QSAN XCubeDAS XD5300 Performance Report

Date: 2016.04.15
Revision: V1.0

PROPRIETARY NOTE

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Revision History

Date / Version	Change List	Owner
2016.04.15 / V1.0	First Version	Nicole Yang

1. XCubeDAS XD5300 Performance Test Report Summary

QSAN XCubeDAS XD5300 DAS systems are designed with the latest 12Gb/s SAS expander, and built for host server easy capacity expanding, application demanding high throughput, high availability, non-stop services, and flexible storage planning with cost effectiveness. With the native ability of 12Gb/s SAS and QSAN's performance optimization, the XD5300 series is both efficient and smooth for high-definition media editing, streaming, broadcasting, high performance computing (HPC) applications, massive data archiving/backup, performance-demanding applications, real time clustering, expansion to VMware Virtual SAN (VSAN Software Defined Storage), and online expansion to public or private cloud storage servers.

The XD5300 solutions set a new storage standard for direct-attached storage. The series provides a smart and elastic runtime configuration of the 10x 12Gb/s SAS wide ports with three topologies support, and allows IT managers fully utilizing the 480Gb/s data bandwidth per system for various applications. The XD5300 series is fully tested with various configurations and the maximum non cache-hit throughput of the XD5300 system is up to 24,000MB/s. The optimized 12Gb/s SAS storage system combined with Qsan's best efficient firmware, well-deployed hardware layout, guaranteed full channel bandwidth to each 12Gb/s SAS port, and central management software, enables XCubeDAS XD5300 to deliver a 24,000MB/s throughput and end-to-end 4 millions IOPS.

The following tables and charts illustrate QSAN XCubeDAS XD5300 DAS system overall performance data. All the following summaries are tested in **Non Cache-Hit** mode.

Table 1: Maximum Sequential Read IOPS

I/O Size (Byte)	Sequential Read IOPS	Comment
512	4,269K	
4K	2,775K	
8K	1,896K	
16K	1,144K	
32K	651K	

Table 2: Maximum Sequential Write IOPS

I/O Size (Byte)	Sequential Write IOPS	Comment
512	1,835K*	*1
4K	2,630K	
8K	1,850K	
16K	1,039K	
32K	570K	

Table 3: Maximum Random Read IOPS

I/O Size (Byte)	Random Read IOPS	Comment
512	4,320K	
4K	3,049K	
8K	2,063K	
16K	1,236K	
32K	607K	

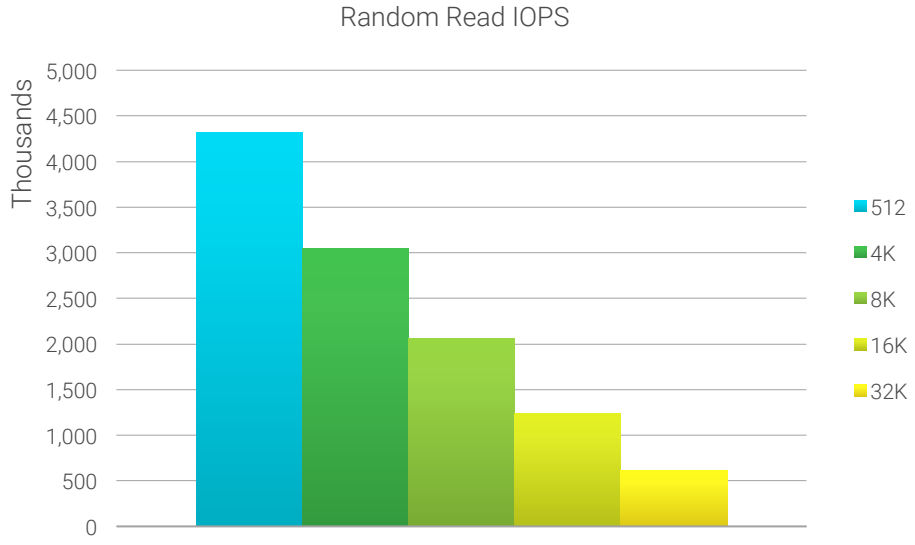


Table 4: Maximum Random Write IOPS

I/O Size (Byte)	Random Write IOPS	Comment
512	1,102K	
4K	656K	*2
8K	319K	
16K	157K	
32K	78K	

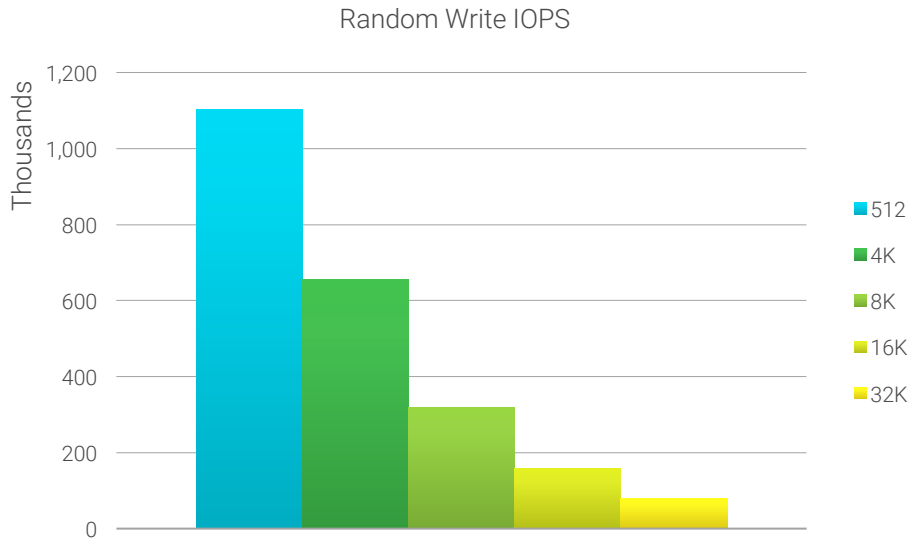
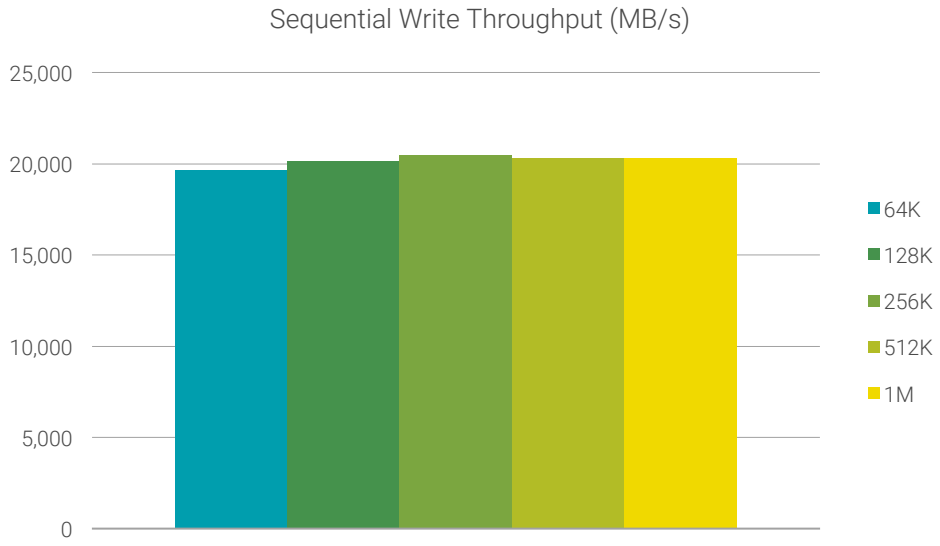


Table 5: Maximum Sequential Read Throughput

I/O Size (Byte)	Sequential Read Throughput	Comment
64K	22,649 MB/s	
128K	23,291 MB/s	
256K	24,119 MB/s	
512K	24,448 MB/s	
1M	24,602 MB/s	

Table 6: Maximum Sequential Write Throughput

I/O Size (Byte)	Sequential Write Throughput	Comment
64K	19,632 MB/s	
128K	20,145 MB/s	
256K	20,465 MB/s	
512K	20,299 MB/s	
1M	20,301 MB/s	



Comment *1:

The size of a NAND-flash page size varies from 2KB, 4KB, 8KB or 16KB nowadays. The smallest unit in the NAND-flash in the SSDs that can be read or written is a page. For sequential write I/O size smaller than a page size, there will be extra overhead to complete every I/O from the SSDs. Unlike hard drives, the average 512B IOPS is slower than 4K IOPS.

In the following paragraphs of this report, the 512B write IOPS are removed to reduce the deviation from the SSD overhead.

Comment *2:

The 4K random write IOPS / 656K here is tested with 24 pcs of Seagate 1200.2 Light Endurance SAS SSD 960G (Model Number: ST960FM0003). The test result here may be limited by the maximum write IOPS which this SSD can perform.

2. Test Configuration

Below is the description of the XCubeDAS XD5300 performance testing configurations, including the test environment, server hardware, operating systems, DAS storage system, SSD, and installations.

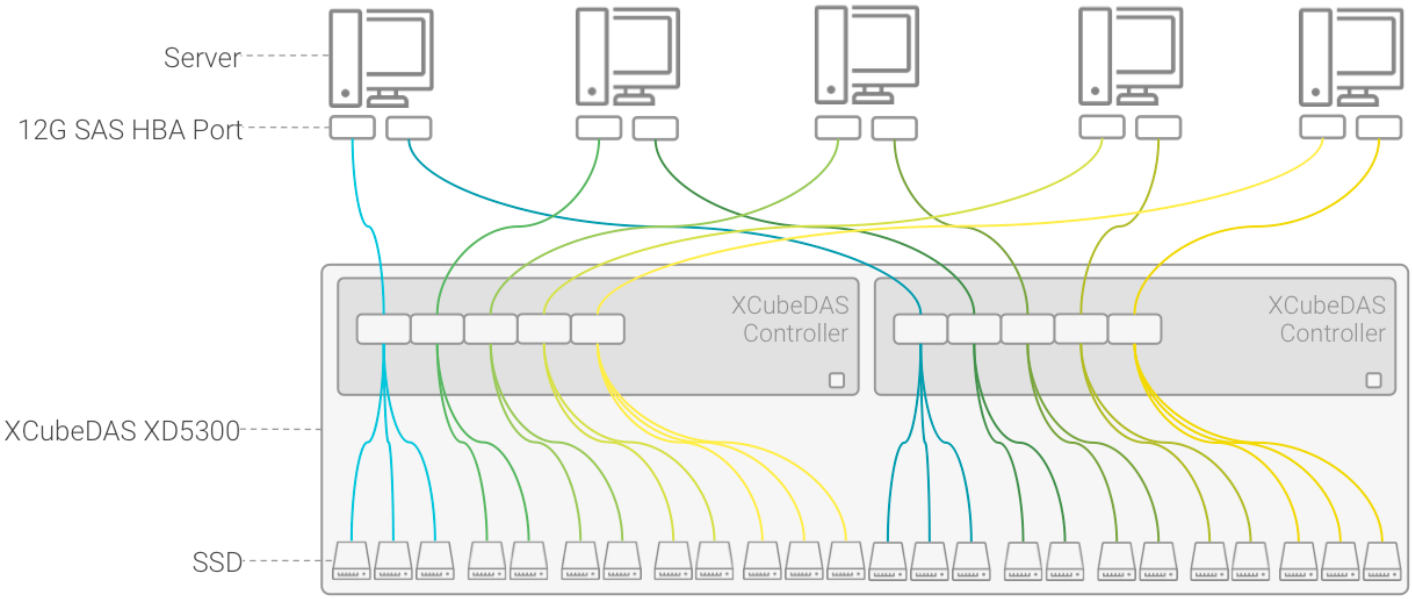


Figure 1: XCubeDAS XD5300 Performance Test Configuration

2.1. Host Configuration

The XCubeDAS XD5300 12Gb/s SAS storage system is directed attached to five different servers. Each server is installed with one Broadcom (Avago/LSI) SAS 9300-16e host bus adapter. Each HBA is connected to both controllers in the XD5300 storage system.

- Server x5
  - Asus RS700 Server, Windows Server 2012 R2, Intel Xeon CPU E5-2620 @2.0GHz, 16GB RAM
- 12Gb/s SAS HBA x5
  - Broadcom (Avago/LSI) SAS 9300-16e host bus adapter
- Iometer configuration
  - Version 2006.07.27 Dynamo
  - 1 worker per SSD
  - Non Cache-hit. All the test cases are configured as non cache-hit.
  - Queue Depth (QD, Outstanding I/Os): 4, 8, 16, 32, 64, 128, 256, and 512
  - Test cases
    - 100% Read; Sequential IOPS: 512B, 4K, 8K, 16K, 32K
    - 100% Write; Sequential IOPS: 4K, 8K, 16K, 32K
    - 100% Read; Random IOPS: 512B, 4K, 8K, 16K, 32K
    - 100% Write; Random IOPS: 4K, 8K, 16K, 32K
    - 100% Read; Sequential Throughput: 64K, 128, 256K, 512K, 1M
    - 100% Write; Sequential Throughput: 64K, 128, 256K, 512K, 1M
    - 90% Read; 10% Write; Random IOPS: 4K, 8K, 16K, 64K
    - 80% Read; 20% Write; Random IOPS: 4K, 8K, 16K, 64K
    - 70% Read; 30% Write; Random IOPS: 4K, 8K, 16K, 64K
    - 60% Read; 40% Write; Random IOPS: 4K, 8K, 16K, 64K
    - 50% Read; 50% Write; Random IOPS: 4K, 8K, 16K, 64K

2.2. XCubeDAS XD5300 Configuration

The XCubeDAS XD5300 12Gb/s SAS storage system is installed with 24 Seagate SAS SSD. Each XD5300 controller is built in with 5x 12Gb/s SAS ports; each port is configured as separated zone for different server. The detailed installation is illustrated in the “Figure 1: XCubeDAS XD5300 Performance Test Configuration”.

- Storage system: QSAN XCubeDAS XD5300 12Gb/s SAS storage system, 24 bays
  - Zone 1 at XD5300 controller 1 and controller 2 port 1
    - Disk slot: 1, 2, 3, 13, 14, 15
    - 6 Iometer workers
  - Zone 2 at XD5300 controller 1 and controller 2 port 2
    - Disk slot: 4, 5, 16, 17
    - 4 Iometer workers
  - Zone 3 at XD5300 controller 1 and controller 2 port 3
    - Disk slot: 6, 7, 18, 19
    - 4 Iometer workers
  - Zone 4 at XD5300 controller 1 and controller 2 port 4
    - Disk slot: 8, 9, 20, 21
    - 4 Iometer workers
  - Zone 5 at XD5300 controller 1 and controller 2 port 5
    - Disk slot: 10, 11, 12, 22, 23, 24
    - 6 Iometer workers
- SAS SSD: Seagate 1200.2 Light Endurance 960GB; Model ST960FM0003
  - Interface: Dual 12Gb/s SAS
  - NAND flash type: eMLC
  - Sequential Read (MB/s) Peak, 128KB: 1,750MB/s
  - Sequential Write (MB/s) Peak, 128KB: 850MB/s
  - Random Read (IOPS) Peak, 4KB QD32: 190K
  - Random Write (IOPS) Peak, 4KB QD32: 35K

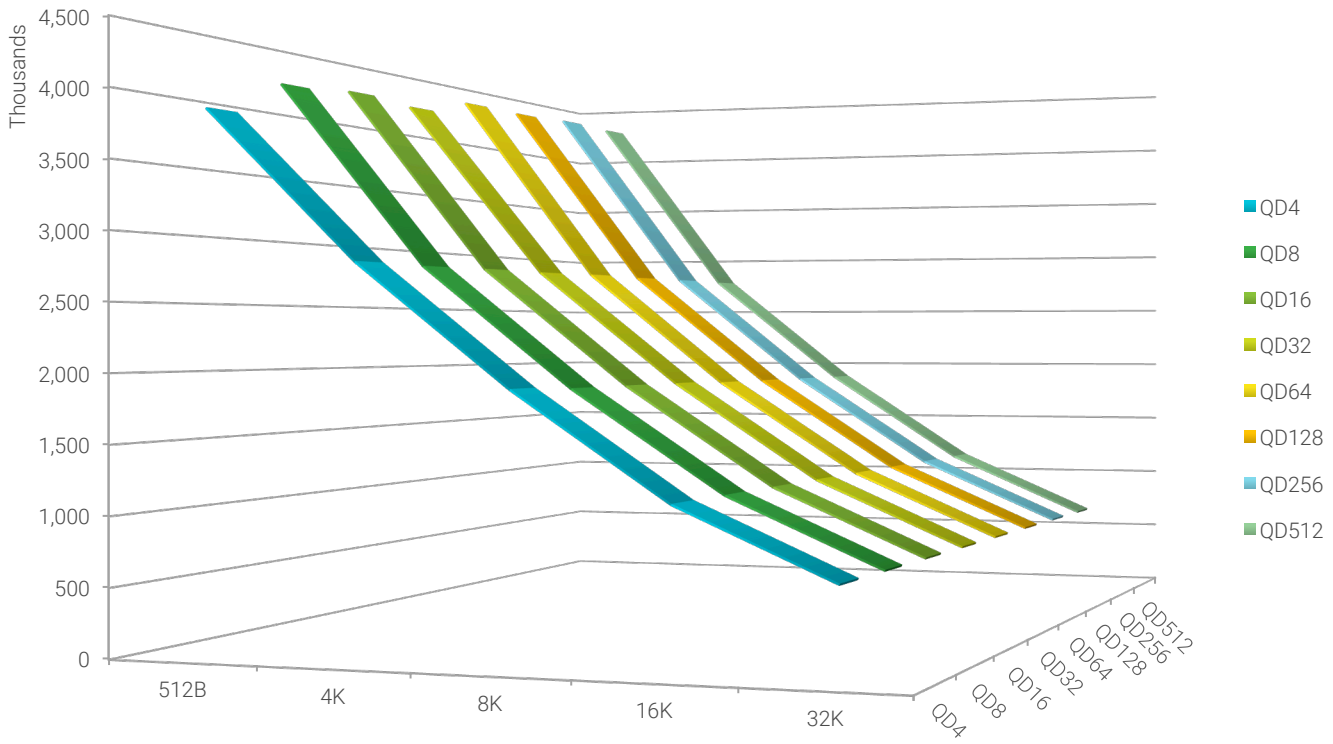
3. Performance Test Result

The following sections illustrate the XCubeDAS XD5300 test results from various combinations of IO sizes, read/write, sequential/random, and queue depths (QD, Outstanding I/Os).

3.1. Sequential Read IOPS

100% Sequential Read IOPS	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
512B	3,862,296	4,129,174	4,167,702	4,133,647	4,255,682	4,251,069	4,268,937	4,257,343
4K	2,771,202	2,765,816	2,770,419	2,768,541	2,774,642	2,770,617	2,772,104	2,769,800
8K	1,896,265	1,881,674	1,882,936	1,882,901	1,872,928	1,873,435	1,873,559	1,874,426
16K	1,143,588	1,142,800	1,142,921	1,142,552	1,141,695	1,141,767	1,141,679	1,141,787
32K	650,358	650,990	650,620	650,606	651,046	650,923	650,957	650,993

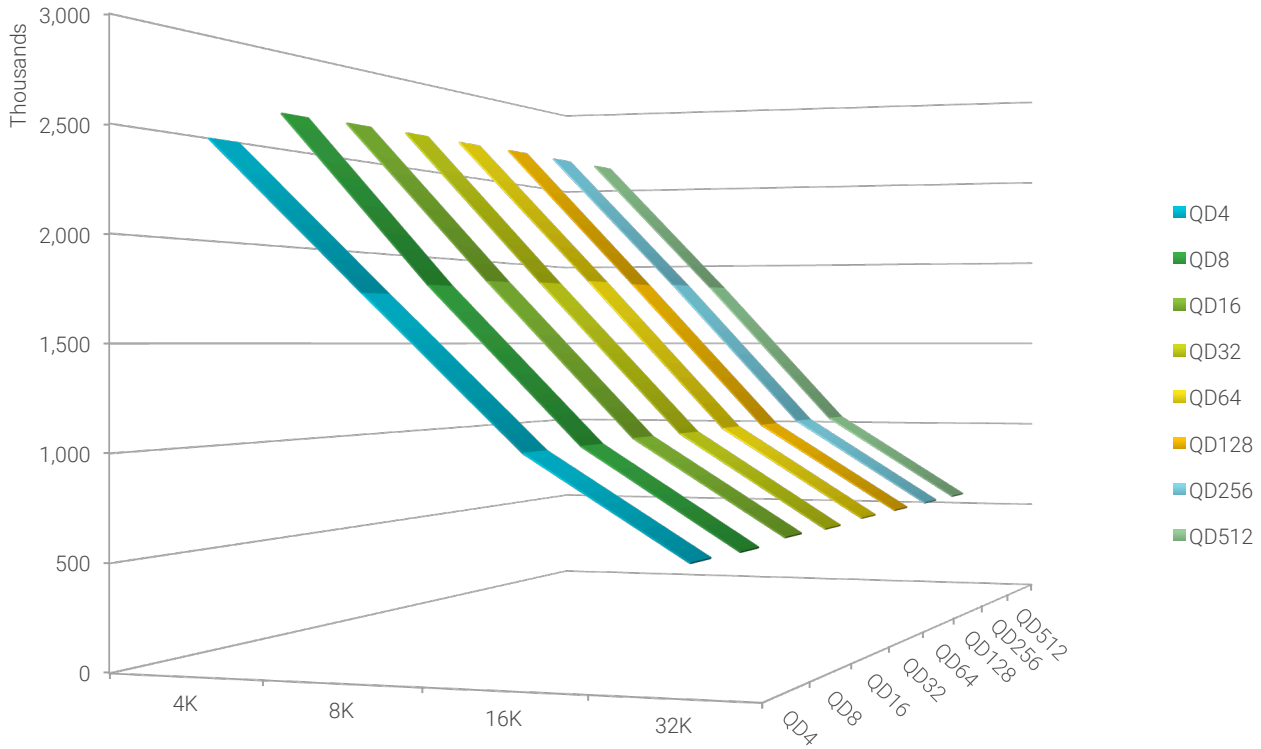
Table 7: Sequential Read IOPS Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512



3.2. Sequential Write IOPS

100% Sequential Write IOPS	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
4K	2,438,944	2,612,615	2,621,394	2,625,695	2,626,065	2,630,227	2,628,232	2,628,885
8K	1,724,021	1,775,631	1,809,800	1,817,714	1,840,987	1,838,990	1,850,821	1,850,750
16K	1,016,881	1,021,141	1,033,990	1,033,216	1,039,829	1,036,473	1,039,968	1,037,975
32K	554,939	549,256	566,110	559,499	569,837	569,169	569,711	569,476

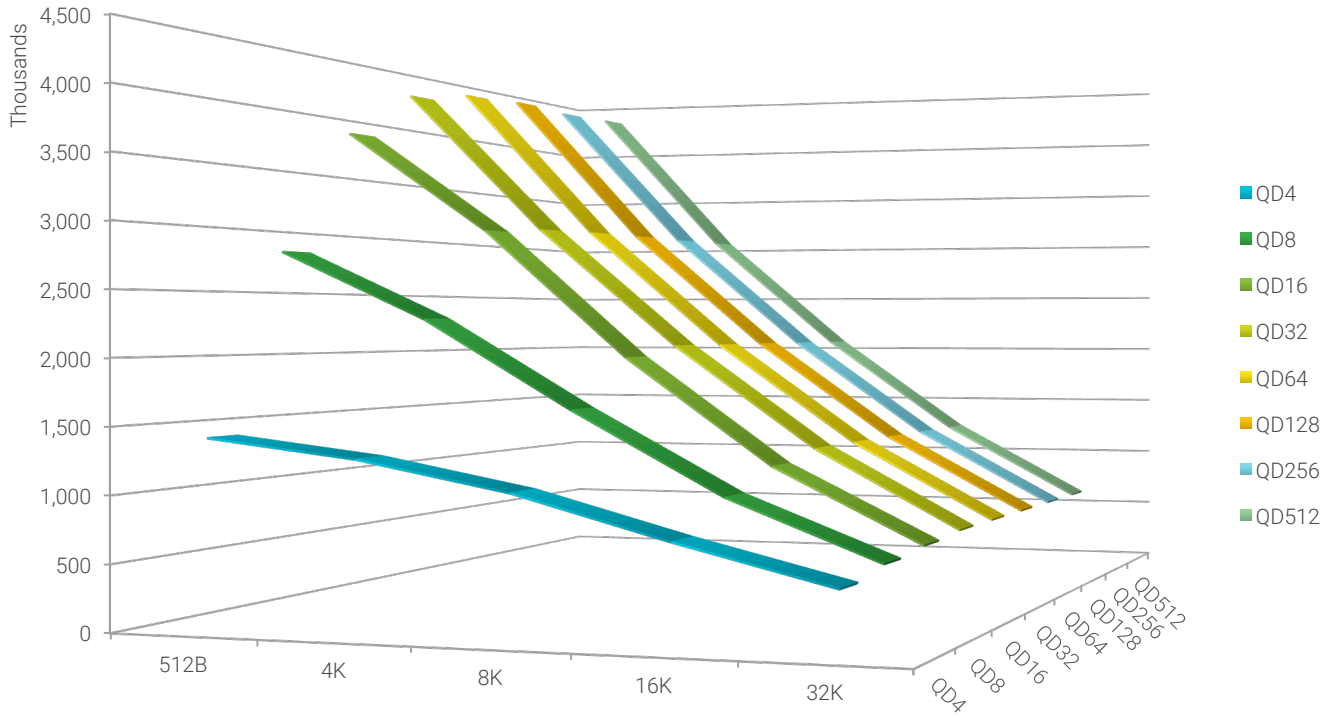
Table 8: Sequential Write IOPS Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512



3.3. Random Read IOPS

100% Random Read IOPS	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
512B	1,410,264	2,802,296	3,793,283	4,191,733	4,292,632	4,320,148	4,299,318	4,314,435
4K	1,274,993	2,282,140	2,990,645	3,035,518	3,047,956	3,048,705	3,047,550	3,047,469
8K	1,059,291	1,604,760	1,979,756	2,063,091	2,062,854	2,062,665	2,062,666	2,062,746
16K	748,546	983,561	1,149,150	1,234,875	1,236,328	1,236,253	1,236,177	1,236,014
32K	465,830	534,390	575,540	606,945	607,246	607,433	607,274	607,456

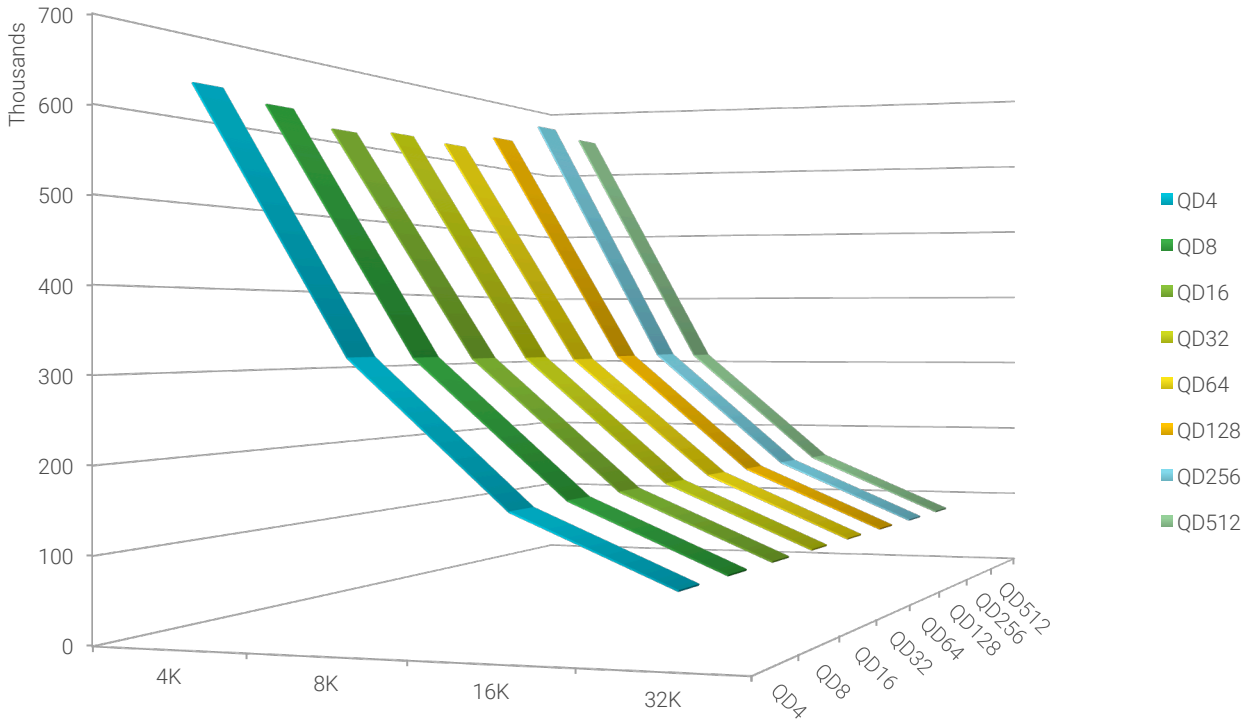
Table 9: Random Read IOPS Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512



3.4. Random Write IOPS

100% Random Write IOPS	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
4K	625,519	616,047	599,934	607,828	605,765	626,435	655,627	647,166
8K	319,290	317,403	314,563	313,750	309,753	312,260	312,871	310,707
16K	155,738	156,583	156,099	156,283	157,077	156,533	156,536	155,762
32K	77,810	77,971	77,837	77,776	77,889	77,823	77,611	77,848

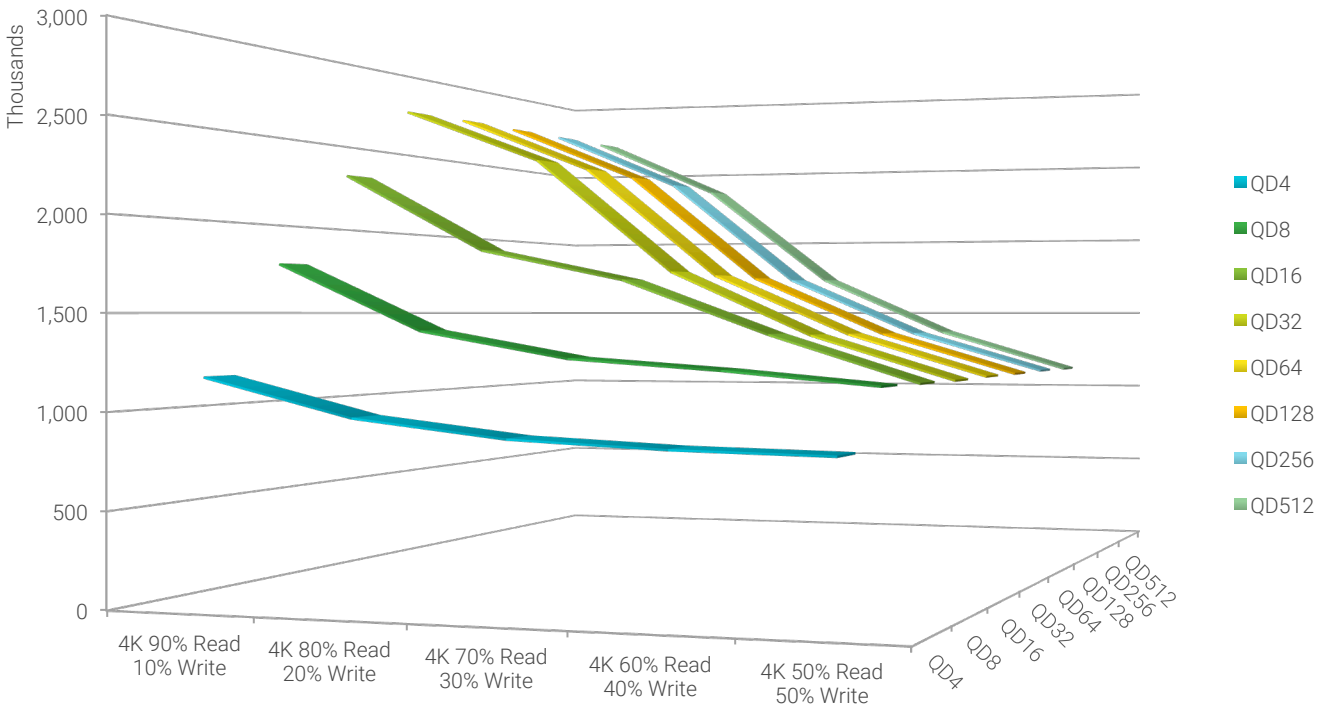
Table 10: Random Write IOPS Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512



3.5. 4K Read/Write Mix Random IOPS

4K Mix Random IOPS	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
90% Read 10% Write	1,172,029	1,761,454	2,276,022	2,696,363	2,703,163	2,700,636	2,700,366	2,698,871
80% Read 20% Write	975,462	1,402,825	1,845,891	2,392,853	2,383,043	2,371,144	2,359,697	2,346,595
70% Read 30% Write	884,556	1,262,399	1,678,776	1,734,575	1,723,504	1,716,428	1,714,529	1,723,887
60% Read 40% Write	847,805	1,207,059	1,382,240	1,372,293	1,371,019	1,367,589	1,364,636	1,367,531
50% Read 50% Write	832,037	1,135,384	1,128,305	1,124,399	1,127,944	1,126,534	1,128,714	1,124,580

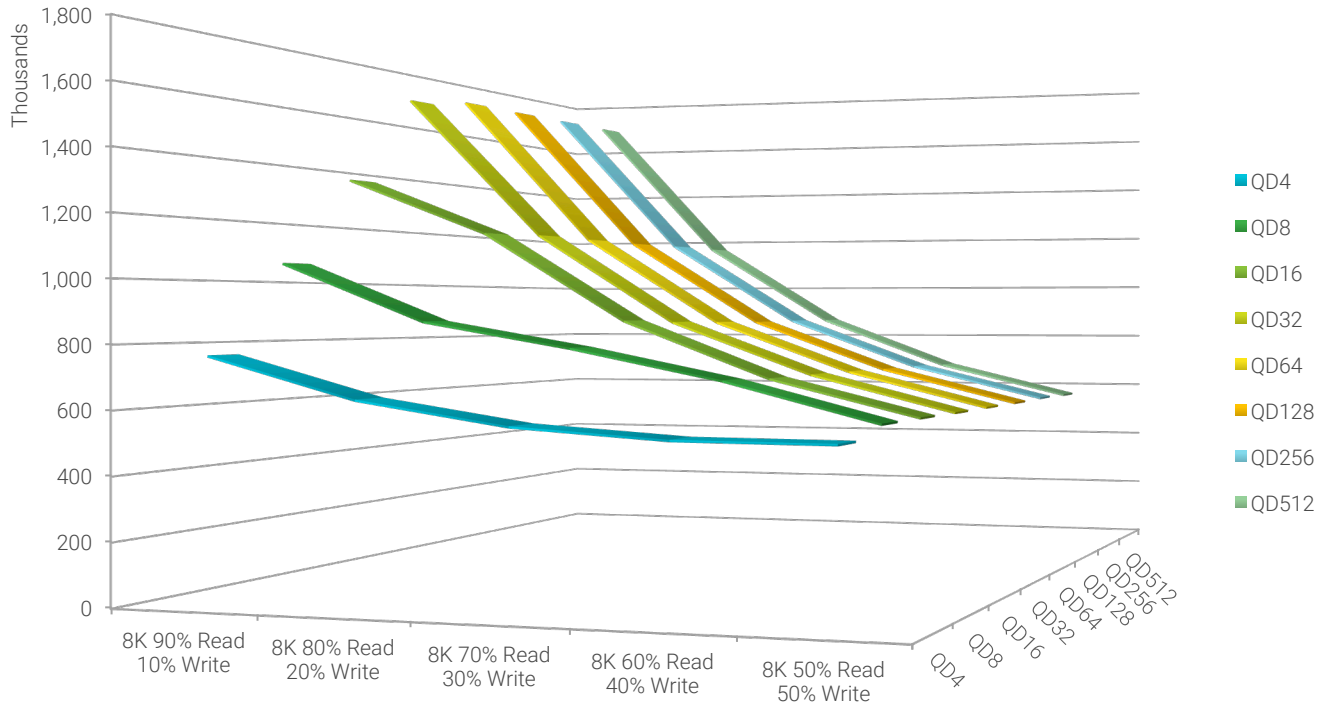
Table 11: 4K Read/Write Mix Random IOPS Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512



3.6. 8K Read/Write Mix Random IOPS

8K Mix Random IOPS	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
90% Read 10% Write	763,005	1,053,385	1,345,420	1,654,088	1,683,500	1,681,943	1,681,317	1,679,980
80% Read 20% Write	633,722	865,669	1,159,798	1,165,481	1,162,621	1,159,297	1,160,987	1,159,054
70% Read 30% Write	561,655	784,337	867,128	861,049	859,034	857,639	860,999	861,709
60% Read 40% Write	530,054	687,720	682,224	683,800	683,212	681,912	683,044	679,626
50% Read 50% Write	526,819	563,646	563,376	561,997	562,438	562,555	564,948	562,470

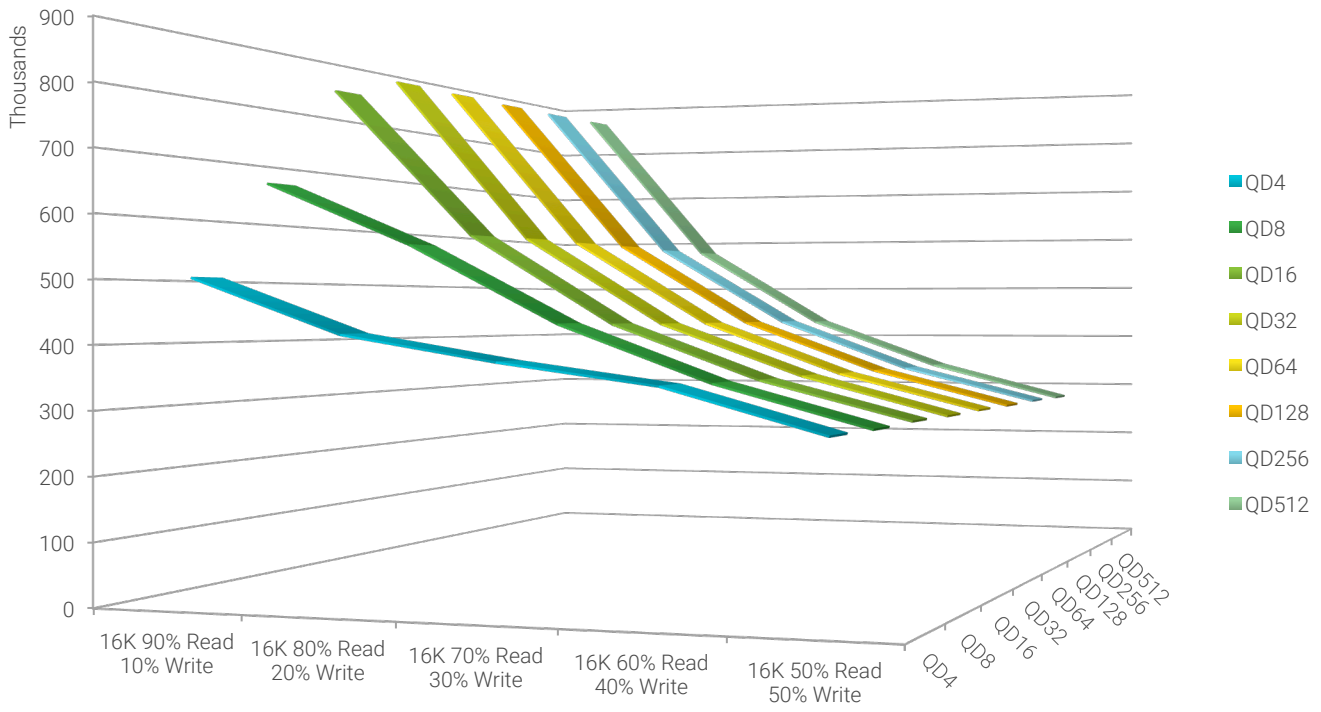
Table 12: 8K Read/Write Mix Random IOPS Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512



3.7. 16K Read/Write Mix Random IOPS

16K Mix Random IOPS	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
90% Read 10% Write	502,021	657,673	827,768	863,583	861,901	859,716	859,255	859,916
80% Read 20% Write	415,536	556,090	577,588	578,845	577,252	576,888	574,487	574,302
70% Read 30% Write	375,873	430,592	429,277	428,392	428,531	429,074	429,656	428,618
60% Read 40% Write	343,251	340,462	339,400	340,308	338,672	339,276	338,753	339,829
50% Read 50% Write	275,566	274,515	276,918	275,977	276,855	276,639	277,515	276,552

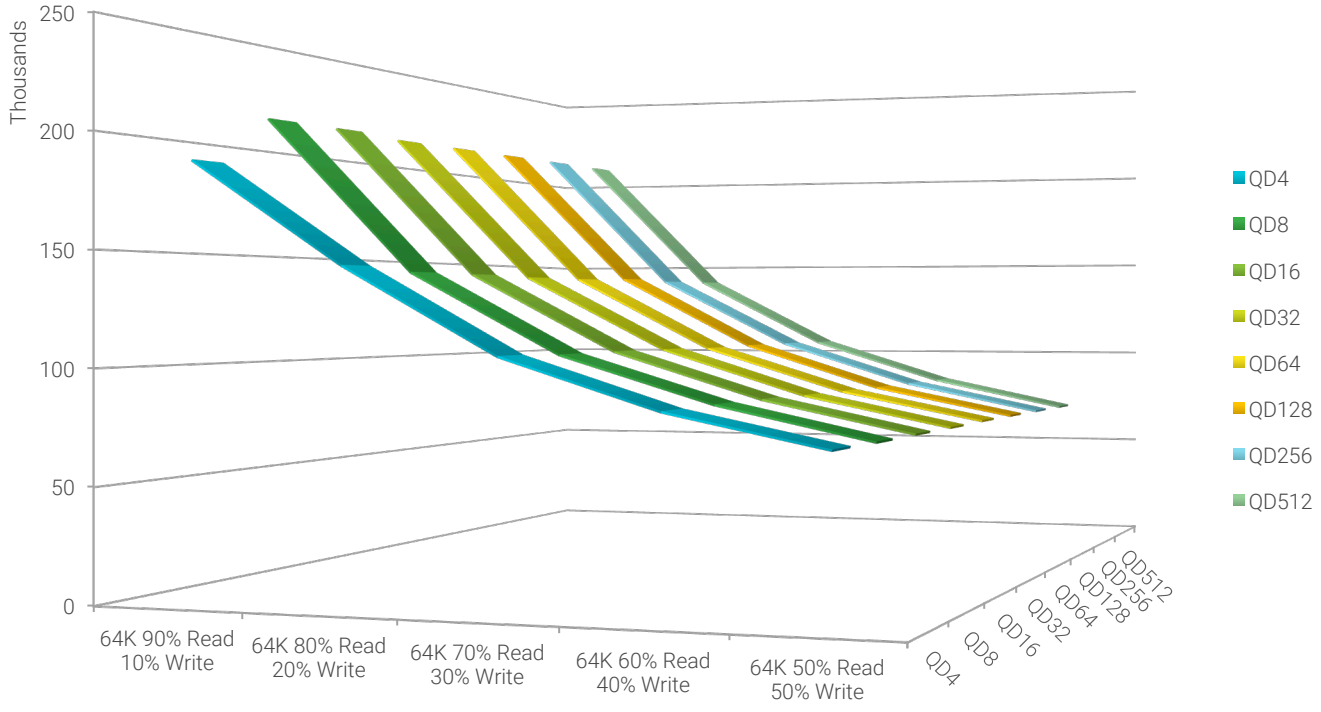
Table 13: 16K Read/Write Mix Random IOPS Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512



3.8. 64K Read/Write Mix Random IOPS

64K Mix Random IOPS	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
90% Read 10% Write	187,964	210,212	210,294	208,887	208,999	209,057	209,104	208,979
80% Read 20% Write	142,907	140,964	140,767	140,102	140,034	140,822	140,116	140,280
70% Read 30% Write	105,540	105,047	105,341	105,269	104,897	105,421	105,580	105,477
60% Read 40% Write	84,063	84,437	84,363	84,004	83,873	83,844	84,108	84,207
50% Read 50% Write	70,118	69,889	69,999	70,041	70,314	70,204	70,057	69,873

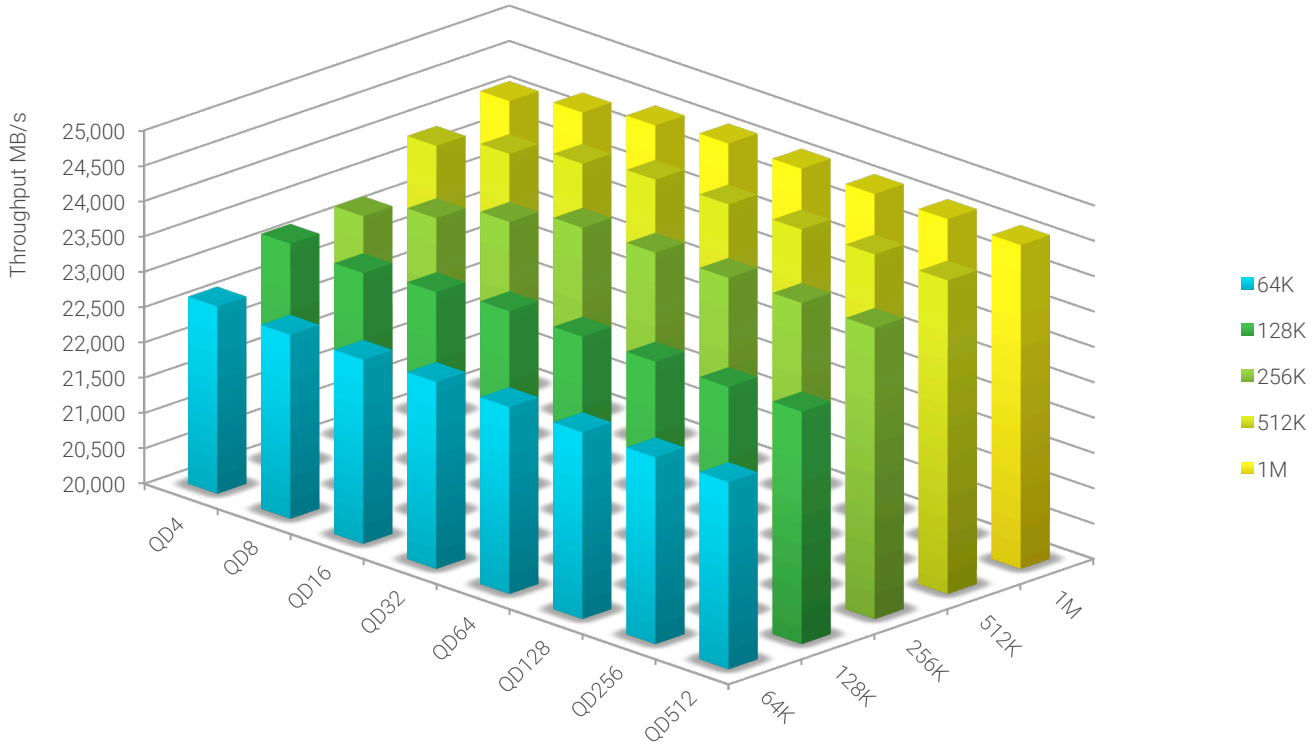
Table 14: 64K Read/Write Mix Random IOPS Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512



3.9. Sequential Read Throughput

100% Sequential Read Throughput (MB/s)	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
64K	22,649	22,604	22,603	22,643	22,642	22,642	22,640	22,644
128K	23,183	23,121	23,206	23,291	23,284	23,285	23,280	23,288
256K	23,219	23,545	23,847	24,117	24,119	24,116	24,115	24,116
512K	23,861	24,100	24,316	24,442	24,448	24,446	24,447	24,433
1M	24,142	24,333	24,503	24,602	24,599	24,594	24,593	24,580

Table 15: Sequential Read Throughput Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512



3.10. Sequential Write Throughput

100% Sequential Write Throughput (MB/s)	QD4	QD8	QD16	QD32	QD64	QD128	QD256	QD512
64K	19,442	19,042	19,604	19,559	19,614	19,583	19,632	19,607
128K	20,044	20,117	20,055	20,145	20,133	20,135	20,059	20,106
256K	20,398	20,435	20,443	20,465	20,419	20,458	20,437	20,457
512K	20,179	20,299	20,295	20,267	20,293	20,256	20,246	20,269
1M	20,297	20,269	20,279	20,301	20,266	20,284	20,253	20,260

Table 16: Sequential Write Throughput Results of Queue Depth 4, 8, 16, 32, 64, 128, 258, and 512