Drive Fitness Test

Part of the drive fitness technologies, Drive Fitness Test (DFT) uses a PC-based program to access special hard drive microcode that is designed to enable Original Equipment Manufacturer (OEM) system manufacturers and service providers to diagnose the proper operation of hard drives. Drive fitness technologies are a set of diagnostic tools, such as DFT and Self-Monitoring Analysis and Reporting Technology (S.M.A.R.T.), that provide error logging and self-test capabilities.

Designed to address problem situations where end users suspect hard drive malfunction, the DFT program can be integrated into the system diagnostic package, which system integrators can distribute by diskette, CD-ROM, or in a special protected partition on the hard drive. DFT can then be invoked by the end user, possibly at the direction of the system OEM telephone support staff.

It has been discovered that, in most problem situations, DFT finds that a suspected hard drive problem is in fact not a malfunctioning hard drive. In this way, DFT can significantly reduce end user disruption and the growing expense associated with hard drive replacement, while helping end users determine the root cause of the problem.

The hard drive diagnosis problem

OEM system manufacturers typically support end users via telephone centers that answer calls, diagnose problems, and instruct end users with corrective actions. One of the biggest challenges in remote support is rapid and correct diagnosis of a problem's root cause so that the right fix can be applied. An end user often describes a symptom (for example, "Windows will not boot") that has many possible causes. Often, end users assume that the hard drive is defective ("so probably my hard drive is broken").

End users have a natural tendency to assume that there is a hard drive defect, because programs and data reside on the hard drive — and many error messages are not easily understandable, such as "data error occurred in user application at 8E000."

Costly replacement

Incorrect diagnosis of the hard drive is expensive for the OEM system manufacturer, but incorrect diagnosis is discovered only when the returned hard drive is tested and verified as No Defect Found (NDF). Unfortunately, the drive replacement cost has already been incurred, yet the true system problem might still be uncorrected.

Many OEM customers' telephone support centers receive problem calls within 30 days of shipment from the owners of as many as one to two percent of the new systems shipped. A significant number of these calls involve problems that potentially result in unnecessary hard drive replacements, so up to one percent of hard drives might potentially be returned within 30 days of shipment. It has been our experience, however, that approximately 80 percent of these returns are NDF. Many of the remaining 20 percent are found to have been damaged by the end user but replaced at the system OEM's expense.

In addition to the cost, hard drive replacement is traumatic and disruptive for end users and therefore should be viewed as the repair of last resort. If the hard drive is replaced but is not defective, the end user has experienced a disruption. Yet the underlying problem could still recur. According to a survey by PC Magazine[1], customer satisfaction with accurate repair is a key indicator in repeat buying. Based on 17,000 responses, repeat buying correlated more closely with repair satisfaction than with percent of systems needing repair.

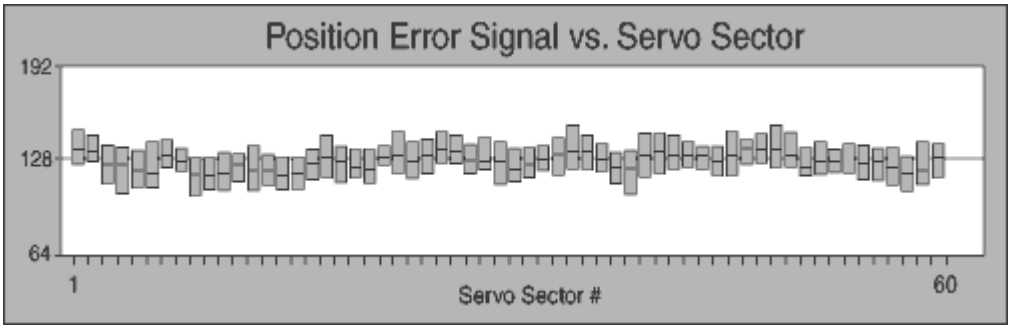
What is Drive Fitness Test?
Drive Fitness Test (DFT) is a technology that uses a PC-based software program that accesses Hitachi hard drive microcode to enable diagnosis of hard drive operation.

DFT microcode in the hard drive
DFT microcode automatically logs significant error events, such as hard errors and a history of all reassigned sectors. This log is kept in a special reserved area of the drive.

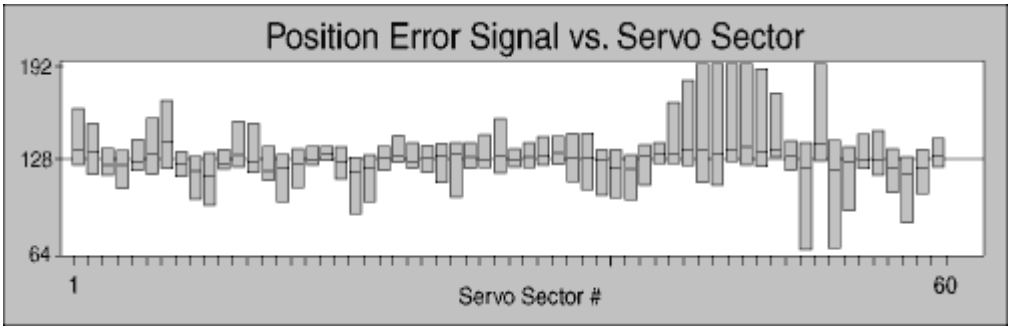
DFT microcode also performs mechanical analysis of the hard drive in real time. Parameters such as disk shift, servo stability, and Repeatable Runout (RRO) can be calculated dynamically by reading the servo's Position Error Signal (PES) and analyzing the patterns in the PES. This is a powerful, new concept -- the signals that control the actuator with sub-micron accuracy are also used to analyze the mechanical status of the disk stack, actuator, and servo system.

The DFT microcode also supports the creation and use of a special protected "diagnostic partition" on the media. This so-called logical volume is a separate range of sector addresses that can be used to contain the DFT software and other diagnostic software.

Example of patterns analyzed by DFT microcode:
PES of good drive



PES of defective drive



DFT software
DFT is a program that diagnoses the state of a hard drive by using S.M.A.R.T. as well as other special microcode features. DFT software is intended to be bundled together with other diagnostic software by the system OEM to create a standalone package. A version of DFT with a menu for end users is available for download at www.hitachigst.com/support/downloads/.

DFT is standalone software that runs under DOS independent of the end user operating system. Once DOS is booted, DFT can execute whether or not other software is operating properly.

DFT executes and categorizes the drive into one of four states:

1. Drive is defective
2. Drive has been damaged by shock
3. Drive will soon fail (S.M.A.R.T. flag set)
4. Drive is operating properly and replacement is not necessary

The value of DFT is that fault diagnosis is automated, not subjective. The end user and the service personnel can determine whether the hard drive hardware is malfunctioning, and take the appropriate action accordingly.

DFT software test modes
DFT software supports three test modes: Quick Test, Media Scan, and Exerciser.

In Quick Test mode, DFT:

- Verifies functionality
- Reads and analyzes the error history of the drive
- Checks the S.M.A.R.T. function for impending failure
- Performs detailed mechanical analysis based on PES
- Reads and writes with every head
- Scans the drive's first 500K sectors, which contain vital programs and data

Quick Test mode is designed to complete in less than two minutes and diagnose status in more than 90 percent of problem call situations. This mode is intended to run while the end user is online with the OEM telephone support staff.

In Media Scan mode, DFT performs the Quick Test and also reads every sector to verify full media data integrity. Media Scan Mode is designed to complete in approximately 15 to 30 minutes, depending on the hard drive capacity. It is intended to be run by the system OEM during system manufacture to verify the media surface. Media Scan mode can also be run by an end user who suspects that defective media sectors might exist. However, media scanning is not required to determine past error-free operation. Because of the error logging microcode, the Quick Test is designed to determine in less than two minutes whether there has been error-free operation during the history of the drive.

In Exerciser mode, DFT performs random reads and writes for a user-specified length of time. This mode is designed to simulate normal drive use and is intended to find the small class of intermittent problems that appear and disappear.

DFT results are logged in the drive's reserved area for future reference. Each log record is a snapshot of the status of the drive. Certain records in this wrap-around log can be marked and saved. This enables permanent recording of key drive parameters at well defined times, such as at the time of system manufacture or the time of end user installation.

Storing DFT on the drive in a protected area for instant access
A key enabler to successful hard drive verification in a telephone environment is rapid access to the diagnostic software, which should reside on the hard drive in a location that is always known. In a problem call situation, however, the normal software to access the drive might not be working properly. To solve this dilemma, DFT microcode is designed to support the creation of a "logical volume" in which the OEM system manufacturer can store diagnostic programs, including DFT.

Product strategy for DFT

ATA desktop and mobile hard disk drives introduced since late 1998 have full DFT microcode support, and the DFT program supports ATA drives introduced since 1995. Support for SCSI drives might be added at a later date. [2]

Frequently asked questions about DFT

Q: What is the relationship of DFT to S.M.A.R.T.?

A: S.M.A.R.T. is a technology designed to enable a hard drive to predict impending catastrophic failure. S.M.A.R.T. is implemented in hard drive microcode. To use S.M.A.R.T., a system OEM writes software that reads the S.M.A.R.T. status at the ATA or SCSI interface and presents the S.M.A.R.T. status to the end user. In the latest S.M.A.R.T. revision, commands can also perform some self testing of the hard drive.

Drive Fitness Test is a logical extension of S.M.A.R.T. in three ways:

1. Microcode: DFT microcode includes enhanced diagnostic capabilities that complement and supplement the S.M.A.R.T. implementation while supporting logical volume creation and use.
2. Software: DFT is a program that reads the status of S.M.A.R.T. attributes and provides other diagnostic capabilities.
3. Meaning of Verification: S.M.A.R.T. attributes predict imminent catastrophic failure. As such, a hard drive with good S.M.A.R.T. status will not soon experience catastrophic failure. However, there are many defect situations or malfunctions that are not related to catastrophic failure, such as a single sector with a hard error. More of these situations can be diagnosed by using DFT.

Q: Do you plan to enhance DFT over time?

A: As with all technologies, we expect advancements over time. For example, consider bad sector repair. If a sector with bad ECC is detected, DFT can overwrite the sector and "repair" it. Or, if the sector is permanently damaged, it can be reassigned. Thus, DFT could be enhanced to include an additional outcome: "Drive was defective, but now it is repaired."

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1 PC Magazine, July 1998, pp. 219-237
2 Development plans are subject to change at any time without prior notice.