*RoHS Compliant*

# Serial ATA Flash Drive

*Specification for SAFD 18P*

**November 30th, 2011**

*Version 1.0*

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# Features:

- **Standard Serial ATA 2.6**
  - Serial ATA 2.6
  - SATA II, 3.0 Gbps
  - ATA-compatible command set

- **Capacities**
  - 8, 16, 32, 64, 128 GB

- **Performance***
  - Burst read/write: 300 MB/sec
  - Sustained read: up to 260 MB/sec
  - Sustained write: up to 215 MB/sec

- **Intelligent endurance design**
  - Built-in hardware ECC, enabling up to 16/24 bit correction per 1024 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

- **Zero power data retention**
  - No battery required for data storage

- **Temperature ranges**
  - Operation:
    Standard: 0°C to 70°C  (32 ~ 158°F)
    Extended: -40°C to 85°C (-40° ~ 185°F)
  - Storage: -40°C to 100°C (-40° ~ 212°F)

- **Supply voltage**
  - 3.3V & 5V

- **Power consumption (typical)***
  - Active mode: 978 mA (Max)
  - Idle mode: 303 mA

- **Form factor**
  - 1.8 inch (78.5 x 54 x 5, unit: mm)

- **Connector**
  - 7-pin SATA male connector
  - 9-pin SATA power connector

- **Shock & Vibration**
  - Shock: 50g (approx.)
  - Vibration: 15g (approx.)

- **RoHS compliant**

*Varies from capacities. The values addressed for performance and power consumption are typical and may vary depending on settings and platforms.

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# Table of Contents

# 1. Product Description

## 1.1 Introduction

Apacer's Serial ATA Flash Drive (SAFD) 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.

SAFD 18P drive is designed with a single-chip controller, offering capacities of up to 128 gigabytes and providing full support for the SATA II high-speed interface standard. It can operate at sustained access rates of up to higher than 200 megabytes per second, which is much more ideal for storage than traditional SATA-based hard disk drive currently available on the market.

In addition to buffer management through dynamical allocation, SAFD 18P adopts the Apacer-specific static 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. SAFD 18P 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

SAFD 18P 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.
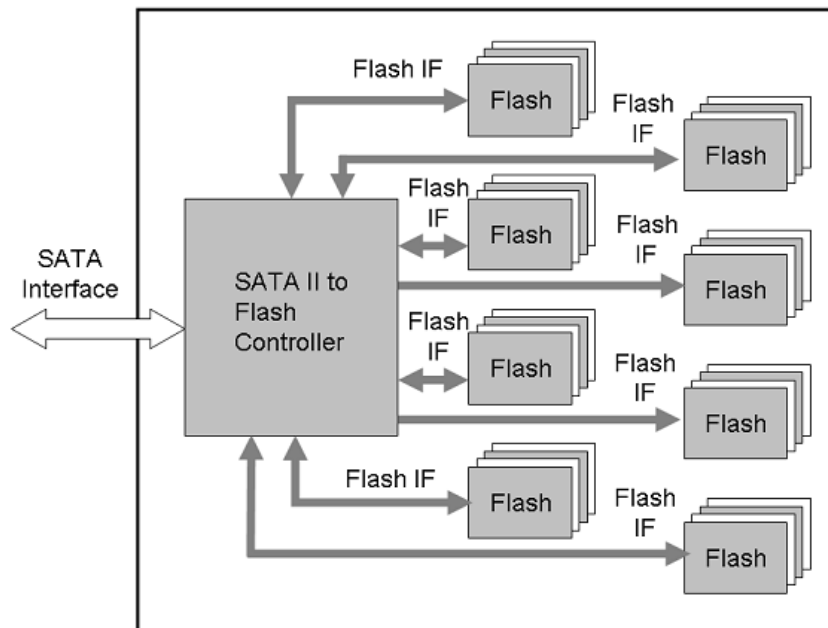


**Figure 1-1** Apacer SAFD 18P block diagram

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## 1.3    ATA Mode Support

SAFD 18P 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 SAFD 18P 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** |
|----------|-------------|-----------|-------|---------|-----------|
| 8 GB | 7,012,196,352 | 13,587 | 16 | 63 | 13,695,696 |
| 16 GB | 16,013,942,784 | 16383 | 16 | 63 | 31,277,232 |
| 32 GB | 32,017,047,552 | 16,383 | 16 | 63 | 62,533,296 |
| 64 GB | 64,023,257,088 | 16383 | 16 | 63 | 125,045,44 |
| 128 GB | 128,035,676,10 | 16383 | 16 | 63 | 250,069,60 |

*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 SAFD 18P is shown in Table 1-2.

**Table 1-2** Performance specification

| Performance \ Capacity | 8 GB | 16 GB | 32 GB | 64 GB | 128 GB |
|----------|------|-------|-------|-------|--------|
| Sustained Read (MB/s) | 255 | 260 | 260 | 260 | 245 |
| Sustained Write (MB/s) | 100 | 205 | 190 | 215 | 165 |

Note: Performances vary from flash configurations.

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# 1.6    Pin Assignments

Table 1-3 describes SAFD 18P signal segment, and Table1-4, its power segment.

**Figure 1-2** Micro-SATA Connectors

Power Segment
Pin P1

Signal Segment
Pin S1
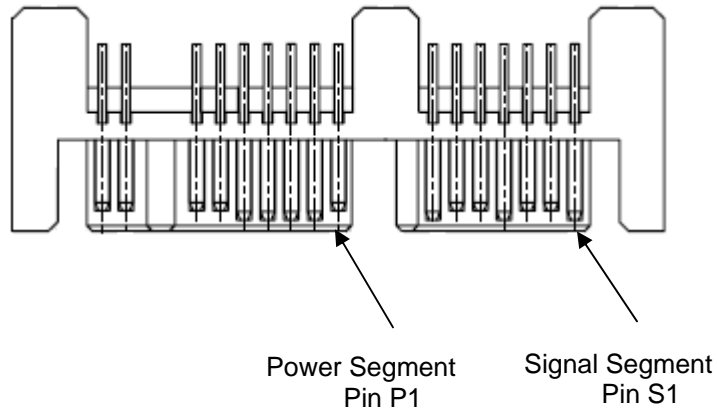
**Table 1-3** Signal segment

| 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 | Type | Signal/Description |
|-----|------|--------------------|
| P1 | V33 | 3.3 V Power |
| P2 | V33 | 3.3 V Power |
| P3 | GND | |
| P4 | GND | |
| P5 | V5 | 5 V Power |
| P6 | V5 | 5 V Power |
| P7 | GND | Ground/Reserved |
| P8 | Optional | NC |
| P9 | Optional | NC |

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**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 r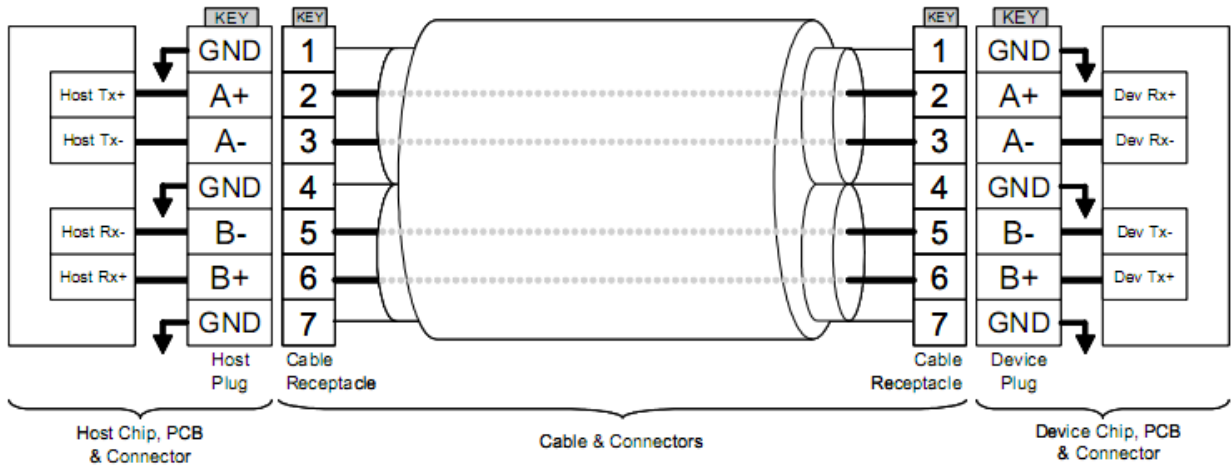ight shows the Device with TX/RX differential pairs also connected to the cable. Notice also the ground path connecting the shielding of the cable to the Cable Receptacle.

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# 2. Software Interface

## 2.1 Command Set

Table 2-1 summarizes the ATA commands supported by SAFD 18P.

**Table 2-1** Command set (1 of 2)

| Command | Code | FR[1] | SC[2] | SN[3] | CY[4] | DH[5] | LBA[6] |
|---|---|---|---|---|---|---|---|
| Check-Power-Mode | E5H | - | - | - | - | D[8] | - |
| Execute-Drive-Diagnostic | 90H | - | - | - | - | D | - |
| Flush-Cache | E7H | - | - | - | - | D | - |
| Identify-Drive | ECH | - | - | - | - | D | - |
| Idle | E3H | - | Y | - | - | D | - |
| Idle-Immediate | E1H | - | - | - | - | D | - |
| Initialize-Drive-Parameters | 91H | - | Y | - | - | Y | - |
| Read-DMA | C8H or C9H | - | Y | Y | Y | Y | Y |
| Read-Multiple | C4H | - | Y | Y | Y | Y | Y |
| Read-Sector(s) | 20H or 21H | - | Y | Y | Y | Y | Y |
| Read-Verify-Sector(s) | 40H or 41H | - | Y | Y | Y | Y | Y |
| Recalibrate | 10H | - | - | - | - | D | - |
| Security-Disable-Password | F6H | - | - | - | - | D | - |
| Security-Erase-Prepare | F3H | - | - | - | - | D | - |
| Security-Erase-Unit | F4H | - | - | - | - | D | - |
| Security-Freeze-Lock | F5H | - | - | - | - | D | - |
| Security-Set-Password | F1H | - | - | - | - | D | - |
| Security-Unlock | F2H | - | - | - | - | D | - |
| Seek | 7XH | - | - | | Y | Y | |
| Set-Features | EFH | Y[7] | - | - | - | D | - |

**Table 2-1** Command set (2 of 2)

| Command | Code | FR[1] | SC[2] | SN[3] | CY[4] | DH[5] | LBA[6] |
|---|---|---|---|---|---|---|---|
| Set-Multiple-Mode | C6H | - | Y | - | - | D | - |
| Sleep | E6H | - | - | - | - | D | - |
| SMART | B0H | Y | Y | Y | Y | D | |
| Standby | E2H | - | - | - | - | D | - |
| Standby-Immediate | E0H | - | - | - | - | D | - |
| Write-DMA | CAH | - | Y | Y | Y | Y | Y |
| Write-Multiple | C5H | - | Y | Y | Y | Y | Y |
| Write-Sector(s) | 30H | - | Y | Y | Y | Y | Y |

**1.** FR - Features register
**2.** SC - Sector Count register
**3.** SN - Sector Number register
**4.** CY - Cylinder registers
**5.** DH - Drive/Head register
**6.** LBA - Logical Block Address mode supported (see command descriptions for use)
**7.** Y - The register contains a valid parameter for this command.
**8.** For the Drive/Head register:
    Y means both the SAFD and Head parameters are used
    D means only the SAFD parameter is valid and not the Head parameter

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## 2.2    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 SAFD 18P 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 3 vendor-specified SMART Attribute IDs (E5h, EAh-EBh, and E8h) in SAFD 18P. They represent Flash ID, maximum erase count, average erase count, good block count, free-list block count, and firmware version information. When the Apacer SMART Utility running on the host, it analyzes and reports the disk status to the host before SAFD 18P is in critical condition.

# 3. Flash Management

## 3.1 Error Correction/Detection

SAFD 18P implements hardware ECC scheme based on the BCH algorithm which can detect and correct up to 16 bits or 24 bits error in 1024 bytes.

## 3.2 Bad Block Management

Although bad blocks on the flash media are already identified by the flash manufacturer, they can also be accumulated over time during operation. SAFD 18P'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

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

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

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 TRIM

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.

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# 4. Environmental Specifications

## 4.1 Environments

SAFD 18P environmental specifications follow the US Military Standard MIL-STD-810F, as shown in Table 4-1.

**Table 4-1** SAFD 18P 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: 5~55~5 Hz (X, Y, Z)<br>Random: 10-2000 Hz, 16.3 G (X, Y, Z) |
| 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 MTBFs are given in databases and often these values are not really accurate, the prediction result for SAFD 18P 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

SAFD 18P drive 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

Table 5-1 lists the supply voltage for SAFD 18P.

**Table 5-1** SAFD 18P operating voltage

| Parameter | Conditions |
|---|---|
| Supply voltage | 3.3V ±5% (3.135-3.465V) / 5V ±5% (4.75-5.25V) |

## 5.2 Power Consumption

Table 5-2 lists SAFD 18P power consumption.

**Table 5-2** SAFD 18P power consumption (Typical)

| Capacity / Mode | 8 GB | 16 GB | 32 GB | 64 GB | 128 GB |
|---|---|---|---|---|---|
| Active Mode (mA) | 610 | 920 | 978 | 800 | 600 |
| Idle Mode (mA) | 290 | 300 | 303 | 300 | 250 |

Note: power consumptions may vary depending on different flash configurations or platforms.

## 5.3 Electrostatic Discharge

**Table 5-3** Electrostatic discharge

| Item | Amount of Discharge | Voltage | Required Criteria | Complied To Criteria (A,B,C) |
|---|---|---|---|---|
| Air Discharge | 10 | +8kV | B | A |
| | 10 | -8kV | B | A |
| Contact Discharge | 25 | +4kV | B | A |
| | 25 | -4kV | B | A |
| Indirect Discharge (HCP) | 25 | +4kV | B | A |
| | 25 | -4kV | B | A |
| Indirect Discharge (VCP Front) | 25 | +4kV | B | A |
| | 25 | -4kV | B | A |

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| Indirect Discharge (VCP Left) | 25 | +4kV | B | A |
|---|---|---|---|---|
| | 25 | -4kV | B | A |
| Indirect Discharge (VCP Back) | 25 | +4kV | B | A |
| | 25 | -4kV | B | A |
| Indirect Discharge (VCP Right) | 25 | +4kV | B | A |
| | 25 | -4kV | B | A |

## 5.4   Electrical Fast Transient/Burst

**Table 5-4** Electrical Fast Transient/Burst

| Inject Line | Polarity | Voltage kV | Inject Time (Second) | Inject Method | Required Criteria | Complied to Criteria |
|---|---|---|---|---|---|---|
| L-N-PE | ± | 1kV | 60 | Direct | B | A |

**Notes about 5.3 Electrostatic Discharge & 5.4 Electrical Fast Transient/Burst**

The tests performed are from lowest level up to the highest level as required by standard, but only highest level is shown on the report.

Meet criteria A: Operate as intended during and after the test
Meet criteria B: Operate as intended after the test
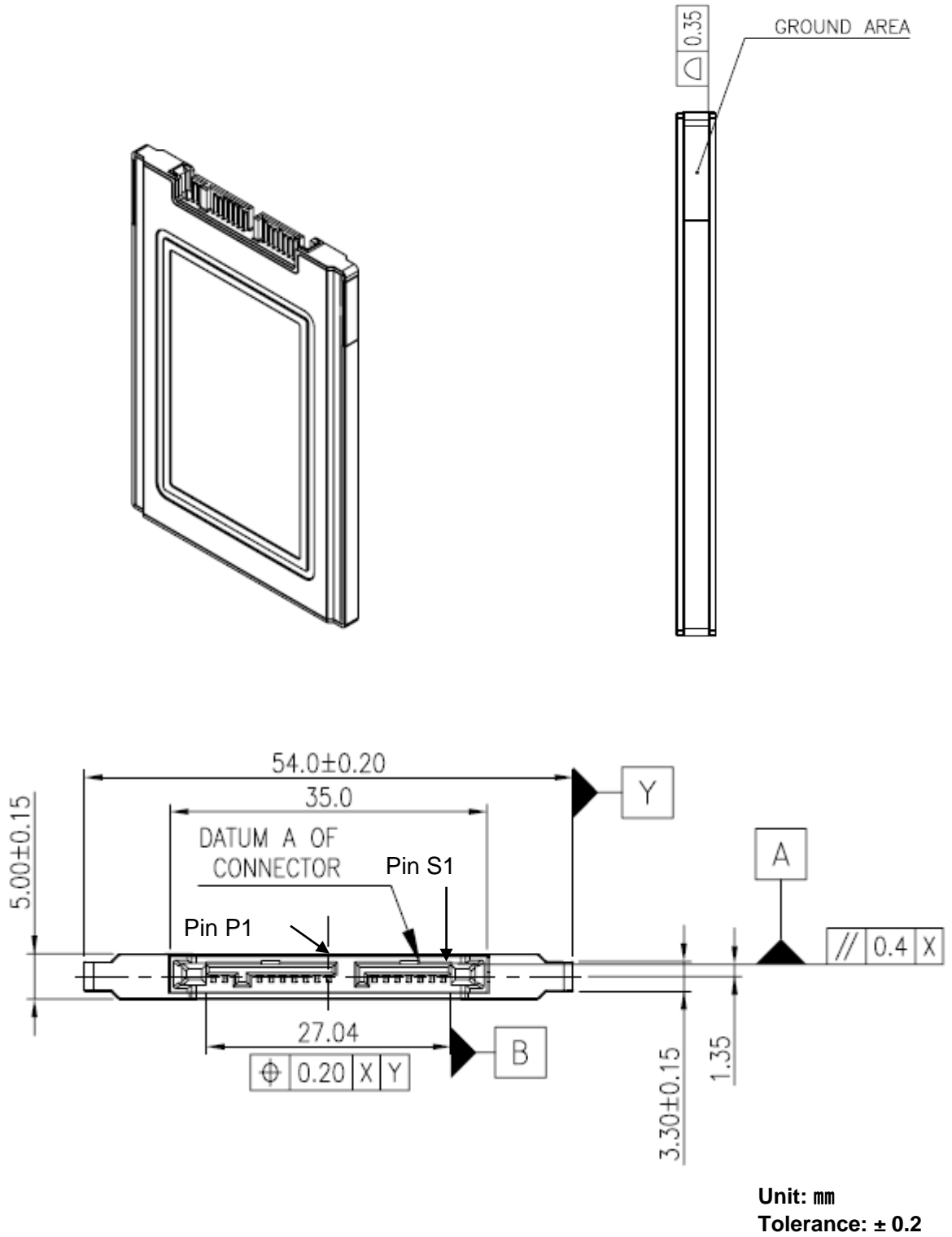Meet criteria C: Loss/Error of function

Additional Information:
EUT stopped operation and could / could not be reset by operator at kV.
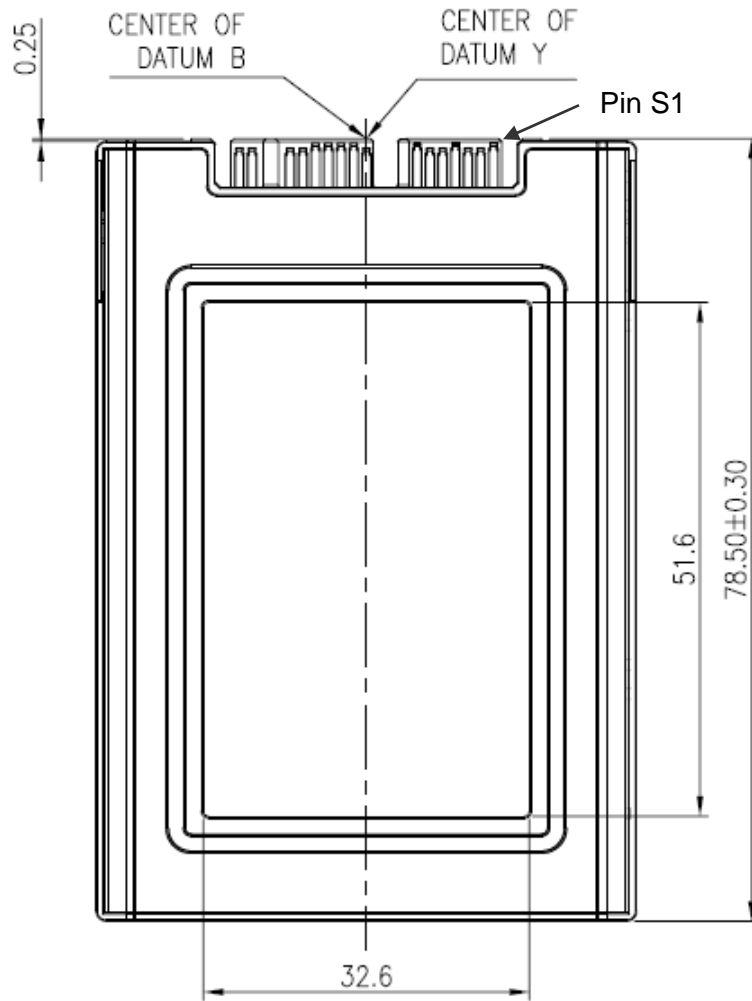No false alarms or other malfunctions were observed during or after the test.

The Contact discharges were applied at least total 200 discharges at a minimum of four test points.
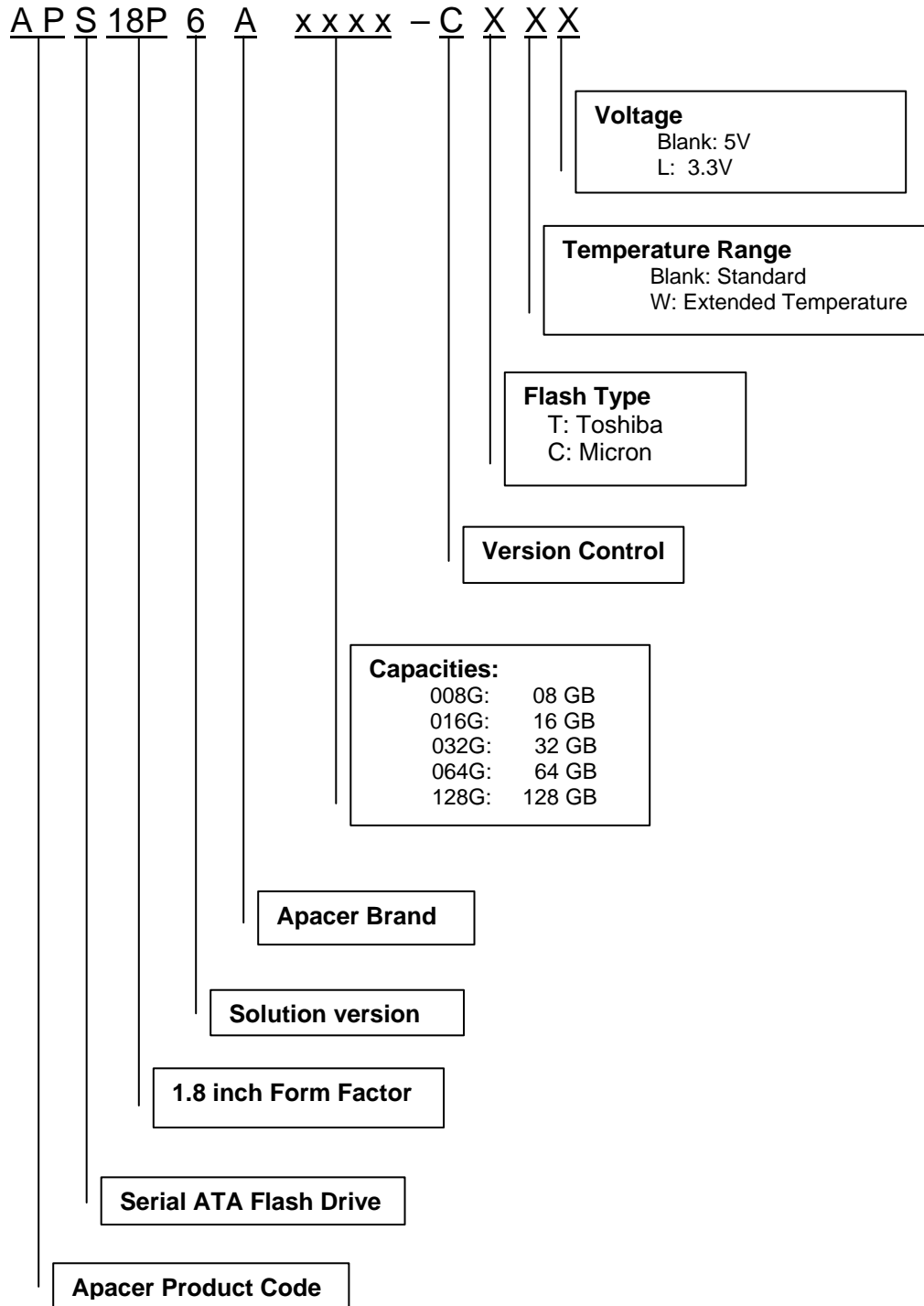
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# 6. Physical Characteristics



GROUND AREA

5.00±0.15

54.0±0.20

35.0

DATUM A OF
CONNECTOR

Pin S1

Pin P1

Y

A

27.04

B

3.30±0.15

1.35

**Unit: ㎜**
**Tolerance: ± 0.2**

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**Unit: mm**
**Tolerance: ± 0.2**

# 7. Product Ordering Information

## 7.1 Product Code Designations

A P S 18P 6 A x x x x − C X X X

**Voltage**
Blank: 5V
L: 3.3V

**Temperature Range**
Blank: Standard
W: Extended Temperature

**Flash Type**
T: Toshiba
C: Micron

**Version Control**

**Capacities:**
008G: 08 GB
016G: 16 GB
032G: 32 GB
064G: 64 GB
128G: 128 GB

**Apacer Brand**

**Solution version**

**1.8 inch Form Factor**

**Serial ATA Flash Drive**

**Apacer Product Code**

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## 7.2 Valid Combinations

**SAFD18P (voltage: 5V)**

| Capacity | Standard | Extended Temperature |
|---|---|---|
| 8 GB | APS18P6A008G-CT | APS18P6A008G-CTW |
| 16 GB | APS18P6A016G-CT | APS18P6A016G-CTW |
| 32 GB | APS18P6A032G-CT | APS18P6A032G-CTW |
| 64 GB | APS18P6A064G-CC | APS18P6A064G-CCW |
| 128 GB | APS18P6A128G-CC | APS18P6A128G-CCW |

**SAFD18P (voltage: 3.3V)**

| Capacity | Standard | Extended Temperature |
|---|---|---|
| 8 GB | APS18P6A008G-CTL | APS18P6A008G-CTWL |
| 16 GB | APS18P6A016G-CTL | APS18P6A016G-CTWL |
| 32 GB | APS18P6A032G-CTL | APS18P6A032G-CTWL |
| 64 GB | APS18P6A064G-CCL | APS18P6A064G-CCWL |
| 128 GB | APS18P6A128G-CCL | APS18P6A128G-CCWL |

**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 | 09/02/2011 |
| 0.2 | Added 64GB & 128GB capacities<br>Updated Product Ordering Information | 10/17/2011 |
| 0.3 | Updated Product Ordering Information | 11/17/2011 |
| 1.0 | Official release | 11/30/2011 |

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