RoHS Recast Compliant

Serial ATA Flash Drive

SAFD18S4 Product Specifications

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Version 1.5

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Features:

- **Standard Serial ATA 2.6 (Gen. 2)**
  - Serial ATA 2.6 (Gen. 2)
  - SATA Ⅱ, 3.0 Gbps
  - ATA-compatible command set
- **Capacities**
  - 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 16/24 bit correction per 1K bytes
  - Static 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
  - S.M.A.R.T.
  - Power Failure Management
  - ATA Secure Erase
  - TRIM
- **NAND Flash Type:** SLC
- **Endurance**
  - 4GB: 320 TBW
  - 8GB: 640 TBW
  - 16GB: 1,280 TBW
  - 32GB: 2,560 TBW
  - 64GB: 5,130 TBW
- **Temperature ranges**
  - Operation: 0℃ to 70℃ (32 ~ 158℉)
  - Extended: -40℃ to 85℃ (-40° ~ 185℉)
  - Storage: -40℃ to 100℃ (-40° ~ 212℉)
- **Supply voltage**
  - 5.0 V ± 5%
- **Power consumption (typical)***
  - Active mode: 335 mA
  - Idle mode: 95 mA
- **Form factor**
  - JEDEC MO-297
  - Only 4mm in thickness
  - Dimensions (54 x 39.8 x 4, unit: mm)
- **Connector**
  - 7-pin SATA signal connector
  - 15-pin SATA power connector
- **Shock & Vibration****
  - Shock: 1500 G
  - Vibration: 15 G
- **RoHS Recast compliant*****
- **Write Protect (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
***Complies with 2011/65/EU standard.

Table of Contents

1. Product Description

1.1 Introduction

Apacer's SAFD18S4 is a solid-state disk (SSD) drive that contains a controller, embedded firmware, and flash media along with a male connector. Compliant with SATA II standard, the drive conforms to most mainstream host system platforms with SATA-compliant interfaces, making it the primary storage solution for replacing traditional hard disk drive.

SAFD18S4 drive is designed with a powerful single-chip controller, offering capacities of up to 64 gigabytes and providing full support for the SATAⅡ high-speed interface standard. It can operate at sustained access rates of up to 160 megabytes per second while operating at relatively low power consumption, this SATA SSD is an ideal replacement for conventional hard disk drive in industrial computing applications.

In addition, SAFD18S4 adopts the Apacer-specific global wear-leveling scheme to allow uniform use of all storage blocks, ensuring that the lifetime of a flash media can be significantly increased and the disk performance is optimized as well. SAFD18S4 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

SAFD18S4 drive includes a single-chip SATAⅡ 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.

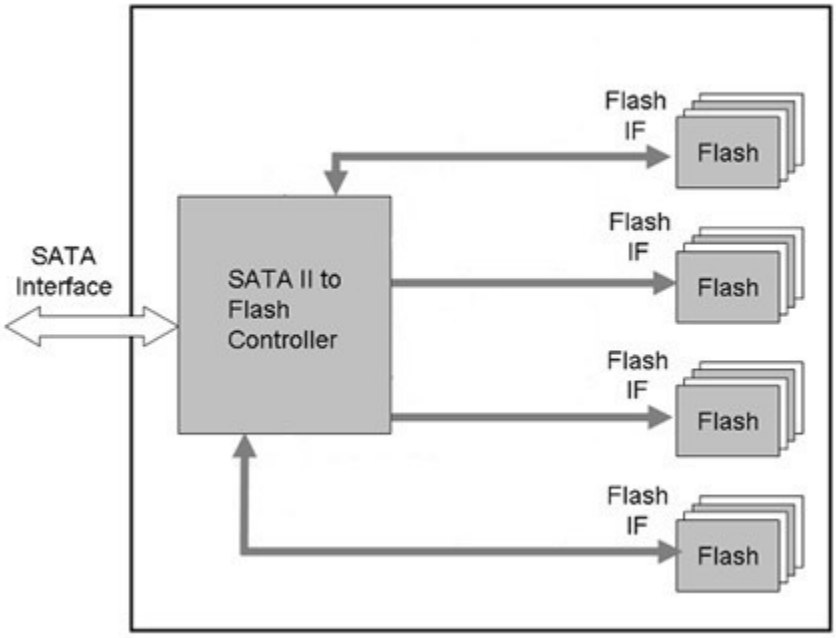


Figure 1-1 Apacer SAFD18S4 block diagram

1.3 ATA Mode Support

SAFD18S4 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 SAFD18S4 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*
4 GB	4,011,614,208	7,773	16	63	7,835,184
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

*Display of total bytes varies from file systems.
**Cylinders, heads or sectors are not applicable for these capacities. Only LBA addressing applies.
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 SAFD18S4 is shown in Table 1-2.

Table 1-2 Performance specification

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

Note: Performance varies from flash configurations or host system settings.

1.6 Pin Assignments

Table 1-3 describes the SAFD signal segment, and Table1-4, power segment.

Figure 1-2 SATA Connectors

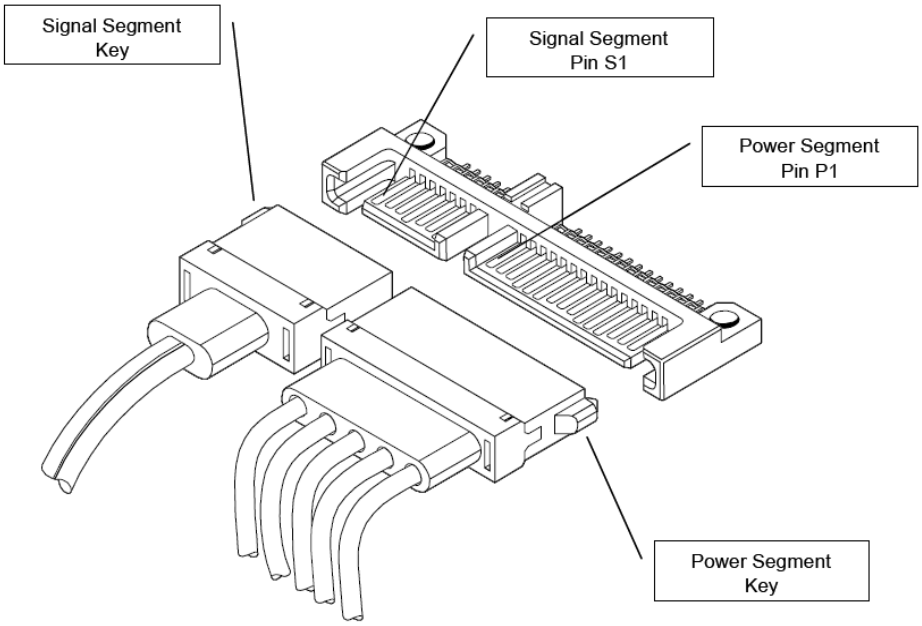


Table 1-3: Signal segment

Name	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 1-4: Power segment

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

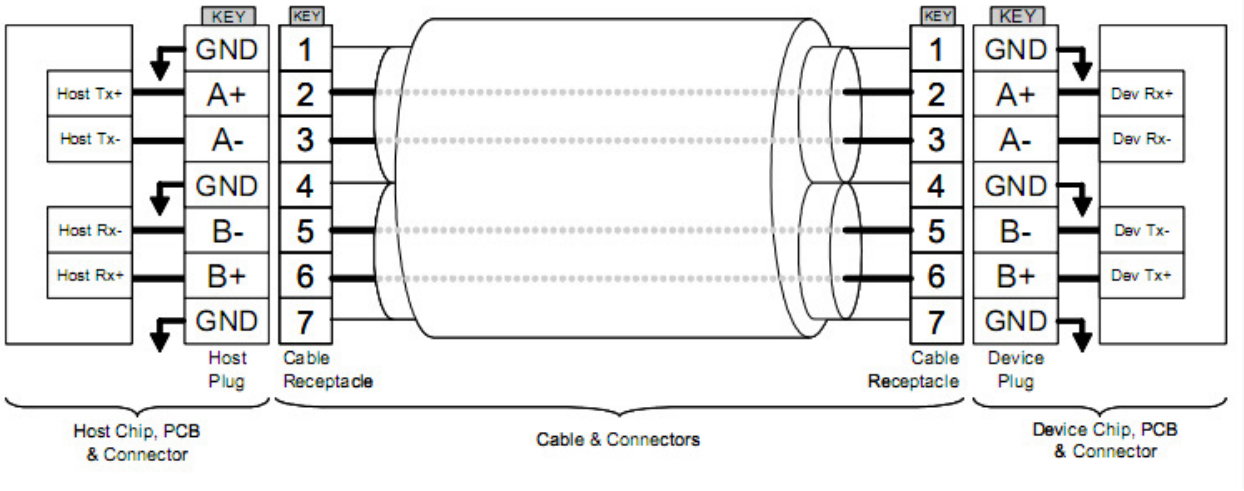


Figure 1-3 SATA Cable/Connector Connection Diagram

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 SAFD18S4.

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

SAFD18S4 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 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.

3.7 TRIM

TRIM, though in capital letters usually, is a memory computation command rather than an abbreviation. It is mainly a SATA command that enables the operating system to inform the SSD (Solid State Drive) which blocks of previously stored data are no longer valid, due to erases by the host or operating system, such as file deletions or disk formatting. Once notified, SSD will begin the discard of the invalid LBAs and retain more space for itself, in fact, the discarded is no longer recoverable.

When an LBA is replaced by the operating system, as with overwrite of a file, the SSD is informed that the originally occupied LBA is determined as no longer in use or invalid. The SSD will not save those blocks in garbage collected sectors. Noticeably, a file deletion command by host or operating system never actually erases the actual content, rather, just the file is marked as deleted. This issue is even specifically noticeable for flash based memory devices, such as SSDs. In fact, an SSD will keep garbage collecting the invalid, previously occupied LBAs, if it is not informed that these LBAs can be erased. Thus, the SSD would experience a significant performance downfall.

4. Environmental Specifications

4.1 Environments

SAFD18S4 environmental specifications follow the US Military Standard MIL-STD-810F, as shown in below table.

Table 4-1 SAFD18S4 environmental specifications

Environment	Specification
Temperature	0℃ to 70℃ (Operating), -40℃ to 85℃ (operating-extended)
	-40℃ to 100℃ (Non-operating)
Vibration	Non-operating : Sine wave, 15(G), 10~2000(Hz), Operating : Random, 7.7(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 SAFD drive. The prediction result for the SAFD18S4 is more than 2,000,000 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

SAFD18S4 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.

The TBW of the device are listed in the following table.

Capacity	TeraBytes Written
4 GB	320
8 GB	640
16 GB	1,280
32 GB	2,560
64 GB	5,130

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 SAFD18S4.

Table 5-1 SAFD18S4 operating voltage

Parameter	Conditions
Supply voltage	5V ±5% (4.75-5.25 V)

5.2 Power Consumption

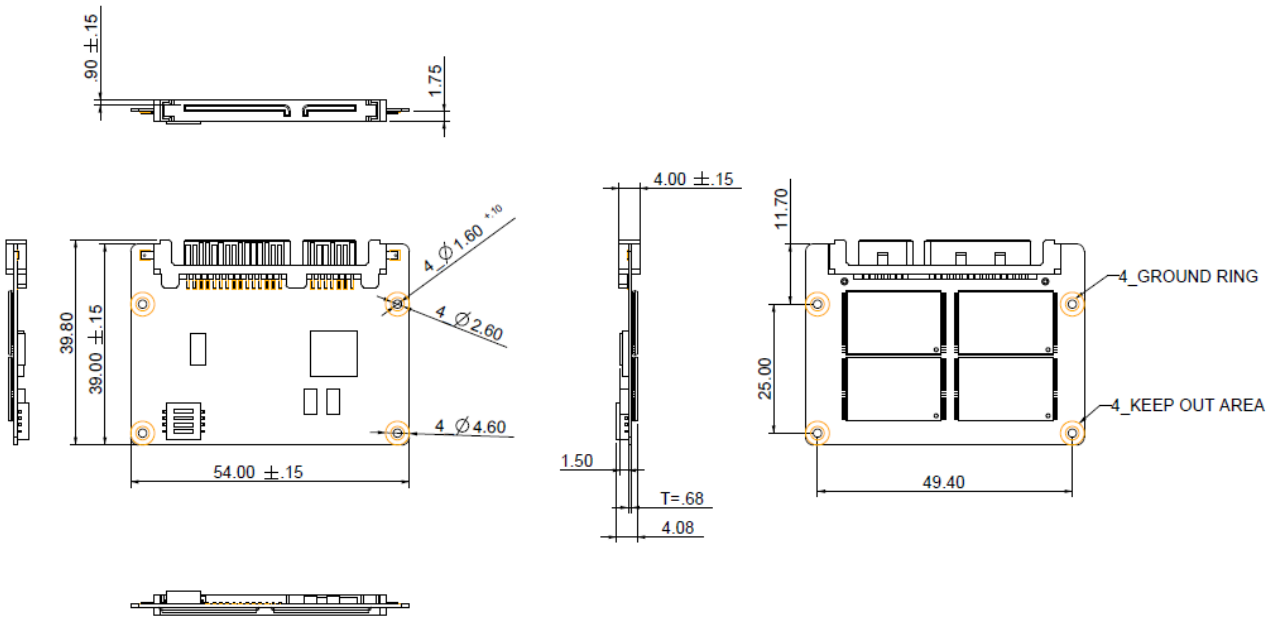
Table 5-2 Power consumption (typical)

Mode \ Capacity	4 GB	8 GB	16 GB	32 GB	64 GB
Active (mA)	250	270	320	335	335
Stand By (mA)	80	80	90	95	95

Note: Power consumptions may vary depending on settings and platforms

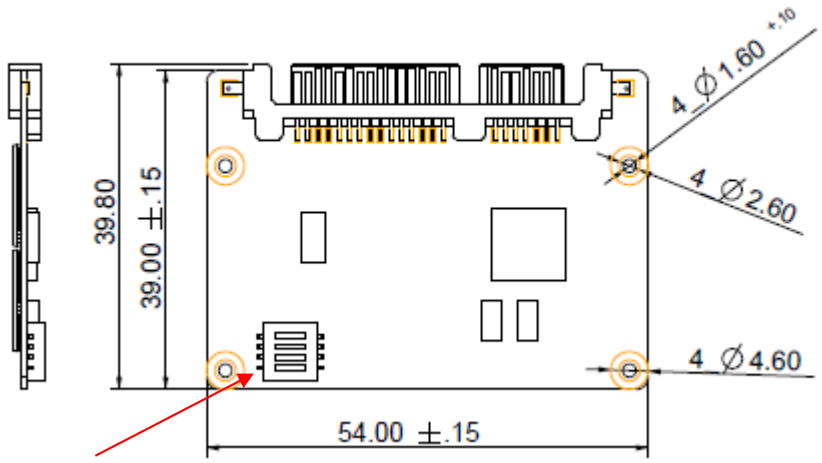
6. Physical Characteristics

6.1 Dimensions

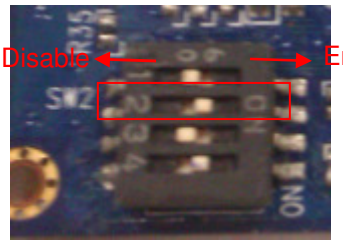


Unit: mm
Tolerance: ± 0.2

6.2 Write Protect Switch (optional)



Write Protect switch



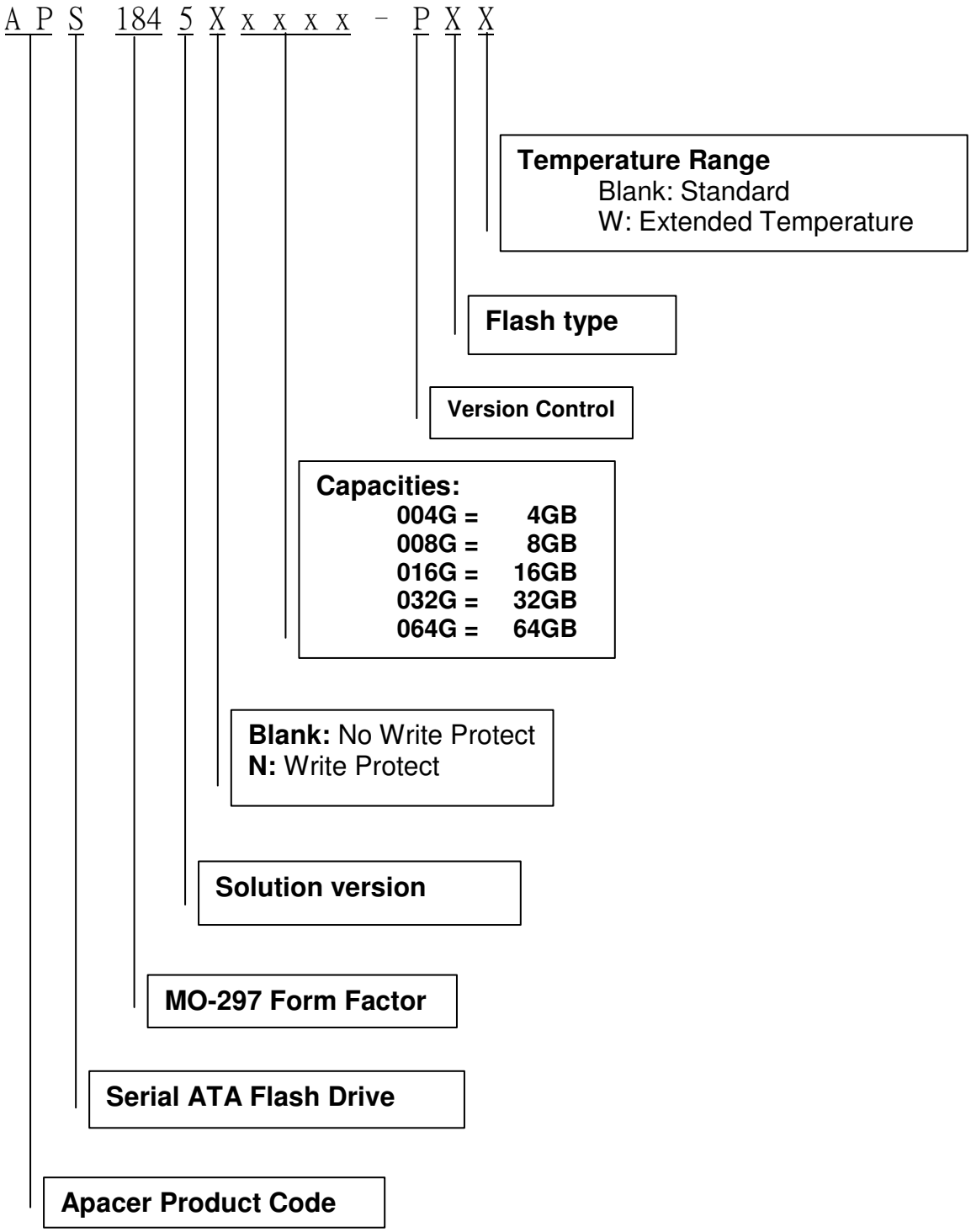
Note: DIP switch 1, 3, and 4 are defined as “reserved” for this model.

Description of Apacer Write Protect:

Apacer implements the Virtual Write scheme that allows write commands to go through the flash controller and data temporarily stored. The OS can still function normally but no data has been actually written into the flash. Since the Virtual Write scheme runs at device level, it requires no software or driver installation and is independent from the host OS.

7. Product Ordering Information

7.1 Product Code Designations



7.2 Valid Combinations

SAFD18S4

Capacity	Standard	Extended Temperature
4GB	APS1845004G-PT	APS1845004G-PTW
8GB	APS1845008G-PT	APS1845008G-PTW
16GB	APS1845016G-PT	APS1845016G-PTW
32GB	APS1845032G-PC	APS1845032G-PCW
64GB	APS1845064G-PC	APS1845064G-PCW

SAFD18S4 with Write Protect

Capacity	Standard	Extended Temperature
4GB	APS1845N004G-PT	APS1845N004G-PTW
8GB	APS1845N008G-PT	APS1845N008G-PTW
16GB	APS1845N016G-PT	APS1845N016G-PTW
32GB	APS1845N032G-PC	APS1845N032G-PCW
64GB	APS1845N064G-PC	APS1845N064G-PCW

Note: Please consult with Apacer sales representatives for availabilities.

Revision History

Revision	Description	Date
0.1	Preliminary release	11/17/2011
1.0	Official release	12/02/2011
1.1	Revised capacity specifications	1/20/2012
1.2	Revised S.M.A.R.T information	03/23/2012
1.3	Updated Product Ordering Information due to firmware upgrade	08/24/2012
1.4	Added Write Protect option	09/27/2012
1.5	Updated Product Ordering Information due to firmware upgrade	05/02/2013

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