FLASH MEMORY OVERVIEW

The ideal memory system optimizes density, nonvolatility, fast readability and cost effectiveness. While traditional memory technologies may individually exhibit one or more of these desired characteristics, no single memory technology has achieved all of them without major tradeoffs—until the introduction of Intel Flash memory.

What Is Flash Memory?

In 1988, Intel introduced ETOX™ flash memory—a high-density, truly nonvolatile, high-performance read-write memory solution, also characterized by low power consumption, extreme ruggedness and high reliability. The cost trend of Intel Flash memory components continues to decline sharply due to three factors:

1. Manufacturing economies inherent in ETOX—Intel's industry-standard EPROM-based flash technology
2. Increases in memory density
3. Rapid growth in production volume

Upcoming multiple bit/cell technology will promote further cost reductions.

A comparison between Intel Flash memory and other solid-state memory technologies underscores the fact that flash offers a design solution with distinct advantages. These advantages are key to future product differentiation for many applications requiring firmware updates or compact mass storage (see Table 1).

- ROM (Read-Only Memory) is a mature, high-density, nonvolatile, reliable and low-cost memory technology widely used in PC and embedded applications. Once it is manufactured, however, the contents of a ROM can never be altered. Additionally, initial ROM programming involves a time-consuming mask development process that requires stable code and is most cost-effective in high volumes.

Easy updateability makes flash memory clearly more flexible than ROM, in most applications.

- SRAM (Static Random-Access Memory) is a high-speed, reprogrammable memory tech-nology which is limited by its volatility and relatively low density. As a volatile memory technology, SRAM requires constant power to retain its contents. Built-in battery back-up is therefore required when the main power source is turned off. Since battery failure is an inevitable fact of life, SRAM data loss is an ever-present danger. Additionally, SRAM requires four to six transistors to store one bit of information. This becomes a significant limitation in developing higher densities—effectively keeping SRAM costs relatively high.

In contrast, Intel Flash memory is inherently nonvolatile, and the single transistor cell design of Intel's ETOX manufacturing process is extremely scaleable, allowing the development of continuously higher densities and steady cost improvement over SRAM.

- EPROM (Electrically Programmable Read-Only Memory) is a mature, high-density, nonvolatile technology which provides a degree of updateability not found in ROM. An OEM may program EPROM as needed to accommodate code changes or varying manufacturing unit quantities. Once programmed, however, the EPROM may only be erase by removing it from the system and then exposing the memory component to ultraviolet light—an impractical and time-consuming procedure for many OEMs, and a virtually impossible task for end-users.

Unlike EPROM, flash memory is electrically re-writable within the host system, making it a much more flexible and easier to use alternative. Flash memory not only offers OEMs high density and nonvolatility, but higher functionality and the ability to differentiate their systems.

- EEPROM (Electrically Erasable Programmable Read-Only Memory) is nonvolatile and electrically byte-erasable. Such byte-alterability is needed in certain applications but involves a more complex cell structure and significant tradeoff in terms of limited density, lower reliability and higher cost, making it unsuitable as a mainstream memory.

Unlike EEPROM, Intel Flash memory technology utilizes a one-transistor cell, allowing higher densities, scalability, lower cost, and higher reliability, while taking advantage of in-system, electrical erasability.

Table 1. Intel Flash Memory vs. Traditional Memory Technologies

Memory	Inherently Non-Volatile	High Density	Low Power	One Transistor Cell	In-System Re-Writable	Code and Data Storage	Byte Alterable	Blocking	Hands-Off Updates
Flash	√	√	√	√	√	√		√	√
SRAM + Battery					√	√	√	√	√
DRAM + Disk		√			√	√	√	√	√
EEPROM	√		√		√	√	√	√	√
OTP/EPROM	√	√	√	√					
Masked ROM	√	√	√	√					

- DRAM (Dynamic Random Access Memory) is a volatile memory known for its density and low cost. Because of its volatility, however, it requires not only a constant power supply to retain data, but also an archival storage technology, such as disk, to back it up.

Partnered with hard disks for permanent mass storage, DRAM technology has provided a low cost, yet space and power-hungry solution for today’s PCs.

Intel Flash memory combines advantages from each of these memory technologies. In embedded memory applications, flash memory provides higher-performance and more flexibility than ROM and EPROM, which providing higher density and better cost effectiveness than battery-backed SRAM and EEPROM. Moreover, the true nonvolatility and low power consumption characteristics of flash memory make it a compelling alternative to DRAM in many applications.