

## SanDisk SSD Performance: Faster Random Read Speed Translates into Enhanced User Experience

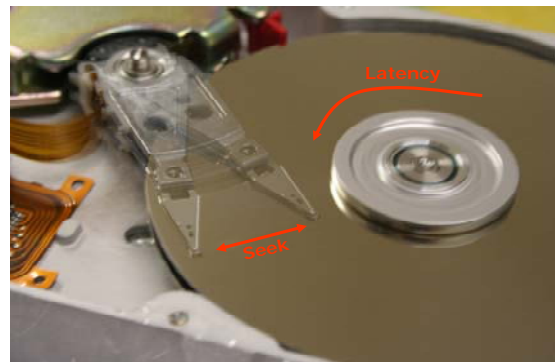
Why random read rate is so important to notebook users, and how a SanDisk solid state drive increases it

### Random vs. Sequential Reads

Everyone wants notebook computers to run faster, but few users are aware of how the mechanical workings of a hard disk drive (HDD) slow down the read operations performed repeatedly throughout the day. The key to understanding this impact is in recognizing the difference between random and sequential reads, and how often each operation is performed.

During random activity, blocks of data are accessed from random locations on different, non-adjacent sectors. During sequential activity, blocks are accessed one after another from adjacent sectors.

During random reads, the hard disk drive incurs a two-fold time penalty: while its head arm moves back and forth to seek data stored in different sectors and while the disk spins into place to align the required sector beneath the head arm.<sup>1</sup>



In contrast, a SanDisk solid state drive (SSD) requires neither of these mechanical activities.

How do these operations figure into everyday computer use? Consider what happens when an application is opened. Applications used in PCs consist of both data files and dynamic-link libraries (DLLs), which contain customized information for every user. Data files are read sequentially, but all of the application's associated DLLs are read and loaded randomly – from five or six disk locations for each DLL. Microsoft PowerPoint, for example, has 100 DLLs, whereas Acrobat Reader has over 1000 DLLs. The first requires 500 to 600 disk locations and the second needs 5,000 to 6,000 to retrieve data. This is why it takes so long to open these applications the first time with a HDD.

### How the HDD Causes an IO Bottleneck

The negative impact of the HDD's mechanical parts is most acute when many small files require random read access, as can be seen in Figure 1. Transfer time is calculated as follows:

$$\text{Transfer time} = \text{interface transfer} + \text{media transfer} + \text{mechanical delay}$$

For a single random read request for a small file such as a DLL, HDD mechanical delay accounts for some 95% of the entire transfer rate. The media transfer (4%) and interface transfer (1%) account for the remainder. In contrast, the SSD has no mechanical delay.

<sup>1</sup> Photo from Wikipedia, <http://en.wikipedia.org/wiki/Image:HDDspin.JPG>

Given the fact that 50% of MobileMark 2005 IO measurements are 4KB random transfers, the IO bottleneck created by the hard disk drive becomes painfully clear. This bottleneck prevents the CPU, whose speed increases with each new generation, from functioning at its peak. The end result is that the user experience is not optimal.

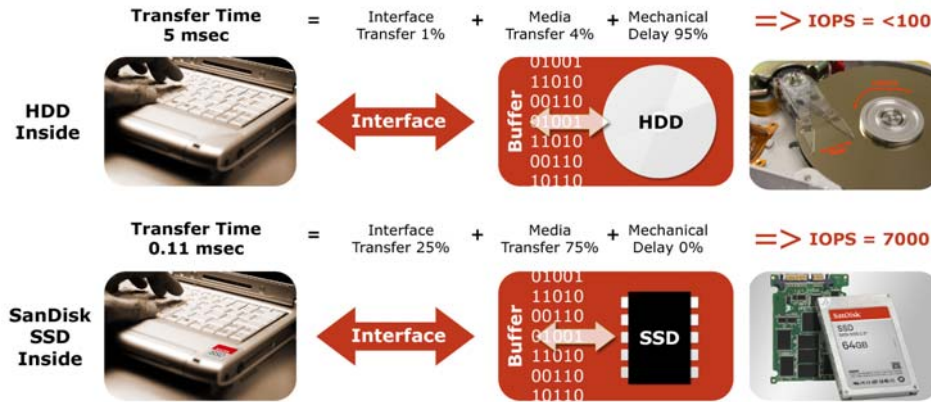


Figure 1: Mechanical Delay of HDD Drastically Reduces IOPS

## How SanDisk SSD Frees the Bottleneck

With no moving parts, the flash-based SSD starts working almost immediately to achieve far better access speeds than the HDD. For an HDD operating at 5,400 revolutions per minute (rpm), the average access time is approximately 17 msec. For SanDisk SSD, access time is fixed at 0.11 msec – orders of magnitude faster. Another factor is input/output per second (IOPS, pronounced I-OPS). For a 512B transfer, SanDisk SSD achieves a rate of more than 7,000 IOPS, compared with less than 100 IOPS for an HDD.

What does this mean for the user experience? SanDisk SSD boots the BIOS and opens applications, for instance, much more quickly than the HDD as shown in Figure 2. What’s more, once applications are open, SanDisk SSD speeds up their concurrent use by performing background tasks more quickly, such as saving the user files periodically based on autosave settings.

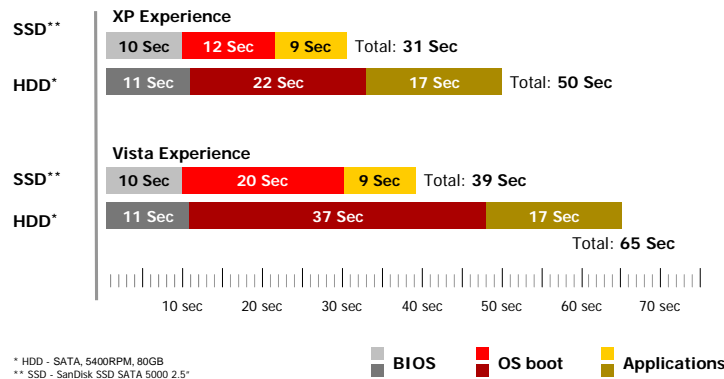


Figure 2: SanDisk SSD Enhances System Performance

This document contains certain forward-looking statements, including, specifications and applications, that are based on our current expectations and involve numerous risks and uncertainties that may cause these forward-looking statements to be inaccurate. Risks that may cause these forward-looking statements to be inaccurate include among others: our products may not perform as expected and other risks detailed from time-to-time under the caption "Risk Factors" and elsewhere in our Securities and Exchange Commission filings and reports, including, but not limited to, Form 10-K and our quarterly reports on Form 10-Q. We do not intend to update the information contained in this press release.