

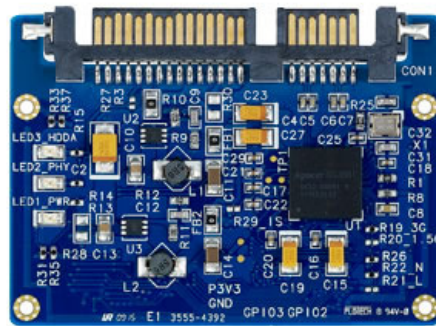
***RoHS Compliant***

**Slim SATA Flash Module - MO-297 Series**

***Datasheet for SAFD18A1-M MLC Slim SATA Flash Module***

**June 19, 2020**

**Revision 1.8**



***This Specification Describes the Features and Capabilities of the Standard and Industrial Temperature MO-297 SATA Modules***

***Please Contact Fortasa Memory Systems Sales for any Custom Features Required For Your Specific Application***



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Features:

- **Standard Serial SATA 3.1**
  - SATA 3.1 command set compatible
  - Serial SATA 6.0 Gbps Interface
  - Backwards compatible with SATA 1.5 and 3.0 Gbps interfaces
  - ATA-8 compatible command set
- **NAND flash type: MLC**
- **MTBF (hours):** >1,000,000
- **Temperature ranges**
  - Operation:
    - Standard: 0°C to 70°C
    - Industrial: -40°C to 85°C
  - Storage: -40°C to 100°C
- **Performance**
  - Burst transfer rate: 600 MB/sec
    - Sustained read: up to 560 MB/sec
    - Sustained write: up to 495 MB/sec
    - Random read 4K: up to 41,000 IOPS
    - Random write 4K: up to 60,000 IOPS
- **Intelligent endurance design**
  - Built-in hardware ECC, enabling up to 76 bit correction per 1024 bytes
  - Global wear-leveling scheme together with dynamical block allocation to significantly increase the lifetime of a flash device and optimize the disk performance
  - Flash bad-block management
    - *Power Failure Management*
    - *ATA Secure Erase*
    - *SMART Command*
    - *Trim Command*
- **Connector Type**
  - 75-pin SATA Based M.2 module pin-out
- **Form factor**
  - JEDEC MO-297
  - Dimensions - 54.0 x 39.8 x 4.0, unit: mm
- **Security Function (optional)\*\*\***
  - Trusted Computing Group (TCG) Opal 2.0
  - AES 256-bit hardware encryption
- **Thermal Sensor for Temperature Management**
- **RoHS Recast compliant (complies with 2011/65/EU standard)**
- **Capacity**
  - 16GB, 32GB, 64GB, 128GB, 256GB, 512GB
- **Low power consumption (typical)**
  - Supply voltage: 5.0 V ± 5%
  - Active mode: 645 mA
  - Idle mode: 100 mA
- **Endurance (Terabytes Written (TBW))**
  - 16 GB: 22 TBW
  - 32 GB: 41 TBW
  - 64 GB: 77 TBW
  - 128 GB: 138 TBW
  - 256 GB: 264 TBW
  - 512 GB: 507 TBW

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## 1 Product Description

### 1.1 General Description

Fortasa's SAFD18A1-M is a high-performance, SATA interface, solid state drive (SSD) designed to replace a conventional SATA hard disk drive. This module supports standard SATA protocol and can be plugged into a standard SATA connector commonly found in rugged laptops, military devices, thin clients, Point of Sale (POS) terminals, telecom, medical instruments, surveillance systems and industrial PCs.

The SAFD18A1-M module offers capacities of up to 512GB, providing full support for the SATA 6GBps high-speed interface standard. It can operate at sustained access rates of up to 560 megabytes per second, which is much faster than other solid-state or traditional HDD SATA drives currently available on the market. **Manufactured using Industrial Temperature rated MLC NAND-flash, this SSD can work in highly demanding environment and withstand wide range of operating temperature from -40°C to +85°C.**

SAFD18A1-M offers high reliability global data wear-leveling scheme to allow uniform use of all storage blocks, increasing the lifetime of Flash media and optimizing drive performance. It also offers Self-Monitoring Analysis and Reporting Technology (S.M.A.R.T.) feature that follows the ATA/ATAPI specifications and uses the standard SMART command B0h to read data from the drive. This capability monitors the drive accesses and provides the host with vital information about drive condition to schedule maintenance and service times.

### 1.2 Functional Block

The SAFD18A1-M drive includes a SATA 6.0 Gps Flash Controller and flash media. The Flash controller integrates the flash management unit to support multi-channel, multi-bank flash arrays.

### 1.3 Capacity Specification

Standard capacity specification of the SAFD18A1-M products are shown in Table 1-1. The table lists the specific capacity and the default numbers of heads, sectors and cylinders (CHS) for each product line.

Table 1-1: Capacity specifications

Capacity	Total Bytes	Cylinders	Heads	Sectors	Max LBA
16GB	16,013,942,784	16,383 <sup>1</sup>	16	63	31,277,232
32GB	32,017,047,552	16383 <sup>1</sup>	16	63	62,533,296
64GB	64,023,257,088	16383 <sup>1</sup>	16	63	125,045,424
128GB	128,035,676,160	16383 <sup>1</sup>	16	63	250,069,680
256GB	256,060,514,304	16383 <sup>1</sup>	16	63	500,118,192
512GB	512,110,190,592	16383 <sup>1</sup>	16	63	1,000,215,216

1. Cylinders, heads or sectors are not applicable for these capacities. Only LBA addressing applies.

*Please contact factory for any non-listed SAFD 18A1 SATA Module capacity or custom CHS requirement.*

# MO-297 SATA Flash Module

## FMS-SAFD18A1xxxx-XAxxX



### 1.4 Performance Specification

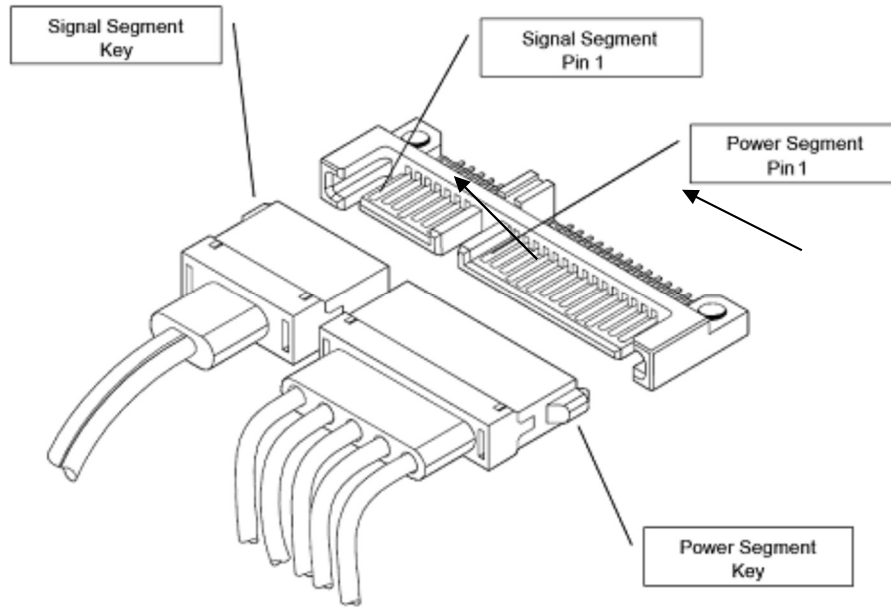
Performances of the SAFD18A1-M devices are listed in Table 1-2.

**Table 1-2:** Performance specifications

<b>Capacity</b>	<b>16GB</b>	<b>32GB</b>	<b>64GB</b>	<b>128GB</b>	<b>256GB</b>	<b>512GB</b>
<b>Performance</b>						
<b>Sustained read (MB/s)</b>	215	490	475	470	465	560
<b>Sustained write (MB/s)</b>	155	155	455	445	485	495
<b>Random Read IOPS (4K)</b>	18,000	24,000	37,000	38,000	41,000	39,000
<b>Random Write IOPS (4K)</b>	12,000	16,000	30,000	38,000	57,000	60,000

**1.5 Pin Assignments**

**Figure 1-2:** Micro-SATA connectors



**Table 1-3:** Signal Segment

Pin	Signal	Description
S1		Ground
S2	RxP	Serial Data Receiver
S3	RxN	
S4		Ground
S5	TxN	Serial Data Transmitter
S6	TxP	
S7		Ground

**Table 1-4: Power Segment**

<b>Pin</b>	<b>Signal</b>
<b>P1</b>	<b>Not Used (3.3V)</b>
<b>P2</b>	<b>Not Used (3.3V)</b>
<b>P3</b>	<b>Not Used (3.3V)</b>
<b>P4</b>	<b>Ground</b>
<b>P5</b>	<b>Ground</b>
<b>P6</b>	<b>Ground</b>
<b>P7</b>	<b>5V</b>
<b>P8</b>	<b>5V</b>
<b>P9</b>	<b>5V</b>
<b>P10</b>	<b>Ground</b>
<b>P11</b>	<b>DAS</b>
<b>P12</b>	<b>Ground</b>
<b>P13</b>	<b>Not used (12V)</b>
<b>P14</b>	<b>Not Used (12V)</b>
<b>P15</b>	<b>Not Used (12V)</b>



## 2. Software Interface

### 2.1 Command Set

Table 2-1 summarizes the command set with the paragraphs that follow describing the individual commands and the task file for each.

**Table 2-1: Command set**

Command	Code	Command	Code
Check-Power-Mode	E5H	Security-Disable-Password	F6H
Data Set Management	06h	Security-Erase-Prepare	F3H
DCO	B1h	Security-Erase-Unit	F4H
Download Microcode PIO	92h	Security-Freeze-Lock	F5H
Download Microcode DMA	93h	Security-Set-Password	F1H
Execute-Drive-Diagnostic	90H	Security-Unlock	F2H
Flush-Cache	E7H	Seek	7XH
Identify-Drive	ECH	Set-Features	EFH
Idle	E3H	Set MAX Address	F9H
Idle-Immediate	E1H	Set MAX Address EXT	37H
Initialize-Drive-Parameters	91H	Set-Multiple-Mode	C6H
Read Buffer	E4	Set-Sleep-Mode	E6H
Read DMA (W retry)	C8H	SMART	B0H
Read DMA (W/O retry)	C9H	Stand-By	E2H
Read DMA EXT	25H	Stand-By-Immediate	E0H
Read FPDMA Queued	60H	Write Buffer	E8H
Read Log EXT	2FH	Write DMA	CAH or CBH
Read-Multiple	C4H	Write DMA EXT	35H
Read-Multiple EXT	29H	Write DMA FUA EXT	3DH
Read Native Max Address	F8H	Write FPDMA Queued	61H
Read Native Max Ext	27H	Write Log EXT	3FH
Read-Sector(s)	20H or 21H	Write-Multiple	C5H
Read-Sector(s) EXT	24H	Write-Multiple EXT	39H
Read-Verify-Sectors	40H or 41H	Write-Multiple FUA EXT	CEH
Read-Verify-EXT	42H	Write-Sector(s)	30H or 31H
Recalibrate	10H	Write-Sector(s) EXT	34H
		Write Uncorrectable	45H

**Table 2-2: Trusted Computing Feature Set**

Command	Code	Command	Code
Trusted Receive	5Ch	Trusted Send	5Eh
Trusted Receive DMA	5Dh	Trusted Send DMA	5Fh

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

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### 3. Flash Management

#### 3.1 Error Correction/Detection

The SAFD18A1-M Module implements a hardware BCH-based ECC scheme to achieve up to 76 bit correction per 1024-bytes.

#### 3.2 Wear Leveling

All NAND flash devices are limited by a finite number of write cycles. Under a standard file system, frequent file table updates are mandatory. As a painful side effect of OS file overhead, some areas of flash address space wear out faster than others. As these certain sections get a substantially higher write occurrence the whole drive can wear out very quickly. This uneven wear would significantly reduce the lifetime of the whole device, even if majority of the Flash sectors are far from the write cycle limit. Fortasa's SATA Flash Drive products offer advanced data wear leveling which distributes Flash writes evenly across the drive memory space. By utilizing this advanced wear leveling feature, the lifetime of the media can be significantly extended.

#### 3.3 Power Failure Management

The Low Power Detection on the Flash controller initiates cached data saving before the power supply to the device drops too low for operation. This feature prevents the device from system crash and ensures data integrity during an unexpected brownout. This feature makes sure that there are no catastrophic failures of the drive due to system power glitches.

#### 3.4 ATA Secure Erase

Accomplished by the Secure Erase (SE) command, which added to the open ANSI standards that control disk drives, "ATA Secure Erase" is built into the disk drive itself and thus far less susceptible to malicious software attacks than external software utilities. It is a positive easy-to-use data destroy command, amounting to electronic data shredding. Executing the command causes a drive to internally completely erase all possible user data. This command is carried out within disk drives, so no additional software is required. The erase process will not stop until it is completed. In case of power failure, the erase process will continue when the power is reapplied to the device.

#### 3.5 S.M.A.R.T. Technology

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.

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
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

### 3.6 TRIM Command Support

Over time the performance of SSD degrades as user continually writes and erases data. The ATA-TRIM command “formats” the SSD to optimize the drive performance. A TRIM enabled SSD running an OS with TRIM support will stay closer to its peak performance without much performance variance.

### 3.7 SATA Power Management

The SAFD18A1-M Module 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.

Note:

1. The behaviors of power management features depend on host/device settings.

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### 3.8 Thermal Sensor

SAFD18A1-M Module contains a Thermal Sensor that measures module temperature. The module temperature can be obtained by polling SMART Command attribute ID 194 (0xC2). When the device temperature reaches a pre-set temperature threshold, the module performance will be reduced to limit the power draw and prevent the module from overheating.

### 3.9 AES 256-bit Encryption (optional)

SAFD18A1-M Module incorporates Advanced Encryption Standard (AES) 256-bit which is an industry standard in data security and has been adopted by U.S. government and now widely used for symmetric-key data encrypting in order to meet higher level of data security requirements.

### 3.10 TCG OPAL SSC V2.0 Compliant (optional)

OPAL SSC (Security Subsystem Class) is specified by Trusted Computing Group. It is to define key management and access control features for self-encrypting drives. This specification uses a concept of pre-boot partition for user authentication. It is an optional authentication method in addition to ATA security. However, due to restriction on OPAL SSC specification, ATA security command will be disabled under OPAL SSC mode.

## 4. Environmental Specifications

### 4.1 Environments

Environmental specification of the SAFD18A1-M Flash Module series follows the MIL-STD-810F standard as shown in Table 4-1.

**Table 4-1:** Environmental specifications

Environment		Specification
Temperature	Operation	0°C to +70°C (standard); -40°C to +85°C (industrial)
	Storage	-40°C to +85°C
Vibration (Operating)		7.69 GRMS, 20~2000 Hz/random (compliant with MIL-STD-810G)
Vibration (Non Operating)		4.02 GRMS, 20~2000 Hz/random (compliant with MIL-STD-810G)
Shock (Operating)		50G,11ms
Shock (Non-Operating)		1500G, 0.5ms (compliant with MIL-STD-883K)

### 4.2 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in the Flash drive. Based on provided component data, SAFD18A1-M is rated at more than 1,000,000 hours.

Notes about the MTBF:

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

### 4.3 Certification and Compliance

The SAFD18A1-M complies with the following standards:

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

### 4.4 Endurance

The endurance of a storage device is predicted by a JEDEC approved test methodology. 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. Please contact Sales to learn more about this analysis and calculations.

Capacity	DWPD
16GB	22
32GB	41
64GB	77
128GB	138
256GB	264
512GB	507

#### Notes:

- 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

## 5. Electrical Specification

### 5.1 Operating Voltage

**Caution: Absolute Maximum Stress Ratings** – Applied conditions greater than those listed under “Absolute Maximum Stress Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these conditions or conditions greater than those defined in the operational sections of this data sheet is not implied. Exposure to absolute maximum stress rating conditions may affect device reliability.

**Table 5-1:** Operating range

Range	Ambient Temperature	Conditions
Standard	0°C to +70°C	5V ± 5% (4.75-5.25V)
Industrial	-40°C to +85°C	5V ± 5% (4.75-5.25V)

### 5.2 Power Consumption

Table 5-2 lists the SAFD18A1-M power consumption.

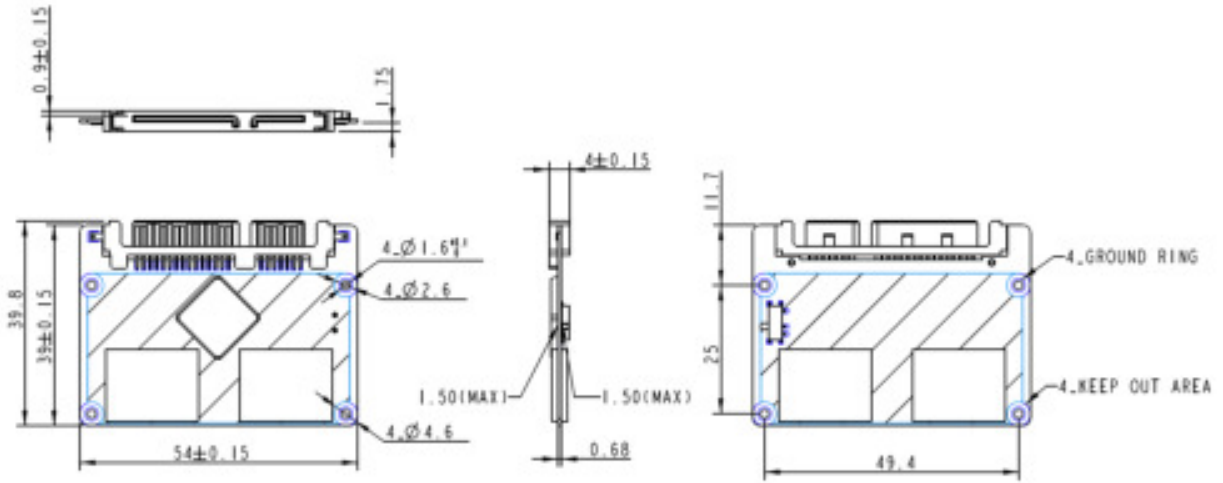
**Table 5-2** Typical power consumption

Performance \ Capacity	Capacity					
	16GB	32GB	64GB	128GB	256GB	512GB
Active Mode (mA)	400	420	445	480	645	500
Idle Mode (mA)	105	105	110	110	105	105

## 6. Physical Characteristics

### 6.1 Physical Dimensions

Figure 6-1 illustrates the overall physical dimensions of the SAFD18A1-M drive.

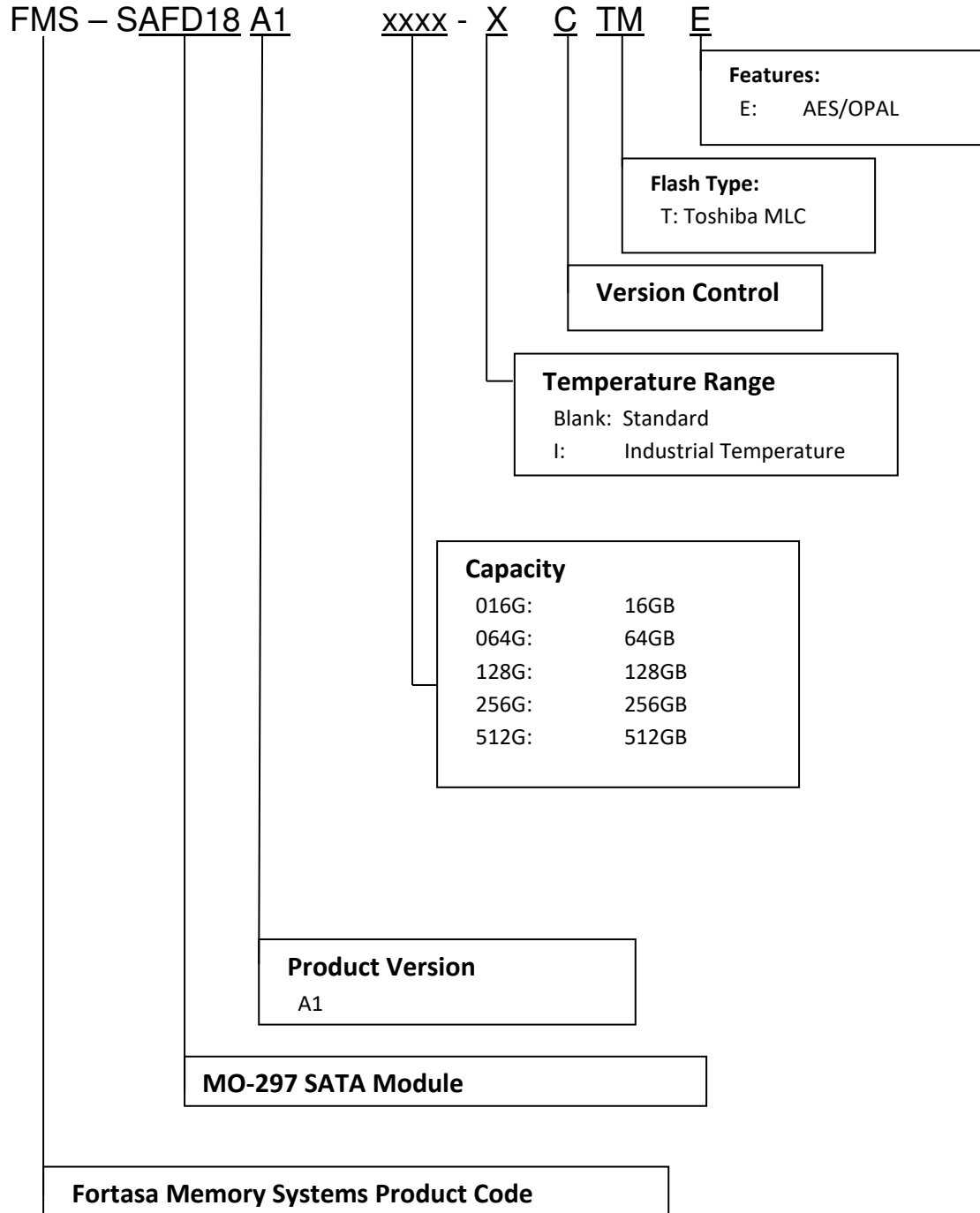


**Figure 6-1** SAFD18A1-M physical dimensions



**7. Product Ordering Information**

**7.1 Product Code Designations**



## 7.2 Valid Combinations

### AES Encryption Disabled

Capacity	Standard Temperature Model Numbers	Industrial Temperature Model Numbers
16GB	FMS-SAFD18A1016G-CTM	FMS-SAFD18A1016G-ICTM
32GB	FMS-SAFD18A1032G-CTM	FMS-SAFD18A1032G-ICTM
64GB	FMS-SAFD18A1064G-CTM	FMS-SAFD18A1064G-ICTM
128GB	FMS-SAFD18A1128G-CTM	FMS-SAFD18A1128G-ICTM
256GB	FMS-SAFD18A1256G-CTM	FMS-SAFD18A1256G-ICTM
512GB	FMS-SAFD18A1512G-CTM	FMS-SAFD18A1512G-ICTM

### AES Encryption Enabled

Capacity	Standard Temperature Model Numbers	Industrial Temperature Model Numbers
16GB	FMS-SAFD18A1016G-CTME	FMS-SAFD18A1016G-ICTME
32GB	FMS-SAFD18A1032G-CTME	FMS-SAFD18A1032G-ICTME
64GB	FMS-SAFD18A1064G-CTME	FMS-SAFD18A1064G-ICTME
128GB	FMS-SAFD18A1128G-CTME	FMS-SAFD18A1128G-ICTME
256GB	FMS-SAFD18A1256G-CTME	FMS-SAFD18A1256G-ICTME
256GB	FMS-SAFD18A1512G-CTME	FMS-SAFD18A1512G-ICTME

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

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## 8. Revision History

Revision	Date	Description	Comments
1.0	9/20/2017	Initial Release	
1.1	7/5/2018	Modified Part Numbers	
1.2	7/20/2018	Revised ECC from 40 bits to 76 bits error in 1K bytes at 3.1 Error Correction/Detection	
1.3	8/20/2018	Added Endurance to Specifications Overview Added 4.4 Endurance	
1.4	8/23/2018	Updated 2.1 Command Set	
1.5	7/12/2019	Updated 7.2 Product Ordering Information due to FW change	
1.6	11/15/2019	Updated the notes for 4.4 Endurance	
1.7	6/16/2020	Updated the description of 3.2 Bad Block Management	
1.8	6/19/2020	Updated 7.2 Product Ordering Information due to FW change	