Application Note *VIB-D-01*

FIELD OF APPLICATION

- **A** Aerospace
- **B** Audio & Acoustics
- **C** Automotive Development
- **D Data Storage**
- **G** General Vibrometry
- **M** Microstructures & -systems
- **P** Production Testing
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- **T** Structural Testing
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LDV Investigation of Unstable Air Bearing Resonance Effects on Low Flying Heads

Hard disk drives (HDD) with higher data density and faster access times rely heavily on the stability of the read-write head while flying over the magnetic media. Recognizing the importance of this stability, Hitachi development engineers have studied the air bearing between the head and the media for a sequence of successively lower flying heights (gaps). This sequence of heights was produced by reducing the air pressure surrounding the HDD. A Polytec LDV was used to monitor the head response at each flying height. Once instabilities were known, methods were developed to dampen out excessive vibration levels that might damage the head-media interface.

Introduction

The flying height of a head in a HDD can be decreased simply by reducing the ambient pressure in a vacuum chamber. During the "pump down condition", all the heads in the HDD fly much closer to the media than at ambient pressure. The reduction in pressure was done gradually, decreasing the separation between the head and the disk in a very careful, controlled way. The lower flying height or separation between head and disk is necessary to determine the vibrations of the head and suspension when the head interacts with defects in the disk, i.e., asperities or disk defects.

If a head or suspension can be developed which can *counteract* the harmful resonances then a more robust head/disk interface system can be easily developed for future HDD designs.

The vacuum chamber also simulates the effects of high-altitude on the HDD. A head flying at 10 nm at sea level will typically experience a 2 nm drop at 3000 meters (10,000 ft) due to reduced air pressure and fly at 8 nm. Any decrease in flying height poses a reliability problem in that some files will fail if the overall air bearing design doesn't allow some protection to changes in surrounding air pressure. New air bearing designs now are stressing low fly height sensitivity to pressure changes in ambient conditions.

When designing a HDD head-media interface, the flying height is often set as a compromise between competing effects.

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Generally, the greater the flying height the less likely an environmental shock or vibration will crash the head on the media. The smaller the flying height, the greater the head read/write resolution for magnetic domains.

This study was designed to measure the air bearing resonance sensitivity to various vacuum levels starting at one atmosphere. The head/disk separation is strongly vacuum dependent with 0.5 atm giving the lowest head/disk separation when compared to 1 atm. Vibration resonance modes of the air bearing were investigated at leading and trailing edges (roll and pitch sensitivity) as air pressure was reduced. A Polytec LDV monitored the flying behavior of the top head in the drive (Figure 1).

Both stable and unstable conditions were found and a method was devised to dampen out the most severe vibration levels. A HDD file was built with a special air bearing with a flying height (ID through OD range) that was less sensitive to changes in air pressure (different flying heights).

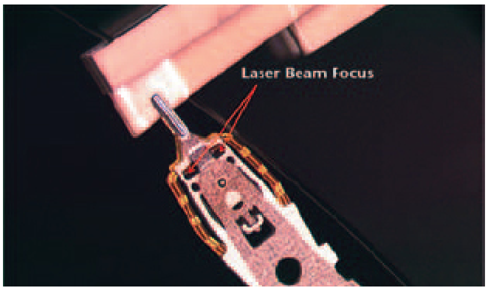

Figure 1: Read/write head showing laser vibrometer probe spots

Experiment

The front cover of the drive was modified with an optically clear glass plate so a laser probe could be projected onto the top head in the drive. The drive was then placed in a vacuum chamber with a clear Plexiglas front door. The HDD was positioned in the chamber so that a laser probe could pass through both windows and still reach the top head. This technique allows a non-invasive measurement to be performed on one head in the file. The reflected laser light carrying the vibration signal was received back at the vibrometer.

A strong resonance signal of 263 kHz was discovered on the trailing edge of the slider with the laser beam reflecting through the suspension and focused onto one of the two trailing edge corners of the head. This signal was identified as a pitch mode signal.

The same frequencies were also prominent on both the suspension and ILS cable leading from the suspension. It is surmised that the 263 kHz signal propagates from one head to all the other heads (via the suspension and ILS cable). The vibration is initiated by the touchdown of one of the heads onto the disk surface during vacuum pump-down.

A series of tests with a control file were performed to determine if the same pitch mode signal exists at other vacuum levels.

Results and Discussion

Before the LDV measurements were made, the file was subjected to a magnetic clearance test in which the file was followed by a magnetic signal Wallace equation analysis. As the air pressure was reduced, the magnetic signal increased in amplitude until one of the heads touched the magnetic media and the signal was perturbed.

It is observed that when the first head touches down all the other heads in the drive become unstable and fail also. The clearance test was the initial indicator of the small separation between the disk surface and the head. In addition, it was used to determine the flying height stability of the heads before and after touchdown.

To corroborate the findings observed from the clearance tests, an LDV probe was placed on the top head in the file. Scanning and single point measurements were then made on a flying head. For the 2-D scanning measurements, typical points of measurement on and around the slider and suspension were chosen.

Figure 2 shows the 263 kHz signal that causes the suspension at the area of the head mount to oscillate with both bending and torsional modes. The rest of the suspension remained essentially stationary without any significant oscillation.

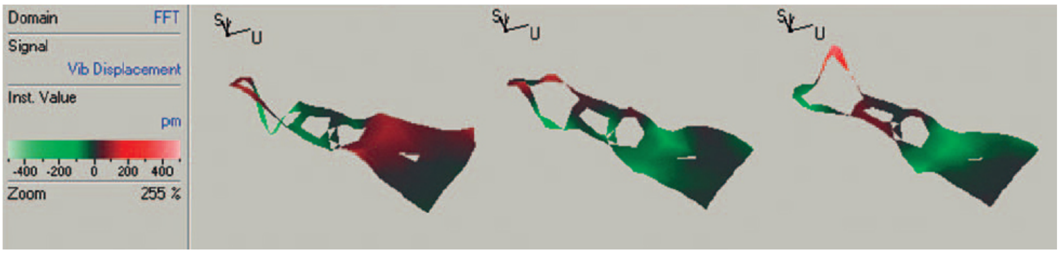

Figure 2: PSV Scanning Vibrometer measurement of bending and torsional oscillation of the suspension

For single point measurements, the LDV was focused on the head's trailing edge corner. A 263 kHz signal from the pitch mode resonance of the head is shown in Figure 3 (left). This vibration mode was obtained at higher vacuum levels. The flying height has decreased to a point where the head is influenced by the surface roughness of the disk and the lubricant levels coating the surface of the disk.

The 263 kHz pitch resonance is found not only on the head but also on the suspension and ILS. The 263 kHz resonance signal was not found on the disk. The 263 kHz vibration source is observed to be emanating from the trailing edge, ID and OD corners of the head.

The magnitude of the 263 kHz resonance increases with lower air pressure. At 1.0 atm the 263 kHz vibration level is the smallest; 0.9 atm, somewhat larger; and 0.7 atm, the largest vibration amplitude. Dampening along the ILS was considered to prevent other heads from being sources and sinks of vibration.

The suspension was dampened via the load dimple that is located either at the 50% or at the 33% separation point of the head on the suspension. A suitable viscous fluid was put into the load dimple where it acted as a visco-elastic dampening fluid. The 263 kHz signal disappeared when this technique was applied (Figure 3, right).

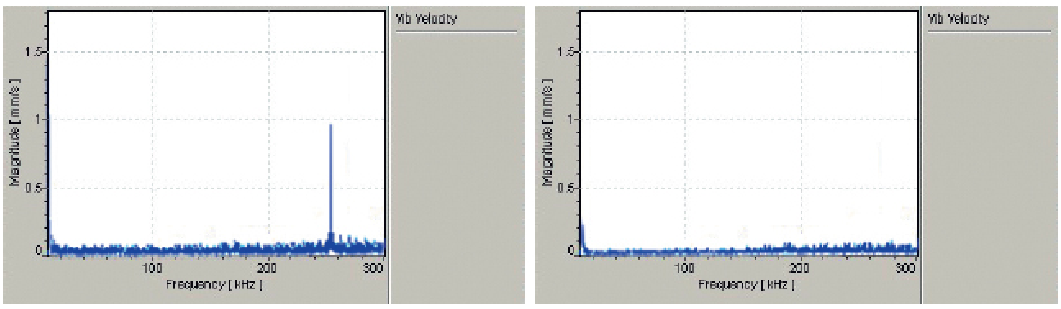

Figure 3: The 263 kHz resonance signal before (left) and after (right) application of viscous fluid

Conclusion

Using an LDV, the vibration spectrum of a HDD head was monitored at different ambient pressures. An unstable pitch mode resonance signal was found at lower pressures corresponding to a reduced flying height and close proximity to the media surface.

For a head that flies at large clearance heights the probability that this mode would become unstable is very low. However, due to the action of changing air pressure there is a probability that some of the heads in a file may start to approach the surface of the disk.

To prevent the possibility of encountering this pitch mode resonance phenomenon, a viscous liquid was used as a dampening fluid between the head and the suspension. This not only prevented the vibration resonance from occurring but also prevented it from being transmitted to the other heads in the file.

Future designs using the existing air bearing design can either use this technique, i.e. dampening the suspension at the load dimple point, or design a more in-sensitive air bearing to prevent changes in air pressure from allowing the head to come into contact with the surface of the disk.

More work in this area is needed in the coming new generation of HDDs since flying heights will soon approach the surface roughness of the disk, i.e. around 4 nm.

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If you have specific requirements or need help for you custom solution, please contact Polytec's application engineers.