Vibration Suppression Approach Boosts Server Reliability

Net-centric communications technologies are in high demand by today's military. New approaches to shock and vibration suppression are opening new solutions for system developers.

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Probably more than in any other industry, networking applications for the military market mandate superior uptime, performance and reliability. That's pushed manufacturers of server solutions to continually evaluate, develop and enhance integrated technologies and components to match the needs in this demanding industry. Adding to the challenge, it is incumbent on server solution suppliers to also deliver products that meet system longevity requirements of five years or longer.

Although not specifically required for military applications, systems designers may opt for carrier-grade server solutions that meet strict NEBS (Network Equipment Building Systems) requirements, which have been established for the telecommunications or central office market. Carrier-class features in these servers are very applicable for systems deployed in the extreme and space-constrained environments of military aircraft, ships and field datacenters. Servers designed to these stringent specifications help ensure highly reliable operation under rugged conditions such as wide temperature variations, high altitude and increased exposure to shock and vibration.

Figure 1

An example of systems whose environmental requirements are similar to those defined by the NEBS specifications are large aircraft-based installations like the E-8C Joint Surveillance and Target Attack Radar System (JSTARS) aircraft.

With the ability to be used as standard building blocks for a broad range of military, aerospace and government market applications, communication rack-mount servers have consistently demonstrated long life reliability under harsh conditions. These NEBS-3-compliant servers can be an optimal solution for a variety of military network infrastructure systems, including switching, storage, content delivery, intrusion detection and prevention, VPN/firewall and unified threat management. The critical importance of the communication infra-

structure to today's military demands the highest quality components.

Testing and Analysis

Servers that meet NEBS standards are an excellent choice for many military applications since they are designed to endure environmental extremes far beyond that required of standard enterprise-class equipment. While these systems are likely not appropriate for ultra-extreme environments such as tanks and fighter aircraft, there are many ground-based, ship-based and even large aircraft-based installations whose environmental requirements are similar to those defined by the NEBS specifications (Figure 1). These specifications address issues that are likewise critical to military equipment including temperature and humidity, shock and vibration, fire suppression, safety and emissions and airborne contaminants.

It is crucial that military systems contractors look to experienced, trusted server suppliers for equipment designed from the start to meet these rugged requirements. Contractors that try to use equipment originally built for standard commercial installations but "hardened" in certain aspects of the design will generally find that they do not fully meet the requirements and often result in added costs and delays in their program as these deficiencies are discovered. Instead, they benefit from suppliers that can demonstrate their server's rugged design features through a rigorous testing and analysis process. Contractors can be confident that the capabilities claimed by NEBS-compliant systems are legitimate as they are backed by extensive testing conducted by an independent test lab and documented in a detailed test report.

Figure 2

Vibration suppression technologies have been integrated into this communication rackmount server to ensure system performance and reliability.

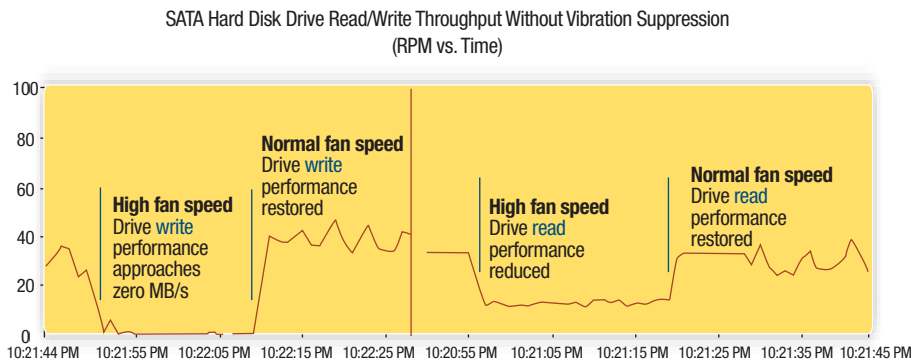

Figure 3

Without vibration suppression technology, reading performance is reduced, but writing performance is reduced to zero when fan speed is toggled between normal and high speeds. The user sees an hourglass or error message that indicates the hard disk drive is not available when performance is at zero Mbyte/s throughput.

Vibration and Reliability

Many system designers have only recently become aware that vibration can significantly affect system reliability and performance. At one time, vibration was seen as a problem that manifested itself on the purely mechanical parts of a system: fasteners coming loose, cable intermittents or disconnections, boards unseating and so forth. But a new culprit has arisen in the form of reduced disk drive and overall system performance. Since shock and vibration are such an expected part of most military installations, contractors must be sure the equipment they specify can tolerate vibration from sources like heavy equipment, vehicles, generators, engines or other types of machinery that operate in or near network installations.

So can vibration really have a noticeable impact on system performance? As part of ongoing analysis and through internal testing by Kontron engineers, it was found that systems were experiencing an unexpected performance loss

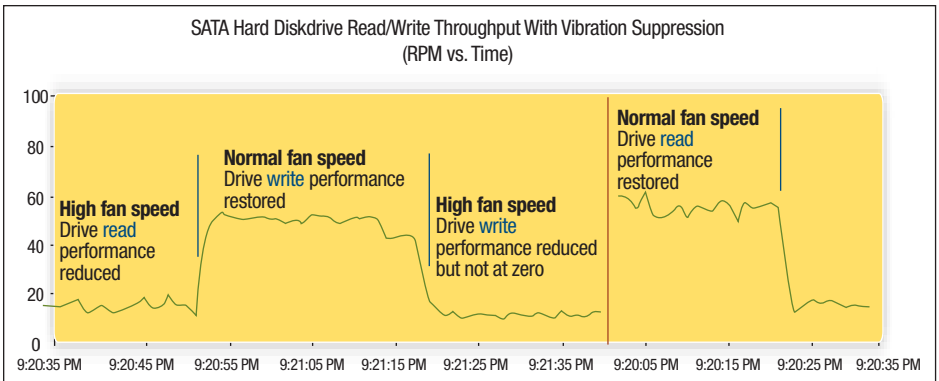

Figure 4

Integrating vibration suppression technologies shows in this test that reading/writing performance is improved and writing is no longer at zero when the fan speed is toggled between normal and high speeds. That means hard disk drives are always available and with the expected performance.

when subjected to extreme temperatures. After comprehensive testing, the cause was narrowed down to the operation of the hard drives, which were experiencing excessive re-syncs of the drive's heads due to the added vibration caused by the system's fan speed increase in response to the temperature changes.

An extensive evaluation was done on how vibration affects hard drives, to identify the sources of vibration, and to determine the best solutions to reduce the negative impact vibration has on system performance. If the vibration within the system was interfering with sensitive hard drive performance, imagine how external vibration that is commonplace in military settings could threaten systems?

The Cause and Detrimental Effects

System fans used for thermal management are the primary source of internally generated vibration. Because today's higher-power systems require increased thermal management that is typically accomplished through greater airflow, fans have had to markedly increase their rotational speeds, with some fans now spinning at over 18,000 RPM. Higher fan rotation speeds have resulted in both increased amplitude and frequency of system vibration in order to maintain system cooling specifications.

Today's hard disk drives are more sensitive than ever to vibration, which has led to greater performance issues. Hard drive sensitivity comes from their increased rotational speeds and higher bit densities making them more susceptible and vulnerable to shock and vibration. When you couple high-capacity hard drive vulnerability with higher speed thermal management system fans, it is clear that today's networking equipment must consider vibration as a real threat to system performance.

Performance issues resulting from increased vibration may not be immediately obvious. A degradation in system performance can be caused by a long list of other hardware or software problems. What pinpoints the cause of vibration is if the degradation occurs when the fans are running at high speeds, such as when the system responds to increased ambient temperatures. The user may note that as the ambient temperatures rise, the system performance falls. Or they may notice a correlation of performance loss with the operation of nearby equipment that produces significant vibration. They may further note that at certain limits the system can degrade to a point where a drive goes "offline" or worse, the system crashes. This is certainly not an acceptable response for a mission-critical system.

Vibration Suppression

For this reason, new, innovative vibration suppression technologies are now integrated into communication rackmount servers that significantly reduce the effects of vibration within the chassis. These new techniques benefit customers by allowing denser systems to operate at higher temperatures or in areas subject to external vibration thus enabling the customer to deploy their solutions in environments not previously possible. In addition, they benefit from being able to use a greater variety of hard disk types and sizes instead of being limited to a few "extra rugged" devices. It is expected that the next-generation hard drives will likely be even more sensitive to vibration given the increase in areal bit density and reduction in overall drive mass. By employing these vibration suppression technologies, servers have greater "headroom" to accommodate these new drives.

A proprietary vibration suppression approach has been developed for the company's line of communication rackmount servers (Figure 2). The approach was to significantly reduce the amount of vibration by isolating both vibration-generating devices and vibration-sensitive devices. By utilizing vibration-absorbing material, both the fans and hard drives can be isolated from direct contact with the system's metal infrastructure so they literally "float" inside the chassis. To be fully effective, vibration suppression needed to be a key requirement in the initial design methodology. For example, the design of a typical enterprise server tightly integrates a hard drive "cage" to the main chassis walls and/or floors. From a design and cost point-of-view, this may seem efficient, but it allows vibration to be transmitted directly from the chassis to the hard drives. To help eliminate this particular vibration issue, it is better to create a self-contained drive cage. Isolating the entire cage from the chassis is shown to greatly reduce vibration-induced performance loss of the drives over drive isolation alone.

More than the Sum of Components

System reliability is a dynamic equation that can change under varying operational circumstances. Troubleshooting a server design is more than the sum of its components, and simply putting off-the-shelf rubber grommets everywhere will not guarantee an optimal solution.

The size, shape, number, location and most importantly the type of material selected, will all affect the magnitude of the vibration reduction. In reality, the challenge is to attenuate certain frequencies that hard drives are particularly sensitive to rather than the overall reduction in vibration. Plus, frequencies that affect system performance vary from drive to drive, so there is no simulation technique that exists that would accurately model a system's vibration patterns.

Kontron has developed a proprietary software program that accurately measures hard drive performance related to drive type, fan speed, system configuration and external vibration sources. Using this software, server designs can be analyzed under various vibration reduction techniques, looking at the effects of system fans and the effects of vibration from the spinning hard drives on themselves and on neighboring drives. It also allows designers to analyze vibration from sources external to the system such as those often found in military installations.

Analyzing Other Components

Solving the issues associated with vibration does not stop at isolating the problematic components. In fact, isolation may not always be the best solution. The best solution may be in changing the mass of a structure for better attenuation of vibration. If the design has many smaller, lighter, independent structures, it actually may be more sensitive to vibration than one monolithic structure. Only careful experimentation and testing can identify the best solution.

Employing high-quality fans with carefully balanced blades and high-quality bearings is another step in meeting specific vibration limits. As systems become more powerful, it is important that there be a continual evaluation process of new fan and disk drive products in the industry to ensure that systems continue to deliver the best performance and reliability possible.

Before and After Comparison

Figure 3 and Figure 4 show the test results of system vibration from a server before and after vibration suppression technology has been integrated into its design. Affecting the performance and reliability of crucial military networking applications, vibration is certainly an issue that needs careful attention by contractors specifying equipment containing sensitive hard disk drives. Testing, thorough analysis and good design methodologies employed by server suppliers have enabled the development of innovative vibration suppression technologies to alleviate many of these issues. Military systems that integrate servers with these technologies can be assured of systems that operate reliably in demanding and rugged environments.

As hard drive suppliers continue to offer higher density drives, and the cost per usable gigabyte of rotational drives is expected to remain lower compared to solid-state drives for the foreseeable future, server suppliers will need to stay diligent in their development of new technologies for the reduction of vibration-induced hard drive performance degradation. For future designs, lower-vibrating fans and reduced sensitivity hard drives plus new isolation and support materials will be required so that military systems continue to reap the benefits of continued server technology advancements. ▮▮

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