RoHS Compliant

Value Added Serial ATA Flash Drive

Specifications for SAFD 251

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Version 1.5

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Features:

- **Standard Serial ATA Interface**
  - SATA Revision 1.0 compliance
  - SATA 1.5 Gbps interface speed
  - ATA command set
- **Connector type**
  - 7-pin signal connector
  - 15-pin power connector
- **Power consumption (typical)***
  - Supply voltage: 5V
  - Active mode: 260mA
  - Idle mode: 130mA
- **Performance***
  - Burst transfer rate: 150 MB/sec
  - Sustained read: 28 MB/sec
  - Sustained write: 18 MB/sec
- **Capacity**
  - 256, 512 MB
  - 1, 2, 4, 8, 16, 32 GB
- **NAND Flash Type: SLC**
- **Temperature ranges**
  - Operation: 0℃ to 70℃
  - Storage: -40℃ to 100℃
- **Flash management**
  - Advanced wear-leveling algorithms
  - S.M.A.R.T. technology
  - Built-in hardware ECC
  - Flash block management
  - Power failure management
  - ATA Security Erase
- **Form factor**
  - 2.5 inch
  - Dimensions: 100 x 69.85 x 9.30, unit: mm
- **RoHS compliant**

*Varies from capacities. The values addressed for Performance and Power consumptions are typical and may vary depending on settings and platforms.

Table of Contents

1. Product Description

Apacer's SAFD251 is an industrial-oriented SATA Flash Drive SSDs (solid state drives) that are more rugged, more reliable and more power-efficient in comparison to the mechanical hard drives. Without any moving parts, the SAFD251 is designed for embedded applications such as rugged laptops, military devices, thin clients, Point of Sale (POS) terminals, telecom, medical instruments, surveillance systems and industrial PCs. The SAFD Series is the best drop-in replacement for high-maintenance HDD where reliability and performance are major concerns.

SAFD251 includes a built-in microcontroller and the file management firmware that communicates with the SATA standard interface. The SSD is designed to work at 5 Volts and uses a standard SATA driver that fits to all major operating systems such as the Windows series. Featuring technologies as Advanced Wear-leveling algorithms, S.M.A.R.T, flash block management, power failure management, and ATA Security Erase, Apacer assures users of a versatile device on data storage.

2. Functional Block Diagram

The SATA Flash Drive (SAFD) includes a SATA controller, a flash management MCU, the flash media, and a SATA standard interface. Figure 2-1 shows the functional block diagram.

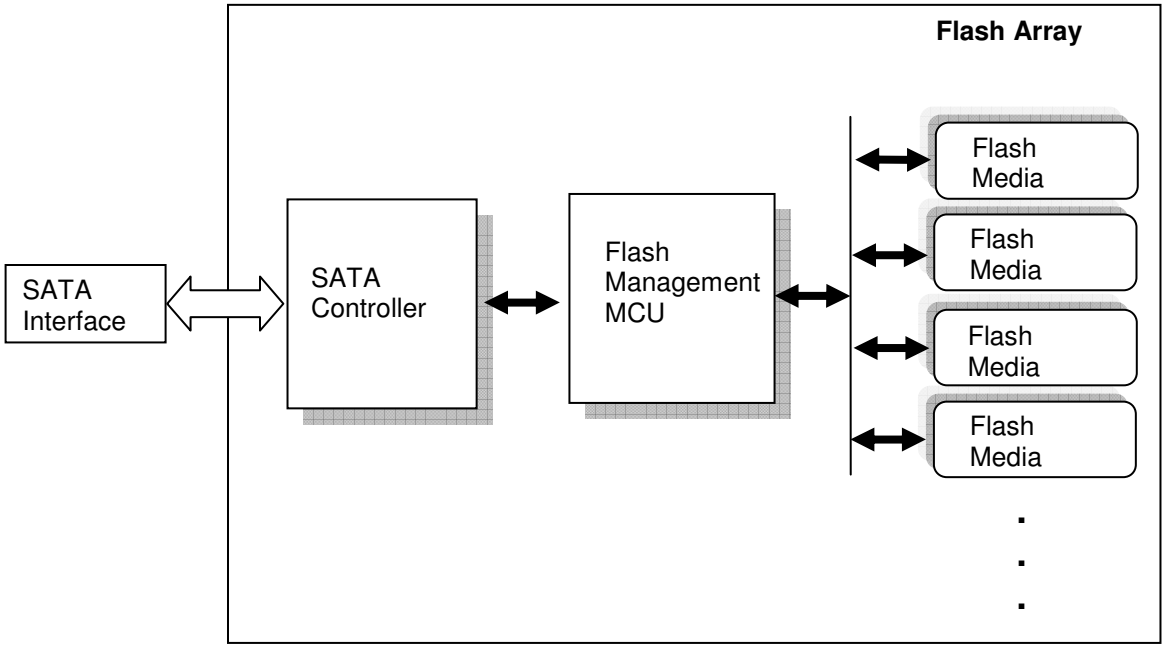


Figure 2-1: Functional block diagram

3. Pin Assignments

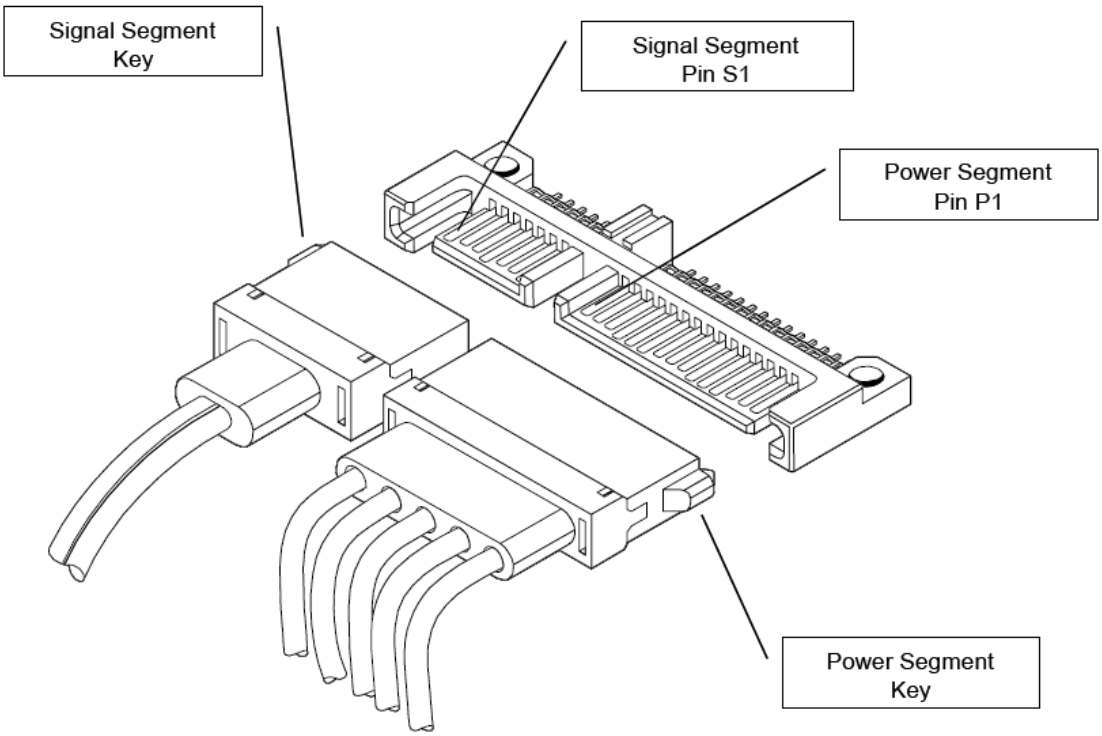


Table 3-1: Signal segment

Pin	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 3-2: 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
P12	Ground
P13	Not used (12V)
P14	Not used (12V)
P15	Not used (12V)

4. Product Specifications

4.1 Capacity

Capacity specification of the SATA Flash Drive product family is shown below.

Table 4-1: Capacity specification

Capacity	Total Bytes	Cylinders	Heads	Sectors	Max LBA
256 MB	256,901,120	980	16	32	501,760
512 MB	512,483,328	993	16	63	1,000,944
1 GB	1,024,966,656	1986	16	63	2,001,888
2 GB	2,048,385,024	3969	16	63	4,000,752
4 GB	4,096,253,952	7937	16	63	8,000,496
8 GB	8,001,552,384	15504	16	63	15,628,032
16 GB	16,001,040,384	16383	16	63	31,252,032[1]
32 GB	32,001,048,576	16383	16	63	62,502,048[1]

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.

4.2 ATA Modes

The SATA Flash Drive supports the following ATA operating modes:

- Supports up to PIO Mode-4
- Supports up to Multi-word DMA Mode-2
- Supports up to Ultra DMA Mode-4

4.3 Performance

Performance of the SATA Flash Drive is listed in Table 4-2.

Table 4-2: Performance by capacities

Capacity / Performance	256 MB	512 MB	1 GB	2 GB	4 GB	8 GB	16 GB	32 GB
Sustained read (MB/s)	28	28	21	20	21	20	20	21
Sustained write (MB/s)	8	8	12	11	11	11	11	18

Note: Performance may vary depending on host system settings.

4.4 Environmental Specification

The SATA Flash Drive environmental specification complies with the US Military Standard MIL-STD-810F, as listed in table 4-4, table 4-5, and table 4-6.

Table 4-4: Temperature and Humidity specification

Parameter	Specification
Operating	0℃ ~ 70℃
Storage	-40℃ ~ 100℃
Humidity	5%.~ 95%R.H, non-condensing

Table 4-5: Vibration specification

Parameter	Specification
Operating	7.69 Grms, X,Y,Z 3-axis, 20 ~2000 Hz (random wave)
Non-operating	15G, X,Y,Z 3-axis, 10 ~ 2000 Hz (Sine wave)

Table 4-6: Shock specification

Parameter	Specification
Operating	50G, 11 ms
Non-operating	1500G, 0.5 ms

5. Flash Management

5.1. Advanced wear-leveling algorithms

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.

5.2 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. Apacer SMART feature adopts the standard SMART command B0h to read data from the drive. When the Apacer SMART Utility running on the host, it analyzes and reports the disk status to the host before the device is in critical condition.

5.3 Built-in hardware ECC

The SATA SSD uses BCH Error Detection Code (EDC) and Error Correction Code (ECC) algorithms which correct up to eight random single-bit errors for each 512-byte block of data. High performance is fulfilled through hardware-based error detection and correction.

5.4 Flash 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.

5.5 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.

5.6 ATA Security 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.

6. Software Interface

6.1 Command Set

This section defines the software requirements and the format of the commands the host sends to the SATA Flash Disk (SAFD). Commands are issued to the SAFD by loading the required registers in the command block with the supplied parameters, and then writing the command code to the Command register.

Table 6-1: Command set (1 of 2)

Command	Code
Check-Power-Mode	E5H or 98H
Execute-Drive-Diagnostic	90H
Erase Sector(s)	C0H
Flush-Cache	E7H
Format Track	50H
Identify-Drive	ECH
Idle	E3H or 97H
Idle-Immediate	E1H or 95H
Initialize-Drive-Parameters	91H
NOP	00H
Read-Buffer	E4H
Read-DMA	C8H or C9H
Read-Multiple	C4H
Read-Sector(s)	20H or 21H
Read-Verify-Sector(s)	40H or 41H
Recalibrate	1XH
Request-Sense	03H
Security-Disable-Password	F6H
Security-Erase-Prepare	F3H
Security-Erase-Unit	F4H
Security-Freeze-Lock	F5H
Security-Set-Password	F1H
Security-Unlock	F2H
Seek	7XH
Set-Features	EFH

Table 6-1: Command set (2 of 2)

Command	Code
SMART	B0H
Set-Multiple-Mode	C6H
Set-Sleep-Mode	E6H or 99H
Standby	E2H or 96H
Standby-Immediate	E0H or 94H
Translate-Sector	87H
Write-Buffer	E8H
Write-DMA	CAH or CBH
Write-Multiple	C5H
Write-Multiple-Without-Erase	CDH
Write-Sector(s)	30H or 31H
Write-Sector-Without-Erase	38H
Write-Verify	3CH

7. Electrical Specifications

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 7-1: Operating range

Ambient Temperature	0℃ to +70℃
Supply voltage	4.75-5.25V

Table 7-2: Absolute maximum power pin stress

Parameter	Symbol	Conditions
Input Power	V_{DD}	-0.3V min. to 6.5V max.
Voltage on any pin except V_{DD} with respect to GND	V	-0.5V min. to VDD + 0.5V max.

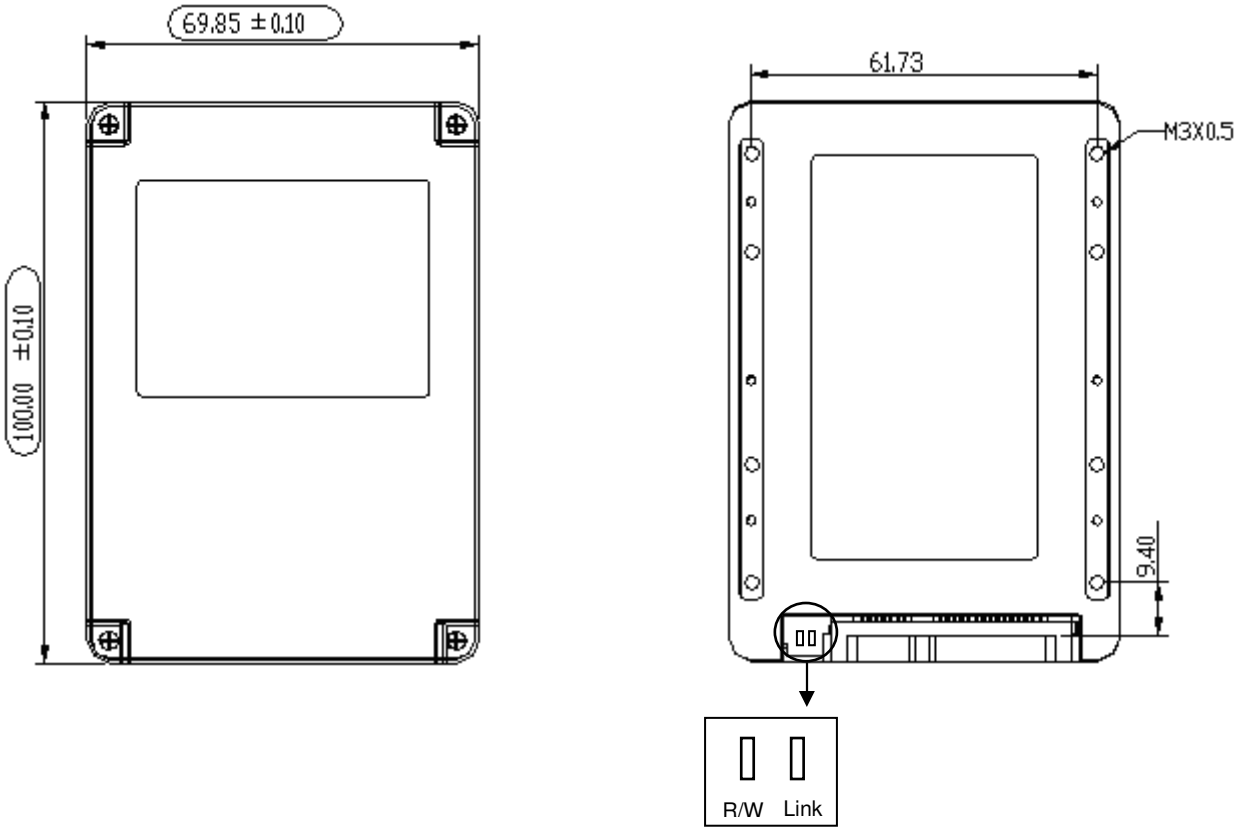
Table 7-3: Recommended system power-up timings

Symbol	Parameter	Typical	Maximum	Units
$T_{PU-READY}$[1]	Power-up to Ready Operation	200	1000	ms
$T_{PU-WRITE}$[1]	Power-up to Write Operation	200	1000	ms

1 This parameter is measured only for initial qualification and after a design or process change that could affect this parameter.

8. Physical Characteristic

8.1 Dimension



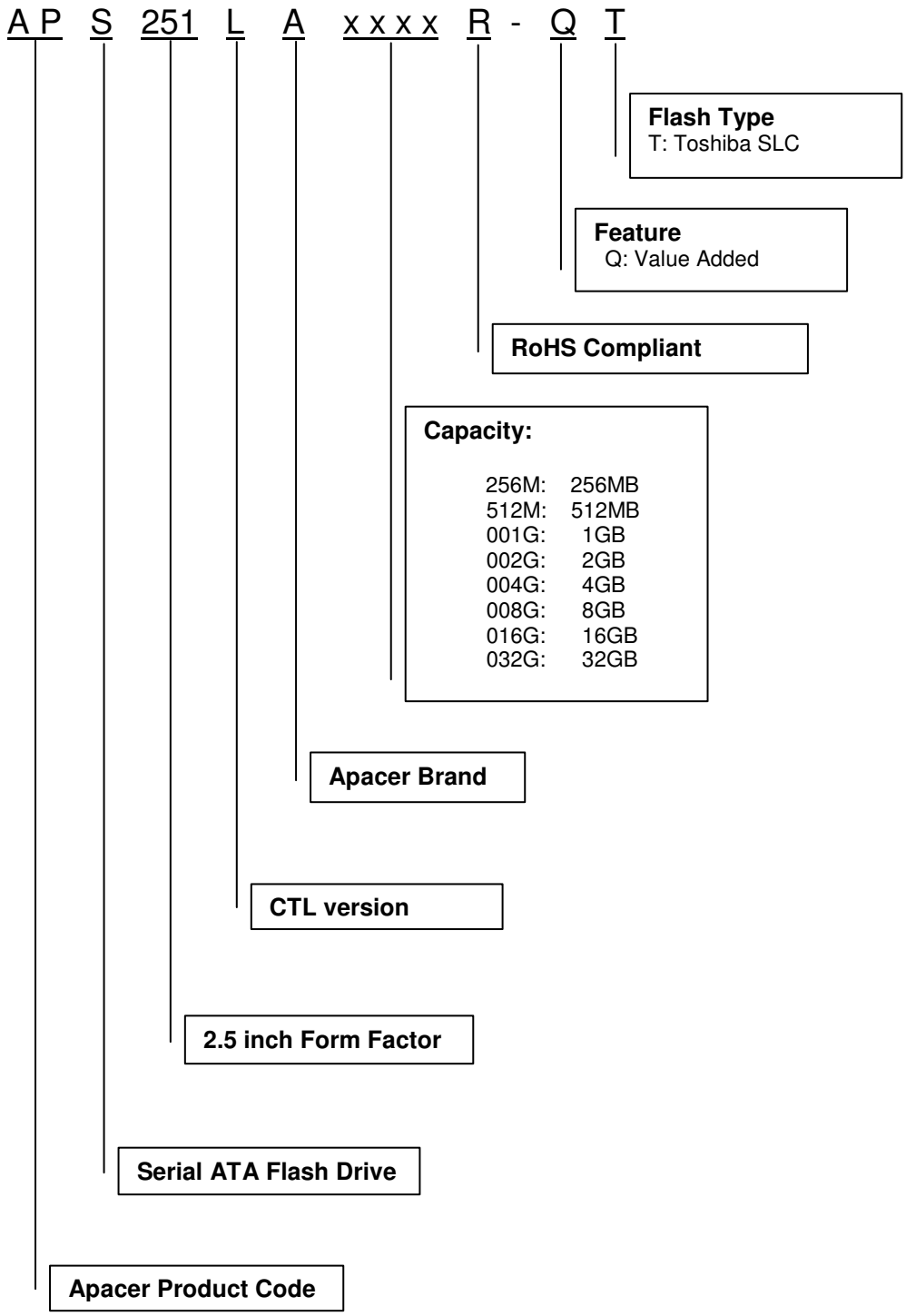
Link (ON): Serial ATA physical layer communication is established.

R/W (Flash): Device activity at command or data transfer.

Unit: mm

9. Product Ordering Information

9.1 Product Code Designation



9.2 Valid Combination

Capacity	Model Number
256MB	APS251LA256MR-QT
512MB	APS251LA512MR-QT
1GB	APS251LA001GR-QT
2GB	APS251LA002GR-QT
4GB	APS251LA004GR-QT
8GB	APS251LA008GR-QT
16GB	APS251LA016GR-QT
32GB	APS251LA032GR-QT

Revision History

Revision	Description	Date
1.0	Official release	December 16, 2008
1.1	Context revised	February 6, 2009
1.2	Updated valid combination wording	March 24, 2009
1.3	Revised performance value、ATA Security Erase name 、product ordering info	March 7, 2011
1.4	Updated performance and product ordering information due to change of NAND flash use	August 1st, 2013
1.5	Modified performance due to change in flash configurations	October 9th, 2013

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