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MicroTCA Ruggedisation for Military Comms

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Introduction

MicroTCA and the Advanced Mezzanine Card (AMC) have proved successful building blocks for modular switched serial architecture solutions. Unsurprisingly, the cost and performance benefits found in commercial embedded systems are attractive to applications spaces with more rugged operating requirements.

To address this, PICMG developed the Rugged MicroTCA specification, MicroTCA.1, and Hardened MicroTCA specifications, MicroTCA.2 and MicroTCA.3. Even under these tougher environmental requirements, MicroTCA's SWaP-C (Size, Weight, Power, and Cost) remain advantageous when compared with alternative solutions.

But what are the challenges when modifying an existing air-cooled AMC design for a rugged application? This paper discusses the experiences of CommAgility's engineers when given just that challenge for a military communications project.

Standard AdvancedMC Product

CommAgility specialises in commercial off-the shelf (COTS) high-performance DSP plus FPGA cards comprising Texas Instruments C6678 multicore DSPs and Xilinx Virtex-7 FPGAs, for example the AMC-D24A4-RF4.

Our customer successfully used such a product in the lab for wireless communication baseband processing, and now wanted to take the project to the next stage with a rugged deployable air-cooled solution for field trials. Beginning development with a non-rugged COTS solution enables customers to minimise the capital costs at the start of projects, which typically comprises a feasibility study period or customer demonstration.

Having invested a great deal of time integrating the COTS card, it was then important when moving to a rugged solution that any architectural changes which affected interface functionality or software compatibility were minimised. Fortunately, the AMC form factor lends itself readily to ruggedization and we were happy to make a proposal that allowed this with minimal impact.

Rugged Specifications

The definition of ruggedization is very much application-specific. There are a number of guidelines available as reference material: for example the environmental specifications for airborne equipment are current contained within the US DoD Military Handbook "Electronic Equipment, Airborne, General Guidelines for", MIL-HDBK-5400 and general equipment in General Guidelines for Electronic Equipment Handbook MIL-HDBK-454A. However, these are guidebooks and not a set of requirements.

The PICMG MicroTCA.1 Air Cooled Rugged MicroTCA Specification was released in 2009. Its aim is to define a version of MicroTCA for use in rugged environments (specifically systems needing to meet more stringent levels of temperature, shock, vibration and humidity) that MicroTCA.0 solutions do not satisfy. It also calls upon base military specifications, including MILHDBK-454A, to define environmental operating temperatures.

This project also had to meet a unique blend of ruggedization requirements. The key environmental service requirements were vibration, shock, temperature and humidity with testing to US Military Standard MIL-STD-810 Revision G "Environmental Engineering Considerations and Laboratory Tests", referred to here as Methods. In addition, a conformal coating to MIL-I-46058C "Insulating Compound, Electrical" was required. This not only allows the card to meet the extended humidity specifications, but also to add electrical resistance.

How CommAgility addressed these challenges within a MicroTCA.1 platform is discussed below.

Shock and Vibration

The shock tests are defined in MIL-STD-810 Method 516.6, and there are eight different procedures defined, which use different ways to cause shock or impact. The tests determine the ability of a device to withstand general physical abuse while in operation.

Procedure IV (transit drop) is the most common referenced, however in this case only Procedure I Basic Design was required. This includes the "drop" test: 18 impact shocks of 15g comprising shocks in opposite directions along each perpendicular axis, with each shock impulse having a time duration of 11 milliseconds.

A review of the existing design resulted in no significant design modifications being required to achieve this level of ruggedization. Of more significance were the changes required to meet vibrational testing, in meeting these the AMC became more resilient to shock in any case.

Vibrational testing is more complex than shock testing and is described in Method 514.6. In this project, Procedure I was required, with an Annex C tailored Category requiring conformance to an acceleration of 5g over the frequency range 5Hz to 2000Hz with a displacement of 0.2".

The weak point of the AMC in this test is typically the backplane connector and latching handle. An essential modification is therefore to use the additional 'Module to Subrack Retention Device' specified in MicroTCA.1-XR2. The AMC is fitted with an extended faceplate having an attachment flange with retention screws. Once the AMC is inserted into the chassis and the latches locked, the retention screws fix the faceplate to the chassis without exerting force on the AMC backplane connector.

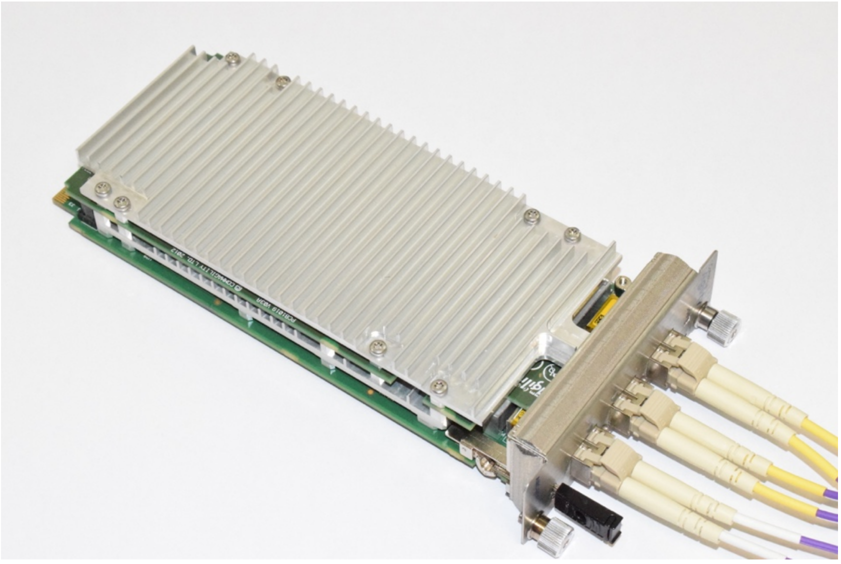

Figure 1: AMC fitted with Module to Subrack Retention Device

Our standard card used small form-factor pluggable (SFP+) optical transceiver modules for such tasks as CPRI and RapidIO connectivity. Concerns over the vibrational stability of SFP+ led us to replace these with fixed short form-factor (SFF) transceivers, which could also be sourced at industrial operating temperatures. Some re-working of the card’s heatsink and PCB for the change in mechanical size and footprint were required to accommodate this.

For the test procedure a vibration test fixture was specially built for the purpose characterising the AMC prior to chassis integration. The test fixture allowed the full functionality of an operational AMC to be verified during vibration and environmental tests, with a focus on backplane signal integrity.

Figure 2: Vibration test jig in the lab, prior to being sent for conformance testing

Operating and Storage Temperature

Operating and storage temperature are defined by two test methods: high temperature in Method 501.5 and low temperature in Method 502.5. These determine the safety, integrity and performance of equipment under the effects of extreme temperatures. The customer application required storage for -40ºC to +55ºC and operation between -20ºC and +55ºC. These requirements are exceeded by the MicroTCA.1-XT1L specification, which has a lower operating temperature requirement of -40ºC.

To ensure compliance, we first checked the bill of materials (BoM) datasheets against the storage and operation requirements of the customer. As a result, several components were upgraded to their industrial operating temperature equivalents, but no redesign was required. We conducted pre-compliance testing in our own environmental chamber to ensure full functionality before sending the equipment to an external test house.

Relative Humidity

Our requirement was required to support a maximum relative humidity (RH) of 95%, non-condensing, in accordance with Method 507.5 Procedure I. This procedure sees how well the equipment can survive in a warm, humid atmosphere during storage and transit, and during natural environmental cycles.

This exaggerated environmental test with exposure to continuous high humidity at cycling elevated temperatures, comprises three 24-hour cycles representing storage and transit conditions followed by three further cycles that replicate the natural cycles. Ideally, the customer should specify a RH and temperature appropriate to their operational environment, but it is more common to use one of the standard test profiles.

MicroTCA.0 has a RH specification of up to 85% RH under normal operation and 90% short term. MicroTCA.1 states that the specification will be application-dependent. After a design audit, and the addition of the conformal coating, we found that to meet the RH requirements no changes were required for the AMC. We ran the equipment through our own environmental chamber at the prescribed RH and temperature profile prior to formal certification at an external test house where the actual temperature cycling was also extended to 240 hours for an increased margin of confidence.

Conformal Coating

MIL-I-46058C, Insulating Compound (For Coating Printed Circuit Assemblies), is a material standard which ensures that a coating meets a specific list of performance metrics. Despite the specification being made inactive in 1998, it remains invaluable as the only conformal coating standard with a qualified product list. Conformal coatings are good practice where long-term exposure to high humidity can cause moisture ingress into electrical component packages where swelling and delamination lead to early life failures.

Compliance is not simply a case of applying a conformal coating: where, how, and when need to be determined. Firstly, a review of the BoM datasheets was required to identify which components had coating restrictions. This was followed by a PCB review to identify where electrical conductivity was required on the card, for example, the AMC edge connector. Having decided to apply the coating by spraying, this enabled us to create a card spray mask.

It was decided to apply the coating after factory acceptance test to ensure any testing or re-work was not hindered by the coating. A final test after applying the coating is made to ensure the coating process has not affected card performance.

Conclusion

The MicroTCA and AMC architecture is an easily ruggedized form factor and provides a versatile ecosystem for a wide range of applications. MicroTCA.1 makes ruggedization and compliance to military specifications a natural progression from MicroTCA.0, allowing low cost development in the lab to seamlessly move to field trial. With our in-depth knowledge of engineering for aggravated test environments, we have demonstrated that COTS AMCs can be ruggedized for field deployment in challenging military projects.

About CommAgility

CommAgility, a Wireless Telecom Group company, is an award-winning developer of embedded signal processing and RF modules, and LTE PHY/stack software, for 4G and 5G mobile network and related applications. CommAgility designs the latest DSP, FPGA and RF technologies into compact, powerful, and reliable products based on industry standard architectures. CommAgility's LTE software for mobile devices and wireless infrastructure includes physical layer and protocol stack for small cells, physical layer and protocol stack for terminals, an advanced scheduler for small cells, and IP development in the areas of advanced PHY algorithms in multi-core SDR platforms. See www.commagility.com

About the author

Paul Moakes PhD CEng MIET is Chief Technology Officer at CommAgility. He has previously held positions at Motorola and Blue Wave Systems. He is co-inventor of two patents in the field of MicroTCA and AdvancedMC. He holds a PhD in Electrical and Electronic Engineering from Sheffield University and a 1st Class Honours degree in Electronic Communications and Computer Systems Engineering from Bradford University.