KIOXIA

Frequently Asked Questions

Questions You Should Ask About the PCIe® 5.0 Interface and EDSFF E3.S SSD Storage

What is the PCIe 5.0 interface and its key benefits?

The PCI Express® (PCIe) 5.0 interface standard developed by PCI-SIG® is an upgrade that brings twice the data transfer speed and bandwidth when compared to the PCIe 4.0 standard (Figure 1). It allows devices to communicate faster with the system CPU and to transfer large chunks of data with less latency. The higher PCIe 5.0 performance utilizes half of the PCIe lanes versus the PCIe 4.0 interface and enables many more devices in a system.

PCIe Specification	Transfer Rate (in GT/s)*	Supported Signal Encoding[1]	Bandwidth (in GB/s)^	Year of Standard Ratification
PCIe 1.0	2.5	8b/10b	8	2003
PCIe 2.0	5.0	8b/10b	16	2007
PCIe 3.0	8.0	128b/130b	32	2010
PCIe 4.0	16.0	128b/130b	64	2017
PCIe 5.0	32.0	128b/130b	128	2019
PCIe 6.0	64.0	PAM-4[2]: FLIT[3]	256	2021

** gigatransfers per second*

^ gigabytes per second

Figure 1: Overview of the PCIe specifications from PCIe 1.0 to PCIe 6.0 (source: PCI-SIG)

Which SSD form factors does the PCIe 5.0 interface support?

PCIe is an interface technology not tied to any SSD form factor - therefore, PCIe 5.0 SSDs could be available in any form factor as long as their electrical/connector specifications support the PCIe 5.0 characteristics. SSD form factors that support the PCIe 5.0 interface include 2.5-inch[4], M.2, and new Enterprise and Datacenter Standard Form Factor (EDSFF) E3.S/E3.L and E1.S/E1.L variants. Today, all industry standard NVMe™ SSDs use the PCIe interface as a physical transport.

What are EDSFF E3.S SSDs?

To address functional limitations associated with 2.5-inch and M.2 SSDs, especially in regards to future enterprise and hyperscale requirements, the SFF Technical Affiliate (SFF-TA) working group of the Storage Networking Industry Association (SNIA) developed the EDSFF E3 specification.

The E3 form factor platform enables system designers to increase overall airflow significantly in compatible systems with the ability to deploy a large number of E3 SSDs to increase storage subsystem performance. The E3 SSD family consists of four different form factors (Figure 2). Server and storage vendors have only recently brought EDSFF supporting systems to market, with the first target being the E3.S variant on newly available PCIe 5.0 platforms.

E3 Form Factors Support:

Multiple device types

Multiple host connect link widths

Different form factor sizes

Increased power envelopes

Continuous operations in high temperature environments

Next-generation high frequency interfaces

E3 SSD Family:

E3 Short Thin (E3.S)
E3 Short Thick (E3.S 2T)
E3 Long Thin (E3.L)
E3 Long Thick (E3.L 2T)

Device	Height	Length	Width
E3.S	76 mm	112.75 mm	7.5 mm
E3.S 2T	76 mm	112.75 mm	16.8 mm
E3.L	76 mm	142.2 mm	7.5 mm
E3.L 2T	76 mm	142.2 mm	16.8 mm

Figure 2: Overview of EDSFF E3 Form Factors

The E3.S form factor targets NVMe SSDs with x4 PCIe link widths (though they can mechanically fit an x16 card edge). They also support power profiles up to 25W, which makes them well suited for general-purpose NVMe server storage subsystems including those with modular and short depth chassis. KIOXIA E3.S SSDs support up to 15.36 terabyte[5] (TB) capacities and have physical dimensions of 76 mm (H) x 112.75 mm (L) x 7.5 mm (W).

Why are E3.S form factor devices linked with PCIe 5.0 enabled servers?

If end users of these OEM systems require PCIe 5.0 performance, their only option is E3.S-compatible systems and SSDs.

E3.S form factors target both NVMe SSDs with x4 PCIe link widths as well as NVMe server subsystems that require very high performance utilizing up to 25W power profiles, of which there is high demand for both. As a complement to the increased PCIe 5.0 speed, the E3.S form factor delivers:

- *Support for multiple device types such as NVMe SSDs, compute express link (CXL), storage class memory (SCM) devices, computational storage devices, low-end accelerators, and front-facing I/O devices such as NICs*
- *Better flexibility relating to SSD and device placement*
- *Greater storage density than the 2.5-inch format per rack unit*
- *Support for the PCIe 5.0 interface as well as next-generation, high-frequency interfaces since the E3 connector provides great signal integrity characteristics and is designed to support the PCIe 6.0 interface*
- *Support for up to 25W power profiles which is required to saturate a PCIe 5.0 x4 link*

As a result, leading server and storage system OEMs have launched a number of E3.S systems deployed with PCIe 5.0 E3.S NVMe SSDs. If end users of these OEM systems require PCIe 5.0 performance, their only option is E3.S-compatible systems and SSDs. The PCIe 5.0 performance that can be achieved ties directly to E3.S form factors, which in turn provides an opportunity for end users to transition to the new E3.S form factor model.

E3.S form factors also provide end users with increased resource efficiencies by not having to manage PCIe 5.0 SSDs in both 2.5-inch and E3.S form factors. This also helps server and storage OEMs to reduce complexity in their procurement and management of SSDs, which in turn helps to manage costs.

What SSDs does KIOXIA offer that combine the PCIe 5.0 interface with EDSFF E3.S form factors?

KIOXIA Corporation offers the KIOXIA CM7 Series enterprise NVMe SSDs (Figure 3) supporting both PCIe 5.0 and E3.S form factors in one device, and includes:

KIOXIA CM7 Series SSDs[9]

CM7-R Series:

The KIOXIA CM7-R Series are read intensive E3.S NVMe SSDs optimized to support a broad range of enterprise applications and workloads that could include data warehousing, business intelligence, artificial intelligence (AI) /machine learning (ML), online transaction processing (OLTP), software defined storage (SDS) and virtualization. The series supports the PCIe 5.0 interface and NVMe 2.0 protocol, delivers high random read performance up to 2,700,000 input/output operations per second (IOPS) and high random write performance up to 310,000 IOPS. The series also features storage capacities up to 15.36 TB, 1 drive write per day[6] (DWPD) of endurance, power loss protection[7] (PLP), and security/encryption options[8].

CM7-V Series:

The KIOXIA CM7-V Series are mixed use E3.S NVMe SSDs optimized to support a broad range of enterprise applications and workloads that could include high performance computing (HPC), OLTP, Internet of Things (IoT), edge computing and media streaming. This series supports the PCIe 5.0 interface and the NVMe 2.0 protocol, and delivers high random read performance up to 2,700,000 IOPS and high random write performance up to 600,000 IOPS. The series features storage capacities up to 12.8 TB, 3 DWPD of endurance, and security/encryption options[8].

Metric	KIOXIA CM7-R (E3.S) Series	KIOXIA CM7-V (E3.S) Series
Interface / Protocol	PCIe 5.0 / NVMe 2.0	PCIe 5.0 / NVMe 2.0
Interface Speed	128 GT/s	128 GT/s
Capacities	1,920 / 3,840 / 7,680 / 15,360 GB	1,600 / 3,200 / 6,400 / 12,800 GB
DWPD	1	3
Sequential Read Performance[10]	up to 14,000 MB/s*	up to 14,000 MB/s
Sequential Write Performance[10]	up to 6,750 MB/s	up to 6,750 MB/s
Random Read Performance[10]	up to 2,700,000 IOPS	up to 2,700,000 IOPS
Random Write Performance[10]	up to 310,000 IOPS	up to 600,000 IOPS

* *megabytes per second*

Figure 3: Overview of KIOXIA CM7 Series E3.S SSDs

Where can you find more information on E3.S form factors?

E3.S form factors, and associated systems and SSDs, are becoming very trendy at present. There are a number of resources, places or locations to find more information, with key ones listed below:

E3.S Info	What's Available	Link
SNIA	E3.S specifications	https://www.snia.org/technology-communities/sff/specifications
	SSD form factors web page	https://www.snia.org/forums/cmsi/knowledge/formfactors
KIOXIA	CM7 Series E3.S SSDs	https://americas.kioxia.com/en-us/business/ssd/enterprise-ssd.html
	E3.S Intro white paper	https://americas.kioxia.com/content/dam/kioxia/en-us/business/ssd/data-center-ssd/asset/KIOXIA_EDSFF_E3_Intro_White_Paper.pdf
	E3.S blog	https://blog-us.kioxia.com/post/2023/06/01/edsff-e3-s-ssds-go-mainstream-in-servers1
	E3.S web content	https://americas.kioxia.com/en-us/business/ssd/solution/edsff.html
UNH-IOL	E3.S system/SSD testing	https://www.iol.unh.edu/testing

NOTES:

[1] Signal encoding converts digital or analog data into a specialized digital format for efficient data transmission or storage.

[2] Pulse Amplitude Modulation 4-level or PAM-4 is a popular signal coding and transmission technology for high-speed signal interconnections in next-generation data centers.

[3] The PCIe 5.0 specification doubles the PCIe 4.0 performance to 32 GT/s transfer rate with PAM-4 signal coding and transmission technology and uses FLIT (Flow Control Unit) as the unit of communication.

[4] 2.5-inch indicates the form factor of the SSD and not its physical size.

[5] Definition of capacity - KIOXIA Corporation defines a megabyte (MB) as 1,000,000 bytes, a gigabyte (GB) as 1,000,000,000 bytes and a terabyte (TB) as 1,000,000,000,000 bytes. A computer operating system, however, reports storage capacity using powers of 2 for the definition of 1Gbit = 2^{30} bits = 1,073,741,824 bits, 1GB = 2^{30} bytes = 1,073,741,824 bytes and 1TB = 2^{40} bytes = 1,099,511,627,776 bytes and therefore shows less storage capacity. Available storage capacity (including examples of various media files) will vary based on file size, formatting, settings, software and operating system, and/or pre-installed software applications, or media content. Actual formatted capacity may vary.

[6] Drive Write(s) per Day (DWPD): One full drive write per day means the drive can be written and re-written to full capacity once a day, every day, for the specified lifetime. Actual results may vary due to system configuration, usage, and other factors.

[7] Power Loss Protection (PLP) support helps to record data that resides in buffer memory to NAND flash memory by utilizing the backup power of the solid capacitor in case of a sudden power supply shut down.

[8] Optional security feature compliant drives are not available in all countries due to export and local regulations.

[9] Product image may represent a design model.

[10] Performance metrics provided by KIOXIA Corporation.

TRADEMARKS:

DISCLAIMERS: