

***RoHS Compliant***

# **Serial ATA Flash Drive**

***SAFD18S3 Specifications***

**July 18, 2011**

***Version 1.3***



***Apacer Technology Inc.***

4<sup>th</sup> Fl., 75 Xintai 5<sup>th</sup> Rd., Sec.1, Hsichih, New Taipei City, Taiwan 221

Tel: +886-2-2698-2888 Fax: +886-2-2698-2889

[www.apacer.com](http://www.apacer.com)

## 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 GB
- **Performance\***
  - Burst read/write: 300 MB/sec
  - Sustained read: up to 115 MB/sec
  - Sustained write: up to 90 MB/sec
- **Intelligent endurance design**
  - Built-in hardware ECC, enabling up to 14/28 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**
- **Data integrity under power-cycling**
  - No battery required for data storage
- **Temperature ranges**
  - Operation:
    - Standard: 0°C to 70°C
    - Extended Temperature: -40°C to 85°C
  - Storage: -40°C to 100°C
- **Supply voltage**
  - 5.0 V  $\pm$  5%
- **Low power consumption\***
  - Active mode: 356 mA@5.0 V
  - Idle mode: 90 mA@5.0 V
- **Form factor**
  - JEDEC MO-297
- **Connector**
  - 7-pin SATA signal connector
  - 15-pin SATA power connector
- **RoHS compliant**

\*Varies from capacities.

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# 1. Product Description

## 1.1 Introduction

Apacer's SAFD18S3 is a solid-state disk (SSD) drive that contains a controller, embedded firmware, and flash media along with a male connector. Using NAND flash memory devices, the SAFD drive interfaces with the host allowing data to be seamlessly transferred between the host and the flash devices.

SAFD18S3 drive is designed with a single-chip controller, offering capacities of up to 16 gigabytes and providing full support for the SATA II high-speed interface standard. It can operate at sustained access rates of up to 100 megabytes per second, which is much faster than any other solid-state or traditional SATA drive currently available on the market.

In addition to buffer management through dynamical allocation, SAFD18S3 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. SAFD18S3 provides the S.M.A.R.T. feature that follows the SATA Rev. 2.6, ATA/ATAPI-7 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

SAFD18S3 drive includes a single-chip SATA II 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.

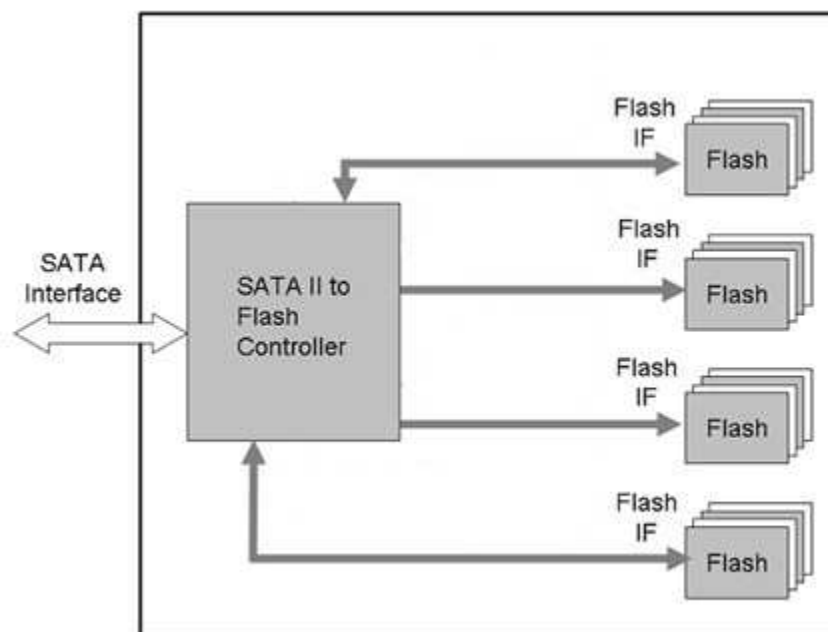


Figure 1-1 Apacer SAFD18S3 block diagram

## 1.3 ATA Mode Support

SAFD18S3 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 SAFD18S3 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     | 3,952,263,168  | 7,658     | 16    | 63      | 7,719,264  |
| 8 GB     | 7,913,816,064  | 1,5334    | 16    | 63      | 15,456,672 |
| 16 GB    | 15,842,017,280 | 1,6383    | 16    | 63      | 30,941,440 |

\*Display of total bytes varies from file systems.

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

## 1.5 Performance

Performance of SAFD18S3 is shown in Table 1-2.

Table 1-2 Performance specification

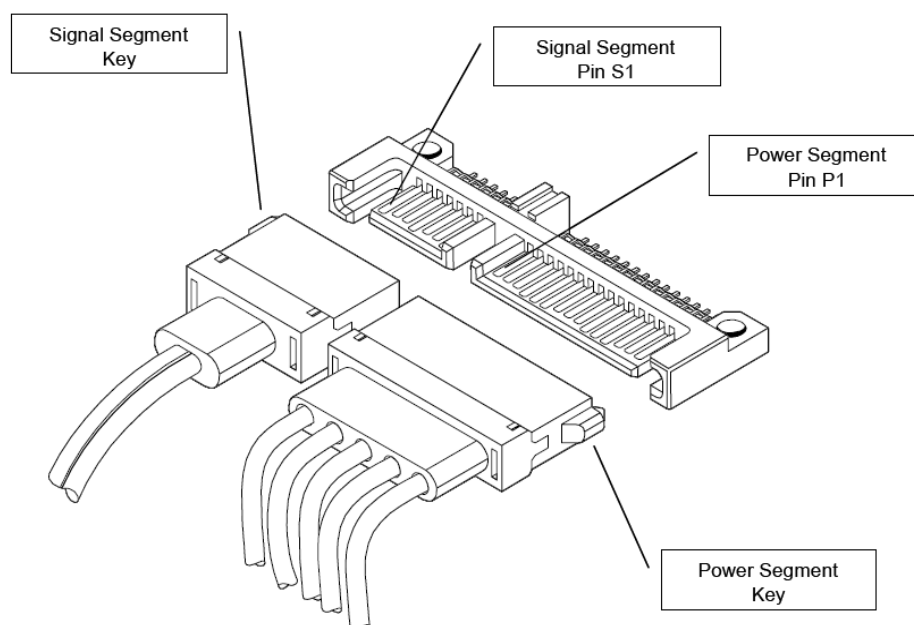
| Capacity               | 4 GB | 8 GB | 16 GB |
|------------------------|------|------|-------|
| Performance            |      |      |       |
| Sustained Read (MB/s)  | 115  | 115  | 115   |
| Sustained Write (MB/s) | 46   | 90   | 90    |

Note: Performance varies from flash configurations.

## 1.6 Pin Assignments

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

**Figure 1-2** SATA Connectors

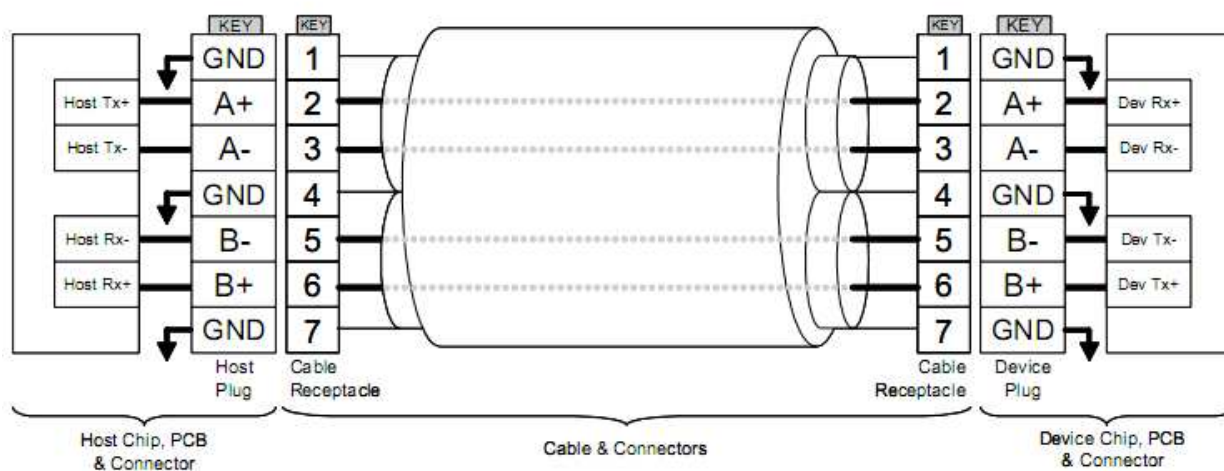


**Table 1-3:** Signal segment

| 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  | Not used (3.3V)    |
| P2  | Not used (3.3V)    |
| P3  | Not used (3.3V)    |
| P4  | Ground             |
| P5  | Ground             |
| P6  | Ground             |
| P7  | 5V                 |
| P8  | 5V                 |
| P9  | 5V                 |
| P10 | Ground             |
| P11 | Reserved/Ground    |
| P12 | Ground             |
| P13 | Not used (12V)     |
| P14 | Not used (12V)     |
| P15 | Not used (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 the SAFD18S3.

**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    |      |                        |



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## 3. Flash Management

### 3.1 Error Correction/Detection

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SAFD18S3 implements a hardware ECC scheme, based on the BCH algorithm. It can detect and correct up to 14 bits or 28 bits error in 1K bytes.

### 3.2 Bad Block Management

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Although bad blocks on the flash media are already identified by the flash manufacturer, they can also be accumulated over time during operation. SAFD18S3's controller maintains a table that lists those normal blocks with disk data, the free blocks for wear leveling, and bad blocks with errors. When a normal block is detected broken, it is replaced with a free block and listed as a bad block. When a free block is detected broken, it is then removed from the free block list and marked as a bad block.

During device operation, this ensures that newly accumulated bad blocks are transparent to the host. The device will stop file write service once there are only two free blocks left such that the read function is still available for copying the files from the disk into another.

### 3.3 Wear Leveling

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The NAND flash devices are limited by a certain number of write cycles. When using a FAT-based file system, frequent FAT table updates are required. If some area on the flash wears out faster than others, it would significantly reduce the lifetime of the whole SSD, even if the erase counts of others are far from the write cycle limit. Thus, if the write cycles can be distributed evenly across the media, the lifetime of the media can be prolonged significantly. This scheme is called wear leveling.

Apacer's wear-leveling scheme is achieved both via buffer management and Apacer-specific static wear leveling. They both ensure that the lifetime of the flash media can be increased, and the disk access performance is optimized as well.

### 3.4 Power Failure Management

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The Low Power Detection on the controller initiates crucial data saving before the power supplied to the device is too low. This feature prevents the device from crash and ensures data integrity during an unexpected power-off.

### 3.5 ATA Secure Erase

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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. Once executed, neither data nor the erase counter on the device would be recoverable, which blurs the accuracy of device lifespan. The process to erase will not be stopped until finished while encountering power failure, and will be continued when power is back on.

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### 3.6 S.M.A.R.T.

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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 SAFD18S3 uses the standard SMART command B0h to read data from the drive for SMART feature as the SATA Rev.2.6 ATA/ATAPI-7 specifications. Based on the SFF-8035i Rev. 2.0 specifications, Apacer SMART defines vendor-specified SMART Attribute IDs (A0h, A1h, A2h, A3h, A4h-A5h) in SAFD18S3. They represent initial back block count, bad block count, spare block count, maximum erase count, and average erase counts respectively. When the Apacer SMART Utility running on the host, it analyzes and reports the disk status to the host before SAFD18S3 is in critical condition.

### 3.7 TRIM

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Made of millions of NAND flash cells, SSD can be written into groups called pages in 4K size generally, but can only be erased in larger groups called blocks of 128 pages or 512KB. These stipulations are partially the source of many performance issues. Until an address gets used again, the SSD has to keep track of every last bit of data that's written on it. The ATA-TRIM instruction tilts the balance in favor of the SSD. TRIM addresses a major part of the performance degradation issue over time that plagues all SSDs. A TRIM enabled drive running an OS with TRIM support will stay closer to its peak performance over time.

## 4. Environmental Specifications

### 4.1 Environments

SAFD18S3 environmental specifications follow the US Military Standard MIL-STD-810F, as shown in below table.

**Table 4-1** SAFD18S3 environmental specifications

| Environment       | Specification  |
|-------------------|--|
| Temperature       | 0°C to 70°C (Operating – Standard); -40°C to 85°C ( Operating – ET*) |
|                   | -40°C to 100°C (Non-operating)                                       |
| Humidity          | 5% to 95% RH (Non-condensing)  |
| Vibration         | Sine wave: 15(G), 10~2000(Hz),<br>Random: 7.7(Grms), 20~2000(Hz)     |
| Shock - Operating | Acceleration: 1,500 G, 0.5 ms<br>Peak acceleration: 50 G, 11 ms      |
| Altitude          | 80,000 ft  |

\*Extended Temperature

### 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. Although many component of MTBF are given in databases and often these values are not really accurate, the prediction result for the SAFD18S3 is more than 2,000,000 hours.

### 4.3 Certification and Compliance

SAFD18S3 complies with the following standards:

- CE – EN55022/55024
- FCC 47CFR Part15 Class B
- RoHS
- MIL-STD-810F
- SATA II (SATA Rev. 2.6)
- Up to ATA/ATAPI-7 ( including S.M.A.R.T.)

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## 5. Electrical Characteristics

### 5.1 Operating Voltage

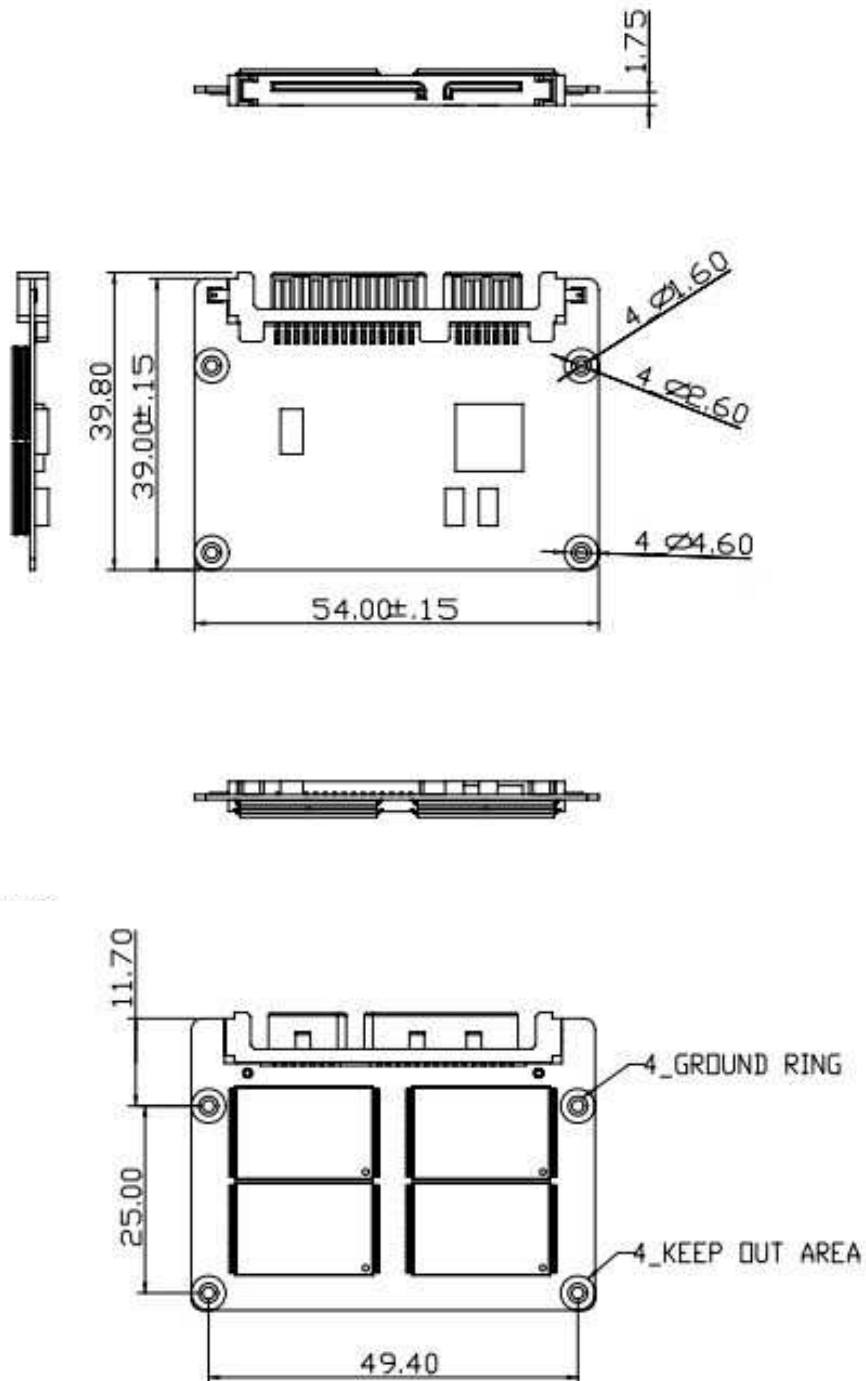
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Table 5-1 lists the supply voltage for SAFD18S3.

**Table 5-1** SAFD18S3 operating voltage

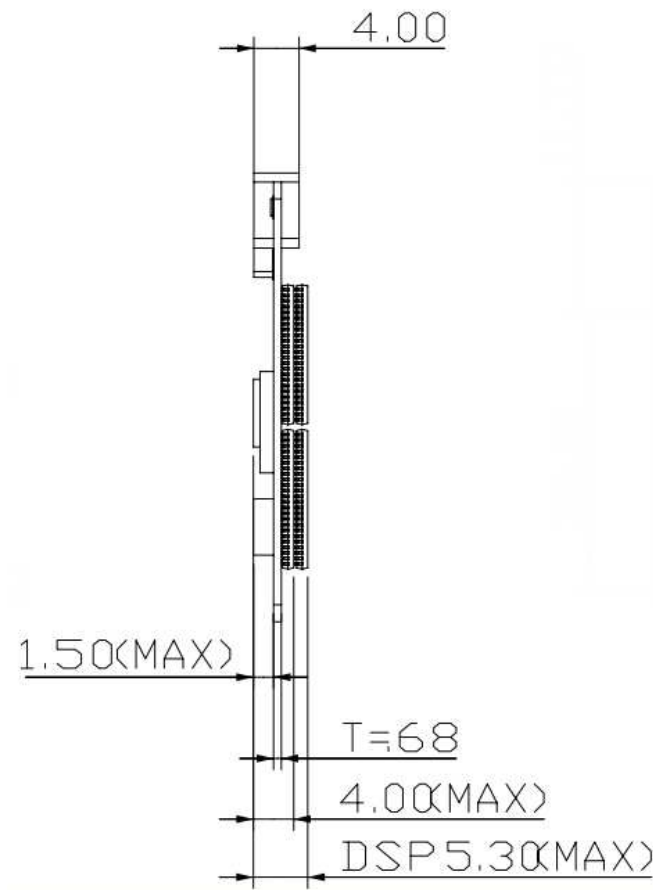
| Parameter      | Conditions                 |
|----------------|----------------------------|
| Supply voltage | 5V $\pm$ 5% ( 4.75-5.25 V) |

## 6. Physical Characteristics



Unit: mm  
Tolerance: ± 0.2

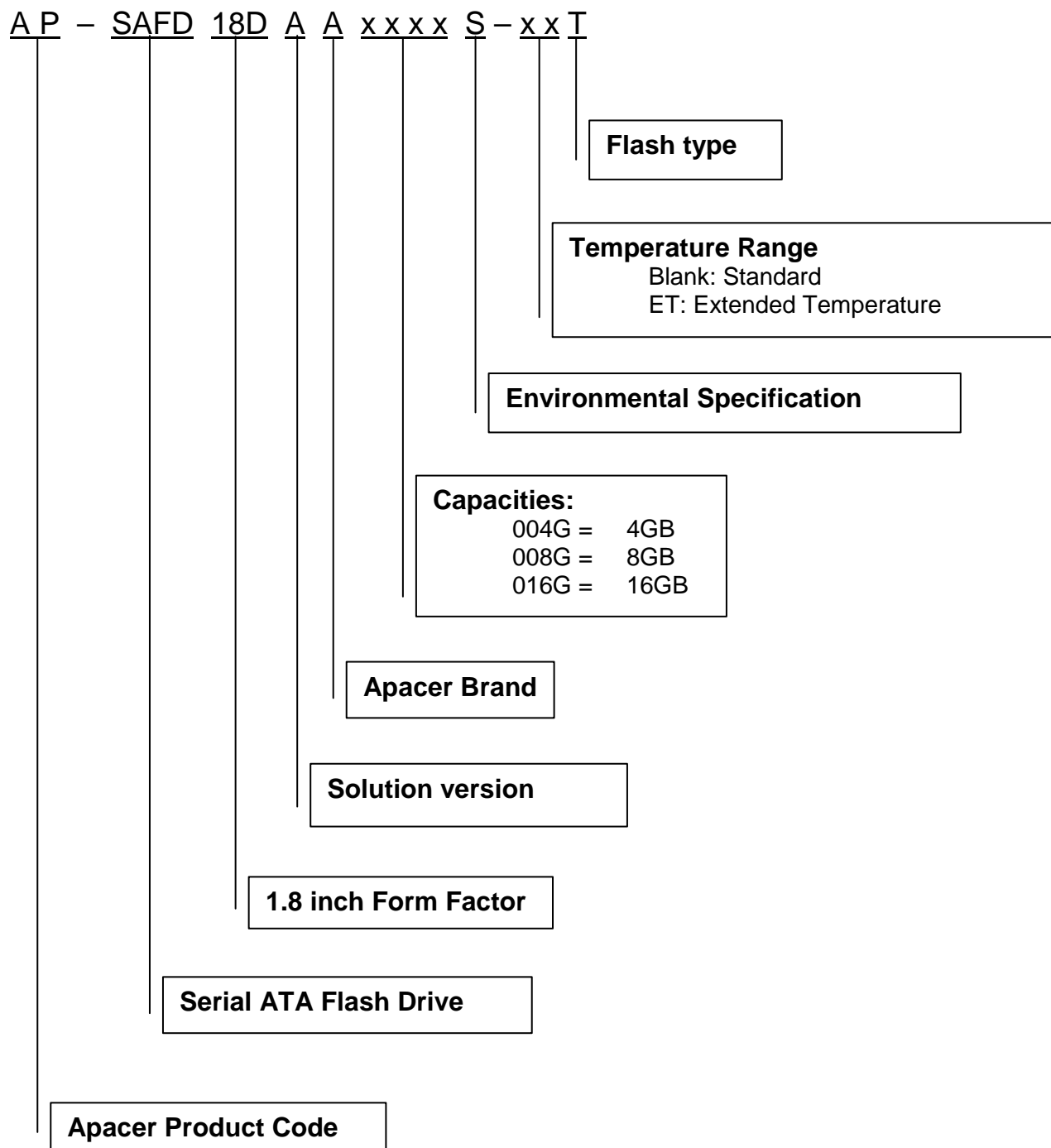
Serial ATA Flash Drive  
AP-SAFD18DAAxxxxS-XT



Unit: mm  
Tolerance:  $\pm 0.2$

## 7. Product Ordering Information

### 7.1 Product Code Designations



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## 7.2 Valid Combinations

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| Capacity | Standard            | Extended Temperature  |
|----------|---------------------|-----------------------|
| 4GB      | AP-SAFD18DAA004GS-T | AP-SAFD18DAA004GS-ETT |
| 8GB      | AP-SAFD18DAA008GS-T | AP-SAFD18DAA008GS-ETT |
| 16GB     | AP-SAFD18DAA016GS-T | AP-SAFD18DAA016GS-ETT |

**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.



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## Revision History

| Revision | Description  | Date       |
|----------|--|------------|
| 0.1      | Preliminary release  | 08/24/2010 |
| 1.0      | Formal release   | 02/24/2011 |
| 1.1      | Updated Performance Specifications   | 04/01/2011 |
| 1.2      | Updated Environmental Specifications   | 04/14/2011 |
| 1.3      | Updated Power Consumption<br>– Active mode: 353 mA -> 356mA<br>– Idle mode: 120 mA -> 90mA | 07/18/2011 |

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## Global Presence

|                              |  |
|------------------------------|--|
| <b>Taiwan (Headquarters)</b> | <b>Apacer Technology Inc.</b><br>4 <sup>th</sup> Fl., 75 Xintai 5 <sup>th</sup> Rd., Sec.1<br>Hsichih, New Taipei City<br>Taiwan 221<br>R.O.C.<br>Tel: +886-2-2698-2888<br>Fax: +886-2-2698-2889<br><a href="mailto:amtsales@apacer.com">amtsales@apacer.com</a> |
| <b>U.S.A.</b>                | <b>Apacer Memory America, Inc.</b><br>386 Fairview Way, Suite102,<br>Milpitas, CA 95035<br>Tel: 1-408-518-8699<br>Fax: 1-408-935-9611<br><a href="mailto:sa@apacerus.com">sa@apacerus.com</a>  |
| <b>Japan</b>                 | <b>Apacer Technology Corp.</b><br>5F, Matsura Bldg., Shiba, Minato-Ku<br>Tokyo, 105-0014, Japan<br>Tel: 81-3-5419-2668<br>Fax: 81-3-5419-0018<br><a href="mailto:jpservices@apacer.com">jpservices@apacer.com</a>  |
| <b>Europe</b>                | <b>Apacer Technology B.V.</b><br>Aziëlaan 22,<br>5232 BA 's-Hertogenbosch,<br>The Netherlands<br>Tel: 31-73-645-9620<br>Fax: 31-73-645-9629<br><a href="mailto:sales@apacer.nl">sales@apacer.nl</a>  |
| <b>China</b>                 | <b>Apacer Electronic (Shanghai) Co., Ltd</b><br>1301, No.251,Xiaomugiao Road, Shanghai,<br>200032, China<br>Tel: 86-21-5529-0222<br>Fax: 86-21-5206-6939<br><a href="mailto:sales@apacer.com.cn">sales@apacer.com.cn</a>   |
| <b>India</b>                 | <b>Apacer Technologies Pvt Ltd,</b><br>#1064, 1st Floor, 7th 'A' Main,<br>3rd Block Koramangala, Bangalore – 560 034<br>Tel: +91 80 4152 9061/62/63<br>Fax: +91 80 4170 0215<br><a href="mailto:sales_india@apacer.com">sales_india@apacer.com</a>               |

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