*RoHS Recast Compliant*

# SATA-Disk Module 4

***SDM4-M 22P/180D-W Customized Specifications for Wyse***

**February 5th, 2014**

*Version 1.2*

***Apacer Technology Inc.***
1F, No.32, Zhongcheng Rd., Tucheng Dist., New Taipei City, Taiwan
Tel: +886-2-2267-8000 Fax: +886-2-2267-2261
www.apacer.com

# Features:

- **Standard Serial ATA Compliance**
  - Serial ATA Revision 2.6
  - SATA 3.0 Gbps interface
  - ATA-compatible command set
- **Capacities**
  - Standard: 8, 16 GB
  - High speed: 8, 16, 32, 64, 128 GB
- **Performance***
  - Interface burst read/write: 300 MB/sec

  Standard:
  - Sustained read: up to 70 MB/sec
  - Sustained write: up to 17 MB/sec

  High-speed:
  - Sustained read: up to 155 MB/sec
  - Sustained write: up to 80 MB/sec
- **Flash Management**
  - Built-in hardware ECC, enabling up to 16/24 bit correction per 1K bytes
  - Static/dynamic wear-leveling
  - Flash bad-block management
  - S.M.A.R.T.
  - Power Failure Management
  - ATA Secure Erase
  - TRIM
- **NAND Flash Type:** MLC
- **MTBF**
  - Greater than 1,000,000 hours
- **Temperature ranges**
  - Operation: 0℃ to 70℃ (32 ~ 158℉)
  - Storage: -40℃ to 100℃ (-40° ~ 212℉)
- **Supply voltage**
  - 5.0 V ± 5%
- **Power consumption (typical)***

  Standard:
  - Active mode: 175 mA@5.0 V
  - Idle mode: 88 mA@5.0 V

  High-speed:
  - Active mode: 310 mA@5.0 V
  - Idle mode: 86 mA@5.0 V
- **Connector type**
  - 7-pin SATA signal connector
  - 15-pin SATA power connector
- **Form factor**
  - SATA Disk Module
  - Dimension: 43.80 x 37.80 x 5.73, unit: mm
- **Shock & Vibration****
  - Shock: 1500 G
  - Vibration: 15 G
- **RoHS Recast compliant (2011/65/EU)**

*Varies from capacities. The values for performances and power consumptions presented are typical and may vary depending on flash configurations or platform settings. The term idle refers to the standby state of the device.
**Non-operating

# Table of Contents

# 1. General Description

Apacer's SATA-Disk Module 4 (SDM4) is a high-performance, embedded SSD designed to replace the conventional SATA hard disk drive. SDM SSD can be plugged into a standard Serial ATA connectors commonly found in desktops, IT-STB, industrial PC and thin client systems. Moreover, SDM4 provides an innovative way for clients with space restrictions in their host system.

Apacer's SDM4 is built in with an efficient microcontroller that drives the potential of NAND flashy and delivers optimal performance. With its compact form factor and SATA 3.0 Gbps interface, this product is well suited for embedded flash storage applications offering customizable and expanded functionalities as well as more cost-effective designs, better performance and increased reliability.

SDM4 Series is designed to work at 5 Volts and uses a standard SATA driver that complies with major operating systems such as Microsoft's Windows series. Featuring technologies as Apacer-specific Wear-leveling algorithms, S.M.A.R.T, flash block management, Power Failure Management, ATA Secure Erase, and TRIM, Apacer assures users of a versatile device on data storage.

## 1.1 Performance-Optimized Controller

The core of SDM4 is the Flash controller, which translates standard SATA signals into the data and controls of the flash media. The SATA and Flash Management controller are specifically designed to attain high data throughput from the host to the flash.

### 1.1.1 Power Management

The controller comes with SATA physical interface (PHY) that takes a significant part of the total power budget of the host or other connected electronics. SATA interface provides the means to place the PHY into lowered power modes. When the parts of power for PHY are shut down to reserve power supply, the ability of the SATA interfaced device to respond to command can be affected. Thus, the SATA protocol is implemented with the capability to track the power modes of the devices and require the additional latency to wake up PHY from lowered power modes.

### 1.1.2 RAM

The controller is implemented with RAM as a data buffer to optimize data transfer between the host and the flash media.

# 2. Functional Block Diagram

SDM4-M includes the SATA and Flash Management controllers, and flash media, as well as the SATA standard interface. Figure 2-1 shows the functional block diagram.

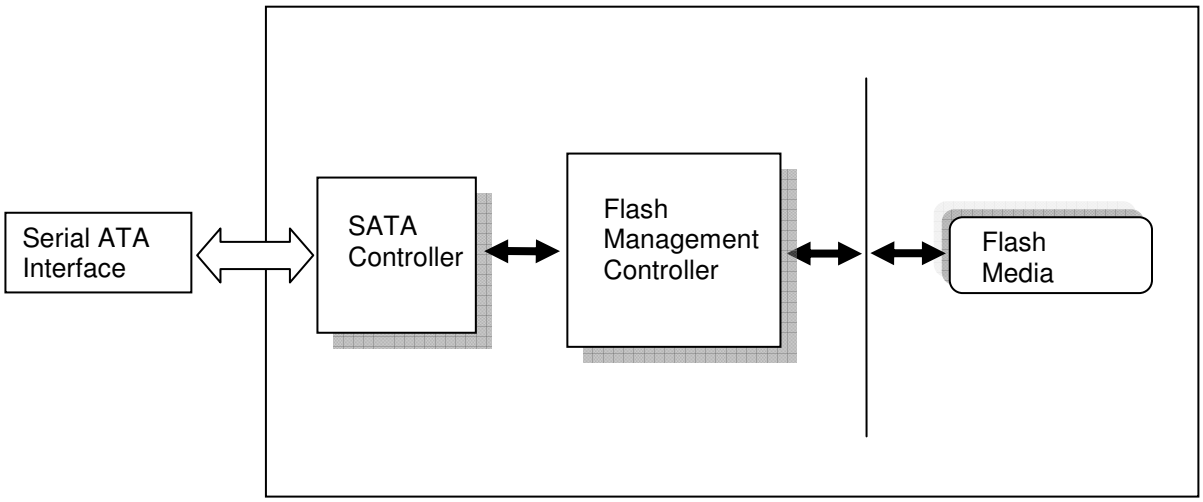



**Figure 2-1:** Functional block diagram

# 3. Pin Assignments

**SATA Connectors**

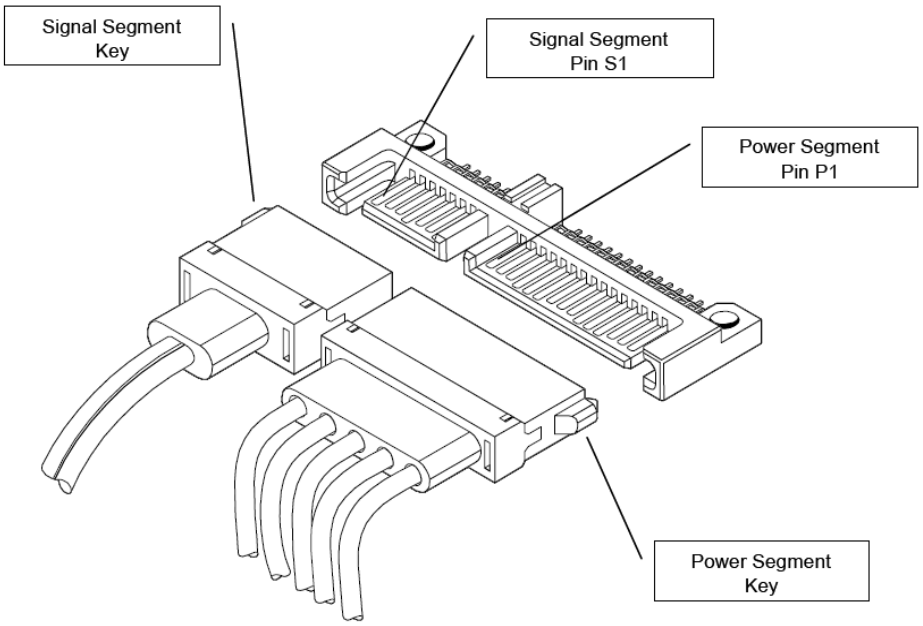



**Table 3-1:** Signal segment

| 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 | 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/Ground |
| P12 | Ground |
| P13 | Unused (12V) |
| P14 | Unused (12V) |
| P15 | Unused (12V) |

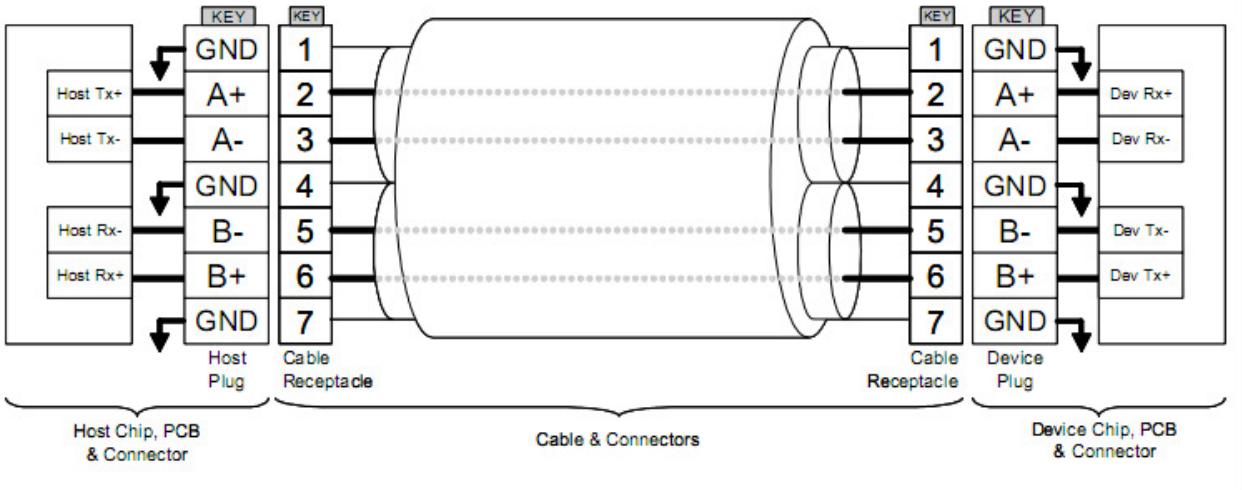



**Figure 3-1** SATA Cable/Connector Connection Diagram

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.

# 4. Product Specification

## 4.1 Capacity

Capacity specification of SDM4-M is available as shown in Table 4-1. It lists the specific capacity and the default numbers of heads, sectors and cylinders for each product line.

**Table 4-1:** Capacity specifications

| Capacity | Total bytes* | Cylinders | Heads | Sectors | Max LBA |
|---|---|---|---|---|---|
| 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 |
| 128 GB | 126,718,694,912 | 16,383 | 16 | 63 | 247,497,451 |

*Display of total bytes varies from file systems, which means not all of the bytes can be used for storage.
**Notes: 1 GB = 1,000,000,000 bytes; 1 sector = 512 bytes.
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 Support

SDM4-M 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-5

## 4.3 Performance

Performances of SDM4-M are listed below in table 4-2 and 4-3.

**Table 4-2:** Performance (Standard)

| Capacity / Performance | 8 GB | 16 GB |
|---|---|---|
| **Sustained read (MB/s)** | 65 | 70 |
| **Sustained write (MB/s)** | 12 | 17 |

**Table 4-3:** Performance (high-speed)

| Performance \ Capacity | 8 GB | 16 GB | 32 GB | 64 GB | 128 GB |
|---|---|---|---|---|---|
| **Sustained read (MB/s)** | 117 | 125 | 135 | 155 | 145 |
| **Sustained write (MB/s)** | 26 | 26 | 38 | 80 | 80 |

Note: Results may differ from various flash configurations or host system settings.

## 4.4 Environmental Specifications

Environmental specification of SDM4-M product family follows the MIL-STD-810 standards as shown in Table 4-4.

**Table 4-4** SDM4-M environmental specifications

| Item | Specification |
|---|---|
| Operating temperature | 0~70(℃) |
| Non-operating temp. | -40~100(℃) |
| Vibration (operating) | 20~2000(Hz), 7.69(g rms), random wave |
| Vibration (non-operating) | 10~2000(Hz), 15(G), sine wave, X, Y, Z axis |
| Shock (operating) | 50(G), 11(ms), half-sine wave, ±X, ±Y, ±Z axis |
| Shock (non-operating) | 1500(G), 0.5(ms), half-sine wave, ±X, ±Y, ±Z axis |

## 4.5 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in SDM4-M. The prediction result for SDM4-M is more than1,000,000 hours.

Notes about MTBF:

The prediction is based on Bellcore analysis method by assuming device failure rate can be generated by the sum of failure rates in each component.

## 4.6 Certification and Compliance

SDM4-M complies with the following standards:

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

# 5. Flash Management

## 5.1 Error Correction/Detection

SDM4-M 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.

## 5.2 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.

## 5.3 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.

## 5.4 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.

## 5.5 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.

## 5.6 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 devices use the standard SMART command B0h to read data out from the drive to activate our SMART feature that complies with the ATA/ATAPI-7 specifications. Based on the SFF-8035i Rev. 2.0 specifications, SMART Attribute IDs shall include Initial bad block count, Bad block count, Spare block count, Maximum erase count, Average erase count and Power cycle. When the SMART Utility running on the host, it analyzes and reports the disk status to the host before the device reaches in critical condition.

## 5.7 TRIM

TRIM is a SATA command that helps improve the read/write performance and efficiency of solid-state drives (SSD). The command enables the host operating system to inform SSD controller whick blocks contain invalid data, mostly because of the erase commands from host. The invalid will be discarded permanently and the SSD will retain more space for itself.

# 6. Software Interface

## 6.1 Command Set

This section defines the software requirements and the format of the commands the host sends to SDM4-M. Commands are issued to SDM4-M 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

| 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 | | |

# 7. Electrical Specification

**Table 7-1:** Operating range

| Item | Description |
|---|---|
| Required voltage | 5V±5% (4.75-5.25V) |
| Operating temperature | 0℃ to +70℃ |

**Table 7-2:** Power consumption – Standard (typical)

| Capacity / Mode | 8 GB | 16 GB |
|---|---|---|
| Active (mA) | 175 | 175 |
| Stand By (mA) | 88 | 88 |

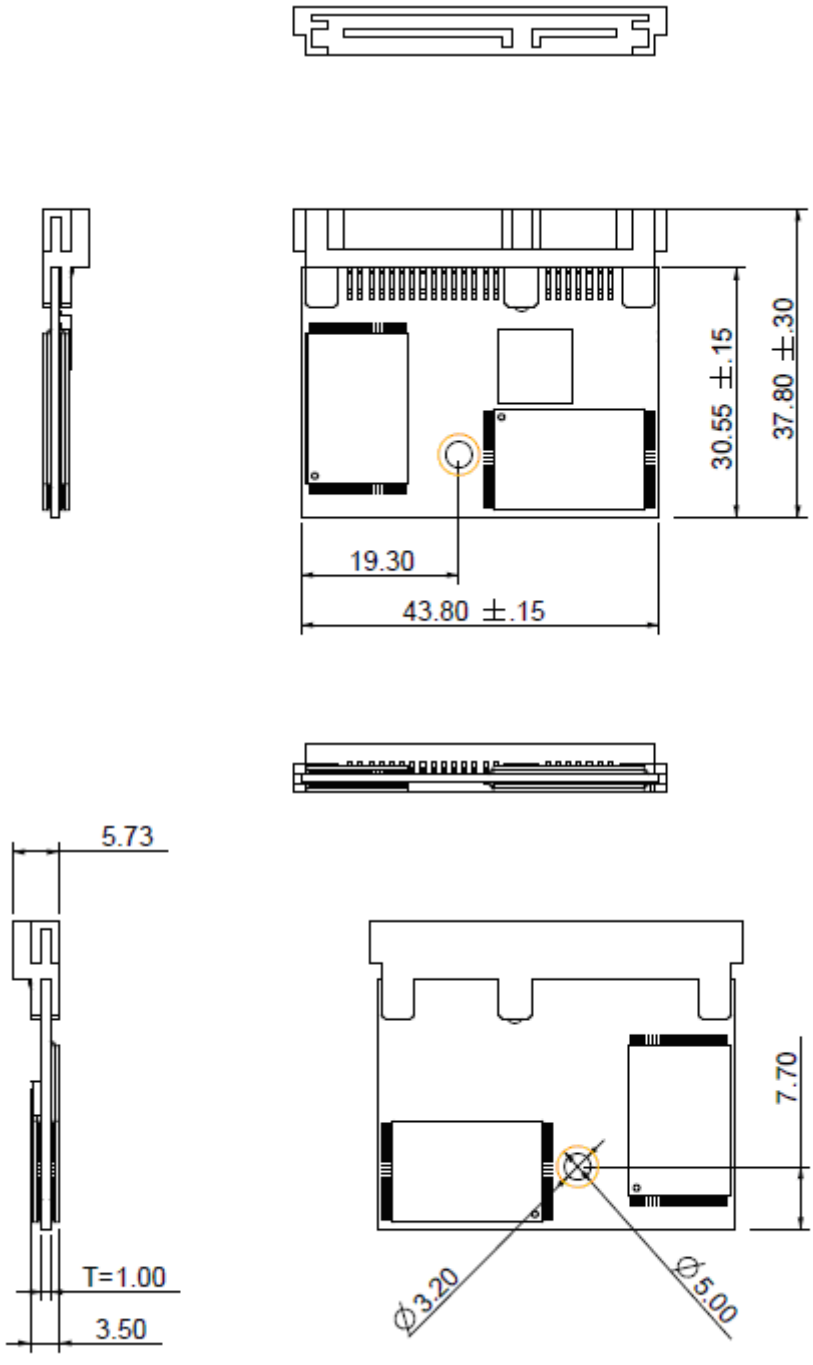
**Table 7-3:** Power consumption – High Speed (typical)

| Capacity / Mode | 8 GB | 16 GB | 32 GB | 64 GB | 128 GB |
|---|---|---|---|---|---|
| Active (mA) | 200 | 200 | 210 | 280 | 310 |
| Stand By (mA) | 70 | 76 | 83 | 83 | 86 |

Note: Power consumptions may vary depending on settings and platforms

# 8. Physical Characteristics

## 8.1 Dimensions




Unit: mm
Tolerance: ± 0.25

# 9. Product Ordering Information

**Standard**

| Capacity | Part Numbers |
|---|---|
| 8GB | 8Y.F1CD2.LR25B |
| 16GB | 8Y.F1DD2.LR25B |

**High speed**

| Capacity | Part Numbers |
|---|---|
| 8GB | 8Y.F1BD4.LR25B |
| 16GB | 8Y.F1CD4.LR25B |
| 32GB | 8Y.F1DD4.LR25B |
| 64GB | 8Y.F1ED4.LR25B |
| 128GB | 8Y.F1FD4.LR25B |

**Note:** Please consult with Apacer sales representatives for availability.

# Revision History

| Revision | Date | Description | Remark |
|---|---|---|---|
| 1.0 | 10/22/2012 | Official release | |
| 1.1 | 03/05/2013 | Added 64GB and 128GB models | |
| 1.2 | 02/05/2014 | Added 8GB and 16GB models as standard type | |

# Global Presence

**Taiwan (Headquarters)**

**Apacer Technology Inc.**
1F., No.32, Zhongcheng Rd., Tucheng Dist.,
New Taipei City 236, Taiwan R.O.C.
Tel: 886-2-2267-8000
Fax: 886-2-2267-2261
amtsales@apacer.com

**U.S.A.**

**Apacer Memory America, Inc.**
386 Fairview Way, Suite102,
Milpitas, CA 95035
Tel: 1-408-518-8699
Fax: 1-408-935-9611
sa@apacerus.com

**Japan**

**Apacer Technology Corp.**
5F, Matsura Bldg., Shiba, Minato-Ku
Tokyo, 105-0014, Japan
Tel: 81-3-5419-2668
Fax: 81-3-5419-0018
jpservices@apacer.com

**Europe**

**Apacer Technology B.V.**
Science Park Eindhoven 5051 5692 EB Son,
The Netherlands
Tel: 31-40-267-0000
Fax: 31-40-267-0000#6199
sales@apacer.nl

**China**

**Apacer Electronic (Shanghai) Co., Ltd**
1301, No.251,Xiaomuqiao Road, Shanghai,
200032, China
Tel: 86-21-5529-0222
Fax: 86-21-5206-6939
sales@apacer.com.cn

**India**

**Apacer Technologies Pvt Ltd,**
# 535, 1st Floor, 8th cross, JP Nagar 3rd Phase,
Bangalore – 560078, India
Tel: 91-80-4152-9061
sales_india@apacer.com