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Nonvolatile SRAMs (nvSRAMs) in Gaming Applications

Abstract

Cypress's nonvolatile static RAM (nvSRAM) technology offers a combination of fast access speed SRAM interface and reliable nonvolatility.

Gaming machines use SRAM memory solutions to record multiple gaming data and to hold the data in case of power failure or power outages. This white paper describes the ideal suitability of Cypress's nvSRAM solutions in these applications.

Nonvolatile SRAMs in Gaming: An Overview

Gaming machines, such as slot machines and video poker machines, have been a foundation of the gaming industry for several years. Generally, the popularity of these machines is dependent on the likelihood of winning money, the machine's reliability, and the entertainment value of the machine relative to other available gaming options.

Currently, the microprocessor-based gaming machines use static random access memory (RAM) for storing the critical and continuously changing runtime processing data, machine states, and other configuration details related to gaming. The processor can easily hook up the RAMs to its standard address, data, and control I/Os and can access the device with the least firmware overhead.This is not the case with disk drives or other flash memories. Since the RAM stores all important configurations, the content of this memory is generally critical to the operation of the gaming machine.

Examples of critical data may include one or more of the following:

- Number of winning outcomes
- Payout for the machine
- Wagering details (for example, number of times wagered or number of coins wagered)
- Currency swipe details
- Coin-in amounts and denominations
- Each player's game record, such as the game levels, items used, and time
- Timer data

One weakness of the RAM memory is its volatile nature that causes content loss when power is removed. In many critical applications where the RAM contents should be saved when system power is not available, a battery or a rechargeable Supercap is used to maintain the power to the SRAM for data retention. Often, gaming regulations also require that battery backup configuration be deployed to retain the game state during any power outage or power failure. The inherent risk in deploying a battery option is the reliability of batteries. System power fluctuation or a glitch on the power supply can severely affect the battery performance and can cause complete battery failure if not properly maintained. In the gaming applications, if the power supply to the gaming machine is lost during critical data transfer, and if the battery backup also fails or is not available, then the system RAM will lose all contents, which can cause a complete system

shutdown or failure. Therefore, to avoid such a catastrophic failure, the gaming machine architects take care in designing a battery-backed RAM solution. Cypress's nvSRAM offers the performance of a standard RAM and does not use battery. nvSRAM does not suffer from battery-related issues and securely saves the critical data in all power-fail conditions, which makes it an ideal alternative for a battery-backed nonvolatile RAM solution.
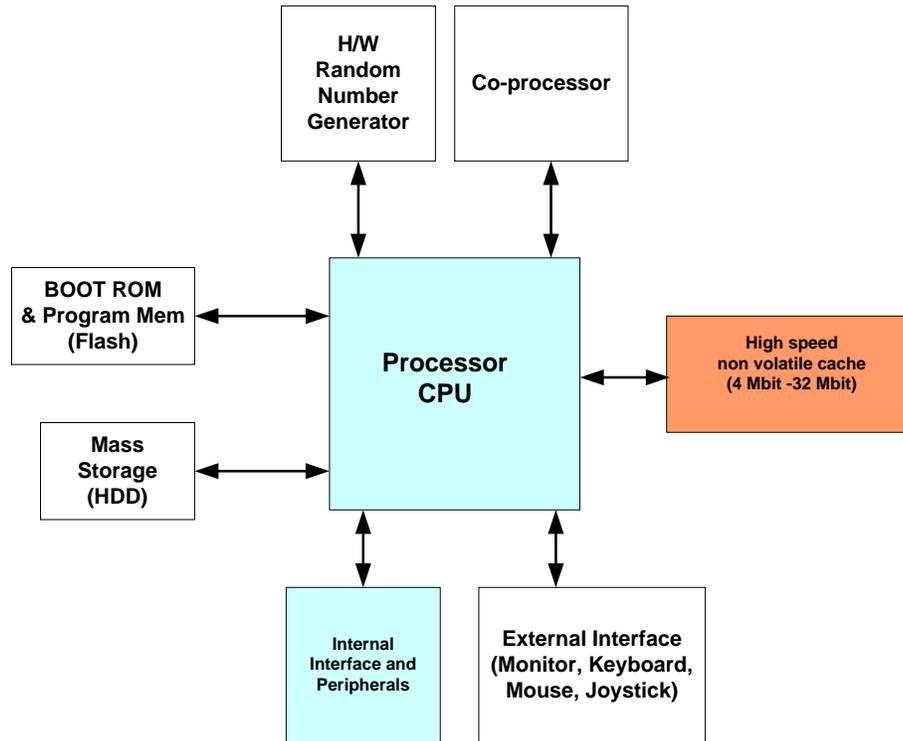
Figure 1 shows a typical block diagram of the gaming machine architecture.

Figure 1. Gaming Machine Architecture Block Diagram

High-speed Nonvolatile Cache

The gaming machine uses the SRAM density (anywhere between 4 Mbit to 32 Mbit) as a cache memory for storing the runtime processing data. The cache memory used in these applications is required to be nonvolatile to save the critical gaming data during power failures. Presently, the RAM cache is made nonvolatile using the battery backup and uses 3.0-V batteries for retaining the RAM contents during power-off as shown in Figure 2.

Because of the growing preference to eliminate batteries, the other alternative nonvolatile memory technologies are becoming more popular in gaming machine designs. Cypress has developed a battery-free monolithic nonvolatile memory solution called nonvolatile SRAM or nvSRAM. Cypress's nvSRAM offers 25-ns access speed (symmetrical write and read operations), which is far superior than the battery-backed solutions, which can provide max access speed up to 45 ns in the best case scenario. A high-speed cache is always preferred in most applications since it directly impacts the system performance.

Battery-backed SRAM Solutions

Gaming machines frequently use battery-backed SRAMs (BBSRAM) to retain critical data during runtime and retain these data on battery power when the system power supply is off. The BBSRAMs use a low-power SRAM (or micropower SRAM) IC, a power controller IC, and a battery on the application board, as shown in Figure 2.

The BBSRAM solutions require extra components and PCB area. Mounting of the battery must be out of the SMD reflow process to avoid its explosion due to excess heat during the reflow soldering. The other challenges associated with battery-based solutions are:

- Susceptibility to system vibration, which can make the mechanical joints used to hold the battery unreliable
- On-schedule maintenance and replacement
- Low MTBF
- Strict green disposal/content laws to follow due to the hazardous components used in batteries.
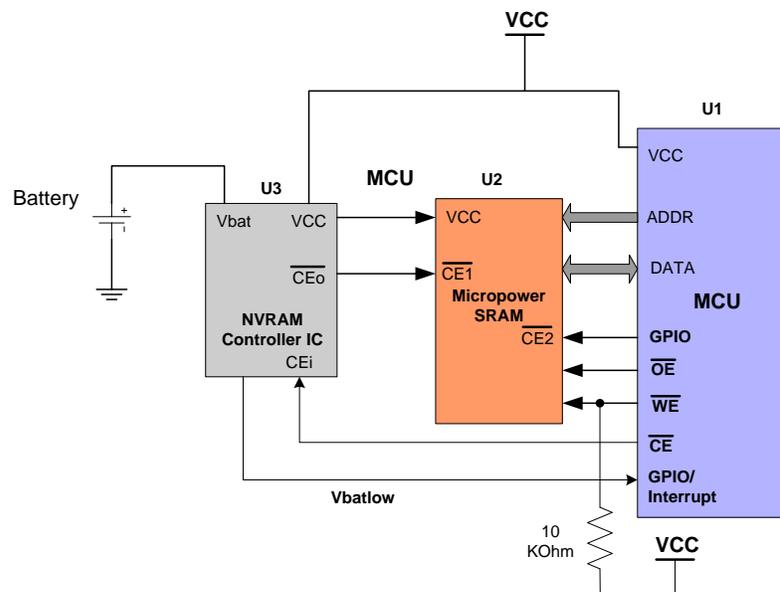
Figure 2. BBSRAM Interface with a Microcontroller

nvSRAM Solution

Cypress's nvSRAM combines standard fast SRAM cells (up to 20-ns access) with the Silicon-Oxide-Nitrite-Oxide-Silicon (SONOS) based nonvolatile memory elements to provide fast asynchronous read/write access speeds and 20 years of data retention across its operating range. A typical nvSRAM interface with a controller is shown in Figure 3.
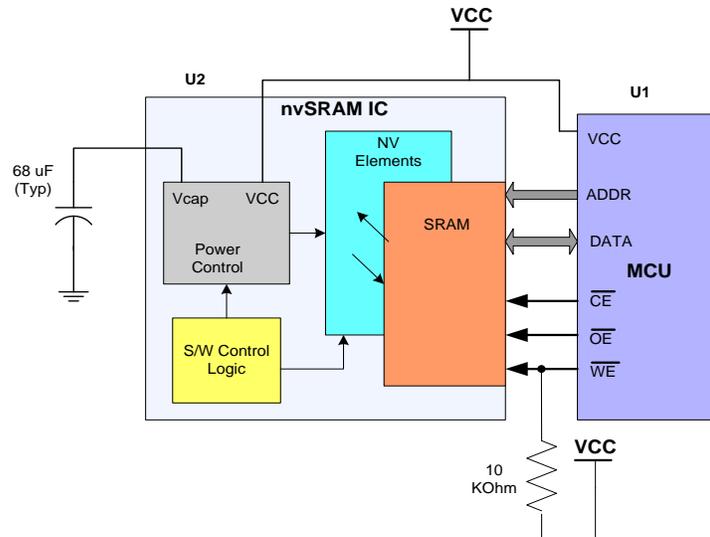
Figure 3. nvSRAM Interface with a Microcontroller

The fast SRAM cells offers a very high-speed read and write access and enables the nvSRAM to be infinitely written or read, just as in standard SRAM. If the power goes down, the data held in SRAM is transferred to the nonvolatile elements integrated with each SRAM cell using the charge stored in a small capacitor connected to the V_{CAP} pin of nvSRAM. The capacitor, required on the nvSRAM V_{CAP} pin, is a few tens of µF, typically 68 µF (see individual datasheets for the permitted range of V_{CAP}) and gets charged through an internal charging circuit during power-up. The charge stored on V_{CAP} is sufficient to copy the SRAM data to nonvolatile elements during power-down, called STORE operation. This STORE operation is transparent to the application because it is automatically executed when V_{CC} power fails below a threshold level (V_{SWITCH}). The parallel transfer of data from SRAM to the integrated nonvolatile elements means that the STORE (transfer of SRAM data to nonvolatile elements) takes the time equivalent to one EEPROM write (byte write or page write) operation. On power-up, the nonvolatile data is automatically transferred back to the SRAM, which is called RECALL operation. This makes nvSRAM a true nonvolatile memory, which can hold the data in its nonvolatile elements when power is off without requiring any external power backup such as batteries or Supercaps.

The STORE andRECALL operations in nvSRAM can also be executed on demand through software commands. The nvSRAM has many additional features, which new applications can use. See the application note, AN6023 - Nonvolatile SRAM (nvSRAM Basics) to get an in-depth understanding of the nvSRAM technology.

Cypress's nvSRAMs provide the fastest and most reliable nonvolatile solutions compared to other existing circuit solutions.

Key Attributes of nvSRAMs

nvSRAMs offer the following benefits and fulfill the requirements of an ideal SRAM device, which is suitable for the nonvolatile cache implementation in gaming applications.

Fast Access: System performance is directly associated with the access speed of the cache memory used. A slow cache memory attached to a fast controller, if not managed properly, can bring down the system performance drastically. Therefore, cache management becomes an important aspect of such a system design. nvSRAM is the fastest nonvolatile RAM in the industry and offers up to 20-ns access speed for all read and write operations. Using nvSRAM instead of a slow SRAM minimizes cache management efforts.

Reliability: The SONOS technology used in nvSRAM provides unmatched reliability. Data retention of 20 years at 85 ºC for the industrial temperature range is one of the highest among nonvolatile RAM technologies available today. This makes nvSRAM the most reliable nonvolatile technology and an ideal choice for gaming applications.

Unlimited Endurance: nvSRAM allows critical data to be written unlimited number of times into its SRAM cells without any possibility of running out of endurance or improper wear-leveling. This takes away all the effort required for implementing the wear-leveling or counting endurance cycles in software when using limited endurance count nonvolatile memories, such as EEPROM and Flash.

Green (No Batteries): Unlike a battery-backed SRAM, nvSRAM is a green solution with no battery involved. It uses only a small capacitor for storing SRAM contents to the nonvolatile elements, which retain data without requiring any additional backup power.

Real Time Clock: Many gaming systems prefer to time-stamp the critical data before writing into a safe location. This typically requires an additional RTC chip and associated components. The nvSRAM comes with an option of the integrated RTC feature. This not only reduces the BOM cost and the board space but also frees up a few dedicated pin resources required to interface with the external RTC device.

nvSRAM Product Specifications

The parallel asynchronous interface nvSRAMs are available from 256 Kbit to 16 Mbit as production parts. Contact your local Cypress Sales Representative for further enquiry. You can also send your related queries directly to nvSRAM@cypress.com. Table 1 lists the essential features of the high-density nvSRAMs.

Parameter	Specifications
Interface	Parallel (Asynchronous)
Memory write and read access time	25 ns
I/O bus	x8/x16/x32
Data throughput	320 Mbps/640 Mbps/1280 Mbps
Single power supply voltage (typical)	3.0 V, 5.0 V
Dual power supply (Separate core and I/O voltage) (V_{CC}/V_{CCQ})	3.3 V/1.8 V
Additional features	RTC, Alarm, Watchdog, Square wave
Packages	44 TSOP-II, 54 TSOP-II, 48 TSOP-I, 165 FBGA

Table 1. Cypress's 16-Mbit nvSRAM

Summary

This white paper discusses the nonvolatile SRAM requirement in gaming applications and shows that the Cypress nvSRAM solution provides the fastest SRAMs and eliminates the battery requirement by using only a small capacitor to provide power for nonvolatile store operation. In addition to being the fastest nonvolatile SRAM solution, nvSRAMs have proven their reliability for over 20 years. The nvSRAMs are available in 16-Mbit densities, which are typically required in gaming applications.

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