SiliconMotion

WHITE PAPER

Silicon Motion's FerriSSD

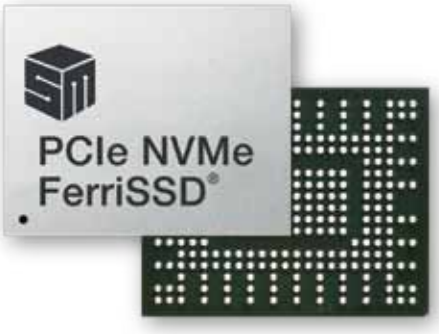
offers the stability and data security required in medical equipment

Around the world, aging populations and an accompanying increase in the prevalence of chronic diseases are driving up demand for medical care. This trend is reflected by strong growth in the global medical device industry. One response to growing pressure on healthcare services is an intensified focus on prevention and early diagnosis, so as to extend the time for which people enjoy healthy lives and to reduce overall expenditure on medical care. This increases demand for high-technology medical equipment, creating new growth opportunities in market sectors such as high-end imaging/diagnostic equipment and smart medical devices.

It is undeniable that the key technologies at the high-value end of medical device markets, for example medical imaging equipment such as ultrasound, X-ray, Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) scanners, have long been the domain of major international manufacturers based in Europe and North America, but manufacturers based in Taiwan also play an important role.

The supply of computing components for increasingly high-tech medical equipment, for example, is a natural extension of Taiwan's position as the global hub of the industrial computer market. The island's manufacturers are known for providing high-quality and cost-effective industrial-grade motherboards. As a result, many major international medical equipment manufacturers have embedded industrial-grade motherboards made in Taiwan as the "brain" of their medical equipment (Figure 1).

Figure 1: Most medical instruments today feature embedded technical grade motherboards



Compact single-chip SSD meets needs of medical equipment designs

Medical equipment must maintain normal operation to safeguard the patient's health and safety. No component can be allowed to fail without warning, and downtime while equipment awaits repair interrupts the provision of medical care. The requirement for reliability applies as much to the industrial-grade motherboards as to any other component in a medical device.

With this in mind, industrial computer manufacturers have always adhered to strict standards of efficiency, stability, and durability in the selection of the components on the motherboard. A solid-state drive (SSD) complies better with these standards than traditional hard disk drives, and so are industrial computer and medical equipment manufacturers' preferred choice of storage component.

Of the various types of SSD products, single-chip SSDs better meet the configuration requirements of medical equipment than SSD modules. This makes FerriSSD single-chip embedded storage solutions made by Silicon Motion highly valued by medical equipment manufacturers.

Why is a single-chip SSD well suited to medical applications? The main reason is that the NAND Flash memory and the controller are packaged in a single chip, which offers two key benefits: small size, and the elimination of external connectors, producing a lighter motherboard in a more convenient form factor (Figure 2). Medical imaging equipment such as ultrasound, X-ray, CT or MRI scanners contain relatively large mechanisms, leaving limited space in which to accommodate the motherboard. So the smaller the motherboard, the better, a point in favor of the single-chip SSD. Another benefit of adopting a single-chip SSD is that the verification cost associated with NAND upgrades can be avoided.

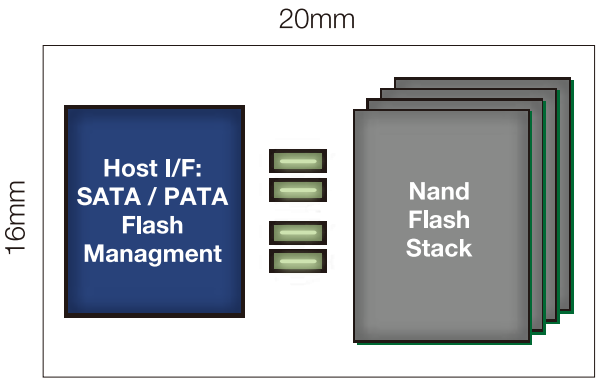


Figure 2: FerriSSD offers the advantage of small size, an important requirement for the design of high-tech medical equipment

In support of the case for the FerriSSD products, it should be noted that Silicon Motion is a global leader in SSD controllers, and maintains close relationships with NAND Flash chip manufacturers. Rigorous testing verifies that the controllers are compatible with every generation of NAND Flash. In addition, Silicon Motion's first products were embedded graphics processing units, and through supplying these products it has built deep relationships with users in the medical equipment industry.

This is why the company understands the operational needs of medical equipment, and has configured the features of the Ferri series of products, with the addition of special security mechanisms, to meet the expectations of users in this market.

Three unique advantages of FerriSSD

Silicon Motion, then, enjoys a leading position in the SSD controller market and a deep relationship with users in the medical equipment industry. As for the FerriSSD product itself, it has three unique advantages which mean that it caters better to the needs of medical equipment manufacturers than competing products, offering more stable operation and better data protection capabilities.
Below, this paper describes these unique advantages in turn.

Patented technology produces excellent stability

First, the requirement for reliability. When FerriSSD was introduced in 2009, most customers directly soldered it on the motherboard: because NAND was very expensive at that time, customers had extremely strict requirements applying to the reliability of single-chip SSDs. Unlike modules, which are easily replaced when a discrete component fails or is damaged, if a single-chip SSD on a motherboard is broken, the entire motherboard has to be scrapped.

Because of this, Silicon Motion sets very strict test conditions for FerriSSD, and all products must be 100% tested. For example, industrial-grade FerriSSD products must undergo reliability tests over a wide temperature range, from a low of -40°C and to a high of +85°C, subjecting the SSD to repeated thermal cycles . For commercial products, the thermal cycling is performed over a narrower range of 0°C to 70°C.

By contrast, SSD modules are unlikely to be tested at temperatures as high as 85°C or 70°C, because the connection interface of the module is frequently affected by high and also by extreme low temperatures, resulting in errors and test failures. Silicon Motion's BGA-packaged single-chip SSD product line does not face the same risk of test failure. The production line test for FerriSSD products uses push-fit sockets, so the problem of test point contact error under extremely low or high temperatures can be greatly reduced, and test errors due to thermal expansion and contraction are less likely to occur.

As a result, FerriSSD has a long track record of achieving a low dPPM rate (defective Parts per Million). When configured in SLC Mode, the products supplied by Silicon Motion are not only cost-competitive, but also offer reliability approaching that of native SLC Flash ICs, making them highly attractive to users in the medical market.

In addition, FerriSSD contains many special technologies which greatly increase the reliability of the product, and extend its value in medical applications. If the reliability of the SSD were not high and the debugging capability poor, it might cause abnormal conditions which could prevent medical equipment from being turned on, or which could disrupt the retrieval of stored data. Either event would impair the quality of medical service provision, and could even have disastrous consequences.

Medical equipment supported by the following unique FerriSSD technologies benefits from a greatly reduced risk of such undesirable consequences.

(1) NANDXtend® Error Code Correction (ECC) Technology

FerriSSD combines the high-performance LDPC Error Code Correction engine patented by Silicon Motion and the RAID function, which provides multiple benefits. First, it enhances the reliability of the product, and second, it greatly extends the Program/Erase (P/E) cycle rating, and prolongs the life of the SSD's NAND Flash storage medium. In addition, NANDXtend can help increase the data storage capability and reduce data errors caused by operation at high temperature (Figure 3).

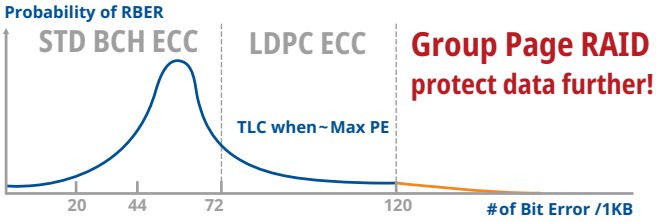


Figure 3: Silicon Motion's patented NANDXtend technology can increase the reliability of medical products

(2) IntelligentScan™ & DataRefresh™

These two technologies are methods of self-testing and self-monitoring. 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 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 60and 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 (Figure 4).

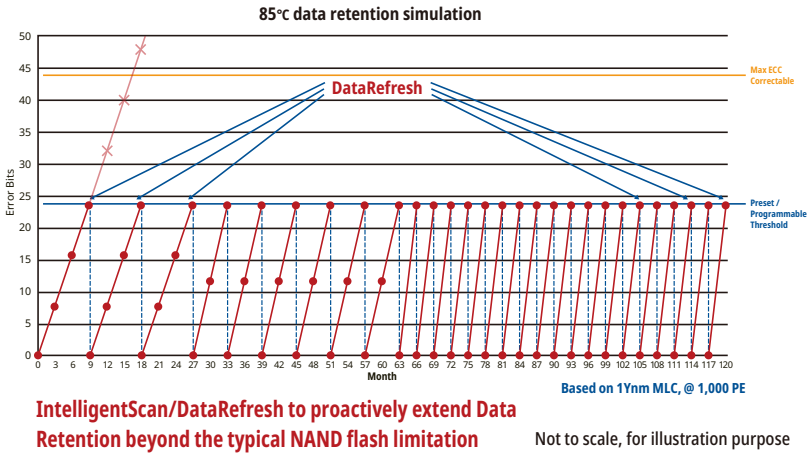


Figure 4: IntelligentScan & DataRefresh can detect cells which are at risk before data is lost

(3) E2E (End-to-End) Data Path Protection

The function of this technology is to verify that data is correct, or to avoid providing incorrect data to the host.

When data is written to the SSD, it normally passes through DRAM and SRAM before being stored in NAND Flash. When the data is read, it returns via the same path. At any of these links the data may be corrupted, either by the component itself, or by environmental factors such as high temperature, interference, or radiation.

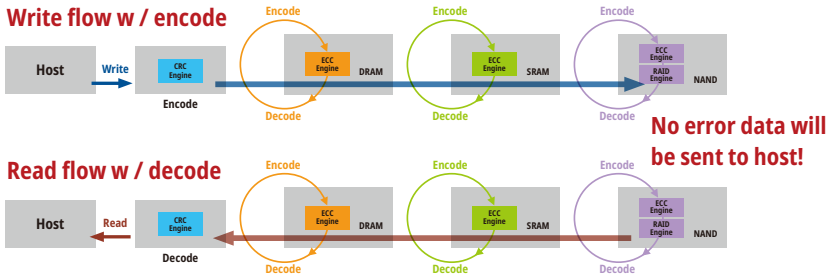


Figure 5: End-to-End Data Path Protection can ensure the integrity of each data entity in the SSD

Regardless of the cause, any error in the data will be detected immediately by the E2E Data Path Protection (Figure 5). This is because a set of parity bits will be generated when the data is written: before the data is read out, the FerriSSD will calculate the parity bits again. If the two sets of parity bits do not match, the SSD will immediately start a restoration process. 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.

Supporting multiple protection mechanisms to prevent leakage of personal data

For medical facilities, it is essential to protect the privacy of patients' personal data. Data stored in a NAND Flash-based storage device must be kept safe from the risk of access and retrieval without proper authorization.

Silicon Motion's development of the Ferri series of products paid particular attention to the encryption of user data. Currently, Ferri series products support TCG Opal 2.0 and AES 256-bit encryption, standard hardware technologies which are commonly applied in the medical market.

In addition, the growth of IoT applications has led many users to call for firmware protection. This stems from the fear that, once firmware (including the SSD driver) is controlled by a hacker, they can command the SSD to execute abnormal actions, such as decryption. This would enable the hacker to steal data, or to activate ransomware to block the SSD, paralyze the equipment, and demand a ransom from the user to unlock it.

To counter this threat, Silicon Motion makes special use of an eFuse (electronic fuse) in the production of FerriSSD products, adding a "Digital Signature" function to FerriSSD firmware and software. The eFuse provides a protection mechanism which is inaccessible to outsiders. It carries a unique set of passwords, so that when hackers open the firmware of FerriSSD, they cannot tamper with it or start the SSD without authorization, since they cannot perform the Digital Signature verification.

Many medical institutions do not trust standard encryption technology, believing that it does not provide sufficient protection against state-sponsored and other highly capable hackers. Users in the medical market can work with Silicon Motion to create a custom "Security Handshake". This can be, for example, checkpoints that only users know, or a set of security chips which store passwords to verify an SSD user's identity. The Security Handshake works in the same way as a password or phrase that no outsider would know, preventing hackers from modifying the firmware of FerriSSD.

Comprehensive data protection in the presence of radiation or other environmental threats

Another competitive advantage of Silicon Motion is its willingness to provide customization services. The most common use case is for applications in which a harsh environment, such as excessively high temperature or high levels of electro-magnetic noise, may cause data damage or loss (Figure 6). Silicon Motion can provide assistance in protecting important data effectively in such environments.

Figure 6: A harsh medical environment may cause data damage or loss

Typical environments where medical equipment is used are exposed to high levels of radioactivity or radiated interference which can impair the operation of medical equipment. Reliable operation in such environments calls for the customization of hardware and firmware to strengthen the equipment's protection against phenomena such as ESD (Electro Static Discharge), EMI (Electro-Magnetic Interference) and EMS (Electro Magnetic Susceptibility). The prevention of damage to medical instruments caused by interference ensures the continued safety of patients.

One-stop support from designing, through mass production to after-sales service

Silicon Motion's FerriSSD product portfolio provides a wide choice of memory density options, from 4GB to 480GB. New products with a capacity of 1TB will be launched in the future.

Other FerriSSD options include a choice of NAND Flash configurations: SLC, MLC and TLC. FerriSSD products are also available with various host interfaces: PCIe, SATA and PATA interfaces are all available to meet the needs of medical equipment manufacturers.

In addition to the FerriSSD products, Silicon Motion also provides embedded storage solutions with an eMMC or UFS interface: the Ferri-eMMC and Ferri-UFS products extend the choice of embedded storage device available to medical equipment manufacturers.

Finally, customer support is another strong suit of the Silicon Motion offering. This is unusual in the embedded computing market: the production volumes of medical equipment are usually not as large as the those of PCs or mobile phones, so NAND Flash suppliers tend to prioritize the provision of support to consumer device manufacturers. But Silicon Motion has deep relationships of co-operation with medical equipment manufacturers which go back to the days when it first started supplying embedded graphics processing units. During the many years since then, Silicon Motion has built a deep understanding of the special and strict requirements that the medical industry has to deal with.

This is why Silicon Motion makes a commitment to providing a one-stop source of services for the medical market, from design, through mass production to after-sales, supporting the industry at every point. Even if the customer's requirement is as little as an RMA, the company will take it seriously, and ensure the constant and stable operation of the customer's medical equipment, to the benefit of ever more patients.

For more information about Ferri Family, please go to
www.siliconmotion.com or send email to **ferri@siliconmotion.com**