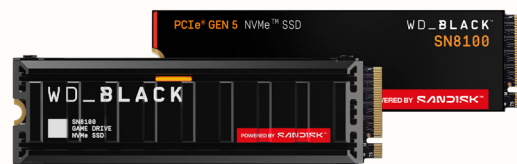


BENEFITS OF PCIe® GEN 5.0 SSDs

Overview

PCIe® Gen 5.0 is the latest leap in storage interface technologies to enable the next generation solid-state drives (SSDs). With the performance advancements of CPUs, GPUs, networks, and DRAM technologies, PCIe® Gen 5.0 SSDs deliver the highest storage performance for workstations and PCs to meet increasingly demanding workloads in development environments, hard-core games, and media rich content creation workflows. In addition, with the integration of AI models into production workflows and DirectStorage in games, new capabilities and features can be unlocked for creators and gamers.



Introduction

The Peripheral Component Interconnect Express (PCIe®) interface is the interface for NVMe™ SSDs, enabling high-speed data transfers between storage and host CPUs and GPUs. The now ubiquitous PCIe® Gen 4.0 has become the de facto interface for consumer SSDs. With the recent advent of PCIe® Gen 5.0 SSDs, which doubles the per-lane bandwidth of Gen 4.0, they offer consumers nearly double the data transfer speeds reaching upwards to 14,900 MB/s.

PCIe® Technical Specifications

PCIe® Gen 5.0 and Gen 4.0 SSDs differ fundamentally in their interface capabilities, which directly influence performance. Key specifications include:

- **Bandwidth:** PCIe® Gen 5.0 offers a per-lane bandwidth of approximately 4 GB/s (32 GT/s). For a typical 4-lane M.2 2280 NVMe™ SSD, this translates to a theoretical maximum bandwidth of 16 GB/s compared to 8 GB/s for Gen 4.0.
- **Power:** Many first generation PCIe® Gen 5.0 SSDs had a substantial higher power consumption often requiring active or passive cooling mechanical solutions (aka heatsinks) due to the additional heat generated to deliver higher data bandwidth than PCIe® Gen 4.0. Consequently, PCIe® Gen 5.0 SSD adoption was slow. The next generation PCIe® Gen 5.0 SSDs utilize a more advanced controller and NAND which reduces power closer to performance PCIe® Gen 4.0 SSDs.
- **Compatibility:** There has been a proliferation of PC motherboards supporting PCIe® Gen 5.0 for SSDs. However, it is encouraged to check the motherboard for details as typically the M.2 slot next to the CPU is the only one with PCIe® Gen 5.0 support. Just like other PCIe® standards, PCIe® Gen 5.0 SSDs are backward compatible with Gen 4.0 slots, though performance will be capped at Gen 4.0 speeds.

Next generation PCIe® Gen 5.0 SSDs deliver significantly higher throughput than today's PCIe® Gen 4.0 SSDs allowing them to be easily added to motherboards or installed in laptops, desktops, and workstations supporting PCIe® Gen 5.0.

SSD Performance Comparison

Performance differences between PCIe® Gen 5.0 and Gen 4.0 SSDs are most evident in sequential and random I/O operations.

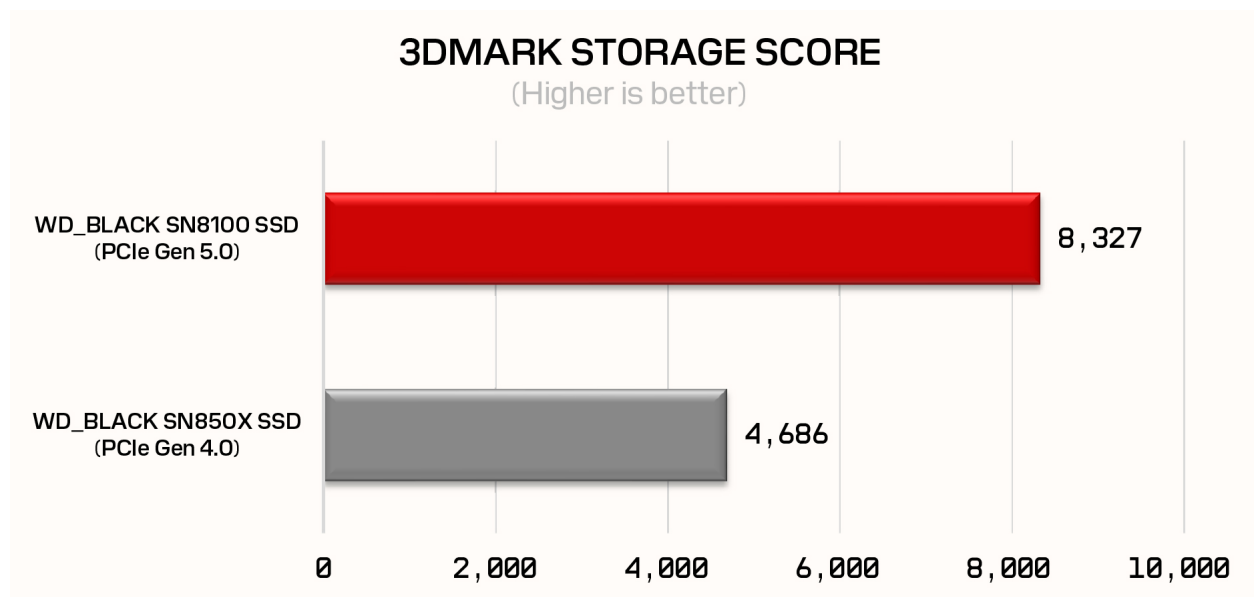
- **Sequential Read/Write Speeds:** PCIe® Gen 4.0 SSDs, such as the WD_BLACK SN850X SSD, typically achieve sequential read/write speeds of up to 7,300 MB/s (1TB – 4TB models) and 6,600 MB/s (2TB – 8TB models), respectively. PCIe® Gen 5.0 SSDs, like the new WD_BLACK SN8100 SSD can achieve faster read speeds up to 14,900 MB/s (1TB – 4TB models) and faster write speeds to 14,000 MB/s (2TB – 4TB), doubled the bandwidth. This represents over 100% improvement in sequential read and write throughput.
- **Random I/O Performance:** Random read/write performance, measured in IOPS (Input/Output Operations Per Second), also improves with Gen 5.0 SSDs. For example, the WD_BLACK SN8100 SSD can deliver up to 2.3 million IOPS (2TB – 4TB models), compared to 1.2 million IOPS for the WD_BLACK SN850X Gen 4.0 SSDs.

Consumer Benefits

The performance advantages of PCIe® Gen 5.0 SSDs easily translate into benefits for consumers including in gaming and content creation.

- **Gaming:** PCIe® Gen 5.0 SSDs can reduce install, launch, updates, game recording, game saves, and level load times in today's games compared to Gen 4.0 simply due to faster transfer rates. Consider the widely used 3DMark Storage benchmark for measuring storage performance in consumer gaming. 3DMark Storage is a synthetic benchmark for gaming storage use-cases and is a good indicator of potential benefits of Gen 5.0 SSDs. Chart 1 depicts that Gen 5.0 SSDs such as the WD_BLACK SN8100 NVMe SSD outperforms PCIe Gen 4.0 SSDs such as the WD_BLACK SN850X NVMe SSD by up to 77%.

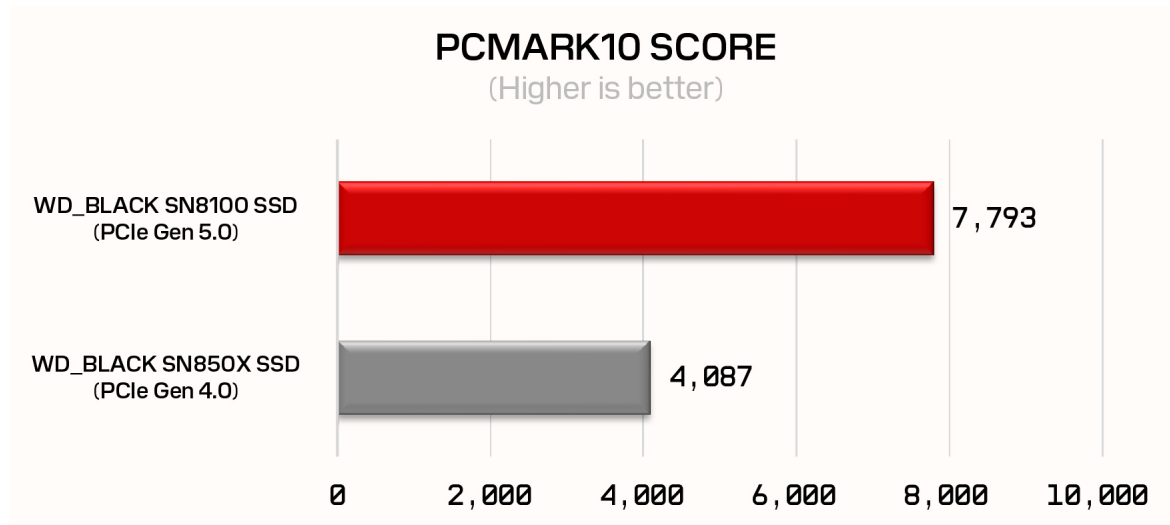
CHART 1: 3DMARK SCORE COMPARISONS



In the future, game developers can take advantage of PCIe® Gen 5.0 SSDs to add real-time ray tracing and enable DirectStorage technologies which provides a direct path between the NVMe™ SSD and GPU, both which are on PCIe® Gen 5.0 interface. DirectStorage bypasses the time-consuming decompression path involving CPU cycles and DRAM access allowing game developers to offer gamers a quicker game launch and level loading as well as a more immersive experience especially for open world games with complicated high-resolution scenes.

- **Content Creation:** Video editing and 3D rendering can benefit significantly from Gen 5.0's higher sequential speeds for loading multiple large digital media such as 8K, enabling faster file transfers, and project rendering. PC Mark 10 which is a synthetic benchmark to measure a variety of consumer workloads including content creation applications. As you can see in Chart 2, the WD_BLACK SN8100 SSD provides up to 90% improvement over the WD_BLACK SN850X SSD.

CHART 2: 3DMARK GAMING SUB-TESTS (MB/S) COMPARISONS



WD_BLACK SN8100 NVMe™ SSDs

As an industry-leader for PCIe® Gen 5 performance and power efficiency, the WD_BLACK™ SN8100 NVMe™ SSDs harness advanced controller and Sandisk™ TLC 3D CBA NAND technologies to deliver up to 14.9 GB/s and 14 GB/s sequential read and write speeds to the host, doubling the data bandwidth of our prior generation WD_BLACK SN850X NVMe SSDs. Creators can now take advantage of the additional storage performance to quickly load large media assets such as 8K video saving critical time in production workflows while having the storage bandwidth for to load advanced AI models enabling features such as upscaling, frame rate increases, and 16x slow motion. Game developers benefit from additional bandwidth for their workflows incorporating thousands of game assets to develop new capabilities such as advance ray tracing providing gamers next level realism. Gamers can immediately benefit from faster game installs, patches, and launches to get back to gaming. For laptop gamers or mobile professionals seeking faster storage performance while maintaining similar battery life, can expect the WD_BLACK SN8100 NVMe SSDs to consumer similar power as our prior generation while delivering 2x power efficiency.

Conclusion

WD_BLACK SN8100 NVMe™ SSDs with PCIe® Gen 5.0 offer substantial improvements over PCIe® Gen 4.0 SSDs, with up to double the sequential throughput, higher IOPS, and lower latency.⁴ These capabilities immediately benefit gamers and content creators and provide substantial performance headroom for advancements in games including DirectStorage technologies or large AI local language models (LLMs) in creator workflows.

- ¹ 1GB = 1 billion bytes and 1TB = 1 trillion bytes. Actual user capacity may be less depending on operating environment.
- ² 1MB/s = 1 million bytes per second. IOPS = input/output operations per second. Based on internal testing; performance may vary depending upon host device, usage conditions, drive capacity, and other factors.
- ³ TBW (terabytes written) values calculated using JEDEC client workload (JESD219) and vary by product capacity.
- ⁴ Over 100% more power efficient than 2TB WD_BLACK SN850X NVMe™ SSD.

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