

SD Flash Memory and the Future of Information Storage The Panasonic Perspective

The SD Memory Card is the latest and most advanced representative of a type of data storage known as flash memory. If you own a digital camera or a portable MP3 audio player, you are probably already familiar with this technology. The small size, low power consumption, and solid-state design of flash-memory cards have made them very popular for use in such products.

Panasonic is one of the co-developers of the SD Memory Card, which incorporates refinements and features that will greatly expand the range of applications for flash memory. And as SD consolidates its position as the de facto standard for flash memory cards, the growth of applications will accelerate. Our purpose here is to outline where SD stands today, where we see it headed in the future, and what the format's impact will be for business and consumers.

1. Flash Memory Fundamentals

The ability to process, store, and transmit data in digital form has radically transformed the way we handle all sorts of information, from business records to telephone conversations to audio and video entertainment. Today we can store huge amounts of data and move it from place to place with astonishing ease and speed. CDs, satellite communication, and the Internet are taken for granted. More, smaller, faster: Those are the bywords of the digital era.

The workhorses of computational data storage have been semiconductor random-access memory (RAM) and magnetic discs (hard drives). Conventional RAM is used for its speed, but any data held in it is volatile, vanishing when the power is turned off. Magnetic-disc storage is nonvolatile and much less expensive than RAM on a bytes-per-dollar basis, but it is also much slower than RAM. Neither is well suited to portable or archival information storage.

The Optical-Disc Revolution

A watershed event in the history of digital information storage was the introduction of the Compact Disc (CD). Although originally conceived as a digital audio medium, CD had the potential to carry approximately 700 megabytes (MB) per disc of any kind of data. Eventually a specification was developed for CD-ROM—CD read-only memory. CD-ROM is a cheap, durable, well-standardized, high-capacity, general-purpose data storage medium that also happens to be extremely portable. It did

not take long for CD-ROM to establish itself as the dominant medium for computer software distribution. It also became popular as a means of publishing certain types of information, such as large databases.

We are currently in the midst of a transition from CD to DVD, an advanced optical-disc format that offers seven to twenty-eight times the data capacity of CD at similar cost. Within a few years, DVD and DVD-RAM (recordable DVD) will be the standard formats for large-scale portable and archival data storage.

Why Flash Memory?

Despite their many virtues, optical discs are not ideal for all portable applications. The size of the discs puts a lower limit on the size of devices designed to use them. Read and write speeds are slow relative even to those of computer hard drives, never mind solid-state memory chips. And because an optical pickup must track a spinning disc in order to retrieve data from it, players are prone to mistracking when subjected to vibration. (Careful design can minimize this last problem but not eliminate it entirely.) They also require significantly more power to operate than purely electronic devices would.

Flash memory, on the other hand, is nonvolatile solid-state storage: Electrical power is required to write data to memory or to retrieve it but not to maintain it. (The write process is called “flashing,” which is where the name comes from.) Flash memory can store a lot of data in a *very* small package. It is also more robust than optical discs, and though not quite as fast as ordinary, volatile solid-state memory (RAM), flash memory is much, much nimbler than any mechanically based storage medium.

Flash-memory cards are not a good choice when DVD-scale data storage is required, because they don’t yet have that sort of capacity at this time. The most popular sizes are currently 32 and 64 megabytes. One reason is that higher-capacity cards are not widely available, though that will certainly change over time. SD Memory Cards with 128-megabyte capacity have recently come to market, for example, with 256-megabyte versions on the near horizon and gigabyte cards under development. Another reason is that flash memory is still relatively costly on a byte-per-dollar basis compared to typical alternative storage formats, such as tape or optical disc, though the disparity will shrink as the market expands.

Today you are most likely to encounter flash memory in devices such as digital cameras and portable MP3 audio players. The small size and low power consumption of flash-memory cards make them very attractive for those sorts of applications, and modern digital compression techniques mesh well with the cards’ data capacities.

The main issues standing in the way of much broader application of flash memory are standardization and security. There are about a half dozen competing formats for flash-memory cards, and until recently none of them had shown signs of gaining a definitive edge over its rivals. History has demonstrated repeatedly that standardization is almost essential to achieving wide public acceptance of new technologies. Prominent examples include the audio cassette, the VHS videocassette, and CD. If one standard for flash-memory cards can establish clear dominance, the total market for flash memory will surge in response. Over the long term, flash memory could become the most widely used storage and interchange format for all kinds of digital information.

Security is another emerging concern. Right now this is primarily a matter of record companies wanting to maintain some control over digital music files distributed via the Internet. Portable players for such files typically use flash-memory cards for storage. But many businesses also would like to protect sensitive or confidential information while it is in storage or transit, as would doctors, hospitals, and others.

2. The SD Memory Card Solution

Several years ago, Matsushita Electric Industrial Company (Panasonic) joined with SanDisk Corporation and Toshiba Corporation to develop a next-generation flash-memory format that could meet the future data-storage needs of both business and consumers. The resulting SD, or Secure Digital, Memory Card boasts a number of compelling advantages over other formats:

- ! **Size.** An SD Memory Card is about the size of a postage stamp. Yet SD cards are already available in capacities ranging from 8 to 128 megabytes, with higher-capacity cards on the way. The small physical package ensures maximum versatility. Almost any electronic device, no matter how small, can incorporate an SD card slot, paving the way for a wide variety of new applications.
- ! **Compatibility.** The SD slot is also compatible with cards based on the earlier-generation MMC (Multimedia Card) format.
- ! **Security.** SD Memory Cards are “smart” devices with a built-in private-key encryption capability that can be used to prevent unauthorized access or copying. This very robust system meets and exceeds the requirements of the Secure Digital Music Initiative (SDMI) for protection of copyrighted content. But since the security is built into the card itself, encrypted content is tied only to the card, not to a specific recording or playback device, so portability is not compromised.
- ! **Speed.** SD’s 4-bit/4-data-line I/O bus allows data transfer rates of up to 10 megabytes per second. Services that deliver large volumes of music and video data are poised for rapid growth. The networks that make up the digital infrastructure are set for major speed increases. When users download content directly from a telecommunications network, the card’s high transfer rate translates directly into savings in communications costs. It also minimizes the amount of time each user needs to be connected, which helps prevent network overload.
- ! **Multipurpose Card Slot.** An unusual feature of the SD card slot is its ability to serve as an I/O port (SDIO) for devices other than memory cards. This capability can give portable devices, such as PDAs and cell phones, additional peripheral and accessory options without increasing size or circuit complexity.
- ! **Open Architecture.** Recognizing the importance of wide industry acceptance and participation, Panasonic and its associates were careful not to fall into the trap of creating a closed, proprietary

format. They have opened their development information to other companies and undertaken an extensive educational program. A complete package of tools is available to facilitate SD product design, including specifications, API documentation, examples, integration services, and technical support. Another important resource is the SD Association (SDA), a broad-based group of companies operating in a diverse array of markets, including consumer electronics, personal computers, software, telecommunications, photographic equipment, and automobiles. The Association was created to help build awareness and to steer future development of the SD Memory Card standard. It currently has more than 300 members and continues to grow. No other memory-card format enjoys such a high level of industry support.

All these advantages are significant, but most important are security and the potential for market dominance by a single standard. Together, they can drive an explosion of applications, products, and business opportunities.

3. Panasonic's Vision

We expect the market for digital exchange of music, video, and secure documents, along with other applications that can benefit from SD Memory Card technology, to reach \$25 billion in just a few years. Over this period, millions of businesspeople and consumers—from early adopters to MIS executives to first-time music downloaders—will buy memory cards and digital devices that accept them. Such devices will include digital cameras, music players, PDAs, mobile phones, computers, and more.

Although much of the focus today is on entertainment applications, such as storage of music and pictures, SD's security features will foster rapid development of other business-to-business and business-to-consumer markets for this advanced memory card. These will include delivery of legal, medical, statistical research, and other data that has up to now been conveyed only through business servers or held in personal computers.

Because of the growing interaction between content providers, customers, and businesses, the devices enabling the interaction need more than ever to be compatible with the latest data-storage technology. And the storage media must be interoperable among a wide range of devices. Products based on the SD Memory Card standard meet both those requirements. A good example can be found in Palm's application of SD in some of its latest PDAs. The PDA can use SD Memory Cards to store and retrieve information and to exchange data with other devices. You can even take a picture from a digital camera, stored on an SD Memory Card, and display it on the Palm PDA. This is just one of many ways in which SD Memory Cards are going to take device interoperability to a new level. No matter what kind of portable device you are using, just grab an SD Memory Card and go.

The demand for a universally accepted technology that can be employed to save, send, and deliver content in an easy to use package with built-in security and copyright protection of the highest caliber is large and rapidly growing. Because so many companies (including very strong competitors) have joined the SD Association or plan to participate, SD is superbly positioned to satisfy that demand. The

opportunity is enormous. Many SD-based products already are available, and many more are on the way.

4. SD Today

Perhaps the easiest way to grasp what SD brings to the table is to look at some of the products already available that use SD Memory Cards. Here are a few highlights from the Panasonic product line.

e-wearâ Audio Players

Panasonic's SD Memory Card audio players are less than 2 inches square and just over half an inch thick. You can wear them on a neck strap or an arm band or simply slip it into a pocket and listen to AAC or MP3 coded audio through headphones. A USB connection allows easy data transfer to or from a personal computer. Despite their tiny size, e-wear players provide all the features you would find in a typical portable CD player. Except they have no moving parts and therefore never will skip.

ipalmâ Digital Cameras

The PV-DC3000 and PV-DC3010 have an SD slot for storing pictures on an SD or MMC card in JPEG or TIFF format. Equipped with a 3.3-megapixel image sensor, this diminutive digital snaphooter can deliver resolutions up to 2,048 x 1,536. Its USB interface and One Button Image Transfer feature make it easy to send images from the camera to your PC. You can even add sound to your pictures.

Digital Palmcorderâ Camcorders

You can't put DV digital video onto an SD Memory Card (yet), so why does the PV-DV201, among others in a whole line of digital camcorders, have an SD slot? Because it can double as a high-resolution digital still camera. Expect to see this become a near-standard feature of digital camcorders.

SD for the Road

And you thought you were happy when you could start playing CDs in your car. In addition to all the standard features of a modern high-end car stereo receiver—AM/FM stereo radio, CD changer control, high-power amplifiers, and so forth—the CQ-SRX7000U sports an SD card slot for playing AAC and MP3 audio files.

Core Components

Besides end-user products, Panasonic also designs and manufactures electronic components for SD Memory Card devices. For example, the company has developed an enhanced chipset for SD-based audio players. It is the first in the industry to incorporate both copyright protection and audio data decoding from SD directly in the hardware, laying the foundation for continued progress in miniaturization of SD-based products with audio functions. This, in turn, will greatly expand the range of electronic products compatible with SD Memory Cards.

5. The Future

The examples described above really just touch the surface of what the future holds for devices and applications built around the SD Memory Card standard. And the next generation is almost upon us. A number of manufacturers are working on new cable- and satellite-TV set-top boxes that will make it easier for consumers to access movies, sports events, and other conventional entertainment programming as well as advanced interactive programming. Internet phones and appliances are ideal settings for the feature-rich, advanced data storage provided by SD Memory Cards. We can also expect to see cordless phones, fax machines, scanners, and even mini-audio components taking advantage of these broadly interoperable, stamp-sized, industry-standard cards.

Recently manufacturers began showing prototypes of alarm systems, climate-control systems, master entertainment system controls, and other home-automation devices with SD-enhanced functionality. Testing has begun on smart home appliances, such as microwave ovens, refrigerators, and conventional ovens, that use SD Memory Cards to improve their performance. SD cards are also central elements of new “bridge” devices that can help integrate the operation of all your home electronics.

On the business side, SD’s advanced encryption and security features will quickly find application in health care, financial services, fitness machines, kiosk handsets, and in-store content servers. SD Memory Cards are already being tested in DVD and DVD-RAM servers, broadcasting system components, security systems, and certain types of cable-television network apparatus.

Overall, the memory-card market is expected to reach \$14 billion in 2001 and \$25 billion in just the next two to three years. Technology System Research estimates that audio/video, PC, and mobile applications will account for about 30% of sales, with game/entertainment cards using SD technology rising to about 10% of the 500 million units sold worldwide by 2005. Some experts believe that the SD form factor’s share of the business-related memory card market will grow to almost 50% by 2005. *Laptop Magazine* takes note of the SD Memory Card’s market strength in its September 2001 issue: “Contributing to SD/MMC (MultiMedia Card) potential is the fact that it’s made by a large number of vendors and a huge community of device manufacturers has signed on to use the format. Its only major weakness is the limited memory capacity—since it’s so new, it’s currently available only in formats up

to 64MB. Higher capacities should emerge next year. IDC, in fact, recently released a report that suggests that SD/MMC will be the market leader by 2004, followed closely by CF [Compact Flash].”

SD’s strong security features will accelerate the trend to direct electronic distribution of existing creative content and encourage the creation of new material for such merchandising channels. They will also facilitate a range of interesting financial services, such as portfolio consulting, e-banking, and e-commerce. Transfer and retrieval of sensitive personal information, such as medical and financial records, will become both easier and safer.

These developments will benefit consumers by making all types of electronic transactions simpler, more secure, and more readily available. In particular, SD Memory Cards will open the door to direct downloading of a much wider array of music, movies, and other entertainment content. This, in turn, will drive increased use of the Internet and spur businesses to develop better, faster, and easier-to-use devices to perform such functions. The SD Memory Card is an efficient, portable data storage format for the 21st Century.

Appendix A: SD Design Specification

The SD Memory Card is designed to address many of the problems that have bedeviled other current and prior data-storage devices. For instance, a common irritation with other types of memory cards is the ease with which they can be inserted incorrectly into their slots. SD cards have thin rails on each side that prevent them from going into a slot the wrong way. The cards also provide visual cues that make it easier to distinguish top from bottom.

Other features are aimed at data protection. Each card has a write-protect slide switch that can be engaged to prevent accidental overwriting or deletion of valuable data. Such mechanical write protection is easier to use and more reliable than the electronic write protection supported by some other types of memory cards. The card also has a terminal guard to shield its electrical conductors from accidental contact. Special engraving makes the terminals as large as possible to ensure reliable connections, and the shape and design of the casing helps keep them free of dust and dirt.

Appendix B: SD Association Members

Appendix C: List of Figures