# Silicon Motion's Ferri Family

How Ferri products offer secure and reliable data storage for gaming equipment

All around the world, liberalization of the laws governing gambling and betting have spurred rapid growth in the market for gaming equipment. The casino business is booming, and this is driving demand not only for gaming machines themselves – slot machines, table games, and amusement and arcade games – but for the associated equipment required to run casino and gaming operations:

- Gaming control centers
- Casino hospitality kiosks
- Entertainment and advertisement display screens
- Surveillance equipment and CCTV
- Servers

Gaming Applications:

Surveillance equipment and CCTV

Controller Module

Server

Gaming control centers

Gaming Machine

Gaming Machine

Gaming Machine

Casino hospitality kiosks

Entertainment and advertisement display screens
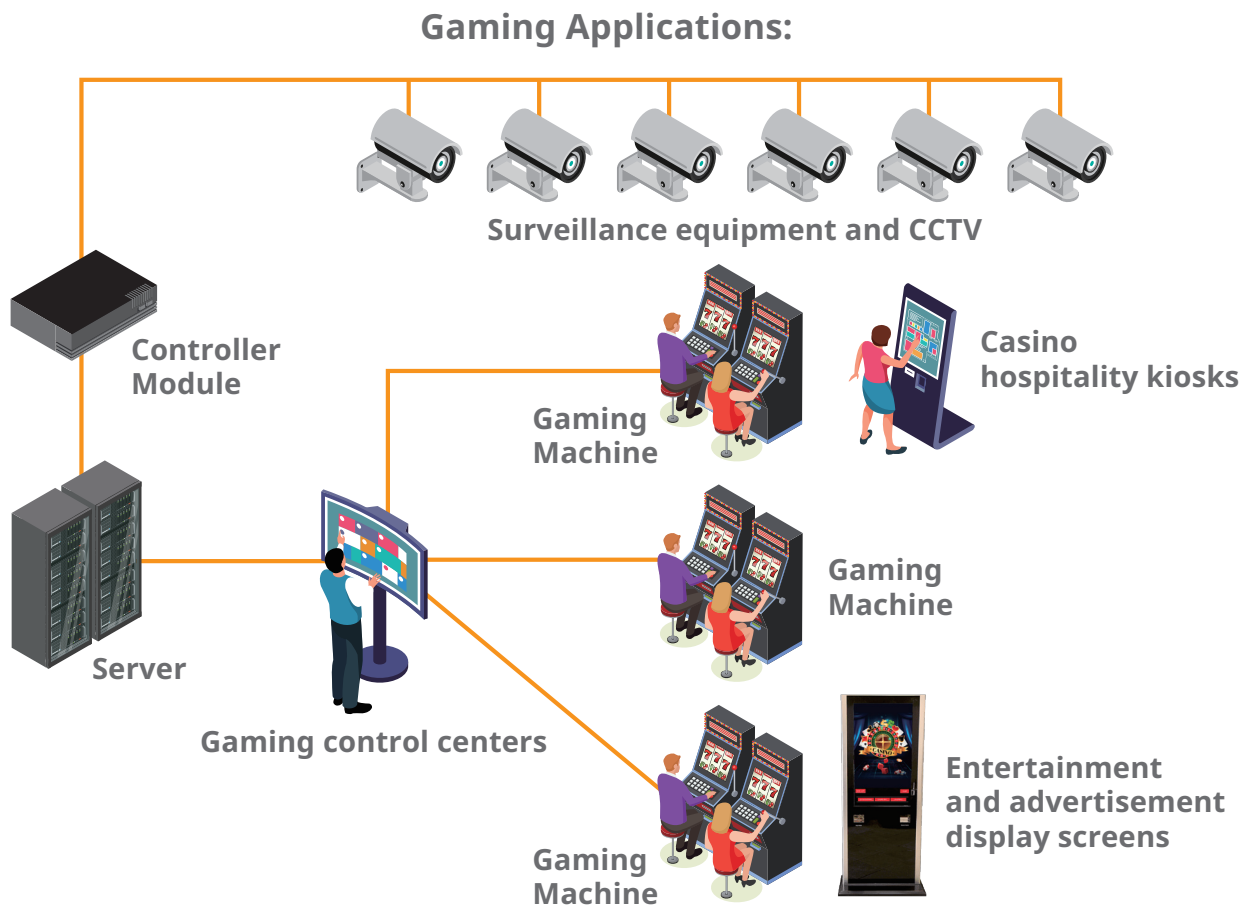
These types of equipment share many of the characteristics of industrial embedded computing systems: the hardware architecture consists of a high-speed processing engine backed by a large data storage capability, and linked to input devices – sensors and buttons – and driving a display screen and speakers.

But the conditions in which gaming equipment operates impose special constraints on the components of gaming equipment, including its storage capability. In particular, gaming equipment requires:

- **Strong security protection** – with large amounts of money at stake, the potential financial gains mean that gaming equipment is exposed to attack from hackers and organized crime gangs

- **Strong protection against electro-magnetic disturbance** – venues for gaming equipment can be electrically noisy environments, and the effect of the discharge of accumulated static electricity can damage or even disable the sensitive electronic components inside gaming technology

- **High reliability and long operating lifetime** – the operators of gaming equipment want it to be available for use 24/7/365. Planned or unplanned downtime interrupts the flow of revenue on which the gaming industry depends.

These requirements apply to all the key elements of a gaming device's hardware architecture, including the storage device which holds application code and user data.
This white paper describes the features of the industrial-grade Ferri family products from Silicon Motion which make them particularly well suited to gaming applications.

Countering threats to the security of storage devices
Gaming is big business, and a hacker who can successfully infiltrate gaming systems can potentially manipulate them, with the effect of disrupting the operation of games, or to trigger illegitimate payouts to a hacker's criminal associates.

Two categories of protection for gaming equipment can counter this threat:

- Protection to bar a hacker from infiltrating equipment

- Protection of sensitive data, so that even if a hacker infiltrates equipment, they will not be able to use data that they access

In Ferri family storage products from Silicon Motion, both these security functions are supported with state-of-the-art technologies.

Barring hackers from gaming equipment's storage device

Every Ferri storage device implements authenticated firmware protection. A secure digital signature is required at system boot before the storage system will start operating. A hacker who attempts to spoof the system by loading compromised firmware which they can control will find that the storage device will not run, and instead sends a security warning to the host processor.

A Ferri storage device will also send an alert to the host processor when it detects any attempt to perform emergency unscheduled maintenance – this is a common means by which hackers attempt to tamper with gaming equipment.

Protecting user data saved in system storage

To stop a hacker from acquiring user data, Ferri products implement full-disk encryption using the industry-standard 256-bit AES cryptographic algorithm. AES-256 cryptography is used by government agencies, financial institutions and the military to protect sensitive data. 'Cracking' the code by brute force is known to require millions of hours of computing operations: AES-256 cryptography provides comprehensive and strong protection for all types of gaming equipment.

An additional dimension of protection is provided by the physical form factor of the FerriSSD product line. These devices offering storage capacity of up to 480GB are supplied in a compact surface-mount BGA package with a footprint of just 16mm x 20mm. This means that they can be mounted on a card or motherboard alongside the host processor. Located inside the main enclosure of the device, a FerriSSD product in a BGA package offers much greater protection against physical tampering than a discrete, external SSD located separately from the motherboard.

Protection against electro-magnetic disturbance

The gaming environment is exposed to large amounts of electrical noise and electro-static charge: this is a result of the presence of multiple high-power devices containing high-frequency, high-temperature components such as microprocessors in an enclosed space.

Here, manufacturers of gaming equipment gain a valuable advantage from Silicon Motion's ability to customize both the hardware and the firmware of its storage products to provide robust protection against electro-magnetic interference (EMI) and electro-static discharge (ESD). These customization options include special enclosure options to provide shielding, stopping EMI from reaching sensitive circuitry inside the storage device. Firmware customization implements additional system safety checks before and during operation of the device.

By preventing damage to gaming equipment caused by external interference, Silicon Motion's Ferri products ensure that they can maintain stable operation and reliable performance, avoiding the financial losses associated with unplanned downtime.

Maintaining reliable storage operation

Built for 24/7/365 operation, gaming equipment is potentially losing revenue opportunities every minute it is not up and running. The reliable operation of data storage, a key component in gaming equipment, is therefore a critical concern for the specifiers and designers of gaming equipment.
Two important features of the Ferri storage products from Silicon Motion enable gaming equipment to promise reliable operation: **High data integrity,** and **Maintenance-friendly design.**

High data integrity across complete device lifetime

It is an inherent characteristic of Flash memory operation that bit errors can occur when data is written to or read from the storage medium. This has the potential to corrupt application software code or user data. Storage products implement error correction software technologies to detect and correct these errors. But bit error rates rise as the NAND Flash medium ages with each Program/Erase (P/E) cycle, and error correction becomes harder to achieve with standard correction technologies.

Silicon Motion solves this problem in the Ferri products with its NANDXtend technology: consisting of a patented, high-performance LDPC Error Code Correction engine and the RAID function, NANDXtend provides multiple benefits (see Figure 1). First, it enhances the reliability of the product, and second, it greatly extends the P/E cycle life, and prolongs the life of the storage device's NAND Flash storage medium. In addition, NANDXtend can help increase the data storage capacity and reduce data errors caused by operation at high temperature.
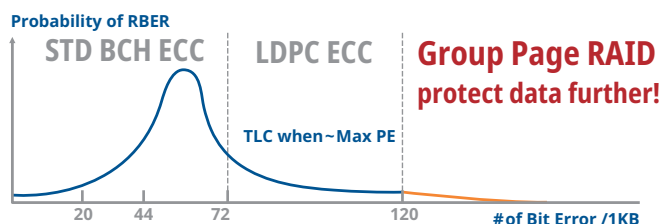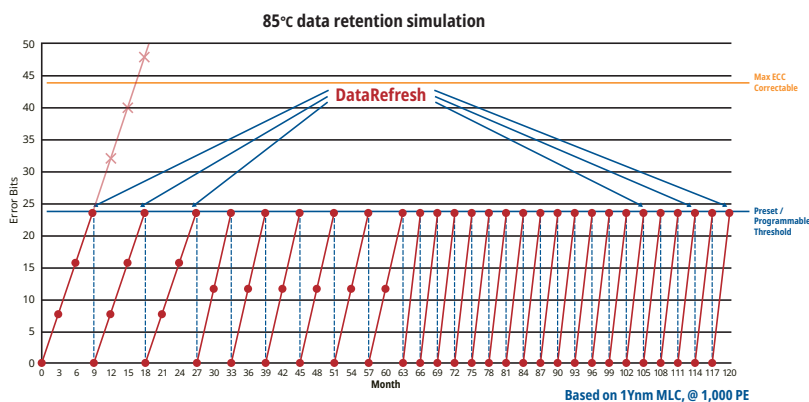

Fig. 1: Silicon Motion's patented NANDXtend technology can increase the reliability of gaming equipment

The Ferri family of products also implement patented technology for maintaining long operating lifetime, without suffering from data errors caused by deterioration of the physical storage medium (the NAND Flash cells). The IntelligentScan™ and DataRefresh™ technologies are methods of self-testing and self-monitoring (see Figure 2).

The execution of "write" and "read" commands on a NAND cell is basically a process of electrical discharging and charging. Let us assume that a new NAND cell stores 100 electrons when written to. Over time, repeated write

Fig. 2: IntelligentScan and DataRefresh can detect cells which are at risk before data is lost

and erase events will volatilize the cell, reducing the cell's capacitance, so that the number of electrons stored by a write command may fall from 100 to 80, then 70, then 60, and so on. When the stored charge declines so much that it falls below a critical threshold, the controller will no longer be able to read the data correctly, resulting in data loss or corruption.

The IntelligentScan function is responsible for checking whether the stored charge has declined below its threshold value. If it has, it reads out the data bit and rewrites it via the ECC engine, and DataRefresh recharges the cell to restore the NAND cell's voltage to the correct level.

These protection mechanisms operate in the bulk NAND Flash storage medium in which data is stored. But data errors can also occur when data is in transit between the NAND Flash array and the host controller, as it passes through SRAM and DRAM volatile memory blocks. These errors can be caused by factors such as high temperature, EMI, or radiation. To eliminate the potential for error at every stage of a stored bit's transmission, Ferri products perform end-to-end data path protection (see Figure 3).

Regardless of the cause, any error in the data will be detected immediately. This is because a set of parity bits will be generated when the data is written: before the data is read out, the Ferri device will calculate the parity bits again. If the two sets of parity bits do not match, the storage device will immediately start a restoration process.

Fig. 3: end-to-end data path protection can ensure the integrity of each data entity in a Ferri storage device

If restoration does not work, it will then immediately notify the host that the data cannot be trusted and is unusable. This instruction, the so-called "Command Abort", prevents the host from using corrupt data, and thus stops it from initiating incorrect actions, and these actions then affecting subsequent operations.

Maintenance-friendly features

To support effective maintenance and monitoring, Ferri storage devices feature a built-in temperature sensor. When combined with a monitoring or telemetry system, this sensor can ensure reliable operation at high temperature, even when operating in a fanless system with no forced-air cooling. The provision of a temperature sensor allows, for instance, the host processor to slow read and write operations when a FerriSSD is close to its maximum temperature threshold, to avoid the risk of a damaging over-temperature event.

This feature is supplemented by remote telemetry, enabling the system operator to monitor the system, determine when to perform scheduled maintenance on devices identified by their location, and even perform optional remote firmware upgrades.
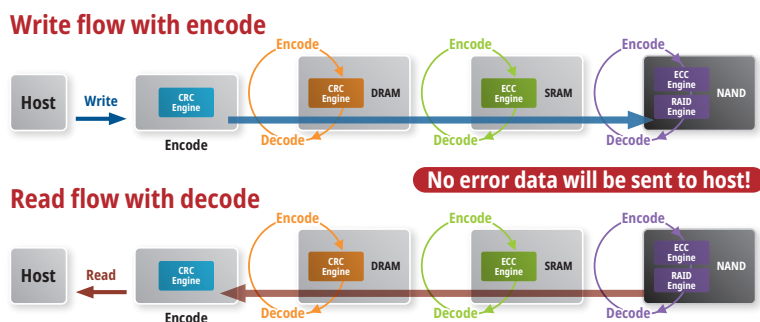
Electronic gaming machines can also be subject to uncontrolled power cycling, for instance when the user turns off mains power to equipment without following a computer's specified shut-down procedure. Ferri products provide a sudden power loss protection mechanism to save data in the event of such an outage: this triggers a data flush to safely store user data, using power from an on-board back-up power supply.

A dependable data storage solution for gaming applications

By securing data against the threat of hacking, protecting the storage medium from interference, and providing for reliable operation and a long operating lifetime, the Ferri storage products meet the key requirements of manufacturers of gaming equipment.

The products are also backed by an expert technical support service and the flexibility to customize hardware and software to meet individual customers' needs, ensuring that gaming equipment manufacturers can deliver on their promise to gaming equipment operators of reliable performance and a long service life.

Silicon Motion: a strong partner to support gaming equipment operators

When choosing embedded storage solutions for gaming applications, equipment manufacturers will also evaluate the capabilities and resources of the storage device supplier. In the case of Silicon Motion, they can be assured of superior technical expertise and flexible customization capabilities.

Silicon Motion's expertise in storage technology derives from its position as the world's leading independent manufacturer of SSD controllers. Silicon Motion draws on decades of experience in the management of advanced, high-density NAND Flash arrays, right up to the latest quad-level cell (QLC) NAND Flash technology. Silicon Motion's investment in research and development continues to produce breakthroughs in NAND Flash management and SSD performance.

To ensure that the Ferri storage solutions are optimized for the requirements of gaming equipment operators, Silicon Motion can implement a set of hardware and firmware customizations, and give gaming equipment manufacturers the system boot and storage options that the gaming industry requires.

SiliconMotion