Rotary Acceleration Feed Forward (RAFF™)

Information Sheet

Rotational Vibration Cancellation Technology in WD Enterprise Hard Drives

Introduction

WD's high performance, high availability enterprise hard drives employ RAFF technology to maintain the highest possible data transfer performance in the high Rotational Vibration (RV) environments commonly found in servers and storage arrays. Hard drive performance is degraded when a hard drive is exposed to vibration induced by one or more of its neighbors in the chassis. This induced vibration shakes the head off a track that is currently being read from or written to, resulting in retries and serious performance consequences.

The Growing Menace To Performance

The most important performance metric of a hard drive is the rate at which data can be transferred to/from a host. This performance is called Data Transfer Rate Performance (DTRP) and can be measured by a test.

A few years ago, drives in enterprise applications operated without any significant DTRP loss. As disk capacities increased, however, tracks were squeezed closer together. Additionally, higher spindle speeds (10,000 RPM, for example) generate higher vibration levels in servers and storage arrays. These two factors make hard drives operating in these environments more susceptible to DTRP degradations.

To maintain their DTRP under high RV environments, the WD enterprise drives employ RAFF technology through an adaptive feed-forward compensation scheme.

What is Rotational Vibration?

There are many ways RV is induced on a hard drive. Some typical sources inside the system chassis originate from fans or other drives' spinning and seeking. However, RV can also be induced by external sources such as rack fans or other systems mounted in the rack. Even linear vibrations applied on a chassis may get converted to RV at the drive level if a chassis is not designed appropriately. An example of this would be a drive bay structure that is not rigidly attached to a chassis.

RV produces the effect of making a hard drive vibrate about an axis. The effect of this vibration on hard drive is a loss of data transfer rate performance. In an RV environment, a hard drive head is prevented from settling on a data track quickly to start reading or writing data and/or is shaken off a track while reading or writing is in progress. Once the head is outside of a safe operating region over the track, either of these conditions will cause the drive to delay its scheduled operation. Until the head returns to and stays within the safe operating region, the drive will not return to normal operation. These unscheduled delays degrade the data transfer performance rate of the drive. Therefore, an RV management system is required to maintain the DTRP required of enterprise class drives.

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How RAFF Works

RAFF overcomes the effects of RV on a hard drive by sensing RV disturbance and controlling head position to keep the drive heads within the safe operating region during read and write operations.

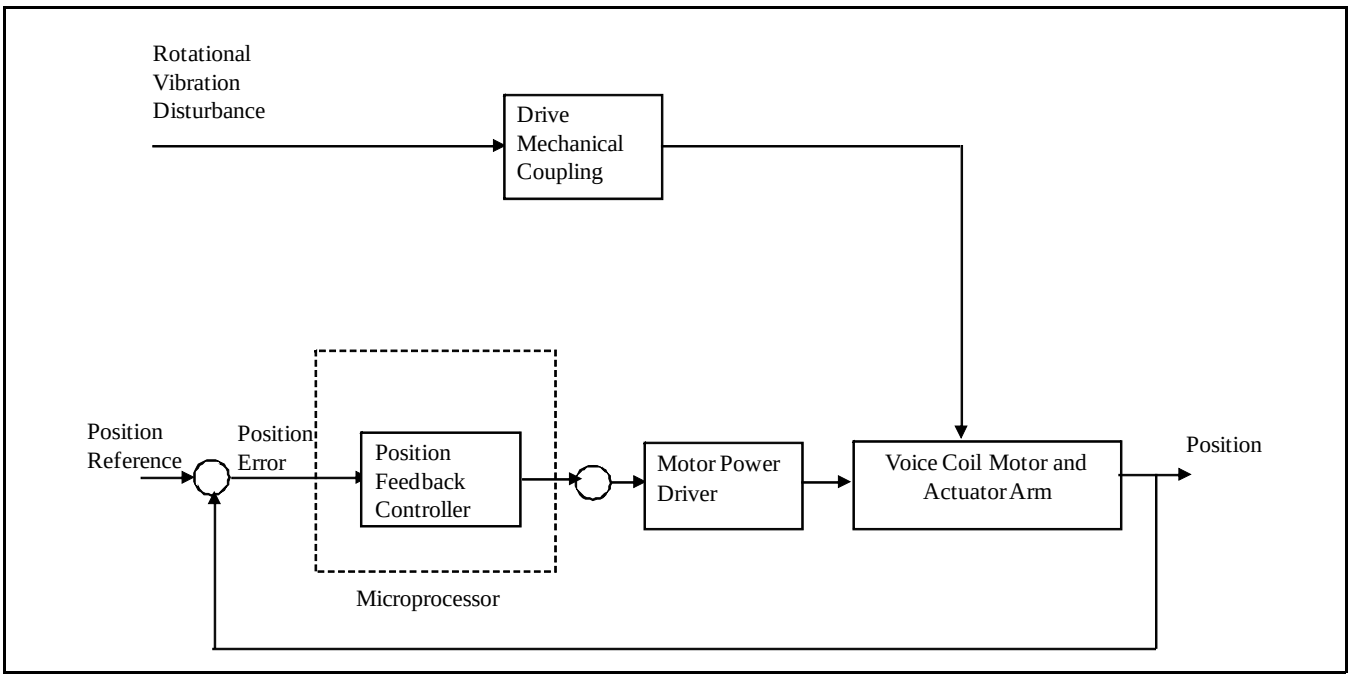
The RAFF implementation has three major components:

- RV sensing
- RV control effort feed-forwarding
- Adaptation to environmental conditions

RV sensing in the RAFF implementation is accomplished by using two linear accelerometers placed on the printed circuit board assembly (PCBA). The sensor locations are optimized for separation distance and PCB mounting conditions. The accelerometers produce signals due to vibration. The two signals are subtracted from each other to generate a Differential Sensor Signal (DSS). This signal is proportional to the vibration magnitude.

RV control effort feed-forwarding is achieved by digitizing the DSS. The digitized DSS is sent to the microprocessor. The microprocessor generates a control effort signal by processing the digitized differential sensor signal according to a sophisticated control algorithm. This feed forward control effort is in addition to the conventional servo control approach in hard drive operations (see Figure 2).

Adaptation to environmental conditions is a key component to deliver the benefits of RAFF. The WD design selectively adapts to individual drive parameters to mitigate RV interference and maintain maximum performance in the hard drive.



Dual Linear Sensor RAFF Functional Block Diagram

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