RoHS Recast Compliant

Serial ATA Flash Drive

mSATA M4 Product Specifications

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Version 1.9

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Features:

- **Standard Serial ATA Revision 2.6**
  - Serial ATA Revision 2.6 compliance
  - SATA 3.0 Gbps
  - ATA-compatible command set
  - ATA modes support
- **Capacities**
  - 2, 4, 8, 16, 32, 64 GB
- **Performance***
  - Burst read/write: 300 MB/sec
  - Sustained read: up to 165 MB/sec
  - Sustained write: up to 150 MB/sec
- **Intelligent endurance design**
  - Built-in hardware ECC, enabling up to 24 bit correction per 1K bytes
  - Static/dynamic wear-leveling
  - Flash bad-block management
  - S.M.A.R.T.
  - Power Failure Management
  - ATA Secure Erase
  - TRIM
- **NAND Flash Type:** SLC
- **MTBF >** 2,000,000 hours
- **Temperature ranges**
  - Operation: 0℃ to 70℃ (32 ~ 158℉)
  - Extended: -40℃ to 85℃ (-40° ~ 185℉)
  - Storage: -40℃ to 100℃ (-40° ~ 212℉)
- **Endurance:** 95 TBW (2GB), 190 TBW (4GB), 380 TBW (8GB), 765 TBW (16GB), 1500 TBW (32GB), 3070 TBW (64GB)
- **Supply voltage**
  - 3.3V ± 5%
- **Power consumption (typical)***
  - Active mode: 490 mA
  - Idle mode: 150 mA
- **Form factor**
  - Mini PCIe form factor (50.8 x 29.85 x 3.40, unit: mm)
  - JEDEC MO-300 compliant
- **Connector**
  - 52-pin mSATA connector
- **Shock & Vibration****
  - Shock: 1500 G
  - Vibration: 15 G
- **RoHS Recast compliant** (2011/65/EU standard)
- **Write Protect enabled by pin configuration*****
- **Write Protect switch (optional)**
  - Enabled by onboard hardware switch

*Varies from capacities. The values addressed here are typical and may vary depending on settings and platforms.
**Non-operating
***Write Protect can be enabled by pin configuration in both standard model and switch-provided model. For more information, please refer to “Pin Assignments” and “Write Protect Enabled by Pin” sections

Table of Contents

1. Product Description

1.1 Introduction

Apacer's mSATA M4 is a solid-state disk (SSD) drive in mini PCIe form factor that contains a controller, embedded firmware, and flash media along with a male connector. mSATA M4 leverages the advantages of standard SATA SSDs in terms of wide compatibilities and reliable performance.

mSATA M4 drive is designed with a single-chip controller, offering capacities of up to 64 gigabytes and is compliant with the SATA 3.0 Gbps high-speed interface standard. Complying with JEDEC MO-300 standard, this mSATA SSD is the widely adopted embedded storage with compact size and exceptional performance.

In addition, mSATA M4 adopts the Apacer-specific global wear-leveling scheme to allow uniform use of all storage blocks, ensuring that the lifespan of a flash media can be significantly increased and the disk performance is optimized as well. mSATA M4 provides the S.M.A.R.T. feature that follows the SATA Rev. 2.6, ATA/ATAPI specifications and uses the standard SMART command B0h to read data from the drive. This feature protects the user from unscheduled downtime by monitoring and storing critical drive performance.

1.2 Functional Block Diagram

mSATA M4 drive includes a single-chip SATA Controller and the flash media, as well as the SATA standard interface. The controller integrates the flash management unit with the controller itself to support multi-channel, multi-bank flash arrays. Figure 1-1 shows the functional block diagram.

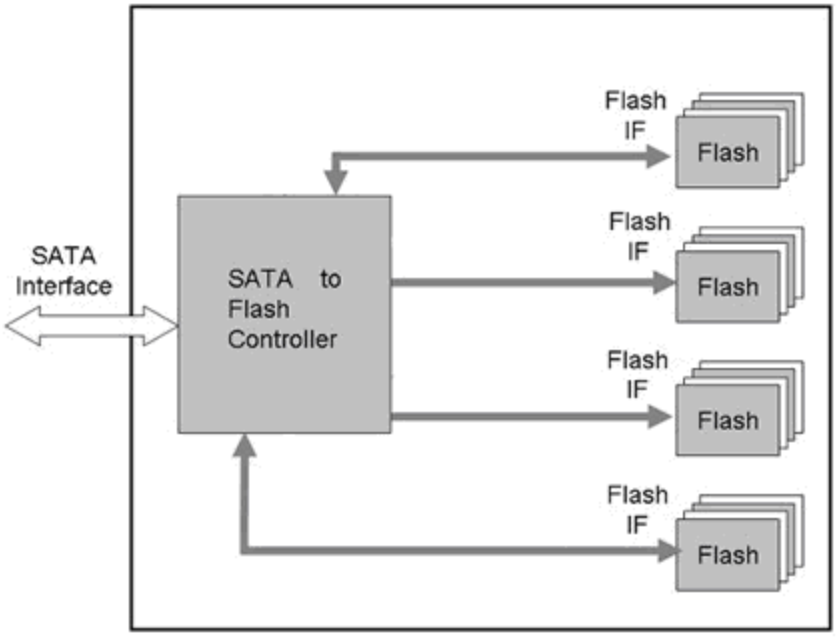


Figure 1-1 Apacer mSATA M4 block diagram

1.3 ATA Mode Support

mSATA M4 provides ATA mode support as follows:

- Up to PIO mode-4
- Up to Multiword DMA mode-2
- Up to UDMA mode-5

1.4 Capacity Specification

Capacity specification of mSATA M4 product family is available as shown in Table 1-1. It lists the specific capacity, the default numbers of logical cylinders and heads, and the number of logical sectors per track for each product line.

Table 1-1 Capacity specification

Capacity	Total Bytes*	Cylinders	Heads	Sectors	Max LBA*
2 GB	2,011,226,112	3,897	16	63	3,928,176
4 GB	4,011,614,208	7773	16	63	7,835,184
8 GB	8,012,390,400	15525	16	63	15,649,200
16 GB	16,013,942,784	16383	16	63	31,277,232
32 GB	32,017,047,552	16383	16	63	62,533,296
64 GB	64,023,257,088	16383	16	63	125,045,424

*Display of total bytes varies from file systems.
**Cylinders, heads or sectors are not applicable for these capacities. Only LBA addressing applies.
**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.

1.5 Performance

Performance of mSATA M4 is shown in Table 1-2.

Table 1-2 Performance specifications

Capacity / Performance	2 GB	4 GB	8 GB	16 GB	32 GB	64 GB
Sustained Read (MB/s)	75	145	155	155	160	165
Sustained Write (MB/s)	26	50	105	105	145	150

Note: Performance varies from flash configurations and/or platform settings.

1.6 Pin Assignments

in assignment of the mSATA M4 is shown in Figure 1-2 and described in Table 1-3.

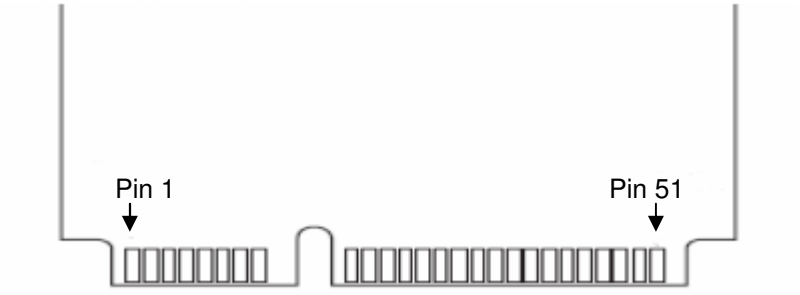


Figure 1-2 Apacer mSATA M4 pin assignment

Table 1-3 Pin Assignment Description

Pin #	Assignment	Description	Pin #	Assignment	Description
1	N/A	N/A	27	GND	Return Current Path
2	+3.3V	3.3V source	28	N/A	N/A
3	N/A	N/A	29	GND	Return Current Path
4	GND	Return Current Path	30	N/A	N/A
5	N/A	N/A	31	Rx-	SATA Differential
6	N/A	N/A	32	N/A	N/A
7	N/A	N/A	33	Rx+	SATA Differential
8	N/A	N/A	34	GND	Return Current Path
9	GND	Return Current Path	35	GND	Return Current Path
10	N/A	N/A	36	Reserved	No Connect
11	N/A	N/A	37	GND	Return Current Path
12	N/A	N/A	38	Reserved	No Connect
13	N/A	N/A	39	+3.3V	3.3V source
14	N/A	N/A	40	GND	Return Current Path
15	GND	Return Current Path	41	+3.3V	3.3V source
16	N/A	N/A	42	N/A	N/A
17	N/A	N/A	43	GND	Return Current Path
18	GND	Return Current Path	44	N/A	N/A
19	N/A	N/A	45	Reserved	N/A
20	N/A	N/A	46	N/A	N/A
21	GND	Return Current Path	47	Reserved	N/A or Write Protect
22	N/A	N/A	48	N/A	N/A
23	Tx+	SATA Differential	49	DA/DSS	Device Activity / Disable Staggered Spin Up
24	+3.3V	3.3V source	50	GND	Return Current Path
25	Tx-	SATA Differential	51	Presence Detection	Shall be pulled to GND by device
26	GND	Return Current Path	52	+3.3V	3.3V source

Notes: Pin47 is N/A by default with high impedance. However, the pin is internally programmed with Write Protect function. If the pin signal is pulled to “low”, Write Protect will be triggered. This pin configured Write Protect is available in both the standard and the model with a hardware switch. There is no functional conflict between the pin-configured and the switch-enabled Write Protect as both adopt the same GPIO pin in the hardware and firmware design.

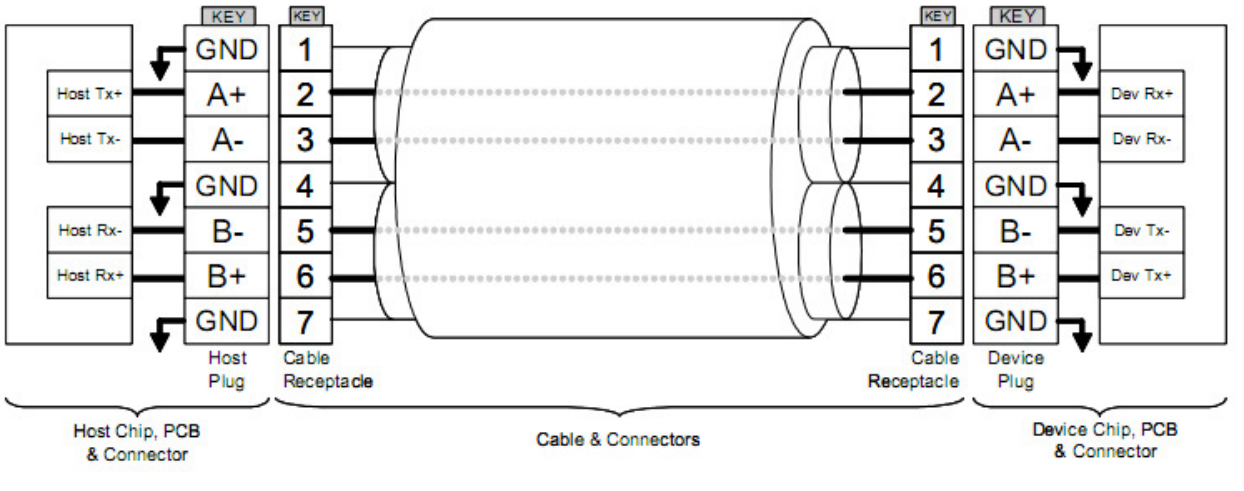


Figure 1-3 SATA Cable/Connector Connection Diagram

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

Table 2-1 summarizes the ATA commands supported by mSATA M4.

Table 2-1: Command set

Code	Command	Code	Command
E5h	Check Power Mode	F3h	Security Erase Prepare
06h	Data Set Management	F4h	Security Erase Unit
90h	Execute Device Diagnostic	F5h	Security Freeze Lock
E7h	Flush Cache	F1h	Security Set Password
EAh	Flush Cache EXT	F2h	Security Unlock
Ech	Identify Device	70h	Seek
E3h	Idle	Efh	Set Features
E1h	Idle Immediate	C6h	Set Multiple Mode
91h	Initialize Device Parameters	E6h	Sleep
C8h	Read DMA	B0h	SMART
25h	Read DMA EXT	E2h	Standby
C4h	Read Multiple	E0h	Standby Immediate
29h	Read Multiple EXT	Cah	Write DMA
20h	Read Sector	35h	Write DMA EXT
24h	Read Sector EXT	C5h	Write Multiple
40h	Read Verify Sectors	39h	Write Multiple EXT
42h	Read Verify Sectors EXT	30h	Write Sector
10h	Recalibrate	34h	Write Sector EXT
F6h	Security Disable Password		

3. Flash Management

3.1 Error Correction/Detection

mSATA M4 implements a hardware ECC scheme, based on the BCH algorithm. It can detect and correct up to 16 bits or 24 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, block 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 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. Wear leveling is an important mechanism that level out the wearing of blocks so that the wearing-down of blocks can be almost evenly distributed. This will increase the lifespan of SSDs. Commonly used wear leveling types are Static and Dynamic.

3.4 Power Failure Management

Power Failure Management plays a crucial role when experiencing unstable power supply. Power disruption may occur when users are storing data into the SSD. In this urgent situation, the controller would run multiple write-to-flash cycles to store the metadata for later block rebuilding. This urgent operation requires about several milliseconds to get it done. At the next power up, the firmware will perform a status tracking to retrieve the mapping table and resume previously programmed NAND blocks to check if there is any incompleteness of transmission.

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 S.M.A.R.T.

S.M.A.R.T. is an acronym for Self-Monitoring, Analysis and Reporting Technology, an open standard allowing disk drives to automatically monitor their own health and report potential problems. It protects the user from unscheduled downtime by monitoring and storing critical drive performance and calibration parameters. Ideally, this should allow taking proactive actions to prevent impending drive failure.

Apacer devices use the standard SMART command B0h to read data out from the drive to activate our SMART feature that complies with the ATA/ATAPI-7 specifications. Based on the SFF-8035i Rev. 2.0 specifications, SMART Attribute IDs shall include Initial bad block count, Bad block count, Spare block count, Maximum erase count, Average erase count and Power cycle. When the SMART Utility running on the host, it analyzes and reports the disk status to the host before the device reaches in critical condition.

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.

4. Environmental Specifications

4.1 Environments

mSATA M4 environmental specifications follow the US Military Standard MIL-STD-810F, as shown in the following table.

Table 4-1 mSATA M4-M environmental specifications

Environment	Specification
Temperature	0℃ to 70℃ (Operating), -40℃ to 85℃ (Extended)
	-40℃ to 100℃ (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

4.2 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in mSATA drive. The prediction result for the mSATA M4 is more than 2,000,000 hours.

Notes about MTBF:

The prediction is based on Bellcore analysis method by assuming device failure rate can be generated by the sum of failure rates in each component.

4.3 Certification and Compliance

mSATA M4 complies with the following standards:

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

4.4 Endurance

Terabytes Written (TBW) is an endurance rating system that indicates the maximum number of terabytes written by the host to the drive. NAND flash has a limit on how many P/E cycles it can withstand before its data retention becomes unreliable. Thus, key factors, such as Write Amplifications and the number of P/E cycles, can influence the lifespan of the drive.

Capacity	TBW (TB)
2 GB	95
4 GB	190
8 GB	380

16 GB	765
32 GB	1500
64 GB	3070

Notes:

- The measurement assumes the data written to the SSD for test is under a typical and constant rate.
- The measurement follows the standard metric: 1 TB (Terabyte) = 1000 GB.

5. Electrical Characteristics

5.1 Operating Voltage

Table 5-1 lists the supply voltage for mSATA M4.

Table 5-1 mSATA M4 operating voltage

Parameter	Conditions
Supply voltage	3.3V ±5% (3.135 - 3.465 V)

5.2 Power Consumption

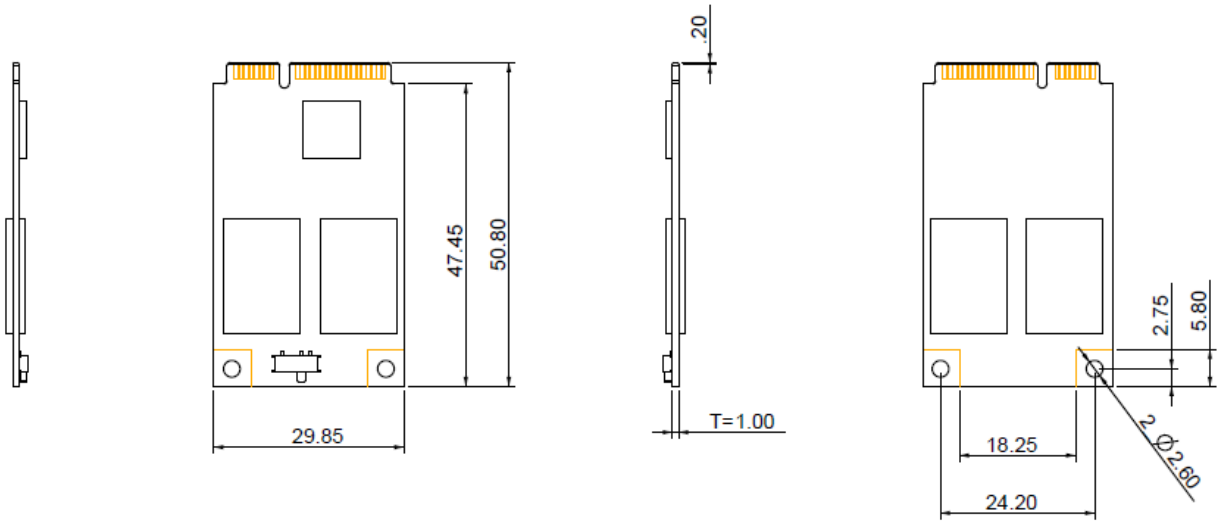
Table 5-2 Power consumption (typical)

Mode \ Capacity	2 GB	4 GB	8 GB	16 GB	32 GB	64 GB
Active (mA)	395	395	430	490	450	480
Standby (mA)	130	130	140	150	140	140

Note: Power consumption may vary from flash configurations and/or platform settings.

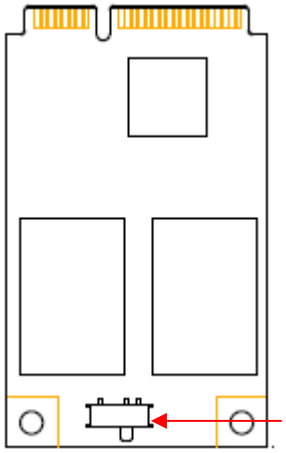
6. Physical Characteristics

6.1 Mechanical Drawing

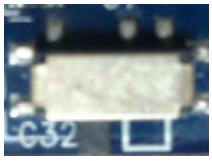


Unit: mm
Tolerance: ± 0.2

6.2 Write Protect Switch (optional)



Write Protect switch



Disable ← → Enable

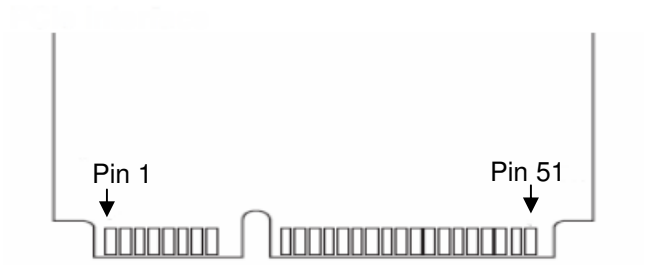
Description of Apacer Write Protect:

To protect unauthorized data writes, Apacer implements Write Protect that functions as “Virtual Write” that allows write commands to go through the flash controller and data is temporarily stored. But since the process is “virtual”, none of the data has been written to the flash. When the host resets or restarts the system, all the temporarily stored data will disappear. Since the Virtual Write scheme runs at device level, it requires no software or driver installation and is independent from the host OS.

7. Write Protect Enabled by Pin

The pin 47 can enable “Write Protect” function, no matter the standard model or the one with hardware switch. By default, the pin is set as “high” signal so that write operations can be performed normally. Once the signal is pulled to “low active”, Write Protect will be activated. Regarding the Write Protect function, it is the same scheme implemented in our Write Protect switch.

The activation/deactivation of the pin-configured Write Protect function may require additional architectural design for the host system.



46	N/A	N/A
47	Reserved	N/A or Write Protect
48	N/A	N/A

GPIO Trigger	Impedance Signal
Write Protect	Low active since triggered

Notes: Write Protect (Virtual Write) is a higher priority command than Erase or other erasure related commands. In other words, when Write Protect is activated, neither Erase nor other erasures can be activated.

This pin is available in both the standard and the model with the hardware switch. There is no functional conflict as both the pin-configured and the switch-enabled Write Protect adopt the same GPIO pin in its hardware and firmware design. If the Write Protect is activated by the pin, it will be deactivated by the pin as well. The following table lists out the Write Protect status corresponding to the enabling/disabling of the pin/switch.

Switch status	Pin47 Signal	Write Protect status
Disabled	Enabled	Enabled
Enabled	Disabled	Enabled
Disabled	Disabled	Disabled
Enabled	Enabled	Enabled

8. Product Ordering Information

8.1 Product Code Designations

A P SDM x x x x M 5 X N – P X X

Temperature Range
Blank: Standard
W: Extended Temperature

Flash Type

Version Control

Configuration
N: Standard

A: w/o Write Protect
P: Write Protect

Solution Version

Package Modifier
M= JEDEC MO-300

Capacity:

002G:	2 GB
004G:	4 GB
008G	8 GB
016G:	16 GB
032G:	32 GB
064G	64 GB

SATA Disk Module

Apacer Product Code

8.2 Valid Combinations

mSATA M4

Capacity	Standard	Extended Temperature
2GB	APSDM002GM5AN-PT	APSDM002GM5AN-PTW
4GB	APSDM004GM5AN-PT	APSDM004GM5AN-PTW
8GB	APSDM008GM5AN-PT	APSDM008GM5AN-PTW
16GB	APSDM016GM5AN-PT	APSDM016GM5AN-PTW
32GB	APSDM032GM5AN-PC	APSDM032GM5AN-PCW
64GB	APSDM064GM5AN-PC	APSDM064GM5AN-PCW

mSATA M4 with Write Protect

Capacity	Standard	Extended Temperature
2GB	APSDM002GM5PN-PT	APSDM002GM5PN-PTW
4GB	APSDM004GM5PN-PT	APSDM004GM5PN-PTW
8GB	APSDM008GM5PN-PT	APSDM008GM5PN-PTW
16GB	APSDM016GM5PN-PT	APSDM016GM5PN-PTW
32GB	APSDM032GM5PN-PC	APSDM032GM5PN-PCW
64GB	APSDM064GM5PN-PC	APSDM064GM5PN-PCW

Note: Please consult with Apacer sales representatives for availabilities.

Revision History

Revision	Description	Date
0.1	Preliminary release	11/07/2011
1.0	Official release	12/02/2011
1.1	Updated Electrical Specification and supply voltage information: from 5V to 3.3V	1/2/2012
1.2	Revised capacity information	1/16/2012
1.3	Added Endurance and Random Read/Write sections	05/04/2012
1.4	Revised mechanical drawing Updated Product Ordering Information due to firmware upgrade	08/15/2012
1.5	Added Write Protect option	11/08/2012
1.6	Added Write Protect information in pin assignment and created a chapter for it	12/21/2012
1.7	Updated Product Ordering Information due to firmware upgrade	03/12/2013
1.8	Modified endurance TBW values due to firmware change	04/22/2013
1.9	Added 2GB capacity	05/13/2014

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