

KIOXIA FL6 Series

Enterprise SCM NVMe™ SSDs

open-e

**Multi-purpose high-performing NVMe™ SSDs
for your data storage appliances.**

KEY BENEFITS:

- ✓ **High-performance and low latency.** The KIOXIA FL6 NVMe™ SSDs help to deliver consistently high IOPS and low latencies.
- ✓ **Multi-purpose drives for tailored data storage setups.** You can benefit from using the KIOXIA FL6 NVMe™ SSDs whether they are used as a read cache, a write log, or data drives, adjusting them to your business needs.
- ✓ **RAM competitive SSD solution.** RAM provides excellent caching performance for demanding applications, but it comes at a high cost. The KIOXIA FL6 NVMe™ SSDs address this by providing high-density flash memory at a significantly lower cost to be used as caching devices.

EXECUTIVE SUMMARY

Open-E, the data storage software provider, evaluated and certified the use of the KIOXIA FL6 NVMe™ SSDs with the Open-E JovianDSS-powered data storage systems. The devices were tested in various data storage scenarios, includ-

ing serving as cache devices that support both write operations (write log) and read operations (read cache), as well as data drives in the all-Flash data storage appliances.



Thanks to their high performance and low latencies, Open-E now recommends the KIOXIA FL6 NVMe™ SSDs for use with Open-E JovianDSS in enterprise-level data storage setups.

CUSTOMER NEED

The world of modern data storage solutions includes a broad spectrum of demands for implementations, starting from HDD-based large capacity storage setups up to the high-performing all-flash types of storage. The most crucial requirements to be met are:

- High capacity to store huge amounts of data.
- Affordability and long lifespan of data storage elements with a reasonable price-performance ratio.
- High speed of read and write operations, low latency levels, as well as less power waste.

Due to that, solution providers are challenged to develop solutions in such a way to meet different requirements for a variety of data storage's real-life business uses. It should guarantee the ability to bring out the best of each storage technology, like scalable and cost-efficient capacity, as well as high endurance and reliability of HDDs, and high performance of SSDs.

"Open-E JovianDSS is a hardware-agnostic data storage system based on the ZFS and Linux, which provides a wide range of possibilities from all-HDD to all-Flash storage setups, as well as advanced caching functionalities. We found out that KIOXIA FL6 NVMe™ SSDs show excellent performance in a variety of our implementations and can address the different business goals of our customers - ultra-high performance when used as data devices in all-Flash setups, and significant cost reduction when used as caching devices supporting HDDs" - says Krzysztof Franek, CEO at Open-E.

THE POWER OF CACHING

Open-E JovianDSS is based on ZFS, a file system that provides advanced read caching functionalities like:

- First read cache level in RAM (ARC - Adaptive Replacement Cache).
- Second read cache level on a fast memory device (L2ARC, Level 2 Adaptive Replacement Cache).

The first read cache level (ARC) supports read operations by storing recently and frequently used data on RAM, as long as there is enough capacity. If the capacity is reaching its limits, the caching process is either switched to the second read cache level (L2ARC), or read operations need to be executed directly from the disk.

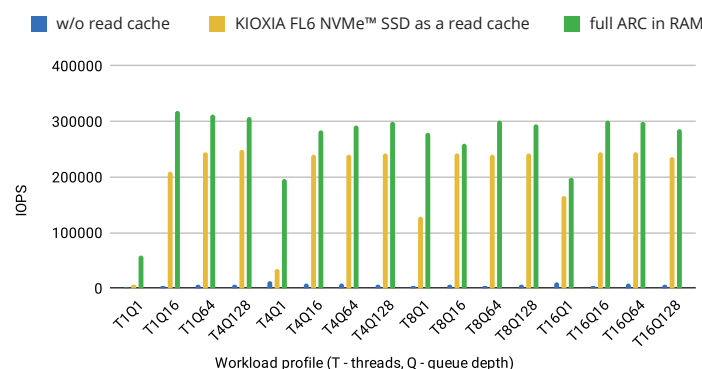
As a **second read cache level**, the **KIOXIA drives delivered a surge in performance (250K IOPS)**, in comparison to the setup with the read operations executed directly from HDD data disks (the average result for this scenario is about **1.3K IOPS**). What is more, the KIOXIA drives showed only slightly lower performance than the setup with all the read operations executed in ARC (**300K IOPS for full ARC**),

which is possible only with a sufficient RAM capacity that is much more expensive. The KIOXIA drive used as a read cache device shows also a **very good latency level, ranging mostly between 0,1 and 0,5 ms**, compared to the full ARC RAM-based cache average of 0,02. The setup without read cache, when reads are directly executed from HDD data drives, completes the operations in a range of 2 - 20 ms.

The results show that the KIOXIA FL6 NVMe™ SSD-based read cache is especially recommended for setups with expected massive read loads, which are often seen in **applications for media streaming and processing platforms, digital platforms, or in virtualized environments**. The Open-E test results proved that KIOXIA FL6 NVMe™ SSD can be considered a reasonable choice and competitive to RAM solutions. Instead of adding more and more RAM capacity, the KIOXIA SSDs can be applied.

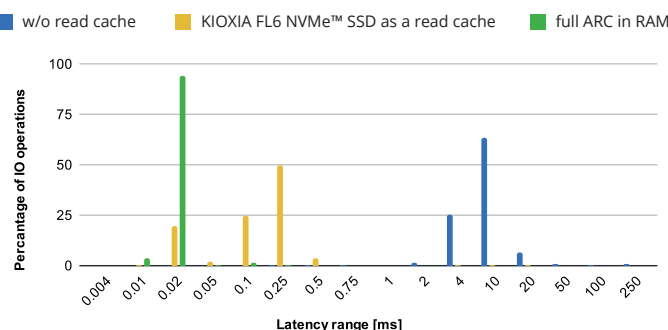
Random Reads IOPS Results

Tests profile: Random operations, 12x Mirror HDD ZPool
Higher is better



Random Reads Latency Results

Tests profile: Random operations, 12x Mirror HDD ZPool, latency distribution for T1Q1
Lower range is better

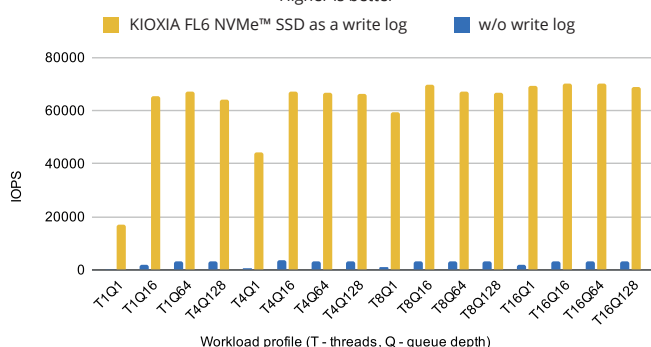


ZFS enables the write operations support as well, by the write log caching tier located on a separated fast memory device, called SLOG. The Open-E Team has established that **while using KIOXIA FL6 NVMe™ SSDs as a write log**,

the storage volume delivered a significantly higher performance with higher, consistent IOPS (about 18 times higher for random write operations, and 2,5 times higher for sequential writes operations, than without write log for HDD-based data storage), and lower latency compared to the HDD's data storage setups without write log (majority of operations are executed within 0,05 ms with a write log; without a caching device it takes 4 - 20 ms). The performance of random write operations is essential for multi-user applications, like virtualized environments, systems with massive multi-source write workloads like CCTV, media files storing and processing, or transactional applications.

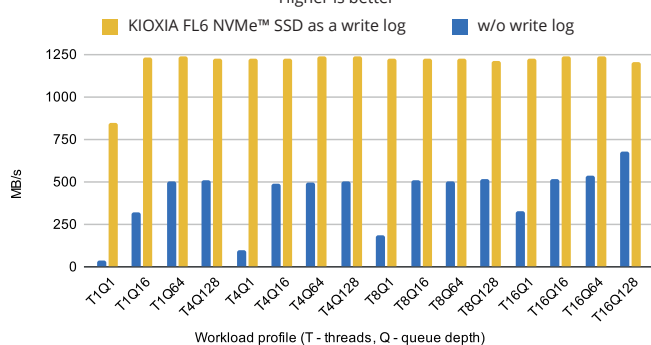
Random Writes IOPS Results

Tests profile: Random operations, 12x Mirror HDD ZPool
Higher is better



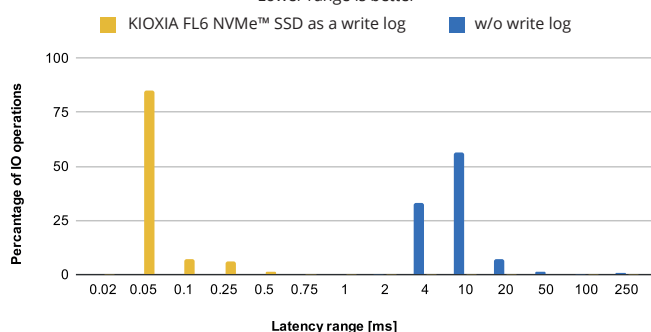
Sequential Writes IOPS Results

Tests profile: sequential operations, 12x Mirror HDD ZPool
Higher is better



Random Writes Latency Results

Tests profile: Random operations, 12x Mirror HDD ZPool, latency distribution for T1Q1
Lower range is better

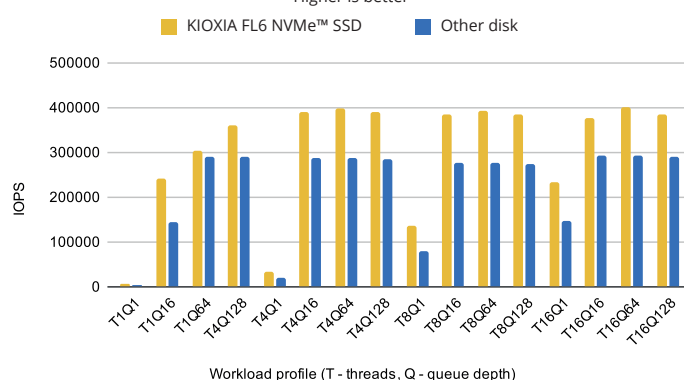


POWERFUL ALL-FLASH DATA STORAGE SOLUTION

KIOXIA FL6 NVMe™ SSDs have been also extensively tested as data drives in the all-Flash data storage appliances¹, in a Single-Node Storage setup, as well as in a Non-Shared Storage Cluster that provides the High Availability feature, and additional performance gains. To provide measurable results, the KIOXIA drives had been compared with the regular NVMe SSD drives. KIOXIA FL6 NVMe™ SSDs outperform the counterpart in terms of both random reads and writes, as well as in sequential reads (while sequential writes achieved comparable results). It means that KIOXIA FL6 NVMe™ SSDs is a perfect choice when it comes to customers that require a high-performance data storage appliance for multi-user purposes like virtualization, database-optimized storage, or media & entertainment file servers.

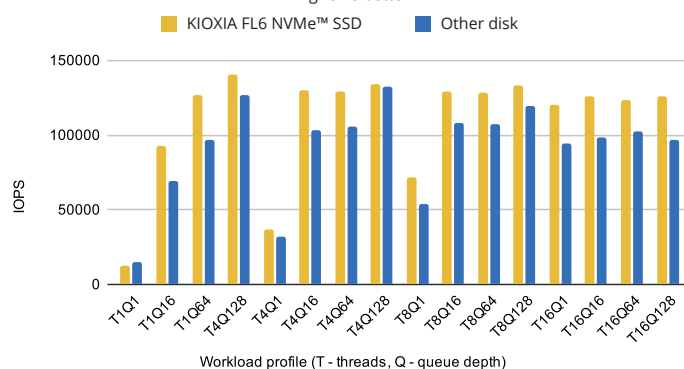
All-Flash Data Storage Reads Results

Tests profile: Random operations, KIOXIA FL6 NVMe™ SSD vs regular NVMe drive
Higher is better



All-Flash Data Storage Writes Results

Tests profile: Random write operations, KIOXIA FL6 NVMe™ SSD vs regular NVMe drive
Higher is better



¹ All-Flash test results presented in this document reflect the performance of the Single-Node data storage setup.

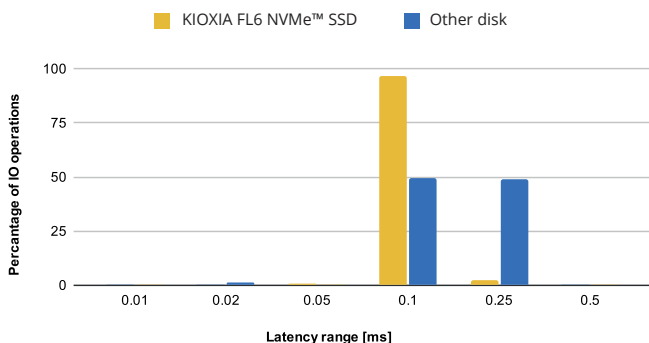
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All-Flash Data Storage Reads Latency Results

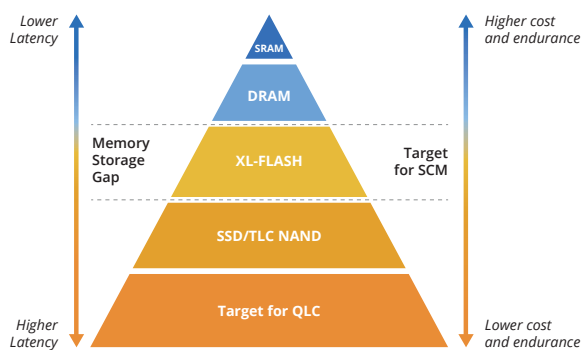
Tests profile: Random write operations, KIOXIA FL6 NVMe™ SSD vs regular NVMe drive
Lower range is better



SOLUTION ARCHITECTURE: KIOXIA FL6 NVMe™ SSDs

The KIOXIA FL6 Series is a dual-port PCIe® 4.0 / NVMe™ SSD that provides excellent system performance with low latency for applications where response time is critical. It utilizes the XL-FLASH technology, and is a perfect fit for enterprise and data center applications to be used as caching devices, such as read/write caching in tiered data storage environments. It can also be used as ultra-fast and long endurance data drives.

Where does KIOXIA FL6 NVMe™ SSDs' XL-FLASH fit in the Memory Hierarchy?



Volatile memory solutions such as DRAM provide the access speed required by demanding applications, but on the other hand, it comes at a high cost. The KIOXIA FL6 NVMe™ SSDs address this by providing high density, lower cost, and non-volatile flash memory.

CONCLUSION

KIOXIA FL6 NVMe™ SSDs, with 60 DWPD endurance and capacities from 800 GB to 3.2 TB, can adjust to a variety of purposes in data storage setups. Thanks to their speed, capacity and endurance (60 DWPD), they will display their outstanding performance as read and write caching devices for HDDs, as well as data drives for all-flash storage solutions. After a set of comprehensive tests, it is indicated that KIOXIA FL6 NVMe™ SSDs are universal and can be implemented in a multitude of setups. Open-E recommends KIOXIA FL6 NVMe™ SSDs to clients for their data and cache devices. Thanks to the combination of performance, low latency, and high endurance, they effectively support customers' common workloads, including databases, virtualization, online transaction processing, and virtual infrastructure.

"With FL6, KIOXIA has released a flash-based storage-class memory SSD with PCIe Gen 4 Interface, which is cost-effectively bridging the gap between DRAM and TLC-based SSDs. We are happy that Open-e as a trusted supplier for Software-Defined Storage systems and as an Expert in Storage Tiering has tested and certified FL6 under the latest Open-E JovianDSS version. We trust that customers will appreciate FL6 superiority within Storage Class Memory products and the benefits FL6 is offering to Server and Storage Systems."- says Frederik Haak, Senior Manager – SSD Marketing and Engineering at KIOXIA Europe GmbH.

The test was performed locally on the Open-E JovianDSS system. The workload was generated by fio 3.28. Random read/write cases were tested on zvols with block size = 4 kB. Sequential read and sequential write on zvols with block size = 64 kB. IOPS, and latency results were generated by fio. ZFS arcstat tool was used to ensure that during random read tests, read cache was utilized fully (99-100% reads from read cache). Test data size: 50 GB. In fio thelibaio engine was used. Test block size: 4 kB for random read, and random write, 1 MB for sequential read and sequential write. Zvol provisioning: thin. Hardware specifications: Intel M50CYP25BSTD server with 2x Intel Xeon Gold 6334, 256 GB - 16x Samsung M393A2K40DB3-CWE 3200 MHz 16 GB DDR4, Broadcom / LSI 9400 SAS HBA storage controller used to connect HDD drives. Tested on Open-E JovianDSS up29r2 b46777.