White Paper

Ruggedized MicroTCA* and AdvancedMC* for Net-Centric Military Applications

Industry Perspective: Ruggedized MicroTCA* and AdvancedMC* for Military Applications

Introduction

The PCI Industrial Computer Manufacturers Group (PICMG) ratified the specification for Micro Telecommunication Computing Architecture (MicroTCA*) in July 2006. Incorporating the Advanced Mezzanine Card* (AMC) module standard, MicroTCA has been adopted by a growing ecosystem of suppliers to the telecommunications industry, as well as vendors serving industrial, medical, military, aerospace and homeland security market segments for embedded computing and communications.

The MicroTCA standard represents the evolution of PICMG's AdvancedTCA* standard for telecommunications. It is designed to meet system-level requirements for reduced size, weight and power (SWAP), in addition to higher levels of compute performance/watt/square inch in communications and computing devices. MicroTCA provides vendors who serve the Department of Defense (DoD) with a framework for the development of validated network-centric platforms for small, highly cost-effective network devices the next generation of network-centric battlefield systems.

The PICMG Subcommittee on Ruggedized MicroTCA is the working group of ecosystem vendors responsible for developing detailed specifications for extended temperature operation, shock/vibration and other characteristics applicable to harsh environments, such as industrial and military applications. Several vendors have proceeded with proof of concept designs in advance of these specification efforts. This paper provides an overview of the status of ruggedized MicroTCA from the perspective of BAE Systems, Emerson Network Power, Hybricon and Schroff Ltd. based on informal surveys conducted by Intel.

Table of Contents

Demanding Environment: WIN-T and JTRS 3
BAE Systems 3
MicroTCA-Based WIN-T JC4ISR Radio 3
Shock and Vibration Testing by BAE 3
Conduction Cooling 4
Emerson Network Power 6
Hybricon 6
Changing the Industry Perspective 7
Conclusion 7
Sidebar: Schroff Ltd. *7*

Demanding Environment: WIN-T and JTRS

A core component of the U.S. Army's Future Combat Systems (FCS) program is the effort to provide enhanced voice and data communications between battalion-level commands through every element down to the individual foot soldier. Essential to this effort is the Joint Tactical Radio System (JTRS) program, also known as software-defined radio, in which a single radio will be capable of performing multiple functions and supporting multiple waveforms. JTRS will enable force elements to share voice, data, and video communications through the Warfighter Information Network-Tactical (WIN-T). The objective of the network is to improve situational awareness through a network that provides the mobility, flexibility and ruggedness needed to meet a wide variety of battlefield conditions.

BAE Systems

As a leading system integrator for prime contractors serving the needs of the military, aerospace industry and government agencies, BAE Systems has a long track record of experience with single board computers (SBC) based on 6U and 3U VMEbus and CompactPCI standards. BAE is now looking at the AMC card standard as the next-generation form factor based on enhanced I/O, power dissipation characteristics and the ultimate cost effectiveness of high-volume manufacturing of COTS products.

BAE considers AMC to be the modern telecommunications industry equivalent of the Eurocard standard and believes that the AMC form factor is ready for wide acceptance across multiple market segments. Beyond telecom applications, BAE believes AMC will be adopted for products in the military and government sectors, where it will ultimately provide volume-based economies of scale. BAE cites the fact that the MicroTCA/AMC ecosystem has already developed. With over a dozen vendors using the AMC form factor with Intel® architecture, BAE believes AMC connectors and cards will provide COTS advantages including cost, volumes and upgradeability to software-defined radios.

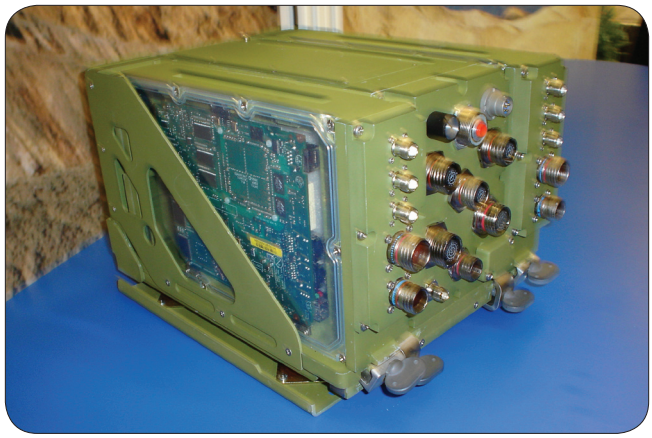

Figure 1. MicroTCA-Based WIN-T JC4ISR Radio.

MicroTCA-Based WIN-T JC4ISR Radio

BAE's WIN-T JC41SR radio proof of concept design is an important step toward the adoption of the MicroTCA and AMC form factors in military applications. JC41SR stands for Joint Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance. BAE has used the proof of concept to demonstrate the suitability of AMC for WIN-T radio applications by performing rigorous operating and non-operating vibration tests on commercially available AMC card edge connectors.

Shock and Vibration Testing by BAE

BAE's goal is to use standard off-the-shelf AMC cards, attached to the chassis with standard screw holes. Ruggedness is essential for the connector to survive in the battlefield environment. Shaker table X and Y-axis vibration tests conducted by BAE were intended to evaluate the possibility that card edge connectors could abrade and lose connectivity under certain vibration conditions.

To evaluate the suitability of AMC for battlefield applications, BAE tested AMC cards to the levels defined in JC4ISR Radio B1 Specification v3.3. The purpose of these vibration tests was to demonstrate the suitability of the AMC connector for use in the WIN-T Radio when subjected to induced levels derived from the worst-case vibration (operating and non-operating) encountered during its lifetime.

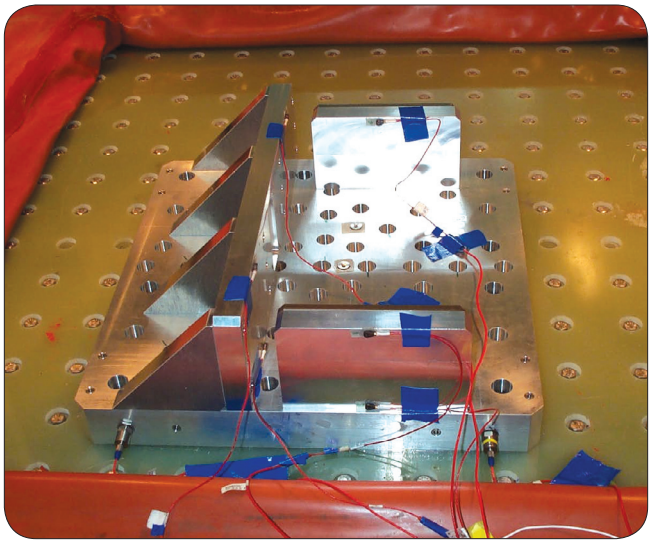

Figure 2. Test fixture for BAE Systems Operational X-Axis Vibration Test (Source: BAE Systems, advanced mezzanine card connector vibration test report for WIN-T JC4ISR radio, 2007).

Tests included worst-case vibration tests, both operating and non-operating, on the AMC connector used in the WIN-T Radio application. The tests were performed with the AMC connector mounted to a fixture. Vibration levels to the fixture were adjusted to simulate the worst-case induced levels that the connector encounters when mounted inside the radio chassis. BAE also conducted accelerated lifetime testing, in which the amplitude of typical vibration is amplified by several orders of magnitude.

The interconnect board and AMC card were mounted to the test fixture as shown in Figure 2. Electrical function was verified, and vibration induced on a shaker table was measured by accelerometers, monitored and recorded. The failure criterion was the first discontinuity of one nanosecond or greater. Test duration for worst-case operational test was two hours per axis, and the duration for the road vibration test was 96 hours per axis.

Operational Vibration Test Results

As seen in Figure 3 (as shown on the next page), on both the X and Y axes:

- There were no discontinuities during the 2-hour test.
- There was no visible wear to the pads on the card.
- There was no visible wear to the contacts on the interconnect board.

Road Vibration Test Results

As seen in Figure 4 (as shown on the next page), on both the X and Y axes:

- There were no discontinuities during the 96-hour test.
- There was no visible wear to the pads on the card.
- There was no visible wear to the contacts on the interconnect board.

Although the AMC cards were not initially specified to deal with increased vibration, they passed the tests with no discontinuities or visible wear to pads on the cards or contacts on the interconnect board. BAE reports that no modifications to the AMC card or its connectors were necessary. After multiple hours of vibration testing there was no loss of contact. Test results demonstrated that contacts did not abrade after testing to the equivalent of 25-year lifecycle.

In addition to meeting all the worst-case vibration specifications:

- The AMC connector withstood severe vibration conditions with no failures or disconnections during testing.
- The AMC cards enabled maximum circuit card assembly surface area in the radio's LRU form factor.
- During shock testing, COTS devices must withstand 20G and 40G testing, which is equivalent to telecom standards.

Conduction Cooling

Airflow cooling is standard in the telecom environment, with a heat sink on the card. In the dusty and dirty battlefield environment, air flow cooling through the chassis is not a viable solution, so BAE provides a custom conduction cooling solution. Keep-outs on a conduction card need to accommodate guide rails, which reduces usable card real estate. BAE engineered a custom heat sink configuration for its AMC-based designs enabling the use of the full area of the card.

The use of building blocks based on the AMC form factor enables BAE to focus on system integration, putting new designs on an AMC card and then adding the card to a chassis to quickly demonstrate new capabilities. AMC provides and extendable form factor that enables the DoD to cost-effectively integrate functionality on the platform over its 20 to 25 year lifespan.

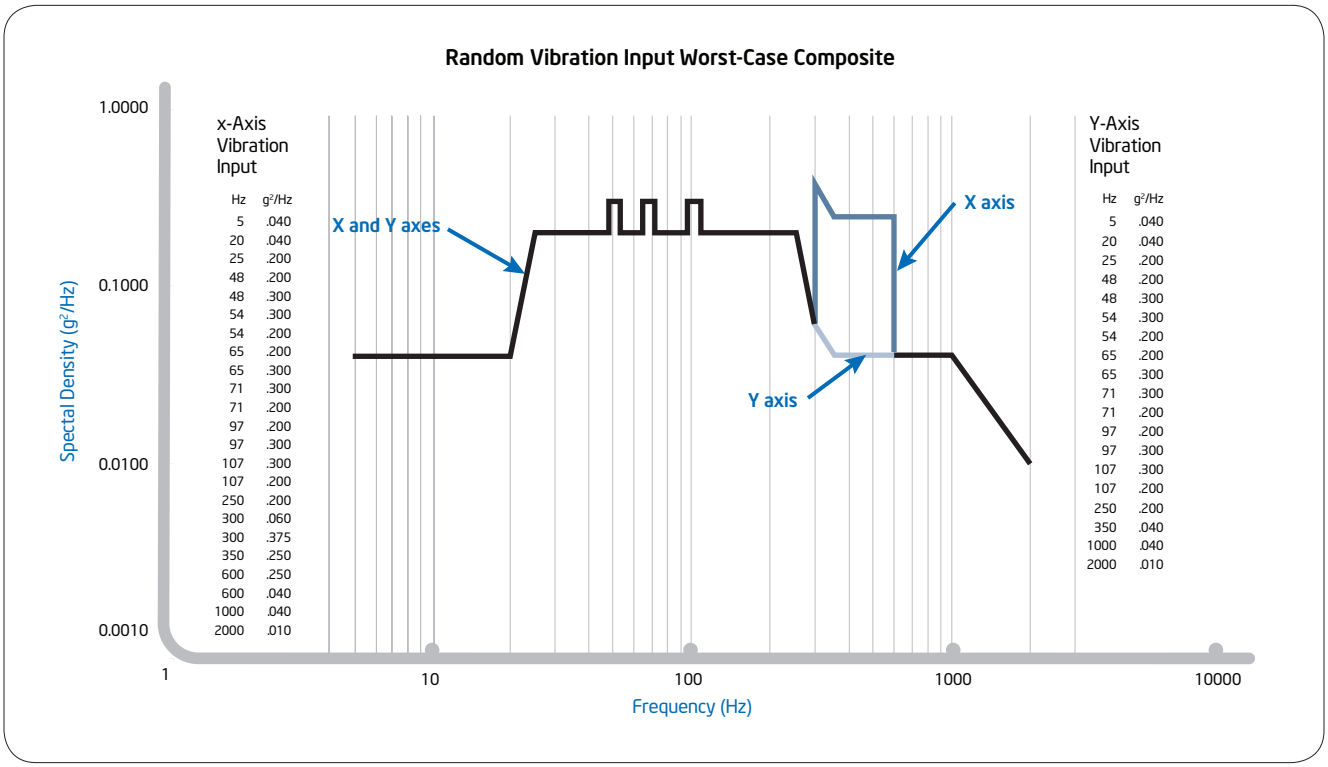

Figure 3. BAE Systems Worst-Case Operational Vibration Test (Source: BAE Systems, advanced mezzanine card connector vibration test report for WIN-T JC4ISR radio, 2007).

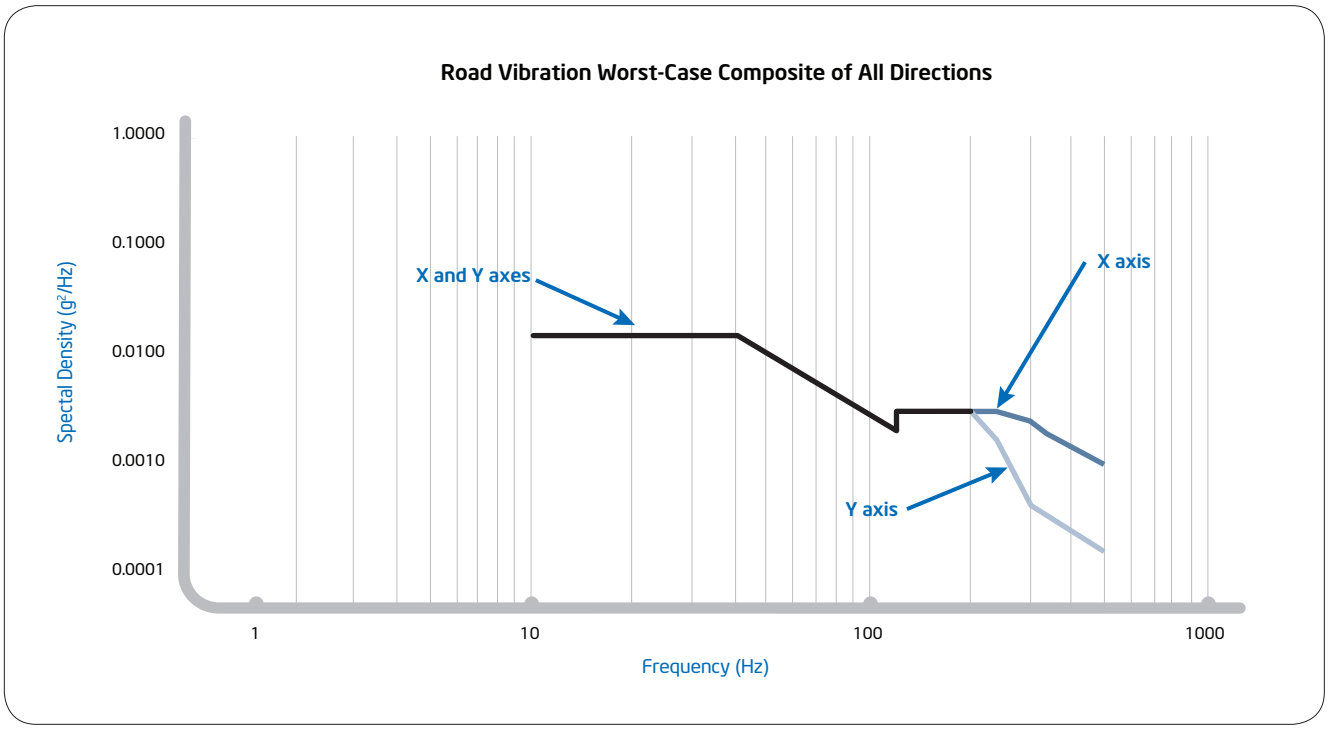

Figure 4. BAE Systems Worst-Case Road Vibration Test (Source: BAE Systems, advanced mezzanine card connector vibration test report for WIN-T JC4ISR radio, 2007).

Figure 5. Hybricon Ruggedized Air-Cooled MicroTCA ATR Chassis.

Emerson Network Power

While VME has been the standard for single-board computers in military applications, the Embedded Computing business of Emerson Network Power (formerly Motorola's Embedded Communications Computing group) reports that the need for additional high band-width communications, computational capability, graphics and I/O capability is driving new requirements at the system level. WIN-T integrated network topology is driving the need for more compute performance per watt at the system level, together with less size, weight and power (SWAP).

According to Emerson, the PICMG AdvancedTCA specification is beginning to drive the deployment of out-of-the-box network topology based on COTS ingredients. On the basis of this market evolution in the network space, the AdvancedMC and MicroTCA specifications were developed to meet the need for more perf-ormance/watt/square inch on a system level. These cost and performance developments allow MicroTCA the flexibility to fit many of the requirements of military, aerospace, homeland security and integrated medical applications.

The adaptation of network topology from the telecom industry will continue to drive volume and minimize infrastructure costs, making these benefits available to the DoD and its prime con-tractors. In addition to these advantages, MicroTCA enables manageability, the latest processor, fabric and platform-level technologies with volume cost efficiencies.

As the MicroTCA specification evolves, Emerson is now involved in filling the gaps, including the development of conduction cooling solutions for ruggedized devices. In cooperation with Intel and vendors of connectors and power supplies, Emerson is working with the PICMG Subcommittee on Ruggedized MicroTCA to dev-elop solutions for convection cooling, wedge locks and packaging ahead of specification development, without changes to the base specification. Emerson believes that military shock, vibration and thermal standards can be attained, without breaking the MicroTCA specification.

Prior to its acquisition by Emerson, Motorola's Embedded Communications Computing group worked with Hybricon Corporation in 2006 to develop the industry's first ruggedized MicroTCA air transport rack (ATR) chassis, accommodating single-width and double-width AMC modules. The proof of concept platform was designed to address the key gaps in the MicroTCA standard within the context of military applications.

Hybricon

Hybricon's Rugged Air Cooled MicroTCA ATR chassis was developed in close cooperation with Emerson Network Power's embedded computing business (formerly Motorola) and Intel. Designed to PICMG AMC and MicroTCA specifications, the design features locking bars to firmly retain the AMC cards into the card cage, providing signifi-cant additional resistance to shock and vibration. A shock-isolated MicroTCA card cage inside the ruggedized ATR chassis attenuates shock and vibration experienced by the cards and enables the chassis to meet stringent ANSI/VITA 47 and MIL-STD-810 shock and vibration requirements. The chassis is also designed to meet military EMI and power requirements that are required in these applications, and it is now being adopted for initial concept development and deployment of MicroTCA on mobile platforms.

In cooperation with Intel and Emerson, Hybricon continues to be actively involved in the PICMG Rugged MicroTCA Subcommittee to enable ruggedized air cooled and conduction cooled MicroTCA applications while maintaining compatibility with the base speci-fication, and continues to develop rugged MicroTCA packaging platforms and solutions.

Hybricon is a solutions-oriented company specializing in the devel-opment of ruggedized electro-mechanical enclosures for several markets. Many of these rugged solutions are sealed enclosures with conduction cooled cards; this is particularly important for many air and ground vehicle applications. Hybricon believes that rugged conduction cooled MicroTCA will be the key enabler to widespread deployment of MicroTCA in mobile applications.

Changing the Industry Perspective

In addition, the use of COTS building blocks based on MicroTCA can change the way the industry looks at nodes in the network, allowing prime defense contractors to add specific applications to AMC cards and assemble systems for test while dramatically shortening development cycle.

Reliance on pre-validated, ruggedized systems can remove substantial development overhead at the front end, the most expensive part of any development effort. Emerson sees ecosystem momentum building as large network-centric development programs begin to move to MicroTCA.

Conclusion

MicroTCA is poised to provide the industry with benefits of commercial off-the-shelf (COTS) technology at the system level that the VMEbus standard provided at the single board computer level when it was introduced more than 25 years ago. Spiral technology insertion in military systems with 20-25 year lifecycles will benefit from the standards-based, out-of-the-box network topology and accelerated development cycle enabled by MicroTCA.

Prime contractors serving the DoD will be able to meet evolving requirements by basing specialized applications on a consistent, validated and scalable system architecture that is available out of the box. The adoption of MicroTCA not only provides faster development, it helps contractors eliminate some of the most costly steps at the front-end of the development process. The ability to serve multiple applications will take on added importance as MicroTCA becomes pervasive, when you take into account the ultimate cost-benefits of volume manufacturing.

Extensive shock and vibration testing, in concert with conduction cooling solutions from leading vendors, continues to demonstrate the suitability of COTS MicroTCA and AMC building blocks for ruggedized military communications and computing applications, including WIN-T.

Schroff Ltd.

Schroff Ltd. is a supplier of mechanical components based on the MicroTCA specification including subracks, backplanes and shelf/chassis assemblies. Schroff plays a key role on testing faceplates and ejectors to provide guidance to the PICMG Subcommittee on Ruggedized MicroTCA. The Schroff design program includes affixing AMC cards to custom cooling plates, similar to custom cooled versions of VME and CompactPCI cards, as part of ongoing ruggedization standards development through the PICMG subcommittee.

Evaluations conducted by Schroff include shock and vibration testing of MicroTCA-based proof-of-concept designs in concert with other vendors and development of best practices for securing AMC cards with wedge locks to withstand severe shock and vibration. Preliminary thermal analysis jointly conducted with Intel has shown positive results for conduction cooled AMC solutions.

Schroff is involved in development of sealed products for industrial and military applications, many of which will need be conductively cooled, and reports it is devoting significant engineering resources to MicroTCA-based product development.

The company views WiMAX base stations as a significant driver for the adoption of MicroTCA devices in volumes which will offer significant economies of scale. The modular architecture of MicroTCA will enable vendors to rapidly build systems for validation. Similar to other vendors surveyed by Intel, Schroff also reports a high degree of customer interest in MicroTCA, as companies begin to port their solutions from proprietary technologies to the standard.

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