WHITEPAPER

Designing for Harsh Environments Using Commercial Off-The-Shelf Products

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Designing For Harsh Envinroments Using Commercial Off-The-Shelf Products

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The need for commercial off-the-shelf (COTS) single board computer (SBC) products continues to grow as higher processing, smaller footprints and lower power requirements become more critical. For design engineers in medical, military, industrial, aeronautics and other fields, the desire for reduced size and heat projection parallels an additional requirement for fanless operation. In this environment, engineers are constantly faced with the challenge of exchanging various aspects of functionality to stay within a particular form factor. Finding COTS products that have all the desired characteristics and are rated to perform in extremely harsh environments creates an additional challenge. However, there are a number of industrial-grade SBC manufacturers who have been successful in designing and manufacturing COTS products specifically for use in these conditions.

OEMs who design products that require high levels of computing in small form factors typically look to the x86 architecture due to its processing capabilities and wide industry acceptance. Computer products designed using this standard architecture are available in a variety of smaller form factors including PC/104, PC/104-*Plus*, EBX, EPIC and Micro TCA. These high-performing, low-profile, industrial-grade embedded form factors are supported by multiple vendors who have taken advantage of a growing trend in x86 chip manufacturing to design chips for extended temperature operation. As the demand increases by industrial and military OEMs for more robust, smaller, faster and lower power requirement SBCs, x86 platforms will continue to provide a solid foundation as capable vendors continue to push the design envelope.

One fundamental factor in system reliability for harsh environments is the proper selection of rugged components, including processors with very low power requirements and extended temperature ratings (-40° to +85°C), extruded aluminum heat sinks and other fanless design solutions, and latching connectors (friction or positive latching) which can virtually eliminate the disconnection of critical components during heavy shock or vibration in the field. Other strategies, such as aggressive thermal management and virtualization of some hardware functions, can also have a great impact on performance. Engineers can also utilize robust validation techniques to replicate conditions seen in harsh environments for testing purposes. This includes environmental stress screening and shock and vibration testing.

Equipment	Application
Military	• Guidance systems • Tracking systems • Communications systems
Homeland Security	• Remote/robotic devices • Unmanned airborne or terrestrial vehicles • Bomb detection equipment
Medical	• Magnetic resonance imaging (MRI) systems • Blood collection and processing systems • Ultrasound equipment
Industrial	• Process automation and control • Assembly equipment • Communications systems

Military and industrial applications where rugged industrial embedded computers can be used.

OEMs who require extreme heat or cold capabilities will find COTS solutions that counter harsh environments in innovative ways. In an extremely hot environment, electronic assemblies must effectively dissipate tremendous amounts of heat as well as balance the thermal stresses created by different materials. COTS thermal management alternatives include fans, heat pipes and cold plates. At the board level, manufacturers can add a metal layer to the PCB to conduct heat away from the board, although this is a very expensive option. Alternative convection thermal management solutions often consist of conduction blocks and extruded aluminum heat sinks with fins. Fans present a more traditional solution, but can have a negative impact on system reliability due to deterioration associated with moving parts.

Extreme cold provides its own set of challenges. In extreme cold, failure to boot and inaccurate analog readings may be the result of the intolerance of some

board-level components for low temperatures. When operating at 20°C and below, solutions include leaving the system on to generate self-heat or installing small electrical heaters within the system enclosure.

Protection of COTS products in harsh environments may also need to be addressed through the system packaging processes. The industry trend is toward increased component density and functionality to decrease system footprint and the use of more powerful microprocessors to increase performance. This trend makes thermal management at the board level progressively more difficult to achieve. Therefore, optimal design and thermal management within a limited space may best be handled at the enclosure level rather than the board level. However, in the final analysis, it is the OEM design engineer's responsibility to either select the appropriate COTS solution for a specific application or to modify the system environment by controlling the enclosure environment.

Long-term product availability is always an issue when designing for embedded systems, and this doesn't change when designing for harsh environments. Desktop and commercial electronic components typically have a lifecycle of only 12 to 18 months - the acute opposite of typical SBCs, where manufacturers need five to ten year availability. The increasing density and functionality of commercial board-level products exacerbates the problem of product obsolescence. The number of parts that can become unavailable increases with the number of features and components designed into a board. As a result, the potential of part obsolescence when choosing a COTS solution must be compared to using fully custom or proprietary products. But system cost, scheduling and performance requirements can balance these risks. COTS manufacturers can work with the OEM to secure enough components to meet future demand. If the risk of obsolescence can be addressed early in the design phase, the upside potential of reduced cost and increased performance can often influence the decision towards a COTS solution.

With the selection of an embedded computer product, it is important to examine the fit between the customer's and the supplier's business models, including such criteria as financial stability, manufacturing process control, manufacturing capacity to meet demand, product quality and reliability, and reputation for on-time delivery and quality of service and support. Selecting appropriate products requires the selection of appropriate vendors who will honor long-term availability commitments and agree to adapt, customize and upgrade their products to meet the needs of the OEM.

In some cases, a COTS solution may not meet OEM requirements for performance and ruggedization. In this instance, the OEM may want to select a vendor who has expertise at customization of their off-the-shelf products, such as application of conformal coating for humidity robustness or installation of custom I/O connectors. Customizing a COTS product can provide substantial cost savings to the OEM in comparison to a completely custom solution.

In order to deploy COTS products in an application that demands relentless endurance, the areas that should be considered by the OEM include: proper selection of products, temperature and environmental stress screening, suitable thermal management practices and overall fit and comfort with the SBC vendor's processes and business practices. Clearly, COTS products are not the answer for every system deployed in extreme conditions. However, the design factors discussed offer openstandards supported by multiple vendors and, in many instances, are designed to provide low-cost, high-performance alternatives to fully custom designed products for deployment in harsh environments.