



Performance and power comparison of 12 3.5-inch desktop-class hard disk drives

Executive summary

Seagate Technology, LLC (Seagate) commissioned Principled Technologies (PT) to conduct tests on the following four groups of 3.5-inch desktop-class hard disk drives to determine the relative performance and power consumption within each group.

- 500GB hard disk drives
 - Seagate® Barracuda® 7200.12
 - Western Digital® Caviar® Blue™
 - Hitachi Deskstar™
- 1TB green or low-power hard disk drives
 - Seagate Barracuda LP
 - Western Digital Caviar Green™
 - Samsung EcoGreen F2
- 2TB green or low-power hard disk drives
 - Seagate Barracuda LP
 - Western Digital Caviar Green
 - Samsung EcoGreen F2
- 2TB high-performance hard disk drives
 - Seagate Barracuda XT
 - Western Digital Caviar Black™
 - Hitachi Deskstar

We tested the standard performance drives in a Dell™ OptiPlex™ 780 desktop system and the high-performance drives in a hand-built system with support for 6Gb/s.

KEY FINDINGS

- In the 500GB, 1TB green, and 2TB green categories, the Seagate Barracuda drive outperformed the competitors' drives on PCMark® Vantage's HDD test, with wins ranging from 2.7 percent to 39.4 percent. (See Figure 1.)
- In the 500GB, 1TB green, and 2TB high-performance categories, the Seagate Barracuda drive outperformed the competitors' drives, with wins ranging from 0.5 percent to 11.1 percent. (See Figure 2.)
- In all four categories, the Seagate Barracuda drives outperformed the competitors' drives, with wins ranging from 7.2 percent to 47.5 percent. (See Figure 3.)
- In the 500GB, 1TB green, and 2TB green groups, the Seagate Barracuda drives consumed from 0.47 to 1.49W less power under load than the competitors' drives. (See Figure 4.)
- In the 500GB and the 1TB green groups, the Seagate Barracuda drives consumed from 0.15 to .99W less power over a 15-minute period of idle time than the competitors' drives. (See Figure 5.)

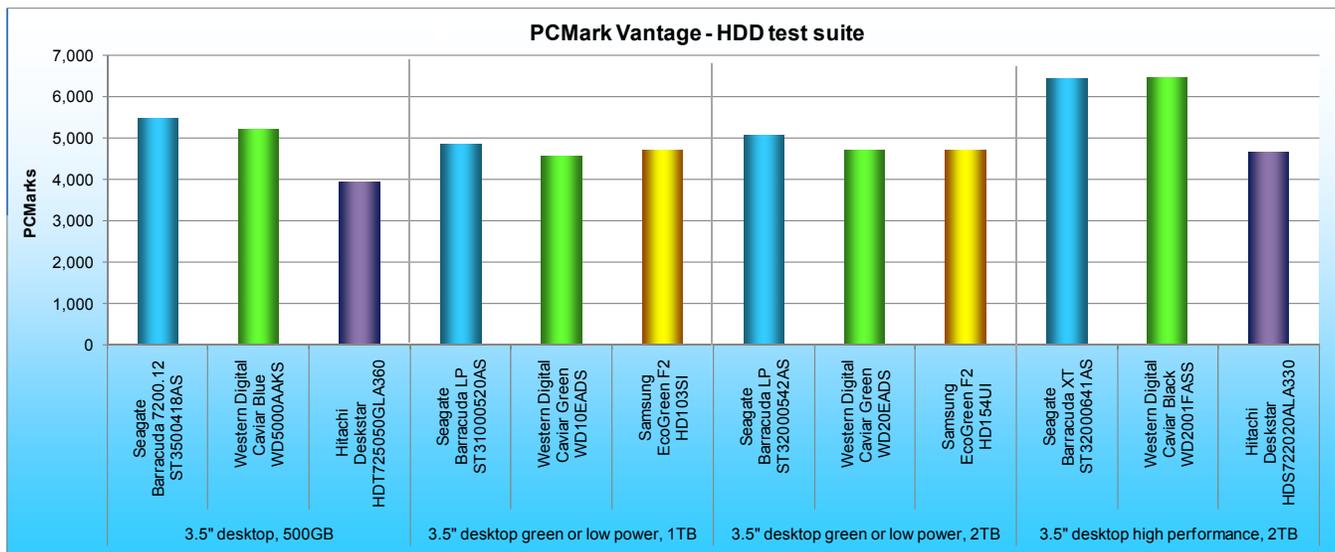


Figure 1: HDD test suite results from PCMark Vantage. Higher numbers are better.

As Figure 1 shows, within the 500GB, 1TB green, and 2TB green categories, the Seagate Barracuda drives outperformed the competitors' drives on PCMark® Vantage's HDD test, with wins ranging from 2.7 percent to 39.4 percent. In the 2TB high-performance category, the Seagate Barracuda XT slightly underperformed the Western Digital Caviar Black by 0.5 percent and outperformed the Hitachi Deskstar drive by 38.4 percent.

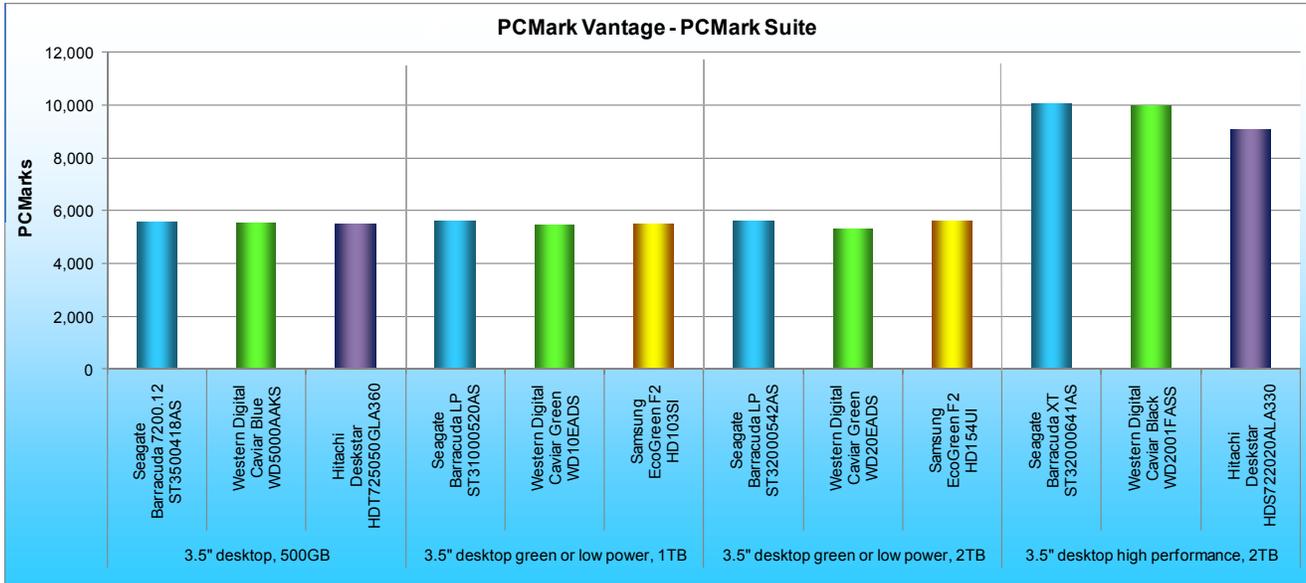


Figure 2: Vantage PCMark Suite results. Higher numbers are better.

The PCMark Suite score rolls the HDD suite results into an overall score. As Figure 2 shows, within the 500GB, 1TB green, and 2TB high-performance categories, the Seagate Barracuda drives outperformed the competitors' drives, with wins ranging from 0.5 percent to 11.1 percent. In the 2TB green category, the Seagate Barracuda LP very slightly underperformed the Samsung EcoGreen F2 by 0.04 percent and outperformed the Digital Caviar Green drive by 5.9 percent.

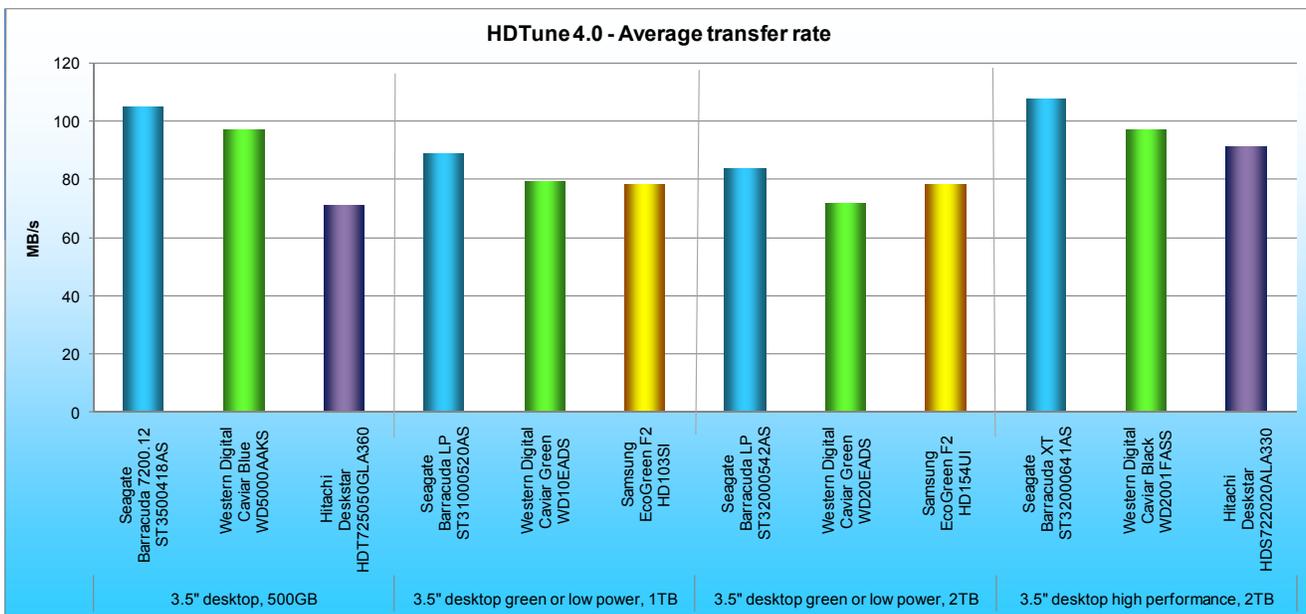


Figure 3: Average transfer rate results for our test systems. Higher numbers are better.

The disk transfer rate is the speed at which data is transferred to and from the disk. Disk transfer rate is generally described in terms of megabytes per second (MB/s). Hard disks have an increasing range of disk transfer rates from the inner diameter to the outer diameter of the disk. HD Tune Pro reports a maximum transfer rate, a minimum transfer rate, and an average transfer rate. For the purposes of our tests, we report the average transfer rate for all hard disk drives.

As Figure 3 shows, in all four categories, the Seagate Barracuda drives outperformed the competitors' drives, with wins ranging from 7.2 percent to 47.5 percent.

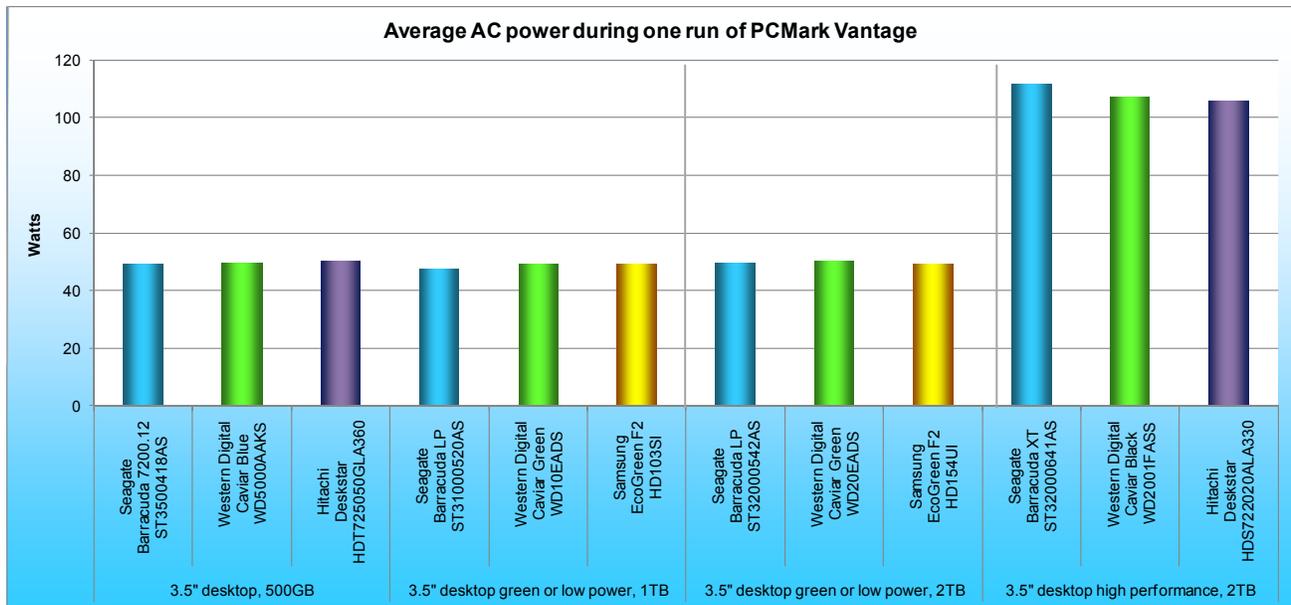


Figure 4: Power usage results for our test systems. Lower numbers are better.

Figures 4 and 5 present the results for average power for the system while under load (Figure 4) and while idle (Figure 5).

As Figure 4 shows, in the 500GB, 1TB green, and 2TB green groups, the Seagate Barracuda drives consumed from 0.47 to 1.49W less power under load than the competitors' drives. In the high-performance 2TB category, the Seagate Barracuda XT consumed 4.44W more than the Western Digital Caviar Black and 5.90W more than the Hitachi Deskstar drives.

As Figure 5 shows, in the 500GB and the 1TB green groups, the Seagate Barracuda drives consumed from 0.15 to .99W less power over a 15-minute period of idle time than the competitors' drives. In the 2TB green category, the Seagate Barracuda LP consumed 0.26W more power than the Western Digital Caviar Green, and 0.58W more power than the Samsung EcoGreen drive. In the high-performance 2TB category, the Seagate Barracuda XT consumed 10.59W more power than the Western Digital Caviar Black and 10.81W more power than the Hitachi Deskstar drives.

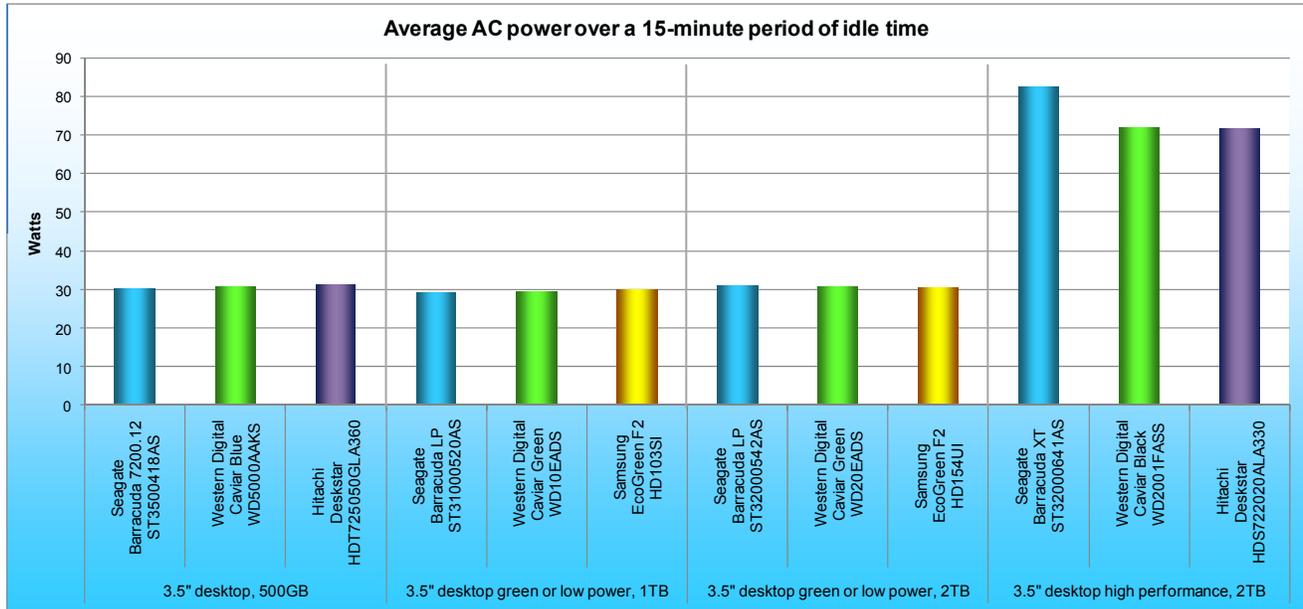


Figure 5: Power usage results for our test systems. Lower numbers are better.

Test methodology

Installing 64-bit Microsoft Windows 7 Ultimate on the Dell OptiPlex 780

1. Install the hard disk drive into the Dell OptiPlex 780.
2. Check the BIOS and verify the SATA control mode is set to AHCI.
3. Reboot the PC with the Microsoft Windows 7 Ultimate DVD in the optical drive.
4. When the application prompts you to do so, press any key to boot from CD or DVD.
5. At the language and preference screen, accept the default options, and click Next.
6. Click Install now.
7. At the Please read the license terms screen, check the I accept the license terms checkbox, and click Next.
8. At the Which type of installation do you want? screen, select Custom (advanced).
9. Click Drive options (advanced).
10. Select the destination disk for the operating system, and click Format.
11. In the Install Windows dialog box, click OK.
12. Once the system finishes formatting the disk, click Next.
13. At the Set Up Windows screen, enter a user name and computer name, and click Next.
14. At the Set a password for your account screen, leave the default of no password, and click Next.
15. Do not enter a Product key. Uncheck Automatically activate Windows when I'm online, and click Next.
16. At the Help protect Windows automatically screen, click Ask me later.
17. At the Review your time and date settings screen, choose Eastern Time (US & Canada) from the drop-down menu, set the clock to the correct time, and click Next.
18. At the Select your computer's current location screen, click Public network.
19. Set the test resolution:
 - a. Right-click the desktop.
 - b. Select Screen Resolution.
 - c. Set the resolution to the maximum supported resolution.
 - d. Click OK.
20. Turn off Windows Automatic Updates:
 - a. Click the Windows Start button.
 - b. Right-click Computer, and select Properties.
 - c. Click Windows Update in the left column.

- d. Click Change settings.
 - e. Select Never check for updates, check Receive recommended updates the same way you receive important updates, and check Allow standard users to install updates on this computer.
 - f. Click OK.
21. Disable Screen Saver and power options:
- a. Right-click the desktop, and select Personalize.
 - b. Click the Screen Saver icon.
 - c. Select None from the Screen Saver drop-down menu.
 - d. Click Change power settings.
 - e. Click Change plan settings next to Balanced plan.
 - f. Set Dim the display, Turn off the display, and Put the computer to sleep options to Never.
 - g. Click Save changes.
22. Disable Security notifications:
- a. Click the Windows Start button.
 - b. Click Control Panel.
 - c. Click System and Security.
 - d. Click Change Action Center settings.
 - e. Uncheck all monitoring alert messages, and click OK.
23. Change User Account Control settings:
- a. Click the Windows Start button.
 - b. Click Control Panel.
 - c. Click System and Security.
 - d. Click Change User Account Control settings.
 - e. Move the slider bar to Never notify, and click OK.
 - f. In the User Account Control dialog box, click Yes.
24. Run Windows Update:
- a. Click the Windows Start button.
 - b. Click All Programs, and select Windows Update.
 - c. Click Check for updates.
 - d. Download and install all important updates through 12/14/09.
25. Run Windows Experience Index:
- a. Click the Windows Start button.
 - b. Right-click Computer, and select Properties.
 - c. Click System rating is not available.
 - d. Click Rate this computer.
 - e. Once Windows Experience Index completes the assessment, record the scores as follows:
 - Base score
 - Processor
 - Memory (RAM)
 - Graphics
 - Gaming graphics
 - Primary hard disk
 - f. Close the rating window.

Installing 64-bit Microsoft Windows 7 Ultimate on the hand-built system

1. Install the hard disk drive into the hand-built system.
 - a. Connect the Seagate to the Marvell 91xx SATA 6G Controller.
 - b. Connect the Western Digital and Hitachi to the Intel PCH SATA AHCI Controller.
2. Turn on the system and press Delete to enter the BIOS. Make the following BIOS changes:
 - a. At the Main Menu, select Integrated Peripherals.
 - b. Change the PCH SATA Control Mode to AHCI.
 - c. When testing the high-performance 6 Gb/s hard drives, change the Turbo SATA3 / USB3.0 from Auto to Turbo SATA3 to ensure that SATA3 is enabled.
 - d. Change the GSATA 6_7 Ctrl Mode to AHCI.
 - e. Press F10 to save the BIOS changes and exit the BIOS.

3. Insert a Microsoft Windows 7 Ultimate 64-bit disc, and reboot the system.
4. When the application prompts you to do so, press any key to boot from CD or DVD.
5. At the language and preference screen, accept the default options, and click Next.
6. Click Install now.
7. At the Please read the license terms screen, check the I accept the license terms checkbox, and click Next.
8. At the Which type of installation do you want? screen, select Custom (advanced).
9. Click Drive options (advanced).
10. Select the destination disk for the operating system, and click Format.
11. In the Install Windows dialog box, click OK.
12. Once the system finishes formatting the disk, click Next.
13. At the Set Up Windows screen, enter a user name and computer name, and click Next.
14. At the Set a password for your account screen, leave the default of no password, and click Next.
15. Do not enter a Product key. Uncheck Automatically activate Windows when I'm online, and click Next.
16. At the Help protect Windows automatically screen, click Ask me later.
17. At the Review your time and date settings screen, choose Eastern Time (US & Canada) from the drop-down menu, set the clock to the correct time, and click Next.
18. At the Select your computer's current location screen, click Public network.
19. Turn off Windows write cache flushing:
 - a. Click the Windows Start button.
 - b. Type `Device Manager` into the Windows Search box.
 - c. Click Device Manager.
 - d. Open Disk drives, and double-click the hard drive name listed.
 - e. Select the Policies tab, and check the box next to Turn off Windows write-cache buffer flushing on the device.
 - f. Click OK.
20. Set the test resolution:
 - a. Right-click the desktop.
 - b. Select Screen Resolution.
 - c. Set the resolution to the maximum supported resolution.
 - d. Click OK.
21. Turn off Windows Automatic Updates:
 - a. Click the Windows Start button.
 - b. Right-click Computer, and select Properties.
 - c. Click Windows Update in the left column.
 - d. Click Change settings.
 - e. Select Never check for updates, check Receive recommended updates the same way you receive important updates, and Allow standard users to install updates on this computer.
 - f. Click OK.
22. Disable Screen Saver and power options:
 - a. Right-click the desktop, and select Personalize.
 - b. Click the Screen Saver icon.
 - c. Select None from the Screen Saver drop-down menu.
 - d. Click Change power settings.
 - e. Click Change plan settings next to Balanced plan.
 - f. Set Dim the display, Turn off the display, and Put the computer to sleep options to Never.
 - g. Click Save changes.
23. Disable Security notifications:
 - a. Click the Windows Start button.
 - b. Click Control Panel.
 - c. Click System and Security.
 - d. Click Change Action Center settings.
 - e. Uncheck all monitoring alert messages, and click OK.
24. Change User Account Control settings:
 - a. Click the Windows Start button.

- b. Click Control Panel.
 - c. Click System and Security.
 - d. Click Change User Account Control settings.
 - e. Move the slider bar to Never notify, and click OK.
 - f. In the User Account Control dialog box, click Yes.
25. Run Windows Update:
- a. Click the Windows Start button.
 - b. Click All Programs, and select Windows Update.
 - c. Click Check for updates.
 - d. Download and install all important updates through 12/14/09.
26. Run Windows Experience Index:
- a. Click the Windows Start button.
 - b. Right-click Computer, and select Properties.
 - c. Click System rating is not available.
 - d. Click Rate this computer.
 - e. Once Windows Experience Index completes the assessment, record the scores as follows:
 - Base score
 - Processor
 - Memory (RAM)
 - Graphics
 - Gaming graphics
 - Primary hard disk
 - f. Close the rating window.

Creating the base test image

At this point, PT uses Symantec's Ghost product to create an image of the base operating system installation. This image facilitates repeatable testing and experimenting.

1. Insert a bootable Ghost CD.
2. Power down the computer.
3. Power on the computer.
4. At the Symantec Ghost screen, click OK.
5. Attach an external USB hard disk.
6. Select Local→Partition→To Image.
7. Click OK.
8. Select the Primary disk, and click OK.
9. Select the source partition, and click OK.
10. In the Copy image to drop-down box, select the external hard disk, name the file `BASE`, and click Save.
11. At the Compress Image dialog, select Fast.
12. At the Proceed dialog, select Yes.
13. When the ghost image is complete, click OK, and exit Ghost.
14. Power down the computer.
15. Disconnect the USB hard disk.
16. Reboot the computer.

Measuring disk performance with PCMark Vantage 1.0.1.0

Installing and patching PCMark Vantage

1. Download the PCMark_Vantage_v100_installer.exe Windows package from www.futuremark.com/benchmarks/pcmarkvantage/download/.
2. Install PCMark Vantage 1.0.0 with the default options by double-clicking the PCMark_Vantage_v100_installer.exe file.
3. Launch PCMark Vantage 1.0.0, enter the registration code, click Register, and click OK.
4. Exit PCMark Vantage 1.0.0.
5. Download the PCMark Vantage 1.0.1.0 Patch (PCMark_Vantage_v101_patch_0910a.exe Windows package) from www.futuremark.com/benchmarks/pcmarkvantage/download/.
6. Install the patch by double-clicking the PCMark_Vantage_v101_patch_0910a.exe file.

Running PCMark Vantage 1.0.1.0

1. Reboot the system.
2. Double-click the PCMark Vantage desktop icon to launch the benchmark.
3. Verify all test suites are selected, and that the HDD Suite target is set to C:.
4. Accept the default settings, and click Run Benchmark.
5. When the benchmark run completes, click Submit results.
6. Take a screenshot of the results, and record them as follows:
 - PCMark Suite
 - Memories Suite
 - TV and Movies Suite
 - Gaming Suite
 - Music Suite
 - Communication Suite
 - Productivity Suite
 - HDD Test Suite
7. Perform steps 1 through 6 two more times, and report the average of the three runs.

Measuring disk performance with HD Tune Pro 4.00

Installing HD Tune Pro 4.00

1. Download the hdtunepro_40x_trial.exe Windows package from <http://www.hdtune.com/download.html>.
2. Install HD Tune Pro 4.0 with the default options by double-clicking the hdtunepro_40x_trial.exe file.

Running HD Tune Pro 4.00

1. Reboot the system.
2. Launch the benchmark from the Start menu (Start→HD Tune Pro).
3. Verify the Read radio button is selected, and click the Start button located in the upper right-hand corner of the Benchmark section of HD Tune Pro 4.00.
4. When the benchmark run completes, select File→Save screenshot from the file menu, appending the filename with `runn`, where `n`=the number of the run.
5. Record the following results:
 - Average transfer rate
 - Access time
 - Burst rate
6. Perform steps 1 through 5 two more times, and report the average of the three runs.

Power measurement procedure

To record each system's power consumption during each test, we used an Extech Instruments (www.extech.com) 380803 Power Analyzer/Datalogger. We connected the power cord from the system under test to the Power Analyzer's output load power outlet. We then plugged the power cord from the Power Analyzer's input voltage connection into a power outlet.

We used the Power Analyzer's Data Acquisition Software (version 2.11) to capture all recordings. We installed the software on a separate PC, which we connected to the Power Analyzer via an RS-232 cable. We captured power consumption at 1-second intervals.

For the idle power consumption tests, we take one 15 minute measurement.

Measuring idle power consumption

Setting up the test

1. Reset the system to the base test image.
2. Turn off the screen saver and the power options to turn off monitor and turn off hard disks in order to prevent them from interfering during the test.
3. Turn the system on and wait 5 minutes.

Running the test

1. Start the Extech 380803 Power Analyzer.

2. Record idle power consumption for 15 minutes.
3. Stop the Extech 380803 Power Analyzer, and extract the power consumption data during idle.

Measuring performance and power under load with PCMark Vantage 1.0.1.0

Setting up the test

1. Reset the system to the base test image.
2. Purchase and install PCMark Vantage 1.0.1.0 as we described in the Installing and patching PCMark Vantage section.
3. Reboot the system.

Running the test

1. Start the Extech 380803 Power Analyzer.
2. Double-click the PCMark Vantage desktop icon to launch the benchmark.
3. Verify all test suites are selected, and that the HDD Suite target is set to C:.
4. Accept the default settings, and click Run Benchmark.
5. When the benchmark completes, stop the Extech 380803 Power Analyzer, and extract the power consumption data for the PCMark Vantage run under load.

Appendix A – Detailed system configuration information

Figure 6 presents the details of the custom-built desktop PC and Dell OptiPlex 780 desktop PC configurations.

System	Custom built	Dell OptiPlex 780
General		
Processor and OS kernel: (physical, core, logical) / (UP, MP)	1P,4C,8L / MP	1P,2C,2L / MP
Number of physical processors	1	1
Single/Dual/Quad-Core processors	Quad	Dual
System power management policy	Balanced	Balanced
Processor power-saving option	EIST	EIST
CPU		
Vendor	Intel	Intel
Name	Core i7	Core 2 Duo
Model number	870	E7500
Stepping	B1	R0
Socket type and number of pins	LGA 1156	LGA 775
Core frequency (GHz)	2.93	2.93
Front-side bus frequency (MHz)	NA	1,066
Quick Path Interconnect frequency (MHz)	5,000	NA
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	1 MB (256 KB per core)	3 MB
L3 cache	8 MB	NA
Platform		
Vendor	Gigabyte	Dell
Motherboard model number	P55A-UD6	0200DY
Motherboard chipset	Intel P55	Intel Q45
Motherboard revision number	11	03
System/motherboard serial number	00241DCBC75E	3QCCHK1
BIOS name and version	Award Software International F6 (11/20/2009)	Dell A01 (09/01/2009)
BIOS settings	AHCI enabled	Default
Hard disk controller	Seagate (Marvell 91xx SATA 6G Controller); WD and Hitachi (Intel PCH SATA AHCI Controller)	Intel 82801JB (ICH10)
Hard disk controller driver	Marvell 1.0.0.1027 (10/09/2009); Intel 8.9.0.1023 (06/04/2009)	Intel 8.9.0.1023 (06/04/2009)
Memory module(s)		
Vendor and model number	Corsair CMX4GX3M2A1600C9	Elpida EBJ10UE8BAFA-DJ-E
Type	PC3-12800	PC3-10600
Speed (MHz)	1,600	1,333
Speed running in the system (MHz)	1,333	1,066
Timing/Latency (tCL-tRCD-tRP- tRASmin)	9-9-9-24	7-7-7-20
Size (MB)	4,096	4,096

System	Custom built	Dell OptiPlex 780
Number of memory module(s)	2 x 2,048 MB	4 x 1,024 MB
Chip organization (Single-sided, Double-sided)	Double-sided	Single-sided
Channel (Single/Dual)	Dual	Dual
Operating system		
Name	Microsoft Windows 7 Ultimate x64	Microsoft Windows 7 Ultimate x64
Build number	7600	7600
Service Pack	NA	NA
File system	NTFS	NTFS
Kernel	ACPI x64-based PC	ACPI x64-based PC
Language	English	English
Microsoft DirectX version	11	11
Graphics		
Vendor and model number	NVIDIA GeForce 9400GT	Intel GMA 4500
Type	Discrete	Integrated
Chipset	GeForce 9400GT	Intel 4 Series Express Chipset Family
BIOS version	62.94.50.0.22	1785.0
Total available graphics memory (MB)	2,813	1,695
Dedicated video memory (MB)	1,024	64
System video memory (MB)	0	0
Shared system memory (MB)	1,789	1,631
Resolution	1,680 x 1,050 x 32 bit	1,680 x 1,050 x 32 bit
Driver	NVIDIA 8.17.11.9562 (11/20/2009)	Intel 8.15.10.1986 (10/30/2009)
Sound card/subsystem		
Vendor and model number	Realtek High Definition Audio	SoundMAX Integrated Digital High Definition Audio
Driver	Realtek 6.0.1.5973 (11/03/2009)	Analog Devices 6.10.2.7260 (06/22/2009)
Ethernet		
Vendor and model number	2 x Realtek PCIe GBE	Intel 82567LM-3 Gigabit
Driver	Realtek 7.6.820.2009 (08/20/2009)	Intel 11.5.4.0 (11/05/2009)
Optical drive(s)		
Vendor and model number	LG GH22NS50	LG GH50N
Type	DVD-RW	DVD-RW
Interface	SATA	SATA
Dual/Single layer	Dual	Dual
USB ports		
Number	12	8
Type	10 x USB 2.0 / 2 x USB 3.0	USB 2.0
Other	2 x eSATA	eSATA
IEEE 1394 ports		
Number	2	NA
Monitor		
LCD type	Dell E2210H	Dell E2210H
Screen size (inches)	21.5	21.5
Refresh rate (Hz)	60	60

Figure 6: System configuration information.

About Principled Technologies

We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help you assess how it will fare against its competition, its performance, whether it's ready to go to market, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.



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