Fig. 1: 3U CompactPCI® plug-in unit

The AdvancedMC assembly form factor is documented in the PICMG® AMC.0 specification. Multiple form factors are documented; the common single-wide form factor and has a PCB outline of 73.5 mm x 180.6 mm. The AMC.0 specification defines three assembly options: a half-height assembly with a 13.88 mm high front panel, and two full-height assemblies, each with a 28.95 mm front panel. Processor AdvancedMC (PrAMC) modules (such as the ASLP10 pictured below) tend to require the full-height assemblies in order to provide sufficient thermal relief for the processor and support components on the AdvancedMC, while I/O AdvancedMCs tend to be well suited for half-height assemblies. The AdvancedMC form factor does not include a definition for a mezzanine or daughter card subassembly; further, the PCB geometry does not accommodate an IEEE 1386/.1 PMC assembly.

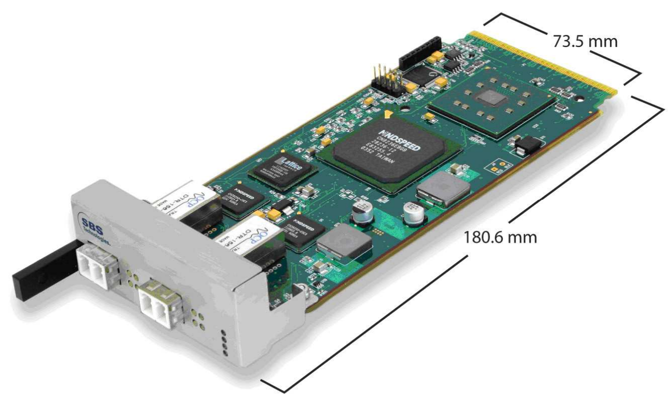

Fig. 2: AdvancedMC™ plug-in unit

Power and Thermal Load Characteristics

The backplane connector for the 3U CompactPCI assembly includes eight 5V power rail contacts and five 3.3V power rail contacts, allowing the plug-in unit to draw an aggregate current load of 50 – 60 W from a chassis power supply. Standard 3U air-cooled and conduction-cooled rack thermal relief resources are typically capable of removing 25 – 30 W of heat from each 4HP (20.48 mm wide) slot in the chassis. Some additional design effort is required on complex 3U CompactPCI assemblies (such as theCV-1 pictured above) to ensure that sufficient thermal evacuation capacity is provided on the assembly to minimize thermal resistance paths in order to permit operation at elevated ambient temperatures (+85C is a common requirement) without destroying operating silicon.

The backplane or carrier connector on the AdvancedMC assembly includes seven +12V power rail contacts and one 3.3V power rail contact, allowing the AdvancedMC to draw an aggregate current load in excess of 80W. However, typical system applications limit the standard single-wide, full height assembly used for PrAMCs to a thermal load of 40W, which is controlled by the chassis system management infrastructure. As with 3U CompactPCI assemblies, thermal relief design for an AdvancedMC module has a primary goal of minimizing thermal resistance between complex (and hot) silicon and elevated ambient temperatures. AdvancedMC applications have typically required operation to +55C in a protected environment such as a data center or switching system, although applications in environments with more extreme temperatures have been proposed.

System Management and Hot-Swap

Hot swap resources are defined for 3U CompactPCI boards, as well as 6U CompactPCI boards, in the PICMG 2.1 specification. However, many 3U CompactPCI chassis products do not provide hot-swap functionality as they are utilized in industrial control or flight computer applications where a power cycle of all cards in the chassis to insert or extract a plug-in unit is acceptable. 3U CompactPCI chassis and board products generally do not implement I2C serial bus wiring or IPMI functionality, as defined in the PICMG 2.9 specification, as the host systems that utilize them are generally closely attended by service personnel while in operation.

The AdvancedMC module contains both hot-swap and IPMI messaging resources, as the module was originally defined to be an element of an ATCA chassis. The hot-swap and IPMI messaging functions are typically implemented using an small microcontroller and associated interface circuit, powered by a 3.3V rail independent of the rest of the circuits on the AdvancedMC. The microcontroller implements system management resources defined in the AMC.0 specification, including power sequencing, hardware resource authentication, and E-keying, which permits a system controller to validate and configure the various serial link interfaces on the AdvancedMC before enabling their operation.

Interconnect Architectures and Failure Modes

The 3U CompactPCI chassis and plug-in unit is built around a PCI bus in the chassis backplane. The backplane bus may be configured as a 32 bit bus (approximately 60 wires total in the backplane) or as a 64 bit bus (approximately 100 wires in the backplane). The chassis contains a system controller and from one to seven peripheral plug-in units. All plug-in units on the bus share access through a request / grant arbitration scheme managed by the system controller. Newer 3U CompactPCI plug-in units (such as the CV-1) may also provide two Gigabit Ethernet ports on general purpose I/O pins in the backplane. While there is no standard backplane wiring or pin configuration definition for 3U CompactPCI cards analogous to the Gigabit Ethernet port definitions for 6U CompactPCI plug-in units defined in PICMG 2.16, a number of system integrators have developed backplane architectures to utilize Gigabit Ethernet ports on 3U

CompactPCI plug-in units to create a fully redundant Ethernet serial fabric as an overlay to the CompactPCI bus for applications requiring direct card-to-card data transfers that exceed the capability of the shared PCI bus.

The AdvancedMC module contains multiple high-speed serial link interface ports to the backplane or carrier. In a typical MicroTCA chassis, an AdvancedMC module will have access to a redundant pair of “fat-pipe” high-speed serial links, utilizing Ethernet, PCI Express®, or SRIO protocols in x1 to x4 lane configurations with each lane capable of operating with a line rate up to 3.125 Gb/s. In addition to these high-capacity links, the AdvancedMC module provides a redundant pair of dedicated Gigabit Ethernet ports and a redundant pair of serial interface ports to mass memory storage devices utilizing S-ATA, SAS, or Fibre Channel protocols. Further, the AdvancedMC is capable of receiving multiple reference clocks to synchronize PCI Express links and/or telecomm traffic. Each of these serial ports includes resources to permit the AdvancedMC to allocate traffic capacity or engineer bandwidth for specific traffic flows, applications, or destination modules. While the MicroTCA specification is still under development, it is currently anticipated that a standard configuration of a MicroTCA chassis will support 12 AdvancedMC modules in addition to a common assembly with serial fabric switch(es), a system controller, and one or more bulk power converters.

Host System Mechanical Packaging and Backplane Connectors

The 3U CompactPCI subrack and chassis assemblies are defined in the suite of IEEE 1101 specification documents. Two assembly definitions are provided: an air-cooled assembly capable of meeting the environment specifications of VITA 47 environment classes EAC1 – EAC6; and a conduction-cooled assembly capable of meeting the environment specifications for harsh and extreme conditions defined in the MIL-810F specification as well as the environment specifications of VITA 47 environment classes ECC1 – ECC4. The 3U CompactPCI assembly meets these requirements in large part through use of a set of gas-tight IEC 60603 connectors, whose ability to meet these stringent requirements have been demonstrated over the years.

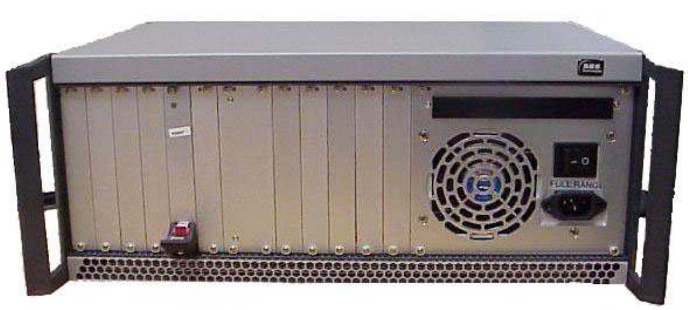

Fig. 3: 3U CompactPCI Rackmount chassis

The MicroTCA specification is still being drafted by a technical committee within the PICMG standards organization, and as such, environment characteristics have not yet been published. However, early speculation holds that the MicroTCA specification will include a standard rack-mount chassis as well as a variety of assemblies that provide a variety of options for packaging and organizing the AdvancedMCs. The MicroTCA assembly is expected to be deployed in air-cooled system environments with controlled temperature and humidity. It is not expected to be directly deployed in harsh or extreme environments as the AdvancedMC module uses gold fingers on a PCB edge to connect to the backplane.

Fig. 4: MictoTCA chassis prototype (prior to specification approval)

Local Front and Rear I/O Resources

An air-cooled single-slot 3U CompactPCI plug-in unit contains a front panel with a surface area approximately 100 mm X 20.48mm. The front panel may include a latch, identification markings, status LEDs, and one or more interface connectors for local cable attachment. The number of LEDs and connectors is defined by the size of the connector(s), product requirements, and available front panel surface area. A conduction-cooled 3U CompactPCI plug-in unit does not contain a front panel and hence does not provide front access cabling. A 3U CompactPCI plug-in unit may be provisioned with a rear transition module, whose form factor is defined by a specification document in the IEEE 1101 suite of documents. As with the front panel on the 3U CompactPCI plug in unit, the rear transition module may contain any number of cable connectors and status LEDs, limited only by the available surface area on the rear transition module PCB and/or faceplate.

A full-height AdvancedMC module contains a front panel with a surface area approximately 28.95 mm x 73.5 mm. The AMC.0 specification provides requirements for an ejector handle and status LEDs, and the assembly may utilize the remaining available surface area for front access cable connectors. The current AMC.0 specification defines a set of contacts for general purpose rear I/O cabling; however, there are no current definitions in the ATCA specification for standard rear access connectors or rear transition modules. As the MicroTCA specification has not yet been published, it is currently unclear whether or not a MicroTCA assembly will have a defined rear transition module for the AdvancedMC.

Summary

Both the 3U CompactPCI chassis and anticipated chassis products conforming to the forthcoming MicroTCA specification provide a system integrator with an environment for low-profile plug-in units each capable of hosting a sophisticated embedded processor node or multiple I/O interface circuits. The selection of a 3U CompactPCI chassis or a MicroTCA chassis will be determined by a number of system architecture and end application characteristics, including operating environment definitions (temperature range, mechanical shock/vibration characteristics, and the like), data traffic characteristics and anticipated flow requirements, system management and hot-swap requirements, and general form factor constraints. The two form factors offer similar power/thermal load characteristics and can accommodate similar types of circuits. For example, SBS Technologies® offers high-capacity embedded Intel Intel® Pentium® M and G4 PowerPC® processing nodes in both 3U CompactPCI and PrAMC products.

In general, the 3U CompactPCI chassis and plug-in units will continue to be appropriate for applications with the following characteristics:

- extended temperature, contaminated atmosphere, and/or other harsh or uncontrolled environment deployments as defined in MIL-810F;
- applications where the host system is mobile, such as a military vehicle, airplane, or space craft;
- applications requiring relatively low data transfer rates among plug-in units (on the order of 1 Gb/s or less per plug-in unit); and/or
- applications where the host system is capable of being placed in an inactive operating state in order to service a plug-in unit in the chassis.

In general, the MicroTCA chassis and plug-in AdvancedMC modules will become appropriate candidates for applications comprising the following characteristics, once the MicroTCA specification is published:

- controlled or semi-controlled environment deployment, particularly deployment in systems in ground benign and ground controlled applications;
- applications requiring high data transfer rates on one or more interface port at the AdvancedMC (eg. greater than 1 - 2 Gb/s per port), applications requiring detailed

traffic engineering definitions for data flow assignments among plug-in units in the chassis, and/or applications requiring multiple physical switch fabrics to physically separate application data traffic from internal system management traffic;

- applications requiring hot-swap power sequencing and/or intelligent system management supervision and control of plug-in unit resources; and/or
- applications requiring high system availability characteristics, including the ability to service a plug-in unit without disrupting the overall application running on the host chassis through deployment of redundant interconnect resources among plug-in units.

References

For additional technical definition, please consult the following specifications:

ANSI / VITA 47-2005, American National Standard for Environments, Design and Construction, Safety, and Quality of Plug-In Units Standard.

IEEE 1101.1-1998, IEEE Standard for Mechanical Core Specifications for MicroComputers Using IEC 60603-2 Connectors.

IEEE 1101.2-1998, IEEE Standard for Mechanical Core Specifications for Conduction-Cooled Eurocards.

IEEE 1101.2-1992, IEEE Standard for Mechanical Core Specifications for Conduction-Cooled Eurocards.

IEEE 1101.11-1998, IEEE Standard for Mechanical Rear Plug-In Units for Microcomputers Using IEEE 1101.1 and IEEE 1101.10 Equipment Practice.

MIL-STD-810F, Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, January 2000.

PICMG 2.0 R3.0, CompactPCI Specification, October 1999.

PICMG 2.1 R2.0, Hot Swap Specification, January 2001.

PICMG 2.9 R1.0, System Management Specification, February 2000.

PICMG AMC.0 R1.0, Advanced Mezzanine Card Base Specification, December 2004.

PICMG MicroTCA, *to be published*

SBS Technologies, Inc., 7401 Snaproll NE, Albuquerque, NM 87109