Big Demo
WDC WDS250G2B0C-00PXH0

Test suite with all possible test cases that creates a big report for demonstration.

January 02, 2023

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SUMMARY

Test suite with all possible test cases that creates a big report for demonstration. The NVMe tested was the WDC WDS250G2B0C-00PXH0 with firmware 211070WD. The device was installed in a HP system, model HP Z1 Entry Tower G5 running Microsoft Windows 11 Pro.

STARTED	ENDED	DURATION
Jan 01, 2023 - 12:34:29.438	Jan 02, 2023 - 01:00:13.040	12:25:43.602

TESTS	27	
PASS	15	55.6%
FAIL	8	29.6%
SKIP	4	14.8%

A total of 27 tests completed 351 verifications for 40 unique requirements.

REQUIREMENTS	40	
PASS	28	70.0%
FAIL	12	30.0%

VERIFICATIONS	351	
PASS	330	94.0%
FAIL	21	6.0%

This test identified the below issues with the drive.

[1] SMART attributes indicate the drive has been operated above the critical temperature which may have caused damage to the drive.

[2] SMART attributes indicate the data written to the drive has exceeded 90% of TBW. This indicates the drive is getting close to the end of the warranty period.

[3] Testing of the Admin Commands found the Get Feature 5 command always fails with IO code 1117.

[4] The timestamp is not accurate and should not be relied on.

[5] The Power On Hours is not accurate and should not be relied on.

[6] The IO write performance does not meet the minimum bandwidth requirements.

Test Summary

TEST	RESULT
Suite start info	FAIL
RQMT: Admin commands shall pass	FAIL
RQMT: Time operating at or above the critical temperature shall be 0	FAIL
RQMT: Data Used shall be less than 90% of TBW	FAIL
Admin commands	FAIL
RQMT: Admin commands shall pass	FAIL
RQMT: Greater than 10,000 admin command shall complete without error	FAIL
Background SMART	PASS
SMART data	PASS
Timestamp	FAIL
RQMT: Timestamp shall be within 1.0 hour(s) of host timestamp	FAIL
RQMT: Timestamp shall run without stopping	FAIL
RQMT: Timestamp count is linear (Coeff > 0.99)	FAIL
RQMT: Timestamp change shall be within 1.0% of host time change	FAIL
Firmware update	SKIP
Firmware activate	SKIP
Firmware download	SKIP
Firmware security	SKIP
Short selftest	PASS
Extended selftest	PASS
Short Burst Performance	FAIL
RQMT: Short burst, sequential writes, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	FAIL
Long Burst Performance	FAIL
RQMT: Long burst end temperature shall be within 5C of start temperature	FAIL
RQMT: Short burst, random writes, 4KiB, QD1 bandwidth shall be greater than 0.1 GB/s	FAIL
RQMT: Short burst, sequential writes, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	FAIL

ASPM latency	PASS
Nonop power times	PASS
Data compression	PASS
Data deduplication	PASS
Read buffer	PASS
Big file writes	PASS
Big file reads	PASS
Short Burst Performance Full Drive	FAIL

RQMT: Short burst, sequential writes, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	FAIL

Long Burst Performance Full Drive	FAIL

RQMT: Long burst end temperature shall be within 5C of start temperature	FAIL
RQMT: Short burst, random writes, 4KiB, QD1 bandwidth shall be greater than 0.1 GB/s	FAIL
RQMT: Short burst, sequential writes, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	FAIL

High bandwidth stress	PASS
High iops stress	PASS
Burst stress	PASS
Temperature cycle stress	PASS
Suite end info	FAIL

RQMT: Admin commands shall pass	FAIL
RQMT: Time operating at or above the critical temperature shall be 0	FAIL
RQMT: Data Used shall be less than 90% of TBW	FAIL
RQMT: Power On Hour change shall be within 1 hour of host time change	FAIL

Requirement Verification Summary

A requirement can be verified multiple times within a test suite. The table below lists the results for each attempt to verify a requirement.

REQUIREMENT	PASS	FAIL
Admin Command average latency shall be less than 50 mS	5	0
Admin Command maximum latency shall be less than 500 mS	5	0
Admin commands shall pass	**5**	**3**
Average latency of slowest 1,825 IO shall not increase more than 50% with concurrent SMART reads	1	0
Critical warnings shall be 0	56	0

Data Used shall be less than 90% of TBW	**0**	**2**
Error count shall not increase	48	0
Greater than 10,000 admin command shall complete without error	**0**	**1**
IO bandwidth behaved as expected with increasing queue depth and block size	4	0
IO read latency within power state exit latencies	1	0
Long burst end temperature shall be within 5C of start temperature	**6**	**2**
Media and integrity errors shall be 0	2	0
No data corruption shall occur running IO	15	0
No errors shall occur running IO	52	0
Percent throttled shall be less than 1%	2	0
Percentage Used shall be less than 90%	2	0
Power On Hour change shall be within 1 hour of host time change	**0**	**1**
Power On Hours Used shall be less than 90% of Warranty Hours	2	0
Power state entry timeout shall meet drive setting	1	0
Prior self-test failures shall be 0	2	0
SMART attribute Data Read shall be within 512,000 bytes of data read	1	0
SMART attribute Data Written shall be within 512,000 bytes of data written	1	0
SMART counters, such as Data Written, shall not decrement	54	0
Self-test Power-On Hours match hours reported in log page 2	4	0
Self-test progress is monotonic	4	0
Self-test progress is roughly linear (Coeff greater than 0.9)	4	0
Self-test result shall be 0 indicating no errors	4	0
Self-test run time shall be less than or equal to 2 minutes	2	0
Self-test run time shall be less than or equal to 44 minutes	2	0
Short burst, random reads, 4KiB, QD1 bandwidth shall be greater than 0.01 GB/s	4	0
Short burst, random writes, 4KiB, QD1 bandwidth shall be greater than 0.01 GB/s	2	0
Short burst, random writes, 4KiB, QD1 bandwidth shall be greater than 0.1 GB/s	**0**	**2**
Short burst, sequential reads, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	4	0
Short burst, sequential writes, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	**0**	**4**
Static parameters, such as Model Number, shall not change	35	0
Time operating at or above the critical temperature shall be 0	**0**	**2**
Timestamp change shall be within 1.0% of host time change	**0**	**1**
Timestamp count is linear (Coeff > 0.99)	**0**	**1**
Timestamp shall be within 1.0 hour(s) of host timestamp	**0**	**1**
Timestamp shall run without stopping	**0**	**1**

NVME INFORMATION

VENDOR	MODEL	SIZE	VERSION
Sandisk	WDC WDS250G2B0C-00PXH0	250 GB	1.4.0

PARAMETER	VALUE
Serial Number	2035A0805352
Number Of Namespaces	1
Namespace 1 EUI64	001b44-8b49bc0ecb
Namespace 1 NGUID	e8238fa6bf530001-001b44-8b49bc0ecb
Namespace 1 Size	250 GB
Namespace 1 LBA Size	512
Firmware	211070WD
Firmware Slots	2
Firmware Activation Without Reset	Supported
Host Memory Buffer	Enabled. Size = 16,384 pages
Autonomous Power State Transition	Supported and Disabled
Volatile Write Cache	Enabled
Host Throttle Threshold TMT1	Disabled
Host Throttle Threshold TMT2	Disabled
Drive Throttle Threshold WCTEMP	80 C
Drive Throttle Threshold CCTEMP	85 C

Power States

STATE	NOP	MAX POWER	ENTRY LATENCY	EXIT LATENCY
0	False	3.5 Watts	Not Reported	Not Reported
1	False	2.4 Watts	Not Reported	Not Reported
2	False	1.9 Watts	Not Reported	Not Reported
3	True	0.02 Watts	3,900 uS (0.003 sec)	11,000 uS (0.011 sec)
4	True	0.005 Watts	5,000 uS (0.005 sec)	39,000 uS (0.039 sec)

PCIe

PCI	VENDOR	VID	DID	WIDTH	SPEED	ADDRESS
Endpoint	Sandisk	0x15B7	0x5009	x4	Gen3 8.0GT/s	Bus 1, device 0, function 0
Root		0x8086	0xA340			Bus 0, device 27, function 0

SMART Attributes

PARAMETER	START	END	DELTA
Available Spare	100 %	100 %	
Available Spare Threshold	10 %	10 %	
Controller Busy Time	19,016 Min	19,277 Min	261 Min
Critical Composite Temperature Time	2 Min	2 Min	
Data Read	416,310.729 GB	420,588.217 GB	4,277.5 GB
Data Units Read	813,106,893	821,461,361	8,354,468
Data Units Written	272,677,705	275,630,817	2,953,112
Data Written	139,610.985 GB	141,122.978 GB	1,512.0 GB
Host Read Commands	10,760,332,660	10,857,068,398	96,735,738
Host Write Commands	5,997,060,441	6,061,862,323	64,801,882
Media and Data Integrity Errors	0	0	
Number of Error Information Log Entries	1	1	
Percentage Used	19 %	19 %	
Power Cycles	199	199	
Power On Hours	2,128	2,134	6
Thermal Management Temperature 1 Count	0	0	
Thermal Management Temperature 1 Time	0 Sec	0 Sec	
Thermal Management Temperature 2 Count	0	0	
Thermal Management Temperature 2 Time	0 Sec	0 Sec	
Unsafe Shutdowns	27	27	
Warning Composite Temperature Time	64 Min	64 Min	
Seconds Throttled	3960 Sec	3960 Sec	
Percent Throttled	0.1 %	0.1 %	
Host Time Seconds	1672605270.028	1672650012.665	44,742.0

SYSTEM INFORMATION

PARAMETER	VALUE
Supplier	HP
Model	HP Z1 Entry Tower G5
BIOS	R01 Ver. 02.15.00
Hostname	DESKTOP-AJDMMEA
OS	Microsoft Windows 11 Pro

PERFORMANCE SUMMARY

Short Burst Performance (2 seconds)

IO PATTERN	EMPTY DRIVE	DRIVE 90% FULL
Random Write, QD1, 4KiB	0.084 GB/s	0.084 GB/s
Random Read, QD1, 4KiB	0.033 GB/s	0.033 GB/s
Random Write, QD32, 4KiB	0.228 GB/s	0.225 GB/s
Random Read, QD32, 4KiB	0.366 GB/s	0.361 GB/s
Sequential Write, QD32, 128KiB	0.229 GB/s	0.230 GB/s
Sequential Read, QD32, 128KiB	1.595 GB/s	1.854 GB/s

Long Burst Performance (10.0 minutes) - Empty Drive

IO PATTERN	AVERAGE	FIRST SEC	FIRST 15 SEC	LAST 120 SEC
Random Write, QD1, 4KiB	0.085 GB/s	0.082 GB/s	0.085 GB/s	0.085 GB/s
Random Read, QD1, 4KiB	0.034 GB/s	0.032 GB/s	0.034 GB/s	0.034 GB/s
Sequential Write, QD32, 128KiB	0.234 GB/s	0.226 GB/s	0.232 GB/s	0.236 GB/s
Sequential Read, QD32, 128KiB	1.897 GB/s	1.828 GB/s	1.899 GB/s	1.896 GB/s

Long Burst Performance (10.0 minutes) - Drive 90% Full

IO PATTERN	AVERAGE	FIRST SEC	FIRST 15 SEC	LAST 120 SEC
Random Write, QD1, 4KiB	0.086 GB/s	0.082 GB/s	0.085 GB/s	0.086 GB/s
Random Read, QD1, 4KiB	0.034 GB/s	0.032 GB/s	0.034 GB/s	0.034 GB/s
Sequential Write, QD32, 128KiB	0.234 GB/s	0.227 GB/s	0.233 GB/s	0.235 GB/s
Sequential Read, QD32, 128KiB	1.898 GB/s	1.827 GB/s	1.899 GB/s	1.902 GB/s

TEST 1: SUITE START INFO

VERIFICATIONS	9	
PASS	6	66.7%
FAIL	3	33.3%

STARTED	ENDED	DURATION
Jan 01, 2023 - 12:34:29.689	Jan 01, 2023 - 12:34:30.096	0:00:00.407

DESCRIPTION

This test reads the NVMe drive information at the start of a test suite. If the drive is unhealthy or worn out the test suite is stopped. At the end of the suite, this start information is compared with the suite end information to verify no unexpected changes occurred during the testing.

This test defines worn out as Percentage Used, Percentage Data Written, or Percentage Warranty Used exceeding 90%. This provides a guard band so no wear percentage exceeds 100% during the test suite. The percentages are determined from the SMART attributes Percentage Used, Data Written, and Power On Hours and the drive specifications TBW and Warranty Years. If TBW and Warranty Years are not provided the Percentage Data Written and Percentage Warranty Used cannot be verified.

A drive is defined as unhealthy if 1) any prior self-test results failed or 2) has critical warnings or media and integrity errors or 3) has operated above the critical temperature or 4) has had an excessive amount of thermal throttling. The self-test results are read from Log Page 6 and the SMART attributes from Log Page 2.

The information is read using the nvmecmd utility [2]. This utility uses NVMe Admin Commands Identify Controller, Identify Namespace, Get Log Page, and Get Feature to get most of the information. A small anount of information is read from the Operating System, such as the driver verison and PCIe parameters.

For additional details see Read and compare NVMe information with nvmecmd [4].

RESULTS

The table below lists the NVMe Admin Commands completed. The nvmecmd utility only supports Namespace 1 and a subset of the log pages and features.

Admin Command	Time (ms)	Return Bytes	Return Code
Identify Controller	36.535	4096	0
Identify Namespace 1	0.554	4096	0
Get Log Page 0x01	0.151	16384	0
Get Log Page 0x02	1.634	512	0
Get Log Page 0x03	0.059	512	0
Get Log Page 0x05	0.020	4096	0
Get Log Page 0x06	0.111	564	0
Get Log Page 0x07	0.168	512	0
Get Log Page 0x07	29.610	33792	0
Get Log Page 0x08	0.169	512	0

Get Log Page 0x08	0.206	33792	0
Get Feature 1	0.052	0	0
Get Feature 2	0.047	0	0
Get Feature 4	0.046	0	0
Get Feature 4 (0x100000)	0.047	0	0
Get Feature 5	0.050	0	1
Get Feature 6	0.054	0	0
Get Feature 8	0.046	0	0
Get Feature 10	0.046	0	0
Get Feature 11	0.045	0	0
Get Feature 12	0.050	256	0
Get Feature 13	0.060	4096	0
Get Feature 14	0.049	8	0
Get Feature 16	0.051	0	0
Get Feature 17	0.052	0	0

Drive Health: Self-Test Results

The most recent 20 self-test results, short and extended, were read from Log Page 6. The drive is considered unhealthy if any prior results are failures.

PARAMETER	VALUE	NOTE
Prior self-test results	20	Logs up to 20
Prior self-test failures	0	

Drive Health: Errors and Warnings

The drive is considered unhealthy if the SMART attributes contain critical warnings or media and integrity errors.

PARAMETER	VALUE	NOTE
Critical Warnings	No	
Media and Integrity Errors	0	

Drive Health: Temperature Throttling

The drive is considered unhealthy if it has operated above the critical temperature or the percentage throttled is above 1%.

Percentage Throttled is defined as 100 * (Hours Throttled / Power On Hours) where Hours Throttled is the cumulative time of all throttle states.

PARAMETER	VALUE	NOTE
Percentage Throttled	0.1%	
Thermal Management Temperature 1 Time	0 sec	0.00 Hours
Thermal Management Temperature 2 Time	0 sec	0.00 Hours

Warning Composite Temperature Time	64 min	1.07 Hours
Critical Composite Temperature Time	2 min	0.03 Hours

Drive Wear

The Percentage Used SMART attribute is the primary reference for drive wear. If the drive Warranty and TBW are specified the Percentage Data Written and Percentage Warranty Used are calculated and verified.

Percentage Data Written is defined as 100 * (Data Written / TBW) where TBW (Terabytes Written) is the total amount of data that can be written to the drive during the warranty period. Data Written is the SMART attribute that reports the data written to the drive.

Percentage Warranty Used is defined as 100 * (Power On Hours / Warranty Hours) where warranty hours is the number of days in the warranty multiplied by 8 hours for client drives or 24 hours for enterprise drives.

PARAMETER	VALUE	NOTE
Percentage Used	19%	SMART attribute
Data Written	139,610.985 GB	SMART attribute
Power On Hours	2,128	SMART attribute
Terabytes Written (TBW)	150 TB	User Input
Percentage Data Written	93.1%	Calculated
Warranty Years	5 years	User input
Warranty Hours	14,600	Calculated
Percentage Warranty Used	14.6%	Calculated

VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Read info : FAIL

Read NVMe information using nvmecmd.

REQUIREMENT	VALUE	RESULT
Admin commands shall pass	Fail	FAIL

Step 2: Verify info : FAIL

Verify drive is healthy and not worn out.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Media and integrity errors shall be 0	0	PASS
Time operating at or above the critical temperature shall be 0	2 min	FAIL
Percent throttled shall be less than 1%	0.1%	PASS
Percentage Used shall be less than 90%	19%	PASS
Data Used shall be less than 90% of TBW	93.1%	FAIL

Power On Hours Used shall be less than 90% of Warranty Hours	14.6%	**PASS**
Prior self-test failures shall be 0	0	**PASS**

TEST 2: ADMIN COMMANDS

VERIFICATIONS	6	
PASS	4	66.7%
FAIL	2	33.3%

STARTED	ENDED	DURATION
Jan 01, 2023 - 12:34:30.111	Jan 01, 2023 - 12:59:11.287	0:24:41.176

DESCRIPTION

This test verifies the reliability and performance of Admin Commands that provide information about the drive: Identify Controller, Identify Namespace, Get Log Page, and Get Feature. Each Admin Command is run several thousand times with no interval between the commands. This quickly builds a large sample to assess reliability and performance.

The test verifies the Admin Command average and maximum latencies. Admin command latency is dependent on multiple factors including OS interrupts, power states, concurrent drive activity, and others. This test measures latencies without concurrent IO and only in the active power state. The latencies reported by the test serve as a standard reference but are likely not the worst case values.

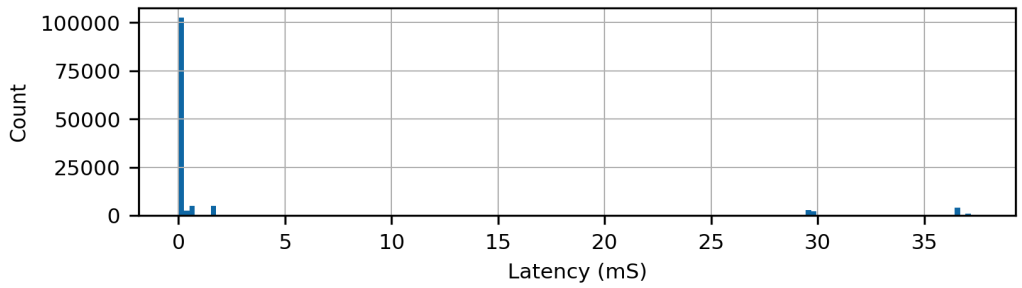
Each command is verified to complete without error. The information returned by each command is compared against the initial reading to verify no unexpected changes occurred. Static parameters, such as Model Number, were verified not to change. SMART counters, such as Data Read, were verified not to decrement. Dynamic parameters, such as Timestamp, are expected to change and are not verified.

RESULTS

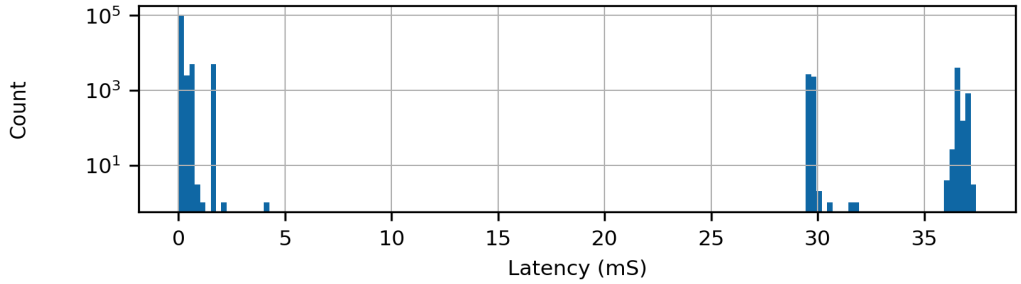
A total of 125,000 Admin Commands were completed with 5,000 reported errors. Each of the 23 command types was run 5,000 times. The latency was measured for each command and the average and maximum is reported in the table below.

PARAMETER	VALUE	LIMIT
Average Latency (All Commands)	2.8 mS	50 mS
Maxmimum Latency (All Commands)	37.4 mS	500 mS

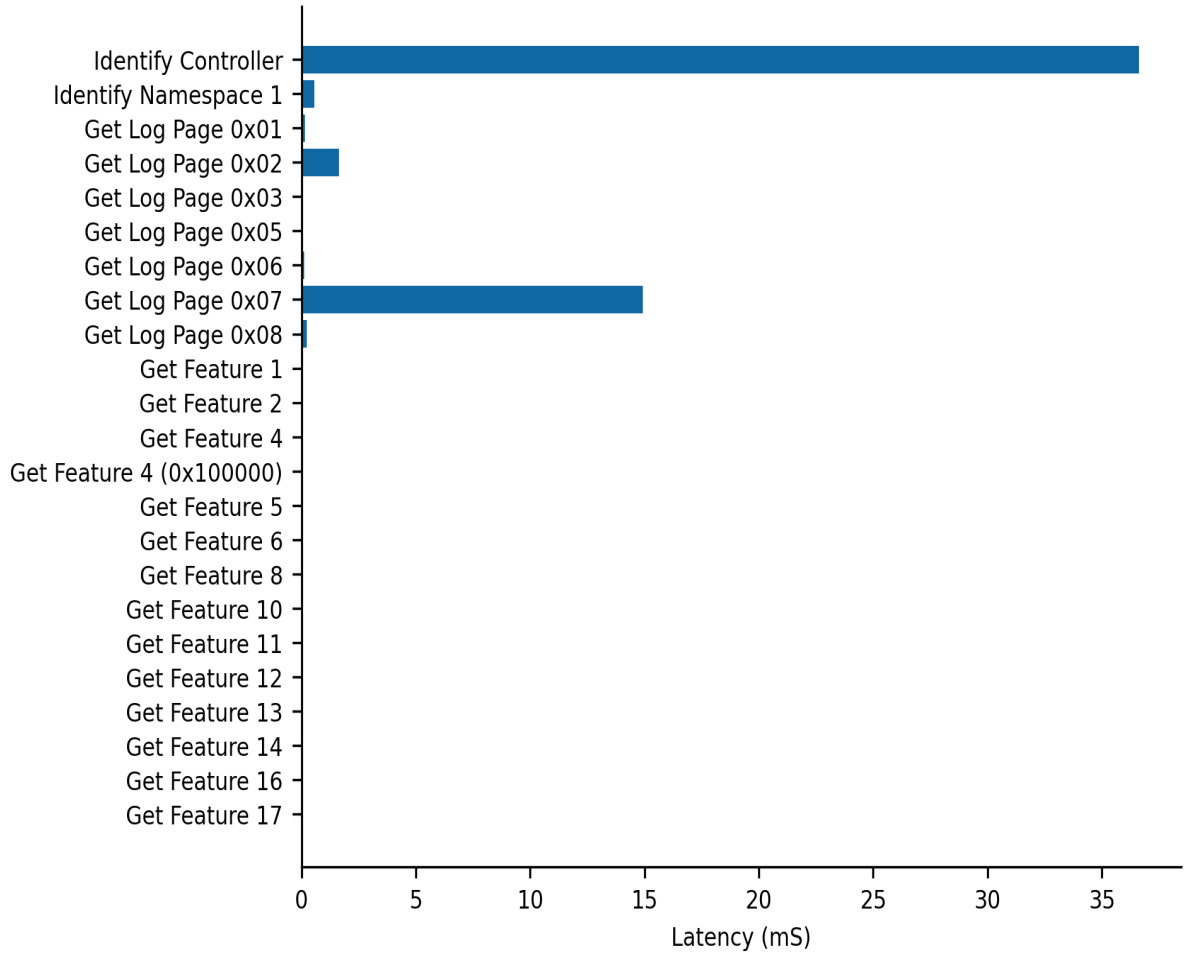
This histogram shows the distribution of Admin Command latencies for all command types.



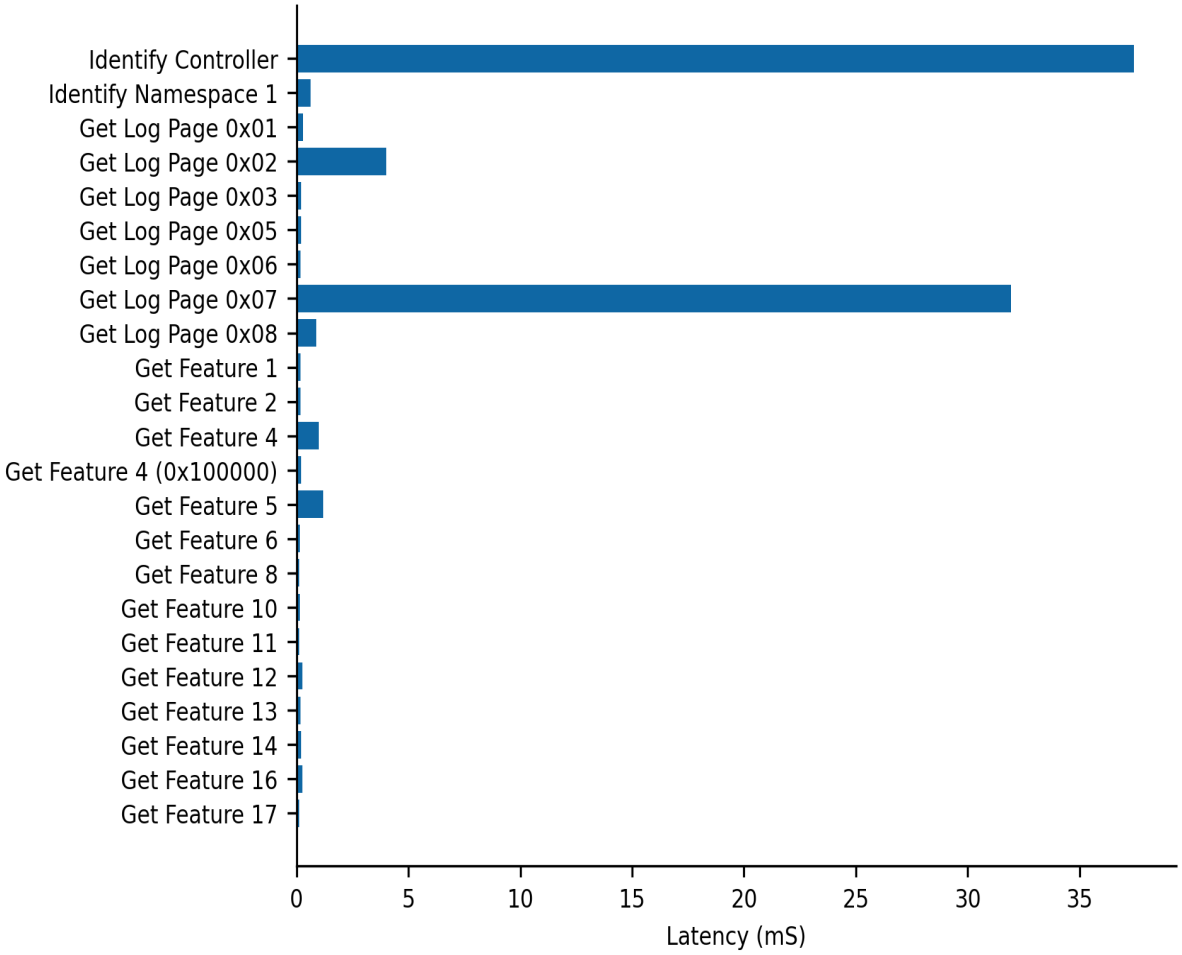
This histogram shows the distribution above on a log scale to better show outliers.



This bar chart shows the average Admin Command latencies for each command type.



This bar chart shows the maximum Admin Command latencies for each command type.



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Run commands : FAIL

REQUIREMENT	VALUE	RESULT
Admin commands shall pass	Fail	FAIL
Greater than 10,000 admin command shall complete without error	5000 / 125,000	FAIL
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Admin Command average latency shall be less than 50 mS	2.8 mS	PASS
Admin Command maximum latency shall be less than 500 mS	37.4 mS	PASS

TEST 3: BACKGROUND SMART

VERIFICATIONS	25	
PASS	25	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 12:59:11.301	Jan 01, 2023 - 13:51:31.354	0:52:20.053

DESCRIPTION

This test verifies reading SMART attributes during normal operation has no adverse effects on IO read and writes. Adverse effects are defined as functional errors, data integrity loss, or an unacceptable increase in IO latency. A typical Enterprise Use Case [9] reads SMART attributes regularly to identify issues that may predict drive failures. Suspect drives can then be replaced prior to actually failing.

This test runs a total of 1,825 Get Log Page 2 commands to simulate one read per day for 5 years. The Get Log Page 2 commands are run at intervals of 500mS to ensure significant idle time between commands which is closer to the actual use case.

The concurrent IO workload is a 50/50 mix of reads and writes, random addressing, 4 KiB block size, and queue depth 2. This workload ensures an IO is always in flight but should not swamp the controller.

RESULTS

A total of 3,650 Get Log Page 2 Commands were completed with 0 reported errors. Get Log Page 2 latency was measured on 1,825 commands run standalone and another 1,825 commands run concurrent with IO reads and writes.

PARAMETER	STANDALONE	CONCURRENT	DELTA
Average Get Log Page 2 Latency	37.51 mS	1.49 mS	-36.02 mS
Maxmimum Get Log Page 2 Latency	37.99 mS	4.19 mS	-33.80 mS

A total of 0 errors occured running IO standalone and 0 errors running concurrent.

A total of 9,286,799 reads were completed standalone. Another 9,277,277 reads were completed concurrent with Log Page 2. In the tables and charts below the slowest IO are defined as the slowest 1,825 IO.

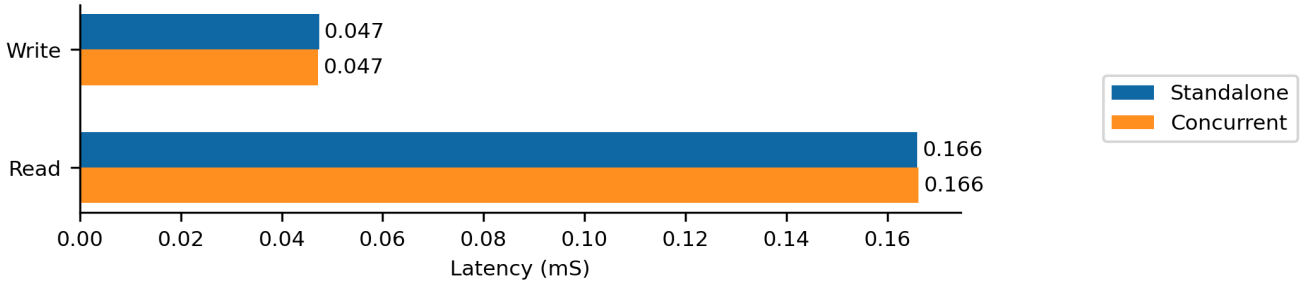
PARAMETER	STANDALONE	CONCURRENT	DELTA
Read Average Latency	0.17 mS	0.17 mS	0.00 mS (0.1%)
Read Average Commit Latency Slowest IO	4.27 mS	4.33 mS	0.07 mS (1.6%)
Read Maximum Latency	36.19 mS	36.48 mS	0.29 mS (0.8%)

A total of 4,700,132 writes were completed standalone. Another 4,690,713 writes were completed concurrent with Log Page 2.

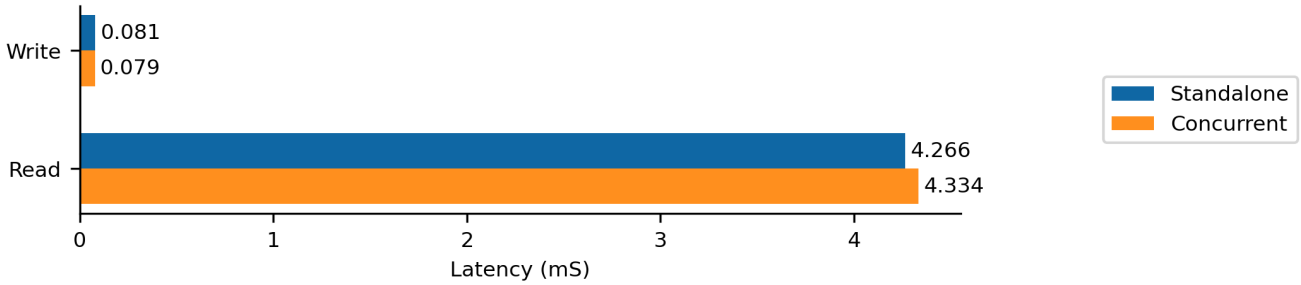
PARAMETER	STANDALONE	CONCURRENT	DELTA
Write Average Latency	0.05 mS	0.05 mS	-0.00 mS (-0.3%)

Write Average Commit Latency Slowest IO	0.08 mS	0.08 mS	-0.00 mS (-2.4%)
Write Maximum Latency	0.34 mS	0.47 mS	0.13 mS (36.8%)

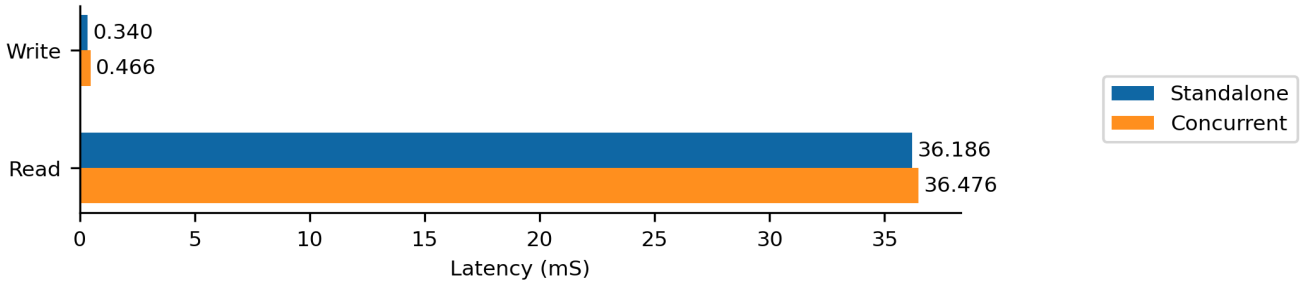
Average IO Latency



Slowest IO Latency



Maximum IO Latency



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Create fio file : PASS

Create small file with verification data, if does not exist.

Step 2: Idle wait : PASS

Wait for idle temperature and garbage collection

REQUIREMENT	VALUE	RESULT
Admin commands shall pass	Pass	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Admin Command average latency shall be less than 50 mS	37.3 mS	PASS
Admin Command maximum latency shall be less than 500 mS	37.6 mS	PASS

Step 3: SMART baseline : PASS

Run Get Log Page 2 command 1,825 times

REQUIREMENT	VALUE	RESULT
Admin commands shall pass	Pass	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Admin Command average latency shall be less than 50 mS	37.5 mS	PASS
Admin Command maximum latency shall be less than 500 mS	38.0 mS	PASS

Step 4: IO baseline : PASS

Baseline IO reads and writes using fio

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 5: Idle wait : PASS

Wait for idle temperature and garbage collection

REQUIREMENT	VALUE	RESULT
Admin commands shall pass	Pass	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Admin Command average latency shall be less than 50 mS	37.3 mS	PASS
Admin Command maximum latency shall be less than 500 mS	37.6 mS	PASS

Step 6: SMART and IO : PASS

Run IO and Get Log Page 2 concurrently

REQUIREMENT	VALUE	RESULT
Admin commands shall pass	Pass	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Admin Command average latency shall be less than 50 mS	1.5 mS	PASS
Admin Command maximum latency shall be less than 500 mS	4.2 mS	PASS
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS
Average latency of slowest 1,825 IO shall not increase more than 50% with concurrent SMART reads	1.608%	PASS

TEST 4: SMART DATA

VERIFICATIONS	9	
PASS	9	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 13:51:31.369	Jan 01, 2023 - 13:57:47.641	0:06:16.272

DESCRIPTION

This test verifies the accuracy of the Data Read and Data Written SMART attributes. The SMART attributes are compared against the disk counters reported by the python psutil package. To ensure a large enough sample for comparison, IO read and writes are run for three minutes in a high bandwidth configuration.

The SMART attribute resolution is 512,000 bytes according to the NVMe Specification [1]. The current test limit has been set to the resolution of the SMART attributes.

RESULTS

PARAMETER	VALUE	DELTA	LIMIT
Bytes written from psutil counter	35,366,838,272		
Bytes written reported by SMART	35,366,912,000	73,728	512,000
Bytes read reported by psutil counter	68,098,269,184		
Bytes read reported by SMART	68,098,048,000	-221,184	512,000

The tables below include fio reported data to determine if anything other than fio was reading or writing the drive during the test. If the drive under test is the OS drive than additional read and writes are likely.

PARAMETER	VALUE	DELTA
Bytes read reported by fio	68,097,671,168	-598,016
Bytes written reported by fio	35,366,371,328	-466,944

VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Create fio file : PASS

If does not exist, create a small file without verification data for fio.

Step 2: Start info : PASS

Verify not in error state

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 3: IO : PASS

Run IO to generate read and write data

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 4: End info : PASS

Verify no unexpected changes during test

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
SMART attribute Data Read shall be within 512,000 bytes of data read	221,184	PASS
SMART attribute Data Written shall be within 512,000 bytes of data written	73,728	PASS

TEST 5: TIMESTAMP

VERIFICATIONS	14	
PASS	10	71.4%
FAIL	4	28.6%

STARTED	ENDED	DURATION
Jan 01, 2023 - 13:57:47.641	Jan 01, 2023 - 14:07:47.721	0:10:00.080

DESCRIPTION

Timestamp Feature Identifier 0Eh is an optional feature that reports the number of milliseconds that have elapsed since the epoch: midnight, 01-Jan-1970, UTC. The timestamp is set to the current time by the host and then the drive increments the timestamp every millisecond. The test reads the Get Feature data structure to get the timestamp info and verify the timestamp has been set by the host and matches the current time.

On some drives, the timestamp may stop under some conditions such as entering into non-operational power states. This test verifies the timestamp has not stopped by reading the synch attribute in the Get Feature data structure.

The test samples the host and drive timestamps every second for several minutes of idle and IO traffic. This verifies the drive timestamp is accurate in multiple power states which is especially important since some stop in non-operational states.

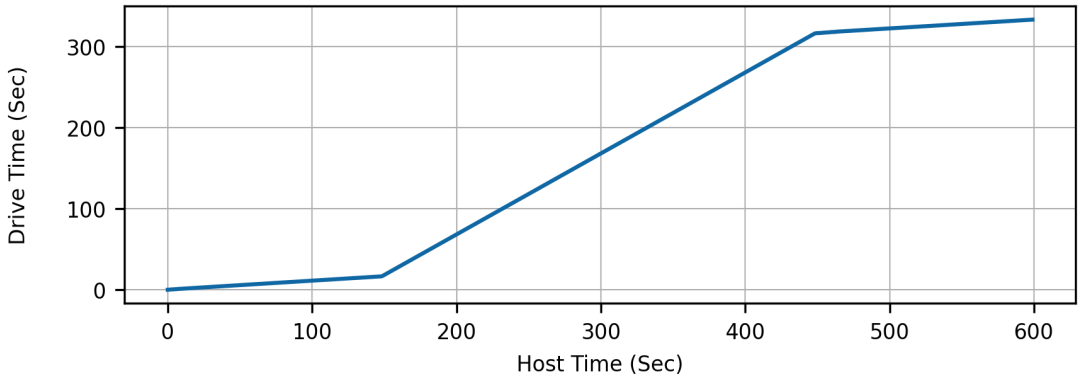
This test uses the host timestamp as the reference. Therefore, any issues with the host timestamp may cause this test to fail.

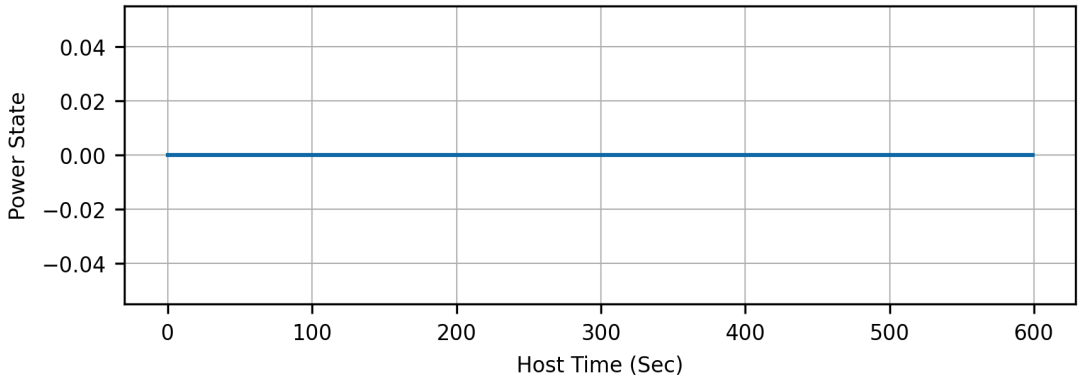
RESULTS

The timestamp synch attribute in the Get Feature data structure was set indicating the timestamp has stopped and may not be valid.

PARAMETER	HOST	DRIVE	DELTA	LIMIT
Starting Timestamp	1,672,322,214,127 mS	1,672,610,267,987 mS	80.0 hrs	1.0 hrs
Timestamp Change	599,674 mS	333,774 mS	44.34%	1.0%

The plot below shows the linearity between the drive and host timestamps. The measured Pearson product-moment correlation coefficent was: 0.980. Anything less than 0.99 indicates the host and drive timestamps do not track as expected. If the tracking is erratic it can be cross-referenced againt the power states in the second plot.





VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : FAIL

Read NVMe information using nvmecmd

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Timestamp shall be within 1.0 hour(s) of host timestamp	80.01 hours	FAIL

Step 2: Create fio file : PASS

Create small file with verification data, if does not exist.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: Wait and IO : PASS

Wait then run IO then wait again.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS
Admin commands shall pass	Pass	PASS

Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

Step 5: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

Step 6: Verify timestamp : FAIL

REQUIREMENT	VALUE	RESULT
Timestamp shall run without stopping	Fail	FAIL
Timestamp count is linear (Coeff > 0.99)	0.98	FAIL
Timestamp change shall be within 1.0% of host time change	44.3%	FAIL

TEST 6: FIRMWARE UPDATE

VERIFICATIONS	0	
PASS	0	0.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 14:07:47.737	Jan 01, 2023 - 14:07:47.753	0:00:00.016

DESCRIPTION

This test updates the NVMe drive firmware. The test downloads and activates the latest firmware version and verifies if does not effect IO traffic, no parameters change, firmware information is updated. All firmware slots are tested.

For additional details see Update firmware with nvmecmd [7].

RESULTS

The test was not completed because the firmware files needed for the update were not found.

TEST 7: FIRMWARE ACTIVATE

VERIFICATIONS	0	
PASS	0	0.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 14:07:47.769	Jan 01, 2023 - 14:07:47.784	0:00:00.015

DESCRIPTION

This test verifies the performance and reliability of firmware activation. Different firmware versions are downloaded to multiple slots. While running a moderate IO stress workload the test continuously activates different slots (versions). The test completes one thousand activations.

Reliability is defined as no IO errors, data corruption, parameter changes, or failed firmware activations.

Performance is defined as the activation time and the maximum IO latency.

For additional details see Update firmware with nvmecmd [7].

RESULTS

The test was not completed because the firmware files needed for the update were not found.

TEST 8: FIRMWARE DOWNLOAD

VERIFICATIONS	0	
PASS	0	0.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 14:07:47.784	Jan 01, 2023 - 14:07:47.803	0:00:00.019

DESCRIPTION

This test verifies the performance and reliability of firmware download. Different firmware versions are downloaded to multiple slots. While running a moderate IO stress workload the test continuously downloads firmware to different slots (versions). The test completes 100 downloads.

Reliability is defined as no IO errors, data corruption, parameter changes, or failed firmware downloads.

Performance is defined as the download time and the maximum IO latency.

For additional details see Update firmware with nvmecmd [7].

RESULTS

The test was not completed because the firmware files needed for the update were not found.

TEST 9: FIRMWARE SECURITY

VERIFICATIONS	0	
PASS	0	0.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 14:07:47.803	Jan 01, 2023 - 14:07:47.816	0:00:00.013

DESCRIPTION

This test verifies the firmware update process is secure. It verifies invalid files cannot be downloaded and actived.

Invalid files tested are corrupted files, files for different devices, etc...

For additional details see Update firmware with nvmecmd [7].

RESULTS

The test was not completed because the firmware files needed for the update were not found.

TEST 10: SHORT SELFTEST

VERIFICATIONS	19	
PASS	19	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 14:07:47.832	Jan 01, 2023 - 14:27:31.964	0:19:44.132

DESCRIPTION

Self-test is a diagnostic testing sequence that tests the integrity and functionality of the controller and may include testing of the media associated with namespaces. The self-test is run using the Device Self-Test Admin Command. There is a short self-test and an extended self-test. This test verifies the short self-test.

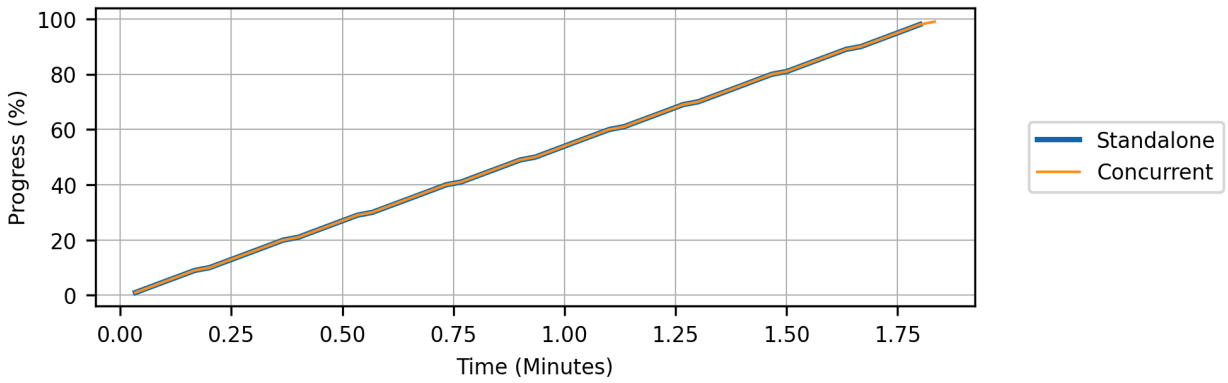
The self-test diagnostic is run standalone and concurrent with a light IO workload. In both cases the diagnostic must pass, complete within 2 minutes as specified in the NVMe specification [1], and report progress in Log Page 6 that is monotonic and roughly linear.

The NVMe specification states the IO performance can be degraded during the self-test but does not specify any limits. The performance difference between standalone and concurrent operation is reported to help determine if running the diagnostic during normal operation is practical.

RESULTS

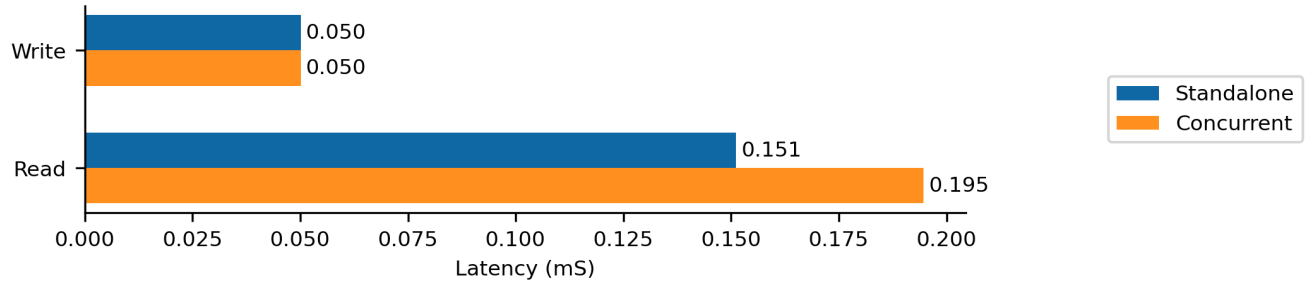
PARAMETER	STANDALONE	CONCURRENT	LIMIT
Run Time	1.834 Min	1.850 Min	2 Min
Progress Monotonocity	Monotonic	Monotonic	Monotonic
Progress Linearity	1.000	1.000	> 0.9

This plot shows the self-test progress reported in Log Page 6 which should be monotonic and roughly linear.

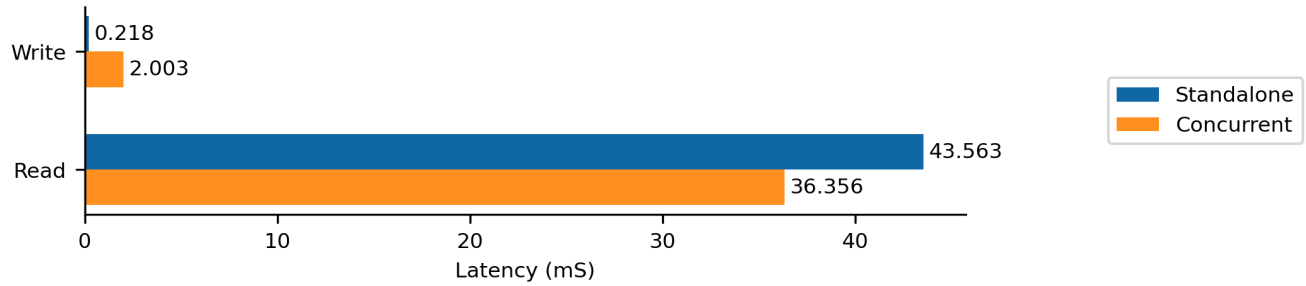


These bar charts show the difference in IO latency between stand-alone and concurrent operation. The tester must determine if the latency difference is acceptable since the NVMe specification does not define any limits.

Average IO Latency

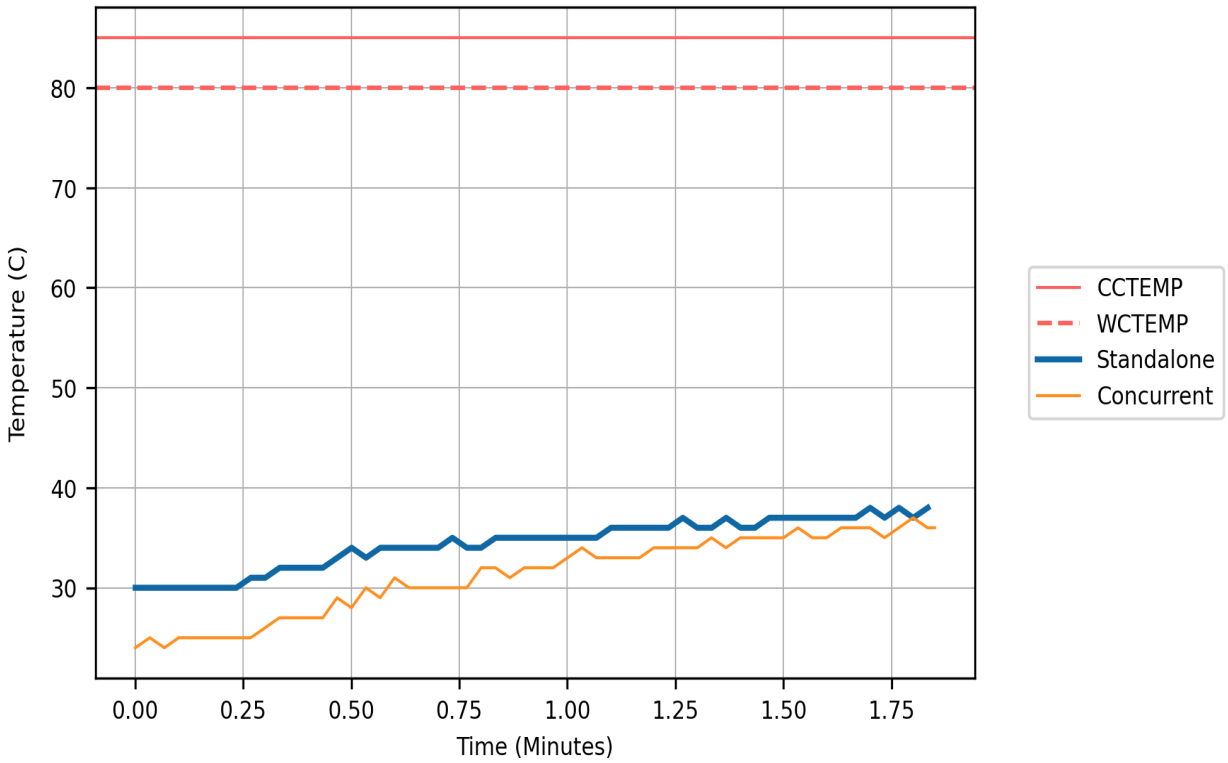


Maximum IO Latency



COMPOSITE TEMPERATURE

This plot shows the drive's composite temperature during the self-test to determine if over-heating is a concern. Thermal throttle limits are shown as red horizontal lines.



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read NVMe information using nvmecmd

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

Create small file with verification data, if does not exist.

Step 3: Selftest standalone : PASS

REQUIREMENT	VALUE	RESULT
Self-test result shall be 0 indicating no errors	0	PASS
Self-test run time shall be less than or equal to 2 minutes	1.83 min	PASS
Self-test progress is monotonic	Monotonic	PASS
Self-test progress is roughly linear (Coeff greater than 0.9)	1.00	PASS
Self-test Power-On Hours match hours reported in log page 2	Match	PASS

Step 4: IO standalone : PASS

Baseline the light IO workload

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 5: Selftest and IO : PASS

Run selftest and IO concurrently

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS
Self-test result shall be 0 indicating no errors	0	PASS
Self-test run time shall be less than or equal to 2 minutes	1.85 min	PASS
Self-test progress is monotonic	Monotonic	PASS
Self-test progress is roughly linear (Coeff greater than 0.9)	1.00	PASS
Self-test Power-On Hours match hours reported in log page 2	Match	PASS

Step 6: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS

SMART counters, such as Data Written, shall not decrement	0	**PASS**

TEST 11: EXTENDED SELFTEST

VERIFICATIONS	19	
PASS	19	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 14:37:32.004	Jan 01, 2023 - 15:34:24.428	0:56:52.424

DESCRIPTION

Self-test is a diagnostic testing sequence that tests the integrity and functionality of the controller and may include testing of the media associated with namespaces. The self-test is run using the Device Self-Test Admin Command. There is a short self-test and an extended self-test. This test verifies the extended self-test.

The self-test diagnostic is run standalone and concurrent with a light IO workload. In both cases the diagnostic must pass, complete within the run time limit, and report progress in Log Page 6 that is monotonic and roughly linear.

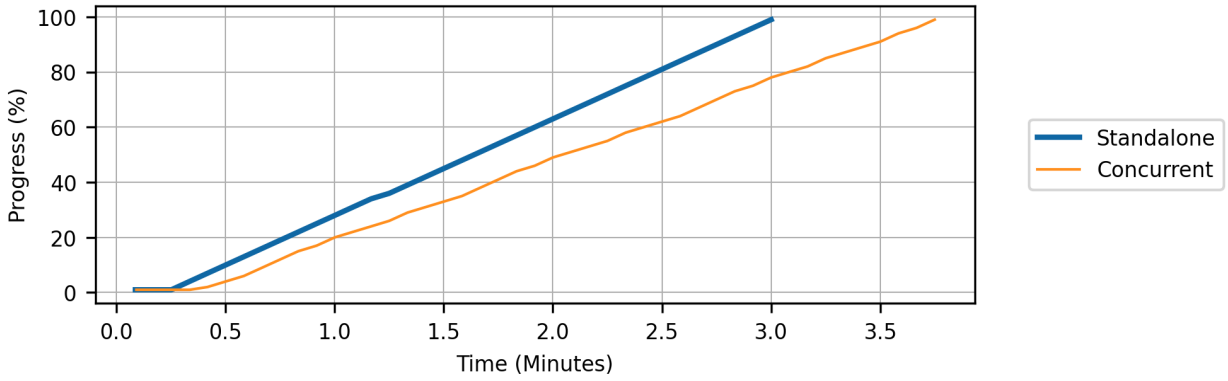
The extended self-test run time limit is from the Extended Device Self-test Time (EDSTT) field. The NVMe specification states EDSTT “this field indicates the nominal amount of time in one-minute units that the controller takes to complete an extended device self-test operation when in power state 0”. There is no maximum run time value defined in the specification therefore it is possible for an extended self-test to take longer than EDSTT and still comply with the specification. However, this test uses the EDSTT as the run time limit. The EDSTT field is 44 minutes for this NVMe drive.

The NVMe specification states the IO performance can be degraded during the self-test but does not specify any limits. The performance difference between standalone and concurrent operation is reported to help determine if running the diagnostic during normal operation is practical.

RESULTS

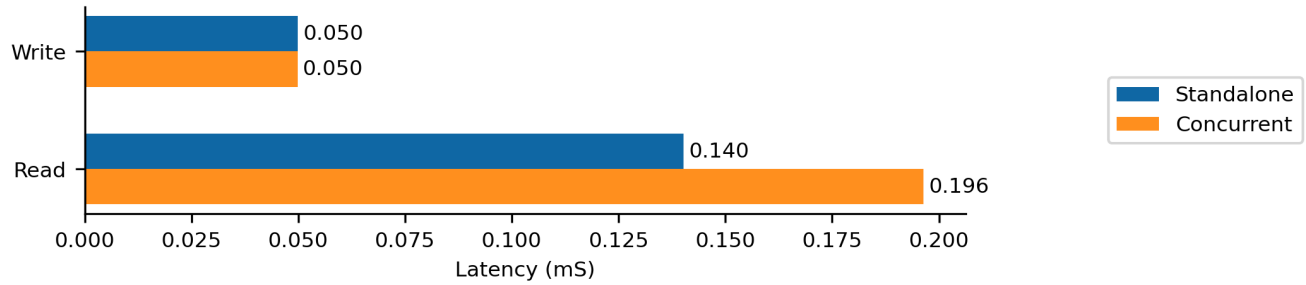
PARAMETER	STANDALONE	CONCURRENT	LIMIT
Run Time	3.034 Min	3.784 Min	44 Min
Progress Monotonocity	Monotonic	Monotonic	Monotonic
Progress Linearity	0.999	0.998	> 0.9

This plot shows the self-test progress reported in Log Page 6 which should be monotonic and roughly linear.

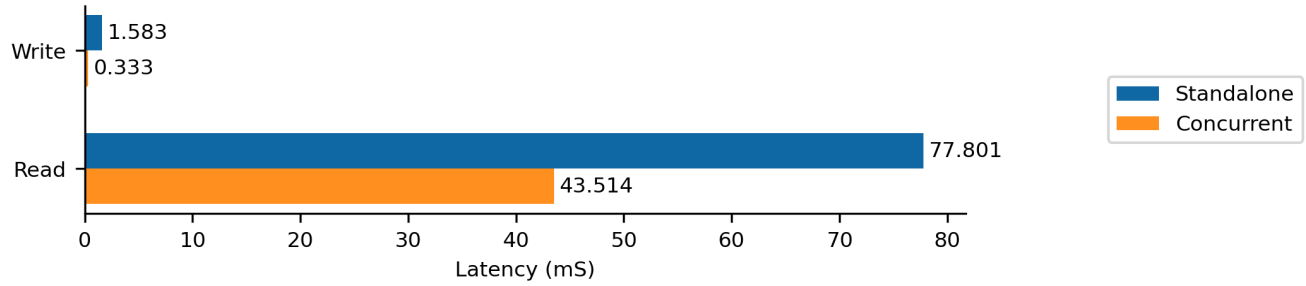


These bar charts show the difference in IO latency between stand-alone and concurrent operation. The tester must determine if the latency difference is acceptable since the NVMe specification does not define any limits.

Average IO Latency

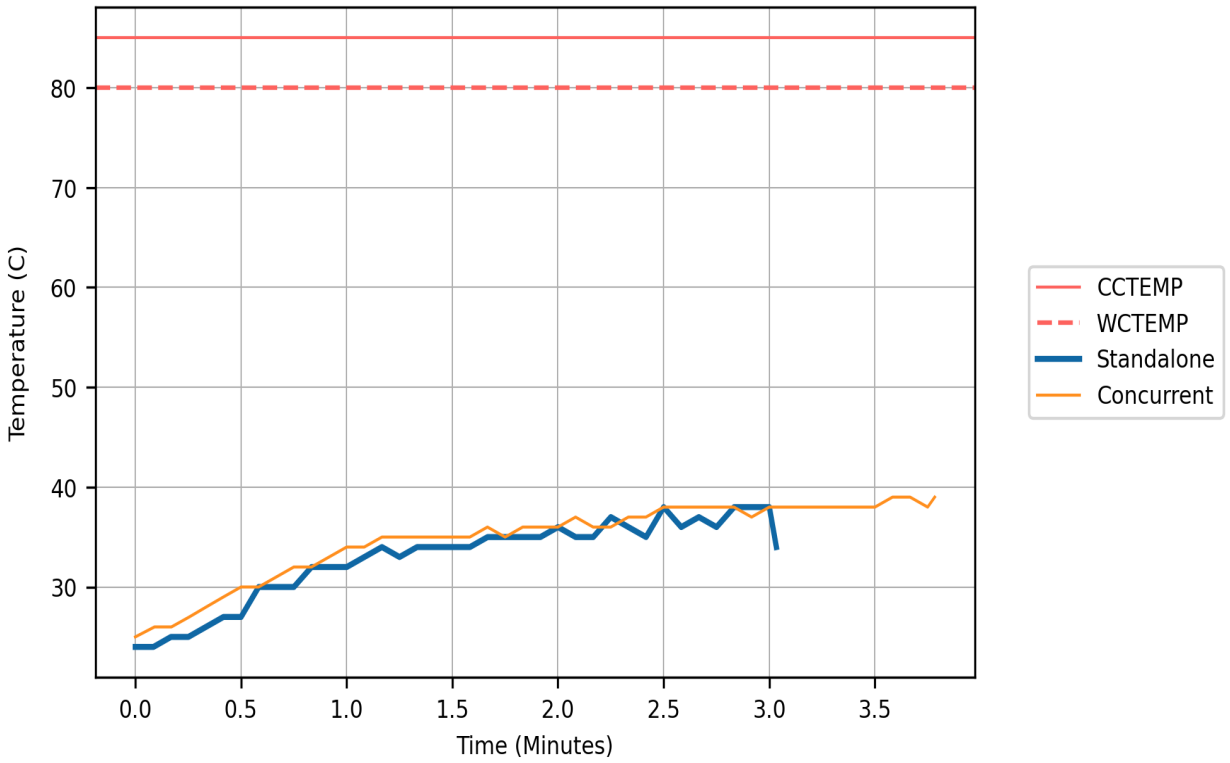


Maximum IO Latency



COMPOSITE TEMPERATURE

This plot shows the drive's composite temperature during the self-test to determine if over-heating is a concern. Thermal throttle limits are shown as red horizontal lines.



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read NVMe information using nvmecmd

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

Create small file with verification data, if does not exist.

Step 3: Selftest standalone : PASS

Run selftest without IO

REQUIREMENT	VALUE	RESULT
Self-test result shall be 0 indicating no errors	0	PASS
Self-test run time shall be less than or equal to 44 minutes	3.03 min	PASS
Self-test progress is monotonic	Monotonic	PASS
Self-test progress is roughly linear (Coeff greater than 0.9)	1.00	PASS
Self-test Power-On Hours match hours reported in log page 2	Match	PASS

Step 4: IO standalone : PASS

Run IO workload without selftest

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 5: Selftest and IO : PASS

Run selftest and IO concurrently

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS
Self-test result shall be 0 indicating no errors	0	PASS
Self-test run time shall be less than or equal to 44 minutes	3.78 min	PASS
Self-test progress is monotonic	Monotonic	PASS
Self-test progress is roughly linear (Coeff greater than 0.9)	1.00	PASS
Self-test Power-On Hours match hours reported in log page 2	Match	PASS

Step 6: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 12: SHORT BURST PERFORMANCE

VERIFICATIONS	16	
PASS	15	93.8%
FAIL	1	6.2%

STARTED	ENDED	DURATION
Jan 01, 2023 - 15:34:24.460	Jan 01, 2023 - 15:54:36.565	0:20:12.105

DESCRIPTION

This test reports the bandwidth for short bursts of IO reads and writes. Short bursts avoid performance reducing behavior such as thermal throttling, excessive SLC write cache misses, and shortage of erased blocks for future writes. Short IO bursts result in high bandwidth measurements ideal for datasheet comparisons and benchmarking applications such as spreadsheets and word processors that intermittently read and write small to medium files.

This test runs a variety of block sizes and queue depths across four common IO patterns: random writes, random reads, sequential writes and sequential reads. The bandwidth should increase as block size and queue depth increase until the bandwidth saturates. This maximum bandwidth is expected to be different between reads and writes but not between random and sequential access types. There is no standard performance specification for drive datasheets so refer to the datasheet of the drive under test to determine the block size and queue depth to compare. No data integrity checking is done to avoid any effect the performance numbers.

Each burst lasts for 2.5 seconds and is followed by an idle period to allow the drive temperature and background activity to return to the initial state. During the idle state the drive is likely to enter a non-operational power state. The latency to exit the non-operational power state would effect the measured bandwidth. To avoid the effects of exiting the power state, this test excludes the first 0.5 seconds of the burst.

The test uses the standard OS software stack which may limit the maximum block size or queue depth. For example, some Linux versions limit the block size to 128KiB.

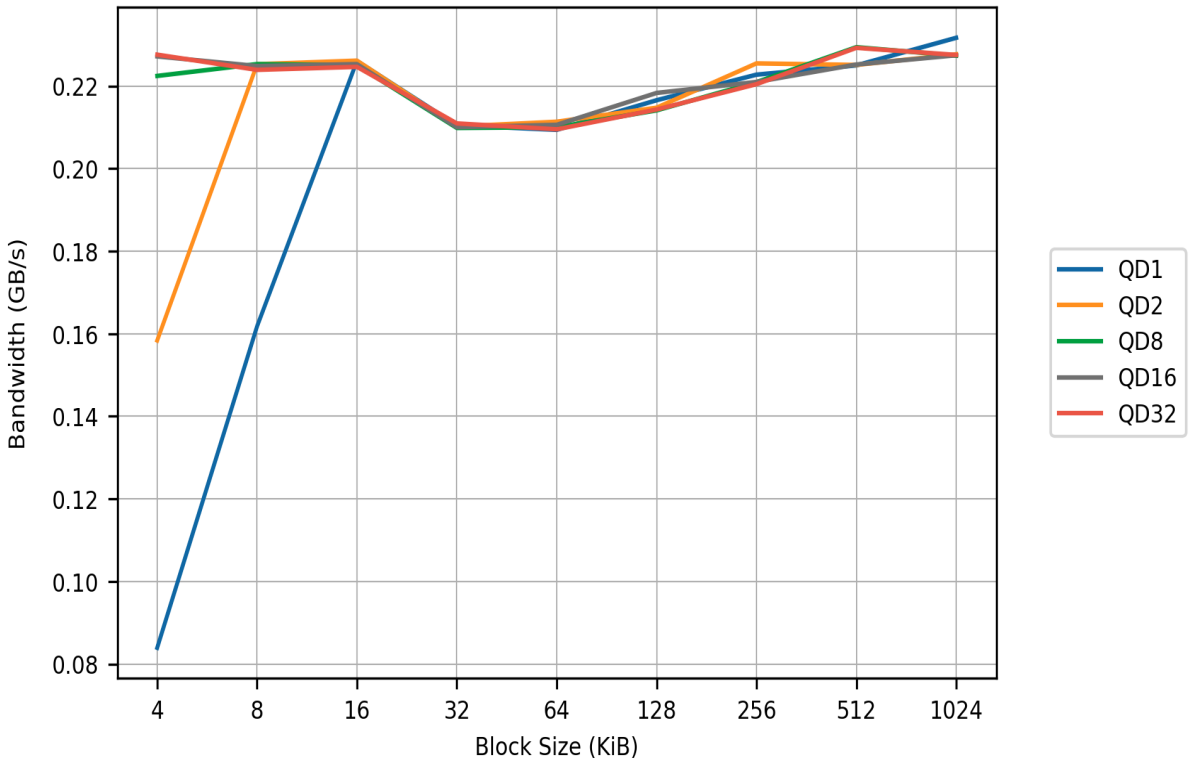
For additional details see NVMe IO performance measurement with fio and nvmecmd [8].

RESULTS

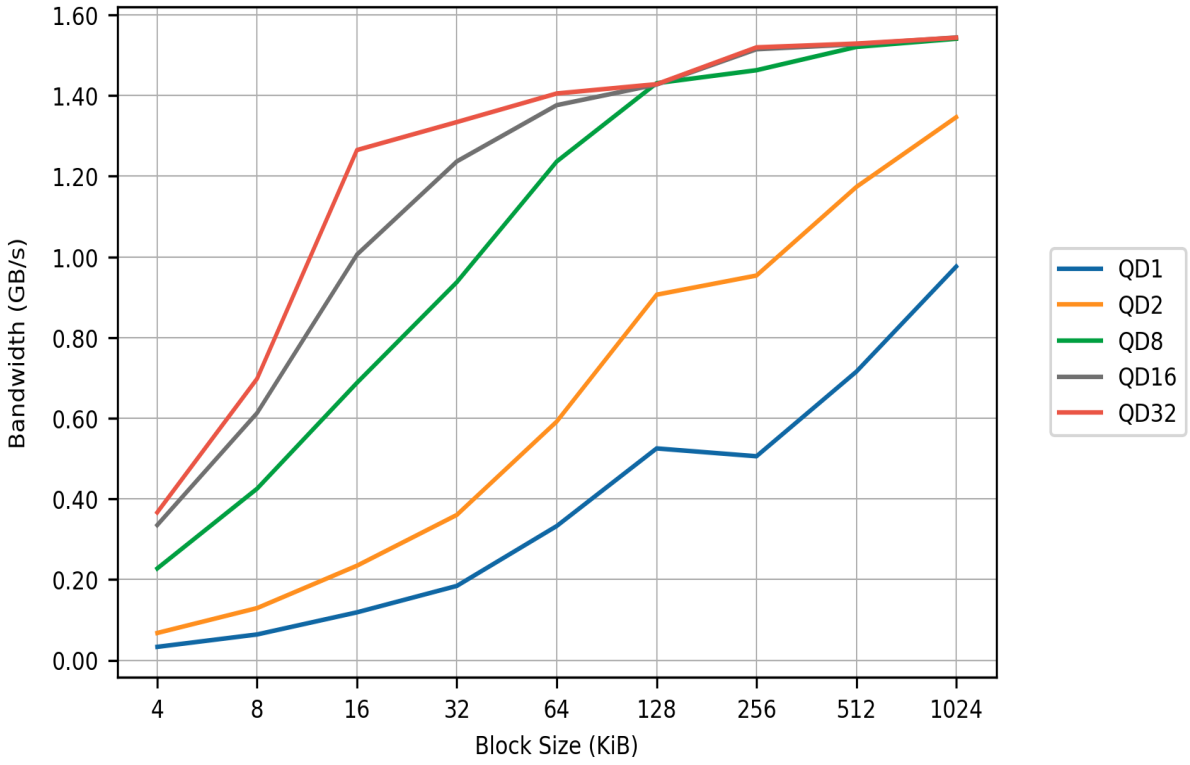
This table shows the bandwidth for several common datasheet and IO benchmark queue depths and block sizes.

IO PATTERN	IOPS	BANDWIDTH	LIMIT	RESULT
Sequential Write, QD32, 128KiB	1,746	0.229 GB/s	1.000 GB/s	FAIL
Sequential Read, QD32, 128KiB	12,169	1.595 GB/s	1.000 GB/s	PASS
Random Write, QD1, 4KiB	20,492	0.084 GB/s	0.010 GB/s	PASS
Random Read, QD1, 4KiB	8,059	0.033 GB/s	0.010 GB/s	PASS
Random Write, QD32, 4KiB	55,565	0.228 GB/s	0.250 GB/s	FAIL
Random Read, QD32, 4KiB	89,443	0.366 GB/s	0.250 GB/s	PASS

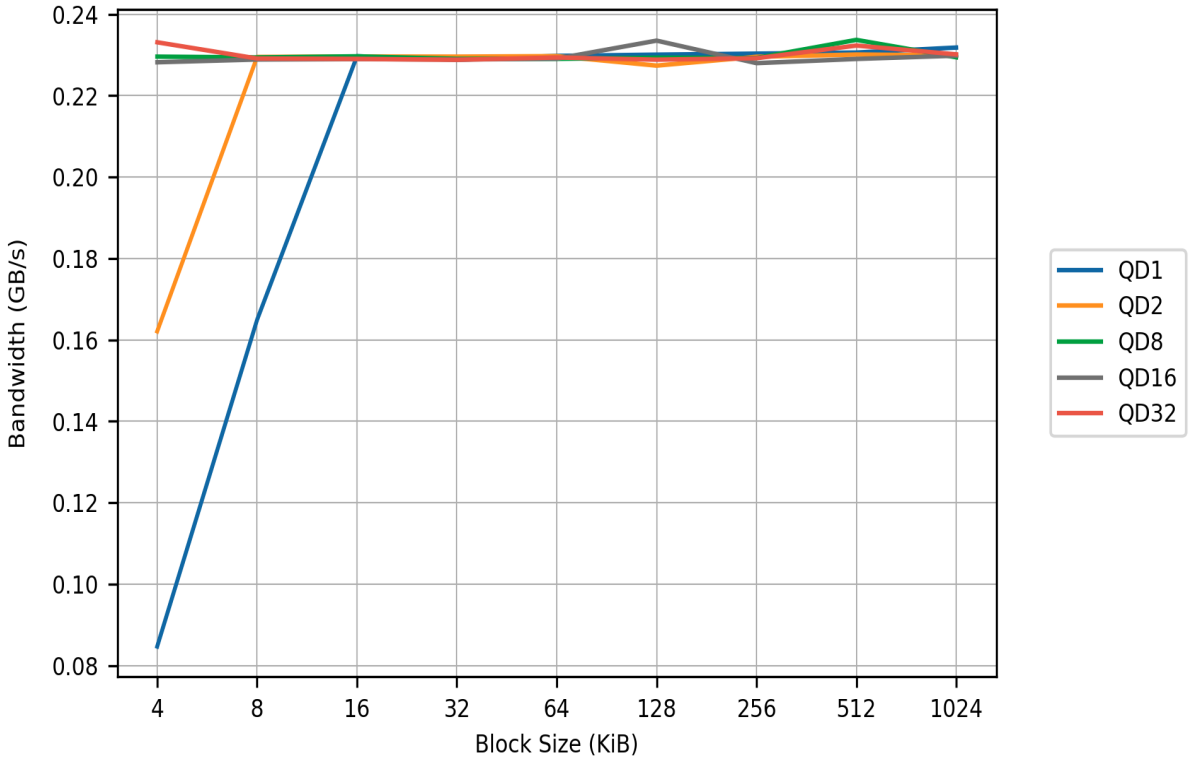
Random Write Bandwidth



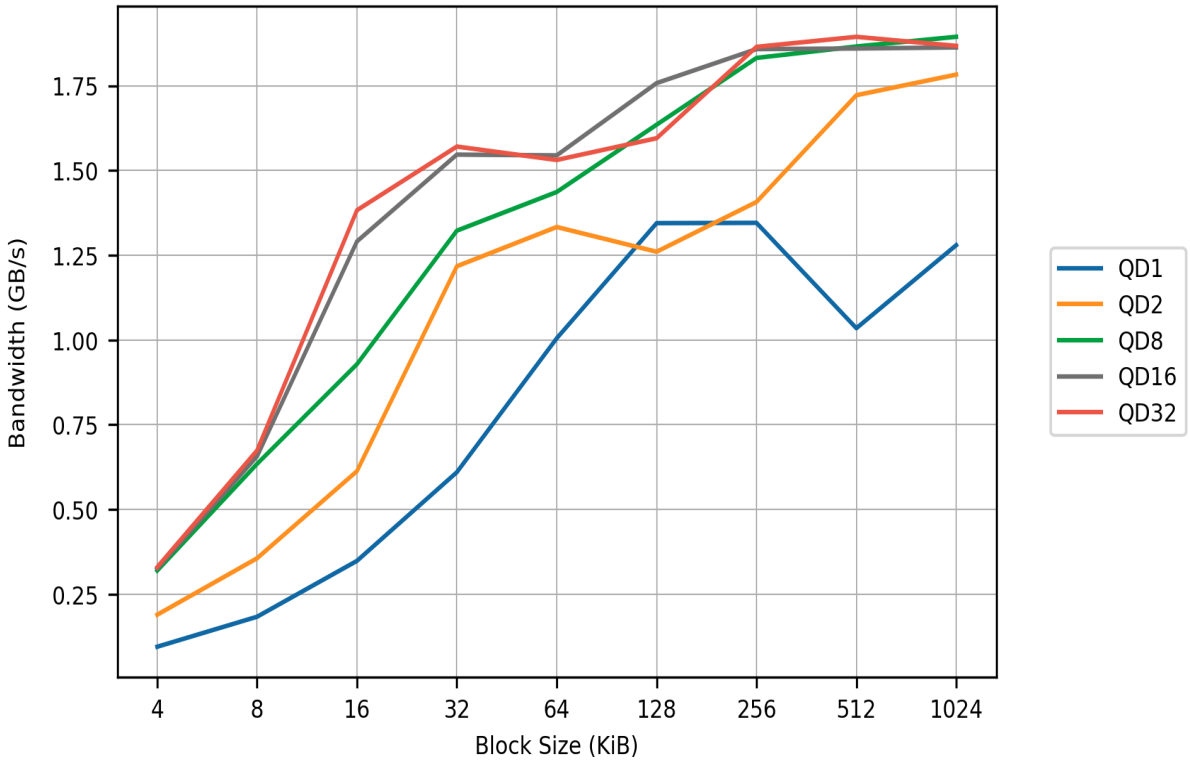
Random Read Bandwidth



Sequential Write Bandwidth



Sequential Read Bandwidth



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

If does not exist, create a small file without verification data for fio.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: Sequential write : PASS

Measure performance of short burst of sequential writes.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 5: Sequential read : PASS

Measure performance of short burst of sequential reads.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 6: Random write : PASS

Measure performance of short burst of random writes.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 7: Random read : PASS

Measure performance of short burst of random reads.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 8: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS

Error count shall not increase	0	PASS

Step 9: Verify performance : FAIL

Verify short burst performance.

REQUIREMENT	VALUE	RESULT
Short burst, random reads, 4KiB, QD1 bandwidth shall be greater than 0.01 GB/s	0.033 GB/s	PASS
Short burst, random writes, 4KiB, QD1 bandwidth shall be greater than 0.01 GB/s	0.084 GB/s	PASS
Short burst, sequential reads, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	1.595 GB/s	PASS
Short burst, sequential writes, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	0.229 GB/s	FAIL
IO bandwidth behaved as expected with increasing queue depth and block size	PASS	PASS

Step 10: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 13: LONG BURST PERFORMANCE

VERIFICATIONS	46	
PASS	43	93.5%
FAIL	3	6.5%

STARTED	ENDED	DURATION
Jan 01, 2023 - 15:54:36.597	Jan 01, 2023 - 18:42:46.225	2:48:09.628

DESCRIPTION

This test measures performance of long bursts of IO. There are four IO patterns: random writes, random reads, sequential writes, and sequential reads. The plots are useful for gaining insight into drive behavior such as write caching, thermal throttling, and background garbage collection. For example, if thermal throttling occurs the plot can tell the time and amount of data read or written before the throttling started. It can also tell the reduction in bandwidth for each level of throttling.

The test reports different bandwidths for each IO pattern. The average bandwidth for the entire IO burst, first second, first 15 seconds, and last 120 seconds. The initial bandwidth is more relevant for use cases that do not continuously access the drive, such as office omputing. The end bandwidth is more relevant for uses cases that continuously access the drive.

RESULTS

This table shows the bandwidth for several common datasheet and IO benchmark queue depths and block sizes.

IO PATTERN	IOPS	BANDWIDTH	LIMIT	RESULT
Sequential Write, QD32, 128KiB	1,789	0.234 GB/s	1.000 GB/s	FAIL
Sequential Read, QD32, 128KiB	14,470	1.897 GB/s	1.000 GB/s	PASS
Random Write, QD1, 4KiB	20,802	0.085 GB/s	0.100 GB/s	FAIL
Random Read, QD1, 4KiB	8,185	0.034 GB/s	0.010 GB/s	PASS

The table below provides the average and ending bandwidth. The ending bandwidth could be significantly lower if thermal throttling or excessive garbage collection occurs.

IO PATTERN	AVERAGE	FIRST SEC	FIRST 15 SEC	LAST 120 SEC
Random Write, QD1, 4KiB	0.085 GB/s	0.082 GB/s	0.085 GB/s	0.085 GB/s
Random Read, QD1, 4KiB	0.034 GB/s	0.032 GB/s	0.034 GB/s	0.034 GB/s
Sequential Write, QD32, 128KiB	0.234 GB/s	0.226 GB/s	0.232 GB/s	0.236 GB/s
Sequential Read, QD32, 128KiB	1.897 GB/s	1.828 GB/s	1.899 GB/s	1.896 GB/s

This table below reports the composite temperature during the IO burst. The expectation is the end and start temperatures should be within the delta limit. A higher temperature could indicate background operations are ongoing.

The table also includes the Throttle Time which is the sum for all throttle levels. Note that the units for throttle levels WCTEMP and CCTEMP is in minutes. Therefore, throttling for less than one minute may not be indicated

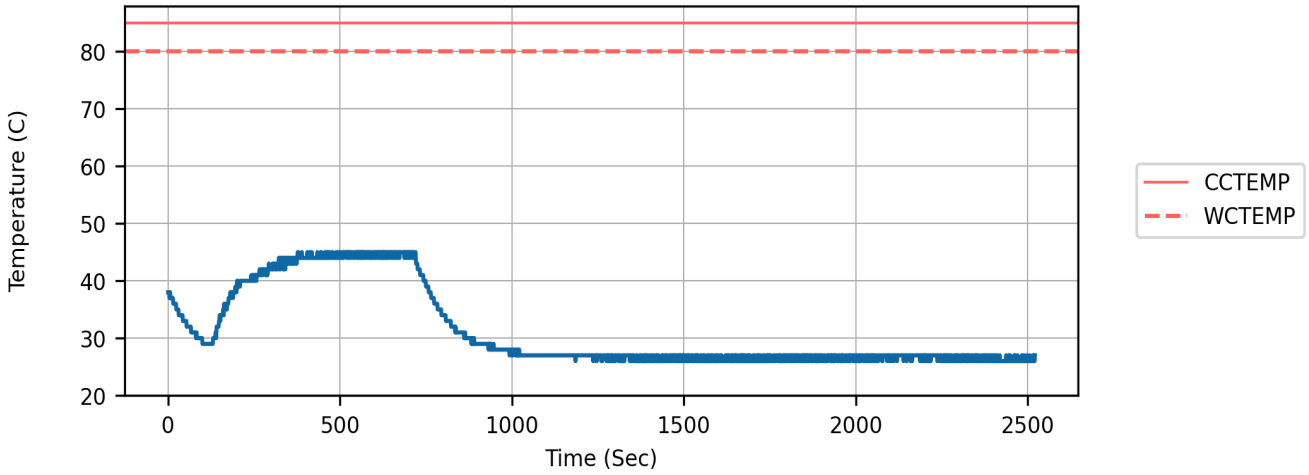
for these levels.

IO PATTERN	THROTTLE	MAX	START	END	DELTA	LIMIT
Random Write, QD1, 4KiB	0 sec	45 C	38 C	26 C	-12 C	5 C
Random Read, QD1, 4KiB	0 sec	41 C	26 C	24 C	-2 C	5 C
Sequential Write, QD32, 128KiB	0 sec	51 C	25 C	24 C	-1 C	5 C
Sequential Read, QD32, 128KiB	0 sec	73 C	24 C	25 C	1 C	5 C

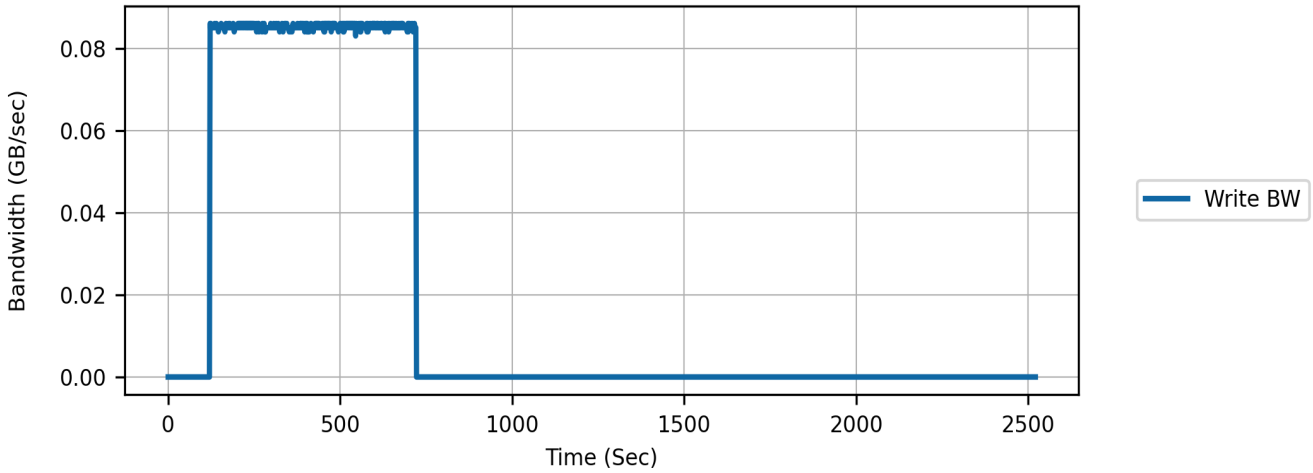
RANDOM WRITES

These plots are for writes using random addressing, block size of 4 KiB, and queue depth of 1.

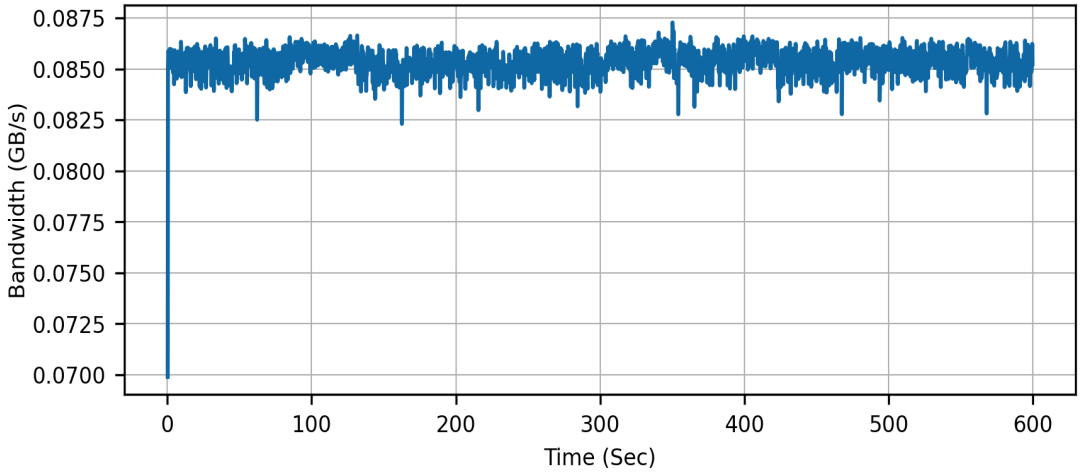
Temperature (Including Idle)



IO Write Bandwidth (Including Idle)



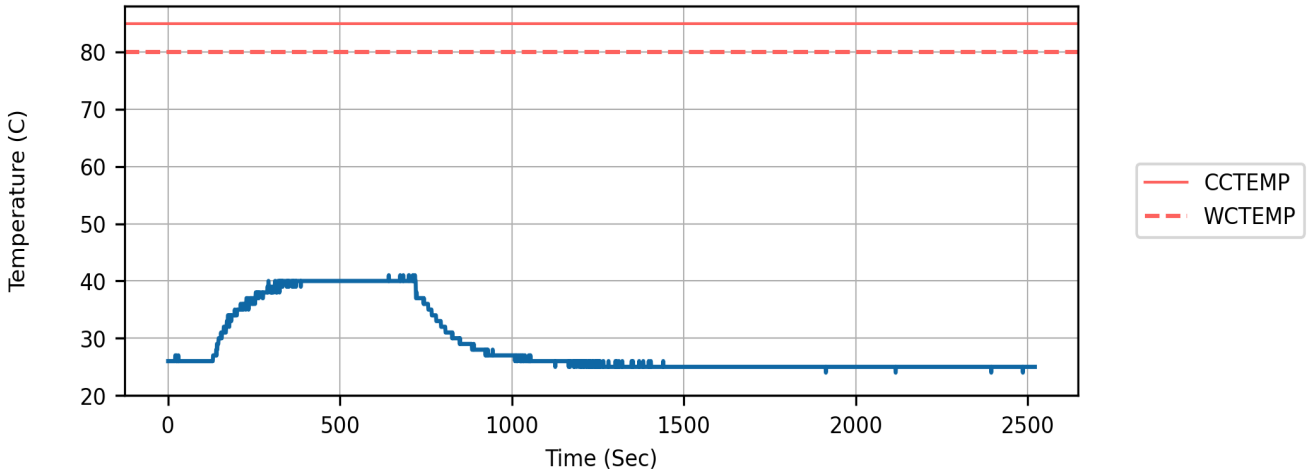
IO Write Bandwidth (Excluding Idle)



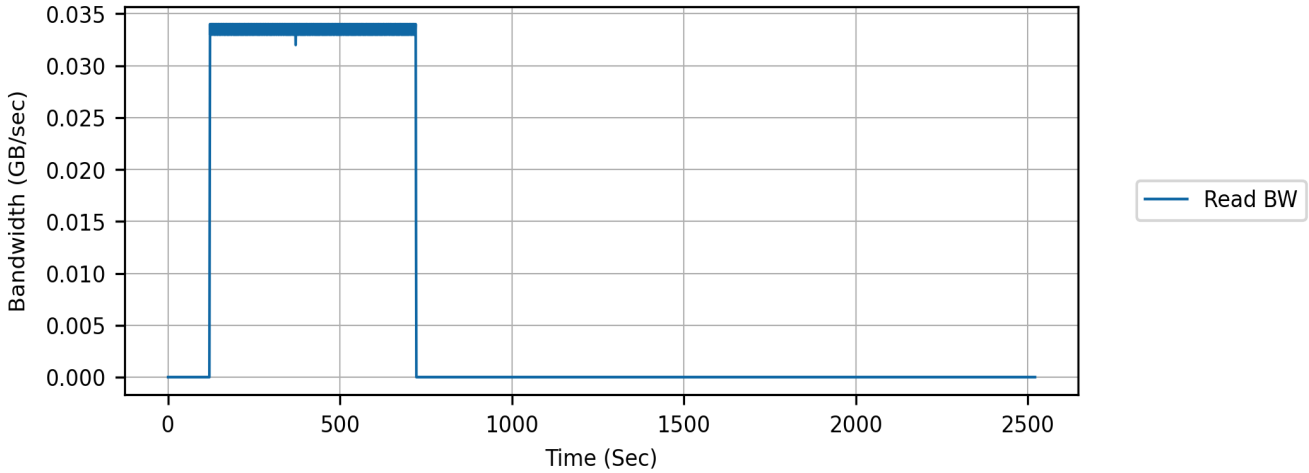
RANDOM READS

These plots are for reads using random addressing, block size of 4 KiB, and queue depth of 1.

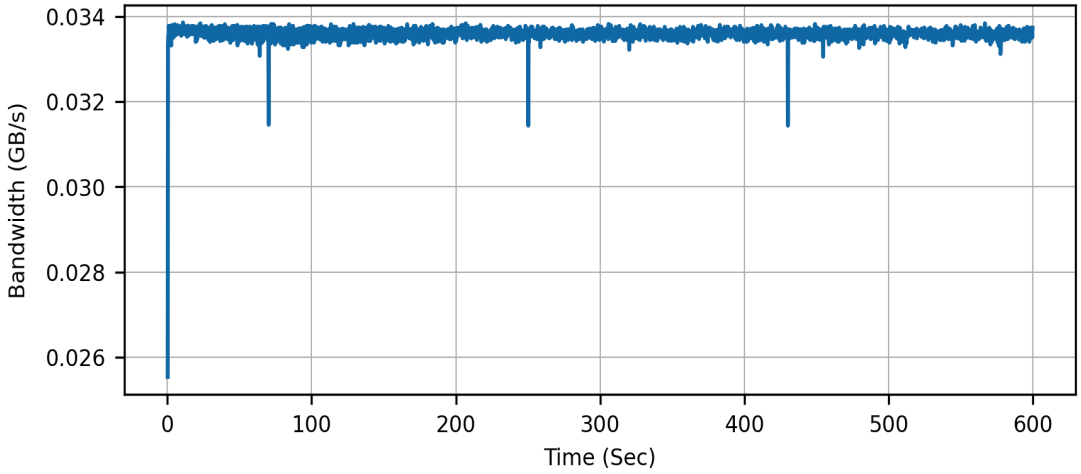
Temperature (Including Idle)



IO Read Bandwidth (Including Idle)



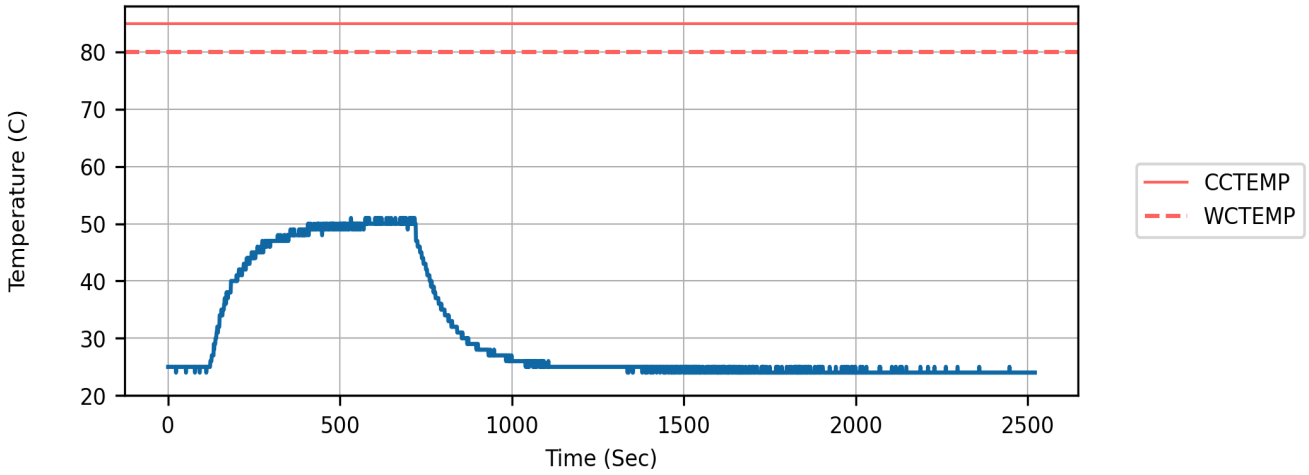
IO Read Bandwidth (Excluding Idle)



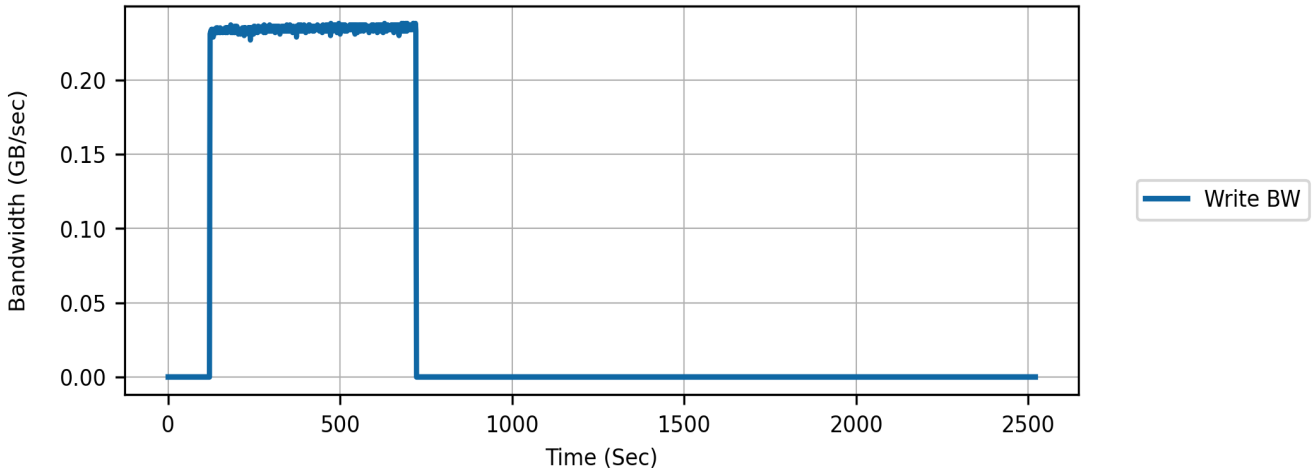
SEQUENTIAL WRITES

These plots are for writes using sequential addressing, block size of 128 KiB, and queue depth of 32.

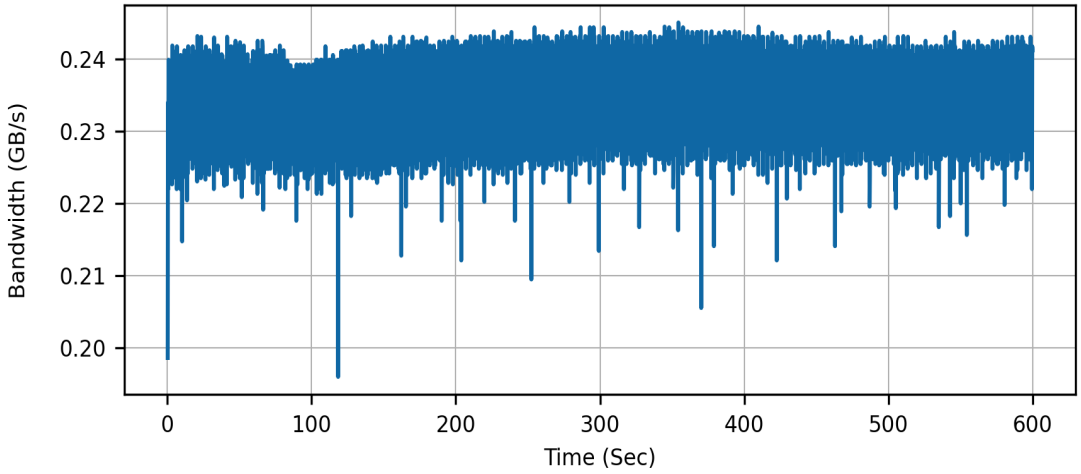
Temperature (Including Idle)



IO Write Bandwidth (Including Idle)



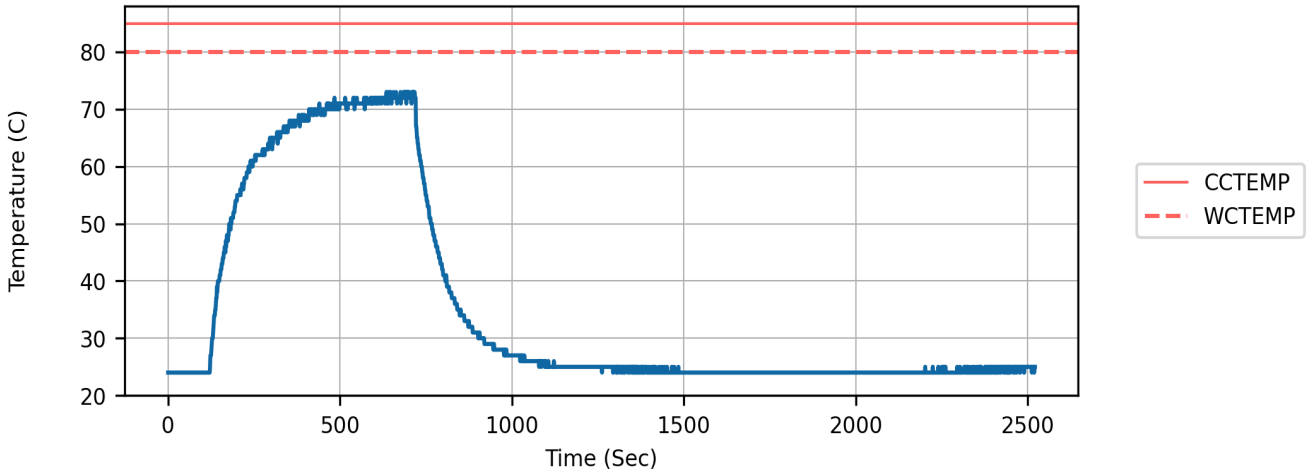
IO Write Bandwidth (Excluding Idle)



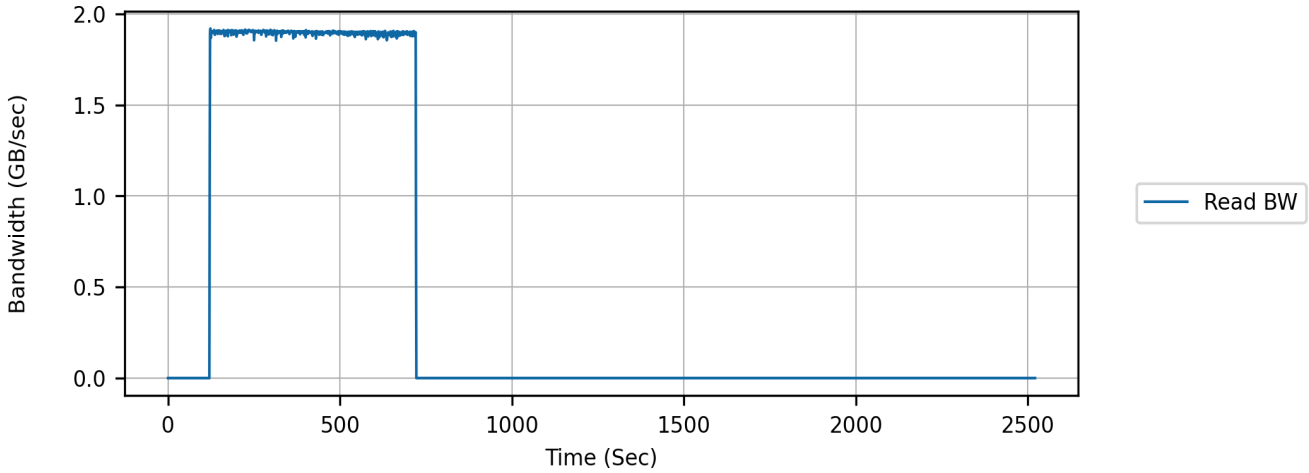
SEQUENTIAL READS

These plots are for reads using sequential addressing, block size of 128 KiB, and queue depth of 32.

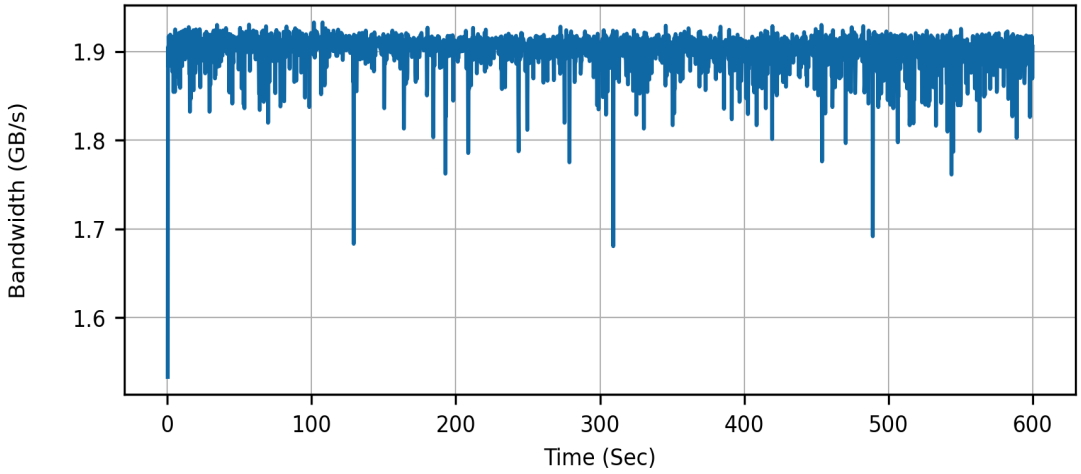
Temperature (Including Idle)



IO Read Bandwidth (Including Idle)



IO Read Bandwidth (Excluding Idle)



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

If does not exist, create a small file without verification data for fio.

Step 3: Random write : FAIL

Start reading NVMe information for random write, size=4096, depth=1

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS
No errors shall occur running IO	0	PASS
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Long burst end temperature shall be within 5C of start temperature	12C	FAIL

Step 4: Random read : PASS

Start reading NVMe information for random read, size=4096, depth=1

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS
No errors shall occur running IO	0	PASS
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Long burst end temperature shall be within 5C of start temperature	2C	PASS

Step 5: Sequential write : PASS

Start reading NVMe information for sequential write, size=131072, depth=32

REQUIREMENT	VALUE	RESULT

Critical warnings shall be 0	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS
No errors shall occur running IO	0	PASS
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Long burst end temperature shall be within 5C of start temperature	1C	PASS

Step 6: Sequential read : PASS

Start reading NVMe information for sequential read, size=131072, depth=32

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS
No errors shall occur running IO	0	PASS
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Long burst end temperature shall be within 5C of start temperature	1C	PASS

Step 7: Verify performance : FAIL

Verify short burst performance.

REQUIREMENT	VALUE	RESULT
Short burst, random reads, 4KiB, QD1 bandwidth shall be greater than 0.01 GB/s	0.034 GB/s	PASS
Short burst, random writes, 4KiB, QD1 bandwidth shall be greater than 0.1 GB/s	0.085 GB/s	FAIL
Short burst, sequential reads, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	1.897 GB/s	PASS
Short burst, sequential writes, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	0.234 GB/s	FAIL
IO bandwidth behaved as expected with increasing queue depth and block size	PASS	PASS

Step 8: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Error count shall not increase	0	**PASS**
Static parameters, such as Model Number, shall not change	0	**PASS**
SMART counters, such as Data Written, shall not decrement	0	**PASS**

TEST 14: ASPM LATENCY

VERIFICATIONS	6	
PASS	6	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 18:42:46.241	Jan 01, 2023 - 18:43:50.209	0:01:03.968

DESCRIPTION

This test measures the read latency for ASPM enabled and disabled. ASPM is....

Read latency is determined by measuring the latency of the first IO read after an idle period long enough that the drive transitions to a lower ASPM state (L0s, L1, L1.1, L1.2). Several samples are taken and the outliers are removed to avoid unrelated latency changes from OS interupts or drive accesses that take the drive out of idle.

RESULTS

The latency in the plot below is for the first read after the idle time for both ASPM enabled and disabled.

VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

If does not exist, create a small file without verification data for fio.

Step 3: IO : PASS

Use fio to run IO reads with different idle times

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 4: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS

Static parameters, such as Model Number, shall not change	0	**PASS**
SMART counters, such as Data Written, shall not decrement	0	**PASS**

TEST 15: NONOP POWER TIMES

VERIFICATIONS	8	
PASS	8	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 18:43:50.225	Jan 01, 2023 - 19:29:01.265	0:45:11.040

DESCRIPTION

This test reports the entry timeout and exit latency for non-operational power states. Exit latency is determined by measuring the latency of the first IO read after an idle period long enough that the drive transitions to a lower power state. Several samples are taken and the outliers are removed to avoid unrelated latency changes from OS interupts or drive accesses that take the drive out of idle.

The entry timeout is the idle time required for the drive to transition to a lower power state. The entry timeout is an OS setting that can be adjusted by the end user. Some systems, such as Windows laptops, typically have different values for battery and AC power. The test determines the entry timeout by increasing the idle time until the resulting IO read latency increases indicating a lower power state was entered.

If Autonomous Power State Transition (APST) is enabled, the drive will automatically transition to a non-operational power state. The value of Idle Time Prior to Transition (ITPT) defines the idle time required before transitioning. The Idle Transition Power State (ITPS) defines the state to transition to. Each Power State can have it's own ITPT and ITPS value.

If APST is disabled, the host OS will transition the drive to the lower power states. This appears to be the case for the inbox Windows driver. The Windows driver uses four parameters to determine the timeout and which state to transition to. The Primary and Secondary NVMe Idle Timeouts work the same as ITPT above. The Primary and Secondary NVMe Power State Transition Latency Tolerance define the state to transition to. The driver transitions to the lowest state where the sum of the entry and exit latency is less than the NVMe Power State Transition Latency Tolerance.

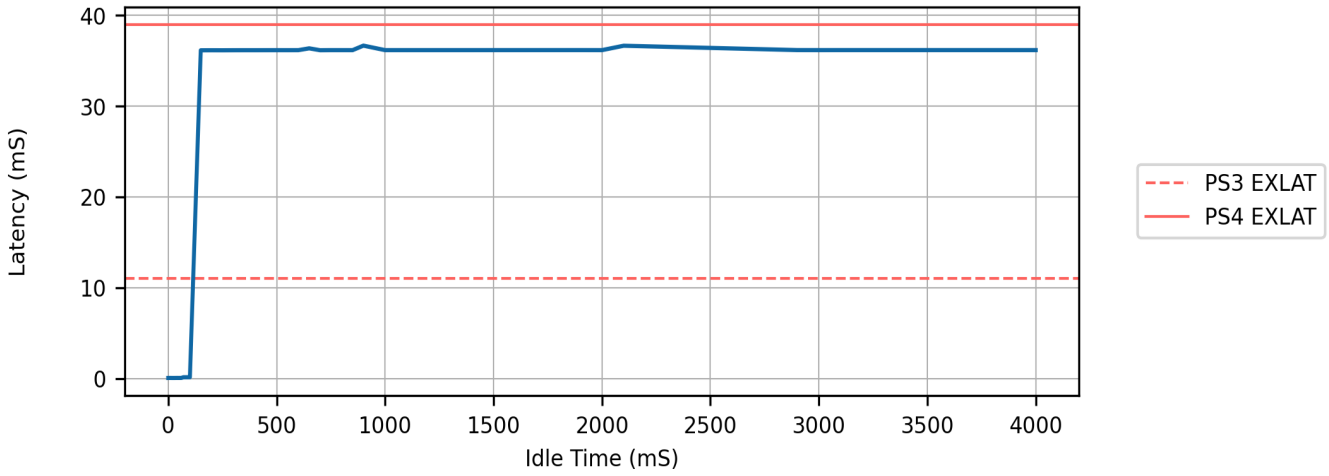
RESULTS

Autonomous Power State Transition (APST) is disabled. The host OS is changing power states.

In the table below a blank cell indicates the value is not reported or doesn't apply. Typically, latency values are not reported for operational power states.

POWER STATE	NOP	ENTRY LATENCY	EXIT LATENCY	TOTAL LATENCY
0	False			
1	False			
2	False			
3	True	3.9 mS	11.0 mS	14.9 mS
4	True	5.0 mS	39.0 mS	44.0 mS

The latency in the plot below is for the first read after the idle time. This should be less than or equal to the power state exit latency.



The table below lists the Windows OS power plan settings.

PARAMETER	AC POWER	DC POWER
ASPM	2	2
NOPPME	0	0
Primary Latency	50 mS	5 mS
Primary Timeout	100 mS	100 mS
Secondary Latency	100 mS	100 mS
Secondary Timeout	800 mS	1000 mS

VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

If does not exist, create a small file without verification data for fio.

Step 3: Idle then IO reads : PASS

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
Power state entry timeout shall meet drive setting	PASS	PASS
IO read latency within power state exit latencies	PASS	PASS

Step 4: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 16: DATA COMPRESSION

VERIFICATIONS	15	
PASS	15	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 19:29:01.328	Jan 01, 2023 - 19:52:18.400	0:23:17.072

DESCRIPTION

This test attempts to determine if the drive implements data compression. Data compression is a feature that reduces the amount of data written to the NAND flash resulting in lower write latency, extended drive life, and reduced garbage collection overhead.

This test reports the average latency for 2 GiB of reads and writes with incompressible and compressible data. Drives with data compression should have lower latency for the compressible data pattern. The compressible data pattern is all 0s. The incompressible data pattern is a unique psuedo-random pattern every write. The read and writes are completed with a queue depth of 1, block size of 8 KiB for random addressing, and block size of 128 KiB for sequential addressing.

RESULTS

IO Latency vs Data Compressibility

IO PATTERN	COMPRESSIBLE	INCOMPRESSIBLE	DELTA	% DELTA
Random Write, 8 KiB, QD1	48.431 mS	49.168 mS	0.737 mS	1.5%
Random Read, 8 KiB, QD1	168.989 mS	168.969 mS	-0.020 mS	-0.0%
Sequential Write, 128 KiB, QD1	558.117 mS	561.166 mS	3.049 mS	0.5%
Sequential Read, 128 KiB, QD1	94.516 mS	95.529 mS	1.013 mS	1.1%

VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

Create file if does not exist.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: Random data write 128K : PASS

Sequential Write, 128 KiB, QD1 with incompressible data.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 5: Random data read 128K : PASS

Sequential Read, 128 KiB, QD1 with incompressible data.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 6: Random data Random write 8K : PASS

Random Write, 8 KiB, QD1 with incompressible data.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 7: Random data Random read 8K : PASS

Random Read, 8 KiB, QD1 with incompressible data.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 8: Zero data write 128K : PASS

Sequential Write, 128 KiB, QD1 with compressible data.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 9: Zero data read 128K : PASS

Sequential Read, 128 KiB, QD1 with compressible data.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 10: Zero data Random write 8K : PASS

Random Write, 8 KiB, QD1 with compressible data.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 11: Zero data Random read 8K : PASS

Random Read, 8 KiB, QD1 with compressible data.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 12: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS

Step 13: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 17: DATA DEDUPLICATION

VERIFICATIONS	15	
PASS	15	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 19:52:18.400	Jan 01, 2023 - 20:04:38.414	0:12:20.014

DESCRIPTION

This test attempts to determine if the drive implements data deduplication. Data deduplication is a feature that reduces the amount of duplicate data written to the NAND flash resulting in lower write latency, extended drive life, and reduced garbage collection overhead.

This test reports the average latency for 2 GiB of writes with repeating and non-repeating data. Drives with data deduplication should have much lower latency for the repeating data pattern. The repeating data pattern uses the same psuedo-random pattern for every block. The non-repeating pattern uses a unique psuedo-random pattern every block. For example, the repeating pattern is a psuedo-random data pattern that is 4 KiB in size when the block size is 4 KiB.

The writes are completed with a queue depth of 1 and block sizes of 4 KiB, 8 KiB, 32 KiB, and 128 KiB. Different block sizes are tried because any data deduplication chunk size is unknown.

RESULTS

Write Latency vs Data Repeatability

IO PATTERN	NONREPEATING	REPEATING	DELTA	% DELTA
Sequential Write, 4 KiB, QD1	46.747 mS	46.679 mS	0.068 mS	0.1%
Sequential Write, 8 KiB, QD1	48.451 mS	48.507 mS	-0.056 mS	-0.1%
Sequential Write, 32 KiB, QD1	132.750 mS	131.990 mS	0.760 mS	0.6%
Sequential Write, 128 KiB, QD1	537.419 mS	533.341 mS	4.078 mS	0.8%

VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

If does not exist, create a small file without verification data for fio.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: 4K unique writes : PASS

Writing unique patterns with block size of 4K.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 5: 8K unique writes : PASS

Writing unique patterns with block size of 8K.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 6: 32K unique writes : PASS

Writing unique patterns with block size of 32K.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 7: 128K unique writes : PASS

Writing unique patterns with block size of 128K.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 8: 4K duplicate writes : PASS

Writing duplicate patterns with block size of 4K.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 9: 8K duplicate writes : PASS

Writing duplicate patterns with block size of 8K.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 10: 32K duplicate writes : PASS

Writing duplicate patterns with block size of 32K.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 11: 128K duplicate writes : PASS

Writing duplicate patterns with block size of 128K.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 12: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS

Step 13: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 18: READ BUFFER

VERIFICATIONS	6	
PASS	6	100.0%
FAIL	0	0.0%

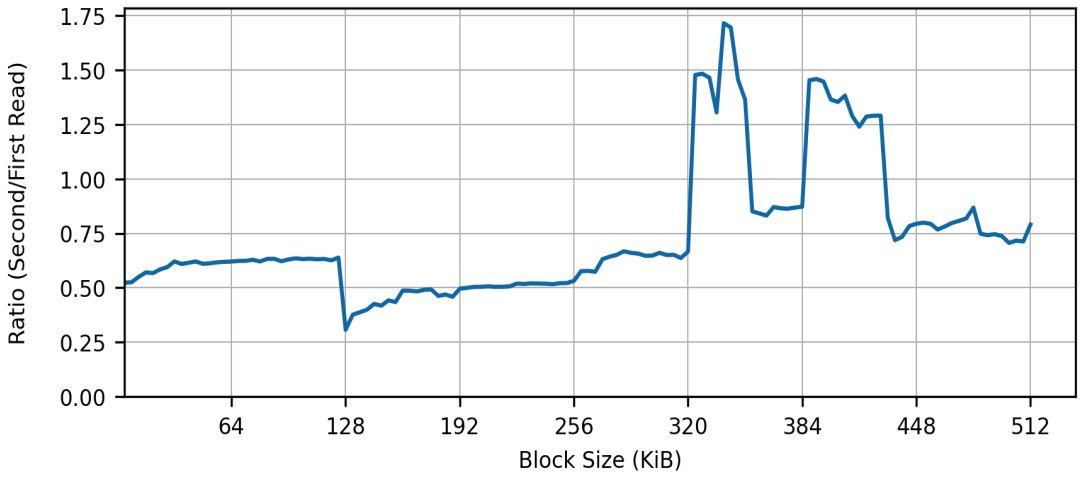
STARTED	ENDED	DURATION
Jan 01, 2023 - 20:04:38.426	Jan 01, 2023 - 20:05:05.243	0:00:26.817

DESCRIPTION

This test attempts to determine if the drive implements a read buffer by reporting the difference in read latency for two subsequent reads to the same address. Drives that have a read buffer should report much lower latency for the second read. Since these are performance measurements no data verification is done.

RESULTS

This plot shows the ratio of two reads to the same address at different block sizes. Devices that buffer reads will have a faster second read. A ratio of 0.5 indicates the second read was twice as fast as the first read.



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

If does not exist, create a small file without verification data for fio.

Step 3: IO : PASS

Run IO trace file using fio

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 4: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 19: BIG FILE WRITES

VERIFICATIONS	12	
PASS	12	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 20:05:05.258	Jan 01, 2023 - 21:01:27.718	0:56:22.460

DESCRIPTION

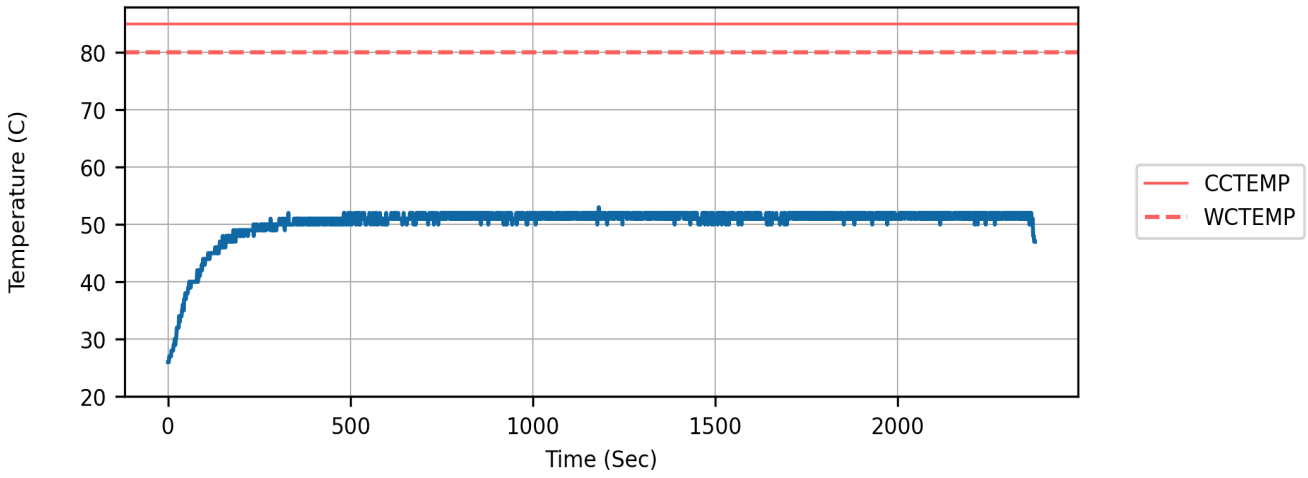
This test writes a big file using continuous, large block, high queue depth, sequential writes. The file size is 90% of the disk size. The total amount of continuous writes completed is 2.5 times the file size. A large amount of continuous writes can identify performance variation from several issues such as thermal throttling, slow garbage collection, and write cache limitations.

After the continous writes have completed, the test waits 180 seconds for background garbage collection to complete. The test then runs several bursts bursts of large block, high queue depth, writes with varying amounts of idle time between them. The different idle times can identify performance behavior of a write buffer or write cache.

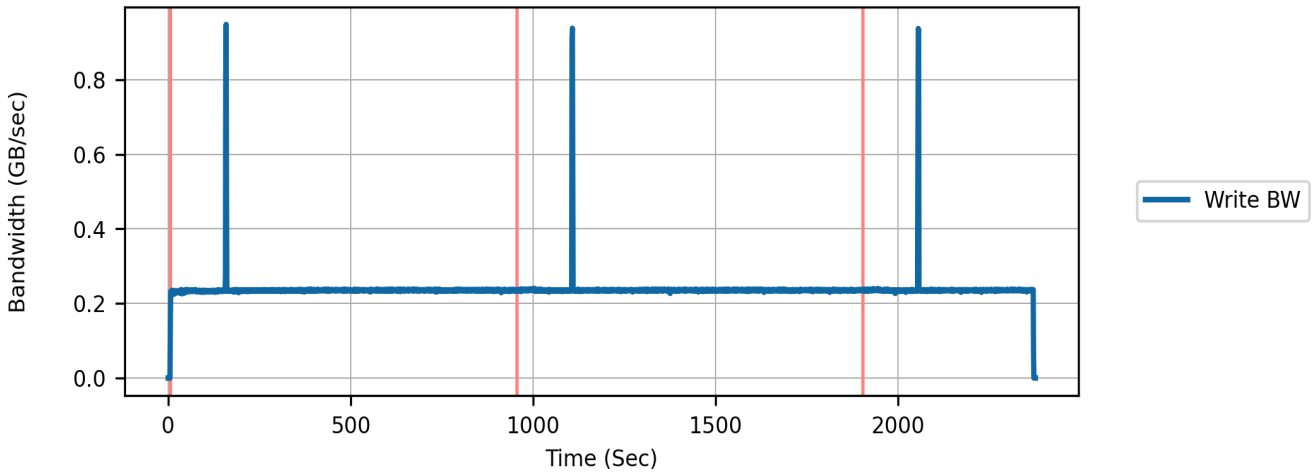
RESULTS

Continuous Writes

The file size tested was 224.4 GB which is 90% of the disk size of 250.0 GB. A total of 561.0 GB were written to the file during at an average bandwidth of 0.24 GB. The plot below shows the composite temperature of the drive during the test along with the thermal throttle limits.



The plot below shows the write bandwidth during the continuous writes. The file was written a total of 2.5 times. The vertical red lines indicate each time a new file write begins.

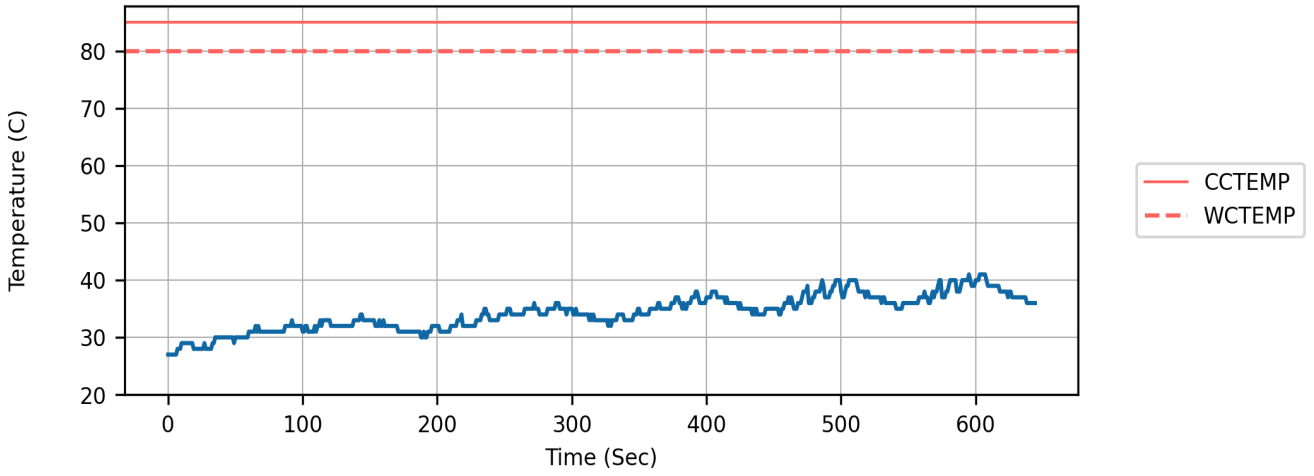


Burst Writes

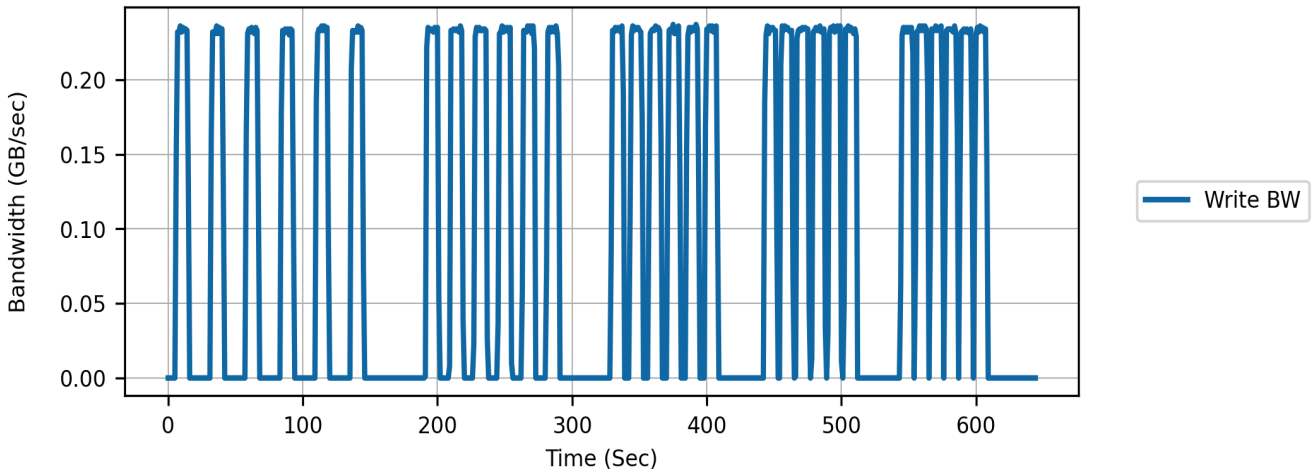
A total of 5 groups of bursts were completed. Each burst group has different idle times between bursts. For devices with write buffers, the bandwidth may decrease as the idle time reduces.

Burst Group	Number of Bursts	Idle Delay	Average Bandwidth
0	6	16 sec	0.233 GB/s
1	6	8 sec	0.233 GB/s
2	6	4 sec	0.233 GB/s
3	6	2 sec	0.233 GB/s
4	6	1 sec	0.233 GB/s

The plot below shows the composite temperature of the drive during the burst writes to the device. The burst workload should not result in thermal throttling.



The plot below shows the bandwidth during burst writes to the big file.



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

Create file if does not exist.

Step 3: Continuous writes : PASS

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
Error count shall not increase	0	PASS

Step 4: Burst writes : PASS

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 5: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS

Error count shall not increase	0	**PASS**

Step 6: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	**PASS**
Error count shall not increase	0	**PASS**
Static parameters, such as Model Number, shall not change	0	**PASS**
SMART counters, such as Data Written, shall not decrement	0	**PASS**

TEST 20: BIG FILE READS

VERIFICATIONS	13	
PASS	13	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 01, 2023 - 21:01:27.733	Jan 01, 2023 - 21:24:32.257	0:23:04.524

DESCRIPTION

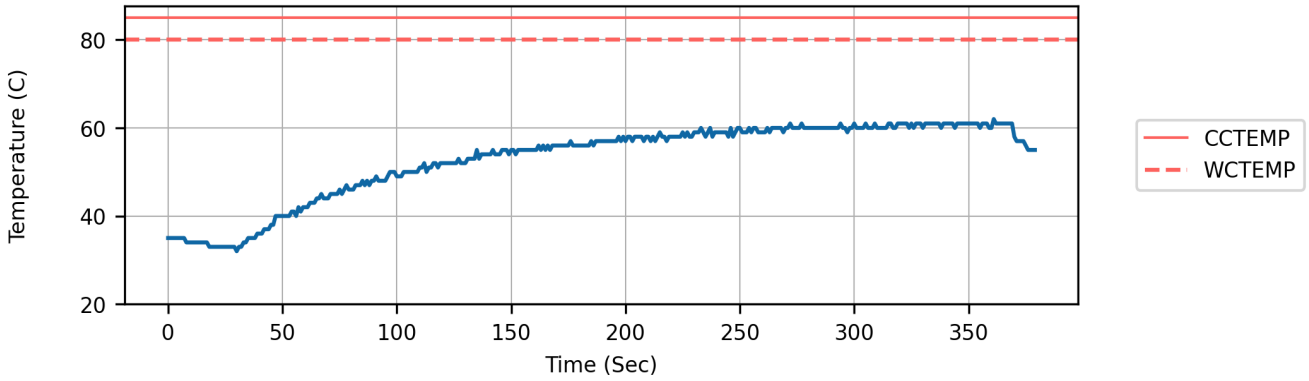
This test reports the bandwidth and distribution of continuous large block sequential and random reads to a big file. The big file is approximately 90% of the disk size. The file is reads 2 times for each addressing mode. This allows comparison of the different addressing modes: sequential and random. Since this test reports performance measurements no data verification is done.

RESULTS

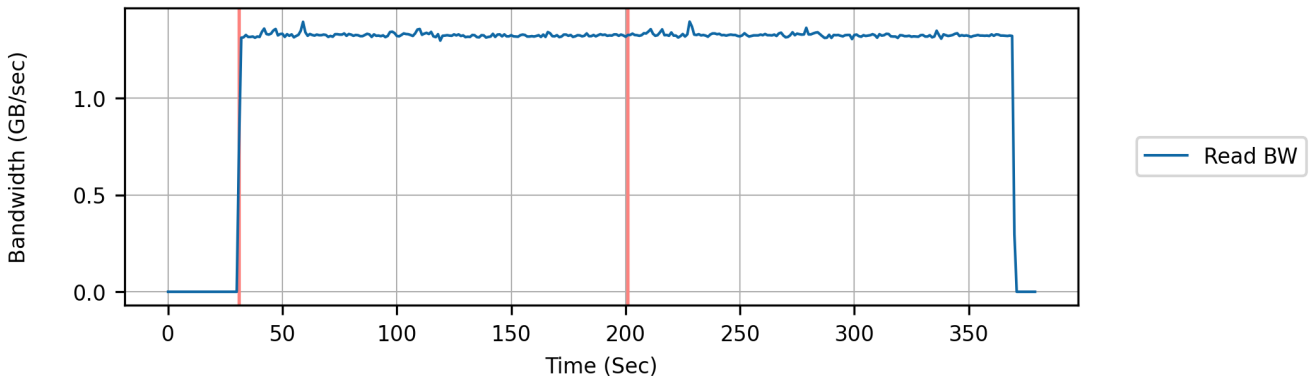
The file size tested was 224.4 GB which is 90% of the disk size of 250.0 GB.

Sequential Reads

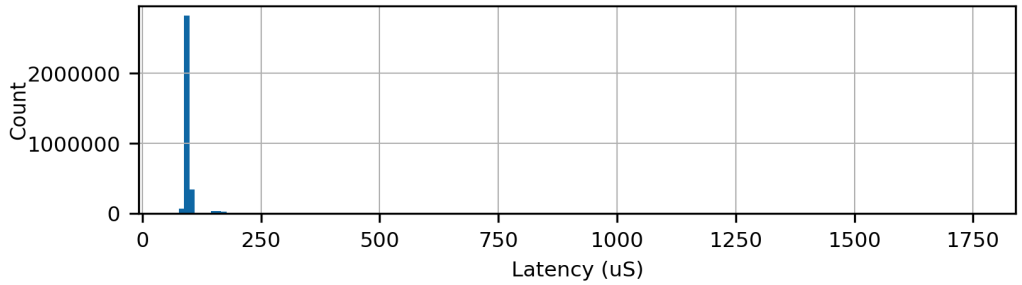
The plot below shows the composite temperature of the drive during the test along with the thermal throttle limits.



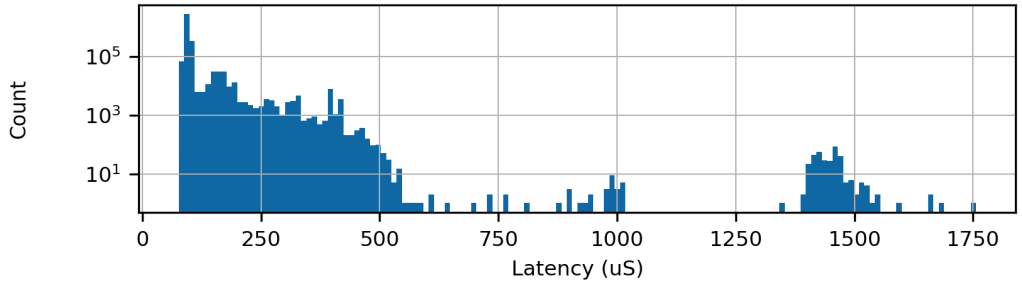
The plot below shows the read bandwidth during the sequential reads.



This histogram shows the latency distribution for 3,424,240 sequential reads. The reads have a block size of 128 KiB and queue depth of 1.

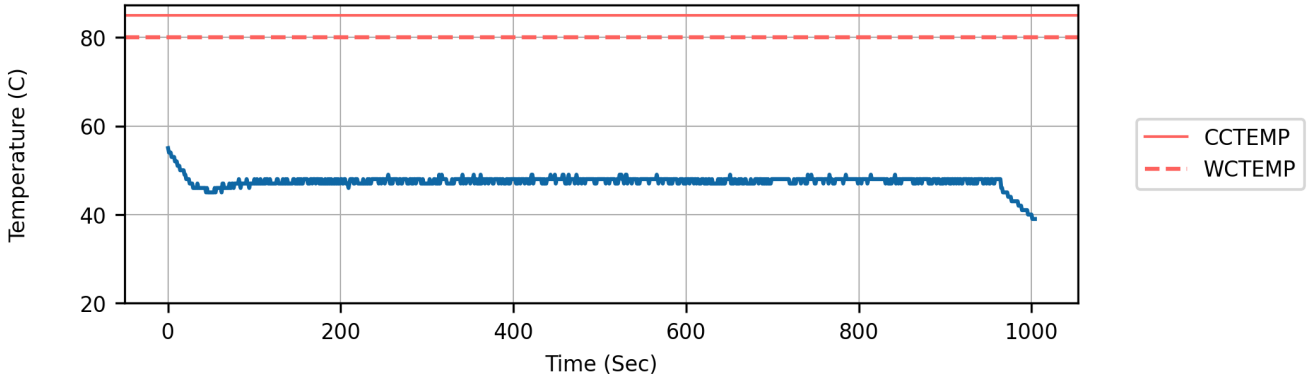


This histogram shows the same data as above except on a log scale to provide better visibility of outliers.

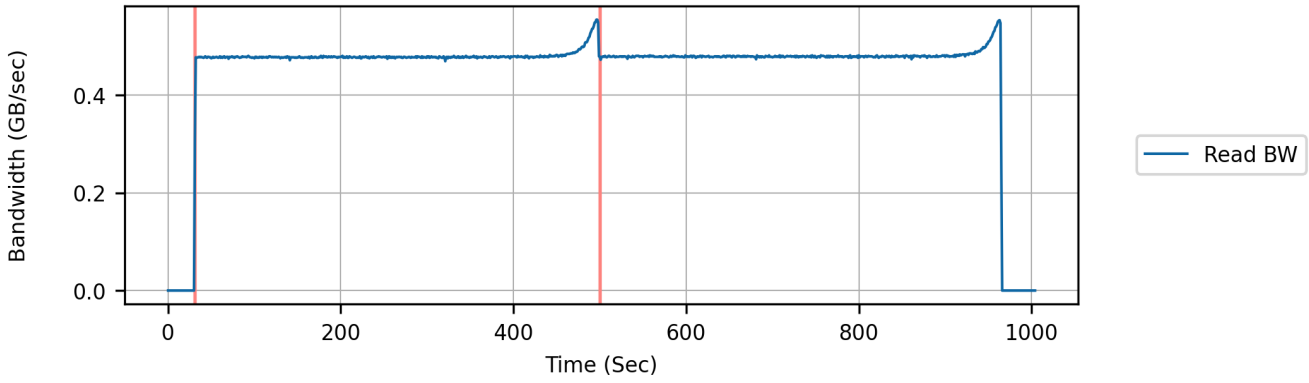


Random Reads

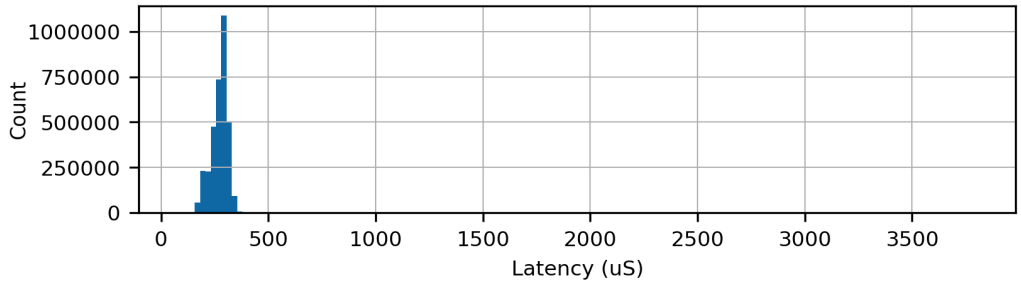
The plot below shows the composite temperature of the drive during the test along with the thermal throttle limits.



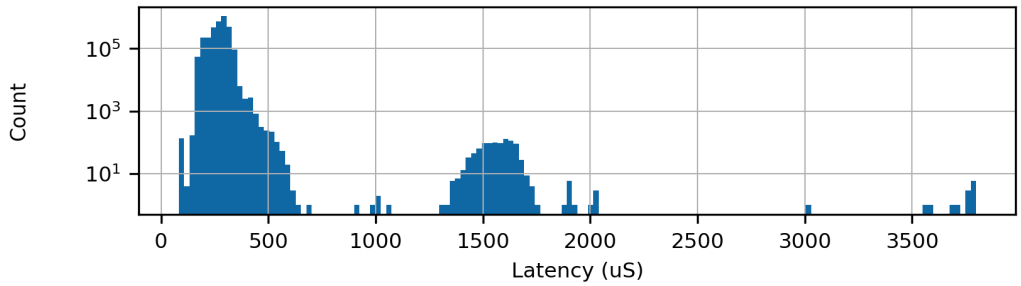
The plot below shows the read bandwidth during the random reads.



This histogram shows the latency distribution for 3,424,240 random reads. The reads have a block size of 128 KiB and queue depth of 1.



This histogram shows the same data as above except on a log scale to provide better visibility of outliers.



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

Create file if does not exist.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: Sequential reads : PASS

Read fio big file several times using sequential reads.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 5: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS

Step 6: Sample info : PASS

Start sampling SMART and power state info every second.

Step 7: Random reads : PASS

Read fio big file several times using random reads.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 8: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS

Step 9: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 21: SHORT BURST PERFORMANCE FULL DRIVE

VERIFICATIONS	16	
PASS	15	93.8%
FAIL	1	6.2%

STARTED	ENDED	DURATION
Jan 01, 2023 - 21:24:32.257	Jan 01, 2023 - 21:44:44.352	0:20:12.095

DESCRIPTION

This test is the same as Short Burst Performance test except the drive capacity is almost full at the start. Full drives may have lower performance than empty drives because of a lower number of erased blocks available for writes and a smaller dynamic cache.

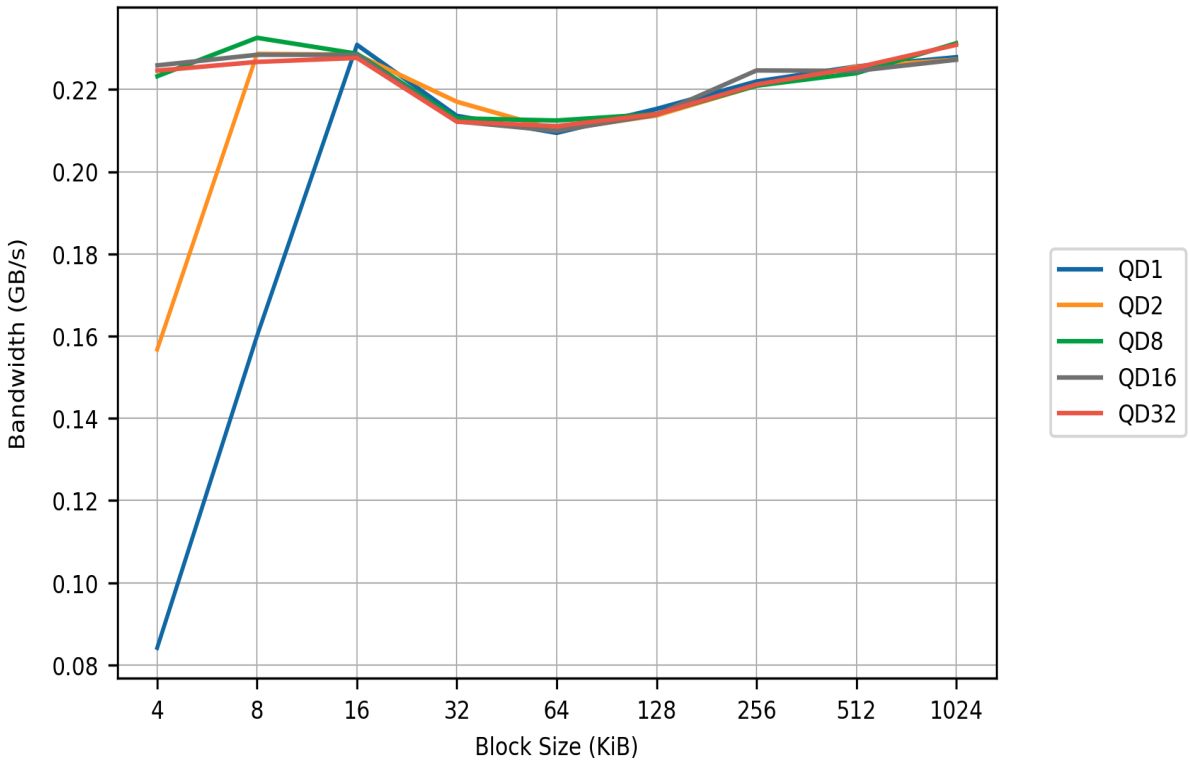
For additional details refer to the Short Burst Performance test.

RESULTS

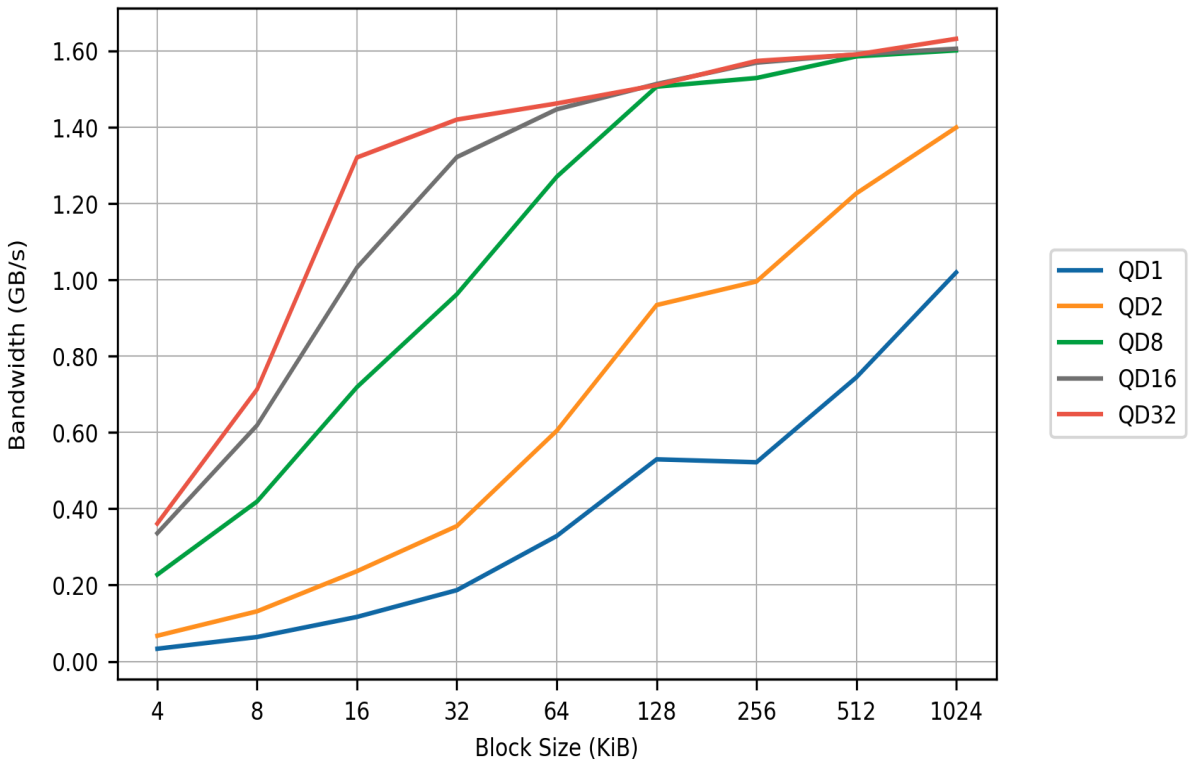
This table shows the bandwidth for several common datasheet and IO benchmark queue depths and block sizes.

IO PATTERN	IOPS	BANDWIDTH	LIMIT	RESULT
Sequential Write, QD32, 128KiB	1,751	0.230 GB/s	1.000 GB/s	FAIL
Sequential Read, QD32, 128KiB	14,144	1.854 GB/s	1.000 GB/s	PASS
Random Write, QD1, 4KiB	20,555	0.084 GB/s	0.010 GB/s	PASS
Random Read, QD1, 4KiB	8,053	0.033 GB/s	0.010 GB/s	PASS
Random Write, QD32, 4KiB	54,830	0.225 GB/s	0.250 GB/s	FAIL
Random Read, QD32, 4KiB	88,106	0.361 GB/s	0.250 GB/s	PASS

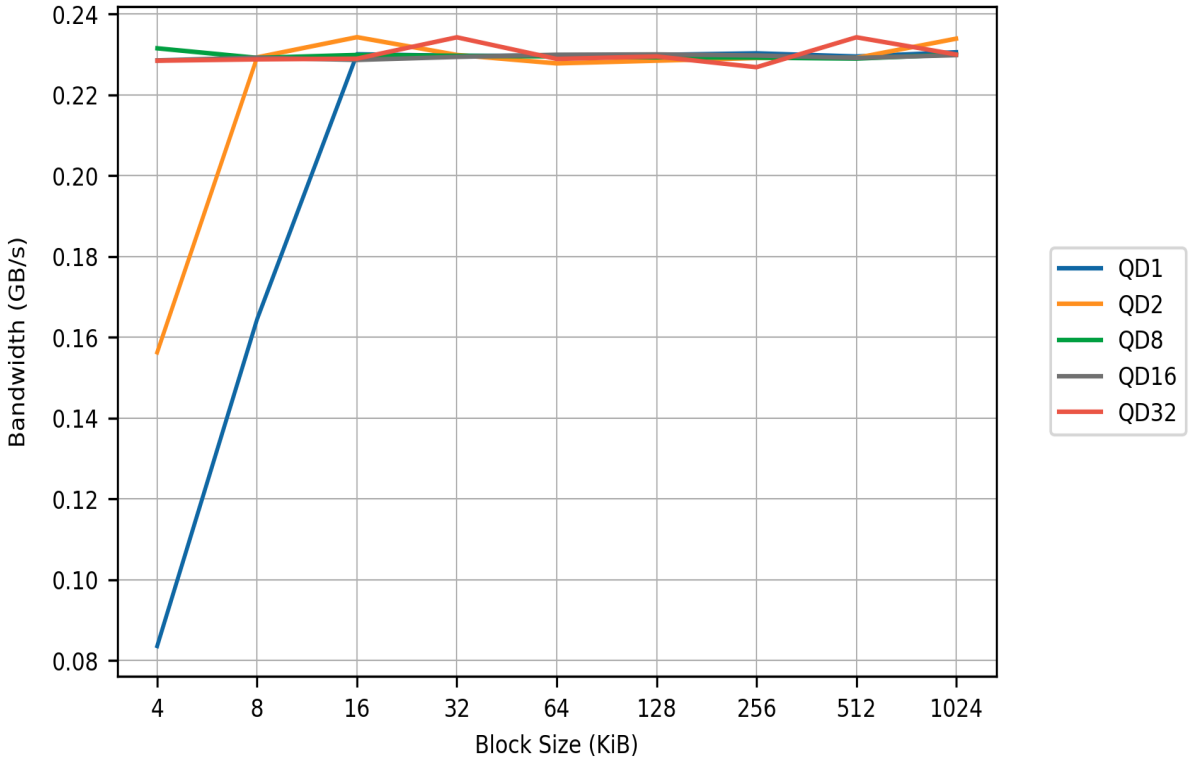
Random Write Bandwidth



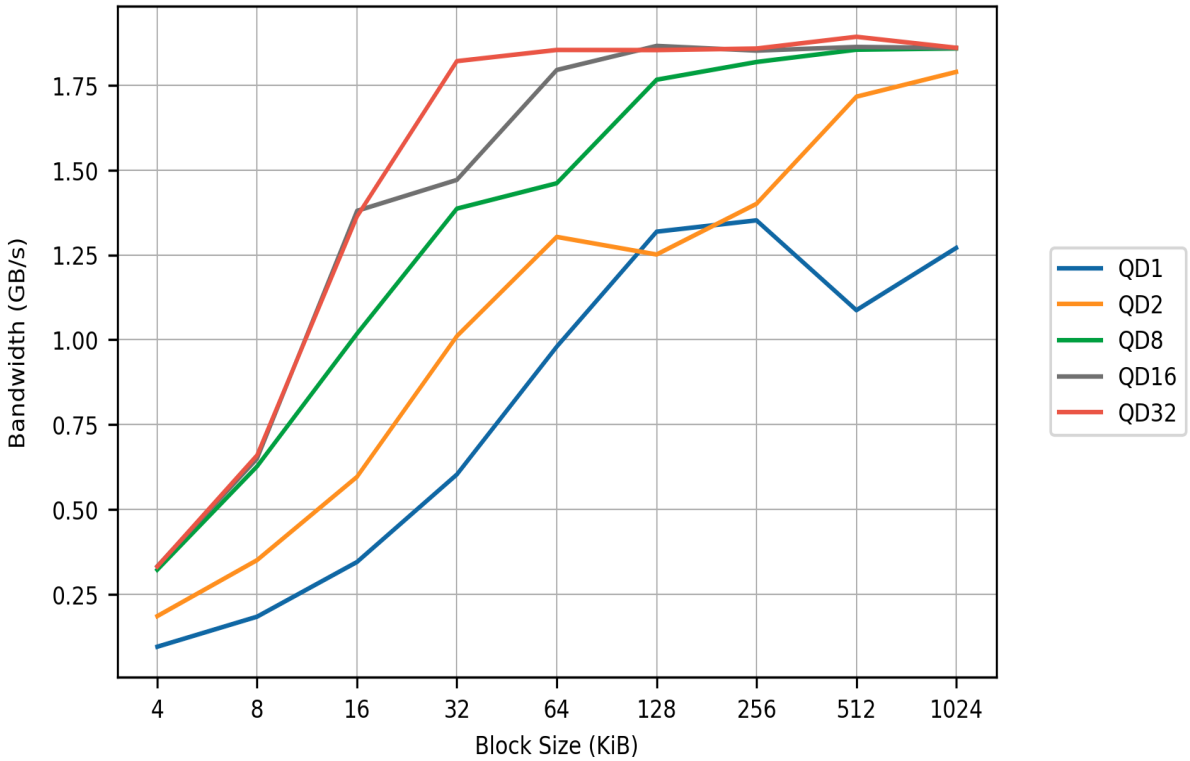
Random Read Bandwidth



Sequential Write Bandwidth



Sequential Read Bandwidth



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

If does not exist, create a small file without verification data for fio.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: Sequential Write : PASS

Measure performance of short burst of sequential writes.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 5: Sequential Read : PASS

Measure performance of short burst of sequential reads.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 6: Random Write : PASS

Measure performance of short burst of random writes.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 7: Random Read : PASS

Measure performance of short burst of random reads.

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS

Step 8: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS

Error count shall not increase	0	PASS

Step 9: Verify performance : FAIL

Verify short burst performance.

REQUIREMENT	VALUE	RESULT
Short burst, random reads, 4KiB, QD1 bandwidth shall be greater than 0.01 GB/s	0.033 GB/s	PASS
Short burst, random writes, 4KiB, QD1 bandwidth shall be greater than 0.01 GB/s	0.084 GB/s	PASS
Short burst, sequential reads, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	1.854 GB/s	PASS
Short burst, sequential writes, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	0.230 GB/s	FAIL
IO bandwidth behaved as expected with increasing queue depth and block size	PASS	PASS

Step 10: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 22: LONG BURST PERFORMANCE FULL DRIVE

VERIFICATIONS	46	
PASS	43	93.5%
FAIL	3	6.5%

STARTED	ENDED	DURATION
Jan 01, 2023 - 21:44:44.368	Jan 02, 2023 - 00:32:55.116	2:48:10.748

DESCRIPTION

This test is the same as Long Burst Performance test except the drive capacity is 90% at the start. Full drives may have lower performance than empty drives because of a lower number of erased blocks available for writes and a smaller dynamic cache.

For additional details refer to the Long Burst Performance test.

RESULTS

This table shows the bandwidth for several common datasheet and IO benchmark queue depths and block sizes.

IO PATTERN	IOPS	BANDWIDTH	LIMIT	RESULT
Sequential Write, QD32, 128KiB	1,788	0.234 GB/s	1.000 GB/s	FAIL
Sequential Read, QD32, 128KiB	14,482	1.898 GB/s	1.000 GB/s	PASS
Random Write, QD1, 4KiB	20,877	0.086 GB/s	0.100 GB/s	FAIL
Random Read, QD1, 4KiB	8,198	0.034 GB/s	0.010 GB/s	PASS

The table below provides the average and ending bandwidth. The ending bandwidth could be significantly lower if thermal throttling or excessive garbage collection occurs.

IO PATTERN	AVERAGE	FIRST SEC	FIRST 15 SEC	LAST 120 SEC
Random Write, QD1, 4KiB	0.086 GB/s	0.082 GB/s	0.085 GB/s	0.086 GB/s
Random Read, QD1, 4KiB	0.034 GB/s	0.032 GB/s	0.034 GB/s	0.034 GB/s
Sequential Write, QD32, 128KiB	0.234 GB/s	0.227 GB/s	0.233 GB/s	0.235 GB/s
Sequential Read, QD32, 128KiB	1.898 GB/s	1.827 GB/s	1.899 GB/s	1.902 GB/s

This table below reports the composite temperature during the IO burst. The expectation is the end and start temperatures should be within the delta limit. A higher temperature could indicate background operations are ongoing.

The table also includes the Throttle Time which is the sum for all throttle levels. Note that the units for throttle levels WCTEMP and CCTEMP is in minutes. Therefore, throttling for less than one minute may not be indicated for these levels.

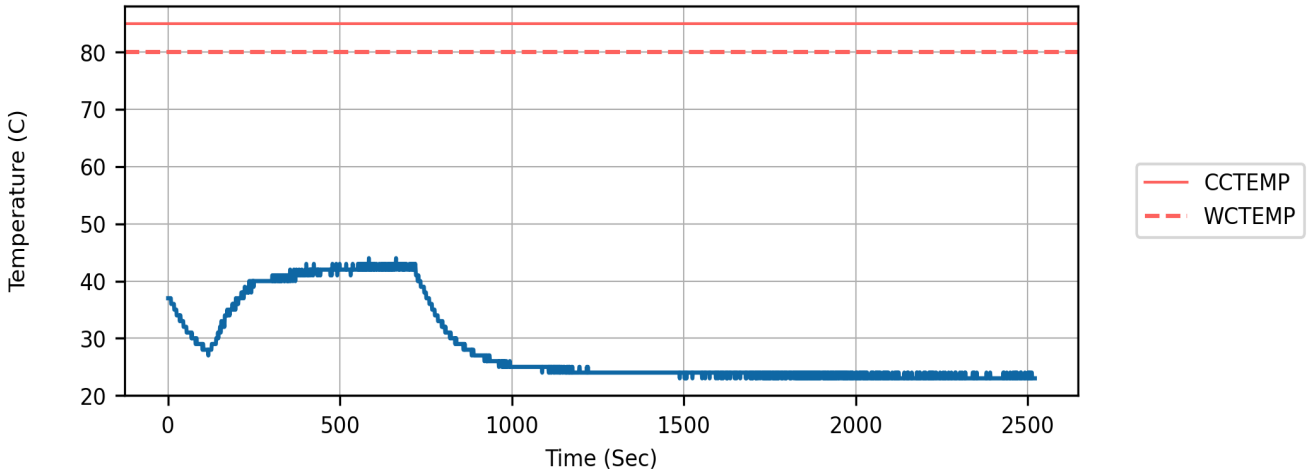
IO PATTERN	THROTTLE	MAX	START	END	DELTA	LIMIT
Random Write, QD1, 4KiB	0 sec	44 C	37 C	23 C	-14 C	5 C

Random Read, QD1, 4KiB	0 sec	40 C	23 C	23 C	0 C	5 C
Sequential Write, QD32, 128KiB	0 sec	49 C	23 C	23 C	0 C	5 C
Sequential Read, QD32, 128KiB	0 sec	71 C	23 C	23 C	0 C	5 C

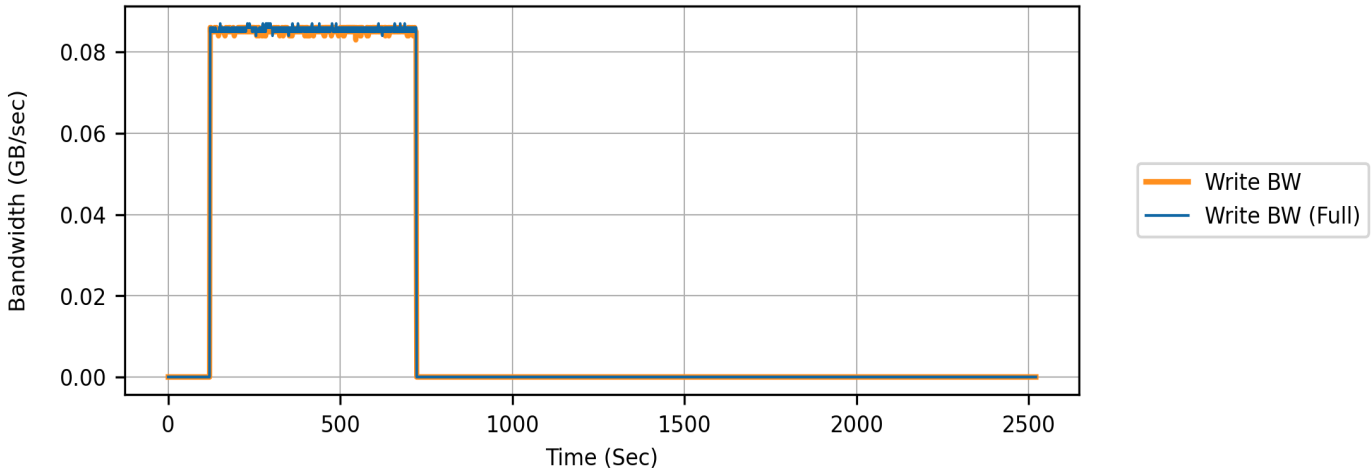
RANDOM WRITES

These plots are for writes using random addressing, block size of 4 KiB, and queue depth of 1.

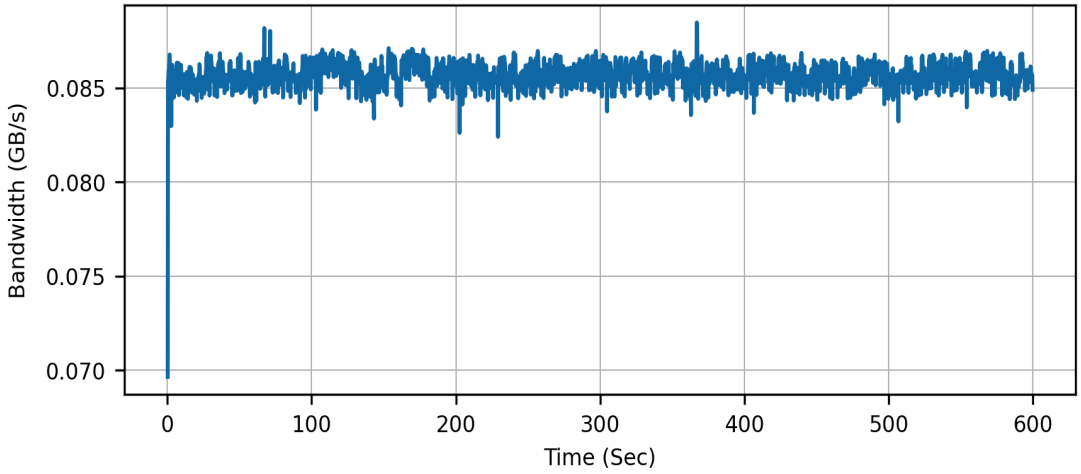
Temperature (Including Idle)



IO Write Bandwidth (Including Idle)



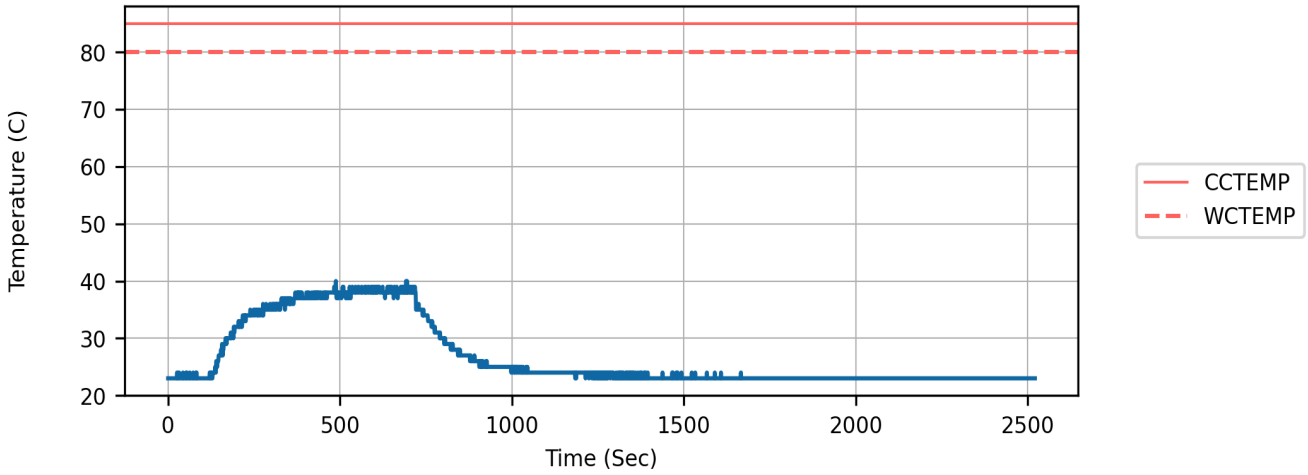
IO Write Bandwidth (Excluding Idle)



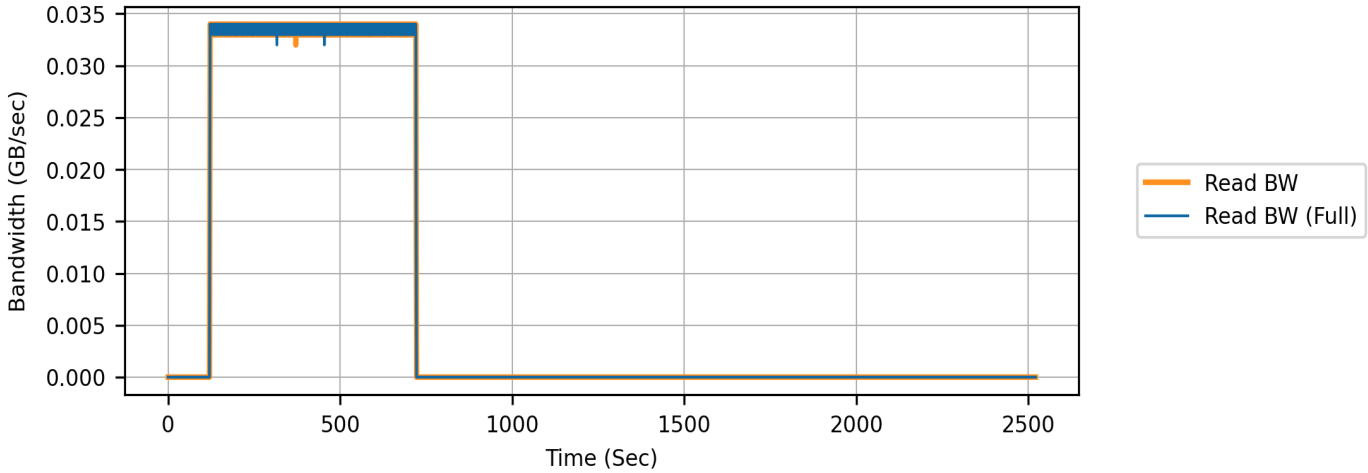
RANDOM READS

These plots are for reads using random addressing, block size of 4 KiB, and queue depth of 1.

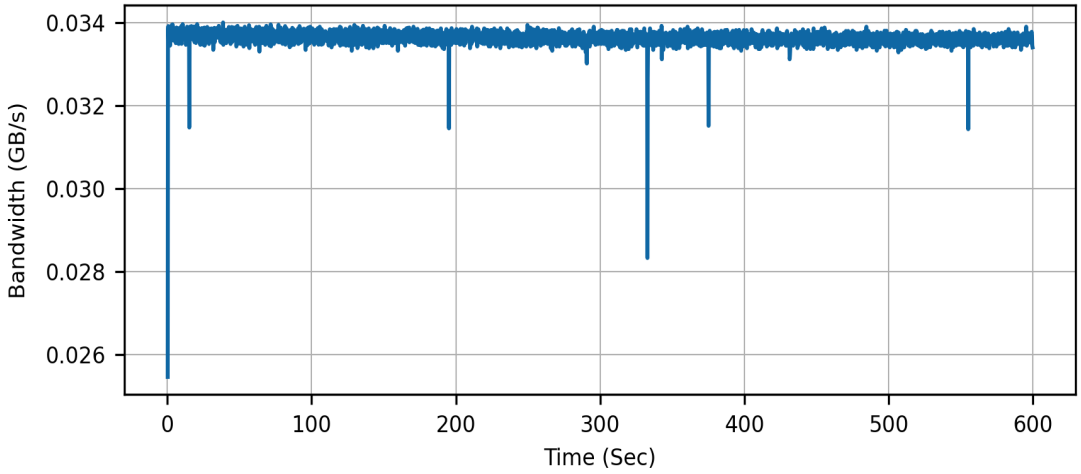
Temperature (Including Idle)



IO Read Bandwidth (Including Idle)



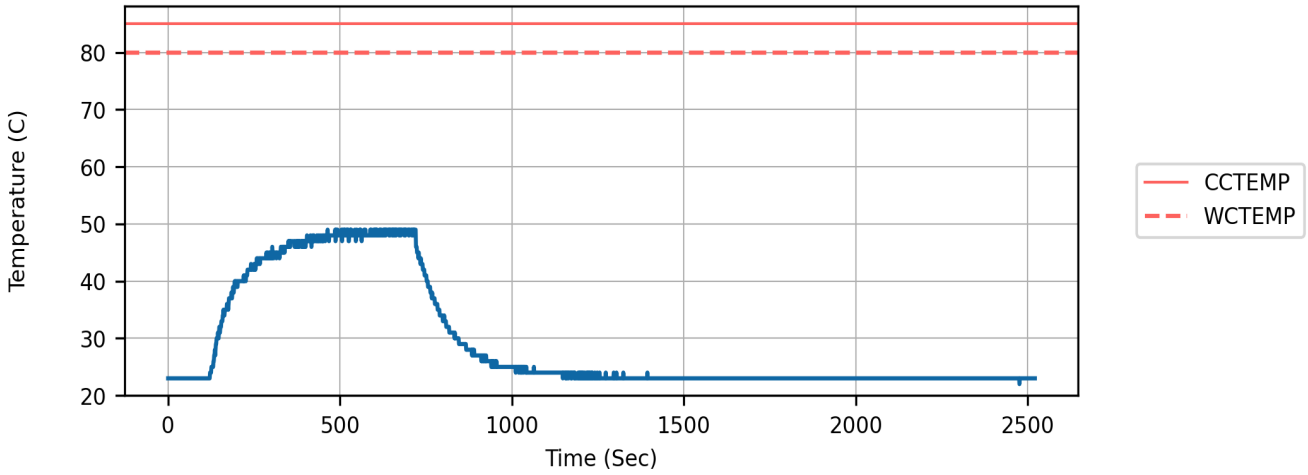
IO Read Bandwidth (Excluding Idle)



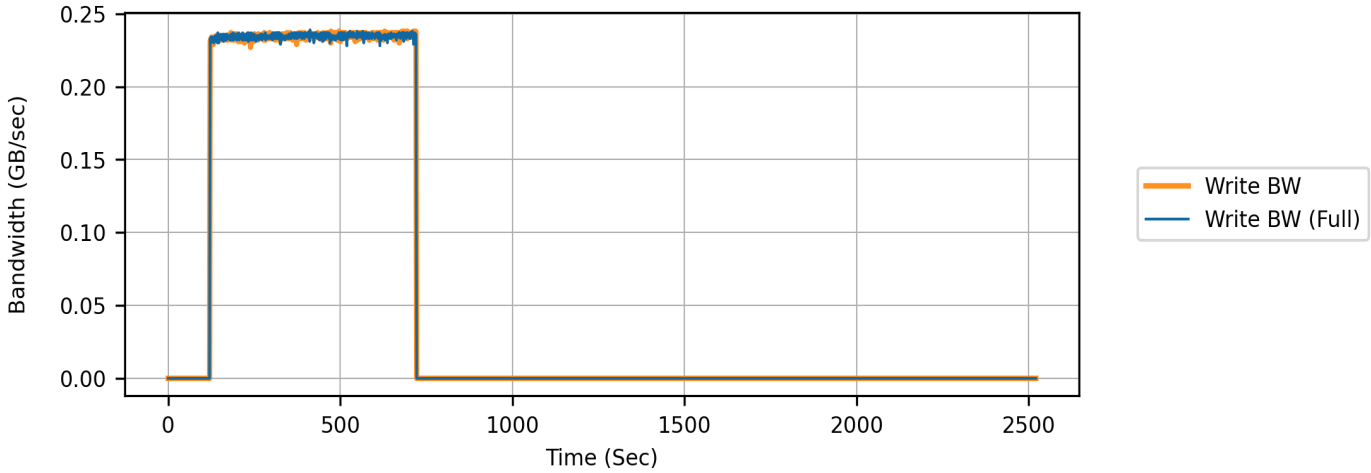
SEQUENTIAL WRITES

These plots are for writes using sequential addressing, block size of 128 KiB, and queue depth of 32.

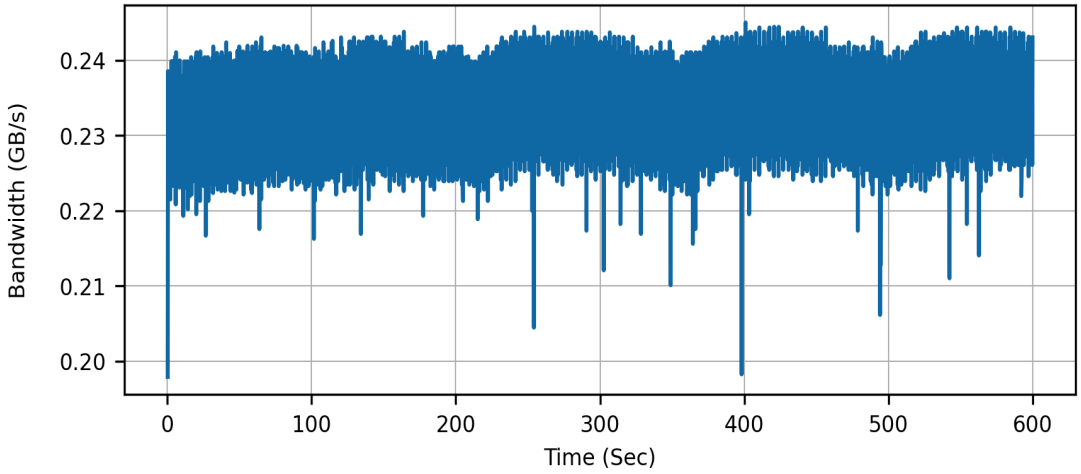
Temperature (Including Idle)



IO Write Bandwidth (Including Idle)



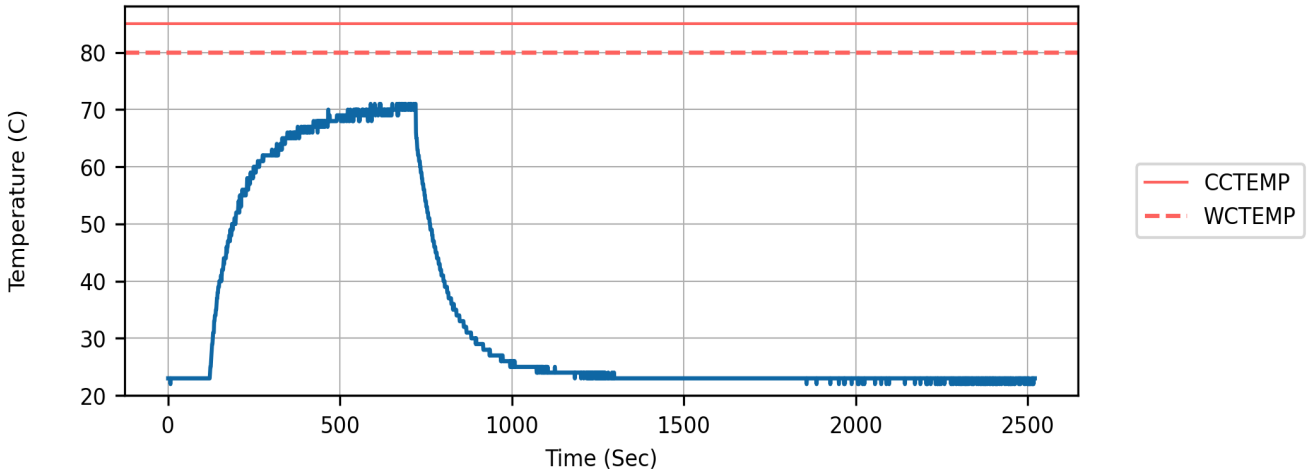
IO Write Bandwidth (Excluding Idle)



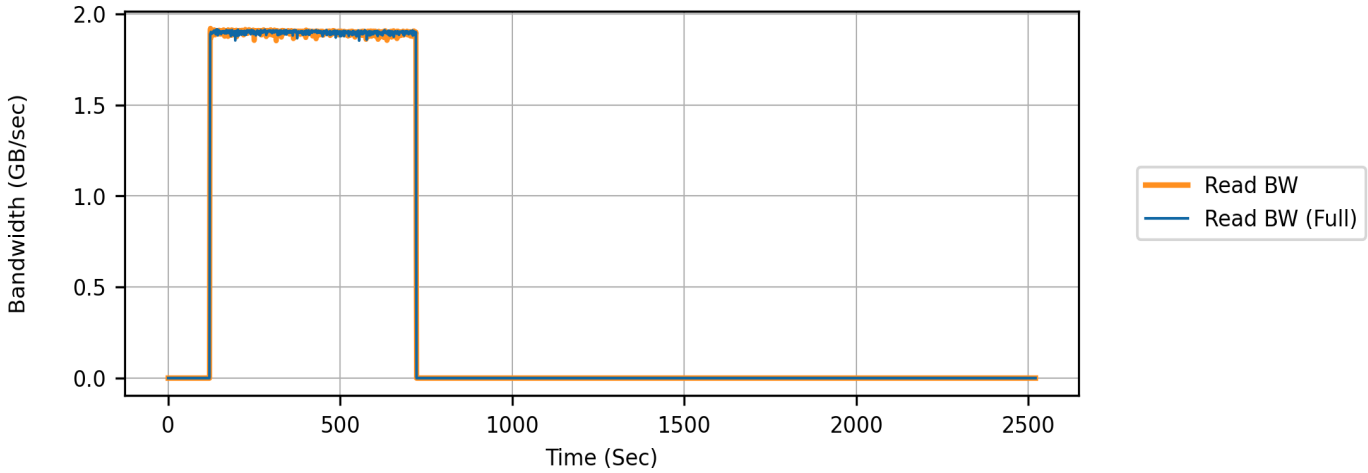
SEQUENTIAL READS

These plots are for reads using sequential addressing, block size of 128 KiB, and queue depth of 32.

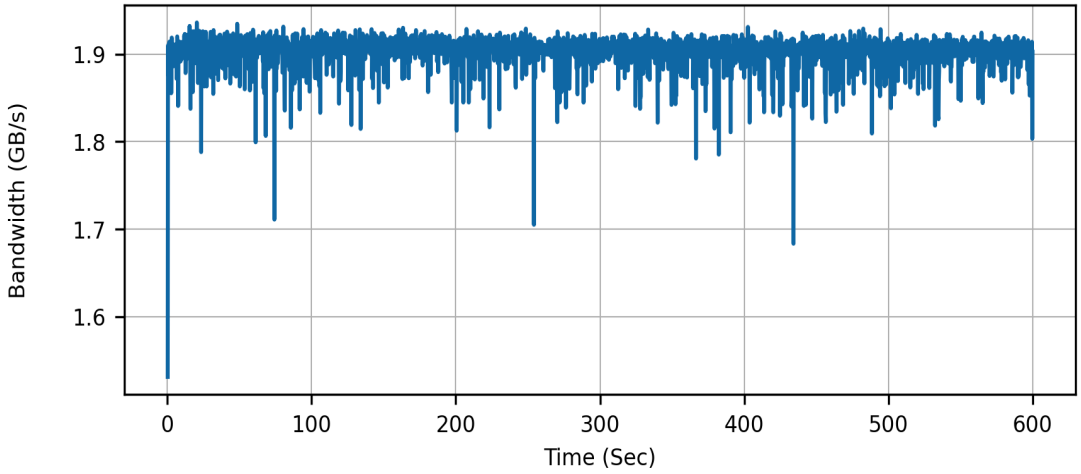
Temperature (Including Idle)



IO Read Bandwidth (Including Idle)



IO Read Bandwidth (Excluding Idle)



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

If does not exist, create a small file without verification data for fio.

Step 3: Random write : FAIL

Start reading NVMe information for random write, size=4096, depth=1

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS
No errors shall occur running IO	0	PASS
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Long burst end temperature shall be within 5C of start temperature	14C	FAIL

Step 4: Random read : PASS

Start reading NVMe information for random read, size=4096, depth=1

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS
No errors shall occur running IO	0	PASS
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Long burst end temperature shall be within 5C of start temperature	0C	PASS

Step 5: Sequential write : PASS

Start reading NVMe information for sequential write, size=131072, depth=32

REQUIREMENT	VALUE	RESULT

Critical warnings shall be 0	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS
No errors shall occur running IO	0	PASS
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Long burst end temperature shall be within 5C of start temperature	0C	PASS

Step 6: Sequential read : PASS

Start reading NVMe information for sequential read, size=131072, depth=32

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS
No errors shall occur running IO	0	PASS
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Long burst end temperature shall be within 5C of start temperature	0C	PASS

Step 7: Verify performance : FAIL

Verify short burst performance.

REQUIREMENT	VALUE	RESULT
Short burst, random reads, 4KiB, QD1 bandwidth shall be greater than 0.01 GB/s	0.034 GB/s	PASS
Short burst, random writes, 4KiB, QD1 bandwidth shall be greater than 0.1 GB/s	0.086 GB/s	FAIL
Short burst, sequential reads, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	1.898 GB/s	PASS
Short burst, sequential writes, 128KiB, QD32 bandwidth shall be greater than 1.0 GB/s	0.234 GB/s	FAIL
IO bandwidth behaved as expected with increasing queue depth and block size	PASS	PASS

Step 8: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Error count shall not increase	0	**PASS**
Static parameters, such as Model Number, shall not change	0	**PASS**
SMART counters, such as Data Written, shall not decrement	0	**PASS**

TEST 23: HIGH BANDWIDTH STRESS

PASS

VERIFICATIONS	9	
PASS	9	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 02, 2023 - 00:32:55.147	Jan 02, 2023 - 00:36:57.160	0:04:02.013

DESCRIPTION

This test verifies drive reliability running high bandwidth IO stress. High bandwidth stress maximizes the amount of data during reads and writes to stress specific drive subsystems. The high bandwidth is achieved with a 50/50 mix of sequential reads and writes, block size of 128 KiB, and queue depth of 32.

Drive reliability is defined as completing all reads and writes without error or data corruption. Data verification is performed on all reads and writes to ensure no data corruption.

RESULTS

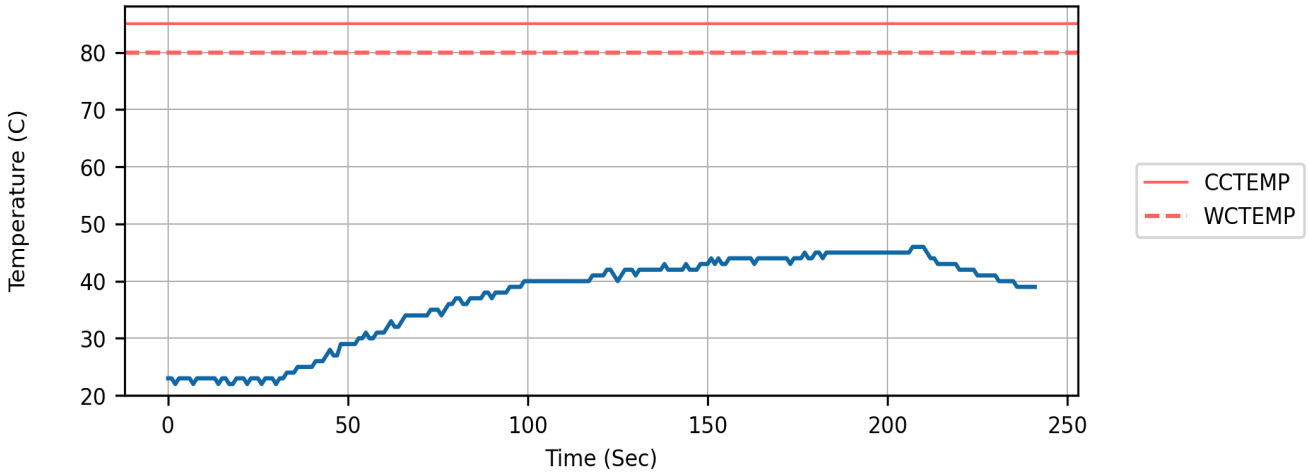
Verify the temperatures and thermal throttling time, if any, in this table are within the expected range.

STRESS TIME	THROTTLE TIME	MIN TEMP	MAX TEMP
3.00 min	0 sec	22 C	46 C

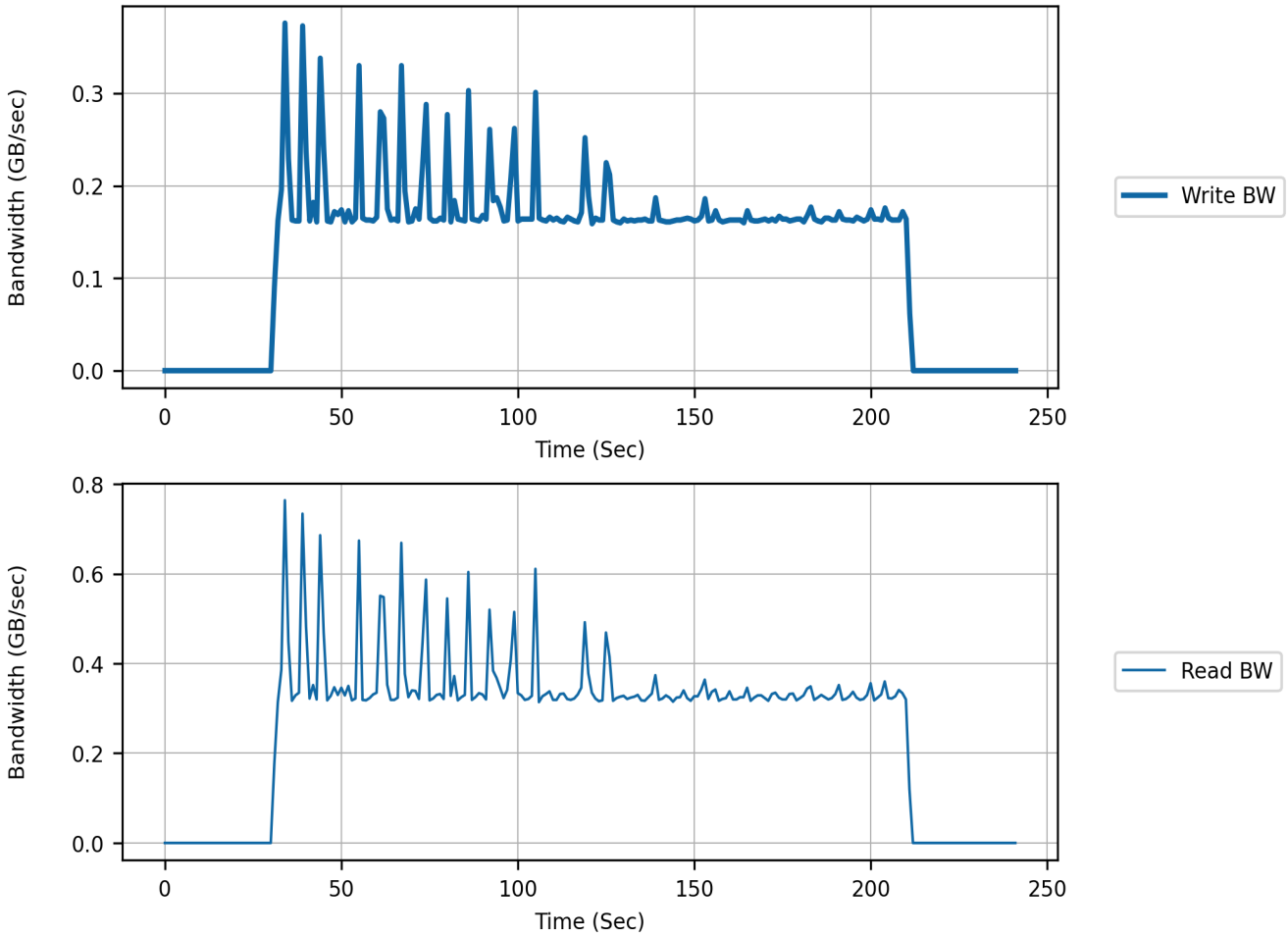
Verify the aggregate bandwidth is within expected range.

DATA WRITTEN	WRITE BANDWIDTH	DATA READ	READ BANDWIDTH
32.1 GB	0.179 GB/s	64.0 GB	0.356 GB/s

This temperature plot includes a 30 second idle time before and after the IO stress. In this plot, verify the temperature behaves as expected. For details see Analyze temperature and bandwidth plots with nvmecmd [5]



The plots below shows the read and write bandwidth during the test including the idle time before and after the IO stress. In these plots, verify the bandwidth behaves as expected. For details see Analyze temperature and bandwidth plots with nvmecmd [5]



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

Use big file if exists, else use or create a small file.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: IO stress : PASS

Run high bandwidth IO stress with fio

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 5: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS

Step 6: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 24: HIGH IOPS STRESS

PASS

VERIFICATIONS	9	
PASS	9	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 02, 2023 - 00:36:57.160	Jan 02, 2023 - 00:41:00.149	0:04:02.989

DESCRIPTION

This test verifies drive reliability running high IOPS IO stress. The high IOPS maximizes the amount of IOs to stress specific drive subsystems. The high IOPS is achieved with a 50/50 mix of random reads and writes, block size of 4 KiB, and queue depth of 8.

Drive reliability is defined as completing all reads and writes without error or data corruption. Data verification is performed on all reads and writes to ensure no data corruption.

RESULTS

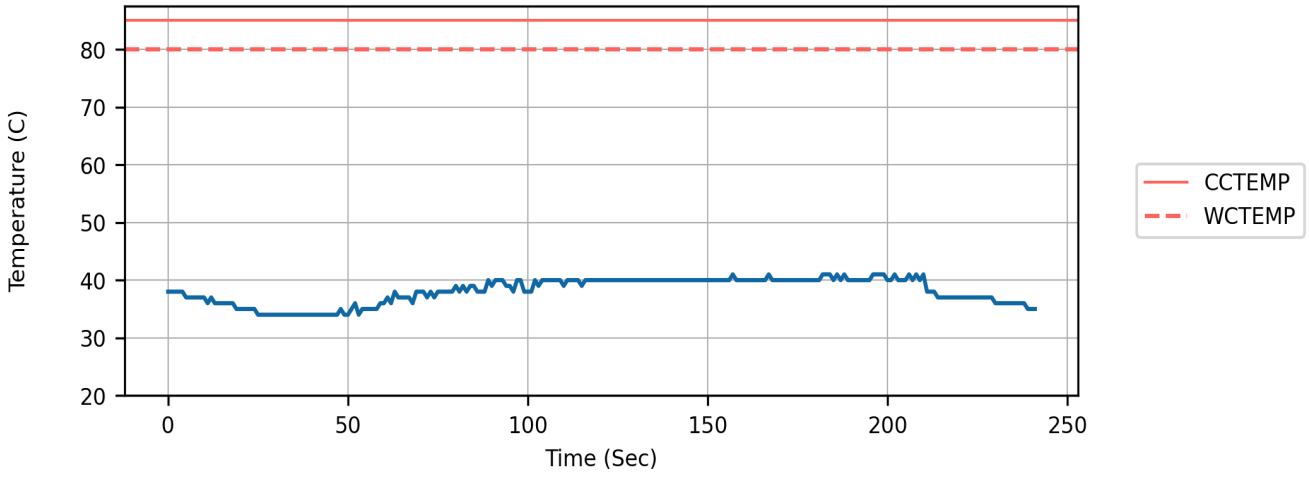
Verify the temperatures and thermal throttling time, if any, in this table are within the expected range.

STRESS TIME	THROTTLE TIME	MIN TEMP	MAX TEMP
180 sec	0 sec	34 C	41 C

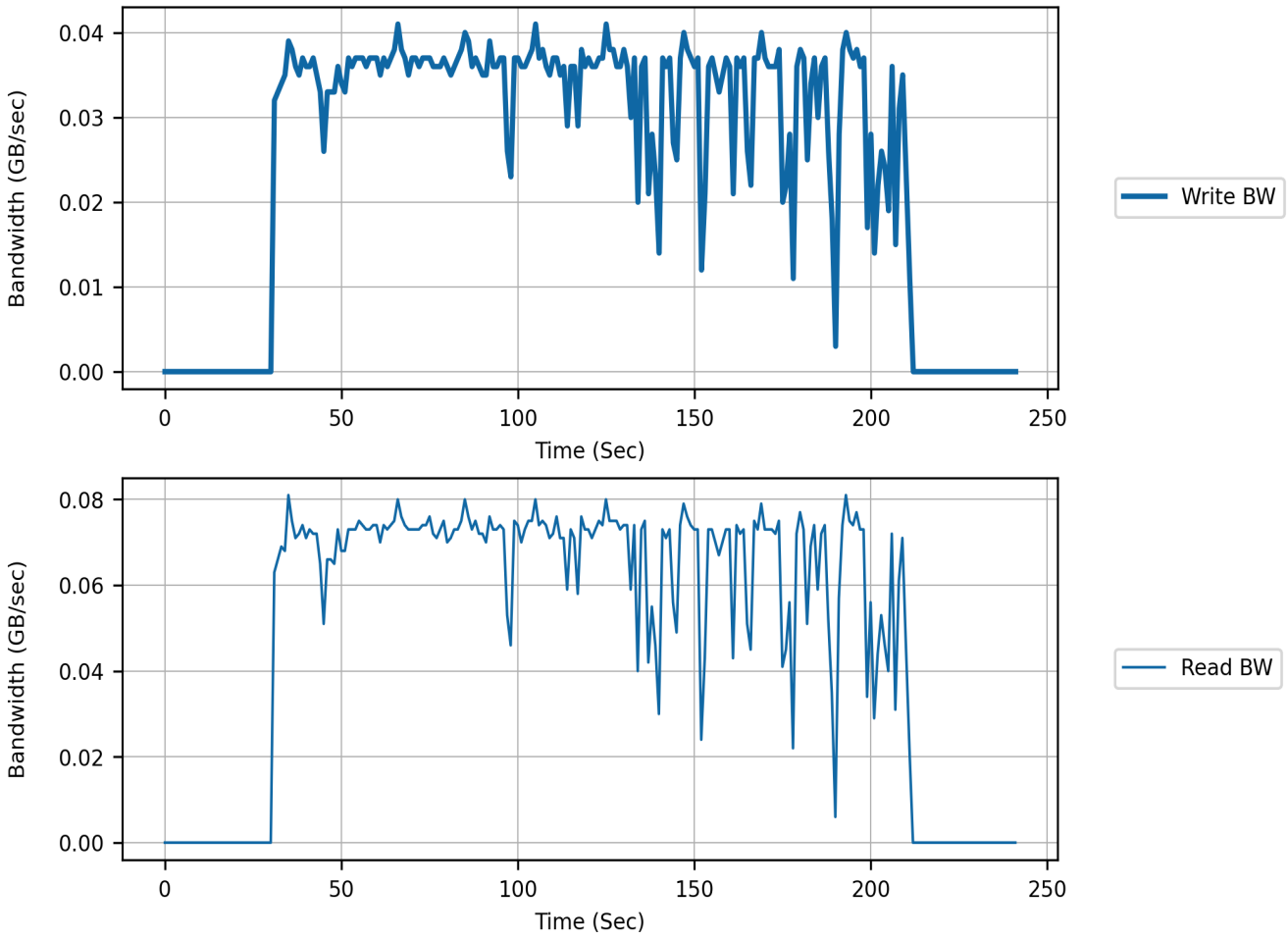
This table lists the amount of IOs during the IO stress.

DATA WRITTEN	WRITE IOPS	DATA READ	READ IOPS
6.1 GB	8.2 K	12.1 GB	16.4 K

This temperature plot includes a 30 second idle time before and after the IO stress. Review the plot and verify the temperature behaves as expected. For details see Analyze temperature and bandwidth plots with nvmecmd [5]



The plots below shows the read and write bandwidth during the test including the idle time before and after the IO stress. Review the plots and verify the bandwidth behaves as expected. For details see Analyze temperature and bandwidth plots with nvmecmd [5].



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

Use big file if exists, else use or create a small file.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: IO stress : PASS

Run high IOPS stress with fio

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 5: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS

Step 6: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 25: BURST STRESS

VERIFICATIONS	9	
PASS	9	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 02, 2023 - 00:41:00.165	Jan 02, 2023 - 00:47:09.172	0:06:09.007

DESCRIPTION

This test verifies drive reliability running short bursts of IO stress. The short bursts of reads and writes are followed by an idle period. This stresses the power management subsystem by constantly transitioning power states. A variety of burst lengths, idle times, queue depths, and block sizes are run with a 50/50 mix of reads and writes.

Drive reliability is defined as completing all reads and writes without error or data corruption. Data verification is performed on all reads and writes to ensure no data corruption.

RESULTS

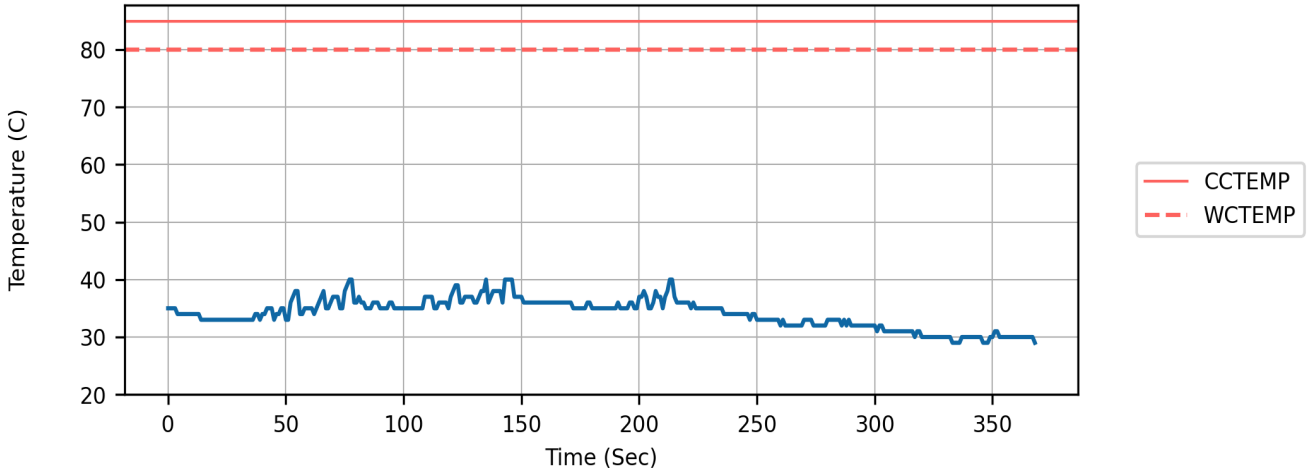
The below bursts were completed. Each burst runs 5 seconds and consists of an idle time followed by read/write of size blocks.

BURST	IDLE TIME	DEPTH	# BLOCKS	BLOCK SIZE
0	1000 mS	1	[1, 100, 10000]	4096
1	1000 mS	1	[1, 100, 10000]	131072
2	1000 mS	32	[1, 100, 10000]	4096
3	1000 mS	32	[1, 100, 10000]	131072
4	1000 mS	1	[1, 100, 10000]	4096
5	1000 mS	1	[1, 100, 10000]	131072
6	1000 mS	32	[1, 100, 10000]	4096
7	1000 mS	32	[1, 100, 10000]	131072
8	1000 mS	1	[1, 100, 10000]	4096
9	1000 mS	1	[1, 100, 10000]	131072
10	1000 mS	32	[1, 100, 10000]	4096
11	1000 mS	32	[1, 100, 10000]	131072
12	10000 mS	1	[1, 100, 10000]	4096
13	10000 mS	1	[1, 100, 10000]	131072
14	10000 mS	32	[1, 100, 10000]	4096
15	10000 mS	32	[1, 100, 10000]	131072
16	10000 mS	1	[1, 100, 10000]	4096
17	10000 mS	1	[1, 100, 10000]	131072

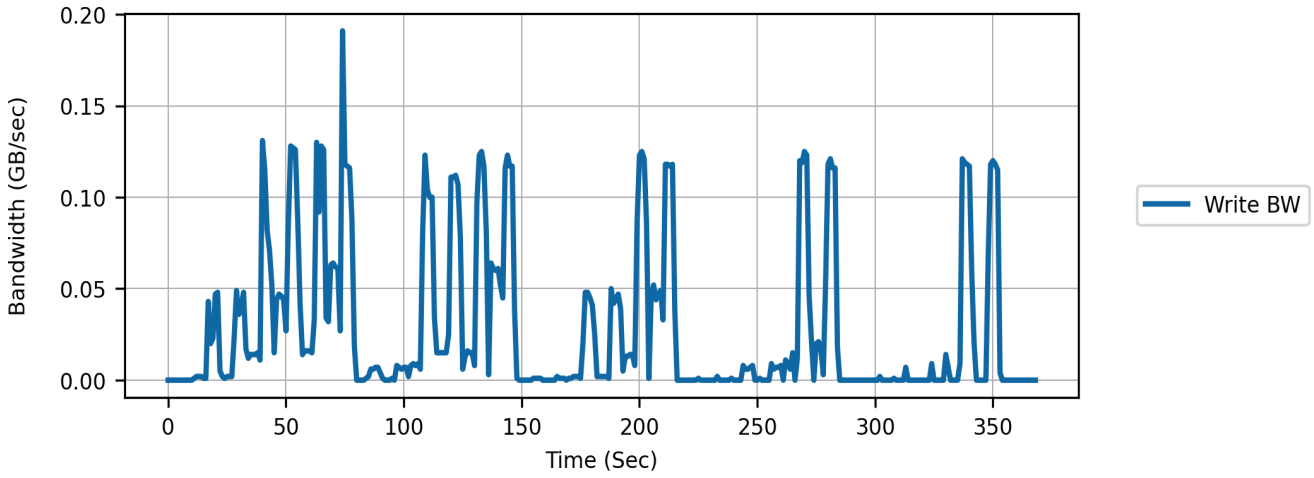
18	10000 mS	32	[1, 100, 10000]	4096
19	10000 mS	32	[1, 100, 10000]	131072
20	10000 mS	1	[1, 100, 10000]	4096
21	10000 mS	1	[1, 100, 10000]	131072
22	10000 mS	32	[1, 100, 10000]	4096
23	10000 mS	32	[1, 100, 10000]	131072
24	100000 mS	1	[1, 100, 10000]	4096
25	100000 mS	1	[1, 100, 10000]	131072
26	100000 mS	32	[1, 100, 10000]	4096
27	100000 mS	32	[1, 100, 10000]	131072
28	100000 mS	1	[1, 100, 10000]	4096
29	100000 mS	1	[1, 100, 10000]	131072
30	100000 mS	32	[1, 100, 10000]	4096
31	100000 mS	32	[1, 100, 10000]	131072
32	100000 mS	1	[1, 100, 10000]	4096
33	100000 mS	1	[1, 100, 10000]	131072
34	100000 mS	32	[1, 100, 10000]	4096
35	100000 mS	32	[1, 100, 10000]	131072
36	1000000 mS	1	[1, 100, 10000]	4096
37	1000000 mS	1	[1, 100, 10000]	131072
38	1000000 mS	32	[1, 100, 10000]	4096
39	1000000 mS	32	[1, 100, 10000]	131072
40	1000000 mS	1	[1, 100, 10000]	4096
41	1000000 mS	1	[1, 100, 10000]	131072
42	1000000 mS	32	[1, 100, 10000]	4096
43	1000000 mS	32	[1, 100, 10000]	131072
44	1000000 mS	1	[1, 100, 10000]	4096
45	1000000 mS	1	[1, 100, 10000]	131072
46	1000000 mS	32	[1, 100, 10000]	4096
47	1000000 mS	32	[1, 100, 10000]	131072
48	5000000 mS	1	[1, 100, 10000]	4096
49	5000000 mS	1	[1, 100, 10000]	131072
50	5000000 mS	32	[1, 100, 10000]	4096
51	5000000 mS	32	[1, 100, 10000]	131072
52	5000000 mS	1	[1, 100, 10000]	4096
53	5000000 mS	1	[1, 100, 10000]	131072
54	5000000 mS	32	[1, 100, 10000]	4096
55	5000000 mS	32	[1, 100, 10000]	131072

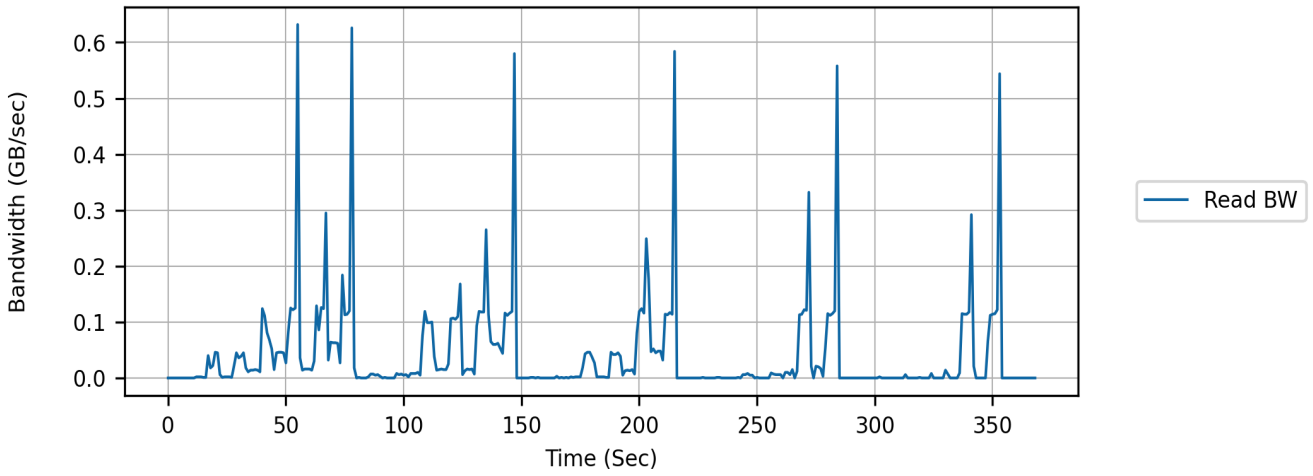
56	5000000 mS	1	[1, 100, 10000]	4096
57	5000000 mS	1	[1, 100, 10000]	131072
58	5000000 mS	32	[1, 100, 10000]	4096
59	5000000 mS	32	[1, 100, 10000]	131072

This temperature plot includes a 10 second idle time before and after the IO stress. Review the plot and verify the temperature behaves as expected. For details see Analyze temperature and bandwidth plots with nvmecmd [5]



The plots below shows the read and write bandwidth during the test including the idle time before and after the IO stress. Review the plots and verify the bandwidth behaves as expected. For details see Analyze temperature and bandwidth plots with nvmecmd [5]





VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

Use big file if exists, else use or create a small file.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: IO stress : PASS

Run bursts of IO stress with fio

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 5: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS

Step 6: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 26: TEMPERATURE CYCLE STRESS

PASS

VERIFICATIONS	11	
PASS	11	100.0%
FAIL	0	0.0%

STARTED	ENDED	DURATION
Jan 02, 2023 - 00:47:09.172	Jan 02, 2023 - 01:00:12.318	0:13:03.146

DESCRIPTION

This test runs IO stress that alternates between periods of high bandwidth reads and idle. This pattern causes the drive's composite temperature to alternate between low and high temperatures. The drive heats up during the IO reads and cools down during the idle time. The thermal expansion and contraction exerts mechanical stress on the drive.

The IO stress is 100% reads with queue depth 32 and block size 128 KiB.

This test is not meant to replace standard component qualification tests such as JESD22-A104 or system environmental tests such as 4-corners.

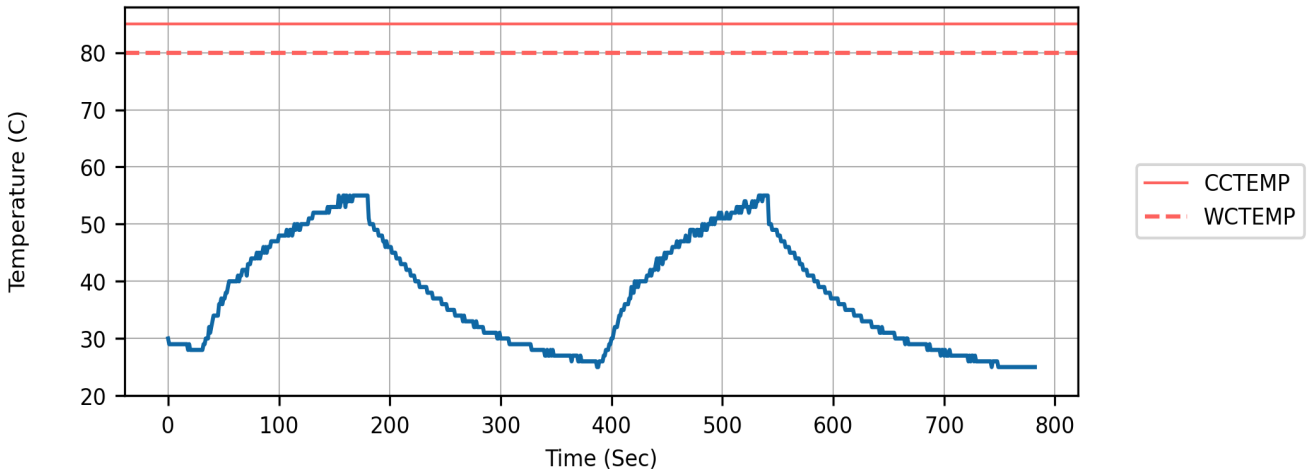
RESULTS

In this table, the Stress Time and Idle Time are for each cycle but the minimum and maximum temperatures are for all cycles.

STRESS TIME	IDLE TIME	NUMBER CYCLES	MIN TEMP	MAX TEMP
150 sec	210 sec	2	25 C	55 C

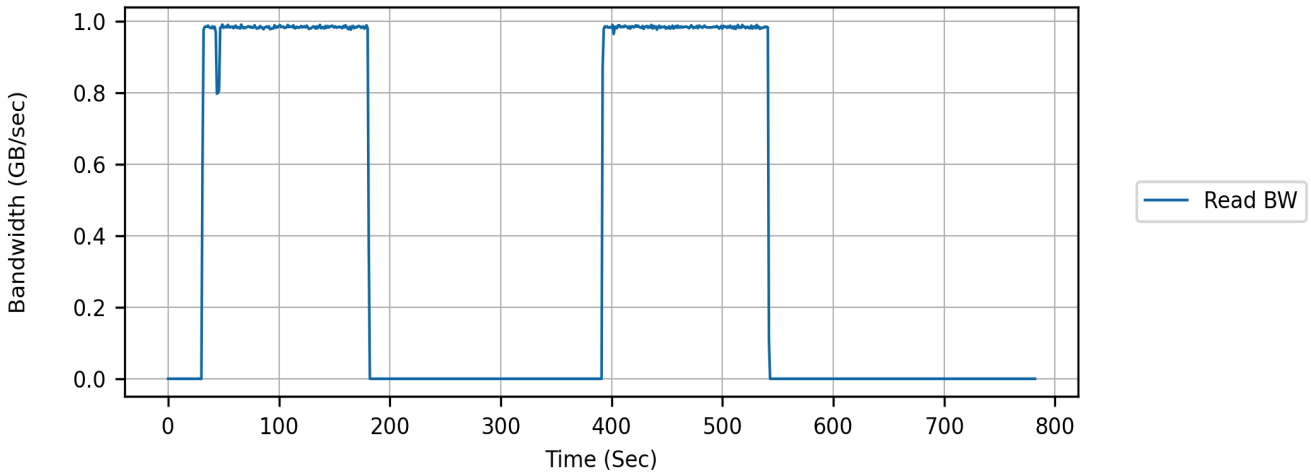
Temperature and IO Bandwidth

Review this temperature plot to verify the temperature behaves as expected. For details see Analyze temperature and bandwidth plots with nvmecmd [5]



Review this bandwidth plot to verify the read bandwidth behaves as expected. For details see Analyze

temperature and bandwidth plots with nvmecmd [5].



VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Test start info : PASS

Read test start info and verify drive not in error state.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS

Step 2: Create fio file : PASS

Use big file if exists, else use or create a small file.

Step 3: Sample info : PASS

Start sampling SMART and power state info every second.

Step 4: IO stress : PASS

Run bursts of IO reads to cycle temperature

REQUIREMENT	VALUE	RESULT
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS
No errors shall occur running IO	0	PASS
No data corruption shall occur running IO	0	PASS

Step 5: Verify samples : PASS

Stop sampling and verify no sample errors

REQUIREMENT	VALUE	RESULT
SMART counters, such as Data Written, shall not decrement	0	PASS
Error count shall not increase	0	PASS

Step 6: Test end info : PASS

Read test end info and verify no errors or unexpected changes occurred during test.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Error count shall not increase	0	PASS
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS

TEST 27: SUITE END INFO

VERIFICATIONS	13	
PASS	9	69.2%
FAIL	4	30.8%

STARTED	ENDED	DURATION
Jan 02, 2023 - 01:00:12.334	Jan 02, 2023 - 01:00:13.025	0:00:00.691

DESCRIPTION

This test reads the NVMe drive information at the end of the test suite and verifies the drive is healthy, not worn out, and no unexpected changes occurred during the test suite.

The test verifies the following unexpected changes do not occur. Static parameters, such as Model and Serial Number, must not change. SMART counters, such as Power-On Hours, must not decrement. Error parameters, such as media and data integrity errors, must not increase. The change in Power On Hours must match the host computer time change.

For additional details see Read and compare NVMe information with nvmecmd [4].

RESULTS

The host reported a time difference of 12:25:42.646 and the change in Power On Hours was 6 .

A total of 319 static parameters were verified with 2 unexpected changes. A total of 23 counter parameters were verified not to decrement.

VERIFICATIONS

This section lists the test steps and requirement verifications.

Step 1: Read info : FAIL

Read NVMe information using nvmecmd.

REQUIREMENT	VALUE	RESULT
Admin commands shall pass	Fail	FAIL

Step 2: Verify info : FAIL

Verify drive is healthy and not worn out.

REQUIREMENT	VALUE	RESULT
Critical warnings shall be 0	0	PASS
Media and integrity errors shall be 0	0	PASS
Time operating at or above the critical temperature shall be 0	2 min	FAIL
Percent throttled shall be less than 1%	0.1%	PASS
Percentage Used shall be less than 90%	19%	PASS

Data Used shall be less than 90% of TBW	94.1%	FAIL
Power On Hours Used shall be less than 90% of Warranty Hours	14.6%	PASS
Prior self-test failures shall be 0	0	PASS

Step 3: Verify changes : FAIL

Verify no unexpected changes from starting info.

REQUIREMENT	VALUE	RESULT
Static parameters, such as Model Number, shall not change	0	PASS
SMART counters, such as Data Written, shall not decrement	0	PASS
Power On Hour change shall be within 1 hour of host time change	6.43 hrs	FAIL
Error count shall not increase	0	PASS

NVME PARAMETERS

TITLE	DESCRIPTION	VALUE
128-bit Host Identifier	Controller support for 128-bit Host Identifier, from CTRATT	Not Supported
ANA Group Identifier Maximum (ANAGRPMAX)	Maximum value of a valid ANA Group Identifier for any controller in the NVM subsystem	Not Supported
ANA Transition Time (ANATT)	Maximum seconds for transition between ANA states or that the controller reports the ANA change state	Not Supported
Abort Command Limit (ACL)	Maximum number of concurrently executing Abort commands supported by the controller	5
Admin Vendor Specific command handling	Admin Vendor Specific Commands use standard format or vendor specific format, from AVSCC	Not Vendor Specific
Aggregation Threshold (THR)	Feature 08h: Recommended minimum number of completion queue entries to aggregate per interrupt vector before signaling an interrupt to the host	1
Aggregation Time (TIME)	Feature 08h: Recommended maximum time that a controller may delay an interrupt due to interrupt coalescing	No Delay
Arbitration Burst (AB)	Feature 01h: Number of commands that may be executed at one time from a particular Submission Queue as power of 2 (2^n)	4 (2^4=16)
Associated Function Type	Controller associated with SR-IOV virtual function or PCI function type from CMIC	PCI
Asymmetric Namespace Access Change Notices	Controller support for asynchronous events Asymmetric Namespace Access Change Notices, from OAES	Not Supported
Asymmetric Namespace Access Reporting	Support for Asymmetric Namespace Access Reporting from CMIC	Not Supported
Asynchronous Event Request Limit (AERL)	Maximum number of concurrently outstanding Asynchronous Event Request commands supported by the controller	8
Atomic Write Unit Normal (AWUN)	Size of write in logical blocks guaranteed to be written atomically across all namespaces with any supported namespace format during normal operation	1
Atomic Write Unit Power Fail (AWUPF)	Size of write in logical blocks guaranteed to be written atomically across all namespaces with any supported namespace format during a power fail or error condition	1
Autonomous Power State Transition	Autonomous Power State Transition support, from APSTA	Supported
Autonomous Power State Transition Enable (APSTE)	Feature 0Ch: Autonomous power state transitions. Also see APSTA	Disabled

Available Space Below Threshold	Critical Warning: Available spare space has fallen below the threshold	No
Available Spare	Normalized percentage (0 to 100%) of the remaining spare capacity available	100 %
Available Spare Threshold	Available spare threshold indicated as a normalized percentage (0 to 100%)	10 %
Block Erase Sanitize	Controller support for block sanitize, from SANICAP	Supported
Command Retry Delay Time 1 (CRDT1)	If DNR is 0 and CRD is 01b in the Completion Queue Entry, indicates the command retry delay time	0 (0 mS)
Command Retry Delay Time 2 (CRDT2)	If DNR is 0 and CRD is 10b in the Completion Queue Entry, indicates the command retry delay time	0 (0 mS)
Command Retry Delay Time 3 (CRDT3)	If DNR is 0 and CRD is 11b in the Completion Queue Entry, indicates the command retry delay time	0 (0 mS)
Commands Supported and Effects Log Page	Controller support for log page attribute Commands Supported and Effects Log Page, from LPA	Supported
Compare NVM Command	Controller support for the Compare NVM command, from ONCS	Supported
Compare and Write Fused Operation	Controller support for the Compare and Write fused operation, from FUSES	Not Supported
Composite Temperature	Current composite temperature of the controller and namespace(s) associated with that controller	26 C
Composite Temperature Over Threshold	Feature 04h: Composite Temperature over threshold limit	80 C
Composite Temperature Under Threshold	Feature 04h: Composite Temperature under threshold limit	-5 C
Controller Busy Time	Time the controller is busy with I/O commands	19,016 Min
Controller ID (CNTLID)	NVM subsystem unique controller identifier associated with the controller	1
Controller Type (CNTRLTYPE)	Specifies the controller type (I/O, Discovery, or Administrator)	I/O Controller
Controller Vendor	Controller vendor from PCI lookup: https://pcisig.com/membership/member-companies	Sandisk
Critical Composite Temperature Threshold (CCTEMP)	Temperature that indicates a critical overheating condition (e.g. possible data loss, device shutdown, extreme throttling, or permanent damage)	85 C
Critical Composite Temperature Time	Time controller is operational and Composite Temperature is greater than the Critical Composite Temperature Threshold	2 Min
Critical Warnings	Controller has asserted one or more critical warnings	No

Crypto Erase	Crypto erase supported as part of secure erase, from FNA	Not Supported
Crypto Erase Sanitize	Controller support for crypto sanitize, from SANICAP	Not Supported
Current Number Of Errors	Current number of error entries in Log Page 1	0
Current Number Of Self-Tests	Current number of self tests reported in log page 6	20
Current Power State (PS)	Feature 02h: Current power state of the controller	0
Current Self-Test Completion	Percentage of the device self-test operation that is complete	0
Current Self-Test Operation	Status of the current device self-test operation	No Test In Progress
Data Read	Data Read in GB calculated from Data Units Read	416,310.729 GB
Data Units Read	Number of 512,000 byte data units read from the controller; does not include metadata	813,106,893
Data Units Written	Number of 512,000 byte data units written to the controller; does not include metadata	272,677,705
Data Written	Data Written in GB calculated from Data Units Written	139,610.985 GB
Dataset Management NVM Command	Controller support for the Dataset Management NVM command, from ONCS	Supported
Device Self-test Command	Controller support for Device Self-test Command, from OACS	Supported
Directive Send and Directive Receive Commands	Controller support for Directive Send and Directive Receive Commands, from OACS	Not Supported
Disable Normal (DN)	Feature 0Ah: Host specifies AWUN and NAWUN are not required and controller shall only honor AWUPF and NAWUPF	Not Supported
Doorbell Buffer Config Command	Controller support for Doorbell Buffer Config Command, from OACS	Not Supported
Driver	OS driver information	Microsoft, 10.0.22621.755, 6/20/2006, stornvme.inf
EG Available Space Below Threshold	Critical Warning: One or more Endurance Groups available spare space has fallen below the threshold	No
EG Critical Warnings	One or more Endurance Groups has asserted one or more critical warnings	No
EG Reliability Degraded	Critical Warning: One or more Endurance Groups reliability degraded due to significant media or internal errors	No
EG in Read Only	Critical Warning: One or more Endurance Groups media has been placed in read only mode	No
Enable Host Memory (EHM)	Feature 0Dh: Controller may use host memory buffer when enabled. See HMPRE	Enabled

Endurance Group Event Log Page Change Notices	Controller support for asynchronous events Endurance Group Event Log Page Change Notices, from OAES	Not Supported
Endurance Group Identifier Maximum (ENDGIDMAX)	Maximum value of a valid Endurance Group Identifier for any controller in the NVM subsystem	0
Endurance Groups	Controller support for Endurance Groups, from CTRATT	Not Supported
Error Log Page Entries (ELPE)	Maximum number of Error Information log entries stored by the controller	256
Extended Data for Get Log Page	Controller support for log page attribute Extended Data for Get Log Page, from LPA	Supported
Extended Device Self-test Time (EDSTT)	Nominal time in minutes to complete extended device self-test when in power state 0	44 Min
FRU Globally Unique Identifier (FGUID)	Globally unique identifier for the Field Replaceable Unit (FRU)	000000-00000000000000000000000000
Firmware Activation Notices	Controller support for asynchronous events Firmware Activation Notices, from OAES	Supported
Firmware Activation Notices Enable	Feature 0Bh: Asynchronous event notification sent to host for Firmware Activation Starting. Also see OAES	Enabled
Firmware Activation Without Reset	Controller support for firmware activation without a reset, from FRMW	Supported
Firmware Active Slot	Firmware slot that loaded the active firmware, from AFI	1
Firmware Commit and Image Download Commands	Controller support for Firmware Commit and Image Download Commands, from OACS	Supported
Firmware Pending Slot	Firmware slot to be activated at the next controller reset, from AFI	Not Reported
Firmware Revision (FR)	Currently active firmware revision	211070WD
Firmware Slot 1 Read Status	Firmware slot 1 read only or read/write, from FRMW	Read/Write
Firmware Slot 1 Revision	Revision of firmware in this slot, see Firmware Revision for Slot # (FRS#)	211070WD
Firmware Slot 2 Revision	Revision of firmware in this slot, see Firmware Revision for Slot # (FRS#)	
Firmware Slots	Number of firmware slots supported by controller, from FRMW	2
Firmware Update Granularity (FWUG)	Minimum granularity and alignment of the data provided in the Firmware Image Download command	4 KiB
Format All Namespaces	Format (excluding secure erase) applies to all namespaces in an NVM subsystem, from FNA	Not Supported

Format NVM Command	Controller support for Format NVM Command, from OACS	Supported
Get LBA Status capability	Controller support for the Get LBA Status capability, from OACS	Not Supported
High Priority Weight (HPW)	Feature 01h: Number of commands that may be executed from the high priority service class in each arbitration round	1
Highest Version Detected	Highest NVMe version detected based on supported features	1.4.0
Host Controlled Thermal Management (HCTMA)	Controller support for host controlled thermal management	Supported
Host Memory Buffer Minimum Descriptor Entry Size (HMMINDS)	Minimum usable size of a Host Memory Buffer Descriptor Entry	No limitations
Host Memory Buffer Minimum Size (HMMIN)	Minimum size that the host is requested to allocate for the Host Memory Buffer feature in 4KiB units	823 (3,292 KiB)
Host Memory Buffer Preferred Size (HMPRE)	Preferred size that the host is requested to allocate for the Host Memory Buffer feature in 4KiB units	51,200 (204,800 KiB)
Host Memory Buffer Size (HSIZE)	Feature 0Dh: Size of host memory buffer allocated in memory page size units	16,384
Host Memory Descriptor List Address (HMDLAL)	Feature 0Dh: Lower 32 bits of the physical location of the Host Memory Descriptor List for the Host Memory Buffer	0x043A1000
Host Memory Descriptor List Address (HMDLAU)	Feature 0Dh: Upper 32 bits of the physical location of the Host Memory Descriptor List for the Host Memory Buffer	0x00000001
Host Memory Descriptor List Entry Count (HMDLEC)	Feature 0Dh: Number of valid Host Memory Descriptor Entries	1
Host Memory Maximum Descriptors Entries (HMMAXD)	Number of usable Host Memory Buffer Descriptor Entries	8
Host Power Source	Current host power source, battery or AC	AC
Host Read Commands	Number of read commands completed by the controller	10,760,332,660
Host Timestamp	Host number of milliseconds since midnight, 01-Jan-1970, UTC	1,672,605,270,028 mS
Host Timestamp Decoded	Host date and time	2023-01-01 12:34:30.028
Host Write Commands	Number of write commands completed by the controller	5,997,060,441

IEEE OUI Identifier (IEEE)	Organization Unique Identifier (OUI) for the controller vendor: http://standards-oui.ieee.org/oui/oui.txt	00-1b-44
Keep Alive Support (KAS)	Granularity of the Keep Alive Timer	Not Supported
LBA Status Information Notices	Controller support for asynchronous events LBA Status Information Notices, from OAES	Not Supported
Low Priority Weight (LPW)	Feature 01h: Number of commands that may be executed from the low priority service class in each arbitration round	1
Maximum Completion Queue Entry Size	Maximum Completion Queue entry size when using the NVM Command Set in bytes reported as a power of two (2^n), from CQES	4 (2^4=16)
Maximum Data Transfer Size (MDTS)	Maximum data transfer size between host and controller in units of minimum memory page size as a power of two (2^n)	7 (2^7=128)
Maximum Number Allowed Namespaces (MNAN)	Maximum number of namespaces supported by the NVM subsystem	0
Maximum Outstanding Commands (MAXCMD)	Maximum number of commands that the controller processes at one time for a particular queue	Not Supported
Maximum Submission Queue Entry Size	Maximum Submission Queue entry size when using the NVM Command Set in bytes reported as a power of two (2^n), from SQES	6 (2^6=64)
Maximum Thermal Management Temperature (MXTMT)	Maximum temperature host may request in the Thermal Management Temperature 1 and 2 fields of Set Features command	85 C
Maximum Time for Firmware Activation (MTFA)	Maximum time the controller temporarily stops processing commands to activate the firmware image	5,000 mS
Media and Data Integrity Errors	Number of occurrences where the controller detected an unrecovered data integrity error	0
Media in Read Only	Critical Warning: Media has been placed in read only mode	No
Medium Priority Weight (MPW)	Feature 01h: Number of commands that may be executed from the medium priority service class in each arbitration round	1
Minimum Thermal Management Temperature (MNTMT)	Minimum temperature host may request in the Thermal Management Temperature 1 and 2 fields of Set Features command	0 C
Model Number (MN)	Model number for the NVM subsystem assigned by the vendor	WDC WDS250G2B 0C-00PXH0
NVM Set Identifier Maximum (NSETIDMAX)	Maximum value of a valid NVM Set Identifier for any controller in the NVM subsystem	0
NVM Sets	Controller support for NVM Sets, from CTRATT	Not Supported

NVM Subsystem Controllers	Single or multiple controllers contained in NVM subsystem from CMIC	Single
NVM Subsystem NVMe Qualified Name (SUBNQN)	The NVM Subsystem NVMe Qualified Name	nqn.2018-01.com.wdc:nguid:E8238FA6BF53-0001-001B448B49BC0ECB
NVM Subsystem PCIe Ports	Single or multiple PCIE ports contained in NVM subsystem from CMIC	Single
NVME MI Send/Receive Commands	Controller support for NVME MI Send/Receive Commands, from OACS	Not Supported
Namespace 1 ANA Group Identifier (ANAGRPID)	ANA Group Identifier of the ANA group of which the namespace is a member	Not Reported
Namespace 1 Active LBA Format	Index of LBA format that namespace is formatted with, from FLBAS	0
Namespace 1 Atomic Boundary Offset (NABO)	The LBA on this namespace where the first atomic boundary starts	7
Namespace 1 Atomic Boundary Size Normal (NABSN)	Atomic boundary size in logical blocks for this namespace for the NAWUN value	7
Namespace 1 Atomic Boundary Size Power Fail (NABSPF)	Atomic boundary size for this namespace specific to the Namespace Atomic Write Unit Power Fail value	7
Namespace 1 Atomic Compare & Write Unit (NACWU)	Namespace specific size of the write operation in logical blocks guaranteed to be written atomically for a Compare and Write fused command	Same as ACWU
Namespace 1 Atomic Write Unit Normal (NAWUN)	Namespace specific size of the write operation in logical blocks guaranteed to be written atomically during normal operation	7
Namespace 1 Atomic Write Unit Power Fail (NAWUPF)	Namespace specific size of the write operation in logical blocks guaranteed to be written atomically during a power fail or error condition	7
Namespace 1 Atomic Writes	If supported NAWUN, NAWUPF, and NACWU used instead of AWUN, AWUPF, and ACWU fields, from NSFEAT	Supported
Namespace 1 Capacity (NCAP)	The maximum number of logical blocks that may be allocated in the namespace	488,397,168
Namespace 1 Deallocate Bit in Write Zeros	Controller support for the Deallocate bit in the Write Zeros command for this namespace, from DLFEAT	Supported
Namespace 1 Deallocate Guard Field	Guard field for deallocated logical blocks that contain protection information is set to the CRC for the value read from the deallocated logical block, from DLFEAT	Not Supported

Namespace 1 Deallocate Logical Block Value	Values read from a deallocated logical block and its metadata, from DLFEAT	All 00h
Namespace 1 Endurance Group Identifier (ENDGID)	Endurance Group with which this namespace is associated	Not Supported
Namespace 1 Exclusive Access All Registrants Reservation	Namespace supports the Exclusive Access - All Registrants reservation type, from RESCAP	Not Supported
Namespace 1 Exclusive Access Registrants Only Reservation	Namespace supports the Exclusive Access - Registrants Only reservation type, from RESCAP	Not Supported
Namespace 1 Exclusive Access Reservation	Namespace supports the Exclusive Access reservation type, from RESCAP	Not Supported
Namespace 1 Extended Data LBA	If supported metadata is transferred at the end of the data LBA, creating an extended data LBA, from FLBAS	Not Supported
Namespace 1 Format Percent Complete	Percentage of the Format NVM command that remains to be completed, from FPI	0
Namespace 1 Format Progress Indicator	Namespace supports the Format Progress Indicator, from FPI	Supported
Namespace 1 Globally Unique Identifier (NGUID)	128-bit value that is globally unique and assigned to the namespace	e8238fa6bf530001-001b44-8b49bc0ecb
Namespace 1 IEEE Extended Unique Identifier (EUI64)	64-bit IEEE Extended Unique Identifier (EUI-64) that is globally unique and assigned to the namespace	001b44-8b49bc0ecb
Namespace 1 IO Optimize Fields	Fields NPWG, NPWA, NPDG, NPDA, and NOWS are defined for namespace and should be used for I/O optimization, from NSFEAT	Not Supported
Namespace 1 Ignore Existing Key Specification	Ignore Existing Key is used as defined in revision 1.2.1 or 1.3+ of NVMe specification, from RESCAP	1.2.1 or earlier
Namespace 1 LBA 0 Data Size (LBADS)	LBA data size in power of two (2^n)	9 (2^9=512) *
Namespace 1 LBA 0 Relative Performance (RP)	Relative performance of this LBA format relative to other LBA formats	Good Performance *
Namespace 1 LBA 1 Data Size (LBADS)	LBA data size in power of two (2^n)	12 (2^12=4096)
Namespace 1 LBA 1 Relative Performance (RP)	Relative performance of this LBA format relative to other LBA formats	Better Performance

Namespace 1 Logical Block Error	Controller support for the Deallocated or Unwritten Logical Block error for this namespace, from NSFEAT	Not Supported
Namespace 1 Metadata Transfer Buffer	Metadata transferred as part of a separate buffer that is specified in the Metadata Pointer, from MC	Not Supported
Namespace 1 Metadata Transfer Extended LBA	Metadata being transferred as part of an extended data LBA, from MC	Not Supported
Namespace 1 NGUID/EUID Not Reused	If supported non-zero NGUID and EUI64 fields for this namespace are never reused by the controller, from NSFEAT	Not Supported
Namespace 1 NVM Capacity (NVMCAP)	Total size of the NVM allocated to this namespace in bytes	250,059,350,016
Namespace 1 NVM Set Identifier (NVMSETID)	The NVM Set with which this namespace is associated	Not Supported
Namespace 1 Number of LBA Formats (NLBAF)	Number of supported LBA data size and metadata size combinations supported by the namespace	2
Namespace 1 Optimal IO Boundary (NOIOB)	Optimal IO boundary in logical blocks for this namespace	Not Reported
Namespace 1 Optimal Write Size (NOWS)	Size in logical blocks for optimal write performance for this namespace	1
Namespace 1 Persist Through Power Loss	Namespace supports the Persist Through Power Loss capability, from RESCAP	Not Supported
Namespace 1 Preferred Deallocate Alignment (NPDA)	Recommended alignment in logical blocks for the Dataset Management command with the Attribute Ö Deallocate bit set to 1	1
Namespace 1 Preferred Deallocate Granularity (NPDG)	Recommended granularity in logical blocks for the Dataset Management command with the Attribute Ö Deallocate bit set to 1	1
Namespace 1 Preferred Write Alignment (NPWA)	Recommended write alignment in logical blocks for this namespace	1
Namespace 1 Preferred Write Granularity (NPWG)	Smallest recommended write granularity in logical blocks for this namespace	1
Namespace 1 Protection First	Namespace supports protection information transferred as first eight bytes of metadata, from DPC	Not Supported

Namespace 1 Protection Information Enabled	Type of Protection Information enabled, if any, from DPS	Disabled
Namespace 1 Protection Information First	Protection information, if enabled, is transferred as the first eight bytes of metadata, from DPS	Last 8 Bytes
Namespace 1 Protection Last	Namespace supports protection information transferred as the last eight bytes of metadata, from DPC	Not Supported
Namespace 1 Protection Type 1	Namespace supports Protection Information Type 1, from DPC	Not Supported
Namespace 1 Protection Type 2	Namespace supports Protection Information Type 2, from DPC	Not Supported
Namespace 1 Protection Type 3	Namespace supports Protection Information Type 3, from DPC	Not Supported
Namespace 1 Shared	Namespace may be attached to two or more controllers in the NVM subsystem concurrently (i.e., may be a shared namespace), from NMIC	Not Supported
Namespace 1 Size	Total calculated size of the namespace in GB	250 GB
Namespace 1 Size in GiB	Total calculated size of the namespace in GiB (1024*1024*1024)	232.9 GiB
Namespace 1 Size in LBA (NSZE)	Total size of this namespace in logical blocks	488,397,168
Namespace 1 Thin Provisioning	If supported the Namespace Capacity reported may be less than the Namespace Size, from NSFEAT	Not Supported
Namespace 1 Utilization (NUSE)	Current number of logical blocks allocated in the namespace	488,397,168
Namespace 1 Write Exclusive All Registrants Reservation	Namespace supports the Write Exclusive - All Registrants reservation type, from RESCAP	Not Supported
Namespace 1 Write Exclusive Registrants Only Reservation	Namespace supports the Write Exclusive - Registrants Only reservation type, from RESCAP	Not Supported
Namespace 1 Write Exclusive Reservation	Namespace supports the Write Exclusive reservation type, from RESCAP	Not Supported
Namespace 1 Write Protected	Namespace is currently write protected due to any condition	No
Namespace Attribute Notices	Controller support for asynchronous events Namespace Activation Notices, from OAES	Not Supported
Namespace Granularity	Controller support for reporting of Namespace Granularity, from CTRATT	Not Supported

Namespace Management and Attachment Commands	Controller support for Namespace Management and Attachment Commands, from OACS	Not Supported
No-Deallocate Inhibited (NDI)	Controller support for No-Deallocate Inhibited (NDI), from SANICAP	Supported
No-Deallocate Modifies Media After Sanitize (NODMMAS)	Indicates if media is modified by controller after a sanitize command started with No-Deallocate After Sanitize bit set to 1, from SANICAP	Media not modified
Non-Operational Power State Permissive Mode	Controller support for temporary exceeding power in non-operational power state for background operation, from CTRATT	Supported
Non-Operational Power State Permissive Mode Enable (NOPPME)	Feature 11h: Controller may temporarily exceed the power limits of any non-operational power state to run controller initiated background operations	Disabled
Non-zero ANAGRPID	Controller support for a non-zero value in the ANAGRPID field of the Namespace Management command, from ANACAP	Not Supported
Number Of Failed Self-Tests	Number of self tests that failed in log page 6	0
Number of ANA Group Identifiers (NANAGRPID)	Number of ANA groups supported by this controller	Not Supported
Number of Error Information Log Entries	Number of Error Information log entries over the life of the controller	1
Number of Namespaces (NN)	Number of valid namespaces present for the controller	1
Number of Power States Support (NPSS)	Number of NVM Express power states supported by the controller	5
OS Location	Drive location reported by the Operating System	\\.\PHYSICALDRIVE1
One Self-Test	Support for one device self-test at a time per system or per controller, from DSTO	Per System
Overwrite Sanitize	Controller support for overwrite sanitize, from SANICAP	Not Supported
PCI Device ID	PCI device identifier assigned for the device	0x5009
PCI Location	PCI bus address in the system	Bus 1, device 0, function 0
PCI Rated Speed	Maximum PCI bus speed the device is rated for	Gen3 8.0GT/s
PCI Rated Width	Maximum PCI bus width the device is rated for	x4
PCI Speed	Current PCI bus speed	Gen3 8.0GT/s
PCI Subsystem Vendor ID (SSVID)	Company vendor identifier assigned by PCI SIG for the subsystem	0x15B7

PCI Vendor ID (VID)	Company vendor identifier assigned by PCI SIG for the controller	0x15B7
PCI Width	Current PCI bus width in lanes	x4
PCIe Management Endpoint (PCIEME)	NVME MI: NVM Subsystem contains a Management Endpoint on a PCIe port	Not Supported
Percentage Used	Vendor specific estimate of the percentage life used, can exceed 100%	19 %
Permanent Write Protect	Controller support for the Permanent Write Protect state, from NWPC	Not Supported
Persistent Event Log	Controller support for log page attribute Persistent Event Log, from LPA	Supported
Persistent Event Log Size (PELS)	Maximum reportable size for the Persistent Event Log	64 KiB
Persistent Memory Unreliable	Critical Warning: Persistent Memory Region has become read-only or unreliable	No
Power Cycles	Number of power cycles	199
Power On Hours	Number of power on hours	2,128
Power State 0 Active Power (ACTP)	Largest average power over 10 seconds in this power state with workload from Active Power Workload (APW)	1.8 Watts
Power State 0 Active Power Workload (APW)	Workload used to calculate maximum power for the active power state	Workload #2
Power State 0 Entry Latency (ENLAT)	Maximum entry latency in microseconds associated with entering this power state	Not Reported
Power State 0 Exit Latency (EXLAT)	Maximum exit latency in microseconds associated with exiting this power state	Not Reported
Power State 0 Idle Power (IDLP)	Typical power consumed over 30 seconds in this power state when idle	0.63 Watts
Power State 0 Idle Time Prior to Transition (ITPT)	Feature 0Ch: Idle time that occurs in this power state prior to transitioning to the Idle Transition Power State in milliseconds	Disabled
Power State 0 Maximum Power (MP)	Maximum power consumed in this power state	3.5 Watts
Power State 0 Non-Operational State (NOPS)	Controller does not process I/O commands in a Non-Operational State	False
Power State 0 Relative Read Latency (RRL)	Relative read latency associated with this power state	0
Power State 0 Relative Read Throughput (RRT)	Relative read throughput associated with this power state	0

Power State 0 Relative Write Latency (RWL)	Relative write latency associated with this power state	0
Power State 0 Relative Write Throughput (RWT)	Relative write throughput associated with this power state	0
Power State 1 Active Power (ACTP)	Largest average power over 10 seconds in this power state with workload from Active Power Workload (APW)	1.6 Watts
Power State 1 Active Power Workload (APW)	Workload used to calculate maximum power for the active power state	Workload #2
Power State 1 Entry Latency (ENLAT)	Maximum entry latency in microseconds associated with entering this power state	Not Reported
Power State 1 Exit Latency (EXLAT)	Maximum exit latency in microseconds associated with exiting this power state	Not Reported
Power State 1 Idle Power (IDLP)	Typical power consumed over 30 seconds in this power state when idle	0.63 Watts
Power State 1 Idle Time Prior to Transition (ITPT)	Feature 0Ch: Idle time that occurs in this power state prior to transitioning to the Idle Transition Power State in milliseconds	Disabled
Power State 1 Maximum Power (MP)	Maximum power consumed in this power state	2.4 Watts
Power State 1 Non-Operational State (NOPS)	Controller does not process I/O commands in a Non-Operational State	False
Power State 1 Relative Read Latency (RRL)	Relative read latency associated with this power state	0
Power State 1 Relative Read Throughput (RRT)	Relative read throughput associated with this power state	0
Power State 1 Relative Write Latency (RWL)	Relative write latency associated with this power state	0
Power State 1 Relative Write Throughput (RWT)	Relative write throughput associated with this power state	0
Power State 2 Active Power (ACTP)	Largest average power over 10 seconds in this power state with workload from Active Power Workload (APW)	1.5 Watts
Power State 2 Active Power Workload (APW)	Workload used to calculate maximum power for the active power state	Workload #2

Power State 2 Entry Latency (ENLAT)	Maximum entry latency in microseconds associated with entering this power state	Not Reported
Power State 2 Exit Latency (EXLAT)	Maximum exit latency in microseconds associated with exiting this power state	Not Reported
Power State 2 Idle Power (IDLP)	Typical power consumed over 30 seconds in this power state when idle	0.63 Watts
Power State 2 Idle Time Prior to Transition (ITPT)	Feature 0Ch: Idle time that occurs in this power state prior to transitioning to the Idle Transition Power State in milliseconds	Disabled
Power State 2 Maximum Power (MP)	Maximum power consumed in this power state	1.9 Watts
Power State 2 Non-Operational State (NOPS)	Controller does not process I/O commands in a Non-Operational State	False
Power State 2 Relative Read Latency (RRL)	Relative read latency associated with this power state	0
Power State 2 Relative Read Throughput (RRT)	Relative read throughput associated with this power state	0
Power State 2 Relative Write Latency (RWL)	Relative write latency associated with this power state	0
Power State 2 Relative Write Throughput (RWT)	Relative write throughput associated with this power state	0
Power State 3 Active Power (ACTP)	Largest average power over 10 seconds in this power state with workload from Active Power Workload (APW)	Not Reported
Power State 3 Active Power Workload (APW)	Workload used to calculate maximum power for the active power state	No workload
Power State 3 Entry Latency (ENLAT)	Maximum entry latency in microseconds associated with entering this power state	3,900 uS (0.003 sec)
Power State 3 Exit Latency (EXLAT)	Maximum exit latency in microseconds associated with exiting this power state	11,000 uS (0.011 sec)
Power State 3 Idle Power (IDLP)	Typical power consumed over 30 seconds in this power state when idle	0.02 Watts
Power State 3 Idle Time Prior to Transition (ITPT)	Feature 0Ch: Idle time that occurs in this power state prior to transitioning to the Idle Transition Power State in milliseconds	Disabled
Power State 3 Maximum Power (MP)	Maximum power consumed in this power state	0.02 Watts

Power State 3 Non-Operational State (NOPS)	Controller does not process I/O commands in a Non-Operational State	True
Power State 3 Relative Read Latency (RRL)	Relative read latency associated with this power state	3
Power State 3 Relative Read Throughput (RRT)	Relative read throughput associated with this power state	3
Power State 3 Relative Write Latency (RWL)	Relative write latency associated with this power state	3
Power State 3 Relative Write Throughput (RWT)	Relative write throughput associated with this power state	3
Power State 4 Active Power (ACTP)	Largest average power over 10 seconds in this power state with workload from Active Power Workload (APW)	Not Reported
Power State 4 Active Power Workload (APW)	Workload used to calculate maximum power for the active power state	No workload
Power State 4 Entry Latency (ENLAT)	Maximum entry latency in microseconds associated with entering this power state	5,000 uS (0.005 sec)
Power State 4 Exit Latency (EXLAT)	Maximum exit latency in microseconds associated with exiting this power state	39,000 uS (0.039 sec)
Power State 4 Idle Power (IDLP)	Typical power consumed over 30 seconds in this power state when idle	0.005 Watts
Power State 4 Idle Time Prior to Transition (ITPT)	Feature 0Ch: Idle time that occurs in this power state prior to transitioning to the Idle Transition Power State in milliseconds	Disabled
Power State 4 Maximum Power (MP)	Maximum power consumed in this power state	0.005 Watts
Power State 4 Non-Operational State (NOPS)	Controller does not process I/O commands in a Non-Operational State	True
Power State 4 Relative Read Latency (RRL)	Relative read latency associated with this power state	4
Power State 4 Relative Read Throughput (RRT)	Relative read throughput associated with this power state	4
Power State 4 Relative Write Latency (RWL)	Relative write latency associated with this power state	4

Power State 4 Relative Write Throughput (RWT)	Relative write throughput associated with this power state	4
Predictable Latency Event Log Change Notices	Controller support for asynchronous events Predictable Latency Event Log Change Notices, from OAES	Not Supported
Predictable Latency Mode	Controller support for Predictable Latency Mode, from CTRATT	Not Supported
RTD3 Entry Latency (RTD3E)	Typical latency to enter Runtime D3 in microseconds	1,000,000 uS (1.000 sec)
RTD3 Resume Latency (RTD3R)	Typical latency resuming from Runtime D3 in microseconds	500,000 uS (0.500 sec)
Read Recovery Levels	Controller support for Read Recovery Levels, from CTRATT	Not Supported
Read Recovery Levels Supported (RRLS)	Controller supported Read Recovery Levels	0x0000
Recommended Arbitration Burst (RAB)	Recommended number of commands that may be executed at one time from a particular Submission Queue as a power of two (2^n)	4 (2^4=16)
Reliability Degraded	Critical Warning: Reliability degraded due to significant media or internal errors	No
Replay Protected Memory Blocks (RPMBS)	Replay Protected Memory Blocks store data to a specific memory area in an authenticated and replay protected manner	Not Supported
Report ANA Change state	Controller is able to report ANA Change state, from ANACAP	Not Supported
Report ANA Inaccessible state	Controller is able to report ANA Inaccessible state, from ANACAP	Not Supported
Report ANA Non-Optimized state	Controller is able to report ANA Non-Optimized state, from ANACAP	Not Supported
Report ANA Optimized state	Controller is able to report ANA Optimized state, from ANACAP	Not Supported
Report ANA Persistent Loss state	Controller is able to report ANA Persistent Loss state, from ANACAP	Not Supported
Required Completion Queue Entry Size	Required Completion Queue entry size when using the NVM Command Set in bytes reported as a power of two (2^n), from CQES	4 (2^4=16)
Required Submission Queue Entry Size	Required Submission Queue entry size when using the NVM Command Set in bytes reported as a power of two (2^n), from SQES	6 (2^6=64)
Reservations	Controller support for reservations, from ONCS	Not Supported
Root PCI Device ID	PCI device identifier assigned for the root device	0xA340
Root PCI Location	PCI bus address for the root device	Bus 0, device 27, function 0

Root PCI Vendor ID	PCI vendor identifier assigned for the root device	0x8086
SGL support in NVM command	SGL support for the NVM Command Set	Not Supported
SMART Critical Warning Notices Enable	Feature 0Bh: Asynchronous event notifications sent to host for SMART Critical Warnings	0x1F
SMART/Health Log Page per Namespace	Controller support for log page attribute SMART/Health Log Page per Namespace, from LPA	Not Supported
SMBus Management Endpoint (SMBUSME)	NVME MI: NVM Subsystem contains a Management Endpoint on an SMBus/I2C port	Not Supported
SQ Associations	Controller support for SQ Associations, from CTRATT	Not Supported
Save/Select Fields in Features Command	Controller support for Save and Select Fields in Features Command, from ONCS	Supported
Secure Erase All Namespaces	Secure erase applies to all namespaces in an NVM subsystem, from FNA	Not Supported
Security Send and Security Receive Command	Controller support for Security Send and Security Receive Command, from OACS	Supported
Self-Test 1 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,128
Self-Test 1 Result	Result of Self-Test	Passed
Self-Test 1 Result Code	Numeric code returned by Self-Test	0
Self-Test 1 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 10 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,122
Self-Test 10 Result	Result of Self-Test	Passed
Self-Test 10 Result Code	Numeric code returned by Self-Test	0
Self-Test 10 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 11 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,122
Self-Test 11 Result	Result of Self-Test	Passed
Self-Test 11 Result Code	Numeric code returned by Self-Test	0
Self-Test 11 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 12 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,122
Self-Test 12 Result	Result of Self-Test	Passed
Self-Test 12 Result Code	Numeric code returned by Self-Test	0

Self-Test 12 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 13 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,121
Self-Test 13 Result	Result of Self-Test	Passed
Self-Test 13 Result Code	Numeric code returned by Self-Test	0
Self-Test 13 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 14 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,121
Self-Test 14 Result	Result of Self-Test	Passed
Self-Test 14 Result Code	Numeric code returned by Self-Test	0
Self-Test 14 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 15 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,121
Self-Test 15 Result	Result of Self-Test	Passed
Self-Test 15 Result Code	Numeric code returned by Self-Test	0
Self-Test 15 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 16 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,121
Self-Test 16 Result	Result of Self-Test	Passed
Self-Test 16 Result Code	Numeric code returned by Self-Test	0
Self-Test 16 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 17 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,120
Self-Test 17 Result	Result of Self-Test	Passed
Self-Test 17 Result Code	Numeric code returned by Self-Test	0
Self-Test 17 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 18 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,120
Self-Test 18 Result	Result of Self-Test	Passed
Self-Test 18 Result Code	Numeric code returned by Self-Test	0
Self-Test 18 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 19 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,119
Self-Test 19 Result	Result of Self-Test	Passed
Self-Test 19 Result Code	Numeric code returned by Self-Test	0

Self-Test 19 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 2 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,128
Self-Test 2 Result	Result of Self-Test	Passed
Self-Test 2 Result Code	Numeric code returned by Self-Test	0
Self-Test 2 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 20 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,115
Self-Test 20 Result	Result of Self-Test	Passed
Self-Test 20 Result Code	Numeric code returned by Self-Test	0
Self-Test 20 Type	Type of Self-Test (short, extended or vendor)	Extended Test
Self-Test 3 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,128
Self-Test 3 Result	Result of Self-Test	Passed
Self-Test 3 Result Code	Numeric code returned by Self-Test	0
Self-Test 3 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 4 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,124
Self-Test 4 Result	Result of Self-Test	Passed
Self-Test 4 Result Code	Numeric code returned by Self-Test	0
Self-Test 4 Type	Type of Self-Test (short, extended or vendor)	Extended Test
Self-Test 5 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,123
Self-Test 5 Result	Result of Self-Test	Passed
Self-Test 5 Result Code	Numeric code returned by Self-Test	0
Self-Test 5 Type	Type of Self-Test (short, extended or vendor)	Extended Test
Self-Test 6 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,123
Self-Test 6 Result	Result of Self-Test	Passed
Self-Test 6 Result Code	Numeric code returned by Self-Test	0
Self-Test 6 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 7 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,123
Self-Test 7 Result	Result of Self-Test	Passed
Self-Test 7 Result Code	Numeric code returned by Self-Test	0

Self-Test 7 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 8 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,122
Self-Test 8 Result	Result of Self-Test	Passed
Self-Test 8 Result Code	Numeric code returned by Self-Test	0
Self-Test 8 Type	Type of Self-Test (short, extended or vendor)	Short Test
Self-Test 9 Power On Hours	Number of power-on hours at the time the device self-test operation was completed or aborted	2,122
Self-Test 9 Result	Result of Self-Test	Passed
Self-Test 9 Result Code	Numeric code returned by Self-Test	0
Self-Test 9 Type	Type of Self-Test (short, extended or vendor)	Short Test
Serial Number (SN)	Serial number for the NVM subsystem assigned by the vendor	2035A0805352
Size	Size in bytes	250000000000.0
Size in GiB	Total calculated size in GiB (1024*1024*1024)	232.9 GiB
Subsystem Vendor	Subsystem vendor from PCI lookup: https://pcisig.com/membership/member-companies	Sandisk
Telemetry Log Notices	Controller support for log page attribute Telemetry Log Notices, from LPA	Supported
Telemetry Log Notices Enable	Feature 0Bh: Asynchronous event notification sent to host for when telemetry data available. Also see LPA	Enabled
Temperature Over/Under Threshold	Critical Warning: A temperature is over or under a temperature threshold	No
Thermal Management Temperature 1 (TMT1)	Feature 10h: Temperature the controller transitions to lower active power states or other vendor specific actions while minimizing the impact on performance	Disabled
Thermal Management Temperature 1 Count	Number of times the controller transitioned to lower power active power states or performed vendor specific thermal management actions while minimizing the impact on performance	0
Thermal Management Temperature 1 Time	Number of seconds controller had transitioned to lower power active power states or performed vendor specific thermal management actions while minimizing the impact on performance	0 Sec
Thermal Management Temperature 2 (TMT2)	Feature 10h: Temperature the controller transitions to lower active power states or other vendor specific actions regardless of the impact on performance	Disabled
Thermal Management Temperature 2 Count	Number of times the controller transitioned to lower power active power states or performed vendor specific thermal management actions regardless of the impact on performance	0

Thermal Management Temperature 2 Time	Number of seconds controller had transitioned to lower power active power states or performed vendor specific thermal management actions regardless of the impact on performance	0 Sec
Timestamp	Feature 0Eh: Number of milliseconds since controller reset or host value (midnight, 01-Jan-1970, UTC)	1,672,319,166,790 mS
Timestamp Decoded	Feature 0Eh: Either date or time since controller reset depending on timestamp origin	2022-12-29 05:06:06.790
Timestamp Feature	Controller support for Timestamp in Features Command, from ONCS	Supported
Timestamp Origin	Feature 0Eh: Timestamp is time from controller reset or host programmed value	Host Programmed
Timestamp Stopped	Feature 0Eh: Timestamp may have stopped counting in some conditions (e.g. non-operational power states)	True
Traffic Based Keep Alive Support	Controller support for restarting the Keep Alive Timer if an Admin command or an I/O command is processed during the Keep Alive Timeout Interval, from CTRATT	Not Supported
UUID List	Controller support for reporting of a UUID List, from CTRATT	Not Supported
Unchanged ANAGRPID	ANAGRPID field does not change while the namespace is attached to any controller, from ANACAP	Not Supported
Unsafe Shutdowns	Number of unsafe shutdowns	27
Vendor Specific Command Configuration	NVM Vendor Specific Commands use vendor specific or other format defined in NVMe specification, from NVSCC	Not Vendor Specific
Verify NVM Command	Controller support for Verify NVM Command, from ONCS	Not Supported
Version (VER)	NVMe version: https://nvmexpress.org/developers/nvme-specification/	1.4.0
Virtualization Mgt Command	Controller support for Virtualization Mgt Command, from OACS	Not Supported
Volatile Backup Failed	Critical Warning: Volatile memory backup device, if present, has failed	No
Volatile Write Cache (VWC)	Presence of a volatile write cache, from VWC	Supported
Volatile Write Cache Enable (WCE)	Feature 06h: Volatile write cache enable	Enabled
Volatile Write Cache Flush All NSID	Volatile Write Cache (VWC) flush command behavior if the NSID value is set to FFFFFFFFh, from VWC	Supported
Warning Composite Temperature Threshold (WCTEMP)	Temperature that indicates an overheating condition where controller operation continues	80 C

Warning Composite Temperature Time	Time controller is operational and Composite Temperature is greater than or equal to Warning Composite Temperature Threshold and less than the Critical Composite Temperature Threshold	64 Min
Windows Power ASPM (AC)	Windows OS Power Setting for PCIe ASPM when host on AC power	Attempt L1
Windows Power ASPM (DC)	Windows OS Power Setting for PCIe ASPM when host on battery power	Attempt L1
Windows Power NOPPME (AC)	Windows OS power setting for NOPPME when host on AC power	Not Supported
Windows Power NOPPME (DC)	Windows OS power setting for NOPPME when host on battery power	Not Supported
Windows Power NVMe Latency 1 (AC)	Windows OS Power Setting. After timeout 1, change to lowest power state with entry+exit latency less than this when host on AC power	50 mS
Windows Power NVMe Latency 1 (DC)	Windows OS Power Setting. After timeout 1, change to lowest power state with entry+exit latency less than this when host on battery power	5 mS
Windows Power NVMe Latency 2 (AC)	Windows OS Power Setting. After timeout 2, change to lowest power state with entry+exit latency less than this when host on AC power	100 mS
Windows Power NVMe Latency 2 (DC)	Windows OS Power Setting. After timeout 2, change to lowest power state with entry+exit latency less than this when host on battery power	100 mS
Windows Power NVMe Timeout 1 (AC)	Windows OS Power Setting. Timeout to transition NVMe to first lower power state when host on AC power	100 mS
Windows Power NVMe Timeout 1 (DC)	Windows OS Power Setting. Timeout to transition NVMe to first lower power state when host on battery power	100 mS
Windows Power NVMe Timeout 2 (AC)	Windows OS Power Setting. Timeout to transition NVMe to second lower power state when host on AC power	800 mS
Windows Power NVMe Timeout 2 (DC)	Windows OS Power Setting. Timeout to transition NVMe to second lower power state when host on battery power	1000 mS
Windows Power Plan	Name of active Windows OS Power Plan	HP Optimized (recommended)
Workload Hint (WH)	Feature 02h: Type of workload expected for a given power state	0
Write Protect Namespace States	Controller support for No Write Protect and Write Protect namespace write protection states and may support the Write Protect Until Power Cycle state and Permanent Write Protect namespace write protection states, from NWPC	Not Supported
Write Protect Until Power Cycle	Controller support for the Write Protect Until Power Cycle state, from NWPC	Not Supported

Write Uncorrectable NVM Command	Controller support for the Write Uncorrectable NVM command, from ONCS	Supported
Write Zeroes NVM Command	Controller support for the Write Zeroes NVM command, from ONCS	Supported
Data Used	Percent of TBW used	93.07399
TBW	Specification for Terabytes Written	150
Warranty Used	Percent of Warranty Used	14.575342465753424
Warranty Hours	Warranty In Hours	14600
Warranty Years	Warranty In Years	5
Size GB	Size in GB	250 GB
Model No Spaces	Model name with file friendly format	WDC_WDS250G2B0C-00PXH0
Model	Model name in friendly format	WDC WDS250G2B0C-00PXH0
Seconds Throttled	Total time throttled in seconds	3960 Sec
Percent Throttled	Total time throttled in percent of power on hours	0.1 %
Namespace 1 Active LBA Size	Size in bytes of the active LBA for Namespace 1	512

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