

COMPUTER CHASSIS VIBRATION TEST OVERVIEW

By Tom Irvine

Email: tomirvine@aol.com

February 28, 1999

Note this test plan overview is based on conversations with Dan Blick of Western Digital.

INTRODUCTION

The overall test objective is to determine the vibration power flow through a chassis containing SCSI devices.

The chassis is assumed to contain a number of hard drive units. A hard drive is the primary SCSI component of interest. Each hard drive is both a source and a recipient of vibration energy. The hard drives are connected both mechanically and electrically by a backplane, as shown in Figure 1.

A specific goal of the testing is to determine the response at a given hard drive due to the vibration of a separate hard drive.

The testing consists of three parts:

1. Transfer function measurement
2. Position error signal evaluation
3. Modal testing

The test plan outlined in this report is intended as an initial approach. Refinement of the plan is expected as data is collected and analyzed.

MEASUREMENT PARAMETERS

Axis

The measurement axis of concern is the rotational vibration about the Z-axis, as shown in Figure 1. This is the yaw vibration.

Torque

A single hard drive is powered and operated. This drive acts as the vibration power source. Both the reaction torque and angular acceleration of this drive are measured. A transfer function will be calculated by dividing angular acceleration by torque. This transfer function is referred to as a frequency response function.

Torque can be calculated from force. Force transducers are available, but force is difficult to measure. Force is analogous to electrical current. The "mechanical circuit" must be broken in order to measure force. There is insufficient space to insert a force transducer between a hard drive and the chassis wall, however.

An alternative is to measure the voice coil motor current I_{vcm} . This can be done by cutting an electrical trace inside a hard drive. A wire loop is inserted to facilitate the current measurement.

The current can be measured as a hard drive undergoes random read and write operations. These operations produce a reaction torque, which in turn produces an acceleration response. The torque is assumed to be proportional to this current.

Angular Acceleration

Angular acceleration can be calculated from a pair of translational accelerometers, as shown in Figure 1. The phase angle between the two accelerometers can be inspected to verify true rotational motion. The relative phase angle should be 180 degrees.

TRANSFER FUNCTION

Source Transfer Function

Consider that a hard drive designated by index i is powered.

A transfer function $H_{ii}(f)$ is calculated as follows

$$H_{ii}(f) = \frac{\alpha_{ii}(f)}{I_{vcm_i}(f)} \quad (1)$$

where

$\alpha_{ii}(f)$ is the Fourier transform of the angular acceleration of the powered drive i .

$I_{vcm_i}(f)$ is the Fourier transform of the voice coil current in the powered drive i .

Note that the transfer function and the acceleration each have two subscripts. The first i indicates that drive i is the source of the power. The second i indicates that drive i is also the response location.

Neighbor Transfer Function

Acceleration measurement must also be measured on each unpowered drive. Consider an unpowered drive designated by index j . Hard drive i is the excitation source.

The neighbor transfer function $H_{ij}(f)$ is calculated as follows

$$H_{ij}(f) = \frac{\alpha_{ij}(f)}{I_{vcm_i}(f)} \quad (2)$$

where

$\alpha_{ij}(f)$ is the Fourier transform of the angular acceleration of the unpowered drive j due to excitation from drive i.

The transfer function is a tool for understanding the relationship between angular acceleration and torque. This function is a required input for modal testing, which is discussed later in this report.

POSITION ERROR

Angular Displacement Functions

An angular displacement Fourier transform $\theta_{ij}(f)$ can be calculated by double-integrating the acceleration Fourier transform for drive j.

$$\theta_{ij}(f) = -\frac{\alpha_{ij}(f)}{(2\pi f)^2} \quad (3)$$

Assume that i equals j in equation (3). In other words, a hard drive is undergoing self-excitation. The arm is assumed to remain stationary due to its inertial mass while the disk undergoes the oscillating angular displacement. The angular displacement is thus a relative angular displacement.

The disk is spinning at some fixed rate. The control algorithm already accounts for this. The problem is that the angular displacement oscillation is superimposed on the spinning rotation. The result is a position error.

The position error may be severe enough that the arm's read/write head cannot perform its required operation at a given instant. Thus, the head must wait until the disk spins around one more time so that another attempt can be made. The performance of the hard drive is thus degraded.

Position Error Signal

The position error signal is designated as PES(f). A limit of acceptable error can be applied against this function. The position error of drive j due to excitation from drive i is calculated as

$$PES_j(f) = [\theta_{ij}(f) R][H_{ERR}] \quad (4)$$

where

R is the radius from the pivot to the read/write head, inside drive j.

H_{ERR} is the error rejection function, which is supplied by the hard drive vendor.

The angular displacement term in equation (4) could be modified to represent the sum of drive j 's reaction to its self-excitation plus its response to excitation from its neighbors.

Modal Testing

The chassis side panel can be divided into a grid. Accelerometers can be mounted at the grid intersection points. The accelerometers would thus be mounted normal to the panel and in the Y-axis. A single drive could be powered and operated. Its voice coil current could be measured to determine the torque, as previously discussed.

A computer with modal software is required to carry out the test. The software could be setup to form the proper transfer functions. The chassis natural frequencies, damping ratios, and mode shapes could thus be determined.

The test can be extended by mounting response accelerometer at additional locations throughout the chassis.

A particular concern is the frequency domain from 500 Hz to 700 Hz. Control algorithms vary from one hard drive model to the next. Most algorithms, however tend to be sensitive in this frequency domain. Ideally, the chassis does not have any significant natural frequencies in this domain.

The purpose of the modal test is thus to determine the dynamic response characteristics of the chassis, with particular concern for the 500 Hz to 700 Hz frequency domain.

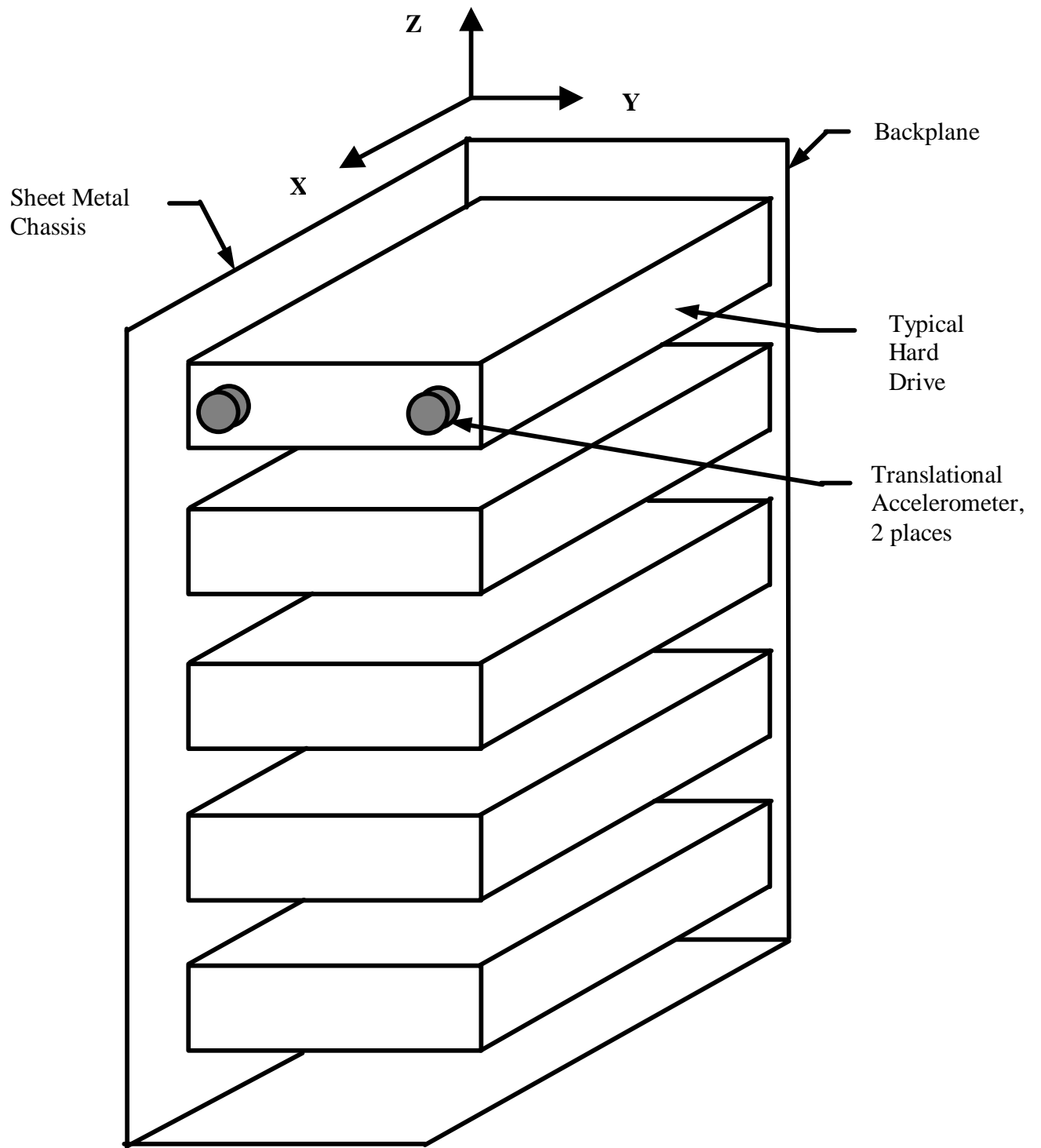


Figure 1. Chassis with Hard Drive Units