KIOXIA

Why Deploy PM7 Series 24G SAS SSDs In Your Data Center?

The SCSI Trade Association is promoting 24G SAS (SAS-4) as its latest SAS generation, doubling the effective bandwidth versus the previous SAS-3 generation. This doubling of bandwidth is expected to continue with each new SAS generation, advancing SSD performance with 24G SAS today and 24G+ SAS on the horizon. There are a number of reasons to deploy 24G SAS in your data center, and in particular, KIOXIA PM7 Series SSDs, but the top five include:

1. **Performance**
   Doubles sequential read performance in SSDs with up to 4,200 megabytes per second (MB/s)[1], features a new encoding process and better management of write operations
2. **Flexible Storage Technology**
   Continues to ship in most servers and storage units today, supports SAS and SATA SSDs and HDDs in large topologies, and is backwards-compatible
3. **Proven Reliability**
   Supports high mean-time to failure (MTTF) and low bit error rate (BER), and achieves low annualized failure rates (AFRs) through die failure recovery and 20-bit Forward Error Correction (FEC)
4. **High Availability and Data Protection**
   Features dual-port capabilities and multiple levels of data security
5. **Broad Portfolio of Options**
   Delivers SSD configurations covering read-intensive and mixed-use workloads in a variety of capacities, endurances and security options

Performance

In SAS-based SSDs and hard drives, data travels by way of two or four lanes in full-duplex, wide-mode. With 24G SAS, each lane supports 22.5 gigabits per second (Gb/s), almost doubling SAS-3 bandwidth from 12 Gb/s. When compared to the SATA interface at 6 Gb/s, 24G SAS delivers almost four times the bandwidth and about eight times the bandwidth in full-duplex mode. Given that business-critical workload demands are on the rise, 24G SAS performance can meet these requirements.

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24G SAS incorporates a new encoding method that improves link efficiency to meet the requirements of the 22.5 Gb/s line rate. This new method incorporates 128b/130b encoding that includes 20-bit FEC, which allows 24G SAS to achieve the same level of data fidelity as 12 Gb/s SAS even though it is transferring data at twice the rate.

In 24G SAS, additional storage intelligence enables applications to manage write streams for better control over background housekeeping tasks and to help reduce garbage collection interruptions and write amplification that can improve performance and help extend SSD life.

When compared to 12 Gb/s SAS SSDs, 24G SAS SSDs outperform them. KIOXIA compared[1] its PM7 Series SSDs (22.5 Gb/s line rate) to its last 12 Gb/s line rate generation, the PM5 Series[2], that included read-intensive and mixed-use workloads, at each series' supported capacities and endurances, in a narrow dual configuration. The read-intensive performance results are presented.

The SSD comparisons include PM7-R Series (24G SAS) and PM5-R Series (12 Gb/s SAS) for capacities from 1,920 GB[3] to 15,360 GB (at 1 DWPD[4] endurance):

PM7-R Series (24G SAS) SSDs

SPECIFICATION	Units	1,920 GB	3,840 GB	7,680 GB	15,360 GB
Sequential Read *(128 KB; QD=32; 18W)*	MB/s	4,200	4,200	4,200	4,200
Sequential Write *(128 KB; QD=32; 18W)*	MB/s	3,400	3,650	4,100	4,100
Random Read *(4 KB; QD=256; 18W)*	KIOPS	720	720	720	720
Random Write *(4 KB; QD=32; 18W)*	KIOPS	155	155	175	160
Random Read Latency *(QD=1; 18W)*	µs	80	80	80	80
Random Write Latency *(QD=1; 18W)*	µs	15	15	15	15

PM5-R Series (12 Gb/s SAS)

SPECIFICATION	Units	1,920 GB	3,840 GB	7,680 GB	15,360 GB
Sequential Read *(128 KB; QD=32; 14W)*	MB/s	2,100	2,100	2,100	2,100
Sequential Write *(128 KB; QD=32; 14W)*	MB/s	2,100	2,100	2,100	2,100
Random Read *(4 KB; QD=64; 14W)*	KIOPS	340	370	385	300
Random Write *(4 KB; QD=32; 14W)*	KIOPS	55	55	55	35
Random Read Latency *(@ QD=1)*	µs	125	125	125	170
Random Write Latency *(@ QD=1)*	µs	35	35	35	35

PM7-R Series Advantages

SPECIFICATION	1,920 GB	3,840 GB	7,680 GB	15,360 GB
Sequential Read	100%	100%	100%	100%
Sequential Write	61%	73%	95%	95%
Random Read	111%	94%	87%	140%
Random Write	181%	181%	218%	357%
Random Read Latency	36%	36%	36%	52%
Random Write Latency	57%	57%	57%	57%

In summary, PM7-R Series 24G SAS SSDs demonstrated significant performance improvements over PM5-R Series 12 Gb/s SAS SSDs:

- *Up to 100% faster sequential read performance*
- *Up to 95% improved sequential write performance*
- *Up to 140% better random read performance*
- *Up to 357% greater random write performance*
- *Up to 52% lower random read latency*
- *Up to 57% lower write latency*

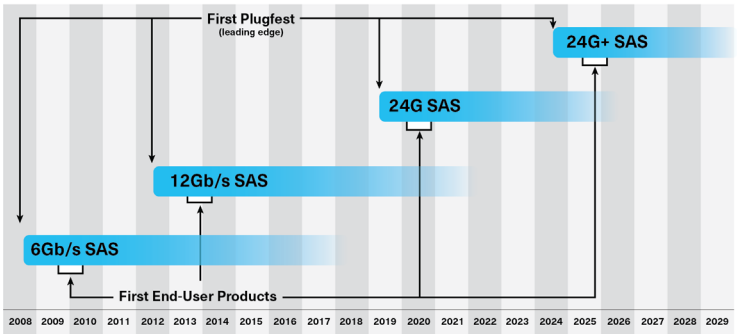
The 24G SAS SSD read-intensive performance results make them a good fit for large data center topologies, and for media streaming/video on demand (VoD), data warehousing and content delivery network (CDN) applications. In a mixed-use environment, 24G SAS SSDs are well-suited for high-performance computing (HPC), database and software defined storage (SDS) applications. For write-intensive workloads, they are ideal for virtualized environments, online transaction processing (OLTP) and e-commerce applications, compute-side artificial intelligence (AI)/machine learning (ML), data analytics and caching.

Flexible Storage Technology

The SAS interface moves data into and out of storage devices using the SCSI protocol. It has a reputation for reliability and is used for applications that require high availability and data protection. SAS is one of the main storage interfaces between computing and storage subsystems in data centers worldwide, and with a defined roadmap (Figure 1).

Most servers today ship with a SAS infrastructure and a backplane that also connects to SATA SSDs and/or HDDs, enabling both SAS and SATA drives to be used in the same drive bay. As future storage

SAS Technology Roadmap



Source: SCSI Trade Association, September 2021

Figure 1: SAS evolution from 6 Gb/s to 24G to 24G+

requirements change, SATA drives can be easily replaced with higher performing and larger capacity 24G SAS SSDs without any changes to the server or SAS infrastructure. Since the SAS interface can support up to 65,535 devices through expanders, it is well-positioned for large data center topologies where thousands of drives are required to support a range of applications. The 24G SAS interface is backwards-compatible with earlier infrastructure generations (12 Gb/s SAS and 6 Gb/s SAS).

Proven Reliability

The SAS interface uses additional SCSI features geared toward error recovery, error reporting and block reclamation that provide further reliability to an already extremely reliable interface. SSDs based on SAS are typically supported by industry-high mean-time to failure (MTTF) of 2.5 million hours and an uncorrectable bit-error rate (UBER) of 1e-17, and are backed by a 5-year warranty[5].

To further improve reliability and continue achieving low AFRs in the new 24G SAS PM6 Series, KIOXIA implemented its sixth-generation die failure management architecture that enables each SSD to sustain a simultaneous two flash memory die failure, recover from it and still read all of the data. In other SSDs, even a single die failure would render them inoperative. Once a PM6 Series SSD has recovered the data, it is moved to a new flash memory die location, ensuring that the drive will continue operating.

Implemented for the first time, the 24G SAS interface delivers 20-bit FEC reliability - a technique used for identifying and correcting errors in digital transmissions over high frequency or noisy communications channels. It can detect and correct errors up to 20 bits long on-the-fly without requiring a retransmission. Where previous SAS revisions only included error detection, 24G SAS includes 20-bit FEC in its 128b/150b encoding scheme. This sophisticated feature enables errors to be corrected in transit so that the optimal throughput can be maintained even under less than ideal operating conditions.

A new adaptive PHY training algorithm (APTA) is also supported within the 24G SAS interface that enables optimal operation in extremely dynamic environments with noisy signal lines, severe temperature ranges or volatile operating voltage swings.

High Availability and Data Protection

Setting a standard, SAS was the first interface to introduce dual-port capabilities which continues to be a requirement for today's high-performance and high-reliability data centers. Dual-ports provide two independent physical connections by which a host system can connect. When supported in SSDs, each of the drives' ports utilizes a separate PHY connection with its own unique address and worldwide network (WWN) identifier. If one of the SAS SSD ports fail or the system level data path is compromised, the remaining port continues operations as if no failure occurred, resulting in higher levels of data availability. Both dual-port and single-port are supported by the 24G SAS PM7 Series.

Multiple levels of data security are also available in PM7 Series 24G SAS SSDs. This includes Sanitize Instant Erase[6] (SIE), Self-Encrypting Drive[7] (SED) and SED with FIPS 140-2 (Level 2)[8] optional models[9].

SIE Drives	Self-Encrypting Drives	FIPS 140-2 Validation
Enables Cryptographic Erase to quickly facilitate making data unreadable when an SSD is taken out of commission or repurposed.	Encrypts/decrypts data written to and retrieved from an SSD via a password-protected alphanumeric key, (continuously encrypting and decrypting the data).	Validates that an SSD's cryptographic module is in compliance with the FIPS 140-2 standard developed by NIST through its rigorous Cryptographic Module Validation Program (CMVP).

Broad Portfolio of Options

SSDs based on 24G SAS follow a legacy of many successful models over the years resulting in the broad support of capacities, endurances and security options, in either single-port or dual-port configurations. KIOXIA's PM7 Series portfolio leverages industry-leading 112-layer BiCS FLASH™ 3D flash memory technology, delivers the largest 2.5-inch[10] SAS SSD capacity at 30.72 TB[3], and are segmented as follows:

- Read-intensive SSDs ranging from 1,920 GB to 30,720 GB capacities at 1 DWPD endurances
- Mixed-use SSDs ranging from 1,600 GB to 12,800 GB capacities at 3 DWPD endurances

Leading server OEMs and SSD vendors have 24G SAS solutions. PM7 Series SSDs are available through KIOXIA America, Inc. authorized sales channels.

Notes:

[1] The PM7 Series 24G SAS SSD performance specifications are available in published marketing assets from KIOXIA America, Inc.

[2] The PM5 Series 12 Gb/s SAS SSD performance specifications are available in published marketing assets from KIOXIA America, Inc.

[3] 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 1 Gbit = 2^{30} bits = 1,073,741,824 bits, 1 GB = 2^{30} bytes = 1,073,741,824 bytes and 1 TB = 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.

[4] Drive Write(s) per Day: 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.

[5] KIOXIA SSDs based on the 24G SAS interface are expected to achieve high quality and reliability through multiple solutions and are backed by a 5-year warranty.

[6] The Sanitize Instant Erase (SIE), Self-Encrypting Drive (SED), FIPS (Federal Information Processing Standards) optional models are available. SIE option supports Crypto Erase, which is a standardized feature defined by the technical committees (T10) of INCITS (InterNational Committee of Information Technology Standards).

[7] SED supports TCG-Enterprise SSCs. For more details, please make inquiries through "Contact us" in each region's website, https://business.kioxia.com/

[8] KIOXIA FIPS drives utilize a security module designed to comply with FIPS 140-2 Level 2 and FIPS 140-3 Level 2, which define security requirements for cryptographic module by NIST (National Institute of Standards and Technology). For the latest validation status of each model, please contact us in each region's website, https://business.kioxia.com/

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

[10] Based on publicly available specifications from 24G SAS-based SSD products as of this publication - February 2023, Rev. 1.0.

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