WD Blue™ 3D NAND SATA SSD

Internal SSD Storage

User Manual

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1 Preface

Typographical Conventions Used

The following typographical conventions are used in this manual:

- *Italics* – Used to indicate a technically defined term or state.
- Constant width – Used to show a literal technical command or response.

Glossary of Abbreviations and Acronyms

DEVSLP	Device Sleep
DIPM	Device Initiated Power Management
ESD	Electrostatic Discharge
FFU	Field Firmware Update
HIPM	Host Initiated Power Management
IOPS	Input/Output Operations Per Second
LBA	Logical Block Addressing
LDPC	Low-density Parity-check
MTTF	Mean Time to Failure
NGFF	Next Generation Form Factor
SLC	Single Level Cell
SMART	Self-Monitoring, Analysis, and Reporting Technology
SSD	Solid State Drive
TBW	Terabytes Written
TLC	Triple Level Cell

2 Introduction

This product manual describes the functional, mechanical, and interface specifications for the WD Blue™ 3D NAND SATA SSD (solid-state drive).

General Description

The WD Blue 3D NAND SATA SSD delivers high performance and reliability with low power consumption in large capacities. It is based on state-of-the-art BiCS3 64L TLC (triple level cell) flash technology and incorporates the proven tiered caching architecture designed to improve responsiveness for corporate and consumer workloads.

The WD Blue 3D NAND SATA SSD is optimized for the demanding power management requirements of Ultrathin and small form factor products. It features Device Sleep (DEVSLP), more frequent use of low-power modes, and fast transitions between various power modes.

The WD Blue 3D NAND SATA SSD also features a robust error-handling mechanism technology which uses a page-level striping with distributed parity for an added layer of data protection. This mechanism thus recovers errors, without interrupting user data flow that other traditional error correction mechanisms cannot.

Available in either a SATA 2.5"/7mm cased or an M.2 2280 form factor, the WD Blue 3D NAND SATA SSD offers drive capacities of 250 gigabyte[1] (GB), 500GB, 1 terabyte[2] (TB), and 2TB.

Key Features

- Flash Technology
  - BiCS3 64L 3D TLC
- Unformatted Capacities[3]
  - 250GB
  - 500GB
  - 1TB
  - 2TB
- Form Factors
  - SATA 2.5"/7mm cased: complies with SFF-8223 and SFF-8201
  - M.2 2280-S2-B-M[4]: complies with PCI Express M.2 (NGFF) Electromechanical Specification, rev. 1.0

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[1] 1 gigabyte (GB) = 1 billion bytes. Some of the drive capacity is used for formatting and other functions and is not available for data storage.

[2] 1 terabyte (TB) = 1 trillion bytes. Available in both the 2.5"/7mm cased and M.2 2280 form factors.

[3] Logical capacity of the drive conforms to the IDEMA HDD Specification. See www.idema.org for details. A portion of the drive capacity is not available for data storage. 1 gigabyte (GB) = 1 billion bytes. 1 terabyte (TB) = 1 trillion bytes.

[4] 250GB, 500GB, and 1TB comply with 2280-S2-B-M, while 2TB complies with 2280-S3-B-M.

  - M.2 2280 is single-sided for all capacities
- Interface to Host
  - SATA III 6Gb/s (rev. 3.2) compliant
  - Backwards compatible with SATA II 3Gb/s and SATA I 1.5Gb/s
  - ATA 8 command set ACS-4
  - NCQ support up to queue depth of 32
  - SMART support
- High Performance[5]
  - Sequential read up to: 560 MB/s
  - Sequential write up to: 530 MB/s
  - 4K random read up to: 95,000 IOPS
  - 4K random write up to: 84,000 IOPS
- Low Power Consumption[6]
  - Maximum active power: less than or equal to 7,900mW
  - Average power: 60mW
  - Slumber low-power mode: 49.9mW - 56.5mW
  - DEVSLP low-power mode: 4.9mW - 11.9mW
- Endurance[7]
  - Up to 500 TBW
- Advanced Flash Management
  - Tiered caching architecture
  - Error-management system
  - TRIM command support
  - Dynamic and static wear leveling
  - Bad block management
  - Background garbage collection
- Dynamic Thermal Throttling
  - Performance may be throttled in order to avoid cases where the temperature exceeds the product allowable temperature envelope
  - Three modes dependent on thermal conditions
- High Reliability
  - Mean time to failure (MTTF): Up to 1,752,000 hours
  - Uncorrectable bit error rate (UBER): 1 bit per 1016 bits read
  - Operational and non-operational shock: 1,500G, 0.5ms half sine
  - Operational vibration: 5gRMS, 10–2000 Hz
  - Non-operational vibration: 4.9gRMS, 7–800 Hz
  - Operational temperature[8]: 0˚C to 70˚C (32˚F to 158˚F)
  - Non-operational temperature and storage[8,9]: -55˚C to +85˚C (-67˚F to 185˚F)

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[5] Performance measured for 500GB product, using CrystalDiskMark (1000MB LBA range) on SATA 6Gb/s host.

[6] Power measured (all capacities) via MobileMark™ 2014 @ 3.3V on SATA 6Gb/s host (drive configured, DIPM enabled, HIPM disabled)

[7] 2TB capacity using JEDEC client workload (JESD219).

[8] Operational temperature is defined as ambient temperature around the SSD. It is not measured from the on-board temperature sensor. It is important to note that on-board temperature sensor readings are expected to be higher than ambient temperature when the SSD is placed inside a system.

Functional Description

The WD Blue 3D NAND SATA SSD supports the following features:

- Support for multi-stream – improves user experience in multitasking systems
- Support for TRIM command – sustains drive's high performance over time
- Minimal write amplification – increases endurance and performance
- Tiered caching, including use of allocated SLC blocks
- Support for ATA register and command set (ATA-8/ACS-4 standard)
- SMART feature support
- Error recovery using Error Correction Code (ECC)
- Self-management of NAND memory defects
- Advanced power management for low-power operation, including DEVSLP capability
- Error-management system - provides a last line of data protection
- Dynamic and static wear leveling to extend the life of the WD Blue 3D NAND SATA SSD

Advanced Flash Management

Defect and Error Management

The WD Blue 3D NAND SATA SSD contains an enhanced defect and error management system that is similar to systems found in hard disk drives (HDDs). If necessary, the device will rewrite data from a defective block to a good block. This action is completely transparent to the host and does not consume any user data space.

The WD Blue 3D NAND SATA SSD soft error rate specification is superior to the HDD specification. In the rare case when a read error occurs, the drive uses Error Detection Code (EDC) and Error Correction Code (ECC) algorithms to recover the data. These defect and error management systems give it unparalleled reliability.

The WD Blue 3D NAND SATA SSD also includes a robust error handling mechanism which can recover errors that other traditional error correction mechanisms cannot. This mechanism can leverage a hardware XOR core to calculate the extra parity on-the-fly with minimal impact in performance.

Wear Leveling

Wear leveling is an intrinsic part of the erase pooling functionality. NAND-based SSDs use dynamic and static wear leveling and automatic block management to ensure an even distribution of write/erase cycles throughout the entire device. These processes guarantee high data reliability and maximize flash life expectancy. Wear leveling is done between all TLC blocks and separately between all SLC blocks.

[9] Non-operational storage temperature does not guarantee data retention.

Bad Block Management

Bad blocks are occasionally created during the life cycle of a flash component. These bad blocks must be marked and replaced dynamically in order to prevent read/write failures. When a bad block is detected, the embedded Bad Block Mapping algorithm removes the block from future use.

Background Garbage Collection

The flash management firmware will perform internal housekeeping activities, such consolidating and flushing the SLC blocks to the TLC storage or reorganizing the data in the TLC array or SLC array. These activities are performed in the background and are transparent to the host, thus improving performance while providing a seamless user experience.

Tiered Caching

The WD Blue 3D NAND SATA SSD uses a tiered caching structure to improve write performance and endurance.

Modern operating systems typically access the storage device using small access blocks; the majority of these being 4KB. These access blocks are incongruent with the physical block size (less than 1MB) of the newer generation of flash memory technology, and writing directly to the TLC array is also slower than writing to SLC blocks. To overcome these hurdles, the WD Blue 3D NAND SATA SSD employs three storage layers:

- Volatile cache — DDR DRAM cache
- Tiered Caching structure — A non-volatile flash write cache
- Mass storage — TLC NAND flash

The tiered caching structure is a pool of X1 blocks which are used as write cache to accumulate and consolidate all writes at high speed. It works in the background, then flushes them into the larger X3 storage blocks and uses optimized write transaction sizes to maximize endurance.

All host data is written to X1 blocks to achieve the highest performance. Three X1 blocks are copied sequentially into one X3 block during the flush to mass storage when exceeding their threshold.

Low-Density Parity-Check (LDPC)

An enhancement introduced with the WD Blue 3D NAND SATA SSD is the low-density parity-check (LDPC) error correction code (ECC) technology. LDPC significantly improves reliability over the previous generation of BCH code, supports progressive levels of error correction, and runs on-the-fly using a dedicated hardware core to minimize latency and impact on overall drive performance. Consequently, it uses less power than deeper dynamic read retries.

Advanced Power Management

The WD Blue 3D NAND SATA SSD includes an advanced power management system that supports Device Initiated Power Management (DIPM). Host Initiated Power Management (HIPM) has been disabled in the WD Blue 3D NAND SATA SSD.

The device can enter in to the SATA Partial and Slumber low-power modes through DIPM. In DIPM, the device sends a request to the host to enter into Slumber mode upon completion of any command.

The device also supports the SATA Device Sleep (DEVSLP) mode. For more information, refer to the SATA revision 3.2 specification available at www.t13.org

3 General Product Specifications

Interface

The device interface complies with the Serial ATA standard published by ANSI. It complies with the SATA 6Gb/s (rev. 3.2) specification and supports ATA-8 Command Set ACS-4. It is also backwards compatible with SATA 3Gb/s (rev. 2.0) and SATA 1.5Gb/s (rev. 1.0).

For more information, refer to the American National Standard X3.221: AT Attachment for Interface for Disk Drives document. Order this document from IHS by calling 1-800-854-7179 or by accessing their web site: http://global.ihs.com

Hardware Configuration

The following table provides the basic hardware configuration values for the WD Blue 3D NAND SATA SSD.

Form Factor	NAND	Capacity	Memory
2.5"/7mm cased	BiCS3 64L eX3	250GB	4 x 2D BGA
2.5"/7mm cased	BiCS3 64L eX3	500GB	4 x 4D BGA
2.5"/7mm cased	BiCS3 64L eX3	1TB	8 x 4D BGA
2.5"/7mm cased	BiCS3 64L eX3	2TB	8 x 8D BGA
M.2-2280 S2	BiCS3 64L eX3	250GB	4 x 2D BGA
M.2-2280 S2	BiCS3 64L eX3	500GB	4 x 4D BGA
M.2-2280 S2	BiCS3 64L eX3	1TB	4 x 8D BGA
M.2-2280 S3	BiCS3 64L eX3	2TB[10]	4 x 16D BGA

Storage Capacity

The following table provides the storage capacities for the WD Blue 3D NAND SATA SSD 2.5"/7mm cased and M.2 2280 form factors.

Unformatted Capacity[11]	Sectors in LBA Mode[12]	Logical Cylinders	Number of Logical Heads	Logical Sectors per Track
250GB	488,397,168	16,383	16	63
500GB	976,773,168	16,383	16	63
1TB	1,953,525,168	16,383	16	63

[10] 2TB (16D) height is up to 1.5mm in soldered state
[11] A portion of the drive capacity used for formatting and other functions is not available for data storage.
[12] 1 Sector = 512 bytes. LBA count based on IDEMA standard.

Unformatted Capacity[11]	Sectors in LBA Mode[12]	Logical Cylinders	Number of Logical Heads	Logical Sectors per Track
2TB	3,907,029,168	16,383	16	63

[11] A portion of the drive capacity used for formatting and other functions is not available for data storage.

[12] 1 Sector = 512 bytes. LBA count based on IDEMA standard.

4 Performance

WD Blue 3D NAND SATA SSD 2.5"/7mm Cased

Parameter	Unit	Queue Depth	250GB	500GB	1TB	2TB
Sequential Read[13] up to:	MB/s	32	550	560	560	560
Sequential Write[13] up to:	MB/s	32	525	530	530	530
Random Read [4KB][13] up to:	IOPS	1	10,000	10,000	10,000	10,000
Random Read [4KB][13] up to:	IOPS	32	95,000	95,000	95,000	95,000
Random Write [4KB][13] up to:	IOPS	1	32,000	32,000	32,000	32,000
Random Write [4KB][13] up to:	IOPS	32	81,000	84,000	84,000	84,000
OFF to ON Resume Time[14]	ms	N/A	100	100	100	100

WD Blue 3D NAND SATA SSD M.2 2280

Performance values for the WD Blue 3D NAND SATA SSD M.2 2280 form factor are identical to the performance values for the WD Blue 3D NAND SATA SSD 2.5"/7mm cased form factor.

[13] Measured using CrystalDiskMark, 1000MB LBA range, on Desktop with Intel Z77 chipset, Windows 8 with Intel iRST version 11.7.0.1013, secondary drive.

[14] OFF to ON resume time assumes graceful shutdown. Resume time is measured from when power is applied to the time when the device is able to complete a host command, e.g., a 4KB read.

5 Power Characteristics

This section provides the measured voltage, power, and current consumed by the WD Blue 3D NAND SATA SSD.[15]

Supply Voltage

Parameter	Specification
Input Voltage: 2.5"/7mm cased	5V ± 5%
Input Voltage: M.2 2280	3.3V ± 5%
Maximum Ripple	100mV (peak to peak), 0Hz to 30MHz
Maximum Supply Rise Time	100ms

Average Active Power Consumption

The *average active power consumption*[16] is defined as the blended read/write/idle power used by the drive while in operation with a commonly used operating system. It is measured using the MobileMark® 2014 benchmark with DIPM (Device Initiated Power Management) enabled. When DIPM is enabled, the drive is allowed to enter low-power modes during host idle times. This benchmark simulates the typical usage of user applications in a Windows environment, providing a reproducible test for measuring average active power consumption.

The following table provides the average active power and average current values for all WD Blue 3D NAND SATA SSD storage capacities (250GB, 500GB, 1TB and 2TB).

Form Factor	Input Voltage	Test	250GB	500GB	1TB	2TB
2.5"/7mm cased	5V ± 5%	Average Power	52mW	54mW	66mW	60mW
		Average Current	10.4mA	10.8mA	13.2mA	12mA
M.2 2280	3.3V ± 5%	Average Power	51mW	49mW	58mW	60mW
		Average Current	15.4mA	14.8mA	17.5mA	18.1mA

[15] Power measurements for WD Blue 3D NAND SATA SSD on SATA 6Gb/s host. Numbers subject to change during release.

[16] Power measurements at 25°C. Based on firmware version with DIPM enabled. Measured using MobileMark® 2014 on PC with Intel® QM87 chipset, Intel® Core™ i5-4300M Processor, 4GB RAM, Windows 8 64-bit.

Average Maximum Operating Power Consumption

Average maximum operating power consumption[17] is measured while the WD Blue 3D NAND SATA SSD is continuously processing sequential read and write commands (tested separately) for at least 1 minute, with a transfer size of 256 sectors per command (128KB). The sampling interval is 125 milliseconds. This benchmark is designed to test the worst-case scenario, i.e., when continuous power is required by the WD Blue 3D NAND SATA SSD during long read or write command sequences.

Note: The power and current values in the following table are average maximum with 20% margin.

Form Factor	Input Voltage	Test	250GB	500GB	1TB	2TB
2.5"/7mm cased	5V ± 5%	Read: Power	2200mW	2050mW	2550mW	2650mW
		Read: Current	440mA	410mA	510mA	530mA
		Write: Power	2250mW	3350mW	3750mW	3800mW
		Write: Current	450mA	670mA	750mA	760mA
M.2 2280	3.3V ± 5%	Read: Power	2200mW	2050mW	2300mW	3000mW
		Read: Current	667mA	621mA	697mA	909mA
		Write: Power	2200mW	3300mW	3750mW	3800mW
		Write: Current	667mA	1000mA	1136mA	1152mA

Peak Power and Maximum Current Consumption

Peak power consumption[17]is the maximum instantaneous power consumption measured while the WD Blue 3D NAND SATA SSD is continuously processing sequential read and write commands (tested separately) for at least one minute with a transfer size of 256 sectors per command (128KB). The sampling interval is 10µs (microseconds). This benchmark is designed to test the worst-case scenario, i.e., when continuous power is required by the WD Blue 3D NAND SATA SSD during long read or write command sequences.

Maximum current refers to the maximum operating power that can be applied continuously to the WD Blue 3D NAND SATA SSD drive without harming the drive.

Note: The power and current values in the following table are average maximum with 20% margin.

[17] Measured at 25°C. Power consumption can vary due to input voltage and ambient temperature variation.

Form Factor	Input Voltage	Test	250GB	500GB	1TB	2TB
2.5"/7mm cased	5V ± 5%	Peak Power	4300mW	5550mW	7600mW	7900mW
		Maximum Current	860mA	1110mA	1520mA	1580mA
M.2 2280	3.3V ± 5%	Peak Power	4350mW	5650mW	7100mW	7350mW
		Maximum Current	1318mA	1712mA	2152mA	2227mA

Maximum In-Rush Current Power Consumption

Maximum in-rush current refers to the maximum instantaneous power consumption of the WD Blue 3D NAND SATA SSD drive after a power cycle until all voltage rails required for operation are stabilized to their nominal values on the drive. The sampling interval is 10µs (microseconds).

Form Factor	Input Voltage	Test Maximum In-Rush
2.5"/7mm cased	5V ± 5%	1.5A
M.2 2280	3.3V ± 5%	1.5A

Low Power Consumption Modes

The WD Blue 3D NAND SATA SSD supports the Partial, Slumber, and DEVSLP low power consumption modes.[17]

Note: Note: The power and current values in the following table are averages for a typical WD Blue 3D NAND SATA SSD drive.

Form Factor	Input Voltage	Power Mode	250GB	500GB	1TB	2TB
2.5"/7mm cased	5V ± 5%	Slumber (Power)	51.4mW	55.4mW	56.0mW	54.5mW
2.5"/7mm cased	5V ± 5%	Slumber (Current)	10.3mA	11.1mA	11.2mA	10.9mA
2.5"/7mm cased	5V ± 5%	DEVSLP (Power)	6.9mW	5.7mW	11.9mW	11.9mW
2.5"/7mm cased	5V ± 5%	DEVSLP (Current)	1.4mA	1.1mA	2.4mA	2.4mA
M.2 2280	3.3V ± 5%	Slumber (Power)	55.9mW	54.7mW	56.5mW	54.7mW
M.2 2280	3.3V ± 5%	Slumber (Current)	16.9mA	16.6mA	17.1mA	16.6mA
M.2 2280	3.3V ± 5%	DEVSLP (Power)	5.1mW	4.9mW	4.9mW	4.9mW

Form Factor	Input Voltage	Power Mode	250GB	500GB	1TB	2TB
M.2 2280	3.3V ± 5%	DEVSLP (Current)	1.6mA	1.5mA	1.5mA	1.5mA

Power Mode Transition Times

The following table specifies the transition times between the DEVSLP and active power states.

Power Mode	250GB	500GB	1TB	2TB
DEVSLP (Resume)	72ms	79ms	104ms	131ms

Graceful Power-off Requirements

On most operating systems, Write Cache is enabled by default. This is a feature of the ATA standard and is not specific to WD Blue 3D NAND SATA SSDs. There may be data residing in the WD Blue 3D NAND cache that have not been written to the flash memory. To ensure that the data is properly committed to flash memory, the WD Blue 3D NAND requires a STANDBY IMMEDIATE command before power down. This command instructs the WD Blue 3D NAND SATA SSD to write all of its volatile data cache to flash memory and returns a GOOD status to the host after its successful completion. This command is handled transparently by most operating systems during the shutdown sequence (e. g., hibernation, shutdown, and standby).

However, if power is lost without warning – leading to an ungraceful shutdown – data loss may occur. This may also lead to a longer power-on time for the subsequent power-up.

6 Thermal Throttling

To protect the integrity of the data and prevent excessive heat dissipation, the X600 3D NAND SATA SSD uses an integrated thermal sensor in the NAND to monitor its critical component temperature. If the sensor temperature rises above the allowable limit, system performance is throttled until the temperature decreases to an acceptable level. The X600 returns to full performance when the temperature returns to a normal range. This performance throttling technique acts as a safety measure.

The X600 3D NAND SATA SSD reads temperature from the integrated thermal sensor every one second. The device then autonomously decides which throttling level is required and reduces performance appropriate to the state.

The following table details the thermal throttling behavior for both the X600 3D NAND SATA SSD 2.5"/7mm cased and M.2 2280 form factors.

Thermal Band	≤74°C	≥75°C	≥83°C	≥87°C
Thermal Throttle State	Normal	Light (up to)	Heavy (up to)	Emergency Shutdown
250GB Read	Refer to Performance Section	250	150	No host I/O available in this state
250GB Write	Refer to Performance Section	60	20	No host I/O available in this state
500GB Read	Refer to Performance Section	250	140	No host I/O available in this state
500GB Write	Refer to Performance Section	60	20	No host I/O available in this state
1TB Read	Refer to Performance Section	250	140	No host I/O available in this state
1TB Write	Refer to Performance Section	60	20	No host I/O available in this state
2TB Read	Refer to Performance Section	240	150	No host I/O available in this state
2TB Write	Refer to Performance Section	70	20	No host I/O available in this state

Light Thermal Throttle performance is defined has performance defined as 10% of Normal. Heavy Thermal Throttle has performance is defined as 650% of Normal. Emergency Shutdown is activated if device temperature is equal to or higher than 87°C for 20 seconds.

7 Endurance

The endurance (longevity) of the WD Blue 3D NAND SATA SSD is calculated using JEDEC client workload (JESD219). Endurance is a direct function of user workload and access pattern. Defined in terms of terabytes written (TBW), endurance represents the amount of data that can be written to the WD Blue 3D NAND SATA SSD during the WD Blue 3D NAND SATA SSD lifetime and varies by product capacity.

Refer to the table below.

Parameter	250GB	500GB	1TB	2TB
Endurance	100 TBW	200 TBW	400 TBW	500 TBW

8 Field Firmware Update (FFU)

Field firmware updates (FFUs) for the WD Blue 3D NAND SATA SSD, when available, are found at the following website (http://kb.sandisk.com). Download and activate these FFUs via the codes indicated in the following table.

Code	Subcommand Name	Phases Included: Download	Phases Included: Save	Phases Included: Activate
01h	Obsolete	n/a	n/a	n/a
03h	Download with offsets, and save microcode for future use	One or more segments	Yes	No[18]
07h	Download and save microcode for future use	One segment only	Yes	No[18]
0Eh	Download with offsets, and save microcode for future use	One or more segments	Yes	No[19]
0Fh	Activate downloaded microcode	No	No	Yes
All others	Reserved	n/a	n/a	n/a

[18] Activation does not occur as part of the processing of the command but is triggered by events that occur after command completion (e.g. power cycle only).

[19] Activation does not occur as part of the processing of the command but is triggered by events that occur after command completion (e.g. power cycle or activate firmware without power cycle with Mode F above).

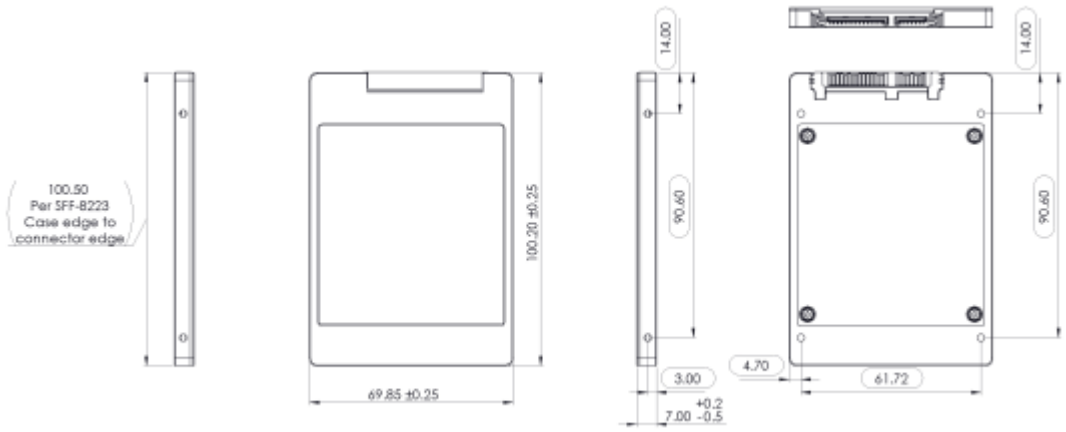
9 Physical Specifications

SATA 2.5"/7mm Cased Form Factor

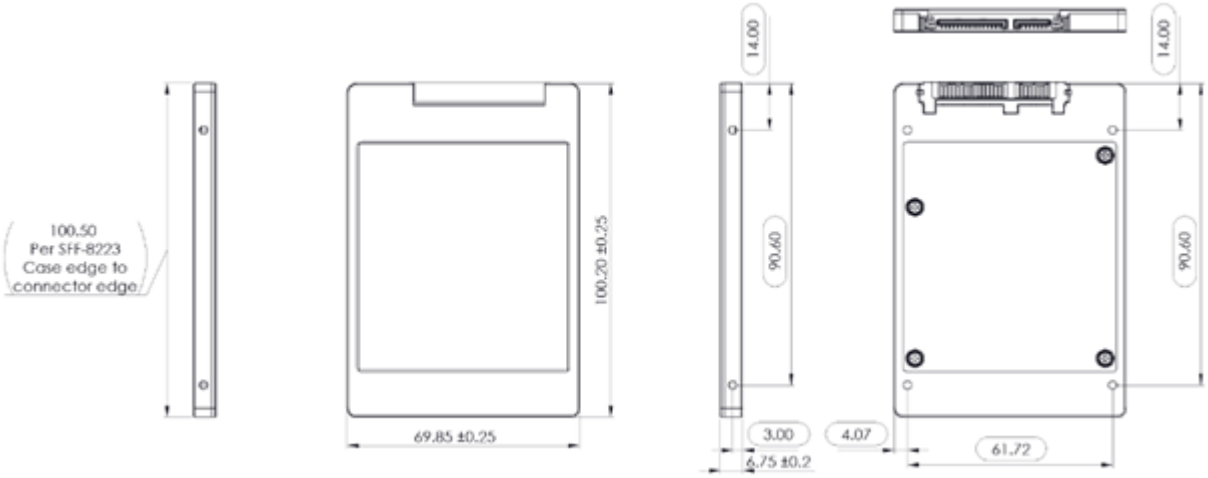
The SATA 2.5"/7mm cased form factor complies with the SFF-8201 and SFF-8223 specifications.

Parameter	Specification
Width	69.85mm ± 0.25mm
Length	100.20mm ± 0.25mm
Thickness	7.0mm ± 0.2mm/-0.5mm
Typical Weight	■ 250GB: 37.4g ■ 500GB: 37.4g ■ 1TB: 37.4g ■ 2TB: 59.7g
Mounting Screws	M3 x 0.5 non-self-tapping or thread forming
Maximum Screw Penetration	3.5mm (0.138")
Screw Torque (nominal/max)	4kgf-cm/7kgf-cm

The figure below is enlarged to show detail, but is not the actual size of the form factor. This figure shows 2.5"/7mm cased full form factor (for 1TB and 2TB capacities only).



The figure below is enlarged to show detail, but is not the actual size of the form factor. This figure shows 2.5"/7mm cased one-half form factor (for 250GB and 512GB capacities only).

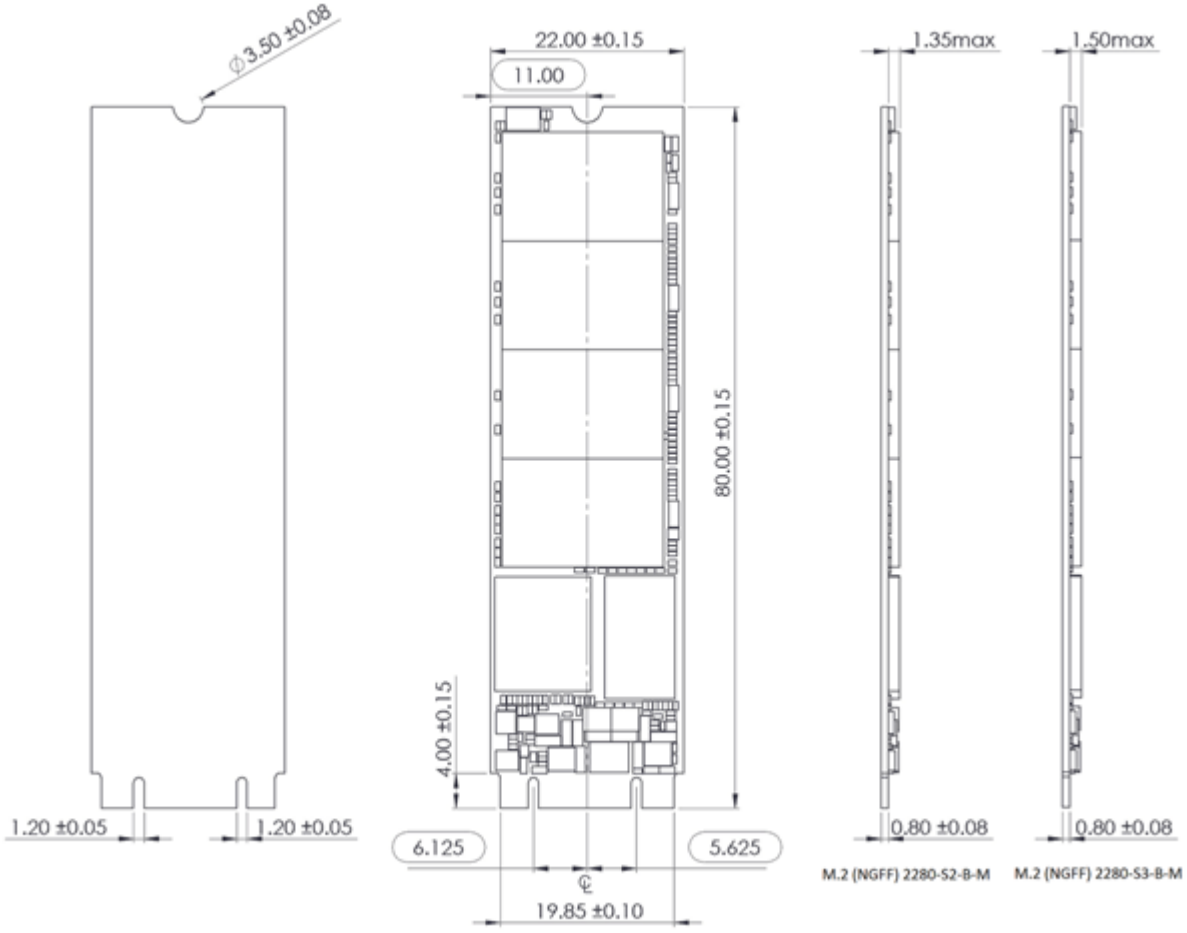


M.2 2280 Form Factor

The M.2 2280 form factor complies with the PCI Express™ M.2 Specification, Revision 1.0. This specification is available at https://pcisig.com/specifications

Parameter	Specifications
Type	250GB, 512GB and 1TB: M.2 2280-S2-B-M
	2TB: M.2 2280-S3-B-M
Width	22 ± 0.15mm
Length	80 ± 0.15mm
Thickness (max)	2.23mm: 250GB, 512GB, 1TB
	2.38mm: 2TB
Typical Weight	7g ± 1g

The figure below is enlarged to show detail, but is not the actual size of the form factor.


Ø3.50 ±0.08
22.00 ±0.15
11.00
80.00 ±0.15
4.00 ±0.15
1.20 ±0.05
1.20 ±0.05
6.125
5.625
19.85 ±0.10
1.35max
1.50max
0.80 ±0.08
0.80 ±0.08
M.2 (NGFF) 2280-S2-B-M
M.2 (NGFF) 2280-S3-B-M

10 Environmental Specifications

Temperature

Parameter	Specifications
Operational[20]	0°C to 70°C (32°F to 158°F)
Non-operational[21]	-55°C to 85°C (-67°F to 185°F)

Humidity

Parameter	Specifications
Operational	
Humidity (Non condensation)	5% to 95%
Maximum wet bulb	30°C
Non-operational	
Humidity (Non condensation)	5% to 95%
Maximum wet bulb	40°C

Vibration

Parameter	Specifications
Operational	5gRMS, 10–2000 Hz, 3 axes
Non-operational	4.9gRMS, 7–800 Hz, 3 axes

Shock

Parameter	Acceleration Force	Half Sine Pulse Duration
Operational/Non-operational	1,500G	0.5ms

[20] Operational temperature is defined as ambient temperature around the SSD. It is not measured from the on-board temperature sensor. It is important to note that on-board temperature sensor readings are expected to be higher than ambient temperature when the SSD is placed inside a system.

[21] Non-operational storage temperature does not guarantee data retention.

Altitude

Parameter	Specifications
Operational/Non-operational	-1,500ft (-457m) to 40,000ft (12,192m)

Electrostatic Discharge (ESD)

Parameter[22]	Test Voltage
Contact	±4kV
Air	8kV

Acoustics

The WD Blue 3D NAND SATA SSD does not generate any acoustic noise (0dB).

EMI/RFI Compliance

Certified Standards Compliance
FCC Part 15 Class B
IECS-003 Class B
EN 55022 Class B
EN 55024
KN 32
KN 35
CNS 13438 2006 (full version)
VCCI: VCCI rules and regulations (latest rev)
AS/NZS CISPR 22: (latest rev)

Chemical Restrictions

The WD Blue 3D NAND SATA SSD complies with:

- European Union's Restriction on Use of Hazardous Substances in Electrical and Electronic Equipment (EU RoHS) Directive 2011/65/EC
- European Union's Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), Regulation (EC) 1907/2006

It also complies with China's management methods for controlling pollution by electronic information products (China RoHS).

[22] Tested per IEC 61000-4-2 Standard.

11 Regulatory Standards and Compliance

The WD Blue 3D NAND SATA SSD conforms to and complies with the directives, regulations, and standards specified in the table below. The WD Blue 3D NAND SATA SSD is certified to meet the qualification criteria of these standards and regulations.

Directives, Regulations and Standards	Description or Regulatory Parties
2014/30/EU	EMC Directive
2014/25/EU	LVD Directive

EMI/EMC Testing Directives, Regulations and Standards	Description or Regulatory Parties
FCC Part 15 Subpart B:2012	FCC (United States)
ICES-003 Issue 5	Canada
EN 55022:2010	Information Technology Equipment–Radio Disturbances Characteristics-Limits and Methods of Measurement
EN61000–3–2:2006+A1:2009+A2:2009	Power Harmonics
EN61000–3–3:2008	Voltage Fluctuation
EN 55024:2010	Information Technology Equipment–Immunity Characteristics-Limits and Methods of Measurement
EN 61000–4–2:2009	Electrostatic Discharge Immunity (±8 kV Air Discharge, ±4 kV Contact Discharge, VCP, HCP)
EN 61000–4–3:2006+A1:2008+A2:2010	Radiated Electromagnetic Field Immunity
EN 61000–4–4:2004+A1:2010	Electrical Fast Transient/Burst Immunity
EN 61000–4–5:2006	Surge Immunity
EN 61000–4–6:2009	Conducted Immunity
EN 61000–4–8:2010	Power Frequency Magnetic Field Immunity
EN 61000–4–11:2004	Voltage Dips Voltage Interruptions
VCCI V-3/2011.04	VCCI (Japan)
AS/NZS CISPR 22:2009	AUS/NZ
BSMI CNS 13438:2006	BSMI (Republic of China)

Safety Directives, Regulations and Standards	Description or Regulatory Parties
UL 60950–1, 2nd Edition, 2007–03–27	N. America (Information Technology Equipment - Safety - Part 1: General Requirements)
CSA 22.2 No. 60950–1–07 2nd Edition, 2007–03 (Covered by CULus)	Canada (Information Technology Equipment - Safety - Part 1: General Requirements)
IEC 60950–1:2005 (Second Edition)	International Electrotechnical Commission

Safety Directives, Regulations and Standards	Description or Regulatory Parties
EN 60950-1:2006 +A11	TUV Bauart (Germany) License ID number 1234500561

12 Windows Device Certifications

HCK Certification

The WD Blue 3D NAND SATA SSD is certified with Windows HCK (Hardware Certification Kit) for Windows 7.

Category	Device
Product Type	Hard Drive
Qualification Level	Logo - Device - Compatible with Windows 7 x32
	Logo - Device - Compatible with Windows 7 x64
	Logo - Device - Compatible with Windows 8.1 x32
	Logo - Device - Compatible with Windows 8.1 x64

HLK Certification

The WD Blue 3D NAND SATA SSD is also certified with Windows HLK (Hardware Lab Kit) for Windows 10.

Category	Device
Product Type	Hard Drive
Qualification Level	Logo - Device - Compatible with Windows 10 x32
	Logo - Device - Compatible with Windows 10 x64

13 Reliability Characteristics

Uncorrectable Bit Error Rate (UBER)

The uncorrectable bit error rate is one error per 10^{16} bits read.

Mean Time to Failure (MTTF)

Mean Time to Failure (MTTF)[23] is a reliability figure that indicates the expected time to failure of non-repairable electronic equipment. Estimates of MTTF made using a prediction methodology based in accordance with the Telcordia Special Report SR-332. The prediction is based on a Parts Stress Analysis.

Quality levels were defined as industrial grade (I) for all of the components. The detailed prediction for the system was performed at a temperature of 25°C in a GB (ground, benign) environment.

The MTTF for all WD Blue 3D NAND SATA SSD form factors and storage capacities is 1,752,000 hours.

[23] Based on internal testing using Telcordia stress part testing.

14 Interface

Supported Standards

The supported standards for the WD Blue 3D NAND SATA SSD are:

- SATA 6Gb/s, Revision 3.2
- ATA-8 Command Set ACS-4

SATA Pin Assignments: Signal

Pin #	Assignment	Description
S1	GND	2nd mate
S2	A+	RxP
S3	A-	RxM
S4	GND	2nd mate
S5	B-	TxM
S6	B+	TxP
S7	GND	2nd mate

SATA Pin Assignments: Power

Pin #	Assignment	Description
P1	V33	Not connected
P2	V33	Not connected
P3	DEVSLP	Device sleep, high signal driven by the host to shut down the SATA interface completely.
P4	GND	1st mate
P5	GND	2nd mate
P6	GND	3rd mate
P7	V5	5V power input, pre-charge, 2nd mate
P8	V5	5V power input
P9	V5	5V power input
P10	GND	2nd mate
P11	DAS	Device Activity Signal
P12	GND	1st mate

Pin #	Assignment	Description
P13	V12	Not connected
P14	V12	Not connected
P15	V12	Not connected

M.2 Pin Assignments

Pin #	Assignment	Description
1	Presence Detection	Pulled low by device
2	+3.3V	3.3V Source
3	GND	Return Current Path
4	+3.3V	3.3V Source
5		No Connect
6		No Connect
7		No Connect
8		No Connect
9		No Connect
10	DAS/DSS#	Device Activity
11		No Connect
12		Mechanical Notch B
13		Mechanical Notch B
14		Mechanical Notch B
15		Mechanical Notch B
16		Mechanical Notch B
17		Mechanical Notch B
18		Mechanical Notch B
19		Mechanical Notch B
20		No Connect
21	OC SSD	GND = SSD
22		
23		No Connect
24		No Connect
25		No Connect
26		No Connect
27	GND	Return Current Path
28		No Connect
29		No Connect

Pin #	Assignment	Description
30		No Connect
31		No Connect
32		No Connect
33	GND	Return Current Path
34		No Connect
35		No Connect
36		No Connect
37		No Connect
38	DEVSLP	Device Sleep, High Signal driven by the host shuts down the SATA interface completely.
39	GND	Return Current Path
40		No Connect
41	+B - TXP	Transmitter Differential Signal Pair
42		No Connect
43	-B - TXN	Transmitter Differential Signal Pair
44		No Connect
45	GND	Return Current Path
46		No Connect
47	-A - RXN	Receiver Differential Signal Pair
48		No Connect
49	+A - RXP	Receiver Differential Signal Pair
50		No Connect
51	GND	Return Current Path
52		No Connect
53		No Connect
54		No Connect
55		No Connect
56		No Connect
57	GND	Return Current Path
58		No Connect
59		Mechanical Notch M
60		Mechanical Notch M
61		Mechanical Notch M
62		Mechanical Notch M

Pin #	Assignment	Description
63		Mechanical Notch M
64		Mechanical Notch M
65		Mechanical Notch M
66		Mechanical Notch M
67		No Connect
68		No Connect
69	PEDET	Ground = SATA
70	+3.3V	3.3V Source
71	GND	Return Current Path
72	+3.3V	3.3V Source
73	GND	Return Current Path
74	+3.3V	3.3V Source
75	GND	Return Current Path

15 Supported ATA Commands

Command Set

The following table defines the common ATA commands supported by the WD Blue 3D NAND SATA SSD. Specifics of each ATA command's operation can be found in the ATA/ATAPI Command Set ACS-4 Specification which is available at: http://www.t13.org

Command Name	ATA8	Code
Check Power Mode	Retired/M	98h/E5h
Data Set Management	Obs/O	05h/06h
TRIM		01h
Accessible Max Address Configuration	O	78h
Sub-command: Get Native Max Address EXT		0000h
Sub-command: Set Accessible Max Address EXT		0001h
Sub-command: Freeze Accessible Max Address EXT		0002h
Download Microcode/Download Microcode DMA	O/O	92h/93h
Sub-command: Download with offsets and save microcode for immediate and future use	O	03h
Sub-command: Download (without offsets) and save microcode for immediate and future use		07h
Sub-command: Download with offsets and save microcode for future use		0Eh
Sub-command: Activate downloaded microcode		0Fh
Execute Device Diagnostic	M	90h
Flush Cache	O	E7h
Flush Cache Ext	O	EAh
Identify Device/Identify Device DMA	M/Obs	ECh/EEh
Idle	Retired/M	97h/E3h
Idle Immediate	Retired/M	95h/E1h
Initialize Drive Parameters	Obs	91h
Read Buffer/Read Buffer DMA	O/O	E4h/E9h
Read DMA	O	C8h
Read DMA Ext	O	25h
Read DMA w/o Retry	Obs	C9h
Read FPDMA Queued	O	60h
Read Log Ext/Read Log DMA Ext	O/O	2Fh/47h
Sub-command: Log Directory		00h

Command Name	ATA8	Code
Sub-command: Extended Comprehensive SMART Error Log		03h
Sub-command: Device Statistics Logs		04h
Sub-command: List of supported log pages		00h
Sub-command: General Statistics		01h
Sub-command: SSD Statistics		07h
Sub-command: Extended SMART Self-test Log		07h
Sub-command: NCQ_Error Log		10h
Sub-command: SATA PHY Event Counters Log		11h
Sub-command: Identify Device Data Log		30h
Sub-command: List of Supported Pages		00h
Sub-command: Copy of IDENTIFY DEVICE Data		01h
Sub-command: Capacity		02h
Sub-command: Supported Capabilities		03h
Sub-command: Current Settings		04h
Sub-command: ATA Strings		05h
Sub-command: Security		06h
Sub-command: Serial ATA		08h
Sub-command: Thermal Throttling Log		DEh
Read Multiple	Obs	C4h
Read Multiple Ext	Obs	29h
Read Sectors	O	20h
Read Sectors Ext	O	24h
Read Sectors w/o Retry	Obs	21h
Read Verify Sectors	O	40h
Read Verify Sectors Ext	O	42h
Read Verify Sectors w/o Retry	Obs	41h
Recalibrate	Obs	1Xh
Sanitize Device	O	B4h
Sub-command: Sanitize Status Ext		00h
Sub-command: Crypto Scramble Ext	SED Only	11h
Block Erase Ext		12h
Sub-command: Sanitize Freeze Lock Ext		20h
Security Disable Password	O	F6h
Security Erase Prepare	O	F3h
Security Erase Unit	O	F4h
Security Freeze Lock	O	F5h

Command Name	ATA8	Code
Security Set Password	O	F1h
Security Unlock	O	F2h
Seek	Obs	7Xh
Set Features	M	EFh
Sub-command: Enable write cache		02h
Sub-command: Set transfer mode		03h
Sub-command: Enable Advanced Power Management (APM)		05h
Sub-command: Enable SATA features		10h
Sub-command: DMA Setup FIS Auto-Activate Optimization		02h
Sub-command: Device-initiated power state transitions		03h
Sub-command: Software Setting Preservation		06h
Sub-command: Device Sleep		09h
Sub-command: Disable read look-ahead		55h
Sub-command: Disable reverting to power-on defaults		66h
Sub-command: Disable write cache		82h
Sub-command: Disable Advanced Power Managment (APM)		85h
Sub-command: Disable SATA features		90h
Sub-command: DMA Setup FIS Auto-Activate Optimization		02h
Sub-command: Device-Initiated Interface Power Management		03h
Sub-command: Software Setting Preservation		06h
Sub-command: Device Automatic Partial-to-Slumber transitions		07h
Sub-command: Device Sleep		09h
Sub-command: Enable read look-ahead		AAh
Sub-command: Enable reverting to power-on defaults		CCh
Set Multiple Mode	Obs	C6h
Sleep	Retired/M	99h/E6h
Smart	O	B0h
Sub-command: Read Attribute Values (Read Data)		D0h
Sub-command: Read Attribute Thresholds	Obs	D1h
Sub-command: Enable/Disable Attribute Autosave	Obs	D2h
Sub-command: Save Attribute Values		D3h
Sub-command: Execute Offline Immediate		D4h
Sub-command: Execute Short Self-test routine (Offline)		01h
Sub-command: Execute Extended Self-test routine (Offline)		02h

Command Name	ATA8	Code
Sub-command: Execute Selective Self-test routine (Offline)		04h
Sub-command: Abort Offline Immediate routine		7Fh
Sub-command: Execute Short Self-test routine (Captive)		81h
Sub-command: Execute Extended Self-test routine (Captive)		82h
Sub-command: Read Log		D5h
Sub-command: Write Log		D6h
Sub-command: Enable Operations	Obs	D8h
Sub-command: Disable Operations	Obs	D9h
Sub-command: Return Status		DAh
Sub-command: Enable/Disable Automatic Offline	Obs	D8h
Standby	Retired/M	96h/E2h
Standby Immediate	Retired/M	94h/E0h
Trusted Non-Data	O, SED Only	5Bh
Trusted Receive	O, SED Only	5Ch
Trusted Receive DMA	O, SED Only	5Dh
Trusted Send	O, SED Only	5Eh
Trusted Send DMA	O, SED Only	5Fh
Write Buffer/Write Buffer DMA	O/O	E8h/EBh
Write DMA	M	CAh
Write DMA Ext	O	35h
Write DMA FUA Ext	O	3Dh
Write DMA w/o Retry	Obs	82h
Write FPDMA Queued	O	61h
Write Log Ext/Write Log DMA Ext	O/O	82h
Write Multiple	M	C5h
Write Multiple Ext	O	39h
Write Multiple FUA Ext	M	CEh
Write Sectors	M	30h
Write Sectors Ext	O	34h
Write Sectors w/o Retry	Obs	31h
Write Uncorrectable Ext	O	45h
Psuedo-UECC with Logging		55h
Flagged-UECC without Logging		AAh

Legend: M = Mandatory, O = Optional, Obs = Obsolete But Supported, Retired = Retired But Supported

Identify Device Data

The following table defines the specifics of the IDENTIFY DEVICE data returned by the WD Blue 3D NAND SATA SSD.

Word Address	Default Value	Total Bytes	Data Field Type Information
0	0040h	2	ATA General configuration: bit-significant information
1–6	XXXXh	12	Obsolete/Retired/ Specific
7–8	0000h	4	Reserved
9	0000h	2	Retired
10–19	ASCII	20	Serial number in ASCII (left-justified)
20–22	6	2	Retired/Obsolete
23–26	ASCII	8	Firmware revision in ASCII (left-justified)
27–46	WDC WDSxxxxxxxx-xxxxxx	40	Model number in ASCII (left-justified) for WD Blue 3D NAND SATA SSD. SKU without dash; X depends on capacity and HW configuration
47	8001h	2	R/w Multiple Sector Count
48	4000h	2	Trusted Computing feature set
49	2F00h	2	LBA and MW DMA modes supported
50	4000h	2	Capabilities
51–52	XXXXh	4	Obsolete
53	0007h	2	Field validity
54–58	XXXXh	10	Obsolete
59	D101h	2	Sanitize and multiple sector setting
60–61	XXXXh	4	ATA total number of sectors addressable in LBA mode
62	0000h	2	Obsolete
63	0007h	2	MW DMA Transfer Modes

Word Address	Default Value	Total Bytes	Data Field Type Information
64	0003h	2	Advanced PIO transfer modes supported
65	0078h	2	Minimum MDMA transfer cycle time per word in ns
66	0078h	2	Recommended MDMA transfer cycle time per word in ns
67	0078h	2	Minimum PIO transfer cycle without flow control
68	0078h	2	Minimum PIO transfer cycle with IORDY flow control
69–70	XXXXh	2	Reserved
71–74	0000h	8	Reserved for IDENTIFY PACKET DEVICE command
75	001Fh	2	Queue Depth
76	870Eh	2	SATA capabilities
77	0084h	2	SATA Additional capabilities (0002=1.5Gb/s, 0004=3Gb/s, 0006=6Gb/s)
78	014Ch	2	SATA Features Supported
79	0040h	2	SATA Features Enabled
80	03F0h	2	Major Version number
81	0110h	2	Minor Version number
82	346Bh	2	Command and features sets supported #1
83	7D09h	2	Command and features sets supported #2
84	4163h	2	Command and features sets supported #3
85	3469h	2	Command and features sets enabled #1
86	BC09h	2	Command and features sets enabled #2
87	4163h	2	Command and features sets enabled #3

Word Address	Default Value	Total Bytes	Data Field Type Information
88	207Fh	2	ATA - Ultra DMA modes supported and selected
89	0001h	2	Time required for security erase-unit completion (all capacities complete less than 2 minutes)
90	0032h	2	Time required for enhanced security erase unit completion
91	0080h	2	Current advanced power management (APM) value
92	FFFEh	2	Master Password Identifier
93	0000h	2	COMRESET Result
94	0000h	2	Acoustic Management Value
95	0000h	2	Stream Min Request Size
96	0000h	2	Streaming Transfer Time-DMA
97	0000h	2	Streaming Access Latency
98–99	0000h	4	Streaming Performance Granularity
100–103	XXXXh	8	48-bit # of LBAs
104	0000h	2	Streaming Transfer Time-PIO
105	0010h	2	Max # 512-byte Blocks in LBA Range Entries
106	4000h	2	Physical Sector Size/ Logical
107	0000h	2	Inter-Seek Delay for ISO-7779
108	0000h	2	WWN
109	0000h	2	WWN
110	0000h	2	WWN
111	0000h	2	WWN
112–115	0000h	2	Reserved
116	0000h	2	Reserved for INCITS TR-37–2004

Word Address	Default Value	Total Bytes	Data Field Type Information
117–118	0000h	4	Logical Sector Size
119	401Ch	2	Command/Feature Sets Supported #4
120	401Ch	2	Command/Feature Sets Enabled
121–126	0000h	12	Reserved
127	0000h	2	Obsolete
128	0021h	2	Security Status
129–159	0000h	62	Reserved Vendor-Unique Bytes
160	0000h	2	CFA Power Mode 1
161–175	XXXXh	30	Reserved
176–205	2020h	60	Current Media Serial Number
206	0000h	2	SCT Command Transport
207–208	0000h	4	Reserved for CE-ATA
209	4000h	2	Alignment-logical within Physical Block
210–211	0000h	4	Wr/Rd/Vfy Sector Count Mode 3
212–213	0000h	4	Wr/Rd/Vfy Sector Count Mode 2
214	0000h	2	NV Cache Capabilities
215	0000h	2	NV Cache Size in Logical Blocks (LSW)
216	0000h	2	NV Cache Size in Logical Blocks (MSW)
217	0001h	2	NV Cache Read Transfer Speed in MB/s
218	0000h	2	NV Cache Write Transfer Speed in MB/s
219	0000h	2	NV Cache Options
220	0000h	2	Wr/Rd/Vfy Feature Set-Current Mode
221	0000h	2	Reserved
222	10FFh	2	Transport Major Version Number
223	0000h	2	Transport Minor Version Number

Word Address	Default Value	Total Bytes	Data Field Type Information
224–233	0000h	20	Reserved for CE-ATA
234	0001h	2	Min Sector Count for Download Microcode Mode 3
235	0080h	2	Max Sector Count for Download Microcode Mode 3
236–254	0000h	38	Reserved
255	3BA5h	2	Integrity Word-Checksum

Log Pages

The following table defines the list of supported Log Pages accessible through SMART WRITE LOG, SMART READ LOG, READ LOG EXT and WRITE LOG EXT commands.

Log Address	Total Pages	Log Address Description	Access
00h	1	General Purpose Log Directory	GPL, SMART Log
01h	1	Summary SMART Error Log	SMART Log
02h	2	Comprehensive SMART Error Log	SMART Log
03h	1	Extended Comprehensive SMART Error Log	GPL
04h	8	Device Statistics Log	GPL, SMART Log
06h	1	SMART Self-Test Log	SMART Log
07h	1	Extended SMART Self-Test Log	GPL
10h	1	NCQ Error Log	GPL
11h	1	SATA PHY Event Counters Log	GPL
30h	8	Identify Device Data Log	GPL, SMART Log
80–9Fh	16	Host Vendor-specific Logs	GPL, SMART Log
DEh	1	Thermal Throttling Logs	GPL

16 Ordering Information

The following table uses a generic sample SKU to explain and describe the format of a WD Blue 3D NAND SATA SSD SKU.

SKU	Details
WDS250G1B0A-00H9H0	WD Blue 3D NAND SATA SSD 2.5" 7mm 250GB
WDS500G1B0A-00H9H0	WD Blue 3D NAND SATA SSD 2.5" 7mm 500GB
WDS100T1B0A-00H9H0	WD Blue 3D NAND SATA SSD 2.5" 7mm 1000GB
WDS200T1BOA-00H9H0	WD Blue 3D NAND SATA SSD 2.5" 7mm 2000GB
WDS250G1B0B-00AS40	WD Blue 3D NAND SATA SSD M.2 2280 250GB
WDS500G1B0B-00AS40	WD Blue 3D NAND SATA SSD M.2 2280 500GB
WDS100T1B0B-00AS40	WD Blue 3D NAND SATA SSD M.2 2280 1000GB
WDS200T1B0B-00AS40	WD Blue 3D NAND SATA SSD M.2 2280 2000GB

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4779–705170-A00 August 2017