ADVANCEDTCA/MICROTCA FOR MILITARY APPLICATIONS

MicroTCA matures to meet rugged requirements at sub-VPX price point

By Brandon Lewis, Associate Editor

Despite early skepticism from the defense electronics community, the MicroTCA (µTCA) standard, which spawned from the telecommunications industry, is gaining fans among military system designers due to its rugged nature and low price point – especially when compared to VPX.

Engineers upgrading platforms such as the U.S. Army Bradley Fighting Vehicle like the combination of ruggedization and low cost associated with MicroTCA technology. Photo courtesy BAE Systems.

Budget cuts and the drive toward commonality often represent opportunities for designers of Commercial Off-The-Shelf (COTS) electronics that advance a Modular Open Systems Approach (MOSA) to defense spending and acquisition. As a result, suppliers of low-price point products based on standards that evolved from the high-volume telecommunications (telecom) industry – such as AdvancedTCA (ATCA) and its smaller form factor companion MicroTCA (µTCA) – are winning more contracts every year.

Aside from cost, these products also need to meet military specifications, and rugged variants of the µTCA specification now meet or exceed the shock, vibration, and thermal qualifications of VPX platforms, doing so at roughly half the cost. Telecom applications often have similar ruggedization requirements to military applications, and that industry's economies of scale enable platforms like µTCA to realize deeper price reductions than traditional military COTS technology. Defense primes such as BAE Systems in Arlington, VA, are now collaborating with industry to drive rugged versions of µTCA into the military marketplace.

"Several military programs will soon be leaving their present architecture and moving over to µTCA," says Mark Leibowitz, Chief Systems Engineer, Mission Computing, BAE Systems (www.baesystems.com). "If we compare µTCA to VPX, which happens to be the competing standard, they are very similar. However, in this economy, where contracts are dwindling and competition is fierce, cost is the driving factor. Using µTCA offers a cost benefit of approximately 50 percent over a VPX solution. In the µTCA world, the target platform drives cost, not a specific program. With AdvancedMC (AMC) modules for telecom as their target, µTCA vendors look at what is needed and build the product. They can then adapt that product to a µTCA.2 or .3 solution by virtue of putting a clamshell on the module. Remember, they are developing that AMC for clientele looking at large-scale quantities supported by a larger ecosystem. VPX solutions target a specific program and design a product by contract.

"Multiple companies that are designing AMCs will look at what the telecom industry needs and lay out a roadmap that includes processor modules, µTCA Carrier Hubs (MCHs), 10 GbE/40 GbE switches, and so on," he continues. "In developing that product, they are targeting a price that is not driven by a military program. VPX, on the other hand, comes from the VME world, with modules priced at different economies of scale. Once [VPX vendors] add Hardware Platform Management (HPM) the price goes up even higher, even though VPX platforms have basically leveraged design details from the µTCA infrastructure in that regard (see sidebar on page 42)."

MicroTCA meets VITA 47 and innovates on thermal dissipation

To date, critics of µTCA in military applications have charged that the specification family does not provide the shock, vibration, and thermal benchmarks necessary for harsh environments. In response, the µTCA.2/.3 specifications were engineered to rugged requirements and incorporate unique cooling concepts to realize gains in heat dissipation.

Environmental Category and Range		µTCA.2 (Hybrid Air/ Conduction Cooled)	µTCA.3 (Conduction Cooled)
Operating Temperature	–5 °C to +55 °C	MIL-FC1	TEL-1
	–40 °C to +55 °C	MIL-FC2	MIL-CC2
	–40 °C to +70 °C	MIL-FC3	MIL-CC3
	–40 °C to +85 °C	MIL-FC4	TEL-2, MIL-CC4
Non-Operating Temperature	–40 °C to +70 °C		TEL-1
	–40 °C to +85 °C	MIL-FC1, MIL-FC2	MIL-CC2
	–45 °C to +85 °C		TEL-2
	–50 °C to +100 °C	MIL-FC3	MIL-CC3
	–55 °C to +105 °C	MIL-FC4	MIL-CC4
Operating Vibration	1 G (Sine)		TEL-1
	8 G (Random)		TEL-2
	12 G (Random)	(All Classes)	MIL-CC2, MIL-CC3, MIL-CC4
Operating Shock	15 G		TEL-1
	25 G		TEL-2
	40 G/11 ms	(All Classes)	MIL-CC2, MIL-CC3, MIL-CC4
Altitude	–460 m to 18300 m	(All Classes)	(All Classes)

Table 1 | MicroTCA.2 (µTCA.2) and µTCA.3 modules are able to realize ruggedization levels that meet or exceed MIL-SPEC requirements.

Figure 1 | Pictured are a µTCA.2 module (left) and system (right). In a µTCA.2 solution, when a module is inserted into the chassis its wedgelocks facilitate thermal dissipation through hybrid air/conduction cooling. Photos courtesy of WaveTherm Corporation in Morrisville, NC.

"As far as thermals, shock, and temperature range, µTCA.2 and .3 are modeled around VITA 47 (Table 1)," Leibowitz says. "We had an independent test lab conduct vibration and shock testing at levels beyond the extremes – about 10 percent higher than VITA 47 requirements – up to 50 Gs of shock. We had superb test results, and not only did we do military testing, we did telecom testing on top of that, like mixed-flow gas, a very stringent test that the military does not even test to." (*Editor's note: µTCA.2 Thermal and µTCA.3 Connector Test Reports by Contech Research are available in the resources section at www.picmg.org.)*

In order to achieve high levels of ruggedization, µTCA.3 employs rugged conduction-cooled modules that surpass MIL-STD-810 and RTCA/DO-160 environmental testing, Leibowitz continues. As the µTCA.3 specification was completed first, many of its mechanical features were inherited by µTCA.2, which was originally intended as an air-cooled-only module standard, he notes. However, wedgelock design innovations led to a hybrid cooling approach in µTCA.2 that yields thermal dissipation improvements of as much as 32 percent over standard conduction-cooled modules, Leibowitz explains.

"When the .2 specification originally kicked off, the charter was to develop a rugged air-cooled module," says Michael Borthwick, Chief Mechanical Engineer, Mission Computing, BAE Systems. "In initial discussions, what we wanted to really accomplish was to leverage a lot of the work that went into the .3 specification. For example, much of the testing done by independent test labs on the interconnect system for .3 also applied to .2.

"Early on we decided upon a .2 form factor that preserved the wedgelocks mounted on the edges of the module [from .3]. That approach evolved into a wedgelock that would allow air to pass through while still providing the mechanical retention needed to leverage those earlier test results," he explains. "From there, the committee members recognized that not only would we have air passing through the wedgelocks, but we would have an additional opportunity to conduct heat out through those wedgelocks and spread the heat load through the sidewall. That was the birth of the 'hybrid' concept and where the efficiencies can potentially be realized – not only do you have air flowing directly over the module and removing heat through convection, you also have air conducted from the clamshell into the wedgelock and into the chassis sidewall (Figure 1).

"The other thing we were looking to leverage besides the mechanical retention was a module that would permit Two-Level Maintenance (TLM)," Borthwick continues. "We conducted Electrostatic Discharge (ESD) testing for .3, and to accomplish TLM for .2 we retained the clamshell approach. After the charter evolved into the hybrid approach, we performed independent thermal testing to characterize the exact efficiencies we could achieve.

"The clamshell wraps around a standard AMC.0 board; any .0 board can be used in the clamshell," Borthwick says. "It's important to note that the same clamshell form factor is used for both μTCA.2 and μTCA.3, which – similar to VITA 47 – are module-level specifications. In terms of board pitch, the .2 and .3 rugged solutions share the standard AMC module sizes – Compact .6 mm, Mid-size .8 mm, and Full-size 1.2 mm – so you are able to maintain the standard pitch sizes for the module space in your backplane. So if you are developing a solution in the lab and you have X number of cards in an air-cooled bench-top development chassis and now want to leverage everything you did in a μTCA.0 chassis into your MIL system, the pitching remains the same."

"μTCA.0, .1, .2, .3, and .4 all have a fully defined architecture. When you develop a chassis today and deploy your system, you know that you can change that system later on without changing your backplane," Leibowitz says. "In a VPX solution, the implementation varies. Consider the detailed design of a VPX chassis. If you want to change it, you will basically have to go to a vendor and ask, 'Can you build me that same card?' This is because the pitches vary so much and various types of backplane connectors are not interchangeable from vendor to vendor. In the VPX world, functionality affects the solution, and because you can put just about anything on the pinout, the result is a very customized solution."

A legacy of platform management

A critical component of MicroTCA (μTCA) systems is platform management technology inherited from the AdvancedTCA (ATCA) architecture, says Mark Leibowitz, Chief Systems Engineer, BAE Systems in Greenlawn, NY. Platform management enables communication with all of the modules in a system to measure their health, including temperature, voltage, and network control, he continues. It also allows for remote firmware upgrades so that new images can be quickly loaded into multiple or inaccessible slot cards, Leibowitz adds.

"One key thing when you look at the origin of μTCA is that it derived from ATCA, which had an Intelligent Platform Management Interface (IPMI)," Leibowitz says. "As a part of the health management system, IPMI gives you a robust solution."

"The key is that it is inherent in the system," says Michael Borthwick, Chief Mechanical Engineer, Mission Computing, BAE Systems. "From the outset of the ATCA specification, many of the health management and features were built in from the bottom up. Now you see trends in VPX where they are trying to add some of those features. However, they are trying to integrate those features into the established specification, which presents some challenges."

"μTCA.2 and μTCA.3 add another level of platform management, which includes Field Replaceable Unit (FRU) information that gives you the ruggedization level of the module," Leibowitz says. "The MicroTCA Carrier Hub (MCH) reads each AdvancedMC (AMC) and logs the ruggedization level of the card against the ruggedization level defined for the chassis. It then tells the system integrator if they have the right module in there or if someone put in a lower grade module than the system is rated for."

Another advantage of the MCH is that it allows 1 Gigabit Ethernet (GbE), 10 GbE, or Serial RapidIO to be brought through copper or fiber optics to the μTCA backplane, which can support multiple fabrics simultaneously, Leibowitz continues. Whereas VPX allows for only one backplane fabric, this feature enables a different technology to be used for communications with the processor and I/O, easing implementation of distributed solutions, he adds.

COTS, interoperability drive down defense costs

As the Department of Defense (DoD) looks to extend the longevity of system designs through open architecture hardware platforms, interoperability has become a key tenet of subsystem acquisition. Because μTCA is defined at the module level, different variants can be achieved within a μTCA chassis by swapping out AMC cards and accompanying hardware. Combined with a non-military COTS price point, this ensures maximum value from deployed μTCA systems.

"μTCA.2 and μTCA.3 are interchangeable," Leibowitz says. "All you have to do is interchange μTCA.3's standard wedgelock and μTCA.2's open airflow wedgelock to interchange the modules. One of the things industry was asking for was the ability to move from a conduction-cooled module to an air-cooled solution. They can do that with the same clamshell design, which actually keeps the cost of the final solution down.

"Whether on large-scale platforms or the smaller UAV-type platforms, defense programs today are demanding MOSA for computer architecture designs," Leibowitz continues. "This allows the government to get the best bang for their dollar. Technology insertions over time become easier because there are no proprietary, sole-source items. A MOSA solution leverages more of the COTS market, which opens up the vendors able to support the technology needed for that architecture.

"Rugged μTCA systems are starting to be delivered – we are on the verge of seeing widespread use of the architecture, he adds. "It takes two to five years after new specifications are released before you start seeing products being deployed." **MES**