Seagate® IronWolf® Pro125 SSD

Product Manual

User Capacity	Model
240 GB	ZA240NX10001
480 GB	ZA480NX10001
960 GB	ZA960NX10001
1920 GB	ZA1920NX10001
3840 GB	ZA3840NX10001

Revision History

Version and Date	Description of Changes
Rev A, July 2020	First document release.

Contents

Seagate Technology Support Services

For Internal SSD Support, visit: https://www.seagate.com/support/products/

For Firmware Download and Tools Download for Secure Erase, visit: https://www.seagate.com/support/downloads/

For information regarding online support and services, visit: http://www.seagate.com/contacts/

For information regarding Warranty Support, visit: http://www.seagate.com/support/warranty-and-replacements/

For information regarding data recovery services, visit:
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1. Introduction

The Seagate® IronWolf® Pro 125 SSD is a purpose-built NAS SATA SSD for professional and business NAS applications, and delivers superior sustained performance, endurance and reliability ideal for SSD Caching, Tiered Storage, and All Flash Array.

Table 1   The IronWolf Pro 125 SSD Features

Feature	Description	
Capacity (User)	■ 240 GB, 480 GB, 960 GB, 1920 GB, 3840 GB	
Certifications, Eco-Compliance	■ CE, UL, cUL, RCM, BSMI, KCC, TUV, Microsoft WHQL, VCCI, CB ■ RoHS, WEEE, EAEU RoHS (Russian) ■ Secure Data Deletion See Section 9. *Safety Certifications, and Compliance*	
Dimension	■ Width: 69.85±0.25 millimeters ■ Length: 100.10±0.25 millimeters ■ Height: Maximum 7.10 millimeters	
Endurance	Total Bytes Written ■ 240 GB: 435 TB ■ 480 GB: 875 TB ■ 960 GB: 1750 TB ■ 1920 GB: 3500 TB ■ 3840 GB: 7000 TB	
Logical Block Size	■ 512 bytes	
Form Factor	■ 2.5 inch × 7 mm Standard SSD	
Interface Compliance	■ Fully compliant with ATA-8/ACS-4 Standard ■ Compliant with SATA Revision 3.2 and 3.1 ■ Supported protocol AHCI and ASC2 command set ■ Compatible with SATA 1.5 Gbps, 3 Gbps, and 6Gbps interfaces ■ PIO, DMA, UDMA supported ■ Native Command Queuing (NCQ): up to 32 commands ■ Data Set Management Command Trim support	
NAND	■ BiCS4 cTLC	
Performance Random	■ Read: Up to 96,000 IOPS ■ Write: Up to 30,000 IOPS	See Section 2.2 *Performance*
Performance Sequential	■ Read: Up to 545MB/s ■ Write: Up to 520MB/s	
Power Consumption	■ Active mode: <5000mW ■ Idle mode: <1900mW	See Section 2.3 *Power*.
Power Loss Data Protection	■ In-process writes to the NAND are completed in the event of an unexpected power loss	
Power Management	■ OS-aware hot-plug/hot-swap support	

Table 1   The IronWolf Pro 125 SSD Features *(continued)*

Feature	Description	
Reliability	■ SMART thermal monitoring ■ MTBF: 2 million hours ■ UBER: 1 read error per 10^{17} bits read ■ End-to-End data-path protection	
Shock and Vibration	Shock ■ Non-Operating: 1500G, duration 0.5m	See Section 2.4 *Environmental Conditions*
	Vibration ■ Non-Operating: Random, 1.52 Grms, 20 to 80 Hz Frequency	
Temperature	■ Operating: 0°C to 70°C ■ Non-operating: -40°C to 85°C	
Voltage	■ 5V±5%	
Data Retention	■ 12 months power-off retention at 30°C per JEDEC client standard	
Waranty	■ Five years, or when the device reaches Host TBW, whichever happens first. Endurance rating valid for SSD Life Remaining > 1% (SMART E7h>1).	
Weight	■ 240 GB: 55.2 g, 1.95 oz ±5% ■ 480 GB: 55.6 g, 1.96 oz ±5% ■ 960 GB: 58.5 g, 2.06 oz ±5% ■ 1920 GB: 60.1 g, 2.11 oz ±5% ■ 3840 GB: 61.7 g, 2.17 ±5%	

1.1   Reference Documents

In case of conflict between this document and the following reference document, this document takes precedence.

■ SATA Specifications
   — Serial ATA Revision 3.2
   — SATA-IO Commands for ATA-8
■ Trusted Computing Group (TCG) Documents
   — Storage Work Group Security Subsystem Class: Opal, Version 2.00
■ Solid State Drive Requirements and Endurance Test Methods
   — JESD218
   — JESD219
■ Seagate Documentation
   — SeaTools™ SSD GUI User Guide - Publication Number: 100837824
   — SeaChest for SSD User Guide - Publication Number: 100847684
   — Seagate Safety and Compliance Guide - Publication Number: 100860164

2. Specifications

2.1 Models and Capacity

Table 2   Models and Capacity

Capacity	LBA Count	Models
240 GB	468,862,128	ZA240NX10001
480 GB	937,703,088	ZA480NX10001
960 GB	1,875,385,008	ZA960NX10001
1920 GB	3,750,748,848	ZA1920NX10001
3840 GB	7,501,476,528	ZA3840NX10001

NOTE   About capacity:

- Sector Size: 512 Bytes

- User-addressable LBA count = (97696368) + (1953504 x (Desired Capacity in Gb-50.0)) From International Disk Drive Equipment and Materials Association (IDEMA) (*LBA1-03_standard.doc*)

2.2   Performance

Table 3   IronWolf Pro125 Sequential Read / Write Performance

Capacity	Sequential Read (128KB)	Sequential Write (128KB)	Random Read	Random Write
	MB/s	MB/s	IOPS (4K)	IOPS (4K)
240 GB	545	360	90,000	12,000
480 GB	545	500	96.000	16,000
960 GB	545	520	96,000	25,000
1920 GB	545	520	96,000	30,000
3840 GB	545	520	96,000	30,000

NOTE   About performance:

- All metrics represent sustained values, across full LBA range.

- Performance may vary based on the SSD's firmware version, system hardware, and configuration.

- Performance measured with FIO v3.7 on CentOS 7 host.

2.3   Power

Table 4   Power Consumption

Capacity	Maximum Average Active (mW)	Peak Active (mW)	Maximum Average Idle (mW)
240 GB	2500	2700	1400
480 GB	3000	3100	1400
960 GB	4000	4500	1600
1920 GB	4400	4900	1800
3840 GB	5000	5500	1900

NOTE   About power consumption:

- The measured power voltage is 5 V.

- The average value of power consumption is achieved based on 100% conversion efficiency.

- Power Consumption can differ according to flash configuration and platform.

2.4 Environmental Conditions

Table 5 Temperature, Humidity, Shock

Specification	Value
Temperature 　　　Operating (case temperature at specific airflow)	0°C to 70°C -40°C to 85°C
Humidity 　　　Operating 　　　Non-operating (storage)	90% 93%
Shock 　　　Non-operating	1,500 G, duration 0.5 ms
Vibration 　　　Non-operating	1.52 G$_{RMS,}$ (20Hz to 80Hz, Frequency)

NOTE　　　**Temperature** is measured without condensation. Operating mode temperature is measured by temperature sensor, SMART Attribute C2h.

NOTE　　　**Shock and vibration** results assume that the SSD is mounted securely with the input vibration applied to the SSD mounting. These specifications do not cover connection issues that may result from testing at this level. The measured specification is in root mean square (RMS) form.

- **Non-operating Shock.** The limits of non-operating shock applies to all conditions of handling and transportation. This includes both isolated SSD and integrated SSDs. Shock may be applied in the X, Y, or Z-axis.

- **Non-Operating Vibration.** The limits of non-operating vibration shall apply to all conditions of handling and transportation. This includes both isolated SSD and integrated SSDs. Vibration may be applied in the X, Y, or Z-axis.

2.5　Reliability and Endurance

Table 6　Reliability and Endurance

Specification	Value
Mean time between failures (MTBF)	2 million hours
Bit Error Rate	1 error in 10^{17} bits read
Endurance	Total Bytes Written ■　240 GB: 435 TB ■　480 GB: 875 TB ■　960 GB: 1750 TB ■　1920 GB: 3500 TB ■　3840 GB: 7000 TB

NOTE　About endurance:

■　The SSD achieves the specified MTBF in an operational environment that complies with the operational temperature range specified in this manual.

■　Operating temperatures are measured by temperature sensor, SMART Attribute ID C2h.

■　Endurance rating valid for SSD Life Remaining > 1% (SMART E7h>1).

■　Endurance is characterized while running Client JESD219A workload (per JESD218A specification).

3. Mechanical Information

3.1 Dimensions and Weight

Height: Maximum, 7 mm+0.10/-0.30

Width: 69.85 mm±0.25 mm

Length: 100.10 mm±0.25 mm

Weights
- 240 GB: 55.2 g, 1.95 oz ±5%
- 480 GB: 55.6 g, 1.96 oz ±5%
- 960 GB: 58.5 g, 2.06 oz ±5%
- 1920 GB: 60.1 g, 2.11 oz ±5%
- 3840 GB: 61.7 g, 2.17 ±5%

NOTE   All dimensions are in millimeters.

Figure 1 Top View
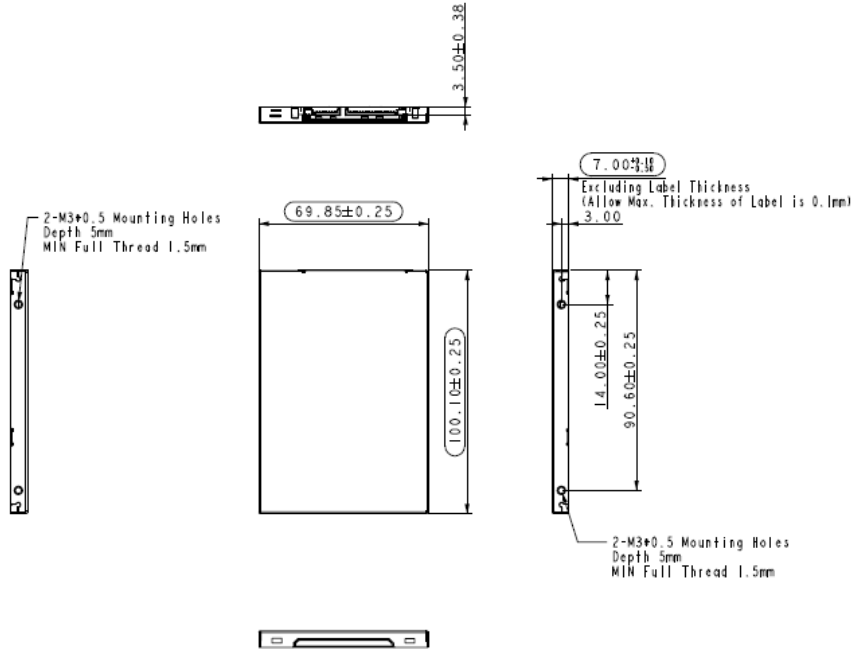
Figure 2 Bottom View
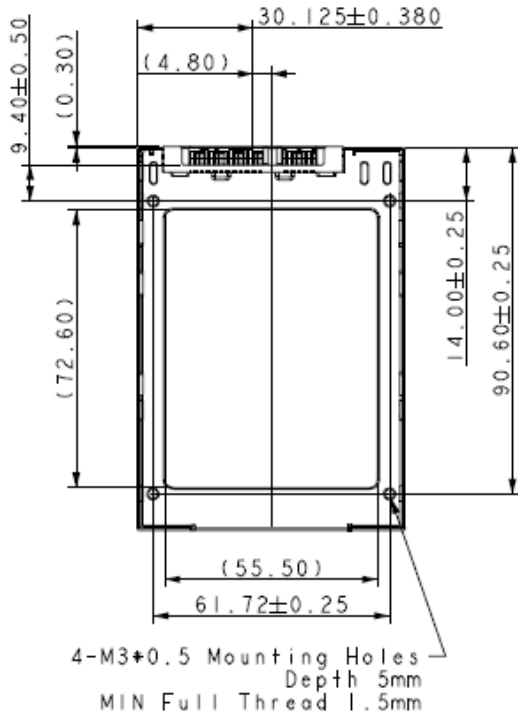
4. Pin and Signal Descriptions

Table 7   Serial ATA Connector Pin Signal Definitions

Pin	Name	Definition
S1	Ground	Ground
S2	A+	Differential signal pair A+ and A-
S3	A-	
S4	Ground	Ground
S5	B-	Differential signal pair B- and B+
S6	B+	
S7	Ground	Ground

NOTE   Key and spacing separate the signal and power segments.

4.1   Power Pin Definitions

Table 8   Power Pin Definitions

Pin	Function	Definition
P1	not used	Not Used (3.3 V)
P2	V33	Not Used (3.3 V)
P3	DEVSLP	SATA PHY Power Control
P4	GND	Ground
P5	GND	Ground
P6	GND	Ground
P7	V5	5 V Power, Precharge
P8	V5	5 V Power
P9	V5	5 V Power
P10	GND	Ground
P11	Reserved	Reserved
P12	GND	Ground
P13	not used	Not Used (12 V pre-charge)
P14	V12	Not Used (12 V)
P15	V12	Not Used (12 V)

NOTE   About Power Pin Signal Definitions:

- Key and spacing separate the signal and power segments.
- Uses 5 V power only; 3.3 V (P1-P2) and 12 V (P13-P15) power are not used.

5. Supported ATA Command List

The IronWolf Pro 125 SSD complies with ATA-8. See Section 1.1 *Reference Documents*. All mandatory and many optional commands and features are supported.

5.1   ATA Feature Set

The following table summarizes the ATA feature set and commands that the IronWolf Pro 125 SSD supports.

Table 9   ATA Feature Set

Feature	Supported
48-Bit Address feature set	Yes
General feature set	Yes
Native Command Queuing (NCQ) feature set	Yes
Power Management feature set	Yes
Security feature set	Yes
SMART feature set	Yes

5.2   ATA Command Description

Table Legend:

Y means **Support**.

O means **Option**, default is **No support**.

- means **No support.**

Table 10 ATA Command Description

Op Code	Support	Description	Op Code		Support	Description
00h	Y	NOP	B6h	12h	-	NV Cache: QUERY NV CACHE PINNED SET DMA EXT
03h	-	CFA REQUEST EXTENDED ERROR	B6h	13h	-	NV Cache: QUERY NV CACHE MISSES DMA EXT
06h	Y	DATA SET MANAGEMENT	B6h	14h	-	NV Cache: FLUSH NV CACHE
08h	-	DEVICE RESET	C4h		Y	READ MULTIPLE
0Bh	-	REQUEST SENSE DATA EXT	C5h		Y	WRITE MULTIPLE
10h	Y	RECALIBRATE	C6h		Y	SET MULTIPLE MODE
11h-1Fh	-	RECALIBRATE	C7h		-	READ DMA QUEUED
20h	Y	READ SECTOR(S)	C8h		Y	READ DMA
21h	Y	READ SECTOR(S) WITHOUT RETRY	C9h		Y	READ DMA WITHOUT RETRY

Table 10 ATA Command Description *(continued)*

Op Code	Support	Description	Op Code	Support	Description
22h	-	READ LONG	CAh	Y	WRITE DMA
23h	-	READ LONG WITHOUT RETRY	CBh	Y	WRITE DMA WITHOUT RETRY
24h	Y	READ SECTOR(S) EXT	CCh	-	WRITE DMA QUEUED
25h	Y	READ DMA EXT	CDh	-	CFA WRITE MULTIPLE WITHOUT ERASE
26h	-	READ DMA QUEUED EXT	CEh	Y	WRITE MULTIPLE FUA EXT
27h	Y	READ NATIVE MAX ADDRESS EXT	D1h	-	CHECK MEDIA CARD TYPE
29h	Y	READ MULTIPLE EXT	DAh	-	GET MEDIA STATUS
2Ah	-	READ STREAM DMA EXT	DEh	-	MEDIA LOCK
2Bh	-	READ STREAM EXT	DFh	-	MEDIA UNLOCK
2Fh	Y	READ LOG EXT	E0h	Y	STANDBY IMMEDIATE
30h	Y	WRITE SECTOR(S)	E1h	Y	IDLE IMMEDIATE
31h	Y	WRITE SECTOR(S) WITHOUT RETRY	E2h	Y	STANDBY
32h	-	WRITE LONG	E3h	Y	IDLE
33h	-	WRITE LONG WITHOUT RETRY	E4h	Y	READ BUFFER
34h	Y	WRITE SECTOR(S) EXT	E5h	Y	CHECK POWER MODE
35h	Y	WRITE DMA EXT	E6h	Y	SLEEP
36h	-	WRITE DMA QUEUED EXT	E7h	Y	FLUSH CACHE
37h	Y	SET MAX ADDRESS EXT	E8h	Y	WRITE BUFFER
38h	-	CFA WRITE SECTORS WITHOUT ERASE	E9h	Y	READ BUFFER DMA
39h	Y	WRITE MULTIPLE EXT	EAh	Y	FLUSH CACHE EXT

Table 11 ATA Command List (continued)

Op Code	Support	Description	Op Code			Support	Description
3Ah	-	WRITE STREAM DMA EXT	EBh			Y	WRITE BUFFER DMA
3Bh	-	WRITE STREAM EXT	ECh			Y	IDENTIFY DEVICE
3Ch	-	WRITE VERIFY	EDh			-	MEDIA EJECT
3Dh	Y	WRITE DMA FUA EXT	EEh			-	IDENTIFY DEVICE DMA
3Eh	-	WRITE DMA QUEUED FUA EXT	EFh	01h		-	SET FEATURES: Enable 8-bit PIO transfer mode (CFA feature set only)
3Fh	Y	WRITE LOG EXT	EFh	02h		Y	SET FEATURES: Enable write cache
40h	Y	READ VERIFY SECTOR(S)	EFh	03h		Y	SET FEATURES: Set transfer mode based on value in Count field
41h	Y	READ VERIFY SECTOR(S) WITHOUT RETRY	EFh	05h		Y	SET FEATURES: Enable advanced power management
42h	Y	READ VERIFY SECTOR(S) EXT	EFh	06h		-	SET FEATURES: Enable Power-Up In Standby feature set
44h	-	Reserved	EFh	07h		-	SET FEATURES: Power-Up In Standby feature set device spin-up
45h	O	WRITE UNCORRECTABLE EXT	EFh	0Ah		-	SET FEATURES: Enable CFA power mode 1
47h	Y	READ LOG DMA EXT	EFh	0Bh		-	SET FEATURES: Enable Write-Read-Verify feature set
50h	-	FORMAT TRACK	EFh	10h	01h	-	SET FEATURES: Enable use of Serial ATA feature
51h	-	CONFIGURE STREAM	EFh	10h	02h	Y	SET FEATURES: Enable DMA Setup FIS Auto-Activate optimization
57h	Y	WRITE LOG DMA EXT	EFh	10h	03h	Y	SET FEATURES: Enable Device-initiated interface power state (DIPM) transitions
60h	Y	READ FPDMA QUEUED	EFh	10h	04h	-	SET FEATURES: Enable use of Serial ATA feature
61h	Y	WRITE FPDMA QUEUED	EFh	10h	05h	-	SET FEATURES: Enable use of Serial ATA feature
70h	Y	SEEK	EFh	10h	06h	O	SET FEATURES: Enable Software Settings Preservation (SSP)
71-76h	-	SEEK	EFh	10h	07h	Y	SET FEATURES: Enable Device Automatic Partial to Slumber transitions
77h	Y	SET DATE AND TIME EXT	EFh	10h	09h	O	SET FEATURES: Enable Device Sleep

Table 12 ATA Command List (continued)

Op Code		Support	Description	Op Code			Support	Description
78h		Y	ACCESSIBLE MAX ADDRESS CONFIGURATION	EFh	42h		-	SET FEATURES: Enable Automatic Acoustic Management feature set
79-7Fh		-	SEEK	EFh	43h		-	SET FEATURES: Set Maximum Host Interface Sector Times
87h		-	CFA TRANSLATE SECTOR	EFh	44h		-	SET FEATURES: Vendor Specific ECC byte
90h		Y	EXECUTE DEVICE DIAGNOSTIC	EFh	55h		Y	SET FEATURES: Disable read look-ahead feature
91h		Y	INITIALIZE DEVICE PARAMETERS	EFh	5Dh		-	SET FEATURES: Enable release interrupt
92h		Y	DOWNLOAD MICROCODE	EFh	5Eh		-	SET FEATURES: Enable service interrupt
93h		Y	DOWNLOAD MICROCODE DMA	EFh	5Fh		-	SET FEATURES: Enable NDRQ Feature
94h		-	STANDBY IMMEDIATE	EFh	66h		Y	SET FEATURES: Disable reverting to power-on defaults
95h		-	IDLE IMMEDIATE	EFh	81h		-	SET FEATURES: Disable 8-bit PIO transfer mode (CFA feature set only)
96h		-	STANDBY	EFh	82h		Y	SET FEATURES: Disable write cache
97h		-	IDLE	EFh	85h		Y	SET FEATURES: Disable advanced power management
98h		-	CHECK POWER MODE	EFh	86h		-	SET FEATURES: Disable Power-Up In Standby feature set
99h		-	SLEEP	EFh	8Ah		-	SET FEATURES: Disable CFA power mode
A0h		-	PACKET	EFh	8Bh		-	SET FEATURES: Disable Write-Read-Verify feature set
A1h		-	IDENTIFY PACKET DEVICE	EFh	90h	01h	-	SET FEATURES: Disable use of Serial ATA feature
A2h		-	SERVICE	EFh	90h	02h	Y	SET FEATURES: Disable DMA Setup FIS Auto-Activate optimization
B0h	D0h	Y	SMART: READ DATA	EFh	90h	03h	Y	SET FEATURES: Disable Device-initiated interface power state (DIPM) transitions
B0h	D1h	Y	SMART: READ ATTRIBUTE THRESHOLDS	EFh	90h	04h	-	SET FEATURES: Disable use of Serial ATA feature

Table 12 ATA Command List (continued)

Op Code		Support	Description	Op Code			Support	Description
B0h	D2h	Y	SMART: ENABLE/DISABLE AUTOSAVE	EFh	90h	05h	-	SET FEATURES: Disable use of Serial ATA feature
B0h	D3h	Y	SMART: SAVE ATTRIBUTE VALUES	EFh	90h	06h	Y	SET FEATURES: Disable Software Settings Preservation (SSP)
B0h	D4h	Y	SMART: EXECUTE OFF-LINE IMMEDIATE *note2	EFh	90h	07h	Y	SET FEATURES: Disable Device Automatic Partial to Slumber transitions
B0h	D5h	Y	SMART: READ LOG	EFh	90h	09h	O	SET FEATURES: Disable Device Sleep
B0h	D6h	Y	SMART: WRITE LOG	EFh	AAh		Y	SET FEATURES: Enable read look-ahead feature
B0h	D8h	Y	SMART: ENABLE OPERATIONS	EFh	BBh		-	SET FEATURES: Default ECC byte
B0h	D9h	Y	SMART: DISABLE OPERATIONS	EFh	C2h		-	SET FEATURES: Disable Automatic Acoustic Management feature set
B0h	DAh	Y	SMART: RETURN STATUS	EFh	C3h		-	SET FEATURES: Enable/Disable the Sense Data Reporting feature set
B0h	DBh	Y	SMART: ENABLE/DISABLE AUTOMATIC OFF-LINE	EFh	CCh		Y	SET FEATURES: Enable reverting to power-on defaults
B0h	E0h	-	SMART: Vendor specific	EFh	DDh		-	SET FEATURES: Disable release interrupt
B1h	C0h	Y	DEVICE CONFIGURATION: RESTORE	EFh	DEh		-	SET FEATURES: Disable SERVICE interrupt
B1h	C1h	Y	DEVICE CONFIGURATION: FREEZE LOCK	EFh	DFh		-	SET FEATURES: Disable NDRQ Feature
B1h	C2h	Y	DEVICE CONFIGURATION: IDENTIFY	F1h			Y	SECURITY SET PASSWORD
B1h	C3h	Y	DEVICE CONFIGURATION: SET	F2h			Y	SECURITY UNLOCK
B1h	C4h	Y	DEVICE CONFIGURATION: IDENTIFY DMA	F3h			Y	SECURITY ERASE PREPARE
B1h	C5h	Y	DEVICE CONFIGURATION: SET DMA	F4h			Y	SECURITY ERASE UNIT
B4h	0000h	O	SANITIZE DEVICE: SANITIZE STATUS EXT	F5h			Y	SECURITY FREEZE LOCK
B4h	0011h	O	SANITIZE DEVICE: CRYPTO SCRAMBLE EXT	F6h			Y	SECURITY DISABLE PASSWORD
B4h	0012h	O	SANITIZE DEVICE: BLOCK ERASE EXT	F8h			Y	READ NATIVE MAX ADDRESS
B4h	0014h	O	SANITIZE DEVICE: OVERWRITE EXT	F9h	00h		Y	SET MAX: SET MAX ADDRESS

Table 12 ATA Command List (continued)

Op Code		Support	Description	Op Code		Support	Description
B4h	0020h	O	SANITIZE DEVICE: SANITIZE FREEZE LOCK EXT	F9h	01h	Y	SET MAX: SET MAX PASSWORD
B4h	0040h	O	SANITIZE DEVICE: SANITIZE ANTIFREEZE LOCK EXT	F9h	02h	Y	SET MAX: SET MAX LOCK
B6h	00h	-	NV Cache: SET NV CACHE POWER MODE EXT	F9h	03h	Y	SET MAX: SET MAX UNLOCK
B6h	01h	-	NV Cache: RETURN FROM NV CACHE POWER MODE EXT	F9h	04h	Y	SET MAX: SET MAX FREEZE LOCK
B6h	10h	-	NV Cache: ADD LBA(S) TO NV CACHE PINNED SET DMA EXT	F9h	05h	Y	SET MAX: SET MAX SET PASSWORD DMA
B6h	11h	-	NV Cache: REMOVE LBA(S) FROM NV CACHE PINNED SET DMA EXT	F9h	06h	Y	SET MAX: SET MAX UNLOCK DMA

NOTE The following apply:

- Value 00h: Execute SMART off-line routine in off-line mode (30 secs)

- Value 01h: Execute SMART short self-test routine in off-line mode (1 min)

- Value 02h: Execute SMART extended self-test routine in off-line mode (2 mins)

- Value 03h: Execute SMART conveyance self-test routine in off-line mode (3 mins)

6. SMART Support

The IronWolf Pro 125 SSD supports the SMART command set.

6.1   SMART IDs

Table 13 SMART IDs, Bytes, Byte Index, and Descriptions

Bytes	0	1	2	3	4	5	6	7	8	9	10	11	?
Description	**Byte Index**												
	ID	Flag 0	Flag 1	Value	Worst	**DATA**							Threshold
Number of Accumulation of Uncorrectable Errors	01h	0Bh	00h	64h	64h	Host UNC Error Count		0	0	0	0	0	32h
Power-On hours Count	09h	12h	00h	64h	64h	Power on hours		0	0	0	0	0	00h
Drive Power Cycle Count	0Ch	12h	00h	64h	64h	Power on/off cycles			0	0	0	0	00h
Spare Blocks Available	10h	12h	00h	64h	64h	Spare Blocks Available by drive		0	0	0	0	0	00h
Remaining Spare Blocks	11h	12h	00h	64h	64h	Remaining Spare Blocks by drive		0	0	0	0	0	00h
SATA PHY Error Count	A8h	12h	00h	64h	64h	SATA PHY error count (Continue count)			0	0	0	0	00h
Bad Block Count(Early / Later)	Aah	03h	00h	Note1*		Total Early Bad Block Count		0	0	Total Later Bad Block Count		0	0Ah
Erase count (average, max, erase count)	Adh	12h	00h	64h	64h	Max Erase Count		Avg Erase Count		Min Erase Count		0	00h
Unexpected Power Loss count	Aeh	12h	00h	64h	64h	Unexpected Power Loss Count		0	0	0	0	00h

Table 14 SMART IDs, Bytes, Byte Index, and Descriptions--continued

Bytes	0	1	2	3	4	5	6	7	8	9	10	11	?
Description						Byte Index							
	ID	Flag 0	Flag 1	Value	Worst	DATA							Threshold
Wear Range delta	B1h	00h	00h	64h	64h	Wear Range delta Note2*	0	0	0	0	0	0	00h
Unexpected Power Loss Count	C0h	12h	00h	64h	64h	Unexpected Power Loss Count						0	00h
Temperature (only Toshiba or thermo sensor embedded)	C2h	23h	00h	127 - Current Temperature	127 - Highest Temperature	Current temperature		Lowest temperature		Highest temperature		0	00h
Number of accumulation CRC error (read/write data FIS CRC error)	Dah	0Bh	00h	64h	64h	SATA PHY error count						0	32h
SSD life remaining	E7h	13h	00h	64h	64h	Note3*	0	0	0	0	Throttling level	0	00h
Read Failure Block Count	E8h	13h	00h	64h	64h	Flash Read Fail Count				Raw Read Error Rate	?	0	00h
Lifetime Writes to Flash (G Unit)	E9h	0Bh	00h	64h	64h	Lifetime Writes to Flash by GiB						0	00h
NAND read (Sectors)	Eah	0Bh	00h	64h	64h	NAND read (Sectors)						0	00h
Lifetime Writes to Flash (Sector Unit)	Ebh	0Bh	00h	64h	64h	Lifetime Writes to Flash by Sector						0	00h
Host Writes (G Unit)	F1h	12h	00h	64h	64h	Lifetime Writes from Host by GiB						0	00h
Host Reads (G Unit)	F2h	12h	00h	64h	64h	Lifetime Reads from Host by GiB						0	00h
Write Protect Detail	F6h	03h	00h	253 - Write Protect Value	253 - Write Protect Value	Write Protect Detail Note4*						0	FDh
Health Check Timer	F7h	02h	00h	64h	64h	Health Check Timer (min)						0	00h

NOTES

1. "Bad Block Count (Early / Later) ID 170 (AAh)" Value = 100 * [1 - (Total later bad block count per drive / Total acceptable bad block count per drive)]. This formula calculates the percentage of spare block. Value will range from 100 to 0.

2. "Wear Range Delta ID 177 (B1h)" (max erase count - least erase count) / (P-E Cycle) * 100 (percentage).

3. "SSD life remaining ID 231 (E7h)"
   SSD life remaining = 100-{(average erase count/Rated PE Cycle) * (100)}

4. "Write Protect Detail ID 246 (F6h)"
   Write Protect Type
   bit 4 FTL_ERR_WP
   bit 5 FTL_ERR_ASSERT_WP
   bit 7 FTL_ERR_NAND
   bit 9 FTL_ERR_PCAP_WP
   bit 10 FTL_ERR_PFAIL_UNFINISH_WP

7. Feature Details

7.1 Flash Management

7.1.1 Error Correction Code (ECC)

Flash memory cells deteriorate with use. This can generate random bit errors in the stored data. The IronWolf Pro 125 SSD applies the LDPC ECC algorithm to detect and correct 340bits/2K Byte errors occur during read process, to make sure the SSD reads correctly, and to protect data from corruption.

7.1.2 Wear Leveling

NAND flash devices can undergo only a limited number of program/erase cycles. Commonly, the SSD does not use areas of the flash media evenly. If the SSD updates some areas more frequently than others, this reduces the lifetime of the device. Wear Leveling extends the life of the NAND Flash by evenly distributing write and erase cycles across the media.

Seagate's advanced Wear Leveling algorithm spreads the flash usage throughout the whole flash media area. Implementing dynamic and static Wear Leveling algorithms improves the life expectancy of the NAND flash.

7.1.3 Bad Block Management

Bad blocks do not function properly and they can contain more invalid bits. This can make stored data unstable and bad block reliability is not guaranteed. Blocks identified and marked as bad by the manufacturer are called "Early Bad Blocks". Bad blocks that develop during the lifespan of the Flash are called "Later Bad Blocks". Seagate's bad block management algorithm detects the factory-produced bad blocks and manages bad blocks that appear with use. This practice prevents the drive from storing data in bad blocks and improves data reliability

7.1.4 TRIM

The TRIM feature improves the read/write performance and speed of SSDs. SSDs cannot overwrite existing data, so the available space becomes smaller with each data block use. The TRIM command tells the SSD [through the operating system] which data blocks can be removed permanently because they are no longer in use. The SSD erases these unused data blocks.

7.1.5 SMART

SMART, stands for Self-Monitoring, Analysis, and Reporting Technology. SMART is an open standard that allows an SSD to automatically detect its health and report potential failures. When SMART records a failure, users can replace the SSD to prevent unexpected outage or data loss. SMART can also inform users of impending failures while there is still time to copy data to another device.

7.1.6 Over Provisioning

Over Provisioning (OP) preserves an additional area beyond user capacity in an SSD, which is not visible to users and cannot be used by them. OP improves performance and IOPS (Input/Output Operations per Second) by providing the controller additional space to manage P/E cycles. OP enhances the reliability and endurance as well. Moreover, the write amplification of the SSD becomes lower when the controller writes data to the flash.

7.1.7 Firmware Upgrade

Firmware provides a set of instructions on how the device communicates with the host. Firmware upgrades are typically available with added features, fixed compatibility issues, and improved read/write performance.

7.1.8 Thermal Throttling

Thermal throttling prevents components in an SSD from over-heating during read and write operations. The IronWolf Pro 125 SSD design provides an on-die and onboard thermal sensor. With this accuracy, firmware can apply different levels of throttling to protect efficiently and proactively through the SMART reading.

Table 15 Thermal Throttling

Item	Content
tmt1 threshold	68°C per Smart reported
tmt2 threshold	70°C per Smart reported
Protect threshold	80°C per Smart reported
Fatal threshold	120°C from on-die thermal sensor
Resume performance threshold	60°C per Smart reported
Temperature polling frequency	Every 1 sec
TMT1_state impact	±10% CE
TMT2_state impact	-30% CE

7.1.9 Garbage Collection

Garbage collection allocates and releases memory to accelerate the read/write processing and improve performance. When there is less available space, the SSD slows down the read/write processing and implements garbage collection to release memory.

7.2 Advanced Device Security Features

7.2.1 Secure Erase

Secure Erase is a standard ATA format command which writes all of "0xFF" to fully wipe all the data on hard drives and SSDs. When this command issues, the SSD controller erases its storage blocks and returns to its factory default settings.

7.3   SSD Lifetime Management Terms

Here's an explanation of common terms that describe SSD Lifetime Management.

- **Total Bytes Written (TBW)** measures the lifespan of the SSD. This measurement represents the amount of data written to the device. To calculate the TBW of an SSD, use the following equation:

$$TBW = [(NAND\ Endurance) \times (SSD\ Capacity)] / [WAF]$$

- **NAND Endurance.** NAND endurance refers to the P/E (Program/Erase) cycle of a NAND flash.
- **SSD Capacity.** The SSD capacity is the specific capacity in total of an SSD.
- **WAF.** Write Amplification Factor (WAF) is a numerical value. This value represents the ratio between the amount of data that an SSD controller needs to write and the amount of data that the host's flash controller writes. A WAF, near 1, guarantees better endurance and lower frequency of data written to flash memory.

TBW in this document is based on the JEDEC 218/219 workload.

7.3.1   Media Wear Indicator

Actual life indicator reported by SMART Attribute 231 (E7h) Life Remaining by percentage. This indicator recommends User to replace drive when reaching to 0%.

7.3.2   Read Only Mode (End of Life)

When the SSD is aged by program/erase cycles, media wear-out may cause increasing numbers of bad blocks. When the number of usable good blocks falls outside a defined usable range, the drive notifies the host through AER event and Critical Warning to enter Read Only Mode to prevent further data corruption. When this happens, the user should replace the SSD with another one immediately

7.4   Adaptive Approach to Performance Tuning

7.4.1   Predict and Fetch

When the Host tries to read data from the SSD, the SSD performs only one read action after receiving one command. However, the IronWolf Pro 125 SSD applies Predict and Fetch to improve the read speed. When the host issues sequential read commands to the SSD, the SSD expects that the following are also read commands. Therefore, before receiving the next command, flash has prepared the data. This accelerates data processing time, and the host needs less wait time to receive data.

7.4.2   Throughput

Based on the available space of the SSD, the IronWolf Pro 125 SSD regulates the read/write speed and manages the performance of throughput. When the SSD has more space, the firmware continuously performs read/write actions. There is no need yet to implement garbage collection to allocate and release memory to accelerate the read/write processing and improve performance. When the SSD has less available space, it slows down the read/write processing and implements garbage collection to release memory.

8. SeaTools Drive Management

SeaTools® is a free drive management software from Seagate. The SeaTools (GUI) monitors health, and tests and analyzes drives. It is data safe and simple to install on your system. SeaTools provides the following resources:

- Health Monitoring
- Drive Test and Maintenance
- Drive Status
- Test
- Disc Wizard
- Firmware Update
- Erase Commands

To download SeaTools and get more information, visit here:

https://www.seagate.com/in/en/support/downloads/seatools

9. Safety Certifications, and Compliance

You can find up to date information on safety certifications, and component compliance requirements for Seagate devices on the Seagate Support page, here: https://www.seagate.com/support/

To see the Seagate HDD and SSD Regulatory Compliance and Safety document, go here: https://www.seagate.com/files/www-content/forms/compliance/regulatory-compliance-and-safety-100838899-A.pdf

9.1   Regulatory Model Numbers

The following regulatory model number represents all features and configurations in the IronWolf Pro 125 SSD

■   STA023