Design Industrial Systems with Reliability

Design, Testing and Performance Considerations Drive High Mean Time Between Failure

Designing Systems for Reliability :

Design, Testing and Performance Considerations Drive High Mean Time Between Failure Industrial PCs (IPCs) are all about performance and reliability, expected to handle their assigned tasks efficiently and without fail. Performance demands are ever increasing and quad-core systems enabled by Intel's 45nm process technology are readily delivering greater and greater levels of processing and network throughput. Today's industrial PCs are, in fact, handling massive computing and visualization workloads in faster, cooler and quieter performing systems.

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Reliability is perhaps the design engineer's greatest challenge and presents a complex issue based on any number of factors such as the choice of rugged components to be used, the layout of the system itself, the working environment and end-use of the design, which must all be supported by appropriate testing and performance validations executed in advance of both design and implementation. Much of this is wrapped up in the relatively simple Mean Time Between Failure (MTBF) rating – an important, but not entirely effective, measurement of user expectations.

MTBF rates are fairly consistent across the industrial PC manufacturing industry even though not all manufacturers develop their systems using the same standards and guidelines. There are also variables in embedded components, environmental testing expertise and overall design knowledge that affect MTBF rates.

As a result, design engineers must evaluate system reliability well beyond MTBF, including the design and manufacturing elements used to determine the rating, the performance demands required from their specific end-use application and methods to achieve both reliability and performance in a cost-effective, high value system.

MTBF as a Design Concept

MTBF is a measurement designed to offer a statistical approximation of how long a system will last before an incapacitating fault occurs during operation. In its most basic definition, the higher the MTBF, the more reliable the system. End-users, however, can demand much more from this equation – and project engineers or engineering managers working in certain markets may have a range of specific arithmetic requirements that must be applied to determine the most appropriate MTBF. Ultimately, the recipe for determining system longevity is based on the thermal, electrical and environmental stresses placed on each component and system subassembly.

MTBF is always an estimate based on a wide range of parameters. As a result, it may not be the most accurate representation of how a given product may perform in the field. At the same time, it is still an important characteristic for determining the suitability of a system for a potential application and a real challenge to make meaningful to end-users.

Considering the value of reliability, or perhaps the cost of failure, is a definitive way to view MTBF in system design development. In industrial applications, product failure can mean loss of revenue or data based on costly downtime. In military applications, failures can endanger soldiers or equipment. And frequently, these high performance systems are placed into such unique and demanding environmental settings, failure may present a significant challenge in merely being able to get the same system back in place quickly.
Reliability and failure concerns are driving increased product quality as an overall trend in high performance systems. Quality and ultimately reliability of a product is the culmination of components, materials, processes and expertise that go into design and manufacture. Manufacturers who manage revision control and long-term product availability are a critical part of this equation – addressing total cost of ownership over a multi-year product lifecycle as part of the reliability requirement.

Testing Defines Reliability Measurements

ACCRETE executes an extensive range of protocols such as safety and emissions, shock, vibration and drop testing as the most conventional method to determine MTBF. These testing scenarios not only verify rugged performance but also determine the viability of the system's external packaging, and its ability to be shipped within its own rugged chassis.

For vibration and shock tests, the test system is held in a fixed position via girders and threaded rods to a shaker and slip table. Specific levels of shock and vibration are applied and verified on three axes of the test object, in this case the rugged chassis of an industrial PC. Results are reported and evaluated in terms of both mechanical damage and verified functionality. During testing, a running control signal is recorded, and assists in determining any functional issues that may occur along with any mechanical or visual damage to the system.

For some customers additional testing can provide greater confidence in system reliability. ACCRETE performs extended tests such as HALT (Highly Accelerated Life Testing) and HASS (Highly Accelerated Stress Screening) to meet the needs of specific customers. In a close approximation of real world operations, HALT is performed in the design phase of product development. HALT exposes the product to an incremental cycle of environmental variables such as temperature, shock and vibration, applied together and separately in random combinations. Ultimately it
is the goal of HALT testing to break the product; weaker components are identified and addressed one at a time until a high reliability factor is proven. HASS is a form of HALT testing, and is ongoing screening of production units themselves. The purpose of HASS is to not to break the product, but rather to verify its performance during the cycling of various and extreme environmental stresses.

Additional testing is where ACCRETE differentiates from other manufacturers and improves the validation data that goes into the MTBF rating. Very specific environmental tests, such as thermal modeling, ensure the design layout is functional with no hot spots. Applications of dust and water simulate extremely rugged environments and in turn verify the system's ability to perform in precise and very demanding physical conditions.
The ACCRETE KISS family of products consisting of 1U, 2U and 4U rugged industrial PCs, for example, was tested further to validate that they offer additional protection to adverse environmental conditions, such as dust and liquid ingress, therefore enhancing reliability by keeping these harmful contaminants away from the internal components. For these tests, dust and dripping water were applied in a lab setting and incidental operator contact was simulated by inserting a test wire into the systems' ventilation slots. In each of these testing scenarios, no performance or mechanical failures were observed. Each KISS product has an IP rating (Ingress Protection Rating).

Environmental testing is just one piece of the puzzle for defining a rugged system. Reliability must come from more than a high MTBF rating, and designers need to understand the reliability and performance trends driving the overall industrial PC industry.

Compatibility Testing Extends Reliability

Every industrial system can contain a broad range of components, features and performance levels, all intended to work together as one reliable system or set of systems. But addressing these diverse industrial requirements with custom systems can be costly in many ways. As a result, project engineers are considering the overall value of development time versus cost versus implementing a finished system with validated performance and reliability. Ready-to-go configurable systems – tested for compliance with a range of hard drives, data storage options, media accelerators, Ethernet cards, processors and other critical components – are providing a speedy and cost-effective path to ensure maximum uptime and reliable, long-term performance.

Configurable systems are modular and scalable to application requirements, offering an alternative to custom designs that might necessitate a higher minimum order, extended compatibility tests or arduous certification efforts. Project engineers are able to choose specific components and functions, essentially building a system that contains their required processor, type and size of memory, mechanical parts, and hardware and software options, all pre-tested and validated for performance compatibility.

Reliability factors such as power management, thermal ow and cooling characteristics – even chassis design, cushioning of the drives and overall layout of the system are critical issues that ACCRETE addresses as part of a configurable system. Ensuring high reliability and low operating cost in the end-use of the system comes from platform stability, which makes a significant impact on getting systems up and running faster, more efficiently and well prepared for an MTBF requirement of up to 50,000 hours. The manufacturing strength and expertise that goes into developing these configurable systems translates effectively to custom requirements as well, and as a result
ACCRETE is able to move faster and more efficiently through the custom design process.

Configurable solutions integrate matching building blocks such as identical chipsets, and simplify software adaptation for all form factors. Based on the PICMG 1.3 standard, industrial servers address bandwidth issues by replacing system host board (SHB)-to-backplane parallel bus interfaces with high-speed serial links. Emphasizing mechanical compatibility with the PICMG 1.0 standard,the PICMG1.3 SHB connects to PCI Express peripherals via the backplane; multiple PCI Express links on the backplane can operate at x1, x4, x8 or x16. Data bottlenecks are eliminated, systems use additional PCI Express interfaces while keeping the PCI bus, and PCI and PCI-X option cards can take advantage of legacy high-speed parallel links as well as streamlined interconnects.

Today's industrial PCs make the most of these performance options, and deliver complex feature sets that vary dramatically depending on the end-use application. For example, certain applications may require increased drive capabilities, perhaps up to terabyte drives, in order to handle larger amounts of video and graphics. These applications are frequently storage intensive and may also demand DVD drives, media accelerators or more powerful graphics processing units. Applications such as battlefield simulation, flight training, commercial driving instruction, measuring real-time radiation characteristics from a mobile ground vehicle, or even real-time data processing in a hospital operating theater or computer server room, may require certain special adjustments in available features and performance, all contained within proven rugged construction.

Quad Core Performance Benefits

The range of embedded markets and applications, and in particular industrial PC implementations, are in fact seeing significant and long-term impact from multi-core processing technology from Intel.

Dual core chips are commonly integrated into many popular embedded computing platforms such as CompactPCI, Computer-on-Module, TCA-5000 and VPX – and industrial PCs are leading the charge to quad core integration in a non-server platform. Based on Intel's hafnium-based 45nm high-k metal gate silicon process technology, multi-core chips such as the dual core Intel® Core™2 Duo processors and four core Intel® Core™ i7 processors, have improved the power-to-performance ratio dramatically for industrial systems. Enhanced Intel® SpeedStep Technology allows the system to dynamically adjust processor voltage and core frequency, which can result in decreased average power consumption and decreased average heat production. Less power = less heat = a more reliable system. The Intel® Core™2 Quad processor is the first quad-core processor within the Intel® Core™2 processor product line with embedded lifecycle support, defined by Intel'sguarantee of five to seven years of product availability and support. This enables ACCRETE to extend product offerings long-term, an important benefit to system engineers needing to maintain system availability, or add to their equipment base without requalification processes. In a quad core system, four complete execution cores are placed within a single processor, resulting in exceptional performance and responsiveness in multi-threaded and multi-tasking environments. Quad core systems carry out more instructions per clock cycle, their shorter and wider pipelines execute commands more quickly, and their improved bus lanes move data more quickly throughout the system.

Monitoring Reliability During System Deployment

The primary principle supporting the development and implementation of industrial PCs is to provide a rugged computing environment where the required processes – no matter how demanding – are safely and reliably executed. And once a rugged system is implemented into a critical industrial application, monitoring the health of the system becomes an important part of validating performance and can allow project engineers to recognize potential malfunctions before they happen.

Optional monitoring applications such ACCRETE's PCCM (PC Condition Monitoring) provide a web-based means for observing critical system components in use, anticipating impending malfunctions, and notifying administrators to manage the issue. Essentially a form of preventive maintenance, PCCM lets industrial systems avoid downtime and minimize their total cost of ownership of the system in place.

Only by constantly monitoring the system's vital operating parameters, such as processor temperature, fan speeds, power supplies, and hard drive status, is it possible to recognize potential hardware and software failures ahead of time and take appropriate measures. Recording of the event allows the administrator to track down the cause of the pending malfunction, determine the appropriate response and archive the data for future review.

Unlike many tools for the consumer PC user that require extensive knowledge of the system ardware, PCCM is specifically adapted to the product range of the OEM customer for greater security without the additional expense.

ACCRETE Designs for Reliability

From a design perspective, industrial PCs represent some of the most challenging and complex engineered systems found in an incredible range of demanding physical and computing environments. Deployed systems span such a breadth of industrial applications, even within single market segments such as medical or defense and aerospace, yet the project engineer or engineering manager must somehow build in the right features for long-term, rugged deployment with an ever increasing need for high performance.

Smaller and smaller form factors are likely to have an important impact on industrial PCs as well, driving designers to pack even more performance punch into smaller physical space.

As size restrictions complicate design layout, expertise in developing reliable designs will become even more critical.

As a result, configuring systems for reliability and flawless, long-term performance can be a challenge for implementing industrial systems quickly and effectively.

Long-term use, low level noise tolerance, ruggedness for shock and vibration, extended availability of additional systems – these are just some of the requirements that face project engineers and engineering managers as they develop reliable systems for medical, communications, automation, process control, transportation, military and defense, and more. Configurable solutions are helping project engineers meet the reliability challenge, offering more and more features, validated performance capacities and time-to- market advantages.

Rugged and reliable design will continue to evolve, and will impact system design elements such as robust controls, rugged construction, high grade power supplies, sealed connectors, slim chassis for desktop or rackmount integration, quad core available performance and the ability to reliably accommodate any number of CPU and backplane options.

ACCRETE's extensive reliability testing evaluates the key characteristics that validate systems designed for continuous operation as rugged and reliable. Yet reliability is complicated by application demands, so determining MTBF and setting end-user expectations for long-term reliable performance is a complex process that starts very early in the development phase. Winning designs will address this, keep total cost of ownership low, and provide a solid understanding of the end-use application requirements, its current reliability demands and an eye toward future generations of the same industrial implementation.