Noise Reduction Using Dampening in Voice Coil Motors/Actuators of Hard Disk Drives

Forward: Reduced acoustics has increasingly become an important parameter for hard disk drives. Suppliers are using new technologies and techniques to bring quieter drives to the market. This white paper addresses one of several methods being employed.

Walker C. Blount
Sr. Engineer

October 2001
IBM Storage Technology
San Jose, CA 95193
blount@us.ibm.com
Contents

2 Introduction
2 Voice Coil Motor/Actuator System
3 Noise Reduction Using A VCM Damper
5 Conclusion
5 References

Introduction
Reducing the acoustic noise of hard disk drives (HDD) has become an important goal for system designers integrating HDDs in their platforms. HDD designers have employed a number of techniques in the design of these drives to minimize generated acoustic noise. These techniques have included the use of fluid dynamic bearing spindle motors, the design of components to minimize vibration and frequency resonance, and the use of dampers to eliminate noise and vibration. Using these technologies, HDD developers at IBM have created the industry’s quietest hard disk drives in its latest generation of mobile hard disk drives.

This paper addresses one method employed to reduce acoustic noise in the Voice Coil Motor/Actuator System. Also included is a brief history and discussions on future directions of the actuator system.

Voice Coil Motor / Actuator System
Early hard disk drives used stepper motor actuator systems. The stepper motors used in these early drives were slow, temperature and position sensitive, and were generally unreliable. These devices were open loop systems, providing no active feedback on head position over the track and no track following capability.

With further advancements in HDD technology, newer hard disk drives today use rotary actuator systems which employ a closed-loop feedback signal to position the heads over the track and provide the capability of track following.

The Voice Coil Motor/Actuator System consists of a Head Gimbal Assembly (HGA), Actuator, Voice Coil Motor, and control electronics (flex circuit and amplifier). The HGA consists of a slider, where the head is attached, and a suspension. The actuator consists of an arm and a pivot ball bearing assembly. The VCM is composed of a magnetic coil and two yoke plates (top and bottom) where permanent magnets are bonded in place.

The Voice Coil Motor (VCM) mechanism in HDDs is similar to that of an audio speaker. Electromagnetic force creates movement of the energized coil relative to the stationary magnet. In the case of the speaker, the cone moves creating sound. In the case of the HDD actuator assembly, the energized coil moves the heads at the end of the head gimbal assembly.

As areal density continues to increase and track spacing becomes tighter, dual stage actuators will be integrated in the future. Simply stated, a secondary
micro-actuator system is employed for finer control of seeking and track following. The secondary micro-actuator could be in some designs, a push pull piezoelectric, electrostatic, or an electromagnetic actuator that typically would be located between the head suspension and actuator arm. Another design could place the micro-actuator between the suspension and slider.

Noise Reduction Using A VCM Damper

Hard disk drives have two primary sources for noise and vibration: the spindle motor/disk assembly and the Voice Coil Motor/Actuator assembly. New motor technologies such as fluid dynamic bearing motors are being used to reduce spindle noise, the source of the majority of acoustic noise. The remaining noise is generated by the VCM and components of the actuator assembly. Noise is generated from the actuator is a result of high frequency resonance and low frequency vibration. Low frequency and high frequency noise is generated from vibrations of the structure during seeking. One method of reducing this noise is by using a VCM damper. The VCM damper is located between the HDD top cover and the magnetic yoke plate of the VCM. It can be bonded to the top cover or the top yoke plate. The damper provides stiffness for low frequency noise, operating within the confines of the top cover
and the magnetic yoke plate. The noise is attenuated as a result of the added
stiffness to the structure provided by the damper. In some HDD designs, using
a VCM damper can reduce noise as much as 2dBA.

The mechanical behavior of the damper is determined by the properties
of the materials used and the geometry of the design. The material properties
of the damper determine its ability to store mechanical strain energy—called
the material's elastic modulus. The material's capacity to dissipate the energy
is the measured damping. Young's Modulus is a number that defines the ratio
of stress to strain or storage modulus of the material. Metallic materials are
generally stiff and elastic and will have a high Young's modulus. This material
will be poor in dissipating this energy due to its low damping capabilities.
Other materials, such as polymeric materials, have both the viscous and elastic
properties that can store a significant amount of energy and can dissipate
a high amount of energy creating significant damping. This assumes the
material has high damping properties. These polymer materials are known
as “viscoelastic damping polymers.” Suppliers provide a number of polymeric
materials for hard disk drive applications.

Selection of a damping material is dependent on frequency range and
operating temperature of the application. Once this has been defined, using a
supplier’s nomograph or other methodology to characterize the material, the
storage modulus and the loss factor of the material can be determined. Testing
of the HDD in a dynamic mode with the damping material will determine if
the design criteria has been met.

As an example, on the nomograph below, the Loss Factor and Storage
Modulus are determined by selecting the frequency of the application. A
horizontal line is extended from that frequency until the desired application
temperature is intersected. A vertical line is extended from the first
intersection point of the desired frequency and temperature so that it
intersects the Loss Factor and Storage Modulus curves. The Loss Factor and
Storage Modulus values are found on the left hand scale by extending a line
horizontally from these second intersection points on the Loss Factor and
Storage Modulus performance curves.
Solutions to vibration and noise dampening have become an increasingly important metric in the design of HDDs

Conclusion
Vibration and noise dampening is becoming more important with the introduction of higher performing hard disk drives and the fact that HDDs are finding more opportunities in consumer electronics. In both cases, there are requirements for lower acoustical noise. Solutions to vibration and noise may encompass the use of new technologies, design of components that minimize resonance and vibration, design of the actuator system that minimizes or eliminates resonance modes, and damping materials that may be used on certain components. As with all HDD designs, the efficiency of controlling vibration and structural noise will depend on the dynamic behavior of the overall system. HDD designers are continually challenged to bring all of these elements together to produce the optimal design that meets the criteria for the various applications these devices are being designed in.

References
[4] H Lin, Q li, Z he, S Chen - Development of a Single Coil Coupled Force VCM Actuator For High TPI Magnetic Recording
[5] 3M Viscoelastic Damping Polymer Technical Data Sheet

General product information for other IBM hard disk products is available by calling 1-800-IBM-5214 (United States) or 507-286-5825 (outside of the United States). Information is available via the internet at ibm.com/harddrive.
Product description data represents design objectives and is provided for comparative purposes; actual results may vary depending on a variety of factors. Product claims are true as of the date of the first printing. This product data does not constitute a warranty, and there are no guarantees or warranties regarding its accuracy. Questions regarding IBM warranty terms of the methodology used to derive this data should be referred to an IBM representative. Data subject to change without notice.