

RoHS Recast Compliant

## Serial ATA Flash Drive

SM23P-300 Product Specifications

(Toshiba 15nm)



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Version 1.1



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## Specifications Overview:

- **Compliance with SATA Revision 3.2**
  - SATA 6.0 Gbps interface
  - Backward compatible with SATA 1.5 and 3.0 Gbps interfaces
  - ATA-8 command set
- **Capacity**
  - 8, 16, 32, 64, 128, 256, 512 GB
- **Performance\***
  - Burst read/write: 600 MB/sec
  - Sequential read: Up to 560 MB/sec
  - Sequential write: Up to 500 MB/sec
  - Random read (4K): Up to 41,000 IOPS
  - Random write (4K): Up to 59,000 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
- **Endurance (in Terabytes Written: TBW)**
  - 8 GB: 9 TBW
  - 16 GB: 25 TBW
  - 32 GB: 57 TBW
  - 64 GB: 115 TBW
  - 128 GB: 238 TBW
  - 256 GB: 487 TBW
  - 512 GB: 974 TBW
- **Temperature Range**
  - Operating:
    - Standard: 0°C to 70°C
    - Wide: -40°C to 85°C
  - Storage: -40°C to 100°C
- **Supply Voltage**
  - 3.3 V ± 5%
- **Power Consumption\***
  - Active mode: 1,095 mA
  - Idle mode: 185 mA
- **Form Factor**
  - JEDEC MO-300
  - Dimensions: 50.80 x 29.85 x 4.85, unit: mm
- **Shock & Vibration\*\***
  - Shock: 1,500 G
  - Vibration: 15 G
- **NAND Flash Type: MLC**
- **MTBF: >1,000,000 hours**
- **Reliability**
  - Thermal Sensor
  - Thermal Management Technique (optional)
- **Apacer CorePower** – Implementation of Tantalum Capacitors to serve as backup power supply, capable of withstanding extended ambient temperature
- **RoHS Recast Compliant (Complies with 2011/65/EU Standard)**

\*Varies from capacities. The values for performances and power consumptions presented are typical and may vary depending on flash configurations or platform settings.

\*\*Non-operating

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# 1. General Descriptions

## 1.1 Introduction

Apacer SM23P-300 is a well-balanced solid-state disk (SSD) drive with compact form factor (JEDEC MO-300) and great performance. Designed in SATA 6.0 Gbps interface, the mSATA SSD is able to deliver exceptional read/write speed, making it the ideal companion for heavy-loading embedded or server operations with space constraints for host computing systems. 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 SM23P-300 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	Max LBA
8 GB	8,012,390,400	15,525	16	63	15,649,200
16 GB	16,013,942,784	16,383	16	63	31,277,232
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

\*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 SM23P-300 is listed below in Table 1-2.

**Table 1-2** Performance Specifications

Performance	Capacity						
	8 GB	16 GB	32 GB	64 GB	128 GB	256 GB	512 GB
<b>Sequential Read* (MB/s)</b>	135	280	325	560	560	560	560
<b>Sequential Write* (MB/s)</b>	65	135	270	480	450	500	500
<b>Random Read IOPS** (4K)</b>	8,000	14,000	23,000	37,000	37,000	41,000	41,000
<b>Random Write IOPS** (4K)</b>	3,000	7,000	15,000	30,000	42,000	58,000	59,000

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

Pin assignment of the SM23P-300 is shown in Figure 1-1 and described in Table 1-3.



Figure 1-1 Pin Assignment

Table 1-3 Pin Assignment Description

Pin	Type	Description	Pin	Type	Description
1	Reserved	No Connect	27	GND	Ground
2	+3.3V	3.3V source	28	Reserved	No Connect
3	Reserved	No Connect	29	GND	Ground
4	GND	Ground	30	Reserved	No Connect
5	Reserved	No Connect	31	-A	Host Transmitter Differential Signal Pair
6	Reserved	No Connect	32	Reserved	No Connect
7	Reserved	No Connect	33	+A	Host Transmitter Differential Signal Pair
8	Reserved	No Connect	34	GND	Ground
9	GND	Ground	35	GND	Ground
10	Reserved	No Connect	36	Reserved	No Connect
11	Reserved	No Connect	37	GND	Ground
12	Reserved	No Connect	38	Reserved	No Connect
13	Reserved	No Connect	39	+3.3V	3.3V source
14	Reserved	No Connect	40	GND	Ground
15	GND	Ground	41	+3.3V	3.3V source
16	Reserved	No Connect	42	Reserved	No Connect
17	Reserved	No Connect	43	Device Type	No Connect
18	GND	Ground	44	DEVSLP	Device Sleep
19	Reserved	No Connect	45	Reserved	No Connect
20	Reserved	No Connect	46	Reserved	No Connect
21	GND	Ground	47	Reserved	No Connect
22	Reserved	No Connect	48	Reserved	No Connect
23	+B	Host Receiver Differential Signal Pair	49	DAS/DSS	Device Activity Signal/Disable Staggered Spin-up
24	+3.3V	3.3V Source	50	GND	Ground
25	-B	Host Receiver Differential Signal Pair	51*	Detect	0 ohm
26	GND	Ground	52	+3.3V	3.3V source

\*Notes about Pin51: It is a presence detection pin that shall be connected to GND by a 0 ohm to 220 ohm Resistor on device. Please see the diagram below.



**BI-directional host-side Implementation of P51 for compatibility with non-mSATA devices (Informative)**

## 2. Software Interface

### 2.1 Command Set

This section defines the software requirements and the format of the commands the host sends to SM23P-300. Commands are issued to SM23P-300 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	F6h	Security Disable Password
90h	Execute Diagnostics	F3h	Security Erase Prepare
E7h	Flush Cache	F4h	Security Erase Unit
ECh	Identify Device	F5h	Security Freeze Lock
E3h	Idle	F1h	Security Set Password
E1h	Idle Immediate	F2h	Security Unlock
91h	Initialize Device Parameters	7Xh	Seek
C8h	Read DMA	EFh	Set Features
25h	Read DMA EXT	C6h	Set Multiple Mode
60h	Read FPDMA Queued	E6h	Sleep
47h	Read Log DMA EXT	B0h	S.M.A.R.T.
2Fh	Read Log EXT	E2h	Standby
C4h	Read Multiple	E0h	Standby Immediate
20 or 21h	Read Sector(s)	CAh	Write DMA
40 or 41h	Read Verify Sector(s)	35h	Write DMA EXT
10h	Recalibrate	61h	Write FPDMA Queued
57h	Write Log DMA EXT	3Fh	Write Log EXT
C5h	Write Multiple	30h or 31h	Write Sector(s)

**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.

Code	SMART Subcommand
D0h	READ DATA
D1h	READ ATTRIBUTE THRESHOLDS
D2h	Enable/Disable Attribute Autosave
D4h	Execute Off-line Immediate
D5h	Read Log (optional)
D6h	Write Log (optional)
D8h	Enable Operations
D9h	Disable operations
DAh	Return Status

### General SMART attribute structure

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

\*Byte 5: LSB

### 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
175 (0xAF)	Bad Cluster Table Count
192 (0xC0)	Unexpected Power Loss Count
194 (0xC2)	Temperature
241 (0xF1)	Total sectors of write

## 3. Flash Management

### 3.1 Error Correction/Detection

SM23P-300 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. When host performs program/erase command on a block, bad block may appear in Status Register. 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

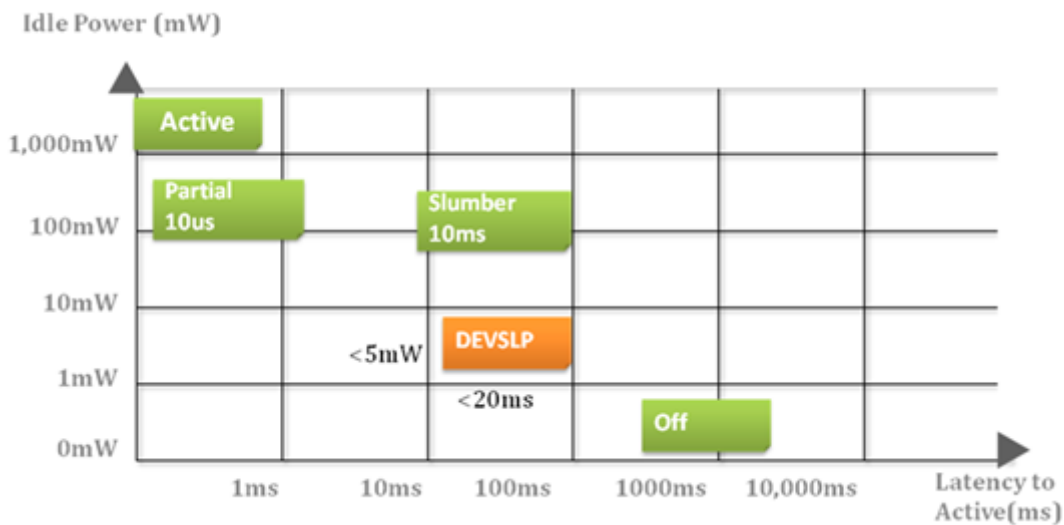
Power Failure Management plays a crucial role when power supply becomes unstable. Power disruption may occur when users are storing data into the SSD, leading to instability in the drive. However, with Power Failure Management, a firmware protection mechanism will be activated to scan pages and blocks 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 DEVSLP (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 <sub>DIn</sub>	Tolerated input voltage.	-0.5 V	3.6 V
V <sub>HAssert</sub>	Voltage presented to host if signal not driven low. Value specified for all allowable I <sub>HAssert</sub> .	-	2.4 V
I <sub>HNegate</sub>	Device current delivered to host if host driving signal low. Value specified at V <sub>HNegate</sub> voltage of 0 V.	-	100 µA

### 3.9 SATA Power Management

By complying with SATA 6.0 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  $\mu$ s (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  $\leq$  5 mW; host assertion time  $\leq$  10 ms; exit timeout from this state  $\leq$  20 ms (unless specified otherwise in SATA Identify Device Log).

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

## 4. Reliability Features

### 4.1 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.

### 4.2 Thermal Management Technique (optional)

Thermal management technique 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 SM23P-300 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-operating)
Vibration	Non-operating: Sine wave, 15(G), 10~2000(Hz), Operating: Random, 7.69(GRMS), 20~2000(Hz)
Shock	Non-operating: Acceleration, 1,500 G, 0.5 ms Operating: Peak acceleration, 50 G, 11 ms

### 5.2 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in SM23P-300. The prediction result for SM23P-300 is more than 1,000,000 hours.

Note: The MTBF is predicated and calculated based on “Telcordia Technologies Special Report, SR-332, Issue 2” method.

### 5.3 Certification and Compliance

SM23P-300 complies with the following standards:

- CE
- FCC
- RoHS
- MIL-STD-810F

## 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
8 GB	9
16 GB	25
32 GB	57
64 GB	115
128 GB	238
256 GB	487
512 GB	974

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 = 1,024 GB.

## 6. Electrical Specifications

### 6.1 Operating Voltage

Table 6-1 lists the supply voltage for SM23P-300.

**Table 6-1** Operating Range

Item	Range
Supply Voltage	3.3V $\pm$ 5%

### 6.2 Power Consumption

Table 6-2 lists the power consumption for SM23P-300.

**Table 6-2** Power Consumption

Capacity Mode	8 GB	16 GB	32 GB	64 GB	128 GB	256 GB	512 GB
Active (mA)	580	505	545	715	755	1,095	805
Idle (mA)	215	140	160	145	145	185	130

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.

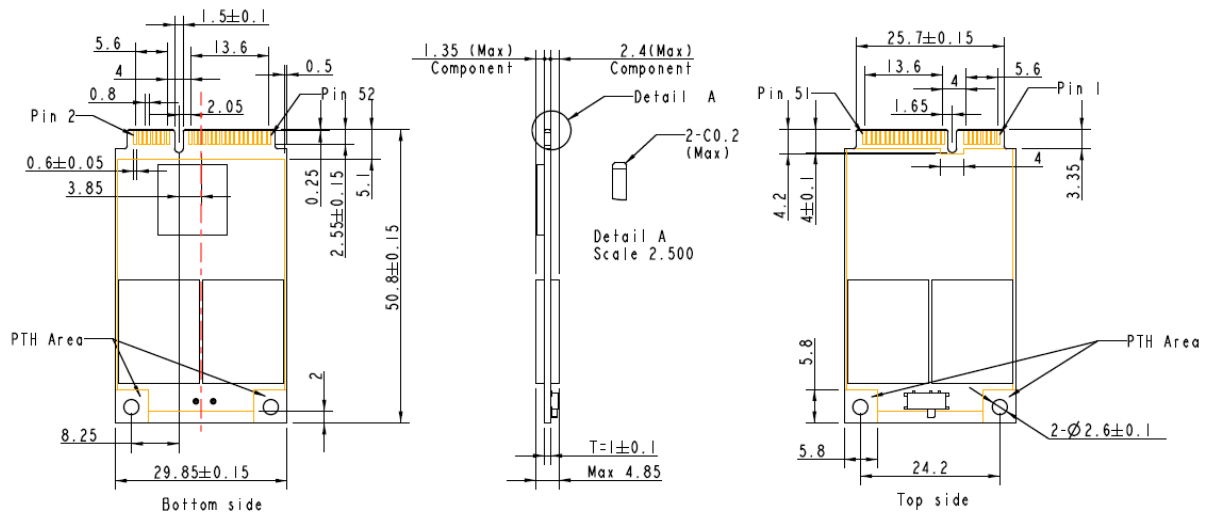
### 6.3 Apacer CorePower

If the voltage supply is cut, for instance, accidental power off or sudden blackout, the data would be shortly lost. To protect SSD data integrity from this disastrous scenario, Apacer has developed the hardware-based technology named Apacer CorePower. The CorePower equips SSDs with electrolytic capacitors that can deliver urgent power current so that the flash controller can take this extended moment to flush cached data and essential metadata into NAND Flash blocks.

In addition to electrolytic capacitors which guarantee SSD data integrity, an inbuilt IC detector also serves the same purpose as well as ensures the stability of data transmission. The detector is designed to take proactive measures for the aforementioned disastrous scenario. When supply voltage drops below a minimum threshold, the detector will send out signals to the flash controller notifying it to stop operating to prevent poor performance or erratic operation. In the meanwhile, signals will also be sent to DRAM to have cached data flushed into NAND Flash blocks so as to avoid data loss, similar to the function performed by electrolytic capacitors.

SM23P-300 is equipped with Tantalum Capacitors which have lower power leakage, higher operating temperature and higher volume-efficiency (high capacitance in small volume) than many other types of capacitors. The compact size and the high reliability are ideal for embedded computing systems.

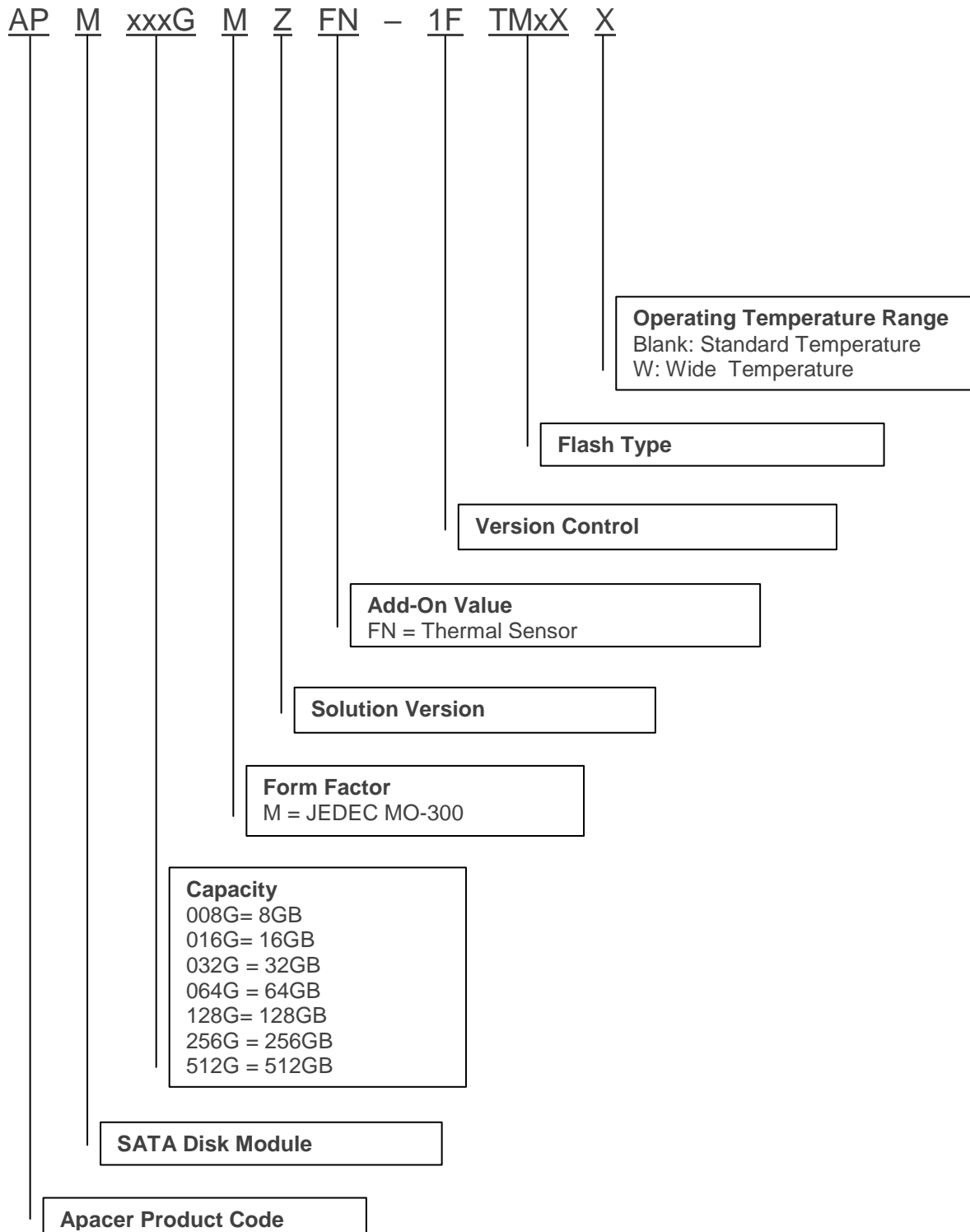
## 7. Mechanical Specifications



Unit: mm  
Tolerance:  $\pm 0.2$

## 8. Product Ordering Information

### 8.1 Product Code Designations



## 8.2 Valid Combinations

Capacity	Standard Temperature	Wide Temperature
8GB	APM008GMZFN-1FTM	APM008GMZFN-1FTMW
16GB	APM016GMZFN-1FTM1G	APM016GMZFN-1FTM1GW
32GB	APM032GMZFN-1FTM1G	APM032GMZFN-1FTM1GW
64GB	APM064GMZFN-1FTM1G	APM064GMZFN-1FTM1GW
128GB	APM128GMZFN-1FTM1G	APM128GMZFN-1FTM1GW
256GB	APM256GMZFN-1FTM1G	APM256GMZFN-1FTM1GW
512GB	APM512GMZFN-1FTM1G	APM512GMZFN-1FTM1GW

**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
0.1	Preliminary release	9/7/2018
1.0	- Added Endurance to Specifications Overview page - Added 5.4 Endurance	1/4/2019
1.1	- Renamed extended temperature to wide temperature - Replaced DataDefender with Power Failure Management	9/11/2019

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