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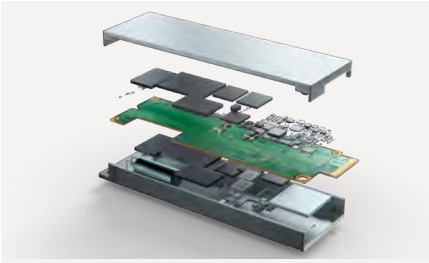
Performance Brief

DATA CENTER
D5-P5430

Read-Intensive Workloads Drive QLC Adoption for Cloud and Enterprise Storage



Solidigm™ D5-P5430 QLC SSDs provide the right performance, density, and total cost of ownership for today's mainstream workloads.

Storage workloads have changed

It seems the world today has an endless ability to create and consume increasingly vast amounts of data. This data tsunami has fundamentally reshaped storage needs, with accelerated growth in read-intensive workloads accompanied by a steady decline in SSD endurance levels on average. Two recent large-scale studies illustrate this point:

- **94% of workloads are read-intensive, with a median read-to-write ratio of approximately 78/22.**[1]
- **99% of SSDs consume less than 15% of their usable life.**[2]

Read-intensive workloads are everywhere

Mainstream and read-intensive workloads are ubiquitous in the cloud and in enterprise storage. Mainstream workloads include applications and usages such as email and unified communications and collaboration servers, general-purpose servers, object-based storage, virtual desktop infrastructure (VDI), and more. These workloads tend to cluster around an 80/20 read-to-write mix and are widely deployed in most enterprises. On the higher range, read-intensive usages and applications such as content delivery networks (CDNs), data lakes, data pipelines, imaging databases, video-on-demand (VOD) services, and more cluster around the 90/10 or higher read-to-write mix.

The best fit for these workloads

In our read-intensive world, triple-level cell (TLC) SSDs might not be right-sized for these applications. While they deliver strong read performance, these drives might not provide the best fit for mainstream and read-intensive workloads for a few reasons:

- Most workloads are composed of low write activity.
- An overwhelming majority of SSDs use less than 15% of their rated drive life.[2]
- When considering available form factors and maximum capacity points, TLC SSDs support only one-fourth of the capacity in the same space as quad-level cell (QLC) SSDs.[3]

QLC SSDs: Right-sized for mainstream and read-intensive workloads

Solidigm QLC SSDs deliver read performance that's equivalent to TLC SSDs, along with strong write performance and ample endurance for many workloads. The following table, normalized on a TLC SSD, shows how QLC performance, endurance, and maximum-capacity-per-drive compares with a range of TLC SSDs.

Product	SR 128K QD256	SW 128K QD256	RR 4K QD256	RR 8K QD256	RW 4K QD256	Endurance[4] DWPD | Max PBW	Max Cap.
Samsung PM9A3[4]	1.01X up to 6900 MB/s	0.73X up to 4100 MB/s	1.1X up to 1.1M IOPS	0.98X up to 0.55M IOPS	0.8X up to 200K IOPS	1X | 0.5X up to 1 DWPD | 14 PBW	0.5X 7.68TB
Micron 7450 Pro[4]	1X up to 6800 MB/s	1X up to 5600 MB/s	1X up to 1.0M IOPS	1X up to 0.56M IOPS	1X up to 250K IOPS	1X | 1X up to 1 DWPD | 28 PBW	1X 15.36TB
Solidigm D5-P5430[4,5]	**1.03X** up to 7000 MB/s	0.55X up to 3000 MB/s	**0.97X** up to 0.971M IOPS	**1.25X** up to 0.7M IOPS	0.48X up to 120K IOPS	0.58X | **1.14X** up to 0.58 DWPD | 32 PBW	**2X** 30.72TB
Kioxia CD6-R[4]	0.91X up to 6200 MB/s	0.71X up to 4000 MB/s	1X up to 1.0M IOPS	0.8X up to 0.45M IOPS	0.34X up to 85K IOPS	1X | 1X up to 1 DWPD | 28 PBW	1X 15.36TB

Endurance concerns emerge with bit-per-cell transitions. With Solidigm QLC SSDs delivering 3,000 program/erase (PE) cycles on massive capacities, available lifetime writes (in petabytes written [PBW]) can exceed TLC SSDs.

Even more important than PBW is the reality of endurance needs. A large-scale study showing the read dominance of most workloads also examined how many TLC SSDs in its dataset of approximately 2 million drives could have used QLC SSDs instead. The study found that at 1,000 PE cycles, almost 95% of those drives could have been replaced with QLC SSDs, while at 3,000 PE cycles (coincidentally the rating for the D5-P5430 QLC drive), the opportunity would increase to nearly 99%.[1] This points to a massive opportunity to "right-size" SSDs for mainstream and read-intensive workloads to deliver more value.

QLC benefits

QLC SSDs are suitable for a wide range of workloads. In addition, IT administrators can realize up to 3x smaller rack footprint, 20% lower energy cost, and 31% lower total solution cost versus an all-TLC array for object storage.[6] The Solidigm D5-P5430 shows the density, total cost of ownership, and sustainability opportunities ahead for these workloads.

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[1] USENIX. "A Study of SSD Reliability in Large Scale Enterprise Storage Deployments." February 2020. www.usenix.org/conference/fast20/presentation/maneas.

[2] USENIX. "Operational Characteristics of SSDs in Enterprise Storage Systems: A Large-Scale Field Study." February 2022. www.usenix.org/system/files/fast22-maneas.pdf.

[3] There is a maximum of 48 E3.S drives and 24 U.2 drives per 2U chassis (source: SNIA. "Enterprise and Data Center SSD Form Factor – the end of the 2.5in disk era?" August 2020. www.snia.org/sites/default/files/SSSI/EDSFF%20Webcast%208-4-2020%20fnl.pdf). In comparing the D5-P5430 (E3.S) versus the Microsoft 7450 Pro (U.2), the 15.36 TB U.2 Micron 7450 Pro yields 15.36 TB x 24 = 368.64 TB, whereas the 30.72 TB D5-P5430 yields 30.72 TB x 48 = 1,474.56 TB, resulting in 4x more capacity with the D5-P5430. Micron source: Micron. "Micron 7450 NVMe™ SSD Storage." Accessed April 2023. www.micron.com/products/ssd/product-lines/7450.

[4] Solidigm performance and PBW using 100% 16K RW for D5-P5336 and 100% 4K RW for D5-P5430. Samsung, Micron, and KIOXIA performance and PBW from highest capacity drives available. Sources: Samsung. "Samsung V-NAND SSD PM9A3." 2022. https://image.semiconductor.samsung.com/resources/data-sheet/Samsung_SSD_PM9A3_Data_Sheet_Rev1.0.pdf. Micron. "Micron® 7450 SSD With NVMe®." May 2022. https://media-www.micron.com/-/media/client/global/documents/products/product-flyer/7450_nvme_ssd_product_brief.pdf. KIOXIA. "CD6-R Series (KCD61LUL/KCD6XLUL/KCD6DLUL/KCD6FLUL) Data Center NVMe™ Read-intensive SSD." 2022. https://americas.kioxia.com/content/dam/kioxia/shared/business/ssd/data-center-ssd/asset/productbrief/dSSD-CD6-R-product-brief.pdf.

[5] Solidigm. D5-P5430 product specifications and current five-quarter roadmap.

[6] Comparing total cost of ownership (TCO) of a 30.72 TB D5-P5430 with 7,000 MB/s throughput, 25 W average active power, and 5 W idle power versus a 15.36 TB (highest capacity available) Micron 7450 (source: Micron. "Micron 7450 NVMe™ SSD Storage." Accessed April 2023. www.micron.com/products/ssd/product-lines/7450.) with 6,800 MB/s throughput, 20 W average active write power, and 5 W idle power. This comparison assumes 42U rack capacity, 34U available for storage, 2U servers at 24 x U.3 TLC and 36 x E3.S QLC drives per server. Calculated duty cycles to deliver equivalent throughput per TB: 20% for TLC array, 38.9% for all-QLC solution. RAID1 mirroring and five-year refresh used for both. Key common cost assumptions: power cost = $0.15/kWh, power usage effectiveness (PUE) factor = 1.60, empty rack purchase cost = $1,200, system cost = $10,000, rack cost for deployment term = $171,200. Calculations based on Solidigm TCO estimations as of March 2023 using internal Solidigm TCO estimator tool.