Rotational Vibration Testing of Hard Disk Drives

Project # 502

One of the problems that mechanical design engineers often encounter when working with hard disk drives (HDDs) is rotational vibration or RV as it is commonly called. When the RV characteristics of an operational HDD become too large or contain certain spectral content, the drive's performance is often compromised. Poor seek times, read/write errors and even lost data can be the result of excessive RV.

E-A-R Specialty Composites has developed a number of solutions to reduce RV when an HDD is mounted in typical consumer and enterprise electronic devices. In order to analyze an RV problem and quantify the effectiveness of such treatments, a relatively simple way to measure HDD RV has been developed and is explained here.

Utilizing a multi-channel signal analyzer, two accelerometers and a bit of clever programming, E-A-R engineers have devised a quick and easy test procedure that can gauge and quantify HDD RV. These data can then be used to analyze HDD dynamics, develop RV solutions and validate the results. Here's a brief description of the methodology and an example of a pure tone RV calibration test.

Definition

A system will undergo *rotational vibration* when an oscillating moment is applied. When a hard disk drive is idle, the oscillation can be caused by friction in the spindle bearings or by rotational imbalance of the platter(s). When the drive is under read/write or seek conditions, inertia forces from activity of the actuator arm can cause RV.

Rotational vibration is characterized by **rad/sec^2**, which is the rotational analog of linear acceleration **m/s^2** or **G**.

The rotational power of a system is represented as **(rad/sec^2)^2/Hz**, which is the rotational analog of **G^2/Hz**.

Test Setup

Here is a sketch of a simple test setup to measure HDD RV.

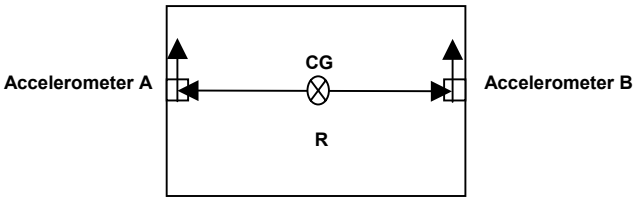

Figure 1: Geometry for RV calculation

The distance between the two accelerometers is **R**. The center of gravity of the hard drive is centered to both length and width of the hard drive in the orientation shown above. To determine the rotational *power spectral density*, the linear measurements from the two accelerometers are taken using the two digitized signals as a function of time.

Here is the equation, using metric units:

$$RV = FFT\left[\frac{(A(t) - B(t))*9810}{R}\right]$$

A(t) and **B(t)** are the digitized acceleration time signals from Accelerometer A and B.

FFT stands for Fast Fourier Transform.

RV is rotational vibration in **rad/sec^2**.

Aearo E·A·R Specialty Composites

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Resulting Data

E-A-R's data acquisition system gathers a *time domain* signal for the HDD RV, given in radians/second^2. From this, a *frequency response* and a power spectral density are computer-generated. For example, the top graph in Figure 2 depicts the time domain signal for a sinusoidal input moment of a hard drive at 159 Hz. The middle and bottom graphs show the frequency response and power spectral density. Most often it is this bottom figure that hard drive manufacturers use to characterize the vibration in a system.

In an actual lab project, E-A-R applications engineers will utilize all three views (time domain, frequency domain and power spectral density) of the RV data to analyze the system and determine the controlling factors for the given HDD and supporting structure. It should also be noted that actual HDD RV data looks quite different from the pure-tone data provided in this example. Real RV data is typically more broadband—especially during seek conditions.

Once the system dynamics are well understood, a series of treatments are installed and evaluated using the same test procedure. E-A-R can often reduce RV levels by adding damped isolation, structural damping or making other modifications to the mounting system or chassis structure. Once the best treatment (or combination of treatments) is obtained, a final RV measurement is taken and compared to the original baseline RV data.

Attenuation of HDD RV can be a very challenging task. Utilization of highly damped materials during the design stage will help keep this problem at bay. For more information on how to measure and control HDD RV, contact E-A-R Specialty Composites.

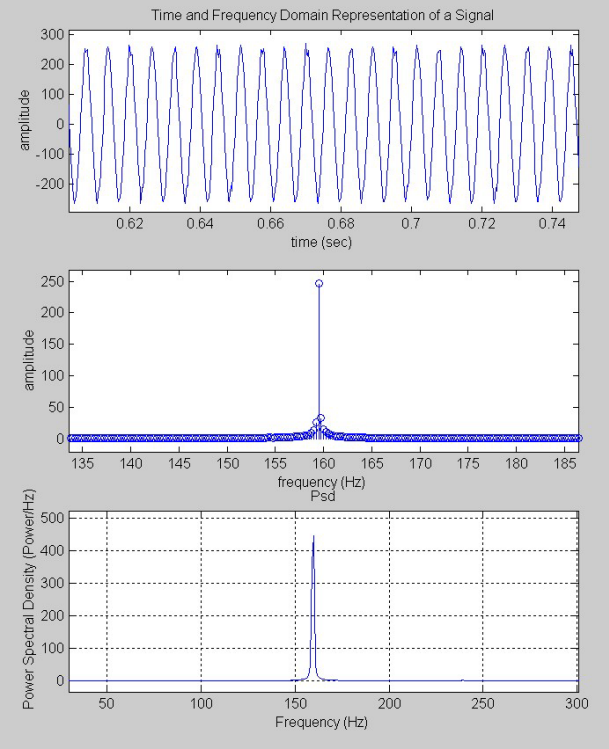

Figure 2: RV Test Result

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