



“Command completion time measurement tool White Paper

IDEMA JAPAN Consumer HDD committee

Chairman Ryosuke Shimizu Matsushita Electric Industrial Co., Ltd. 1-15 Matsusuo-cho, Kadomacity Osaka, JAPAN 571-8504 Phone: 81-50-3487-3377 Fax: 81-6-6905-4608 shimizu.ryosuke@jp.panasonic.com	Vice Chairman Seiji Kawagoe Toshiba Co. Digital Media Network Company 1-1 Shibaura 1, Minato-ku Tokyo, JAPAN 105-8001 81-3-3457-2463 81-3-5444-9400 seiichi.kawagoe@toshiba.co.jp	Vice Chairman Shoji Tanaka SONY Co. Chemical Device Business Group Disc & Memory Device Div 5-1-12 kitashinagawa shinagawa-ku Tokyo 81-3-5448-2549 81-3-5448-3257 shoji.tanaka@jp.sony.com
--	---	---

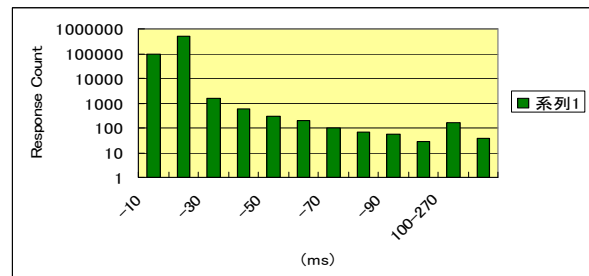
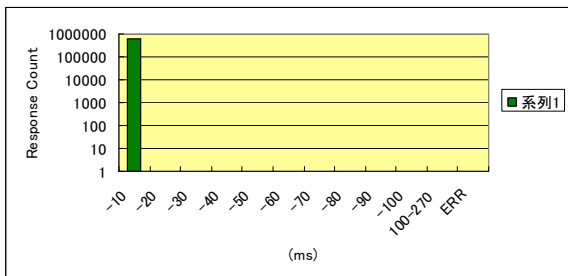
1. Introduction

The purpose of this white paper is to introduce testing method which is good for designing PVR application design. These two methods give the parameter about which CE maker discuss about CE application of HDD with an HDD maker.

Two procedures are explained in this white paper. The first is a simple testing procedure that involves only a sequential access to HDD and a simple data analysis method. The other is a detailed testing procedure that involves HDD access with seek and a detailed but rather complex data analysis method. In AV application, the meaning of HDD performance differs from that in IT application. **The best case in access speed is not as important as sustaining responses below a certain level.** Both procedures share the same goal to detect the rate and magnitude of responses and offer a way to analyze AV performance numerically.

2. Simple benchmark

- | | |
|------------|--|
| 1) Method | 1. 1ch Read in all surfaces
2. Sequential
3. every 128KB (256 sectors)
4. make Command Completion time to histogram |
| 2) Purpose | 1. Firm wear mature ness
2. Head and Media reliability
3. HDD relative evaluation : initial - Life test |
| 3) Example | Case1 |



3. Detailed benchmark

A. Procedure

a) Seek pattern

Three seek patterns, Outer-to-Inner, Inner-to-Outer, and Middle-to-Zigzag, are used in this test method. The default head position is fixed for each pattern, the outermost track for Outer-to-Inner, the innermost track for Inner-to-Outer, the track where max_LBA/2 is located for Middle-to-Zigzag. The commands to be measured are issued when the head is tracking the default position. After the command completion, the head is again positioned on the default track. Figure 1, 2, and 3 show each test pattern.

b) Measured Commands

It is recommended to perform the test under a fast host data transfer mode such as Ultra DMA Mode 4. Under a slow host transfer mode, the host data transfer dominates the command completion time, and it becomes difficult to observe HDD characteristics such as seek speed. The sector count per command is fixed at 256 sectors. Time duration between a command register write and a command completion interrupt is measured as command completion time. The seek distance in terms of LBA and the command completion time are recorded.

c) Seeking the default track and SEEK command problem

After each command completion time measurement, the head must be positioned on the default track. In order to do so, SEEK command might come up as the reasonable way. However, there are some problems in how SEEK command is implemented in HDD's. Some drives return SEEK command completion even though the head is not tracking on the target track. If a command completion time is measured under such a condition, an accurate measurement becomes impossible since the default head position is not fixed.

In order to avoid this problem, the following method is used. When READ command is measured, WRITE command is used to position the head on the default track and vice versa. The reason to use the opposite command to seek the default position is that the same command as measured command is unable to ensure actual seek if the cache is enabled.

	Measured Command		Seek
Read Test	READ		WRITE
Cache	On	Off	Off
Write Test	WRITE		READ
Cache	On	Off	Off

Tab. 1: Measured Command and Seek Command

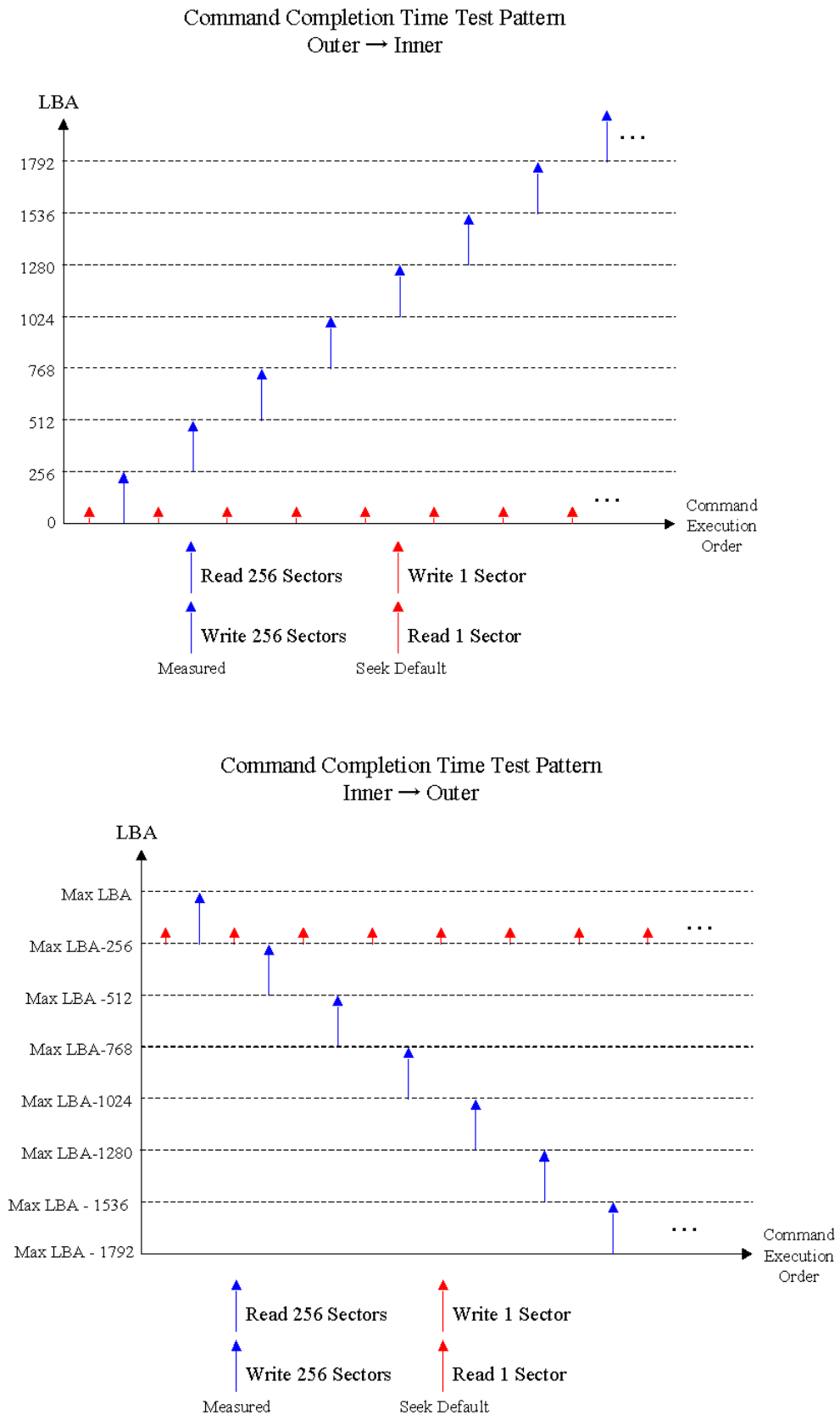
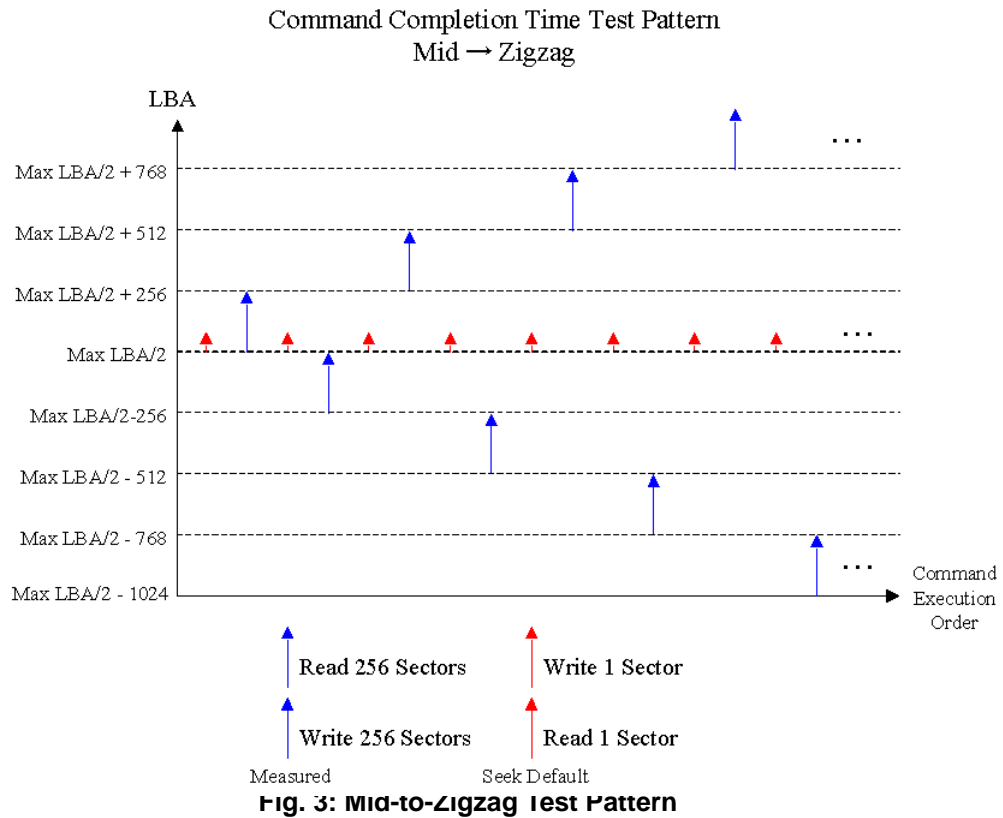


Fig. 2: Inner-to-Outer Test Pattern

IDEMA-JAPAN "Command completion time measurement tool" Proposal



B. Data Analysis

Figure 4 shows an example of test results. The target HDD is a typical 5400rpm 80GB HDD.

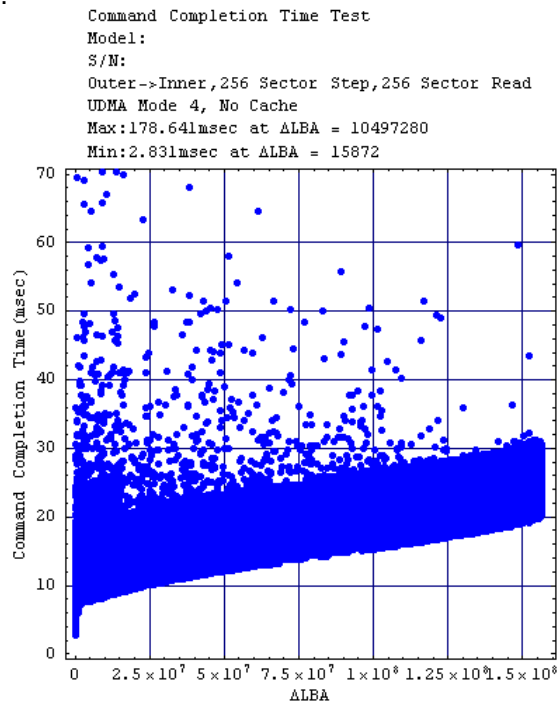


Fig. 4: Example of Read Test Result

IDEMA-JAPAN “Command completion time measurement tool” Proposal

In the figure, a belt of data points with a width of approximately 11msec is observed. Data points that belong to this data belt are considered as command completions without retries. The belt width corresponds to the drive's rotational latency. In this drive's case, the revolution period is about 11msec and matches with the width of the belt. The lower boundary of the belt indicates the command completions without retries and rotational latencies. The belt's lower boundary draws an increasing curve, and it indicates increasing seek time.

A distribution and magnitude of retries are a major interest in AV-HDD performance analysis. The depth of retry corresponds to the number of disk revolutions taken for the command completion. Generating a histogram with respect to command completion time can provide some information of retry distribution. However, a seek curve makes separation of command completions with respect to the disk revolution impossible. In order to solve this problem, the data modification is proposed.

By subtracting the belt's lower boundary curve, the overall data can be made flat and the data points can be separated into each disk rotational period. The lower boundary is calculated as the following. First, local minimum points for every 6000 samples are extracted from the original data. Then, the curve is obtained by applying a linear interpolation to the extracted local minimum points. An example is shown in Figure 5.

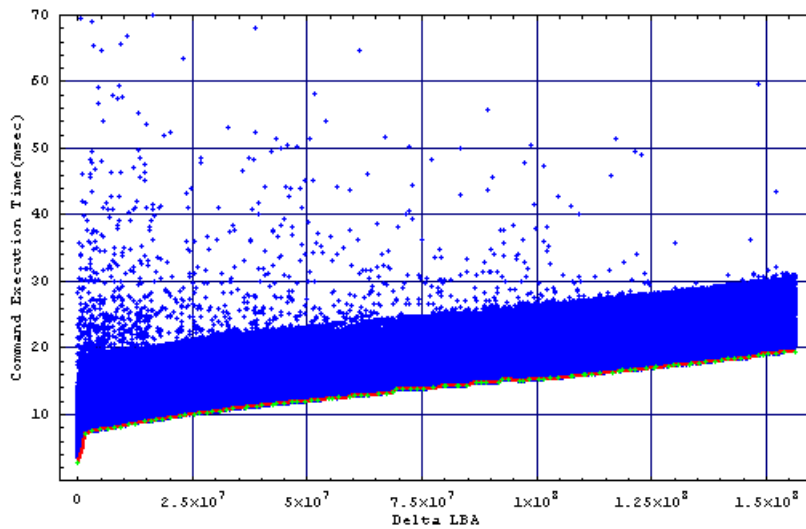


Fig. 5: Lower Boundary Curve

By subtracting the lower boundary curve, the data can be made flat as shown in Figure 6.

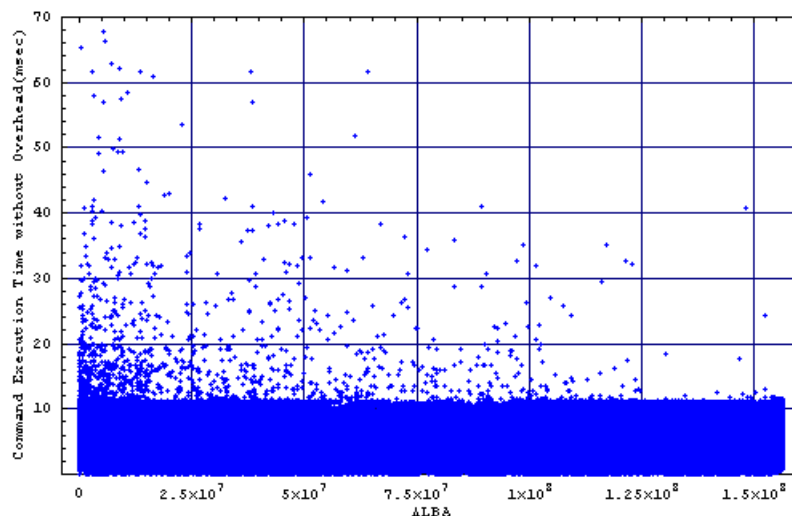


Fig. 6: Flat Data

IDEMA-JAPAN "Command completion time measurement tool" Proposal

A histogram with respect to the command completion time without overhead is obtained. The result is shown in Figure 7. In the figure, areas separated by dashed lines represent the disk rotational period. The revolution number corresponds to the depth of retries. As a result, the frequency of retries with respect to the retry depth can be numerically obtained.

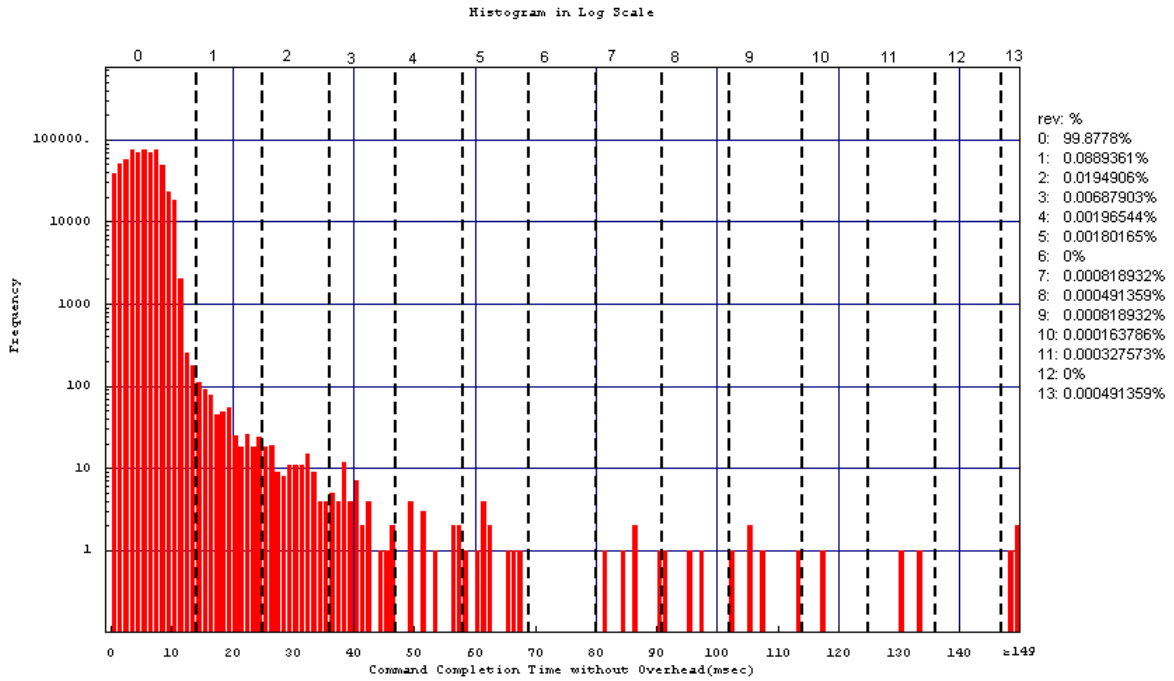


Fig. 7: Histogram