Seagate

Technology Paper

Storage Integration and Reliability in Video Surveillance

Today's video surveillance systems have substantial workloads and often operate 24 hours a day, 7 days a week. With such constant operational strain and large amounts of critical data involved, design practices to improve system reliability are always a good investment.

Modern video surveillance systems currently rely on hard drives as the storage medium for video capture. Hard drives used in these systems are the only major electro-mechanical element in an otherwise solid-state device. Therefore, special consideration should be given to the best practices for hard drive integration into a video surveillance unit.

When it comes to storage integration, much of the current information available to manufacturers is related to consumer digital video recorders, which typically have very different requirements from a video surveillance system. A keen understanding of hard drive installation and operational requirements is critical to achieving optimal reliability and performance from your storage solution. While the concerns of vibration and shock, proper mount designs and thermal management apply to all video surveillance configurations, manufacturers should be aware of how to best protect the hard drive within unique system infrastructures. This will contribute to better overall performance and longevity of the drive.

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Performance Degradation Due to Vibration and Shock

Vibration

Vibration is defined as the continuous displacement of a mechanical system in an oscillatory motion.[1] A hard drive within a surveillance system can experience several types of vibration: 1) translational, which occurs along the x, y or z axis of the drive, 2) multi-axial, which takes place along multiple axes at once, and 3) rotational, a twisting or spinning motion about an axis.

Hard drives are most sensitive to rotational energy that occurs about the motor spin axis (z axis), which is perpendicular to the top cover of the drive. Therefore, rotational vibration (RV) can be a significant issue for hard disk drives, which frequently create this type of energy themselves during operation. RV can diminish the data transfer rate of the disk drive by causing the actuator head to move off the track as the drive rotates about the axis. As a result, significant reductions in hard drive performance (sometimes over 50%) can result from RV.[2]

RV energy is typically generated by the following sources: 1) the drive's self-excitations due to seek activity, 2) additional components within the chassis, including other drives, fans or CD-ROMS, and 3) external forces acting upon the system.

Emerging trends in the surveillance industry also have an important part in RV performance. With the increasing demand for higher megapixel resolutions and the immense growth forecasted for IP cameras, areal density continues to increase, resulting in higher tracks per inch (TPI). Increased TPI necessitates improvements in servo designs, as the actuator must be precisely directed to the tightly packed tracks on the drive. Updates in servo designs mean improved RV performance, but ever-increasing TPI continues to slow servo progression.[3]

Shock

Shock is defined as the temporary disruption of a mechanical system through a rapid transfer of energy to that system. The shock environment is described using three primary components: 1) pulse shock, which represents accelerations or displacements, 2) velocity shock, which deals with a sudden change in velocity, as when a falling object hits the ground, and 3) the shock response spectrum, which describes how a system responds to a shock event. As pulse shocks are most easily measured, they are commonly used to express shock events.[4]

Because shock often disrupts many of the natural frequencies within a storage system, it can cause numerous failures, including permanent deformation, loosened hardware and component-to-component impacts.[4] According to Michael Staiano, an engineer with Seagate Technology, most shock damage to hard drives occurs during integration. Protecting your drive prior to installation and while it is outside the operating environment is paramount to extending the life of the drive and enhancing its reliability.

In a 2010 evaluation of a video recording system, Seagate findings validated this idea. Various drop tests were performed on the system, simulating both operational and non-operational scenarios. A triaxial accelerometer was attached to the drive base plate to measure shock response. Results showed that base plate contact with hard surfaces is most likely to cause drive damage, while significant amounts of shock energy are needed at the system level to cause such damage.[5]

With the drive mounted into the system chassis, the bare device was dropped onto a hard tile floor from 30 inches above the ground. Additionally, the system in its packaging was actually tossed around the room. These events were less likely to cause damage to the drive than dropping the base plate a mere six inches onto a hard surface such as a tabletop.

Evaluating the Effects of Vibration and Shock

As demonstrated by the Seagate drop test, the effects of shock are best measured using an accelerometer to provide feedback during shock events. When testing vibration performance, drive throughput becomes the primary gauge. In either case, the hard drive is a key component to evaluating the effects of shock or vibration.

Manufacturers and system designers can conduct their own experiments to determine hard drive performance within the specific operating environment. While utilizing an accelerometer will help evaluate shock performance, the following steps will help determine the level of RV energy created within a system.

For drive mount evaluation, throughput performance of the drive can first be measured while mounted in the system. It can then be compared to the drive's performance while mounted in a best-case scenario structure. To create this best-case environment, the drive can be mounted in a heavy, rigid block outside the chassis.

In this type of test, the drive is used to measure RV created from seek activity while the drive is mounted in a system. If RV is at a high level or within sensitive frequencies, the drive throughput performance will decrease in relation to the baseline, best-case measurement. This testing can also be used to determine whether other components in the chassis or external sources are responsible for the vibration and resulting throughput loss.

Furthermore, manufacturers have additional options for drive mount evaluation in the form of freeware software programs like Iometer.

Proper Mounting Designs

Though many consumer digital recording systems utilize isolation-mount design for storage integration, surveillance configurations typically work well with more rigid mounts. Isolators are often used to improve acoustics in a video recording infrastructure, but most surveillance systems do not have extensive acoustic needs like those found in consumer digital recording systems. Hard-mount designs not only hold the disk drive rigid to reduce RV energy, they also provide a more economical means of integrating hard drives into a surveillance configuration. Isolators can be an unnecessary added cost and can actually intensify vibration issues in certain situations.

Because hard drives in surveillance systems can experience high seek activity as the drive handles numerous video streams, the mount should be as rigid as possible to hold the drive firmly in place. This rule applies to a variety of surveillance architectures, from embedded DVR configurations commonly used in convenience stores, to centralized storage designs, where rack-mount storage and storage enclosures with high drive counts are common. Whatever the configuration, the drive (or drives) should be held secure in the carrier or the chassis to support the high-seek workloads in today's increasingly sophisticated surveillance systems.

For surveillance designs used in high-shock environments, such as law enforcement and military vehicles, trains and so forth, isolation becomes an important factor for reliability and performance. In these cases, both shock and vibration are key issues, and the mount design must account for internal excitation sources, in addition to external forces.

General Isolation Requirements

When shock is the primary concern, there are specific guidelines to keep in mind for isolated-mount designs.

- Because secondary shock is more detrimental to hard disk drives than the initial shock event, good clearance or sway space around the drive is vital.
- Isolators must be of high quality, with reliable damping properties.
- The side mounting holes near the corners of the drive should be used to provide symmetrical support during shock events.
- The mounting bracket should provide a rigid structure for the overall mount design.
- The chassis structure of the hard disk drive mount must be robust and rigid.

If I were to pick a best-case mount, it's typically a rigid mount that holds the drive symmetrically using the side mounting holes. This minimizes RV energy due to seek activity by not allowing this energy to be kicked back into the drive in such a way that we see throughput loss.

Michael Staiano
Seagate Technology

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Even if shock is the main issue, an isolation design cannot dismiss the potential for diminished performance from vibration. In some cases, a properly designed isolation system can improve chassis vibration performance at the drive level when the chassis structure is exposed to an external vibration source. However, poorly designed isolation systems can intensify vibration at certain frequencies, resulting in lower throughput performance and potential contact among chassis components.

In addition to the guidelines outlined above, the following factors are crucial elements of an isolation design that favorably affects vibration performance:

- Because isolators and the drive create a damped spring-mass system, all isolated systems have resonant frequencies. It is typically desirable to design a system with a low natural frequency. Isolation-resonant frequency should be:
  - Within the frequency range of the drive's vibration specifications
  - Sufficiently damped to ensure vibration amplitude is within the drive's specifications
  - Aligned outside of the spindle once-per-rev (OPR) frequencies of the intended disk drive to avoid spindle unbalance issues
  - Aligned outside of system or cabinet excitation and resonance frequencies[6]
- Isolation mount materials should be stable, with consistent performance over the entire expected temperature range.

Table 1 provides additional guidance on how to apply best practices to your particular surveillance architecture.

Thermal Management

Your storage solution might not be exposed to traumatic shock events or excessive excitation sources. It might even be held securely within the appropriate mount design. But none of this will matter if the drive is not cooled effectively. Hard drive performance and reliability are highly dependent upon proper thermal management practices within the operating environment.

Hard drives have two categories of specified operating temperatures: 1) the maximum ambient temperature (for example, 0°C to 60°C), which refers to the environment surrounding the disk drive, and 2) the maximum base plate temperature (for example, 69°C). The base plate temperature is the more important parameter and is used to characterize drive operating temperature at given ambient conditions. When the base plate temperature is measured in relation to the ambient temperature of the mounted system, it is possible to estimate how hot the hard drive will operate in a variety of ambient temperatures.

Table 1. Storage Integration Best Practices At-a-Glance

What are you building?	Key Design Considerations		
	Vibration	**Shock**	**Thermal Management**
Multi-Mobile Surveillance DVR	• Isolation system designed with low natural frequency • Mount design accounts for internal excitation sources, in addition to external forces	• Adequate sway space • High-quality isolators • Use of side mounting holes for symmetrical support • Rigid structure of overall mount design	• Drive is properly vented for natural convection cooling to occur • Forced convection may be required depending on environmental requirements
Small, Embedded Surveillance DVR	• Drive held secure and rigid within the carrier to minimize RV energy	• Not a primary concern for these designs—proper handling prior to installation is key	• Drive is properly vented for natural convection cooling to occur, or • Mount design allows for conduction cooling to occur
Mid-size, Multi-drive Surveillance DVR	• Each individual drive held secure within the chassis or carrier to minimize RV energy	• Chassis is stiff and allows for adequate sway space between internal components	• Mount design allows for conduction cooling to occur, or • Forced convection cools the drives with minimized excitations to the chassis
Large-scale, Multi-drive Surveillance NVR or Rack Mount RAID/JOB	• Each individual drive held secure within the chassis or carrier to minimize RV energy • Design accounts for additional excitations • System's resonance frequency is kept at a generated by multiple drives minimum to prevent transmission of RV energy	• Chassis is stiff and allows for adequate sway space between internal components	• Mount design allows for conduction cooling to occur, or • Forced convection cools the drives with minimized excitations to the chassis

For example, if the ambient temperature is 25°C, and the drive's base plate measures at 50°C, the result is a delta of 25°C. This means that if the ambient temperature is increased to 35°C, the disk drive can be estimated to operate at a base plate temperature of 60°C.

Suggested Cooling Methods

In order to maintain the specified operating temperatures for your hard drive and to optimize its reliability, the appropriate methods of cooling must be applied.

Conduction cooling is more efficient when hard-mounting a drive to a mechanical structure, as the chassis itself pulls much heat away from the drive. Conduction methods can also be well suited for embedded systems, which don't rely on fans for cooling.

Convection cooling is usually a better option for isolated mounts or hard mounts that don't allow heat to be easily pulled from the drive. Many surveillance systems rely on forced convection, or the use of fans to cool the drive. In forced convection setups, it is important that the hard drive remain the number one priority for cooling. The fan should pull air from the outside environment and move it across the disk drive first, rather than the power supply, CPU or any other heat-producing component.

As embedded systems become more popular, forced convection will not always be an option. In these scenarios, the hard drive must be positioned with vents above and below it, allowing the drive to continuously experience airflow and be cooled through natural convection.

Whether using conduction or convection methods of cooling, the hard drive should be distanced from any hot components in the chassis design, including the power supply and CPU. The drive should also be positioned so that it is not directly above a heat source. Following these general guidelines will help prevent serious damage to the drive and maximize overall performance.

Conclusion

Video surveillance systems will continue to play critical roles in a variety of market segments as they are used for traffic monitoring, security and preserving evidence. According to IMS Research, the digital storage capacity of the global surveillance marketplace will reach approximately 3.2 billion gigabytes in the year 2013.[7] With such vast amounts of surveillance data, reliable storage solutions are an absolute necessity.

In addition to choosing a storage product that is designed for its specific workload and data category, it is crucial to implement smart and strategic practices for hard drive integration and operation.

By thoroughly evaluating the effects of vibration and shock on the storage system, developing a proper mount design to protect it from such forces and following proper thermal management procedures, you can ensure optimal performance and reliability from your storage solution for years to come.

1 *Guidelines for Chassis Vibration Isolation*. Michael Staiano, Seagate, November 2000.
2 *Are All Hard Drives Created Equal? Examining Rotational Vibration in Desktop vs. Enterprise*. David Szabados, Seagate Technology, May 19, 2010.
3 *Rotational Vibration Index*. Michael Foster, Seagate Technology, January 2001.
4 *Guidelines for Chassis Shock Isolation*. Seagate Technology, September 2000.
5 *Consumer DVR Drop Study*. Presentation by Seagate Technology, July 28, 2010.
6 *Customer Chassis Design Guidelines*. Presentation by Seagate Technology, June 12, 2007.
7 *Enterprise and IP storage used for video surveillance global market will be worth over $2.5 billion in 2013*. IMS Research, March 2010. www.the-infoshop.com/press/iz115570.shtml

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AMERICAS Seagate Technology LLC 10200 South De Anza Boulevard, Cupertino, California 95014, United States, 408-658-1000
ASIA/PACIFIC Seagate Singapore International Headquarters Pte. Ltd. 7000 Ang Mo Kio Avenue 5, Singapore 569877, 65-6485-3888
EUROPE, MIDDLE EAST AND AFRICA Seagate Technology SAS 16–18, rue du Dôme, 92100 Boulogne-Billancourt, France, 33 1-4186 10 00