Using Rotational Vibration Safeguard (RVS) Control to Minimize Disturbance Effects in Hard Disk Drives

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Understanding hard disk drive disturbance issues

Hard disk drives are used in a wide variety of environments, each with its own unique disturbance characteristics. These disturbances can result in undesired off-track motion of the disk drive head. The disk drive must then wait for the head to reposition itself over the data track before it can read or write information. The accumulation of these delays decreases the drive's input/output performance.

In particular, this impacts server-class disk drives, which are often installed in multi-drive arrays.The seeking actions and spindle rotations of adjacent drives create disturbances that typically result in decreased performance compared to the undisturbed case. The standard compensation technique for this problem is through design of the feedback head position controller. However, every array is different, and it is virtually impossible to optimize the feedback controller so that disk drives perform at their peak in every situation. Maintaining the on-track position becomes increasingly challenging as track widths decrease to keep pace with demands for increased storage capacity.

How Rotational Vibration Safeguard, (RVS), is used to minimize disturbance effects

The Rotational Vibration Safeguard employs sensors on the exterior of the drive to measure the effects of disturbances—caused by external as well as some internal forces—directly. These sensors are similar to those that have proven to be reliable for shock sensing in many generations of IBM's mobile-class disk drives. The disturbance measurement is used to correct for disturbance effects before they appear in off-track motion of the head. This technique has a faster reaction time than the standard feedback head position controller, which cannot compensate for the disturbance until it appears in off-track motion of the head.

There are several advantages of utilizing RVS over traditional methods:

- Because the disturbances are measured directly, RVS is insensitive to changes in the disturbance characteristics, and ensures minimal degradation of performance due to these disturbances
- It also allows the standard feedback controller to be optimized without regard to specific operating disturbance environments
- Because the measured disturbance is used in a feedforward manner, it is not subject to the mechanical constraints that may limit the feedback

Highlights

Rotational Vibration Safeguard (RVS) minimizes disturbance effects

controller design

Both linear and rotational disturbances exist in the disk drive operating environment. However, it is typically the rotational disturbances that have the most impact on performance. Today's balanced rotary actuators are relatively insensitive to linear vibration, which is why RVS concentrates on measurement of rotational disturbances.

Figure 1 shows a block diagram of the technique. The standard feedback position control is shown in black. It receives position information written on the disk from the head signal. The measured position is compared to the desired position, and an appropriate control output is generated so that the head is moved to the desired position.

The RVS controller is shown in blue. It takes the measured disturbance from the sensors and generates an additional control signal that is combined with the standard feedback control signal. The RVS signal is designed so that when the disturbance propagates to the head position, the actuator generates a force to exactly cancel out the disturbance effects before the head moves off track and causes a delay.

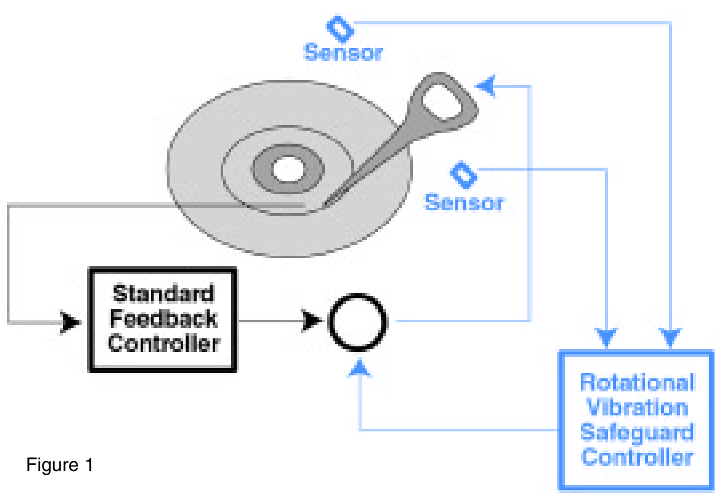

Figure 1

Figure 1: Block diagram of disk drive control system

Figure 2 shows two position traces as the head approaches a new track

Highlights

while under the effects of an external disturbance. The first (black) trace is the position of the head without the benefit of RVS. The disturbance results in large oscillations of the position. The second (blue) trace shows how the RVS control is able to cancel the effects of the disturbance and be in a position to read or write more quickly.

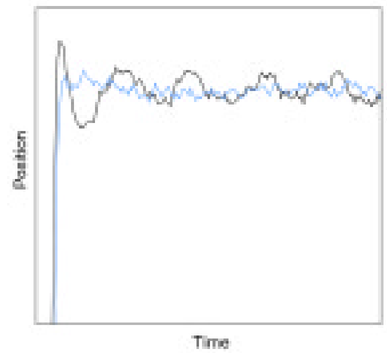

Figure 2: Accessing a track while under the influence of a disturbance

RVS eliminated the effects of inter-drive disturbances

Figure 3 demonstrates how improved positioning and rejection of disturbances relates to performance. The first (green) bar represents input/output performance in the undisturbed condition. The second (black) bar exhibits typical performance degradation due to inter-drive interference in a multi-disk array. The third (blue) bar shows how RVS eliminates the effects of these inter-drive disturbances to regain the performance level of the undisturbed case.

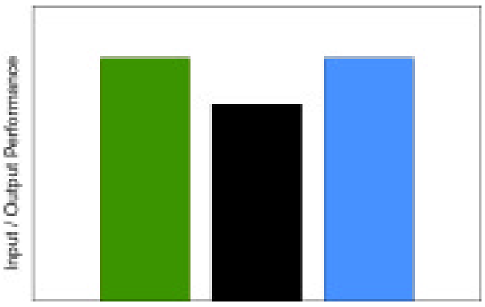

Figure 3: Performance Comparison

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