Apacer

RoHS Compliant

Serial ATA Flash Drive

SM230-25 Product Specifications

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Version 2.3

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Apacer

Specifications Overview:

- **Compliance with SATA Revision 3.2**
  - SATA 6 Gb/s interface
  - Backward compatible with SATA 1.5 and 3 Gb/s interfaces
  - ATA-8 command set
- **Capacity**
  - 32, 64, 128, 256, 512 GB
  - 1 TB
- **Performance***
  - Burst read/write: 600 MB/sec

  Standard:
  - Sequential read: Up to 560 MB/sec
  - Sequential write: Up to 495 MB/sec
  - Random read (4K): Up to 41,000 IOPS
  - Random write (4K): Up to 71,000 IOPS

  AES & Opal Implemented:
  - Sequential read: Up to 560 MB/sec
  - Sequential write: Up to 495 MB/sec
  - Random read (4K): Up to 34,000 IOPS
  - Random write (4K): Up to 65,000 IOPS
- **Flash Management**
  - Built-in hardware ECC
  - Global Wear Leveling
  - Flash bad-block management
  - Flash Translation Layer: Page Mapping
  - S.M.A.R.T.
  - Power Failure Management
  - Device Sleep
  - ATA Secure Erase
  - TRIM
  - Hyper Cache Technology
  - SMART Read Refresh™
- **SATA Power Management Modes**
- **NAND Flash Type:** MLC
- **MTBF:** >1,200,000 hours
- **Temperature Range**
  - Operating:
    Standard: 0°C to 70°C
    Wide: -40°C to 85°C
  - Storage: -40°C to 100°C
- **Supply Voltage**
  - 5.0 V ± 10%
- **Power Consumption***
  - Active mode: 485 mA
  - Idle mode: 105 mA
- **Connector Type**
  - 7-pin SATA signal connector
  - 15-pin SATA power connector
- **Form Factor**
  - 2.5”
  - Dimensions: 100.00 x 69.85 x 6.90, unit: mm
- **Security (optional)**
  - Trusted Computing Group (TCG) Opal 2.0
  - AES 256-bit hardware encryption
- **Reliability**
  - Thermal Sensor
  - Thermal Throttling (optional)
- **Endurance (in Terabytes Written: TBW)**
  - 32 GB: 69 TBW
  - 64 GB: 137 TBW
  - 128 GB: 295 TBW
  - 256 GB: 513 TBW
  - 512 GB: 1,181 TBW
  - 1 TB: 2,222 TBW
- **RoHS Compliant**

*Varies from capacities. The values for performances and power consumptions presented are typical and may vary depending on flash configurations or platform settings. The term idle refers to the standby state of the device.

Table of Contents

1. Product Description

1.1 Introduction

Apacer's SM230-25 is a well-balanced solid-state disk (SSD) drive with standard form factor and great performance. Designed in SATA 6 Gb/s interface, the SSD is able to deliver exceptional read/write speed, making it the ideal companion for heavy-loading industrial or server operations.

In regard of reliability, the drive comes with various implementations including powerful hardware ECC engine, power saving modes, wear leveling, flash block management, S.M.A.R.T., TRIM, and power failure management.

1.2 Capacity

Capacity specifications of SM230-25 are available as shown in Table 1-1. It lists the specific capacity and the default numbers of heads, sectors and cylinders for each product line.

Table 1-1 Capacity Specifications

Capacity	Total bytes*	Cylinders	Heads	Sectors	Total LBA
32 GB	32,017,047,552	16,383	16	63	62,533,296
64 GB	64,023,257,088	16,383	16	63	125,045,424
128 GB	128,035,676,160	16,383	16	63	250,069,680
256 GB	256,060,514,304	16,383	16	63	500,118,192
512 GB	512,110,190,592	16,383	16	63	1,000,215,216
1 TB	1,024,209,543,168	16,383	16	63	2,000,409,264

*Display of total bytes varies from file systems, which means not all of the bytes can be used for storage.
**Notes: 1 GB = 1,000,000,000 bytes; 1 sector = 512 bytes.
LBA count addressed in the table above indicates total user storage capacity and will remain the same throughout the lifespan of the device. However, the total usable capacity of the SSD is most likely to be less than the total physical capacity because a small portion of the capacity is reserved for device maintenance usages.

1.3 Performance

Performance of SM230-25 is listed below in Table 1-2 and 1-3.

Table 1-2 Performance Specifications (Standard)

Capacity / Performance	32 GB	64 GB	128 GB	256 GB	512 GB	1 TB
Sequential Read* (MB/s)	560	560	560	560	550	555
Sequential Write* (MB/s)	265	475	485	485	495	495
Random Read IOPS (4K)**	27,000	38,000	41,000	41,000	40,000	41,000
Random Write IOPS (4K)**	38,000	62,000	69,000	70,000	71,000	71,000

Table 1-3 Performance Specifications (AES and Opal implemented)

Capacity / Performance	32 GB	64 GB	128 GB	256 GB	512 GB
Sequential Read* (MB/s)	560	560	560	560	550
Sequential Write* (MB/s)	265	445	485	485	495
Random Read IOPS (4K)**	25,000	33,000	34,000	34,000	34,000
Random Write IOPS (4K)**	36,000	57,000	63,000	64,000	65,000

Note:
Results may differ from various flash configurations or host system setting.
*Sequential performance is based on CrystalDiskMark 5.2.1 with file size 1,000MB.
**Random performance measured using IOMeter with Queue Depth 32.

1.4 Pin Assignments

Table 1-4 describes the SFD signal segment, and Table1-5, power segment.

Figure 1-1 SATA Connectors

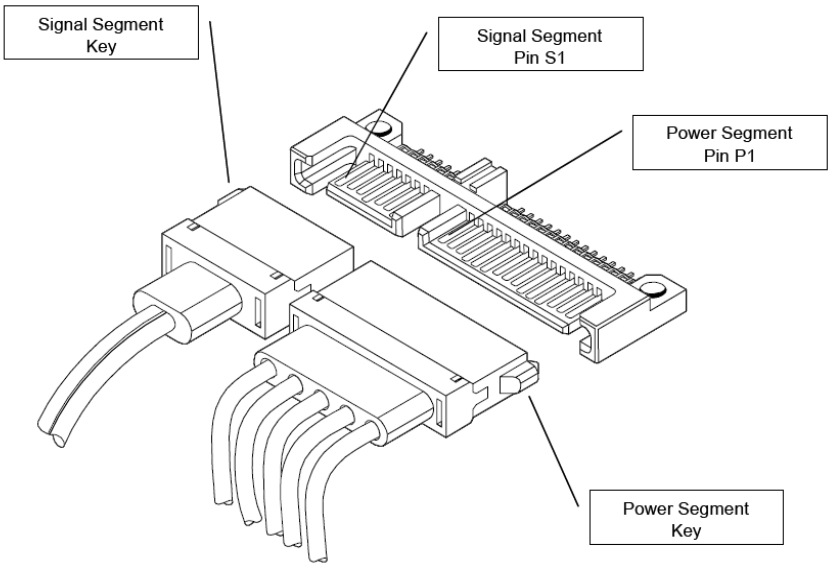


Table 1-4 Signal Segment

Pin	Type	Description
S1	GND	
S2	RxP	+ Differential Receive Signal
S3	RxN	- Differential Receive Signal
S4	GND	
S5	TxN	- Differential Transmit Signal
S6	TxP	+ Differential Transmit Signal
S7	GND	

Table 1-5 Power Segment

Pin	Signal/Description
P1	Unused (3.3V)
P2	Unused (3.3V)
P3	Device Sleep
P4	Ground
P5	Ground
P6	Ground
P7	5V
P8	5V
P9	5V
P10	Ground
P11	DAS
P12	Ground
P13	Unused (12V)
P14	Unused (12V)
P15	Unused (12V)

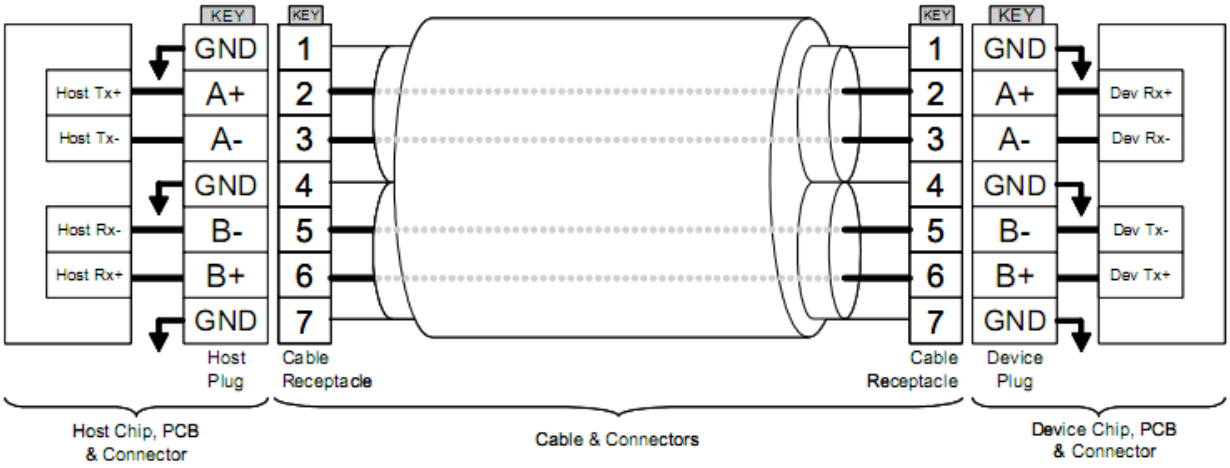


Figure 1-2 SATA Cable/Connector Connection Diagram

The connector on the left represents the Host with TX/RX differential pairs connected to a cable. The connector on the right shows the Device with TX/RX differential pairs also connected to the cable. Notice also the ground path connecting the shielding of the cable to the Cable Receptacle.

2. Software Interface

2.1 Command Set

This section defines the software requirements and the format of the commands the host sends to SM230-25. Commands are issued to SM230-25 by loading the required registers in the command block with the supplied parameters, and then writing the command code to the Command register.

Table 2-1 Command Set

Code	Command	Code	Command
E5h	CHECK POWER MODE	F4h	SECURITY ERASE UNIT
06h	DATA SET MANAGEMENT	F5h	SECURITY FREEZE LOCK
92h	DOWNLOAD MICROCODE	F1h	SECURITY SET PASSWORD
90h	EXECUTE DEVICE DIAGNOSTIC	F2h	SECURITY UNLOCK
E7h	FLUSH CACHE	70h	SEEK
EAh	FLUSH CACHE EXT	EFh	SET FEATURES
ECh	IDENTIFY DEVICE	C6h	SET MULTIPLE MODE
E3h	IDLE	E6h	SLEEP
E1h	IDLE IMMEDIATE	B0h	SMART
91h	INITIALIZE DEVICE PARAMETERS	E2h	STANDBY
E4h	READ BUFFER	E0h	STANDBY IMMEDIATE
C8h	READ DMA	E8h	WRITE BUFFER
25h	READ DMA EXT	CAh	WRITE DMA
60h	READ FPDMA QUEUED	35h	WRITE DMA EXT
C4h	READ MULTIPLE	3Dh	WRITE DMA FUA EXT
29h	READ MULTIPLE EXT	61h	WRITE FPDMA QUEUED
2Fh	READ LOG EXT	3Fh	WRITE LOG EXT
47h	READ LOG DMA EXT	57h	WRITE LOG DMA EXT
20h	READ SECTOR	C5h	WRITE MULTIPLE
24h	READ SECTOR EXT	39h	WRITE MULTIPLE EXT
40h	READ VERIFY SECTORS	CEh	WRITE MULTIPLE FUA EXT
42h	READ VERIFY SECTORS EXT	30h	WRITE SECTOR
10h	RECALIBRATE	34h	WRITE SECTOR EXT
F6h	SECURITY DISABLE PASSWORD	45h	WRITE UNCORRECTABLE EXT
F3h	SECURITY ERASE PREPARE		

Table 2-2 Trusted Computing Feature Set

Code	Command	Code	Command
5Ch	TRUSTED RECEIVE	5Eh	TRUSTED SEND
5Dh	TRUSTED RECEIVE DMA	5Fh	TRUSTED SEND DMA

Note: This feature set is only applicable to products implemented with AES and Opal functions.

2.2 S.M.A.R.T.

S.M.A.R.T. is an abbreviation for Self-Monitoring, Analysis and Reporting Technology, a self-monitoring system that provides indicators of drive health as well as potential disk problems. It serves as a warning for users from unscheduled downtime by monitoring and displaying critical drive information. Ideally, this should allow taking proactive actions to prevent drive failure and make use of S.M.A.R.T. information for future product development reference.

Apacer devices use the standard SMART command B0h to read data out from the drive to activate our S.M.A.R.T. feature that complies with the ATA/ATAPI specifications. S.M.A.R.T. Attribute IDs shall include initial bad block count, total later bad block count, maximum erase count, average erase count, power on hours and power cycle. When the S.M.A.R.T. Utility running on the host, it analyzes and reports the disk status to the host before the device reaches in critical condition.

Note: Attribute IDs may vary from product models due to various solution design and supporting capabilities.

Apacer memory products come with S.M.A.R.T. commands and subcommands for users to obtain information of drive status and to predict potential drive failures. Users can take advantage of the following commands/subcommands to monitor the health of the drive.

Table 2-3 SMART Subcommand Set

Code	SMART Subcommand
D0h	READ DATA
D1h	READ ATTRIBUTE THRESHOLDS
D2h	ENABLE/DISABLE ATTRIBUTE AUTOSAVE
D4h	EXECUTE OFF-LINE IMMEDIATE
D5h	SMART READ LOG
D6h	SMART WRITE LOG
D8h	ENABLE OPERATIONS
D9h	DISABLE OPERATIONS
DAh	RETURN STATUS

Table 2-4 General SMART Attribute Structure

Byte	Description
0	ID (Hex)
1 – 2	Status Flag
3	Value
4	Worst
5*-11	Raw Data

*Byte 5: LSB

Table 2-5 SMART Attribute ID List

ID (Hex)	Attribute Name
9 (0x09)	Power-on Hours
12 (0x0C)	Power Cycle Count
163 (0xA3)	Max. Erase Count
164 (0xA4)	Avg. Erase Count
166 (0xA6)	Total Later Bad Block Count
167 (0xA7)	SSD Protect Mode (Vendor Specific)
168 (0xA8)	SATA PHY Error Count
171 (0xAB)	Program Fail Count
172 (0xAC)	Erase Fail Count
175 (0xAF)	Bad Cluster Table Count
192 (0xC0)	Unexpected Power Loss Count
194 (0xC2)	Temperature
231 (0xE7)	Lifetime Left
241 (0xF1)	Total Sectors of Write

3. Flash Management

3.1 Error Correction/Detection

SM230-25 implements a hardware ECC scheme, based on the BCH algorithm. It can detect and correct up to 76 bits error in 1K bytes.

3.2 Bad Block Management

Current production technology is unable to guarantee total reliability of NAND flash memory array. When a flash memory device leaves factory, it comes with a minimal number of initial bad blocks during production or out-of-factory as there is no currently known technology that produce flash chips free of bad blocks. In addition, bad blocks may develop during program/erase cycles. Since bad blocks are inevitable, the solution is to keep them in control. Apacer flash devices are programmed with ECC, page mapping technique and S.M.A.R.T to reduce invalidity or error. Once bad blocks are detected, data in those blocks will be transferred to free blocks and error will be corrected by designated algorithms.

3.3 Global Wear Leveling

Flash memory devices differ from Hard Disk Drives (HDDs) in terms of how blocks are utilized. For HDDs, when a change is made to stored data, like erase or update, the controller mechanism on HDDs will perform overwrites on blocks. Unlike HDDs, flash blocks cannot be overwritten and each P/E cycle wears down the lifespan of blocks gradually. Repeatedly program/erase cycles performed on the same memory cells will eventually cause some blocks to age faster than others. This would bring flash storages to their end of service term sooner. Global wear leveling is an important mechanism that levels out the wearing of all blocks so that the wearing-down of all blocks can be almost evenly distributed. This will increase the lifespan of SSDs.

3.4 Flash Translation Layer – Page Mapping

Page mapping is an advanced flash management technology whose essence lies in the ability to gather data, distribute the data into flash pages automatically, and then schedule the data to be evenly written. Page-level mapping uses one page as the unit of mapping. The most important characteristic is that each logical page can be mapped to any physical page on the flash memory device. This mapping algorithm allows different sizes of data to be written to a block as if the data is written to a data pool and it does not need to take extra operations to process a write command. Thus, page mapping is adopted to increase random access speed and improve SSD lifespan, reduce block erase frequency, and achieve optimized performance and lifespan.

3.5 ATA Secure Erase

ATA Secure Erase is an ATA disk purging command currently embedded in most of the storage drives. Defined in ATA specifications, (ATA) Secure Erase is part of Security Feature Set that allows storage drives to erase all user data areas. The erase process usually runs on the firmware level as most of the ATA-based storage media currently in the market are built-in with this command. ATA Secure Erase can securely wipe out the user data in the drive and protects it from malicious attack.

3.6 Power Failure Management

Power Failure Management plays a crucial role when power supply becomes unstable. Power disruption may occur when users are storing data into the SSD, leading to instability in the drive. However, with Power Failure Management, a firmware protection mechanism will be activated to scan pages and blocks once power is resumed. Valid data will be transferred to new blocks for merging and the mapping table will be rebuilt. Therefore, data reliability can be reinforced, preventing damage to data stored in the NAND Flash.

3.7 TRIM

TRIM is a SATA command that helps improve the read/write performance and efficiency of solid-state drives (SSD). The command enables the host operating system to inform SSD controller which blocks contain invalid data, mostly because of the erase commands from host. The invalid will be discarded permanently and the SSD will retain more space for itself.

3.8 SATA Power Management

By complying with SATA 6 Gb/s specifications, the SSD supports the following SATA power saving modes:

- ACTIVE: PHY ready, full power, Tx & Rx operational
- PARTIAL: Reduces power, resumes in under 10 µs (microseconds)
- SLUMBER: Reduces power, resumes in under 10 ms (milliseconds)
- HIPM: Host-Initiated Power Management
- DIPM: Device-Initiated Power Management
- AUTO-SLUMBER: Automatic transition from partial to slumber.
- Device Sleep (DevSleep or DEVSLP): PHY powered down; power consumption $\leqq$ 5 mW; host assertion time $\leqq$ 10 ms; exit timeout from this state $\leqq$ 20 ms (unless specified otherwise in SATA Identify Device Log).

Note: The behaviors of power management features would depend on host/device settings.

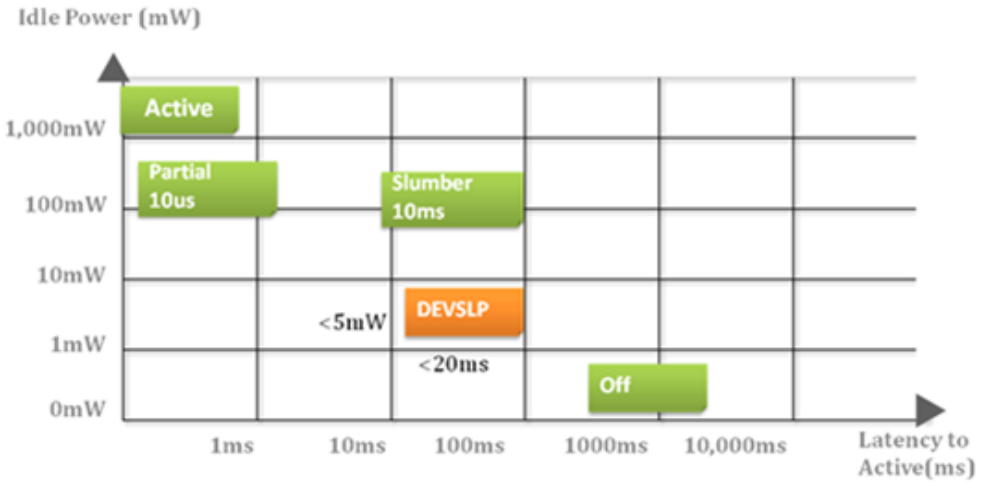
3.9 Hyper Cache Technology

Apacer proprietary Hyper Cache technology, a non-volatile SLC write cache, provides excellent performance to handle various scenarios in industrial use.

Using this method, a portion of the available capacity is being treated as SLC (1bit-per-cell) NAND flash memory in the Multi-Level Cell (MLC) models, two bits per cell technology, consists of a number of low and high pages. Apacer Hyper Cache Technology collects low pages for extraordinary performance, called Hyper Cache mode. And, the rest of high pages are combined together and performs normal MLC performance, called MLC mode. When data is written to SSD, the firmware will direct the data to Hyper Cache mode, thus improving the write speeds drastically.

3.10 Device Sleep (DevSleep or DEVSLP) Mode

Device Sleep is a feature that allows SATA devices to enter a low power mode by designating a particular pin as DEVSLP signal with an aim to reducing power consumption.



Parameter	Description & Conditions	Min	Max
V_{DIn}	Tolerated input voltage.	-0.5 V	3.6 V
$V_{HAssert}$	Voltage presented to host if signal not driven low. Value specified for all allowable $I_{HAssert.}$	-	2.4 V
$I_{HNegate}$	Device current delivered to host if host driving signal low. Value specified at $V_{HNegate}$ voltage of 0 V.	-	100 uA

3.11 SMART Read Refresh™

Apacer's SMART Read Refresh plays a proactive role in avoiding read disturb errors from occurring to ensure health status of all blocks of NAND flash. Developed for read-intensive applications in particular, SMART Read Refresh is employed to make sure that during read operations, when the read operation threshold is reached, the data is refreshed by re-writing it to a different block for subsequent use.

4. Security & Reliability Features

4.1 TCG Opal (optional)

Developed by the Trusted Computing Group (TCG), an organization whose members work together to formulate industry standards, Opal is a set of security specifications used for applying hardware-based encryption to storage devices.

Hardware encryption has many advantages. First of all, it transfers the computational load of the encryption process to dedicated processors, reducing the stress on the host system's CPU. In addition, storage devices complying with Opal specifications are self-encryption devices. Opal specifications also feature boot authentication. When the drive is being accessed, the shadow MBR will request the drive password at boot. The drive will only unlock and decrypt if the correct password is supplied. The other feature is LBA-specific permissions. Users are assigned different permissions for LBA ranges created by the device administrator. Each LBA range is password-protected and can only be accessed by users with the correct key to perform permitted actions (read/write/erase).

4.2 Advanced Encryption Standard (optional)

Advanced Encryption Standard (AES) is a specification for the encryption of electronic data. AES has been adopted by the U.S. government since 2001 to protect classified information and is now widely implemented in embedded computing applications. The AES algorithm used in software and hardware is symmetric so that encrypting/decrypting requires the same encryption key. Without the key, the encrypted data is inaccessible to ensure information security.

Notably in flash memory applications, AES 256-bit hardware encryption is the mainstream to protect sensitive or confidential data. The hardware encryption provides better performance, reliability, and security than software encryption. It uses a dedicated processor, which is built inside the controller, to process the encryption and decryption. This enormously shortens the processing time and makes it efficient.

4.3 Thermal Sensor

Apacer Thermal Sensor is a digital temperature sensor with serial interface. By using a designated pin for transmission, storage device owners are able to read temperature data.

4.4 Thermal Throttling (optional)

Thermal throttling can monitor the temperature of the SSD equipped with a built-in thermal sensor via S.M.A.R.T. commands. This method can ensure the temperature of the device stays within temperature limits by drive throttling, i.e. reducing the speed of the drive when the device temperature reaches the threshold level, so as to prevent overheating, guarantee data reliability, and prolong product lifespan. When the temperature exceeds the maximum threshold level, thermal throttling will be triggered to reduce performance step by step to prevent hardware components from being damaged. Performance is only permitted to drop to the extent necessary for recovering a stable temperature to cool down the device’s temperature. Once the temperature decreases to the minimum threshold value, transfer speeds will rise back to its optimum performance level.

5. Reliability Specifications

5.1 Environmental Specifications

Environmental specifications of SM230-25 product are shown in Table 5-1.

Table 5-1 Environmental Specifications

Environment	Specifications
Temperature	0°C to 70°C (Standard); -40°C to 85°C (Wide)
	-40°C to 100°C (Non-operation)
Vibration	Operation: 7.69(Grms), 20~2000(Hz)/random (compliant with MIL-STD-810G) Non-operation: 4.02(Grms), 15~2000(Hz)/random (compliant with MIL-STD-810G)
Shock	Operation: Acceleration, 50(G)/11(ms)/half sine (compliant with MIL-STD-202G) Non-operation: Acceleration,1,500(G)/0.5(ms)/half sine (compliant with MIL-STD-883K)

5.2 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in SM230-25. The prediction result for SM230-25 is more than 1,200,000 hours.

Note: The MTBF is predicated and calculated based on “Telcordia Technologies Special Report, SR-332, Issue 3” method.

5.3 Certification and Compliance

SM230-25 complies with the following standards:

- CE
- FCC
- RoHS
- MIL-STD-810G

5.4 Endurance

The endurance of a storage device is predicted by TeraBytes Written based on several factors related to usage, such as the amount of data written into the drive, block management conditions, and daily workload for the drive. Thus, key factors, such as Write Amplifications and the number of P/E cycles, can influence the lifespan of the drive.

Table 5-2 Endurance Specifications

Capacity	TeraBytes Written
32 GB	69
64 GB	137
128 GB	295
256 GB	513
512 GB	1,181
1 TB	2,222

Note:

- This estimation complies with JEDEC JESD-219, enterprise endurance workload of random data with payload size distribution.
- Flash vendor guaranteed MLC P/E cycle: 3K
- WAF may vary from capacity, flash configurations and writing behavior on each platform.
- 1 Terabyte = 1,024GB

6. Electrical Specifications

6.1 Operating Voltage

Table 6-1 lists the supply voltage for SM230-25.

Table 6-1 Operating Range

Item	Range
Supply Voltage	5V ± 10%

6.2 Power Consumption

Table 6-2 lists the power consumption for SM230-25.

Table 6-2 Power Consumption

Capacity / Mode	32 GB	64 GB	128 GB	256 GB	512 GB	1 TB
Active (mA)	425	395	390	450	475	485
Idle (mA)	95	95	95	95	100	105

Note:
*All values are typical and may vary depending on flash configurations or host system settings.
**Active power is an average power measurement performed using CrystalDiskMark with 128KB sequential read/write transfers.

7. Physical Characteristics

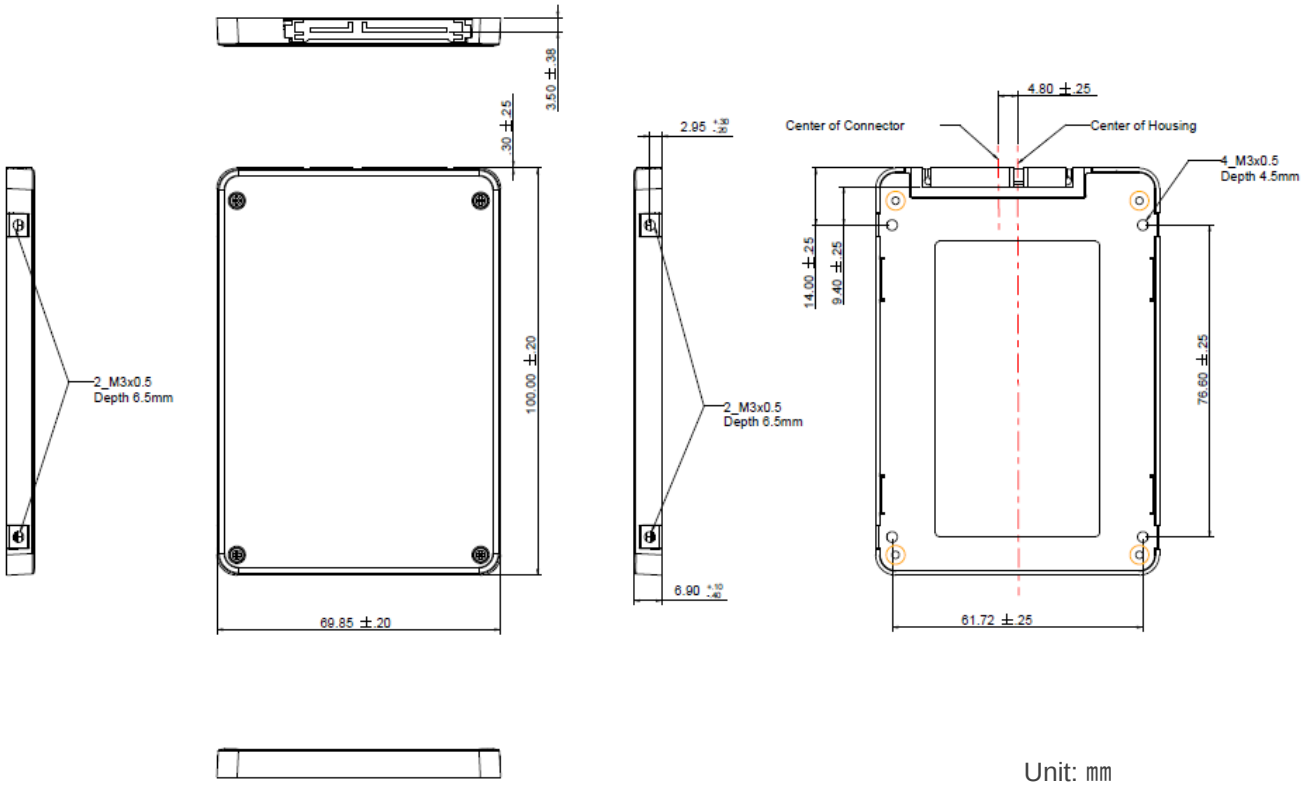
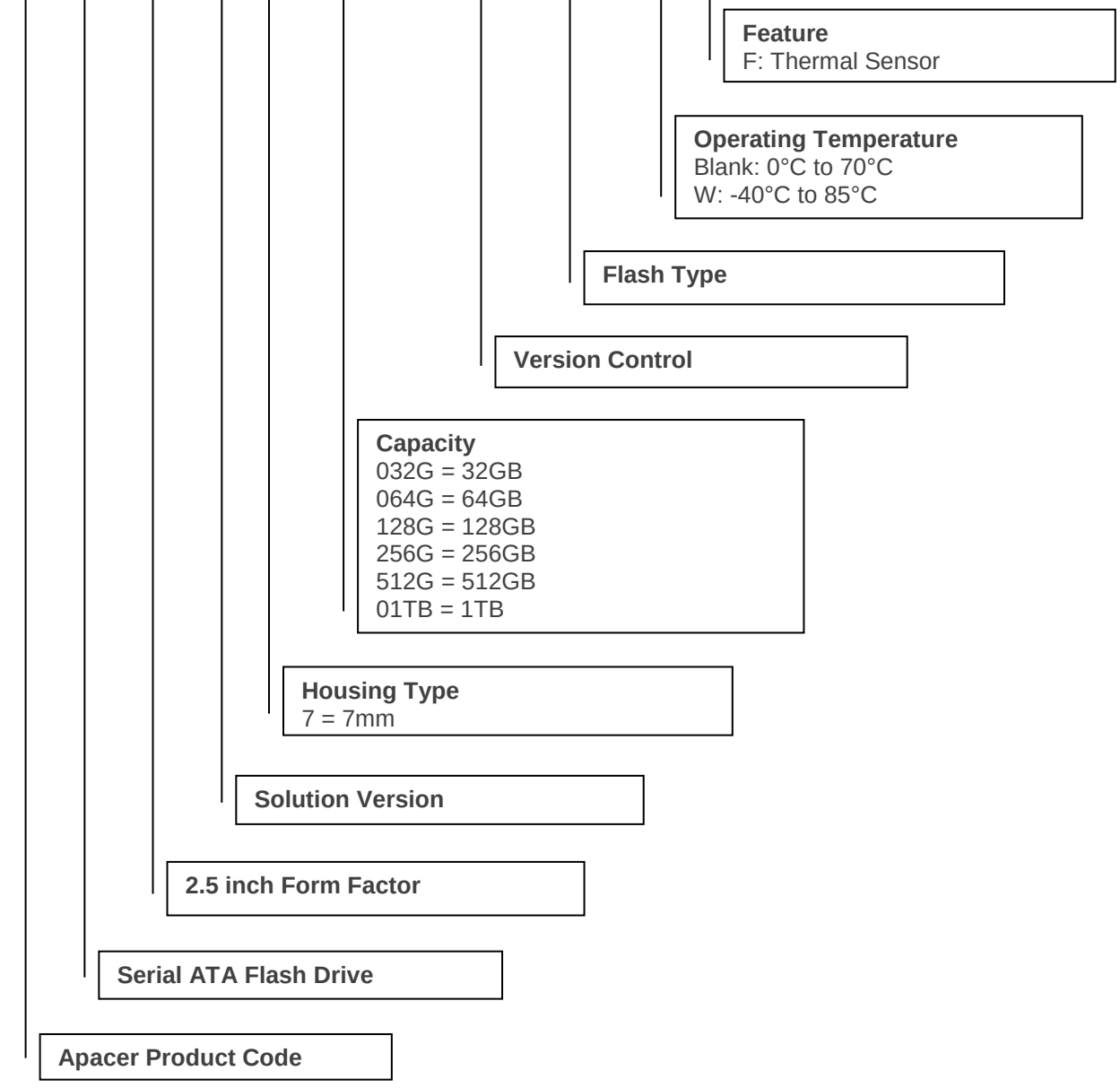


Figure 6-1 Physical Dimensions

8. Product Ordering Information

8.1 Product Code Designations

AP S 25K Z 7 xxXX – 4X TM1G X F



8.2 Valid Combinations

8.2.1 Standard

Capacity	Standard Temperature	Wide Temperature
32GB	APS25KZ7032G-4BTM1GF	APS25KZ7032G-4BTM1GWF
64GB	APS25KZ7064G-4BTM1GF	APS25KZ7064G-4BTM1GWF
128GB	APS25KZ7128G-4BTM1GF	APS25KZ7128G-4BTM1GWF
256GB	APS25KZ7256G-4BTM1GF	APS25KZ7256G-4BTM1GWF
512GB	APS25KZ7512G-4BTM1GF	APS25KZ7512G-4BTM1GWF
1TB	APS25KZ701TB-4BTM1GF	APS25KZ701TB-4BTM1GWF

8.2.2 AES/Opal Function

Capacity	Standard Temperature	Wide Temperature
32GB	APS25KZ7032G-4HTM1GF	APS25KZ7032G-4HTM1GWF
64GB	APS25KZ7064G-4HTM1GF	APS25KZ7064G-4HTM1GWF
128GB	APS25KZ7128G-4HTM1GF	APS25KZ7128G-4HTM1GWF
256GB	APS25KZ7256G-4HTM1GF	APS25KZ7256G-4HTM1GWF
512GB	APS25KZ7512G-4HTM1GF	APS25KZ7512G-4HTM1GWF

Note: Valid combinations are those products in mass production or will be in mass production. Consult your Apacer sales representative to confirm availability of valid combinations and to determine availability of new combinations.

Revision History

Revision	Description	Date
1.0	Official release	8/18/2017
1.1	- Removed DRAM cache support from Features page - Removed the note about DRAM cache from 3.5 Power Failure Management	2/22/2018
1.2	- Added 32-256GB support - Added Security Function to Features page - Added Table 1-3 and 1-4 to 1.3 Performance - Added 3.10 Advanced Encryption Standard - Added 3.11 TCG Opal - Updated 7. Product Ordering Information	3/7/2018
1.3	Added “optional” to Security Function on Features page, 3.10 Advanced Encryption Standard and 3.11 TCG Opal	3/9/2018
1.4	- Changed "Features" to "Specifications Overview" - Added Reliability section to Specifications Overview page - Updated 32-256GB TBW at Endurance on Specifications Overview page and 5.4 Endurance - Added 5. Security & Reliability Features	4/25/2018
1.5	- Removed product photo from the cover page - Removed seq. read/write QD32 performance from the Performance section on Specifications Overview page and 1.3 Performance - Added Thermal Management Technique to Reliability on Specifications Overview page - Updated the SMART ID list at 2.2 S.M.A.R.T. by adding ID 171-172 and 231 - Updated 3.8 DEVSLP (DevSleep or DEVSLP) Mode - Updated 4.3 Thermal Sensor - Added 4.4 Thermal Management Technique - Updated 8. Product Ordering Information	7/9/2018
1.6	- Revised ECC from 72 bits to 76 bits error in 1K bytes at 3.1 Error Correction/Detection - Removed altitude specifications from 5.1 Environmental Specifications	7/13/2018
1.7	- Added product photo to the cover page - Renamed extended temperature to wide temperature - Updated technology description for 3.5 Power Failure Management and 3.8 DEVSLP (DevSleep or DEVSLP) Mode	7/15/2019

Revision	Description	Date
	- Updated shock and vibration specs for Table 5-1 Environmental Specifications - Updated 8. Product Ordering Information due to FW change	
1.8	Updated Table 2-1 Command Set and added Table 2-2 Trusted Computing Feature Set	8/6/2019
1.9	- Changed SATA 6.0 Gbps to SATA 6 Gb/s in accordance with SATA naming guidelines - Capitalized every letter for commands at 2.1 Command Set and SMART subcommand at 2.2 S.M.A.R.T. - Updated endurance rating for 512GB and 1TB and the notes 5.4 Endurance	4/22/2020
2.0	- Updated compliance version with SATA Interface from 3.1 to 3.2 on Specifications Overview page - Updated Table 1-1 by changing max LBA to total LBA	5/27/2020
2.1	- Added Flash Translation Layer: Page Mapping, Hyper Cache Technology and SMART Read Refresh to Flash Management on Specifications Overview page - Updated 3.2 Bad Block Management by changing block mapping to page mapping - Added 3.4 Flash Translation Layer: Page Mapping, 3.9 Hyper Cache Technology and 3.11 SMART Read Refresh - Modified the issue version for the note at 5.2 Mean Time Between Failures (MTBF)	6/16/2020
2.2	Updated the description of 3.2 Bad Block Management	6/19/2020
2.3	- Updated Performance, Power Consumption and Endurance on Specifications Overview page - Updated supply voltage by changing tolerance from ± 5% to ± 10% - Updated Tables 1-2, 1-3 and 5-2 - Updated 8. Product Ordering Information due to FW change	4/13/2021

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