Performance Evaluation of
HP Z Turbo Drive PCIe SSD

Powered by Samsung XP941 technology

Evaluation Conducted Independently by:

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# Table of Contents

Introduction ........................................................................................................................................... 3
What is an SSD? ....................................................................................................................................... 3
What kind of SSD is the HP Z Turbo Drive? ............................................................................................. 4
Benchmark setup and system configurations .......................................................................................... 5
Storage devices evaluated: ....................................................................................................................... 5
Benchmark Programs Used: .................................................................................................................... 6
Benchmark Results ................................................................................................................................. 10
Analysis .................................................................................................................................................. 14
Conclusion .............................................................................................................................................. 14
Appendix ............................................................................................................................................... 15
Resources .............................................................................................................................................. 16
**Introduction**

When computers first hit the market, all information saved on the computer was written onto a spinning hard drive disk (HDD). As technology progressed, HDDs were replaced by solid state drives (SSDs). SSDs present a much faster storage alternative to HDDs. While SSDs can run on a variety of interfaces, the market has currently standardized on SAS and SATA. Now, HP and Samsung are partnering to offer a new form of memory that runs on a PCIe bus. Not only does the PCI-express interface have greater bandwidth than both SATA and SAS, a PCIe-based SSD bypasses the host bus adapter and its accompanying operating system driver stack. The combination provides a shorter path to the motherboard on multiple levels. As such, it is expected that a PCIe-based SSD will perform appreciably faster. Data intensive operations such as video processing, data center services, and cloud storage will significantly benefit from the performance gains. Employing benchmark tools commonly used by the storage industry, OTSI has performed a study of a number of storage devices representing both HDD and SSD classes and compared the results against the performance of the HP Z Turbo Drive PCIe SSD.

**What is an SSD?**

An SSD drive is a solid state storage device that stores persistent data on integrated circuit assemblies. Unlike traditional HDDs which store date on spinning platters, it has no “disk” or other moving parts. The SSD’s main advantage over HDDs is its much faster speed. While the SSD technology stores memory differently, it still uses existing and emerging standard I/O interfaces to integrate into a system. SATA, SAS, USB, eSCSI and PCIe are some of the interfaces SSDs can support. Some SSDs use RAM memory for fast speed, but most SSDs use NAND-based flash memory to store data. RAM storage is not persistent and requires separate power sources to retain its stored data. NAND memory has the advantage of data persistence since it requires no power to retain stored information. NAND memory is extensively used in USB flash drives and mobile phones.
What kind of SSD is the HP Z Turbo Drive?

The HP Z Turbo Drive is a half-height, half-length PCIe-based add-in board that plugs directly into a PCIe slot. It is an HP-designed adapter card that is currently powered by Samsung’s XP941 (M.2 form factor) SSD technology. XP941 contains Samsung’s professional class, MLC NAND flash memory, a 3-core, eight channel UAX controller (designed specifically for PCIe) and firmware. Samsung, the largest producer of SSDs in the world, makes all of the components inside its SSDs including the NAND memory, firmware and controller.

There are two or four 128GB Samsung MLC NAND flash memory modules on the XP941 (two on 256GB drives, four on the 512GB). XP941 uses Samsung’s 10nm-class MLC, which succeeds Samsung’s previous generation 20nm-class MLCs used in the well-established Samsung 840 Pro SSD.

SSDs have consistently become faster. SATA has long been the most common interface for both SSDs and HDDs. SSDs have now become too fast for the SATA 3.0 interface to keep up. Therefore, PCIe is becoming the preferred alternative as the interface for high performance SSDs. Basing the design of the HP Z Turbo Drive on PCIe allows it to overcome the 600 MB/s performance bottleneck of SATA 3.0 and make higher throughput achievable.
**Benchmark setup and system configurations**

To keep testing uniform, all tests in this benchmark were performed on an HP Z420 workstation. For the side-by-side benchmarks, two identical HP Z420 workstations were used. Since the HP Z Turbo Drive, like many other SSDs, can work as a boot drive, a data drive, or both when two are used simultaneously on the same system, both were benchmarked. The complete system configuration is listed in the Appendix. All the tests were run twice: once with one drive as the boot device and a second time with two identical drives (one as a boot drive and the other as a data storage drive). In the two-drive configuration, the benchmark numbers presented were only for the data drive. To ensure uniform performance, the system was disconnected from the network, the system power plan was set to high performance, all the devices were set to never sleep or hibernate, the firewall was disabled, and the anti-virus software was turned off.

(Note: While the HP Z Turbo Drive PCIe SSD, as well as the other devices used in this effort, can function as both boot and data storage devices, which is not true of all SSDs. Some SSDs can only serve as data storage devices, such as Fusion-io’s ioExtreme PCI Express.)

**Storage devices evaluated:**

Nine storage options were tested: two HP Z Turbo Drive 256GB and 512GB drives, three Micron M550s in 128GB, 256GB and 512GB, and one Samsung SM843Tn rounds out the SSD drive list. Three magnetic hard drives: Western Digital 500GB 7200 RPM SATA, Western Digital SATA 10K 500GB, and HP SAS 15K 300GB, were also included.

**List of Storage Devices Benchmarked:**

- HP Z Turbo Drive PCIe SSD 256GB (PCIe)
- HP Z Turbo Drive PCIe SSD 512GB (PCIe)
- Micron M550 128GB SSD (SATA)
- Micron M550 256GB SSD (SATA)
- Micron M550 512GB SSD (SATA)
- Samsung Enterprise SM843Tn 240GB SSD (SATA)
- Western Digital 500GB 7200 HDD (SATA)
- Western Digital 10K 500GB HDD (SATA)
- HP 15K 300GB HDD (SAS)
Benchmark Programs Used:
The following benchmark programs were used:

List of Benchmarks:
- ATTO
- AJA System Test
- BlackMagic Disk Speed Test
- IOMeter
- Passmark
- SPECwpc

ATTO, AJA, BlackMagic and IOMeter are strictly storage benchmarking tools. Passmark and SPECwpc contain components for both storage and other areas. Where possible, benchmarks presented here used both small and large sample storage sizes to simulate a variety of test conditions. The benchmarks were installed on and invoked from the drive being tested. Generally, all benchmarks showed that the data drive performed as well or better than on the boot drive, which was to be expected. In one case (Micron M550 128GB), for IOMeter, which requires a large amount of free space, the system disk was simply not large enough and the sample benchmark size had to be reduced. The reduction in sample size might have improved the IOMeter benchmark number for the Micron M550 128GB.

BlackMagic’s Disk Speed Test is a widely used tool for testing the throughput of a storage device for video related operations and tests the storage device’s ability to serve various video formats. The benchmarks were run with sample sizes of up to 5 GB and an average of the results tabulated. For the best results, the drive needed to run for 10 minutes or more to accumulate stable results.
Passmark Performance Test has modules for evaluating speed of 2D and 3D graphics, memory, CPU, and storage (although it calls its storage benchmark “Disk Mark” it also works on non-disk data storage media). The longest possible options were selected and three iterations run on each configuration. The average of the results was tabulated.

AJA System Test is a straight forward tool provided by AJA Video Systems for checking the performance of any storage device on a system, as part of the evaluation of maximizing video processing performance. It was tested in 3 modes (Disk Read + Write, Sweep Video Frame Sizes and Sweep File Sizes). In each of those modes, it was tested with video resolutions of 1280x720, 1920x1080, 2048x1556 pixels, and sample sizes of 1, 4, 8 and 16 GB. In total, each configuration was clocked for 20 different types of operation.
**IOMeter** is a powerful tool for measurement and characterization of I/O subsystems within both single and clustered configurations. It was initially created by the Intel Corporation and has since been given to the open source community. It has been widely used in the industry, and can be configured to simulate a large variety of storage utilization profiles through the parameters it provides in its user interface. It can measure both storage throughput and the number of I/O operations per second (IOPS).
**SPECwpc** is a huge benchmark suite consisting of multiple professional applications and tools designed to measure all key aspects of workstation performance. It was developed by representatives from major hardware vendors (including HP, AMD, Fujitsu, Dell, Intel, Lenovo, NEC, and NVIDIA). Thirty two workloads were used to test different areas of computing for 6 key industrial categories (Media & Entertainment, Product Development, Life Sciences, Financial Services, Energy and General Operations). The scores from individual tests are aggregated to compute normalized scores of the 6 industrial categories. Like Passmark, SPECwpc measures much more than storage performance, and therefore, the numbers represent both storage-only as well as general performance. SPECwpc needs to be installed since it checks for certain system requirements before it can run correctly. It requires MS HPC Pack 2008 R2 MS-MPI redistributable and will install it, if it’s not there already. This benchmark was run in its entirety with all the default values, even though many of those do not measure storage performance, and takes several hours to complete.
Benchmark Results
The raw and original composite numbers from all benchmarks have been tabulated. The raw numbers have been uniformly combined to create overall scores. All the test scores have been normalized against the slowest drive. The normalization only simplifies the values and does not favor one drive over another.

**Overall storage score:** Combines the normalized storage-only benchmark numbers from all tests into one number for each drive type. (Figure 1)

![Storage Test Score](image)

*Figure 1: Storage Score (a composite of all storage related benchmarks for both boot and data drives).*
**Total score**: Combines scores from all tests into a single normalized number. These tests include storage as well as CPU, RAM, and graphics results. (Figure 2)

![Total System Test Score (Includes Storage Tests)](image)

*Figure 2: Total normalized scores for both boot and data drives*
Total I/O operations per second (IOPS): Represents the number of IOPS from the IOMeter benchmark for both boot and data drives. (Figure 3)

![Figure 3: IOPS (I/O per second) for both boot and data drives](image-url)
**Read throughput in MBs/sec**: Represents the average of all the read/write tests from the ATTO benchmark for both data and boot drives. (Figure 4)

![ATTO Read/Write Test Score Graph](image-url)

*Figure 4: ATTO read, MBs/sec for both boot and data drives*
Analysis

- As the charts show, the two HP Z Turbo Drive PCIe SSDs proved to be the fastest storage in every test case. Multiple ways of charting the data confirmed this.
- It was observed during the benchmarking that PCIe slot 4 provides the fastest performance and is the recommended slot for HP Z Turbo Drive PCIe SSDs.
- Both HP Z Turbo Drive 256 GB and 512 GB perform much faster than the other SSDs and mechanical drives tested. In some instances the read and write performance exceeds the key 1 GB/sec threshold.
- The raw benchmark data indicates that the CPU, graphics and RAM components were not affected by the speed of storage.
- The storage-related benchmarks behave consistently. The SAS HDD drives tested are generally faster than the SATA HDD drives (with one exception) for all storage tests, while the SSD drives are faster than SAS and SATA HDDs, and the PCIe numbers are faster than all else by almost 100%. Storage performance follows a pattern of improvement as one goes from SATA HDDs to SAS HDDs to SATA SSDs to PCIe SSD drives (HP Z Turbo Drive PCIe SSDs).
- In most cases, the performance of the data drive is as good as or better than the root drive.
- The HP Z Turbo Drive 512GB PCIe SSD is faster than the HP Z Turbo Drive 256GB PCIe SSD because it has more NAND modules, allowing for parallel IO operations.

Conclusion

The HP Z Turbo Drive PCIe SSDs (256GB and 512GB) have been shown by this benchmark effort to be the fastest drives among the ones tested. They vastly outperform the other drives tested for very large variations of storage transactions, as well as greatly varying file sizes. The HP Z Turbo Drive PCIe SSDs offer a clear speed benefit to storage-intensive applications such as video processing, data centers, cloud, and CAD applications.
Appendix

Test System Configuration: HP Z420

Computer Type: Desktop
Manufactured by: Hewlett-Packard
Baseboard ID: 1589
Serial Number: us42030016
BIOS version: 3.69
Processor: Intel(R) Xeon(R) CPU E5-1660 v2 @ 3.70GHz
Enabled Processor Count: 12
Total Memory: 32 GB
Graphics Card & Driver: Quadro K5000 -- driver version 331.82
Operating System: Windows 7 (64-bit)
Current Culture: en-US

HP Z Turbo Drive PCIe SSD’s published specs:

<table>
<thead>
<tr>
<th></th>
<th>HP Z Turbo Drive 256GB</th>
<th>HP Z Turbo Drive 512GB</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAND Type:</td>
<td>MLC</td>
<td>MLC</td>
</tr>
<tr>
<td>Read Bandwidth (128KB):</td>
<td>1.08GB/s</td>
<td>1.17GB/s</td>
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<tr>
<td>Write Bandwidth (1MB):</td>
<td>800 MB/s</td>
<td>930 MB/s</td>
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<tr>
<td>Random Read IOPS (4KB):</td>
<td>120K</td>
<td>122K</td>
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<tr>
<td>Random Write: IOPS (4KB):</td>
<td>60K</td>
<td>72K</td>
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<tr>
<td>Endurance (Total Bytes Written):</td>
<td>146 TB</td>
<td>292 TB</td>
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<tr>
<td>Weight:</td>
<td>1.8oz (51g)</td>
<td>1.8oz (51g)</td>
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<tr>
<td>Form Factor:</td>
<td>Half-height, half-length</td>
<td>Half-height, half-length</td>
</tr>
</tbody>
</table>

Supported platforms: All desktop Workstations including HP Z230, HP Z420, HP Z620, and HP Z820 (for both 256GB and 512GB)
Resources


BlackMagic Speed Test: www.blackmagic-design.com

ATTO Test: http://www.attotech.com/disk-benchmark/

Passmark Test: http://www.passmark.com/download/64bitsoftware.htm

AJA System Test: https://www.aja.com/en/software

IOMeter Test: http://www.iometer.org/doc/matrix.html

SPECwpc suite: http://www.spec.org/gwpg/wpc.static/wpcv1info.html

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