Assured performance in extreme environments

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This article shows that delivering truly rugged solutions requires a focused strategy beginning with R&D and ending with robust products. Reliability in extreme environments means more than putting commercial motherboards into an upgraded enclosure; it demands a relentless pursuit of assured performance.

■ As the performance density of integrated circuits increases, every new generation of microprocessor gives embedded computer vendors the opportunity to address a wider range of applications. Many of those opportunities now exist in industries that demand more, not only in terms of processing performance but in the overall system specification. Unlike clock speed, memory bandwidth or communications interfaces, these requirements are not so easily documented on a data sheet. They concern how the system will behave in environments that are extremely hazardous to off-the-shelf computing platforms.

Electronic systems are generally susceptible to extremes in terms of temperature, humidity and vibration. It is relatively easy for a manufacturer to describe a computing platform as ruggedized if it has been housed in an enclosure that provides some protection to environmental conditions, but if that protection doesn't extend to every component within the system, the guarantee may be empty. Nobody invites failure but many industries cannot afford to take that kind of risk; a single component failure can take an entire mission-critical system offline and in many industries, that is simply not an option. Because of its inherent reliability, many industries now choose to specify rugged electronics. The high reliability requirements of the military, defense and aerospace industries may have led the way, but now other industries, such as drilling and mining, mass transit and medical as well as all automation industries, benefit from cost-effective and powerful ruggedized solutions for harsh shop floor, outdoor or in-vehicle applications.

But OEMs need to be careful. Although something may be marketed as designed for extreme environments, or ruggedized, further inspection often reveals components within the system that are not designed to be exposed to constant extremes in temperature, humidity or vibration. If that is the case, the entire system is compromised.

Thus, ruggedization isn't something that can be covered by only utilizing a rugged enclosure; it requires an approach to product design that takes nothing for granted. It must start with R&D that is focused on taking electronics systems to extremes. It demands component selection based on their suitability and not just their features. And it requires that at every step of the design and manufacturing processes, the rugged credentials are verified and validated. Only through this robust approach to product development can a manufacturer really deliver solutions that can be labeled as Extreme Rugged.

In order to deliver reliability at this level, a manufacturer needs to have complete faith in its products and processes; it must push its own limits beyond even the customer expectations. Only by doing this can a manufacturer have complete trust in its own products and ask the same from its customers. Of course, all manufacturers offering rugged computer platforms claim to test their products and comply with industry standards for high reliability, but without a demonstrable commitment to testing at every stage, with documented results that support a robust improvement process, testing remains largely subjective.

This commitment must even extend to customer support. Unlike many manufacturers, ADLINK is a leading embedded computing vendor that involves the customer at the earliest stages of product development, providing a custom service that ensures the product(s) not only meet the vendors own high standards for extreme ruggedness but meet the exact requirements of the customer, too. This level of commitment to customer satisfaction results in embedded solutions that are guaranteed to meet the end-user needs. Extreme rugged embedded solutions developed are tested and certified to operate across an extended temperature range of -40°C to +85°C (-40°F to +185°F). This is far more specific and measurable than the assurance offered by many

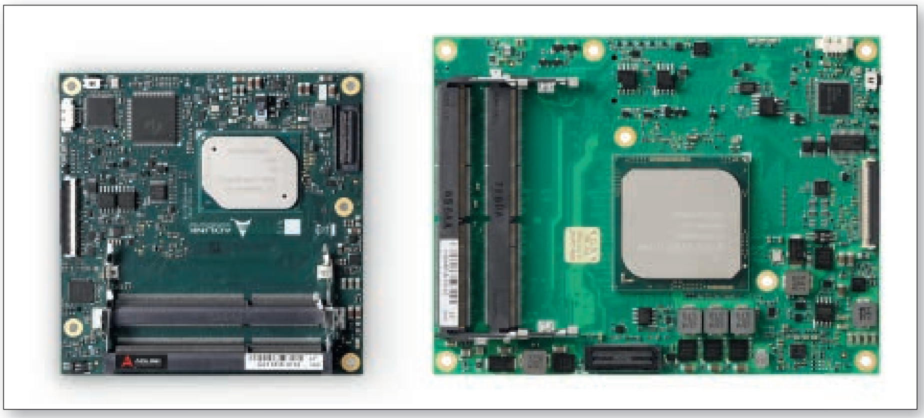

Figure 1. The Extreme Rugged ADLINK COM Express Modules are all MIL-STD-810G and MIL-STD-202G compliant. The server-class Type 7 modules are a perfect fit for operating at the IoT edge in extended temperature ranges from -40°C to +85°C.

manufacturers; extremes that would quickly render commercial components non-functional. This commitment to extreme rugged design demands adherence to the underlying strategy at every stage, from component selection to manufacturing. It impacts thermal management, without doubt, but it also influences the way the board is laid out, the thickness of the PCB substrate and of course the design of the enclosure.

While some manufacturers may feel testing is only part of the final production phase, those with a true focus on rugged design understand that testing must be an integral part of the entire product development and manufacturing process. Testing should be applied at the earliest stages of design, through a wide variety of protocols and methodologies. ADLINK has developed its own Extreme Temperature Testing (ETT) methodology that forms part of the selection process for individual components. In addition, it follows a high-margin circuit design approach that favors components that are proven to function reliably, even when exposed to extremes in temperature across wide voltage ranges. This helps deliver products like the Extreme Rugged COM Express Type 6 Computer-on-Module, for example.

As part of this approach, ADLINK employs IT Equipment (ITE) 180-compliant high-temperature PCB substrates, as recommended by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE). As part of the testing process, all components have documented evaluations for MTBF and full derating calculations. Once a design has been approved it moves to the prototyping stage, which involves more validation and testing using a process intended to really uncover the potential weaknesses of a design. Using repeated test cycles, prototypes are tested to their extremes through combinations of temperature and six-axes vibration stress tests. Inevitably, this arduous process reveals the operating limits of a design, providing valuable data on how to improve the overall product at the earliest possible point – and long before it has the chance to fail in the field.

Figure 2. The MXC-6400 Series delivers an Extreme Rugged compliant solution for intelligent transportation operations such as passenger information systems and CCTV systems for rail transport and maritime control centers.

The same stringent approach to validation is applied to any thermal management solutions employed, both active and passive. This may also involve the use of advanced Computational Fluid Dynamics modelling software, which can help test a design under a number of scenarios during the prototype stage. It may even involve the use of wind tunnel testing to evaluate the effectiveness of heatsinks.

Highly Accelerated Life Test, or HALT, is an important part of this test methodology, as is ETT. It puts components through a series of tests carried out at extremely high and low temperatures, but involves more than placing a motherboard in an oven or chiller. To be truly useful and conclusive, the process requires tests to be carried out in a methodical way, often to a specific customer requirement.

Making testing part of the entire product development process means ETT is used at multiple points in the design cycle. This starts with functional tests that ensure the board boots up across the entire extended temperature range. Engineering samples of a prototype are then subjected to four-corner testing; testing that a board remains stable and reliable at the minimum and maximum temperature and voltage design parameters. Following this, ADLINK test engineers will put the board through thermal shock tests and HALT testing. Only when the design has passed all these tests can it progress to a pilot production run, during which engineers will continue to subject the board to functional and burn-in tests under ETT conditions, in order to fully assess yield.

Once in production, the HALT methodology steps up a gear, by putting increasing levels of stress on components. This includes more temperature cycling, applied over shorter periods of time, along with more aggressive six-axes vibration testing, both in isolation and concurrently. Throughout the application of HALT, engineers constantly monitor and measure critical elements of the system under test, including the processor, interfaces and memory sub-systems. In the event of a fault developing it is analyzed until the cause is identified and a potential design improvement can be evaluated. This process continues until the stress applied causes the component to fail; tested to destruction.

All the data gathered during all of seven HALT stages is used to improve the overall design process. The seven stages of the ADLINK HALT process are as follows. 1) Power on units in continuous functional test loop. 2) Progressively increase extremes of temperature. 3) Induce six-axis vibration. 4) Margin power (±5%). 5) Stress to failure. 6) Evaluate failure. 7) Implement design improvements.

Figure 3. Inside the tiny footprint of the Extreme Rugged HPERC system for defense applications lives the power of a third generation Intel Core i7 processor and optional GPGPU parallel processing engine. Dual removable secure erase RAID-0 SSDs provide 12Gb/s throughput and security for deployment in hostile environments.

Only those products that pass all ETT and HALT tests are labeled as Extreme Rugged, giving customers the assurance they need to put their own products into service. Every test carried out is documented and recorded in a database, which is made available to customers upon request. The same test data is used for own quality assurance audits.

The inclusion of six-axes vibration testing is not arbitrary; extreme environments are typified by exposure to this kind of operating condition. Because of this, it is standard for ADLINK rugged components to meet the main standards imposed by the US Department of Defense; MIL-STD-202G Electronic and Electrical Component Parts Test, and MIL-STD-810G, which is intended to evaluate the performance of equipment when exposed to a lifecycle of environmental stresses. The former includes an exhaustive list of test conditions, including subjecting components to 50G shocks and 11.95 grams of random vibration between 100Hz and 1kHz on multiple axes. In order to meet these stringent requirements, ADLINK employs a range of proven solutions including thicker PCBs and sockets designed to provide higher levels of retention, as well as special attention to high-mass and vulnerable components. This methodology extends to the enclosure design, which delivers a solution that can really be certified Extreme Rugged.

As well as temperature and vibration, other aspects of extreme environments can impact performance and functionality. This extends beyond humidity to include salt spray, as well air-borne contaminants. To address these potential hazards, ADLINK offers conformal coating which is designed to protect sensitive components from particulates such as dust, as well as high levels of moisture which can lead to short-circuits or corrosion. Conformal coating offers protection against these hazards, as well as dendritic growth and general abrasions.

An acrylic coating known as HumiSeal 1B31 is a quick drying and flexible coating that can resist moisture, it can also include a UV tracer that can help with final inspection. The coating can be applied as a spray, by submerging the board in a bath or as a flow coating; however it is applied, the final coating measures on average 3mm in depth and (as the name implies) conforms to the contours of the board. Other coatings available include epoxy, urethane, paraxylene and silicon-based coatings. The wide range of ADLINK Extreme Rugged products have all relevant industry certifications u p t o MIL-I-46058, ISO-7637 and IPC-CC-830, and meet the applicable EMC, safety and environmental standards for rugged solutions in markets such as networking and communications, automation and process control, test and measurement, security and even gaming. The design service provided extends to individual semi- and full-custom design, as well as using stackable modules to create bespoke solutions that are fully supported by off-the-shelf standard products, with long lifecycles and often lower costs. The customized approach includes peripherals and interfaces, as well as offering an assured and future-proof upgrade path. Finally, the Extreme Rugged products are also supported by lifecycles that exceed seven years. ■