Adaptive Formatting in Hitachi Drives

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Introduction

In the late 1990s and early 2000s areal density for hard disk drives (HDD) approximately doubled every year, until reaching about 40Gb/sqin. Recently technology challenges have slowed the annual areal density growth rate to about half of what it had previously been. As advances in HDDs continue, new approaches will be required to further increase areal densities. Hitachi Global Storage Technologies has begun using Adaptive Formatting as one of the technologies which have allowed us to successfully produce HDDs in volume at areal densities higher than 70Gb/sqin.

Section 1. Technology

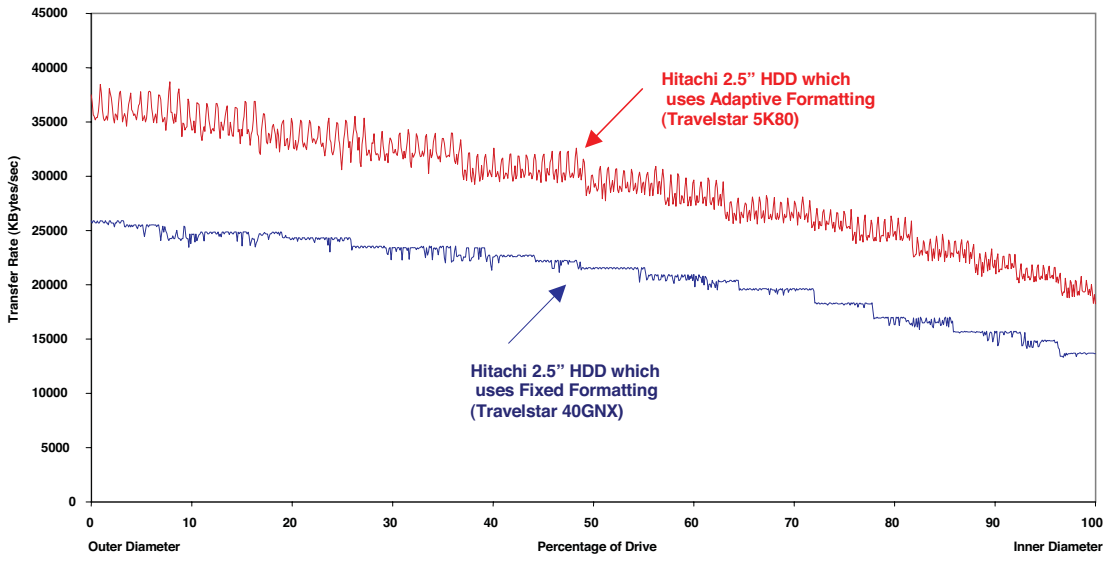
HDD areal density advances are limited by head performance and component tolerances (e.g. head track-width). These two elements are major issues that were impacting advancement of storage capacity in 2.5" HDDs. As a result, a new approach was needed to accommodate variations in component tolerances while increasing areal density. The traditional approach for handling head profiles for different storage capacities was to sort heads/HGAs based on track-width and Soft Error Rate (SER) performance. Different heads were then allocated to HDDs with different capacity design points. This approach was centered on a complex logistics plan and resulted in production output that was difficult to plan and predict.

Hitachi has implemented a new technology called Adaptive Formatting in our HDD manufacturing process. The Adaptive Formatting technology is utilized to provide customers with HDDs that have greater reliability through enhanced optimization of head performance. Each drive is individually tuned at the factory to match the heads and media used in that specific HDD. The media recording surface is formatted with an optimized Bits Per Inch / Tracks Per Inch (BPI/TPI) combination, depending on the performance characteristics of the head associated with that surface. The result is an increase of reliability and performance for specific head and media combinations. This procedure eliminates the possibility of marginal heads that can occur in a drive using fixed BPI/TPI formatting.

Section 2. Performance and Data Transfer Rate Graph

Head behavior characteristics with and without Adaptive Formatting technology can be observed in the graph of an H2bench test shown on the next page. The blue plot in the lower half of the graph represents a drive manufactured without Adaptive Formatting. This HDD uses fixed formatting (i.e. all heads and media are formatted with the same BPI/TPI combination). The red plot in the upper half represents a drive manufactured with Adaptive Formatting. The Y-axis represents the data transfer rate and the X-axis represents the percentage of media surface of the drive from the outer diameter (OD) to the inner diameter (ID).

Data Transfer Rate with H2Bench



The data transfer rate at the outer diameter is faster than that at the inner diameter of the disk. The different data transfer rate points on the curve represent unique head behavior amongst multiple heads within the drive. Using Adaptive Formatting, BPI can vary for each head/disk in the HDD. This creates variability both drive-to-drive and head-to-head. Different BPI translates to different data rate for each head. The data rate measured and observed at any point in time is dependent on which head is used. The sampling rate of the H2Bench graph is such that many points are plotted for each recording zone. Hence, the BPI-dependent transfer rate from each of the heads is displayed about ten to twenty times within each zone in the graph. This explains the "fuzzy" look of the graph representing an HDD with Adaptive Formatting, while the plot representing an HDD without Adaptive Formatting does not have this "fuzzy" look.

Conclusion

Adaptive Formatting is a technology which allows Hitachi to sustain high manufacturing volumes while meeting the ever increasing challenges of advancing areal density, thus meeting our customer requirements of high reliability and performance in HDDs.

References

(1) Performance test data—HGST Systems Integration Test Lab

(2) H2Bench developed by c't magazine: www.heise.de/ct/ftp

(3) Consultation with Spencer Ng (HGST Research), Walker Blount (HGST Mobile Strategy), Patricia Wadkins, Bob Suchomel, Michael Swat (HGST Systems Integration Test Lab), Hiroshi Deki, Takashi T Nakamura, Toshiaki Sakurai (HGST Fujisawa Mobile Development)

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