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## Digital Media Technical Guide

*Portable digital media for digital cameras and other devices*

Kingston®, the world's leading independent manufacturer of memory product is proud to offer this digital media products technical guide to our customers and partners. Kingston has been offering flash and other digital products for years, and this guide is to help explain the various technologies and digital media offerings that are available.





Kingston's 15-year commitment to service and support of its products, customers and partners make Kingston an easy choice for flash memory.

## 1.0 Flash Memory: Empowering A New Generation of Devices

Toshiba invented flash memory in the 1980s as a new memory technology that allowed stored data to be saved even when the memory's device was disconnected from its power source. Since then, flash memory technology has evolved into the preferred storage media for a variety of consumer and industrial devices.

### IN CONSUMER DEVICES, FLASH MEMORY IS WIDELY USED IN:

- Notebook computers
- Personal Digital Assistants (PDAs)
- Global Positioning Systems (GPS)
- Solid-state music players such as MP3 players
- Digital cameras
- Electronic musical instruments
- Cellular telephones
- Television set-top boxes
- Pagers

Flash memory is also used in many industrial applications where reliability and data retention in power-off situations are key requirements, such as in:

- Security systems
- Embedded computers
- Networking and communication products
- Retail management products (e.g. handheld scanners)
- Military systems
- Solid-state disk drives
- Wireless communication devices
- Medical products

## 2.0 Features of Kingston's Flash Memory Products

Kingston's flash memory cards offer many advantages for both consumer and industrial applications:

- **Solid State:** Flash cards have no moving parts and thereby are not subject to the mechanical failure issues of hard drives. Their data reliability and shock and temperature endurance (described on next page) enabled flash cards to dominate the convenience-oriented portable memory products market. These cards also operate silently, with a zero decibel noise level.
- **Small Physical Size (or Form Factor):** Flash memory cards are designed to be easily transported. Convenience is an important criterion, especially for consumer markets.
- **High Data Reliability:** Flash memory is very reliable and some of the flash memory card formats also include Error Correction Code (ECC) checking to detect single-bit errors. For example, Kingston's CompactFlash cards have a rated error specification of less than one (1) bit in 1,000,000,000,000,000 bits read (1 bit per  $10^{15}$  bits read).



Kingston's CompactFlash cards have a rated error specification of less than one (1) bit in 1,000,000,000,000,000 bits read, or one (1) bit per  $10^{15}$  bits read.

- Kingston Flash Data Retention: 10 years
- Kingston Flash Cell Endurance: At least 300,000 write cycles per physical sector
- Wear-Leveling Technology: Kingston flash cards incorporate controllers utilizing wear-leveling technology, which distributes write cycles across the flash card. Wear-leveling thus extends the life of a flash memory card.
- Automatic Bad Sector Remapping: Kingston flash controllers automatically lock out sections with bad memory cells and move the data to avoid data corruption.
  - High-Quality Connectors: Kingston's Flash cards have connectors rated for more than 10,000 insertions.
- Shock and Temperature Durability: In addition to a 5-year warranty against defects, Kingston's flash cards are very rugged and engineered to be durable:
  - Non-operating shock tolerance: 1000G (G=Gravity) forces (e.g. drop resistance)
  - Operating vibration resistance: 15G
  - Operating temperature: 0° C ~ 70° C
  - Humidity: 5% ~ 95%

Note: Industrial flash products are available only for OEM customers.

- High-Capacity: CompactFlash cards can provide large storage capacities in a very small form factor. This flexibility makes it ideal for consumer uses, such as digital film or storage for MP3 music, where portability and convenience are important.
- High-Performance: Flash memory is a high-performance memory technology, faster than many other standard memory alternatives. Many of the flash card technologies embed a microprocessor, typically called a controller, into the product package. Kingston's engineers test and select high-performance controllers to ensure that Kingston's flash cards are among the performance leaders in the industry.
- Low Power Consumption: Unlike standard DRAM memory that needs to be constantly powered on to maintain its data, flash memory is non-volatile and does not require power to maintain its data. Flash memory's low power consumption results in longer battery life for the host device.
- Plug-and-Play Support: Kingston's flash memory line supports plug-and-play. With plug-and-play technology and compatible computer operating systems, a flash memory card can be inserted into a reader socket and be quickly recognized and accessed by the computer.



Kingston's engineers test and select high-performance controllers to ensure that Kingston's flash cards are among the performance leaders in the industry.

- **Hot-Swapping Support:** Hot-swapping allows for plugging or unplugging flash cards into a compatible computer or reader socket without needing to power off and restart the computer. This feature enhances the portability and convenience of flash memory cards for transferring data, pictures or music between 2 computers or devices.

### 3.0 Non-Volatile NOR and NAND Flash Technologies

Unlike Dynamic Random Access Memory (DRAM), flash memory is non-volatile. Non-volatile memory retains data even without being powered-on. For example, when a computer is turned off, all data that was in the computer's DRAM memory is lost; however, when a flash card is removed from a digital camera, all data (and pictures) remains saved on the card.

The ability to retain data is key for flash memory applications such as digital film for digital cameras, cell phones, PDAs and other transportable devices.

There are two major technologies of flash memory: NOR and NAND. Each technology has its strengths that makes it ideal for different kinds of applications, as summarized in the table below:

	NOR Flash	NAND Flash
<b>High-speed Access</b>	Yes	Yes
<b>Page-Mode Data Access</b>	No	Yes
<b>Random Byte Level Access</b>	Yes	No
<b>Typical Uses</b>	Cell Phones BIOS Storage for PCs Networking Device Memory	PDAs Digital Cameras MP3 players Solid State Disk Drives Set-Top Boxes Industrial Storage

#### 3.1 NOR FLASH MEMORY

NOR, named after the specific data mapping technology (Not OR), is a high-speed serial flash technology. NOR flash memory provides high-speed random-access capabilities, being able to read and write data in specific locations in the memory without having to access the memory in sequential mode. Unlike NAND flash, NOR flash allows the retrieval of data as small as a single byte.

NOR flash excels in applications where data is randomly retrieved or written. NOR is most often found built into cellular phones and PDAs and is also used in computers to store the start-up.



The DataPak™ is the perfect solution for notebooks, handhelds, digital cameras or any other digital device.

### 3.2 NAND FLASH MEMORY

NAND flash was invented after NOR flash, and is named after the specific mapping technology used for data (Not AND). NAND flash memory reads and writes in high-speed, serial mode, handling data in small, block sizes (“pages”). NAND flash can retrieve or write data as single pages, but cannot retrieve individual bytes like NOR flash.

NAND flash memory is commonly found in solid-state hard drives, audio and video digital media devices, television set-top boxes, digital cameras and other devices where data is generally written or read sequentially.

For example, most digital cameras use NAND-flash based digital film, as pictures are usually taken and stored sequentially. NAND-flash is also more efficient when pictures are read back, as it transfers whole pages of data very quickly. As a sequential storage medium, NAND flash is ideal for data storage.

NAND flash memory is less expensive than NOR flash memory, and can accommodate more storage capacity in the same die size.

## 4.0 Die-Stacking and Multi-Level Cell Flash technologies

In order to economically increase the amount of bit-storage that a flash memory chip can accommodate manufacturers often utilize die-stacking and multi-level cell technologies. Both techniques result in a flash memory chip having the capability to store more data in a single chip.

### 4.1 DIE-STACKING

Many semiconductor manufacturers use a “die-stacking” technique to double a flash memory chip’s capacity. After the semiconductor wafer fabrication process, they cut out the flash memory silicon “die” and then attach or stack two separate dies together.

For example, when a semiconductor manufacturer stacks two 128-megabit dies together, they form a single 256-megabit flash memory chip.

Die-stacking allows for cost-reduced chip alternatives to the larger-capacity, single-die chips (called “monolithic” chips). Stacking two 1-gigabit chips together, for example, typically costs far less than buying a low-volume monolithic 2-gigabit chip.

Die-stacking is similar to the DRAM chip-stacking technology that Kingston utilizes to produce high-end server modules. As a result, Kingston’s die-stacked flash cards are reliable and deliver high performance.



Kingston flash cards were rated in the best performers in read and write performance by dpreview.

#### 4.2 MULTI-LEVEL CELL (MLC) FLASH TECHNOLOGIES

NAND and NOR flash memory chips typically store one (1) bit value (a '0' or a '1') in each cell. In multi-level flash technologies, three (3) or more values are stored into each cell.

Intel Corporation has introduced NOR StrataFlash™; AMD has introduced NOR MirrorBit™ flash. Other semiconductor manufacturers also manufacture their own multi-level cell technologies.

NAND MLC flash technologies are expected to be introduced in late 2002, and Kingston is already working with its semiconductor manufacturer partners on higher capacity flash cards for 2003.

### 5.0 Flash Card Performance

Flash card performance depends a lot on the host device, which is the flash card's controller as well as the specific flash memory chips used. While the host controller cannot be changed, the use of optimized flash controllers can result in significant time savings when reading or writing data into the flash memory.

For example, Kingston uses optimized, high-performance flash card controllers in its CompactFlash cards. Some flash memory product manufacturers provide "speed" ratings. However, due to a lack of industry standards, comparing different flash products may prove difficult for consumers.

According to an independent comparison of flash cards by dpreview, Kingston flash cards were rated in the best performers in read and write performance (see <http://www.dpreview.com/articles/mediacompare/>).

Kingston continuously works closely with global semiconductor and controller manufacturers to ensure that Kingston flash cards deliver superior price/performance to its customers.

### 6.0 Kingston's Flash Card Product Lines

There are several types of flash storage products or flash cards that are available from Kingston:

- CompactFlash (CF) cards
- MultiMedia Cards (MMC)
- SmartMedia (SM) cards
- SecureDigital (SD) cards

All these form factors will be described in the following sections.





CompactFlash cards were the first small form factor flash memory cards.

### 6.1 COMPACTFLASH (CF) CARDS

CompactFlash, or CF cards, were the first small form factor flash memory cards introduced in 1994. CF cards incorporate a controller and are about the size of a matchbook. CompactFlash cards incorporate an Integrated Device Electronics (IDE) interface similar to hard drives and ATA PC Cards (see Section 7.5). The CompactFlash Association sets the specifications for CF cards.

Kingston's CompactFlash cards are among the fastest available in the industry. The high transfer rate is ideal for use on newer devices such as high-megapixel digital cameras, to ensure that the cameras save pictures faster and are quickly ready for another shot.

CompactFlash memory cards come in a Type I form factor:

INTERFACE	FLASH TYPE	VOLTAGE	PIN COUNT	SIZE IN MM
CompactFlash (Includes built-in controller)	NAND	3.3 and 5 Volts	50	Type I: 36.4 x 42.8 x 3.3

Note: Kingston offers special memory card and reader/writer bundles. Higher capacities may also become available. Please visit [www.kingston.com](http://www.kingston.com) for details.

### 6.2 SMARTMEDIA CARDS (SM, previously called SSFDC)

SmartMedia cards, introduced in 1996, are the thinnest form factor flash storage devices. They were originally called SSFDC, for Solid State Floppy Disk card, as they look like a miniature floppy disk. SmartMedia cards usually incorporate a single flash chip and do not incorporate a controller. Thus, they depend on the host controller to manage all memory reads and writes. The SSFDC Forum sets the specifications for SmartMedia cards.

INTERFACE	FLASH TYPE	VOLTAGE	PIN COUNT	SIZE IN MM
SmartMedia (No built-in controller)	NAND	3.3 and 5 Volts	22	45 x 37 x 0.76

### 6.3 SECUREDIGITAL (SD) CARDS

SecureDigital, introduced in late 2001, is a second-generation derivative of the MultiMediaCard standard (see section 7.4) that is backward-compatible with MultiMediaCards. The SecureDigital format includes several important technological advancements over MultiMediaCard (MMC). These include the addition of cryptographic security protection for copyrighted data/music and a 4X increase in data transfer rates. The SD Card Association sets the specifications for SecureDigital cards.



SmartMedia is a low cost, highly portable flash memory card.

To help support higher-capacity cards, SD cards are slightly thicker than the original MultiMediaCards. This means that devices designed to support SD may also accept MMC (if the host device is not strictly limited to SD media for data security reasons); but devices exclusively designed for MMC will not support the thicker SD cards at this time.

INTERFACE	FLASH TYPE	VOLTAGE	PIN COUNT	SIZE IN MM
SecureDigital (Built-in controller)	NAND	2.7–3.3 Volts	9	32 x 24 x 2.1

#### 6.4 MULTIMEDIACARD (MMC)

MultiMediaCards are the smallest flash cards available, about the size of a postage stamp. They were introduced in 1997 and initially used in the mobile phone and pager markets. Today, they are commonly used in digital cameras and MP3 players. The MultiMediaCard Association sets the specifications for MMC.

INTERFACE	FLASH TYPE	VOLTAGE	PIN COUNT	SIZE IN MM
MultiMedia Card (Built-in controller)	NAND	3.3 Volts	7	32 x 24 x 1.4

#### 6.5 LINEAR FLASH PC CARDS

Linear Flash PC cards, as specified by the Personal Computer Memory Card International Association (PCMCIA), were the first-generation of credit-card sized NOR flash cards introduced in the late 1980s. Linear Flash PC cards do not incorporate a built-in controller and require that the host device manage the memory accesses. Because of the NOR flash design, Linear Flash PC cards support fast random memory accesses and are well suited for code storage and execution applications. Today, Linear Flash PC cards are mainly used in networking, telecommunications, and industrial applications.

INTERFACE	FLASH TYPE	VOLTAGE	PIN COUNT	SIZE IN MM
PCMCIA (No controller built-in)	NOR	3.3, 5 and 12 Volts	68	Type I: 85.6 x 54 x 3.3



Specifically designed for high-speed image transfer, Kingston Flash Card readers are an ideal solution for quickly viewing your digital images on your desktop PC, MAC or notebook.

## 7.0 Flash Card Reader-Writers

The flash card reader-writers allow the flash cards to be used as portable storage for computers as well as for uploading or downloading of pictures, music, and other data without requiring the host device (and without any additional drain on its batteries).

Flash card reader-writers can enable the uploading and downloading of data at higher speeds than a host device is capable of supporting; for example, a USB reader-writer will be much faster than a device using a serial interface. Faster reader-writers reduce the duration of load and unload operations.

Kingston markets a number of flash card readers for the convenient attachment of flash cards to personal computers or notebooks.

Please visit [www.kingston.com/flash](http://www.kingston.com/flash) or Kingston's network of resellers for flash memory bundles that combine flash cards and reader-writers:

## 8.0 CompactFlash to PC Card Adapters

Flash card adapters are convenient slip-in receiving frames that allow a CompactFlash card to be converted into an ATA PC Card (Type II) storage device.

Many notebooks and other devices supporting ATA Type II PC Cards also support CompactFlash cards when CF cards are inserted into a CF-ATA Flash card adapter.

For flash card reader-writers, Kingston recommend the flexible and convenient 6-in-1 (six form factors supported by a single reader-writer) units that can accommodate most of the flash card form factors available today, as listed in section eight (8).

## 9.0 For More Information:

**For additional information on Kingston products, please visit us at: [www.kingston.com](http://www.kingston.com)**

