WD Scorpio® Black™ MX320S-1

SATA Hard Drives

Technical Reference Manual

WD3200BEKT

WD2500BEKT

WD1600BEKT

WD CONFIDENTIAL

Western Digital®

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2679-771280-A01

Document Control Number Definition:

2679-001xxx-	**0xx-Px**	**NRD**
Doc Control No.	Doc Revision Level (WD Caviar Drives) Oxx = Released Version Px = Review Cycle	Non-Released Document

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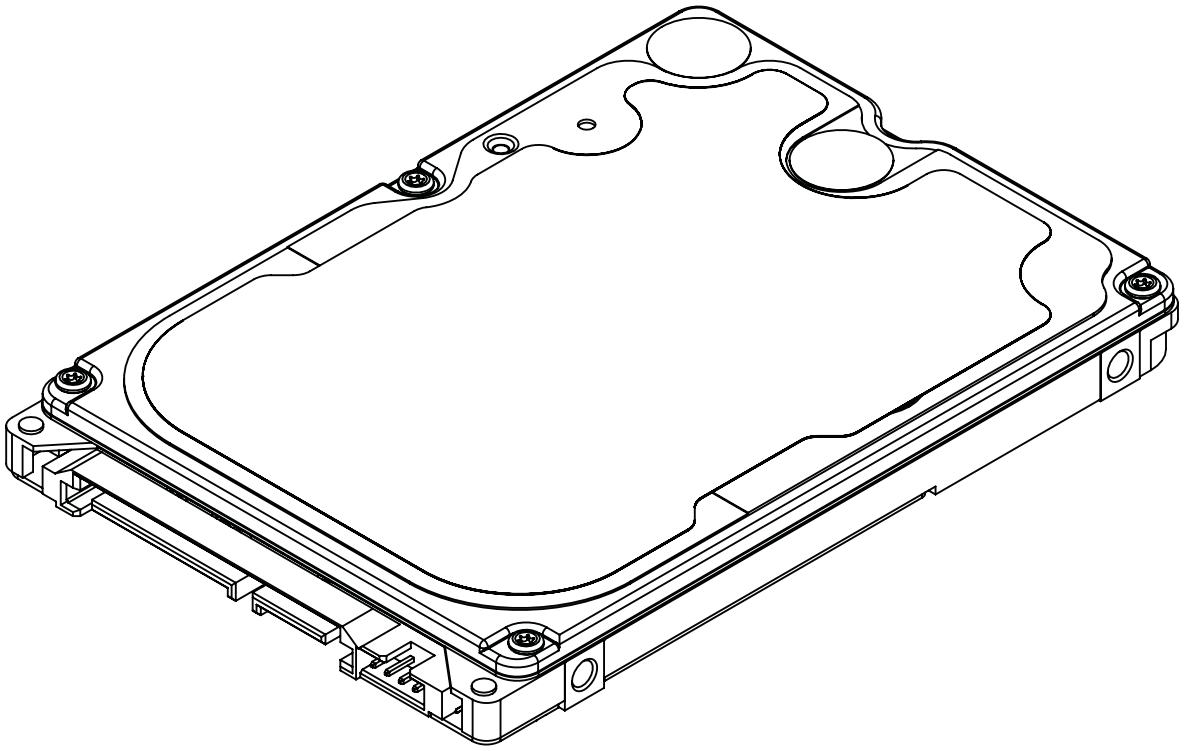

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1.0 DESCRIPTION AND FEATURES

1.1 General Description

WD Scorpio 2.5-inch drives offer fast performance and low power consumption, making them ideal for notebooks and other portable devices.

1.2 Product Features

- **Serial ATA (SATA)** — Serial ATA (SATA) is the next generation bus interface for 2.5-inch hard drives. It is designed to replace Parallel ATA, and has many advantages including increased transfer rate, improved signal integrity, enhanced data protection, and hot plug support.
- **Perpendicular Magnetic Recording (PMR - Writer)** — With PMR technology the magnetization of each data bit is aligned vertically to the spinning disk, rather than longitudinally as has been the case in hard drive technology for decades. This enables more data on a given disk than is possible with conventional longitudinal recording, and provides a platform for future expansion of hard drive densities.
- **Reduced Power Spinup (RPS)** — WD's optimized start up feature specifically designed for the external hard drive and Consumer Electronics (CE) market. Specific focus for RPS is to minimize the duration and magnitude of the peak power consumption from the hard drive.
- **System-on-Chip** - The System-on-Chip (SOC) is the foundation for WD's next generation electronics and firmware architecture. The native SATA SOC lowers component count by integrating a hard disk controller, high performance processor, high speed execution SRAM, and read channel in a 128-pin package.
- **S.M.A.R.T. Command Transport (SCT)** — The SCT Command Transport feature set provides a method for a host to send commands and data to a device and for a device to send data and status to a host using log pages.
- **Reliability Features Set-Data Lifeguard**™ — Representing WD's ongoing commitment to data protection, Data Lifeguard includes features that enhance the drive's ability to prevent data loss. Data Lifeguard data protection utilities include thermal management, an environmental protection system, and embedded error detection and repair features that automatically detect, isolate, and repair problem areas that may develop over the extended use of the hard drive. With these enhanced data reliability features, the drive can perform more accurate monitoring, error repair, and deliver exceptional data security.
- **Hot Plug Support** — SATA supports hot plugging (also known as "hot swapping"), the ability to swap out a failed hard drive without having to power down the system or reboot. This capability contributes to both data availability and serviceability without any associated downtime, making it a critical feature for extending SATA into enterprise applications.
- **Active LED Status** — These drives support external LED requirements. It provides an activity LED output which is ON during command execution and OFF otherwise.
- **Fluid Dynamic Bearings (FDB)** — Bearing design that incorporates a layer of high-viscosity lubricant instead of ball bearings in the hard drive spindle motor. As an alternative to conventional ball bearing technology, FDB designs provide increased non-operational shock resistance, speed control, and improved acoustics.
- **Staggered Spin-Up** — Native SATA feature that allows the system to control whether the drive will spin up immediately or wait until the interface is fully ready.

- **CacheFlow™** —WD's unique, multi-generation caching algorithm evaluates the way data is read from and written to the drive and adapts "on-the-fly" to the optimum read and write caching methods. CacheFlow minimizes disk seek operations and overheads due to rotational latency. CacheFlow supports sequential and random write cache. With write cache and other CacheFlow features, the user can cache both read and write data. The cache can hold multiple writes and collectively write them to the hard drive.
- **48-bit Logical Block Addressing (LBA)** — WD SATA drives support both 48-bit and 28-bit LBA and CHS-based addressing. LBA is included in advanced BIOS and operating system device drivers and ensures high capacity disk integration.
- **Power Management** — WD SATA drives support the ATA and Serial ATA power management command set, allowing the host to reduce the power consumption of the drive by issuing a variety of power management commands.
- **Automatic Defect Retirement** — If the WD SATA drive detects a defective sector while reading, writing, or performing offline data collection, it automatically relocates the sector without end-user intervention.
- **Self-Monitoring, Analysis, and Reporting Technology (S.M.A.R.T.)** — S.M.A.R.T. enables a drive's internal status to be monitored through diagnostic commands at the host level and during offline activities. S.M.A.R.T. devices employ data analysis algorithms that are used to predict the likelihood of some near-term degradation or fault conditions. When used with a S.M.A.R.T. application, the drive can alert the host system of a negative reliability status condition. The host system can then warn the user of the impending risk of data loss and recommend an appropriate action.
- **ATA Security** — WD SATA drives support the ATA Security Mode Feature set. The ATA Security Mode feature set allows the user to create a device lock password that prevents unauthorized hard disk access even if the drive is removed from the host computer. The correct password must be supplied to the hard drive in order to access user data. Both the User and Master Password features are supported, along with the High and Maximum security modes. The Master Password Revision code is also supported.
- **Automatic Acoustic Management (AAM)** — The drive supports the Automatic Acoustic Management feature. This feature allows the host to select the acoustic level of the hard drive.

2.0 SPECIFICATIONS

2.1 Performance Specifications

Average Seek[1] - Read - Write	 12.0 ms average 15.0 ms average
Track-to-Track Seek [1]	2.0 ms average
Full Stroke Seek	24 ms average
Index Pulse Period	11.1 ms (nominal)
Average Latency	4.2 ms
Rotational Speed	7200 RPM
Data Transfer Rate (maximum)[2] - Buffer to Host - Max buffer to disk	 3.0 Gb/s maximum 108 MB/s maximum
Buffer Size	16 MB
Error Rate - Unrecoverable	<1 in 10^{14} bits read
Spindle Start Time - From Power-on to Drive Ready [3] - From Power-on to Rotational Speed [4]	 4.0s average 2.0s average
Spindle Stop Time	8s average
Load/Unload Cycles[5]	600,000

[1] *During continuous Seek, Read, or Write commands, an algorithm in the code will add latency as required to keep the VCM motor from overheating;s seek performance will be impacted under this condition.*

[2] *As used for storage capacity, one megabyte (MB) = one million bytes, one gigabyte (GB) = one billion bytes, and one terabyte (TB) = one trillion bytes. Total accessible capacity varies depending on operating environment. As used for buffer or cache, one megabyte (MB) = 1,048,576 bytes. As used for transfer rate or interface, megabyte per second (MB/s) = one million bytes per second, and gigabit per second (Gb/s) = one billion bits per second. Effective maximum SATA 3 Gb/s transfer rate calculated according to the Serial ATA specification published by the SATA-IO organization as of the date of this specification sheet. Visit www.sata-io.org for details.*

[3] *Defined as the time from power-on to the setting of Drive Ready and Seek Complete including calibration.*

[4] *Defined as the time from power-on to when the full spindle rotational speed is reached.*

[5] *Controlled unload at ambient condition.*

2.2 Physical Specifications

Physical Specifications	**WD1600BEKT**	**WD2500BEKT**	**WD3200BEKT**
Capacity[1]	160,041 MB	250,059 MB	320,072 MB
Interface	SATA 3.0 Gb/s	SATA 3.0 Gb/s	SATA 3.0 Gb/s
Actuator Type	Rotary Voice Coil	Rotary Voice Coil	Rotary Voice Coil
Number of Disks	1	1	1
Data Surfaces	1	2	2
Number of Heads	1	2	2
Bytes per Sector	512	512	512
User Sectors per Drive	312,581,808	488,397,168	625,142,448
Servo Type	Embedded	Embedded	Embedded
Recording Method	Partial DC Target	Partial DC Target	Partial DC Target
ECC	Reed-Solomon	Reed-Solomon	Reed-Solomon

[1] As used for storage capacity, one megabyte (MB) = one million bytes, one gigabyte (GB) = one billion bytes, and one terabyte (TB) = one trillion bytes. Total accessible capacity varies depending on operating environment. As used for buffer or cache, one megabyte (MB) = 1,048,576 bytes. As used for transfer rate or interface, megabyte per second (MB/s) = one million bytes per second, and gigabit per second (Gb/s) = one billion bits per second. Effective maximum SATA 3 Gb/s transfer rate calculated according to the Serial ATA specification published by the SATA-IO organization as of the date of this specification sheet. Visit www.sata-io.org for details.

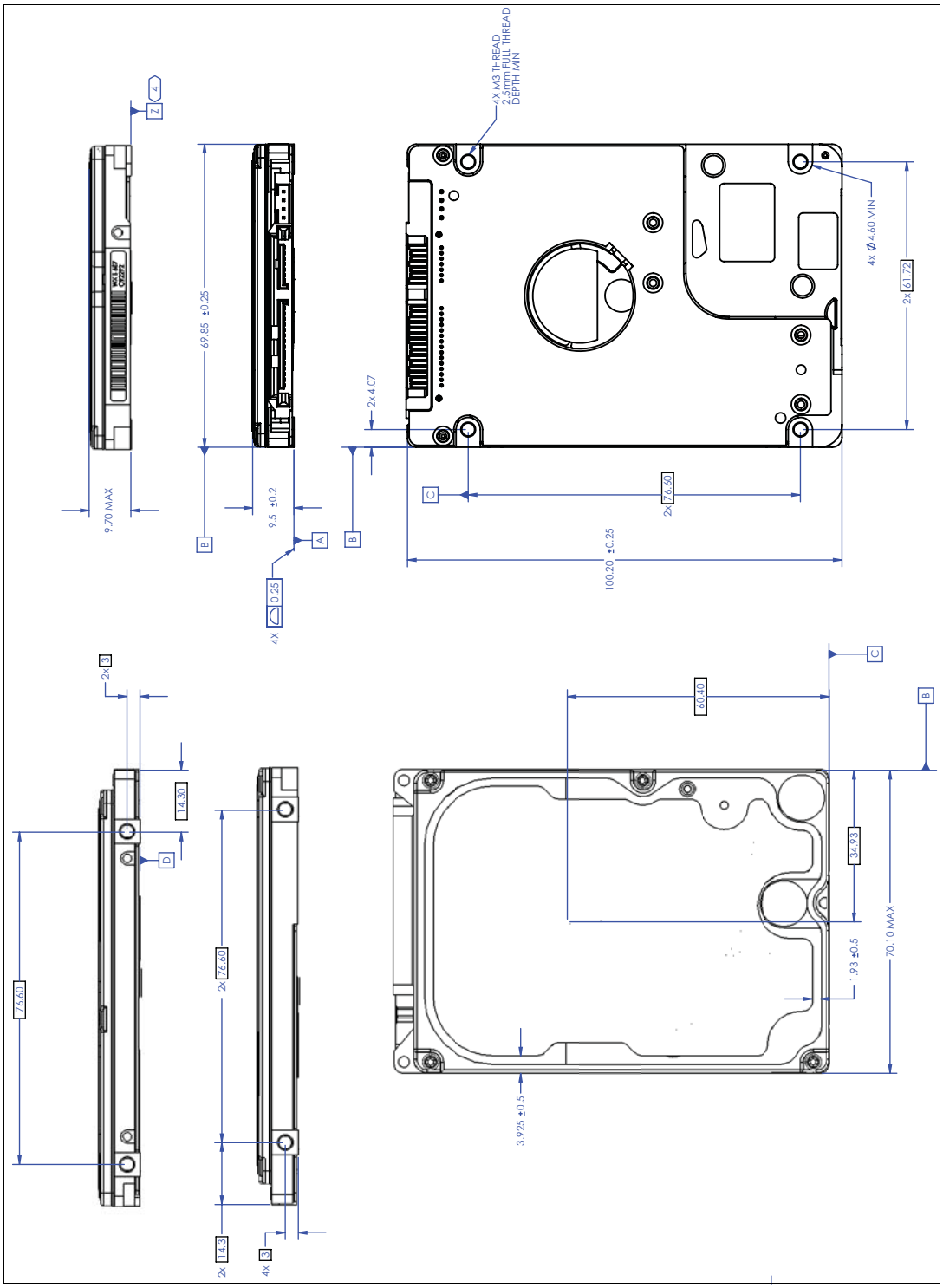
2.2.1 Physical Dimensions

	English		Metric	
	Dimension	**Tolerance**	**Dimension**	**Tolerance**
Height	0.374 inches	±0.01 inch	9.50 mm	±0.20 mm
Length	3.94 inches	±0.01 inch	100.20 mm	±0.25 mm
Width	2.75 inches	±0.01 inch	69.85 mm	±0.25 mm
Weight (typical)	0.23 pounds	—	106 gm	—

2.3 Mechanical Specifications

Figure 2-1 shows the mounting dimensions and locations of the screw holes for the drive.

Figure 2-1. Mounting Dimensions



2.4 Electrical Specifications

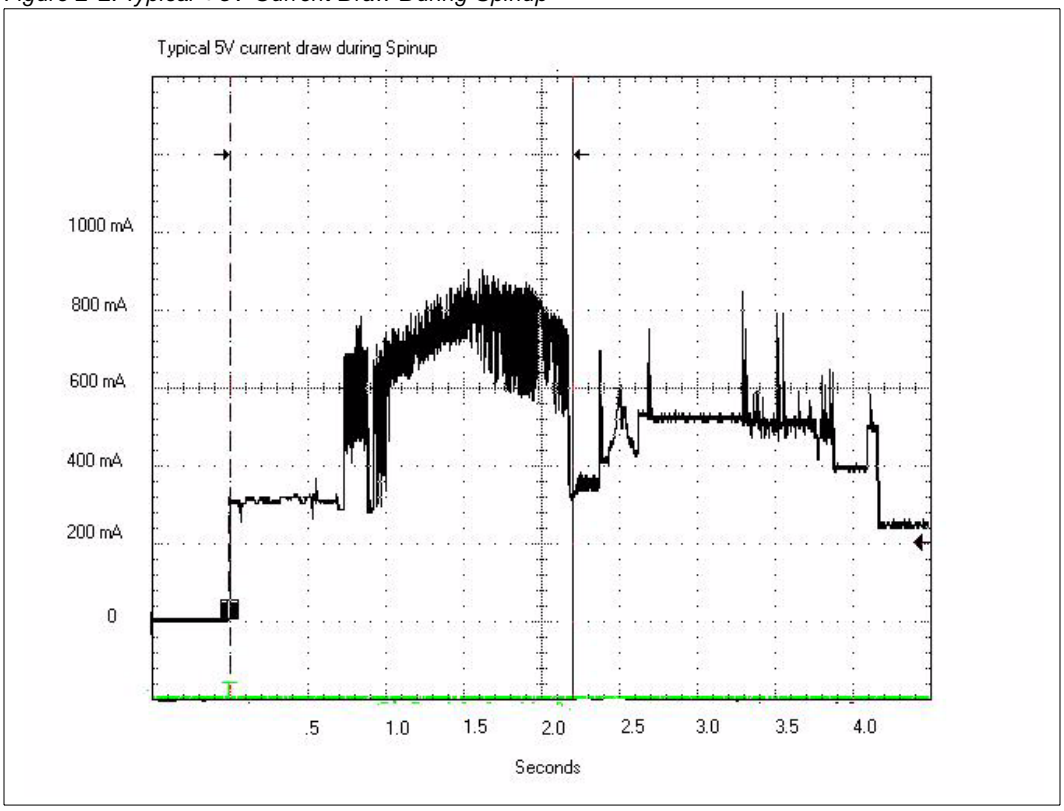
2.4.1 Current Requirements and Power Dissipation

Operating Mode	Current[1]	Power[1]
	5 VDC	
Spinup (max)	1.1 A	5.5W
Read/Write (average)	350 mA	1.75W
Seek (average)	400 mA	2.0W

POWER MANAGEMENT COMMANDS		
Operating Mode	**Current[1]**	**Power[1]**
	5 VDC	
Idle (E1H)(average)	160 mA	0.8W
Standby (E0H)(average)	40 mA	0.2W
Sleep (E6H)(average)	40 mA	0.2W

[1] *All values are typical (25°C and 5V input) except where specified as maximum.*

Figure 2-2. Typical +5V Current Draw During Spinup



Note: Current is 200 mA per 10 mV vertical deflection.

2.4.2 Input Voltage Requirements

The input voltage requirement for these drives is +5.0V ± 5%.

2.4.3 Ripple

	+5 VDC
Maximum Frequency	100 mV (peak-to-peak) 10 KHz - 30 MHz

2.5 Environmental Specifications

2.5.1 Shock and Vibration

Table 2-1. Shock and Vibration

Shock	
Operating (2 ms)	350G
Non-operating (2 ms)	1000G
Note: Half-sine wave, measured without shock isolation and without non-recoverable errors.	
Vibration	
Operating	0.00459 g2/Hz (10-500 Hz)
Non-operating	0.06984 g2/Hz (10-500 Hz)
Drive Generated Vibration	
Operating (average)	0.12 gm-mm
Rotational Shock Non-Operating	
Amplitude	50K rad/sec^2
Duration	2 ms

Operating Vibration

Drives are tested by applying a random or swept sinusoidal excitation in each linear axis, one axis at a time. The drive incurs no physical damage and no hard errors while operating and subjected to continuous vibration not exceeding the level listed in Table 2-1. Operating performance may degrade during periods of exposure to continuous vibration.

Non-Operating Vibration

Note: This specification applies to handling and transportation of unmounted drives.

Drives are tested by applying a random or swept sinusoidal excitation in each linear axis, one axis at a time. The drive incurs no physical damage when subjected to continuous vibration not exceeding the level listed in Table 2-1.

Drive Generated Vibration

Drives are tested by supporting a single drive horizontally in a free-free state and measuring the side-to-side vibration. Self vibration may not exceed the level listed in Table 2-1.

Rotational Shock Non-Operating

Drives are tested by applying a rotational force centered around the actuator pivot. The drive incurs no physical damage when subjected to the rotational force specified in Table 2-1.

Packaged Shock and Vibration

The shipping packaging is designed to meet the National/International Safe Transit Association (N/ISTA) standards for packaged products. The drive incurs no physical damage when subjected to the N/ISTA standards.

2.5.2 Temperature and Humidity

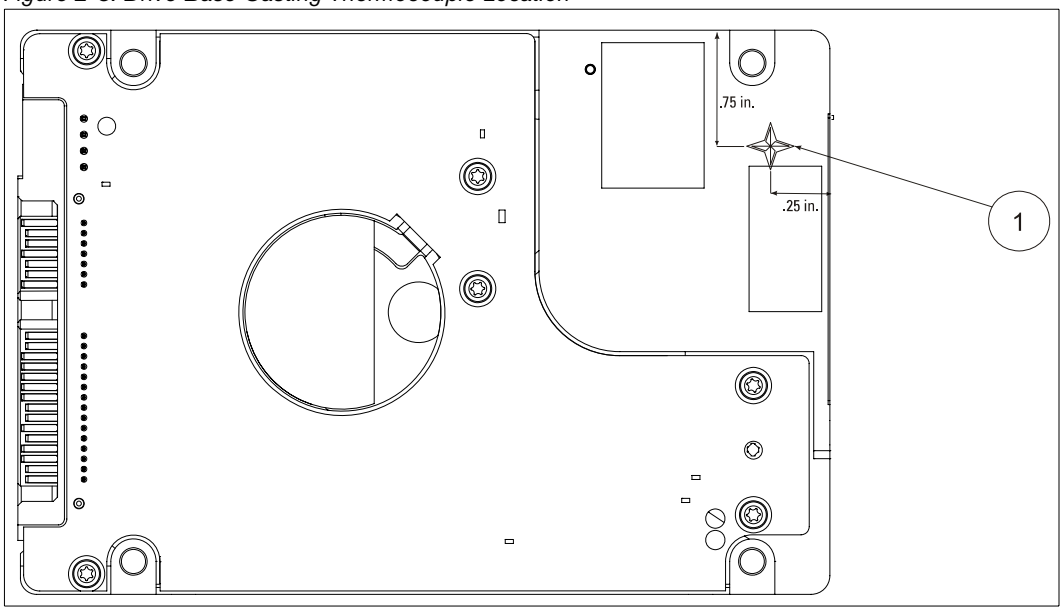
Temperature & Humidity	
Operating ambient temperature[1]	0°C to 60°C (32°F to 140°F)
Max base casting temperature[2]	60°C (140°F)
Humidity	8-90% RH non-condensing 29.4°C (maximum wet bulb)
Thermal Gradient	20°C/hour (maximum)
Humidity Gradient	20%/hour (maximum)
Non-operating Temperature	-40°C to 65°C (-40°F to 149°F)
Humidity	5-95% RH non-condensing 40°C (maximum wet bulb)
Thermal Gradient	30°C/hour (maximum)
Humidity Gradient	20%/hour (maximum)

[1] The system environment must allow sufficient air flow to limit maximum surface temperatures as defined.
[2] See Figure 2-3.

2.5.3 Thermocouple Location

Component	Location
Drive base casting	#1, Figure 2-3

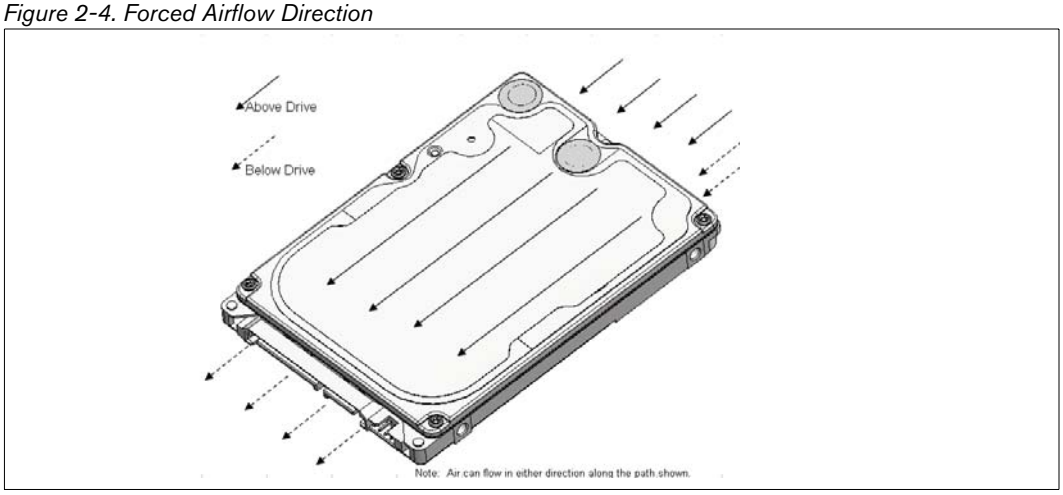
Figure 2-3. Drive Base Casting Thermocouple Location



2.5.4 Cooling

If forced air cooling is required, the drive must be positioned to receive airflow from one or more fans as indicated in Figure 2-4.

Figure 2-4. Forced Airflow Direction



2.5.5 Atmospheric Pressure

Altitude	
Operating	-1,000 feet to 10,000 feet (-305M to 3,000M)
Non-operating	-1,000 feet to 40,000 feet (-305M to 12,000M)

2.5.6 Acoustics

TYPICAL SOUND POWER LEVEL[1]	
Idle (average dBA) [2]	22
Seek (average dBA) [3, 4]	25

[1] Measured per ECMA-74/ISO 7779.
[2] No audible pure tones.
[3] Random seek at a rate of 26 seeks per second.
[4] Seek mode selectable with the Automatic Acoustic Management feature.

2.5.7 RoHS (Restriction of Hazardous Substances)

WD complies with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC of the European Parliament, which is effective in the EU beginning July 1, 2006. RoHS aims to protect human health and the environment by restricting the use of certain hazardous substances in new equipment, and consists of restrictions on lead, mercury, cadmium, and other substances.

The reliability, performance, and specifications of WD products are unchanged from previously manufactured WD products, remaining among the highest in the industry.

2.6 Reliability Specifications

Component Design Life	5 years
AFR	<0.5%[1]
Duty Cycle	40%
Power on Hours (POH)	3120

[1] Ambient temperature 35°C, HDD temperature 40°C.

2.7 Device Plug Connector Pin Definitions

The drive interfaces with the host I/O bus via the SATA interface connection, and receives power from the SATA power connection, illustrated in Figure 2-5 below. Table 2-2 identifies the pin definitions of the SATA connectors and the corresponding signal names and signal functions.

Figure 2-5. Standard Factory Connectors

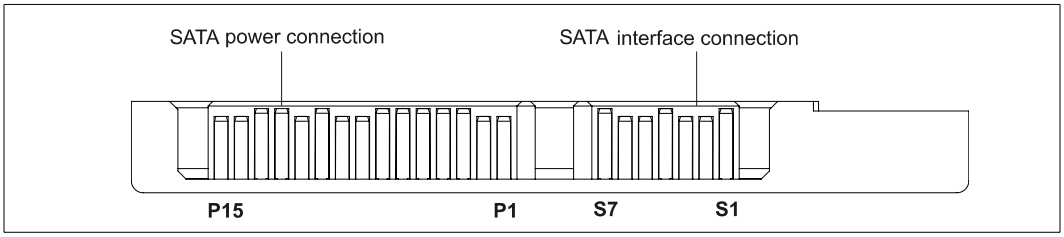


Table 2-2. Device Pin Connector Pin Definitions

Signal segment	S1	Gnd	2nd mate
	S2	A+	Differential signal pair A from Phy
	S3	A-	
	S4	Gnd	2nd mate
	S5	B-	Differential signal pair B from Phy
	S6	B+	
	S7	Gnd	2nd mate
Key and spacing separate signal and power segments			
Power segment	P1	V_{33}	3.3 V power, NOT CONNECTED
	P2	V_{33}	3.3 V power, NOT CONNECTED
	P3	V_{33}	3.3 V power, pre-charge, 2nd mate, NOT CONNECTED
	P4	Gnd	1st mate, GROUND
	P5	Gnd	2nd mate, GROUND
	P6	Gnd	2nd mate, GROUND
	P7	V_5	5V power, Precharge, 2nd mate
	P8	V_5	5V power
	P9	V_5	2nd mate, 5V power
	P10	Gnd	2nd mate, GROUND
	P11	ACT-	Activity LED- (O.C.)/Staggered Spin-up Disable Control
	P12	Gnd	1st mate, GROUND
	P13	V_{12}	12 V power, pre-charge, 2nd mate, NOT CONNECTED
	P14	V_{12}	12 V power, NOT CONNECTED
	P15	V_{12}	12 V power, NOT CONNECTED

2.8 Agency Approvals

ML320S Regulatory Number (R/N): 771692

These drives meet the standards of the following regulatory agencies:

- **Federal Communication Commission:** Verified to comply with FCC Rules for Radiated and Conducted Emission, Part 15, Subpart B, for Class B Equipment.
- **Underwriters Laboratories:** Bi-National UL Standard CAN/CSA-C22.2 No. 60950/UL 60950-1. Standard for Safety of Information Technology Equipment, including Electrical Business Equipment (File E101559).
- **TUV NORD CERT GmbH**: IEC-950 (EN60950) Standard for Safety of Information Technology Equipment, including Electrical Business Equipment. EN60065. Standard of Safety for Audio, Video, and Similar Electronic Apparatus.
- **CE Compliance for Europe**: Verified to comply with EN55022:2006 for RF Emissions and EN55024:1998, A1:2001 + A2:2003, EN61000-3-2:2000, EN61000-3-3:1995 + A1:2001 for Generic Immunity as applicable.
- **C-Tick Compliance for Australia**: Verified to comply with AS/NZ3548 for RF Emissions as required by the Australian Communications Authority.
- **Korean RRL Mark**: Registered as a Class-B product with the South Korean Ministry of Information and Communication.
- **Taiwan BSMI EMI Certification**: Certified as a Class-B product with the Bureau of Standards Metrology and Inspection (BSMI).

2.9 Full Model Number Specification

Table 2-3 below provides a summary specification of the model number suffix for this product platform.

Table 2-3. Full Model Number Description

Model Number Format	ID	Product Brand	RPM	Description
WDxxxxBEKT-XX**PVM**T0	PVM	WD Scorpio Black	7200	MX320S-1 16 MB SATA 3.0 Gb/s Halogen free

3.0 PRODUCT FEATURES

- SATA 3.0 Gb/s
- Perpendicular Magnetic Recording (PMR - Writer)/Tunneling Magneto-Resistive (TuMR - Reader)
- Reduced Power Spinup (RPS)
- System-on-Chip (SOC)
- S.M.A.R.T. Command Transport (SCT)
- Reliability Features Set—Data Lifeguard™
- Hot Plug Support
- Active LED Status
- Fluid Dynamic Bearings (FDB)
- Staggered Spin-Up and Activity Indication (SATA Power Pin 11)
- CacheFlow™
- 48-bit Logical Block Addressing (LBA)
- Power Management
- Self-Monitoring, Analysis, and Reporting Technology (S.M.A.R.T.)
- Security Mode
- Automatic Acoustic Management (AAM)

3.1 SATA 3 Gb/s

SATA 3 Gb/s is the next generation interface for SATA hard drives. It adds to the functionality of the SATA I interface with the following features:

- **Improved Power Management**— provides improved power management features including Host Initiated SATA Power Management (HIPM) and Device Initiated SATA Power Management (DIPM).
- **Staggered Spin-up** — allows the system to control whether the drive will spin up immediately or wait until the interface is fully ready before spinning up.
- **Asynchronous Signal Recovery (ASR)** — robustness feature that improves signal recovery.
- **Enclosure Services** — defines external enclosure management and support features.
- **Backplane Interconnect** — defines how to lay out signal line traces in a backplane.
- **Auto-activate DMA** — provides increased command efficiency through automated activation of the DMA controller.
- **Device Configuration Overlay (DCO)** — allows hiding of supported features via a SATA feature mask.

3.2 Perpendicular Magnetic Recording (PMR-Writer)

In perpendicular magnetic recording (PMR), the magnetization of each data bit is aligned vertically to the spinning disk, rather than longitudinally as has been the case in hard drive technology for decades. In longitudinal recording, as the bits become smaller and closer together, they experience an increasing demagnetizing field, much like two bar magnets that are placed end-to-end repel one another. A property of the media called coercivity must be increased to counteract the demagnetization to keep the bits stable under thermal fluctuations; otherwise data corruption may occur over time. Higher media coercivity has pushed the recording head write field to the limit of known materials.

In perpendicular recording, the adjacent bits attract instead of repel (as with bar magnets placed side by side,) creating more thermally stable bits. In addition, the media contains a magnetically soft underlayer (SUL) beneath the recording layer. This SUL allows a larger effective write field, thus higher coercivity media, enabling further increases in density. Lastly, because of the vertical orientation of the bits, the PMR recording layer tends to be thicker than that used for longitudinal recording, providing increased signal for the read heads. All of these benefits enable WD engineers to reliably pack more data on a given disk than is possible with conventional longitudinal recording.

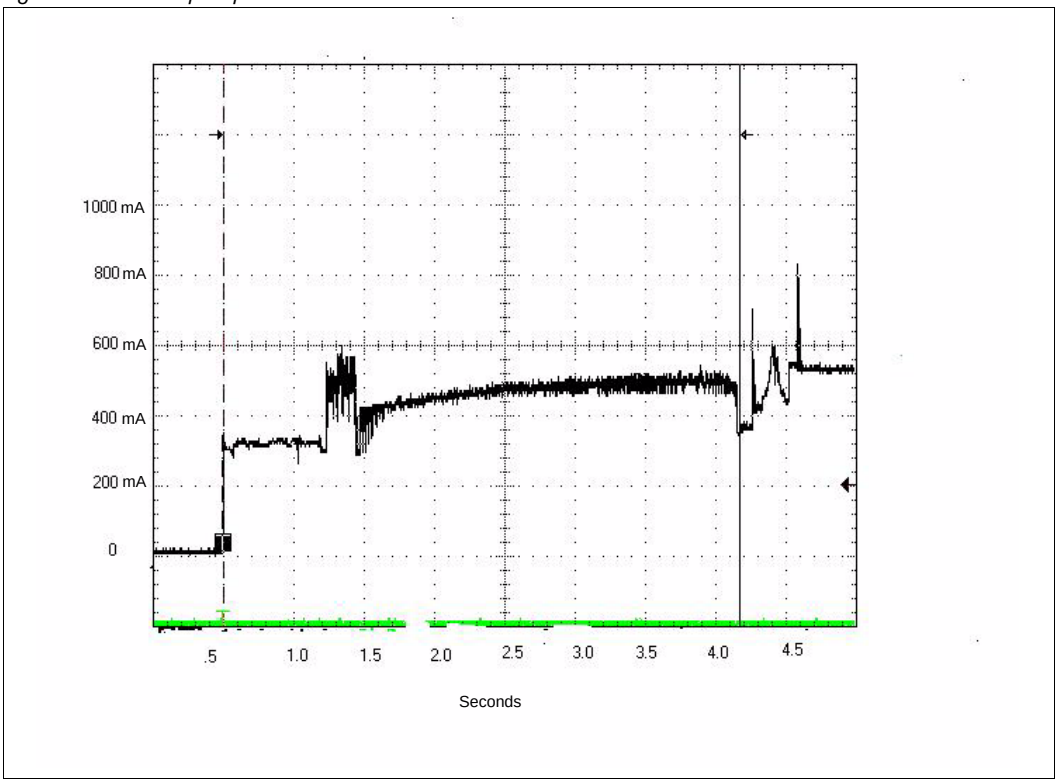
3.3 Reduced Power Spinup (RPS)

Applications for 2.5-inch hard drives like the WD Scorpio include USB external hard drives, notebook systems, and Consumer Electronics (CE). Due to the fact that many of these applications are portable in nature, an option for limiting startup current levels and increasing spinup speed is necessary.

To address this requirement, WD has developed Reduced Power Spinup (RPS) mode. RPS-enabled drives use minimal power consumption during spin up, allowing a greater range of compatibility with various systems and cables in the marketplace.

RPS mode is set via jumper. See figure 5-4 more information.

Figure 3-1. RPS Spinup Profile



Note: Current is 200 mA per 10 mV vertical deflection.

3.4 System-on-Chip (SOC)

The System-on-Chip (SOC) is the foundation for WD's next generation electronics and firmware architecture. The native SATA SOC lowers component count by integrating a hard disk controller, high performance processor, high speed execution SRAM, and read channel in a 128-pin package. The processor has a 5-stage pipeline which can execute instructions in a single cycle and a DSP engine for enhanced operations. The SOC has on-chip tightly coupled memory for high speed code and data execution that maximizes the processing bandwidth for timing critical operations. It has a high performance disk controller that incorporates maximum flexibility, modularity, performance, and low power consumption. The read/write channel has advanced detection capabilities for high-density drives.

3.5 S.M.A.R.T. Command Transport (SCT)

The SCT Command Transport feature set provides a method for a host to send commands and data to a device and for a device to send data and status to a host using log pages. Standard ATA commands may be interspersed with SCT commands, but SCT commands cannot be nested. SCT commands that do not require a subsequent data transfer operation are not interspersed with any ATA commands or each other.

The SCT Command Transport feature set provides a method for a host to send commands and data to a device and for a device to send data and status to a host using log pages. This capabilitility is used to pass commands through a driver interface or a bridge where new or unknown commands may be filtered and not passed to the drive. SCT is also used for issuing commands that require more than 8 parameter bytes. ATA8-ACS provides detailed information on the usage and capabilities of SCT. The SCT feature set includes the following commands:

- Write Same
- Read/Write Long
- Temperature Reporting

3.5.1 Write Same

The Write Same command allows the host to erase the media, or write a pattern repeatedly across the media, with a minimum of data transfer from the host. The host can clear the entire media to zeros or a specific pattern by sending this command with the pattern as a parameter—no data transfer is necessary. Write Same can write the entire media, or just a portion of the media. The host can monitor the progress of the Write Same by issuing SCT Status requests. This frees the host system to do other tasks while the media is being cleared.

3.5.2 Read/Write Long

The function performed by the Long Sector Access command is based on the obsolete ATA READ LONG/WRITE LONG capability, and has been extended beyond 28-bit addressing. The Long Sector data format for both reads and writes is two blocks long (i.e., each block is 512 bytes long). The first block contains the user data. The second data block contains the error correction and detection bytes. The remainder of the second block should contain zeros. Once the SCT command has been issued and the status response indicates that the device is ready to transfer data, log page E1h should be read or written to transfer the data. Long Sector Access commands cause a forced unit access to occur.

3.5.3 Temperature Reporting

The SCT Temperature Reporting (SCT TR) feature allows a host system to access temperature information in the drive. This information can been used to control fans or adjust the usage of various system components to keep the drive within its normal operating temperature. Applications include Enterprise, Laptop, Desktop and Consumer Electronics. SCT TR reports the maximum and minimum sustained operating limits, warning level limits, and drive damage limits. In addition to reporting the limits, SCT TR returns the current drive temperature (a temperature history which the host can use to predict heating or cooling trends) and the maximum temperature acheived during the lifetime of the drive as well as the highest temperature achieved since the power was applied to the drive. Detailed information on this capability can be found in ATA8-ACS.

3.6 Reliability Features Set

3.6.1 Data Lifeguard™[1]

Representing WD's ongoing commitment to data protection, Data Lifeguard includes features that enhance the drive's ability to prevent data loss. Data Lifeguard data protection utilities include thermal management, an environmental protection system, and embedded error detection and repair features that automatically detect, isolate, and repair problem areas that may develop over the extended use of the hard drive. With these enhanced data reliability features, the drive can perform more accurate monitoring, error repair, and deliver exceptional data security.

This self-tuning feature is performed during offline data collection scan. All user sectors on the hard drive are scanned during times of no activity from the host. Any sector determined to be written poorly (e.g., off-track), or that is difficult to recover (e.g., because of a developing media defect or thermal asperity), is marked for repair. Data Lifeguard actively guards your data, even if S.M.A.R.T. operations are disabled.

All WD drives are defect-free and low-level formatted at the factory. After prolonged use, any drive, including a WD drive, may develop defects. If you continue receiving data errors in any given file, use the Data Lifeguard Diagnostics utility to recover, relocate and rewrite the user data to the nearest spare sector and maintain a secondary defect list.

CAUTION: As with all format utilities, some options in the Data Lifeguard Diagnostics utility will overwrite user data.

Download the latest versions of the Data Lifeguard Diagnostic and Data Lifeguard Tools programs at *support.wdc.com.*

3.6.2 Thermal Management

The drive is designed with Thermal Management features for high reliability.

- **State-of-the-art mechanical design**—Mechanical design is optimized to reduce the drive's temperature. State-of-the-art thermal dissipation and windage design is employed.
- **Closed loop servo management**—Thermal management monitors the drive temperature and can control servo operations to maintain a stable operating temperature under high temperature conditions. This is a closed loop servo and thermal control system.
- **S.M.A.R.T. HDA Temperature Attribute**—The S.M.A.R.T. HDA Temperature Attribute is supported.
- **Ducted airflow**—Provides protection to the Read/Write element from heated air.

1. Default shipping configuration has Data Lifeguard feature disabled for power management optimization.

3.6.3 Internal Environmental Protection System

This system protects the inside environment of the drive from contamination. System features include:

- Filtration System to ensure fast clean-up times
- Directed airflow to maximize mechanical cooling
- Increase casting surface area to maximize cooling
- Ducted air flow to protect read/write elements from heated air
- Breather filter located at low pressure area
- Enhanced heat dissipation

3.6.4 Recoverable Errors

A sector marked for repair is written back to the same location. The sector is then read several times to be sure that it was written correctly and that there is no media damage at its location (sector test). If the sector does not easily and consistently read correctly, the sector is then relocated with original data.

3.6.5 Unrecoverable Errors

If an unrecoverable error is found during the offline scan, the sector is marked. Future reads from this location will continue to perform full error recovery. However, the next write to this location will perform a sector test to be sure the media is not damaged, and the sector relocated if the sector test fails.

3.6.6 Self Test

Self Test is a quick way to determine the operation status of a drive. The following Self Tests are supported:

- Quick Test: Completes in less than two minutes.
- Extended Test: Tests all the critical subsystems of the drive.
- Conveyance Test: Quickly identifies issues caused by handling damage.
- Selective Test: Scans host-defined sections of the drive.

The test may be run to completion or be performed as a background task as the drive processes other commands from the host. The host may then poll the drive for runtime status and test results. Since the test is embedded in the drive's firmware, it is always available, requires no installation and can be faster and more effective than a software-based drive test.

3.6.7 ATA Error Logging

ATA Error Logging provides an industry standard means to record error events and supporting information that is then accessible by the host. The event record includes the exact command that caused the failure, the response of the drive, the time of the event and information about the four commands immediately prior to the errant command. Error Logging can reliably and quickly determine whether a system problem is the result of a hard drive failure or other component malfunction. Error Logging retains total error count for the life of the drive and complete records for the last five errors.

3.6.8 Defect Management

Every WD drive undergoes factory-level intelligent burn in, which thoroughly tests for and maps out defective sectors on the media before the drive leaves the manufacturing facility. Following the factory tests, a primary defect list is created. The list contains the cylinder, head, and sector numbers for all defects.

Defects managed at the factory are sector slipped. Grown defects that can occur in the field are mapped out by relocation to spare sectors on the inner cylinders of the drive.

3.6.9 Automatic Defect Retirement

The automatic defect retirement feature automatically maps out defective sectors while reading or writing. If a defective sector appears, the drive finds a spare sector.

The following item is specific to automatic defect retirement on writes (write auto-relocation):

- Data is always written to disk (using automatic defect retirement if required) and no error is reported.

The following item is specific to automatic defect retirement on reads (read auto-relocation):

- When host retries are enabled, the drive will internally flag any unrecoverable errors (DAMNF or ECC). This flagging allows subsequent write commands to this location to relocate the sector only if the sector test fails.

3.6.10 Error Recovery Process

The drive has five means of error recovery:

- ECC On-the-Fly
- Read/Write Retry Procedure
- Extended Read Retry Procedure

ECC On-the-Fly – If an ECC error occurs, the drive attempts to correct it on-the-fly without retries. Data can be corrected in this manner without performance penalty. The details of the correction algorithm appear in the next section.

Read/Write Retry Procedure – This retry procedure is used by all disk controller error types. If the procedure succeeds in reading or writing the sector being tried, then recovery is complete and the controller continues with the command. Each retry operation also checks for servo errors. The procedure ends when error recovery is achieved or when all possible retries have been attempted.

Extended Read Retry Procedure – This retry procedure tries combinations of positive/negative track offsets and data DAC manipulations to recover the data. This retry procedure applies only to read data recovery. The Read/Write Retry procedure performs the actual retry operation.

When an extended retry operation is successful, the controller continues with the command. The controller clears any changes in track offset or data DAC settings before the command continues.

3.7 Hot Plug Support

SATA supports hot plugging (also known as “hot swapping”), the ability to swap out a failed hard drive without having to power down the system or reboot. This capability contributes to both data availability and serviceability without any associated downtime, making it a critical feature for extending SATA into enterprise applications.

WD SATA drives support hot plugging only in systems where a SATA hard drive storage backplane is used.

The Serial ATA revision 2.5 specification requires staggered pins for both the hard drive and drive receptacles. Staggered pins mate the power signals in the appropriate sequences required for powering up the hot plugged device. These pins are also specified to handle in excess of the maximum allowed inrush current that occurs during drive insertion. SATA-compliant devices thus need no further modification to be hot pluggable and provide the necessary building blocks for a robust hot plug solution, which typically includes:

- Device detection even with power downed receptacles (typical of server applications).
- Pre-charging resistors to passively limit inrush current during drive insertion.
- Hot plug controllers to actively limit inrush current during drive insertion.

3.7.1 Hot Plug Technical Issues

Reliable hot plugging of disk drives requires careful design of specific issues. Generally, hot plugging is only allowed when blind mating with a backplane, where there are controlled tolerances for alignment of mating connectors. The main issue is preventing droop (a momentary drop in voltage) of the backplane's voltage busses during insertion because of inrush current to charging bypass capacitors in the disk drive.

3.7.1.1 Methods of Controlling Inrush Current

There are two methods of limiting inrush current when hot plugging disk drives. They are hot plug controller IC's and precharge resistors.

3.7.1.1.1 Hot Plug Controller IC's

Hot plug controller IC's ramp up voltages to the inserted disk drive at a controlled slow rate (a constant dv/dt), after full connector mating has been established. This eliminates almost all inrush current. This method does not require staggered precharge contacts, although there usually is a staggered ground 'mate first' pin(s) to ensure ground connection before making power and signal connections. Sometimes added ground pins on both ends of the mating connector are staggered 'mate last' providing the hot plug controller a clear indication of all other pins making solid contact. From an engineering standpoint, this is the most reliable method of hot plugging disk drives, but is expensive to implement on backplanes.

3.7.1.1.2 Precharge Resistors

Current limiting series precharge resistors on designated power pins make contact before hard power connection is made, providing controlled partial charge of the disk drive's decoupling capacitors. This partial charge is due to IR drop across the precharge resistor caused by disk drive DC loads at partial power. A second current surge occurs when final power connections are made, completing charge of the decoupling capacitors. Use of precharge resistors requires three stages of contact sequencing on the mating connector. The first stage makes initial ground contact, establishing a ground reference between the disk drive and backplane. It also discharges any ESD voltage between the two devices. The second stage contacts connect the precharge resistors, supplying limited current to the inserting disk drive's voltage busses. This allows partial charging of decoupling capacitors on the disk drive. Stage three contacts make hard power and signals connections. The ideal value for precharge resistors is where peak inrush current for both the precharge resistor connections and final hard power connections are similar in amplitude. Even with precharge resistors, there may be some momentary droop of the backplane

voltage busses. This residual droop needs to be eliminated or at least reduced to a very small value because most power distribution budgets do not provide allowances for this droop. Low ESR bulk capacitors installed on the backplane voltage busses for each hot plug connector can minimize this droop. Organic dielectric aluminum electrolytic's like OSCON capacitors are a good choice.

3.7.1.2 Capacitor Inrush Current Issues

Tantalum decoupling capacitors can be damaged if inrush current is excessive. Inrush current issues with Tantalum capacitors are complex, but manufactures recommend, as a general rule, 1 ohm of resistance for every volt being switched or a maximum inrush current of 1 amp. See "Surge in solid Tantalum Capacitors" by John Gill of AVX Corporation. This limits the lowest value of precharge resistance for each voltage bus used to a resistance in ohms equal to the bus voltage in volts.

3.7.1.3 Connector Inrush Current Issues

The SATA specification requires 1.5 amps current capacity for every power connector pin. This is well above the initial precharge resistor inrush current limit set by tantalum capacitor requirements. The second inrush current spike when hard power connection is made along with whatever DC current has been established at that time could exceed 1.5 amps but for too short a period of time (<1 ms) to have any affect on connector reliability.

3.7.1.4 Disk Drive Hot Plug Insertion Velocity

The delay between precharge resistor connections and final power connections must be sufficient to allow precharge resistor charging of the disk drives power busses to at least 90% of maximum value the precharge resistors are capable of. The following compares calculated maximum allowable insertion velocity with SATA specification insertion velocity analysis.

3.7.1.4.1 Calculated Velocity

The minimum SATA mating connector staggered pin spacing is 0.35 millimeters. Disk drives typically have around 20mF input capacitance on power busses. Assuming 20mF total decoupling capacitance and a 10-ohm series precharge resistor, the precharge time constant is 0.2 milliseconds. From this, the maximum total precharge time to 90% of full charge is around 2.2 ´ 0.2 milliseconds or 0.44 milliseconds. Therefore, the maximum insertion velocity allowed is .035 centimeters divided by 0.44 milliseconds giving a maximum insertion velocity of 80 centimeters per second.

3.7.1.4.2 SATA Insertion Velocity Analysis

The SATA specification has done tests with hot plug insertion speed. The fastest insertion velocities achieved produced a staggered contact delay of 3 milliseconds, well within the previous 0.44 millisecond calculated minimum staggered pin delay allowed. The SATA specification also states that the average effective input capacitance of most of the disk drives tested was 20 mF, the same value used in the previous calculations. The hot plug verification test procedure later in this document includes a test to verify this information.

3.7.1.5 SATA Disk Drive Hot Plug Design Issues

The SATA specification provides pins for series precharge resistors allowing use of this less expensive implementation. This does not exclude the backplane designer from using hot plug controller IC's for a more robust design. The only design requirements for the SATA disk drive its self are providing staggered precharge contacts on the hot plug connector per the SATA specification and ensuring that decoupling capacitors can tolerate a momentary inrush current of about 1 ampere.

3.7.1.5.1 Future Disk Drive Design Change Issues

Any increase in effective decoupling capacitance above 20 mF on any of the disk drive's voltage busses could affect the hot plug compatibility. Any significant change in power-up DC load at power up

could also be a problem with backward compatibility. Both these issues need new specification items in drive specifications to set limits for both the disk drive designers and designers of hot plug enclosures.

3.7.1.6 Hot Plug Removal Issues

Generally, removal of hot plug disk drives does not present any technical issues. Drives are usually in a low power state prior to removal. Decoupling capacitors in the disk drive will continue to provide power long enough to soften the sudden loss of current. Bulk capacitors in the power supply and backplane will absorb the drop in power long enough for the regulators to adjust.

3.7.1.7 ESD Issues

Prior to insertion, disk drives can have static charges of thousands of volts relative to the enclosure. This charge needs discharging during the insertion process. If insertion guides are ESD resistive, they will discharge the static charge prior to contact with the mating connector. If the guides are not conductive, then any static charge will discharge at first contact of the mating connector ground pins. This sudden discharge will normally not cause any problems because the static charge of the disk drive is common mode to all internal circuitry making internal differential current and voltages low during discharge. Because of the unpredictable nature of ESD, use of ESD resistive (not metal) insertion guides is a safer solution since it gradually discharges any static charge. Having the disk drive enclosed in a canister also helps ensure proper discharge. It is the responsibility of the hot plug enclosure designer to handle ESD issues in a safe manner.

3.7.1.8 Drive Canisters

Hot pluggable disk drives can be enclosed in a canister for added protection. This added protection is both mechanical and electrical. The main electrical protection is from ESD. Canisters prevent any local discharge onto sensitive parts of the disk drive during handling and insertion. Canisters do increase the cost of the system.

3.8 Active LED Status

The drive supports external LED requirements. It provides an activity LED output which is ON during command execution and OFF otherwise.

The drive strength of this open Drain Drive Active signal is that it can sink 12mA to 0.4V Max. It is 5V tolerant, meaning that the external LED may be driven from +5V or +3.3V so long as the Host system provides a series resistor to limit the LED current to the lower of 12mA or the rated operating current of the LED. As an example with +5V and a 2 volt forward drop across a 10mA LED, a 300 Ohm 5% 1/16W resistor would be suitable. In the case of a 3.3V supply for the same LED, the resistor would be 130 Ohm 5% 1/16W.

The pin corresponding to P11 shall be used for Active LED (see “Device Pin Connector Pin Definitions” on page 11).

3.9 Fluid Dynamic Bearings (FDB)

Bearing design that incorporates a layer of high-viscosity lubricant instead of ball bearings in the hard drive spindle motor. As an alternative to conventional ball bearing technology, FDB designs provide increased non-operational shock resistance, speed control, and improved acoustics.

3.10 Staggered Spinup and Activity Indication (SATA Power Pin 11)

SATA device power connector pin 11 (see “Standard Factory Connectors” on page 11) is defined as a means by the host to DISABLE staggered spinup and it may also be used by the device to provide the host with an activity indication. According to the SATA II specs, "Staggered Spin-up Disable and Activity Signal shall not be enabled at the same time."

3.10.1 Staggered Spinup

When multiple disks are installed in an enclosure, it is desirable to provide a simple mechanism by which a subsystem controller can sequence hard drive initialization to minimize the current load presented during power up. Staggered spinup provides this mechanism by preventing the hard drives from spinning up until after successful PHY initialization (i.e., after PHY enters DP7:DR_Ready state).

Staggered spinup is only applicable during initial power-up. If a drive is spun down using ATA commands—as a result of having been placed in Standby or Sleep power modes, for example—the drive shall spin up following the rules that govern spinup from low power modes described in ATA/ATAPI-6 or later.

3.10.2 Activity Indication

The host controller through SATA power pin 11 may access storage device status and activity. The signal provided by the device for activity indication is a low-voltage low-current signal. It is not suitable for directly driving an LED. A buffer circuit external to the device must be employed to drive the LED. The activity signal is based on an open-collector or open-drain active low driver. The device shall tolerate the activity signal being shorted to ground.

3.11 CacheFlow™

CacheFlow is WD’s unique, multi-generation disk caching system. It incorporates read cache with write cache.

WD designed CacheFlow to obtain maximum performance with today’s most popular operating systems and applications. CacheFlow increases performance over prior caching algorithms by increasing the number of times that requested data is in the cache. This reduces the number of host commands that require actual media access thereby improving overall drive performance.

Typical applications perform a variety of access patterns, such as random, sequential, and repetitive. CacheFlow is designed to dynamically adapt to the changes in access patterns that occur during the course of application execution.

Random mode is the default operational mode for CacheFlow. Once CacheFlow detects a sequential access pattern, it leaves random mode. CacheFlow also performs predictive read operations to increase the probability that data requested in future commands already exists in the cache.

CacheFlow partitions the buffer into multiple segments to allow for the fact that applications may access multiple non-contiguous areas on the disk. CacheFlow tracks the amount of valid data in each segment and controls the deallocation of segments to maximize drive performance.

3.11.1 Write Cache

CacheFlow is designed to improve both single and multi-sector write performance by reducing delays caused by seek time and rotational latency.

The write cache adaptively detects random and sequential access patterns during application execution.

If a defective sector is found during a write cache operation, that sector is automatically relocated before the write occurs.

3.11.2 Read Cache

CacheFlow implements a multiple segment read cache. Cache segments are assigned to read commands as they are received from the host.

Each read segment consists of pre and post read sectors in addition to the host-requested sectors. This maximizes the amount of cache data in the drive's buffer, thereby increasing the likelihood of cache hits and improving overall performance.

3.11.3 48-bit Logical Block Addressing (LBA)

The 48-bit Address feature set allows devices with capacities up to approximately 281 tera sectors or approximately 144 peta bytes. In addition, the number of sectors that may be transferred by a single command are increased by increasing the allowable sector count to 16 bits.

48-bit Address					
Bits (47:40)	**Bits (39:32)**	**Bits (31:24)**	**Bits (23:16)**	**Bits (15:8)**	**Bits (7:0)**
LBA High (exp)	LBA Mid (exp)	LBA Low (exp)	LBA High	LBA Mid	LBA Low

16-bit Sector Count	
Bits (15:8)	**Bits (7:0)**
Sector Count (exp)	Sector Count

3.12 Power Management

The drives support the ATA power management commands that lower the average power consumption of the hard drives. For example, to take advantage of the lower power consumption modes of the drive, an energy efficient host system could implement a power management scheme that issues a Standby Immediate command when a host resident disk inactivity timer expires. The Standby Immediate command causes the drive to spin down and enter a low-power mode. Subsequent disk access commands would cause the drive to spin up and execute the new command.

To avoid excessive wear on the drive due to the starting and stopping of the HDA, set the host's disk inactivity timer to no shorter than ten minutes.

The drives also support the SATA power management feature that lowers the average power consumption of the SATA interface.

3.13 Self-Monitoring, Analysis, and Reporting Technology (S.M.A.R.T.)

S.M.A.R.T. helps you monitor a drive's internal status through diagnostic commands at the host level.

The drive monitors Read Error Rate, Start/Stop Count, Re-allocated Sector Count, Seek Error Rate, Power-on Hours Count, Spin-up Retry Count, Drive Calibration Retry Count, Drive Power Cycle Count, Offline Scan Uncorrectable Sector Count, Ultra ATA CRC Error Rate, Multi-zone Error Rate, Spin-up Time, Relocation Event Count, and Current Pending Sector Count. The hard drive updates and stores these attributes in the reserved area of the disk. The drive also stores a set of attribute thresholds that correspond to the calculated attribute values. Each attribute threshold indicates the point at which its corresponding attribute value achieves a negative reliability status.

3.14 Security Mode

The Security Mode feature set allows the user to create a device lock password that prevents unauthorized hard drive access even if the drive is removed from the computer.

3.14.1 Master and User Passwords

The manufacturer/dealer can set a master password using the Security Set Password command, without enabling the device lock function. The user password should be given or changed by a system user.

Master Password Identifier is supported and set to a default value of 00FE. If a Master Password is set via a Security Set Password Command, a valid Master Password Revision code value of 0001h – 00FEh must be used. A Master Password Identifier of 0000h is ignored.

When the master password is set, the drive does *not* enable the device lock function. When the user password is set, the drive enables the device lock function, and the drive is locked after the next power on reset or hard reset.

3.14.2 Security Levels

High - If High level security is set and the user password is forgotten, the master password can be used to unlock the drive and access the data.

Maximum - If Maximum level security is set and the user password is forgotten, data access is impossible. Only the master password with a Security Erase Unit command can unlock the drive when the device lock function is enabled and the user password has been forgotten. When the Security Erase Unit command is used to unlock the drive, all user data is erased.

3.15 Automatic Acoustic Management (AAM)

The AAM feature allows the host to select the acoustic level of the hard drive. When quiet operation is essential, the drive may be set to operate in the Acoustic Mode to minimize the hard drive's sound level.

The Performance Mode results in slightly higher acoustic levels while optimizing the performance of the drive. The Set Features command is used to set the AAM level.

4.0 AT COMMAND SET

4.1 Host Interface Commands

4.1.1 ATA-7/ATA-8 Commands

Table 4-1 lists the hexadecimal codes specific to each ATA-7/ATA-8 command supported by these hard drives. Refer to the D1699 ATA8-ACS specification for full details on each command.

Table 4-1. ATA-7/ATA-8 Command Opcodes

COMMAND	HEX OPCODE
CHECK POWER MODE	E5
DEVICE CONFIGURATION FREEZE LOCK	B1
DEVICE CONFIGURATION IDENTIFY	B1
DEVICE CONFIGURATION RESTORE	B1
DEVICE CONFIGURATION SET	B1
DOWNLOAD MICROCODE	92
EXECUTE DEVICE DIAGNOSTIC	90
FLUSH CACHE	E7
FLUSH CACHE EXT	EA
IDENTIFY DEVICE	EC
IDLE	E3
IDLE IMMEDIATE	E1
NOP	00
READ BUFFER	E4
READ DMA	C8
READ DMA EXT	25
READ LOG EXT	2F
READ MULTIPLE	C4
READ MULTIPLE EXT	29
READ NATIVE MAX ADDRESS	F8
READ NATIVE MAX ADDRESS EXT	27
READ SECTOR(S)	20
READ SECTORS(S) EXT	24
READ VERIFY SECTOR(S) EXT	42
READ VERIFY SECTORS(S)	40
S.M.A.R.T.	B0
SECURITY DISABLE PASSWORD	F6
SECURITY ERASE PREPARE	F3
SECURITY ERASE UNIT	F4
SECURITY FREEZE LOCK	F5
SECURITY SET PASSWORD	F1
SECURITY UNLOCK	F2
SET FEATURES	EF
SET MAX	F9
SET MAX ADDRESS EXT	37
SET MULTIPLE	C6
SLEEP	E6

COMMAND	HEX OPCODE
STANDBY	E2
STANDBY IMMEDIATE	E0
WRITE BUFFER	E8
WRITE DMA	CA
WRITE DMA EXT	35
WRITE LOG EXT	3F
WRITE MULTIPLE	C5
WRITE MULTIPLE EXT	39
WRITE SECTOR(S)	30
WRITE SECTOR(S) EXT	34

4.1.2 SATA 2.5 Commands

Table 4-2 lists the hexadecimal codes specific to each SATA 2.5 command supported by these hard drives. Refer to the SATA 2.5 specification for full details on each command.

Table 4-2. SATA 2.5 Command Opcodes

COMMAND	HEX OPCODE
READ FPDMA QUEUED	60
WRITE FPDMA QUEUED	61

4.1.3 Obsolete Commands

Table 4-3 lists the hexadecimal codes specific to each obsolete command supported by these hard drives.

Table 4-3. Obsolete Command Opcodes

COMMAND	HEX OPCODE
INITIALIZE DEVICE PARAMETERS	91
RECALIBRATE	10
SEEK	70

4.1.4 SCT Commands

SCT commands provide capabilities not covered in ATA/ATAPI-7 for commands that do not fit the ATA command delivery model. Some SCT commands report completion when the command begins execution. Execution progress for these commands may be checked by requesting SCT status. For instance, the host can track the progress of a Write Same command by issueing a status request once per minute. See ATA8-ACS for a full description of SCT.

Table 4-4. SCT Action Codes

ACTION CODE	DESCRIPTION
0000h	RESERVED
0001h	Long Sector Access
0002h	Write Same
0003h	Error Recovery Control
0004h	Features Control
0005h	SCT Data Tables
0006h	Vendor specific
0007h	BFFFh Reserved
C000h	FFFFh Vendor specific

4.2 S.M.A.R.T. (B0h)

The S.M.A.R.T. command provides access to attribute values, S.M.A.R.T. status, and other S.M.A.R.T. information. These commands can be used for logging and reporting purposes, and for accommodating special user needs.

Prior to writing the S.M.A.R.T. command to the Command Register, the host must write key values into the LBA Mid and LBA High Registers (4Fh, C2h) or the command will be aborted and an error will be reported.

The S.M.A.R.T. command has several sub-commands that are selectable via the Features Register when the host issues the S.M.A.R.T. command. To select a sub-command, the host must write the appropriate sub-command code to the Features Register before issuing the S.M.A.R.T. command. The sub-commands and their respective codes are listed below. For more detailed information on executing S.M.A.R.T. commands, please see the ATA specification.

4.2.1 Read Attribute Values Sub-Command

This command returns a sector of data with the drive's S.M.A.R.T. data structure.

Table 4-5. Definitions for the 512 Bytes.

BYTE	VALUE	DESCRIPTION
0 - 1	0010h	S.M.A.R.T. Data Structure Revision
2 - 361	XX	S.M.A.R.T. Attribute Data
362	XX	Offline data collection status 0Xh OL disabled 8Xh OL enabled X0h scan not run X2h scan complete X4h scan suspended X5h scan aborted
363	XX	Self-Test execution status byte. 00h The previous self-test routine completed without error or no self-test has ever been run 01h The self-test routine was aborted by the host

BYTE	VALUE	DESCRIPTION
		02h The self-test routine was interrupted by the host with a hard or soft reset 03h A fatal error or unknown test error occurred while the device was executing its self-test routine. The device was unable to complete the self-test routine. 04h The previous self-test completed having a test element that failed. The test element that failed is not known. 05h The previous self-test completed having a test element that failed. The electrical element of the test failed. 06h The previous self-test completed having a test element that failed. The servo (and/or seek) test element of the test failed. 07h The previous self-test completed having a test element that failed. The read element of the test failed. 08h The previous self-test completed having a test element that failed. The element damage is suspected to be caused by handling. 09-0Eh Reserved 0Fh Self-test routine in progress
364 - 365	XX	Total time in seconds to complete offline data collection activity
366	XX	Reserved
367	7Bh	Offline data collection capability. Bits are as follows: 0 1 = Offline Immediate Command supported 1 1 = Auto Offline enable\disable command supported 2 0 = Offline will suspend on and will resume after host command 3 1 = Offline read scan implemented 4 1 = DST Short and Extended tests supported 5 1 = DST Conveyance test supported 6 1 = DST Selective test supported 7 0 = Reserved
368 - 369	0003h	S.M.A.R.T. Capability. Bits are as follows: 1 1 = The device saves SMART data prior to going into a power saving mode 1 1 = Device complies with SMART data autosave after an event 2-15 Reserved
370	01h	Error logging capability. Bits are as follows: 0 1 = Error logging supported 1 Reserved
371	XX	Reserved
372	XX	Short self-test routine completion time in minutes
373	XX	Extended self-test routine completion time in minutes
374	XX	Conveyance self-test routine completion time in minutes
375 - 510	XX	Reserved
511	XX	Checksum

4.2.2 Supported Attributes

The drive supports the following attributes.

Attribute	Attribute ID Number	Pre-Failure/Advisory Bit (Status Flags bit 0)[1]
Read Error Rate	1	Pre-Failure
Spin-up Time	3	Pre-Failure
Start/Stop Count	4	Advisory
Re-allocated Sector Count	5	Pre-Failure
Seek Error Rate	7	Advisory
Power-on Hours Count	9	Advisory
Spin-up Retry Count	10	Advisory
Drive Calibration Retry Count	11	Advisory
Drive Power Cycle Count	12	Advisory
Emergency Retract Cycles	192	Advisory
Load/Unload Cycles	193	Advisory
HDA Temperature[2]	194	Advisory
Relocation Event Count	196	Advisory
Current Pending Sector Count	197	Advisory
Offline Scan Uncorrectable Sector Count	198	Advisory
Ultra ATA CRC Error Rate	199	Advisory
Multi-zone Error Rate	200	Advisory

[1] Status bits are typical but may vary.
[2] See "Temperature Reporting" on page 16 for a better mechanism.

Attributes that use the Pre-Failure/Advisory Bit Set can predict potential future degrading or faulty conditions. Attributes with the Failure/Advisory Bit Clear are used for informational purposes only, they do not indicate impending drive failure.

The S.M.A.R.T. data saving process is a background task. After a pre-determined idle period, the self-monitoring data is automatically saved to the disk.

4.2.3 Read Log Sector

There are several logs that can be read with the S.M.A.R.T. Read Log Sector sub-command. The LBA Low Register indicates the log sector to be returned.

Table 4-6. Defined Error Logging Sectors

Log address	Content	Log Cmds	R/W
00h	Log directory	ExtLog	RO
01h	Summary Log (up to 5 errors)	SMART	RO
02h	Comprehensive SMART error log. (5 errors per sectors)	SMART	RO
03h	Extended Comprehensive SMART error log. (4 errors per sectors)	ExtLog	RO
04h-05h	Reserved	Reserved	Reserved
06h	SMART self-test log	SMART	RO
07h	Extended SMART self-test log	ExtLog	RO
08h-0FH	Reserved	Reserved	Reserved
09H	Selective self-test log	SMART	R/W
0Ah-0Fh	Reserved	Reserved	Reserved
11h	SATA PHY Counters	ExtLog	RO
12h-17h	Reserved for Serial ATA	Reserved	Reserved
18h-7Fh	Reserved	Reserved	Reserved
80h-9Fh	Host vendor specific	SMART / ExtLog	R/W
A0h-BFh	Device vendor specific	SMART / ExtLog	VS
C0h-DFh	Reserved	Reserved	Reserved
E0h-E1h	SMART Command Transport(SCT)	SMART / ExtLog	R/W
E2h-FFh	Reserved	Reserved	Reserved

RO – Read Only
R/W – Read / Write
SMART – Supported by B0h command code.
ExtLog – Supported by 2Fh/3Fh command code.
VS – Vendor Specific

4.2.4 Offline Data Collection

The drive supports offline data collection. The multi-zone error rate is an attribute computed from data gathered during offline activities. Offline data collection is initiated by either the S.M.A.R.T. Offline Immediate command or the S.M.A.R.T. Enable Automatic Offline command.

There are two internal firmware timers that control automatic offline data collection. The first internal firmware timer is referred to as the Spin Timer. The Spin Timer accumulates the number of hours the drive is powered on. Once this timer reaches 8 hours, an offline data collection is said to be “pending.” The second internal firmware timer is referred to as the Idle Timer. The Idle Timer accumulates the number of seconds since the drive has received a command from the host. Once the Idle Timer reaches 15 seconds, a “pending” offline data collection process begins. If an in-process automatic offline data collection process is interrupted by a host command, the automatic offline data collection process will then resume after 15 minutes of power on followed by 15 seconds of idle time. If the Standby Timer expires while an offline scan is pending or already in progress, the scan will complete before the drive spins down.

4.3 Identify Device (ECh)

The Identify Device command transfers 512 bytes of data that specify the drive's parameters. Table 4-7 lists the parameters read by the host.

Table 4-7. Identify Device Command

WORD	FIELD DESCRIPTION	VALUE
0	General Configuration	427Ah
1	Obsolete	0
2	Specific Configuration	XXXX
3	Obsolete	0
4	Retired	0
5	Retired	0
6	Obsolete	0
7-8	Reserved for assignment by the CompactFlash™ Association	0
9	Retired	0
10-19	Serial Number (ATA String)	WDnnnnnnnn
20	Retired	0
21	Retired	0
22	Obsolete	0
23-26	Firmware Revision (ATA String)	nnnn
27-46	Model Numbers (ATA String)	"WDC WD1600BEKT-nnnnnn" "WDC WD2500BEKT-nnnnnn" "WDC WD3200BEKT-nnnnnn"
47	READ/WRITE MULTIPLE support	8010h
48	Trusted Computing feature set options	0
49	Capabilities Bit 14-15: Reserved for the IDENTIFY PACKET DEVICE command. Bit 13: 1 = Standby timer values as specified in this standard are supported 0 = Standby timer values shall be managed by the device Bit 12: Reserved for the IDENTIFY PACKET DEVICE command. Bit 11: 1 = IORDY supported 0 = IORDY may be supported Bit 10: 1 = IORDY may be disabled Bit 9: 1 = LBA supported Bit 8: 1 = DMA supported	2F00h
50	Capabilities Bit 15: Shall be cleared to zero. Bit 14: Shall be set to one. Bit 13-2: Reserved. Bit 1: Obsolete Bit 0: Shall be set to one to indicate a device specific Standby timer value minimum	4001h
51-52	Obsolete	0
53	Bit 8-15: Free-fall Control Sensitivity 00h = Vendor's recommended setting 01h-FFh = Sensitivity level. A larger number is a more sensitive setting. Bit 7-3: Reserved Bit 2: If set, the fields reported in word 88 are valid Bit 1: If set, the fields reported in words (70:64) are valid	0007h
54-58	Obsolete	0
59	Current Blocking Factor Value set with Set Multiple command	XX

WORD	FIELD DESCRIPTION	VALUE
60-61	Total number of user addressable logical sectors (DWord)	WDC WD1600BEKT (312,581,808) WDC WD2500BEKT (488,397,168) WDC WD3200BEKT (625,142,448)
62	Obsolete	0
63	Multi-Word DMA Transfer Mode Supported Bit 10: If set, Multiword DMA mode 2 is selected Bit 9: If set, Multiword DMA mode 1 is selected Bit 8: If set, Multiword DMA mode 0 is selected Bit 0-2: If set, Multiword DMA mode 2 and below are supported	XX07h
64	Advanced PIO Modes Supported Bits 0-7: PIO Modes supported	0003h
65	Min. Multi-Word DMA Transfer Cycle Time (ns)	120
66	Manufacturer Recommended Multi-Word DMA Cycle Time (ns)	120
67	Min. PIO Transfer Cycle Time without flow control (ns)	120
68	Min. PIO Transfer Cycle Time with IORDY flow control (ns)	120
69-74	Reserved	0
75	Queue Depth Bit 4-0: Maximum queue depth - 1	31
76	Serial ATA Capabilities Bit 15-13: Reserved Bit 12: Supports Native Command Queuing priority information Bit 11: Supports Unload while NCQ commands outstanding Bit 10: Supports Phy event counters Bit 9: Supports receipt of host-initiated interface power management requests Bit 8: Supports Native Command Queuing (NCQ) Bit 7-3: Reserved for future Serial ATA signaling speed grades Bit 2: 1= Supports Serial ATA Gen2 signaling speed (3 Gb/s) Bit 1: 1= Supports Serial ATA Gen1 signaling speed (1.5 Gb/s) Bit 0: Shall be cleared to zero	0001 1111 0000 0110b 1F06h
77	Reserved for Serial ATA	0000
78	Serial ATA Features Supported Bit 7-15: Reserved for Serial ATA Bit 6: If set, device supports software settings preservation Bit 5: Reserved for Serial ATA Bit 4: If set, device supports in-order data delivery Bit 3: If set, device supports initiating power management Bit 2: If set, device supports DMA Setup Auto-activation Bit 1: If set, device supports non-zero buffer offsets Bit 0: Cleared to zero	0000 0000 010 0 1100b
79	Serial ATA Features Enabled Bits 7-15: Reserved for Serial ATA Bit 6: If set, software settings preservation enabled Bit 5: Reserved for Serial ATA Bit 4: If set, In-order data delivery enabled Bit 3: If set, device initiated power management enabled Bit 2: If set, DMA Setup Auto-activation enabled Bit 1: If set, non-zero buffer offsets enabled Bit 0: Cleared to zero	0000 0000 0X0X XXX0b
80	Major Version Number ATA-8 and below supported	01FEh
81	Minor Version Number	0

WORD	FIELD DESCRIPTION	VALUE
82	Command and feature sets supported Bit 14: If set, NOP command supported Bit 13: If set, Read buffer command supported Bit 12: If set, Write buffer command supported Bit 11: Obsolete Bit 10: If set, Host Protected Area Feature Set supported Bit 9: If set, Device Reset command supported Bit 8: If set, Service interrupt supported Bit 7: If set, Release interrupt supported Bit 6: If set, look-ahead supported Bit 5: If set, Write Cache supported Bit 4: Cleared to 0 to indicate that the PACKET feature set is not supported. Bit 3: If set, mandatory Power Management Feature Set supported Bit 2: Obsolete Bit 1: If set, Security Feature Set supported Bit 0: If set, SMART Feature Set supported	0111 0100 0110 1011b
83	Command Set Supported Bit 15: Shall be cleared to 0 Bit 14: Shall be set to 1 Bit 13: If set, Flush Cache EXT command supported Bit 12: If set, mandatory Flush Cache command supported Bit 11: If set, DCO feature set supported Bit 10: If set, 48-bit Address Feature Set supported Bit 9: If set, AAM feature set supported Bit 8: If set, Set Max Security Extension supported Bit 7: Reserved Bit 6: If set, Set Features subcommand required to spin-up after power-up Bit 5: If set, Power-Up In Standby feature set supported Bit 4: Obsolete Bit 3: If set, Advanced Power Management feature set supported Bit 2: If set, CFA feature set supported Bit 1: If set, Read/Write DMA Queued supported Bit 0: If set, Download Microcode command supported	0111 1111 0000 1001b
84	Command and Feature sets supported Bit 15: Shall be cleared to zero Bit 14: Shall be set to one Bit 13: If set, Idle Immediate with Unload Feature supported Bit 12: Reserved Bit 11: Reserved Bit 9-10: Obsolete Bit 8: If set, 64-bit World wide name supported Bit 7: If set, Write DMA Queued FUA EXT command supported Bit 6: If set, Write DMA FUA EXT and Write Multiple FUA EXT commands supported Bit 5: If set, General Purpose Logging feature set supported Bit 4: If set, Streaming Feature Set supported Bit 3: If set, Media Card Pass Through Command feature set supported Bit 2: If set, Media serial number supported Bit 1: If set, SMART Self-Test supported Bit 0: If set, SMART Error Logging supported	0110 0001 0110 0011b
85	Command and Feature sets supported or enabled Bit 15: Obsolete Bit 14: If set, NOP command supported Bit 13: If set, Read Buffer command supported Bit 12: If set, Write Buffer command supported Bit 11: Obsolete Bit 10: If set, Host Protected Area has been established Bit 9: If set, DEVICE RESET command supported Bit 8: If set, SERVICE interrupt enabled Bit 7: If set, Release Interrupt enabled Bit 6: If set, Read look-ahead enabled Bit 5: If set, Volatile Write cache enabled Bit 4: Cleared to 0 to indicate that the PACKET feature set is not supported Bit 3: Set to 1 to indicate that the Mandatory Power Management feature set is supported Bit 2: Obsolete Bit 1: If set, Security Feature Set enabled Bit 0: If set, SMART Feature Set enabled	0111 0X00 0XX0 10XXb

WORD	FIELD DESCRIPTION	VALUE
86	Commands and Feature sets supported or enabled Bit 15: If set, Words 119-120 are valid Bit 14: Reserved Bit 13: If set, Flush Cache EXT command supported Bit 12: If set, Flush Cache command supported Bit 11: If set, Device Configuration Overlay supported Bit 10: If set, 48-bit Address Feature Set supported Bit 9: If set, Automatic Acoustic Management feature set enabled Bit 8: If set, Set Max Security Extension enabled by Set Max Set Password Bit 7: Reserved Bit 6: If set, Set Features subcommand required to spin-up after power-up Bit 5: If set, Power-Up In Standby feature set enabled Bit 4: Obsolete Bit 3: If set, Advanced Power Management feature set enabled Bit 2: If set, CFA Feature Set enabled Bit 1: If set, Read/Write DMA Queued command supported Bit 0: If set, Download Microcode command supported	1011 11XX 00X0 X001b
87	Commands and Feature sets supported or enabled Bit 15: Shall be cleared to zero Bit 14: Shall be set to 1 Bit 13: If set, Idle Immediate with Unload Feature supported Bit 12: Reserved Bit 11: Reserved Bit 9-10: Obsolete Bit 8: If set, 64-bit World wide name supported Bit 7: If set, Write DMA Queued FUA EXT command supported Bit 6: If set, Write DMA FUA EXT and Write Multiple FUA EXT commands supported Bit 5: If set, General Purpose Logging Feature Set supported Bit 4: Obsolete Bit 3: If set, Media Card Pass Through Command feature set supported Bit 2: If set, Media serial number is valid Bit 1: If set, SMART Self-Test supported Bit 0: If set, SMART Error Logging supported	0110 0001 0110 XX11b
88	Ultra DMA modes Bit 15: Reserved Bit 14: If set, Ultra DMA Mode 6 is selected Bit 13: If set, Ultra DMA Mode 5 is selected Bit 12: If set, Ultra DMA Mode 4 is selected Bit 11: If set, Ultra DMA Mode 3 is selected Bit 10: If set, Ultra DMA Mode 2 is selected Bit 9: If set, Ultra DMA Mode 1 is selected Bit 8: If set, Ultra DMA Mode 0 is selected Bit 7: Reserved Bit 6: Ultra DMA mode 6 supported Bit 5: Ultra DMA mode 5 supported Bit 4: Ultra DMA mode 4 supported Bit 3: Ultra DMA mode 3 supported Bit 2: Ultra DMA mode 2 supported Bit 1: Ultra DMA mode 1 supported Bit 0: Ultra DMA mode 0 supported	0XXX XXXX 0111 1111b
89	Time required for Normal Erase mode SECURITY ERASE UNIT command	XX
90	Time required for Enhanced Erase mode SECURITY ERASE UNIT command	XX
91	Current advanced power management level value	XXXX
92	Master Password Identifier	XXXX
93	Hardware reset result	0
94	Current Automatic Acoustic Management value Bits 15-8: Vendor's Recommended Acoustic Management value Bit 7-0: Current Automatic Acoustic Management value	80XXh
95-99	Not supported	0

WORD	FIELD DESCRIPTION	VALUE
100-103	Total number of User Addressable Sectors for the 48-bit Address feature set (QWord)	WDC WD1600BEKT (312,581,808) WDC WD2500BEKT (488,397,168) WDC WD3200BEKT (625,142,448)
104-107	Not supported	0
108-111	World Wide Name	XXXXXXXXXXXXXXXX
112-118	Not supported	0
119	Commands and feature sets supported (Continued from words 82-84) Bit 15: Cleared to zero Bit 14: Shall be set to one Bit 13-6: Reserved Bit 5: If set, Free-fall Control feature set is supported Bit 4: If set, DOWNLOAD MICROCODE with offsets is supported Bit 3: If set, READ and WRITE DMA EXT GPL optional commands are supported Bit 2: If set, WRITE UNCORRECTABLE EXT is supported Bit 1: If set, Write-Read-Verify feature set is supported Bit 0: Reserved	0100 0000 0001 1000b
120	Commands and feature sets supported or enabled (Continued from words 85-87) Bit 15: Cleared to zero Bit 14: Shall be set to one Bit 13-6: Reserved Bit 5: If set, Free-fall Control feature set is enabled Bit 4: If set, DOWNLOAD MICROCODE with offsets is supported Bit 3: If set, READ and WRITE DMA EXT GPL optional commands are supported Bit 2: If set, WRITE UNCORRECTABLE EXT is supported Bit1: If set, Write-Read-Verify feature set is enabled Bit 0: Reserved	0100 0000 0001 1000b
121-126	Reserved	0
127	Obsolete	0
128	Security Status Bit 15-9: Reserved Bit 8: Security level (0 = High, 1 = Maximum) Bit 7-6: Reserved Bit 5: If set, Enhanced Security Erase supported Bit 4: If set, Security count expired Bit 3: If set, Security Frozen Bit 2: If set, Security Locked Bit 1: If set, Security enabled Bit 0: If set, Security supported	0000 000X 001X XXX1b
129-159	Vendor Specific	0
160	Not supported	0
161-175	Reserved for assignment by the CompactFlash™ Association	0
176-205	Not supported	0
206	SCT Command Transport Bit 15-6: Reserved Bit 5: If set, SCT Command Transport Date Tables supported Bit 4: If set, SCT Command Transport Features Control supported Bit 3: If set, SCT Command Transport Error Recovery Control supported Bit 2: If set, SCT Command Transport Write Same supported Bit 1: If set, SCT Command Transport Long Sector Access supported Bit 0: If set, SCT Command Transport supported	0000 0000 0011 1111b
207-254	Reserved	0
255	Integrity Word Bit 15-8: Checksum Bit 7-0: Signature	XXA5h

4.4 Set Features (EFh)

The Set Features command enables or disables the features listed in the following table

FUNCTION	FEATURES REGISTER	SECTOR COUNT REGISTER
Enable read cache[1]	AAh	Don't care
Disable read cache[1]	55h	Don't care
Enable write cache[1]	02h	Don't care
Disable write cache[1]	82h	Don't care
Set Transfer Mode	03h	Don't care
Enable Advanced Power Management	05h	FEh-Maximum performance 80h-Minimum power consumption without standby
Disable Advanced Power Management	85h	Don't care
Enable use of Serial ATA Feature	10h	02h-DMA Setup FIS Auto-Activate optimization 03h-Device-initiated interface power state transitions 06h-Software Settings Preservation
Disable use of Serial ATA Feature	90h	02h-DMA Setup FIS Auto-Activate optimization 03h-Device-initiated interface power state transitions 06h-Software Settings Preservation
Set Acoustic Mode[2]	42h	80h
Set Performance Mode[2]	42h	FEh
Disable Automatic Acoustic Management [2]	C2h	Don't Care

[1] Changes are only valid while power remains applied to the drive. After power is cycled, the drive reverts to the default settings.
[2] Changes are valid through power cycles and hard resets.

5.0 Installation and Setup Procedures

Hard drives are precision instruments that must be handled with care to prevent damage. It is important to understand that drives are typically damaged due to electrostatic discharge (ESD), pressing on the top cover, rough handling, or shock and vibration. Also refer to the WD 2.5-inch Hard Drive Handling poster (part number 2378-701047) for details on drive handling.

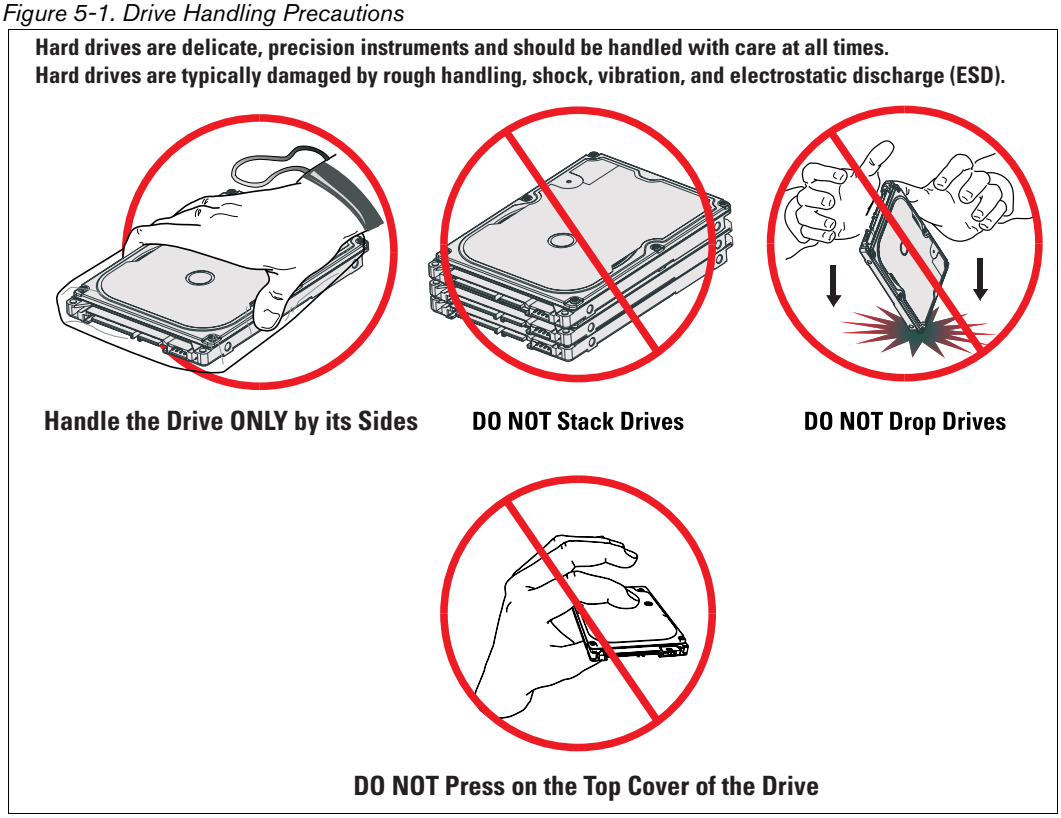
Important: If your system does not support hot plugging (see "Hot Plug Support" on page 20), it must be turned off and unplugged before installing your hard drive.

5.1 Unpacking

5.1.1 Handling Precautions

WD products are designed to withstand normal handling during unpacking and installation. Take care to avoid excessive mechanical shock, pressing on the top cover, or electrostatic discharge (ESD) which can permanently damage the hard drive and void the warranty. Hard drives are typically damaged because of ESD, rough handling, or shock and vibration.

Figure 5-1. Drive Handling Precautions



To avoid ESD problems, wear a properly grounded wrist strap when handling the hard drive. Articles of clothing generate static electricity. Do not allow clothing to come in direct contact with the hard drive or circuit board components.

When the drive is not in its shipping container or installed in its proper host enclosure, it must remain in the antistatic bag. To prevent damage, do not unpack your drive until you are ready to install it.

CAUTION: To avoid damage to internal drive components, do not apply a load greater than 2.6 lbf to a circular 10 mm diameter area anywhere on the top cover. Chassis design should allow for sufficient clearance and support to prevent loads from being transferred to the drive top cover.

5.1.2 Inspection of Shipping Container

Carefully examine the container for obvious shipping damage, such as: holes, signs of crushing, or stains. Notify the carrier and your WD representative if you observe any shipment damage. Always move the shipping container in the upright position indicated by the arrows on the container.

5.1.3 Removal From Shipping Container

Remove the drive from the shipping container only for inspection or installation. Carefully open the box. When removing the drive from the box, follow these precautions:

- Grasp the drive by the sides only; avoid touching the circuit board components.
- Gently place the drive on its antistatic bag on a clean, level, grounded work area.
- Do not stack drives or stand the drive on its edge.

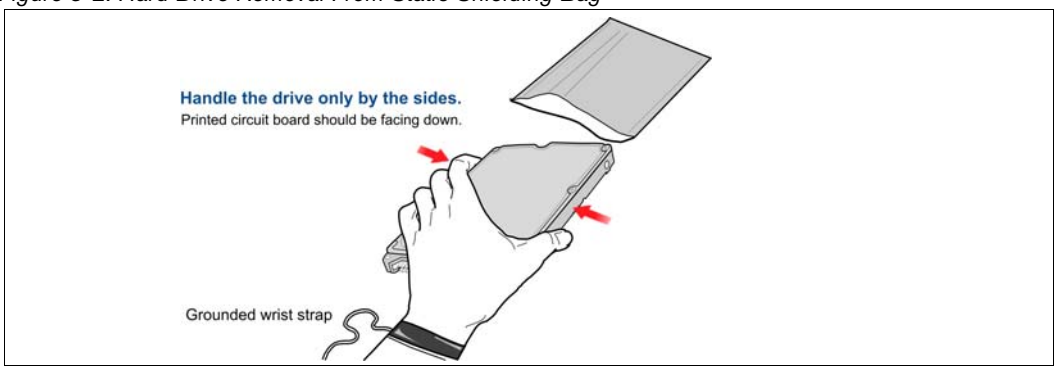
CAUTION: When removing the drive from the shipping container, be careful not to drop it. Dropping the drive can severely damage the head disk assembly or printed circuit board.

5.1.4 Removal From Static Shielding Bag

Before removing the drive from its static shielding bag:

- Make sure that your work station is properly grounded.
- Wear a properly grounded wrist strap with good skin contact.
- Avoid contact with any component on the printed circuit board.

Figure 5-2. Hard Drive Removal From Static Shielding Bag



After attaching your wrist strap, gently remove the drive from the static shielding bag.

- Handle the drive by the sides only; avoid touching the printed circuit board.
- Handle the drive with the printed circuit board facing downward during installation.
- The unit should not be moved during drive activity.
- The unit is not intended as a portable device.
- Do not attempt to open the drive and service it yourself. Removing the cover may expose you to harmful electrical voltages and will void the warranty.
- To allow ventilation, do not block the air slots on the underside and rear of the enclosure.
- Do not remove the tape seal or any labels from the drive; this will void the warranty.

5.1.5 Moving Precautions

If you need to move your computer, turn off the power to automatically park the heads. Parking moves the heads to a safe, non-data landing zone where they lock into place. This helps protect the media and the heads from accidental damage due to vibration, moving, or shipping.

5.2 Mounting Restrictions

Important: Your system must be turned off and unplugged before installing your hard drive.

5.2.1 Orientation

You can mount the hard drive in the X, Y, or Z axis, depending upon the physical design of your system. For best results, mount the drive with all four screws grounded to the chassis. If all four screws are not used, see "Grounding" on page 41.

5.2.2 Screw Size Limitations

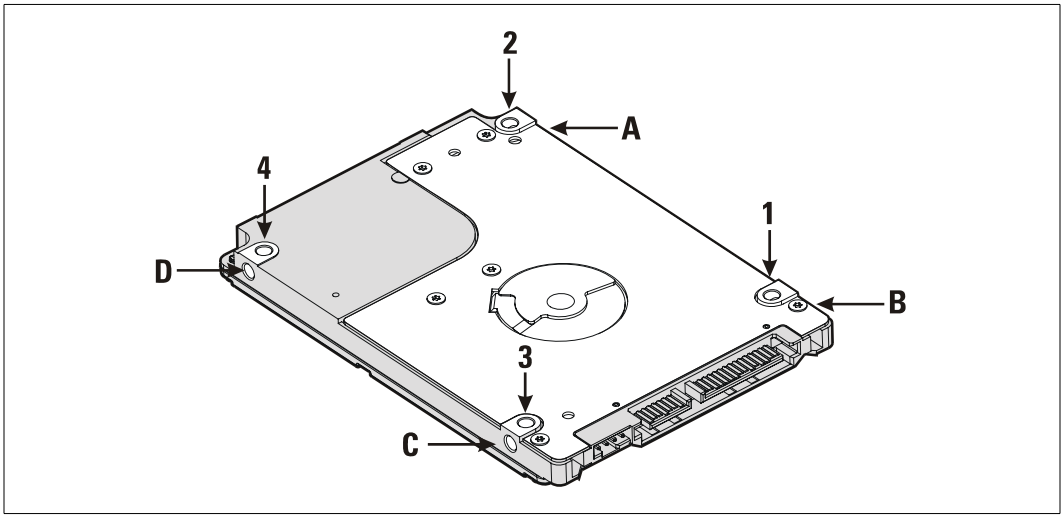
The hard drive is mounted to the chassis using four M 3.0 screws. Recommended screw torque is 5-6 lbf-in.

CAUTION: Screws that are too long damage circuit board components. Side mounted screws should engage 3.0 mm MAX. Bottom mounted screws should engage 2.5 mm MAX.

5.2.3 Grounding

For best results, mount the drive with all four screws in the side grounded to the chassis (positions A, B, C, and D below). You must ground the drive with at least one mounting screw.

Figure 5-3. Grounding Diagram



Side Mounting – Use four metal screws in A, B, C, and D. If less than four screws are used, remove in this order: C, D, and then B. You must use a screw in position A.

Top face Mounting–Use four metal screws in 1, 2, 3 and 4. If less than four screws are used, remove in this order: 2, 4, and then 3. You must use a screw in position 1.

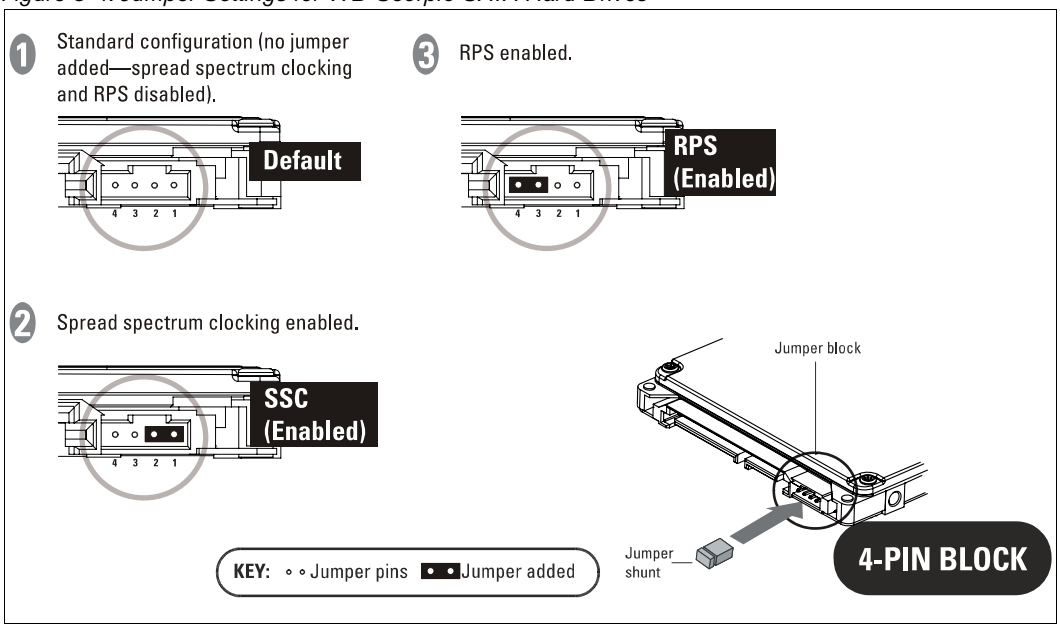
5.3 Jumper Settings

It is not necessary to put a jumper shunt on the drive for notebook use. Advanced settings for the drive are as follows:

SSC Mode – Spread spectrum clocking feature. Default setting is disabled.

RPS Mode – RPS feature. Default setting is disabled

Figure 5-4. Jumper Settings for WD Scorpio SATA Hard Drives



6.0 MAINTENANCE

The hard drive requires no preventative maintenance and contains no user-serviceable parts. The service and repair of WD drives can only be performed at a WD Service Center. Please contact your WD representative for warranty information and service/return procedures.

Observe the following precautions to prolong the life of the drive:

- Do not attempt to open the sealed compartment of the WD drive as this will void the warranty.
- Do not lift a WD drive by the printed circuit board.
- Avoid static discharge when handling a WD drive.
- Avoid harsh shocks or vibrations.
- Do not touch the components on the printed circuit board.
- Do not obstruct or cover any holes on the drive's cover. Air must be able to pass through these holes to the external air filter for normal operation of the drive.
- Observe the environmental limits specified for this product.
- If it becomes necessary to move your computer system, turn off the power to automatically park the heads. Parking the heads moves them to a safe, non-data landing zone and locks them into place. This helps protect the media and the heads from accidental damage due to vibration while moving or shipping.
- To protect your data, back it up regularly. WD assumes no responsibility for loss of data. For information about back-up and restore procedures, consult your operating system manual. There are also a number of utility programs available that you can use to back up your data.

7.0 TECHNICAL SUPPORT

NORTH AMERICA	
US/Canada (Central Time)	**800.ASK.4WDC**
Monday - Thursday	9:00 am - 7:00 pm
Friday	9:00 am - 5:00 pm
Saturday	8:00 am - 5:00 pm
EUROPE	
Central European Time (CET)	**+31.20.4467651**
Monday - Thursday	9:30 am - 12:00 noon
	1:00 pm - 5:30 pm
Friday	9:30 am - 12:00 noon
	1:00 pm - 4:00 pm

7.1 WD Online Services

WD provides a wide variety of technical support services on our Internet site at *support.wdc.com.*

8.0 GLOSSARY

Active LED Status - WD SATA drives support external LED requirements. It provides an activity LED output which is ON during command execution and OFF otherwise.

Annualized Failure Rate (AFR) - A method of measuring failure rates or trends for a group of units at a site. The rates are based on the monthly total number of returned field failure units divided by the total cumulative installed base and multiplied by 12 (to annualize the failure rate).

Automatic Defect Retirement - If defective sectors are found during a read or write, they are automatically mapped out and relocated.

Block - A group of bytes handled, stored, and accessed as a logical data unit, such as an individual file record.

Buffer - A temporary data storage area that compensates for a difference in data transfer rates and/or data processing rates between sender and receiver.

Data Lifeguard™ — Representing WD's ongoing commitment to data protection, Data Lifeguard data protection utilities include thermal management, an environmental protection system, and embedded error detection and repair features that automatically detect, isolate, and repair problem areas that may develop over the extended use of the hard drive.

Data Transfer Rate -The rate that digital data is transferred from one point to another, expressed in bits per second or bytes per second.

- Data Transfer Rate to Disk: The internal disk transfer rate in Mbits per second.
- Data Transfer Rate from the Buffer to the Host: Based on the transfer of buffered data in MB per second.

Defect Management -A general methodology of eliminating data errors on a recording surface by mapping out known bad areas of the media.

ECC On-the-Fly -A hardware correction technique that corrects errors in the read buffer prior to host transfer without any performance penalties. These error corrections are invisible to the host system because they do not require assistance from the drive's firmware.

Error Correction Code (ECC) -A mathematical algorithm that can detect and correct errors in a data field by adding check bits to the original data.

F.I.T. (Functional Integrity Testing) - A suite of tests WD performs on all its drive products to ensure compatibility with different hosts, operating systems, application programs, and peripherals. This testing must be performed before the product can be released to manufacturing.

Fluid Dynamic Bearings (FDB) - Bearing design that incorporates a layer of high-viscosity lubricant instead of ball bearings in the hard drive spindle motor. As an alternative to conventional ball bearing technology, FDB designs provide increased non-operational shock resistance, speed control, and improved acoustics.

Formatted Capacity - The actual capacity available to store data in a mass storage device. The formatted capacity is the gross capacity minus the capacity taken up by the overhead data required for formatting the media.

Hot Plugging - The ability to swap out a failed hard drive without having to power down the system or reboot.

Landing Zone - The heads move to this location on the inner cylinders following a Park command. User data is not stored at this location.

Latency - The period of time that the read/write heads wait for the disk to rotate the data to an accessible position. For a disk rotating at 5400 RPM, the average latency is 5.5 milliseconds.

Logical Address - A storage location address that may or may not relate directly to a physical location. The logical address is usually used when requesting information from a controller. The controller performs a logical-to-physical address conversion and retrieves the data from a physical location in the storage device.

Logical Block Address - An alternative addressing methodology of identifying a given location on an SATA drive that permits disk sizes greater than 528 MB.

Perpendicular Magnetic Recording (PMR) - In PMR, the magnetization of each data bit is aligned vertically rather than longitudinally to the spinning disk. The adjacent bits attract instead of repel (as with bar magnets placed side by side), creating more thermally stable bits.

PRML (Partial Response Maximum Likelihood) - A read channel using sampled data, active equalization and Veterbi detection to accurately retrieve the user data off the disk.

Reduced Power Spinup (RPS) — WD's optimized start up feature specifically designed for the external hard drive and Consumer Electronics (CE) market. Specific focus for RPS is to minimize the duration and magnitude of the peak power consumption from the hard drive.

RoHS (Restriction of Hazardous Substances) — WD complies with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC of the European Parliament, which is effective in the EU beginning July 1, 2006. RoHS aims to protect human health and the environment by restricting the use of certain hazardous substances in new equipment, and consists of restrictions on lead, mercury, cadmium, and other substances.

Rotational Latency - The amount of delay in obtaining information from a hard drive that can be attributed to the rotation of the disk.

RPM (Revolutions per Minute) - Rotational speed of the media (disk), also known as the spindle speed. Hard drives spin at one constant speed. The slower the RPM, the higher the mechanical latencies. Disk RPM is a critical component of hard drive performance because it directly impacts the rotational latency of the disk transfer rate.

Serial ATA (SATA) - SATA is the next generation bus interface for hard drives. It is designed to replace Parallel ATA, and has many advantages including increased transfer rate, improved signal integrity, enhanced data protection, and hot plugging.

Sector - A 512-byte packet of data.

Seek Time - The time it takes for the read/write head to move to a specific block of data on the hard drive. The average seek time is computed by dividing the time it takes to complete a large number of random seeks by the number of seeks performed.

Self-Monitoring, Analysis, and Reporting Technology (S.M.A.R.T.) - A technology to assist the user in preventing possible system down time due to hard drive failure.

S.M.A.R.T. Command Transport (SCT) — The SCT Command Transport feature set provides a method for a host to send commands and data to a device and for a device to send data and status to a host using log pages.

System-on-Chip - The System-on-Chip (SOC) is the foundation for WD's next generation electronics and firmware architecture. The native SATA SOC lowers component count by integrating a hard disk controller, high performance processor, high speed execution SRAM, and read channel in a 128-pin package.

Thermal Asperity - A thermal asperity is a baseline shift in the readback signal due to heating of the magnetoresistive stripe on the head as a result of physical contact with the disk or a particle.

Unrecoverable Error - A read error that cannot be overcome by an ECC scheme or by rereading the data when host retries are enabled.

Write Cache - A feature in CacheFlow that posts "command complete" prior to completing the actual write.

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2679-771280-A01
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