A Failure Analysis Tool for HDD Analysis

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Abstract—The study of piezoelectric material in the past was in the T-Domain form; however, no one has studied piezoelectric material in the S-Domain form. This paper will present the piezoelectric material in the transfer function or S-Domain model. S-Domain is a well-known mathematical model, used for analyzing the stability of the material and determining the stability limits. By using S-Domain in testing stability of piezoelectric material, it will provide a new tool for the scientific world to study this material in various forms.

Keywords—Hard disk drive, failure analysis, tool, time

I. INTRODUCTION

THE HDD is one of the important devices, and the most significant component, of the personal computer (PC). It is estimated that over 90% of all new information produced in the world is being stored on magnetic media, mostly on hard disk drive [1-2]. The HDD is a highly complex, mass-produced, electro-mechanical device that utilizes principles of magnetic recording for data storage. As fundamental elements of modern computer systems and consumer electronic devices, HDDs have managed to combine a steady increase in storage density and capacity with a concomitant decrease in the cost per megabyte. The HDD combines the most recent achievements in the science and technology of magnetic recording, material science and digital signal processing [3].

The general, HDDs in factories - before sent to user handle - must "pass" several reliability and quality tests. These tests are highly complex throughout every step of the process to ensure product quality. Thus, some produced HDDs are not accepted - failed. These failed drives are removed and afterwards, sent to analyze their cause of failure. [4]

Section II describes about the general HDD, from the beginning of "What’s is a HDD?", to components of the HDD and read/write operation of the HDD. The entire FA process is explained in section III, as this software is produced as a FA tool. Section IV will describe the details of this tool. And the step by step method is given in section V. This paper is proposed to support first analysis of HDD.

We assume the FA operating and usage time support in the FA works as a basis. This tool can be used to help reduce the time.

II. THE HARD DISK DRIVE

The HDD is a random access digital data storage device. It features rotating rigid platters on a motor-driven spindle within a protective enclosure. The data is magnetically read from and written to the platter by read/write heads that float on a film of air above the platters. [5]

The component of the HDD, consist head (read/write), disk (platter) spindle, actuator (arm and axis) and connector (IDE and power) as shown in Fig. 1.

![Fig 1 The component of the HDD](image-url)

The HDDs record data by magnetizing ferromagnetic material directionally. Sequential changes in the direction of magnetization represent patterns of binary data bits. The data are read from the disk by detecting the transitions in magnetization and decoding the originally written data.

A typical hard disk drive has two electric motors; a disk motor that spins the disks and an actuator (motor) that positions the read/write head assembly across the spinning disks.

The disk motor has an external rotor attached to the disks; the stator windings are fixed in place. Opposite the actuator at the end of the head support arm is the read/write head (near center in photo); thin printed-circuit cables connect the read-write heads to amplifier electronics mounted at the pivot of the actuator. A flexible, somewhat U-shaped, ribbon cable, seen edge-on below and to the left of the actuator arm continues the connection to the controller board on the opposite side.

The capacity of an HDD may appear to the end user to be a different amount than the amount stated by a drive or system manufacturer due to many things; different units of measuring capacity, capacity consumed in formatting the drive for use by an operating system and/or redundancy.

In modern HDDs, spare capacity for defect management is not included in the published capacity. However, in many early HDDs a certain number of sectors were reserved for spares, thereby reducing capacity available to end users.
In some systems, there may be hidden partitions used for system recovery that reduce the capacity available to the end user.

Because modern disk drives appear to their interface as a contiguous set of logical blocks, their gross capacity can be calculated by multiplying the number of blocks by the size of the block. This information is available from the manufacturers’ specification and from the drive itself through use of special utilities invoking low level commands.

III. THE HDD FUNCTIONALITY

The HDD is used by a computer to store the operating system (OS) and the user’s data. The HDD is one of the most important component of the modern PC: no application will run reasonably without the hard drive. [6]

A. The Magnetic Recording Basics

The reading process includes excitation of the current in the head coil when the head “senses” changes in the magnetic flux. The read voltage pulses at the flux transitions are then translated into sequences of bits equal to 0 and 1. The so-called Wallace's spacing loss factor postulates that the loss of magnetic signal power will be proportional to the media - head separation. This requires magnetic heads to fly as close to the disk surface as possible. That is shown in Fig. 2.

Continuous improvement of the head design allowed extremely high densities of magnetic recording with magnetic bits getting smaller and smaller. But, the head is only one component of the magnetic recording system, with magnetic media being extremely important as well.

The first magnetic media was called “particulate media” because it included particles of iron oxide (as the magnetic medium) and aluminum oxide (for abrasive resistance). Modern magnetic media is called “thin-film media” and consists of very thin layers with a total thickness of about 500 angstroms or 50 nm. The next figure presents a not-to-scale sketch of one of the kinds of thin-film media.

This thin sandwich is usually deposited by physical vapour deposition (when the atoms of different materials are formed on the surface with the minimum of chemical reaction involved) on the metal disk. Magnetic layer is needed to store the data. The reasons for having a thin carbon layer are simple: it increases mechanical durability of the disk and slows down corrosion of the magnetic layer. This carbon is sometimes called a diamond-like carbon (DLC) since it has similar chemistry to the diamond (both are mostly carbon), it is very hard (Diamond is VERY hard!), and it provides low friction.

A thin layer of lubricant on the top is used to minimize the wear of the carbon layer. The all layers are shown in Fig. 4.

B. The Basic hard disk drive concepts

These are descriptions to accompany drive physical and logical organization as shown in Fig. 5.
A part of each track defined with magnetic marking and an ID number. Sectors have a sector header and an error correction code (ECC). In modern drives, sectors are numbered sequentially.

**Cylinder**

A group of tracks with the same radius is called a cylinder (red tracks on the picture belong to one cylinder).

**Data addressing**

There are two methods for data addressing: CHS (cylinder-head-sector) and LBA (logical block address). CHS is used on most IDE drives, while LBA is used on SCSI and enhanced IDE drives.

**Track**

A concentric set of magnetic bits on the disk is called a track. Each track is divided into 512 bytes (usually) sectors.

**Sector**

A part of each track defined with magnetic marking and an ID number. Sectors have a sector header and an error correction code (ECC). In modern drives, sectors are numbered sequentially.

The abnormal head crash can be a sign of a failing HDD, but because the HDD automatically adds them to its own growth defect table, they may not become evident to utilities such as ScanDisk unless the utility can catch them before the HDD's defect management system does, or the backup sectors held in reserve by the HDD enclosure and its outside environment. If the filter fails to provide an effective system for cataloguing, tracking and data collection required for failure analysis. Such analysis is performed on all failed drives received.

An overall FA process must hold responsibility to provide an effective system for cataloguing, tracking and data collection required for failure analysis. Such analysis is performed on all failed drives received.

The FA can be distributed in four levels [8], first level (Electrical Analysis or Isolation) means error definition is chargeable or non-chargeable, this important issue is given first priority. Second level (Electrical Analysis or Identify symptom) means a symptom and possible root cause identification. Next level (Mechanical Analysis) means a root cause identification into component parts related to a failure symptom. And final level (Component Analysis) means a root cause identification of material and a major component (Head, Disk and PCBA). All levels are combined into one issue; time used in throughout all analysis is long. Most of the time is lost in the analysis done in DOS command (In first analyze, it will interface between drive and tools with DOS command). Thus, we develop a tool to shorten this time duration, it will help to reduce the time in half of all processes. This is described detailed in the next section.
V. THE FA SOFTWARE TOOL

The primary objective of this tool is reducing the time for analysis. It can help speed the initial drive’s information retrieval rather quickly. Flowchart of this tool is shown in Fig. 6. First, retrieve the basic drive’s information in order to seek for the failed positions. After that, analyze at that position. We find the root cause of failure at this position. If no cause is apparent, we re-analyze around the failed position initially retrieved for data. Finally, if enough data is attained, summarize to report the root failure cause. All steps (from flowchart) is the general concept or basic FA form. Practical (real operation) usage has much more detailed specifics, which are not further explained here in this paper.

VI. THE PROCEDURE’S GUIDE

The general user can use this tool by the following guide: First, Open the software “HDD Pro”. At first page see insert block “Please input HDD serial number”. You can type the serial number of HDD product and press “OK” (see Fig. 7 (a)). If input serial number is incorrect, the message “Not found” will be shown. Please input the correct serial number. Next, the detail of this product will be shown. “Serial number”, “Model”, “Product number”, “RPM”, and “Failed Position” (see Fig. 7 (b)). Now, we know the failed position. Input that (cylinder-head-sector) into the block and press “OK” (see Fig. 7 (c)). It will show the failed position (red-failed) as bit flip, the table form of data in HDD (see Fig. 7 (d)). And the last page, will show waveform and some additional data (see Fig. 7 (e)). Notice: This software is a reference model to a future product. It cannot provide all information of drive, due to confidentiality.
VII. CONCLUSION

This software tool is a model based on the assumption that FA operating and usage time support in the FA works. It can be used to help analyze the basic problems of the HDD in operating systems effectively and accurately. It can reduce the time to analyze problems from retrieved drive information and other useful data in the FA operation. In the future, FA can utilize usage of this tool ranging from very basic analyzes to more advanced usage.

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