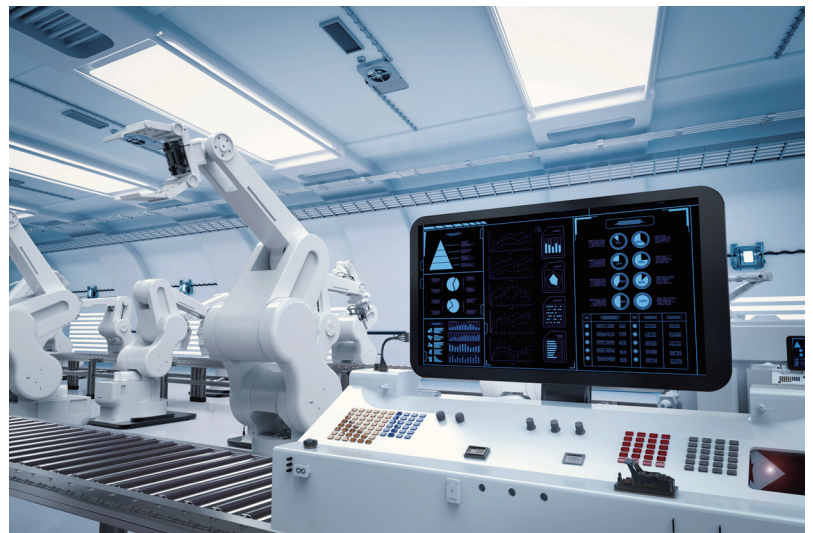# Silicon Motion's FerriSSD®
Enhancing the Safety and Reliability of Computer On Module Designs

The Computer On Module (COM) is the most widely adopted hardware format for embedded computing in the military, transportation, medical, entertainment, networking, and industrial equipment markets. The popularity of the COM format is the result of its many advantages, which include faster embedded system development, risk and cost reduction, and the freedom to customize the system. Use of a COM in a standard form factor also makes it easy to upgrade or replace the technology on backplanes and carrier boards.

Because of the small footprint of the standard COM form factors, COM manufacturers take great pains to select a compact data storage technology. A chip-scale device such as a BGA SSD is a miniature and attractive format, but in the past, the relatively high and volatile price of BGA SSDs deterred manufacturers from using them. Instead, most manufacturers embedded a socket or added a connector for an SD or CompactFlash (CF) card appropriate to the set of functions running on the boot disk.

More recently, serious doubts about the use of SD and CF cards in embedded systems have emerged. In military, medical, automation, transportation, and other fields, huge investment is made in the development of software to run on embedded systems. This means that it is very costly to replace an existing COM board with a new design - product life cycles of 20 years or more are common.

As a result, embedded system manufacturers pay great attention to data security and longevity, and take steps to counter any factors which might interfere with the integrity of data stored on a COM. There is also considerable alarm about the risk of the theft of residual data left behind in the buffer memory of scrapped devices. Attempts to counter this risk by marking devices with a warning about data security on disposal have proved unsuccessful. This has consigned the use of removable media such as SD and CF cards to the past.
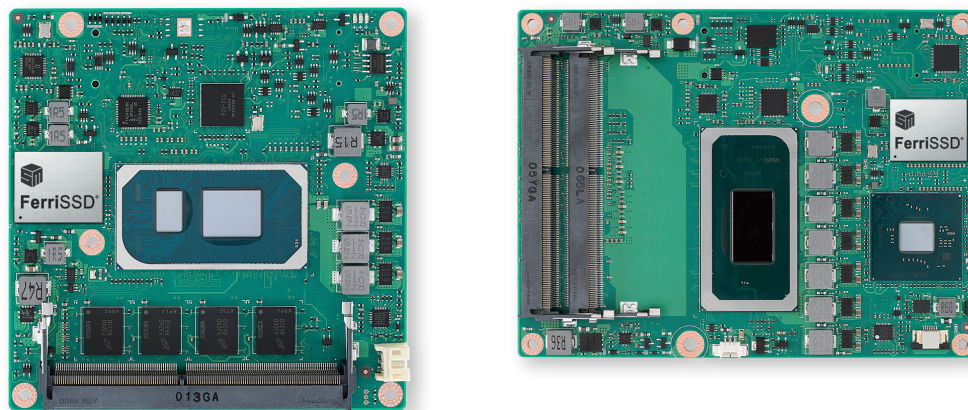
At the same time, the cost-per-gigabyte of NAND Flash storage has fallen in recent years, making NAND-based storage technologies such as the BGA SSD and eMMC more attractive to COM vendors than they were before. In fact, BGA SSD and eMMC storage devices are already in use in various types of embedded computer format, including COM Express Basic, COM Express Compact, COM Express Mini, Qseven (Q7) and ETX. Rising demand for the latest computing technology to run high-level industrial edge-computing algorithms has also spurred the increased production of COM-HPC products, which can take advantage of high-performance SSD technology.

Sustained increase in demand for onboard BGA SSDs

Right up to the present time, then, demand for onboard BGA SSDs in COM systems has been increasing for various reasons.

The first is that COM vendors are turning their focus to costs, and the return on their investments in technology. When SSD technology first reached the market, the cost of SSD devices was relatively high – the price of NAND Flash storage was as much as US$40 per gigabyte. In addition, this price was volatile because of swings in the price of NAND Flash. This made vendors unwilling to embed an SSD as the standard storage option for the module board.

Over time, the cost of NAND Flash fell to much less than US$1 per gigabyte. This made the cost of, for instance, an 8GB SLCmode or a 32GB SSD affordable, encouraging vendors to embed a BGA SSD in a COM board.

The other reason for the growth in demand for SSDs in the COM market is customer demand. In industrial-grade applications, for instance, robust hardware and data protection are essential requirements. SD cards or CF cards are easily removable, which makes the personal data on them vulnerable to theft.

Equipment which operates in military or industrial applications must also satisfy strict requirements for tolerance of high temperatures, shock and vibration and other environmental phenomena. The computer host and every component inside the equipment need to be rated for operation over a wide temperature range, typically from -40°C to 85°C. This applies equally, of course, to storage devices, but SD and CF cards rarely support a wide operating temperature range.

In addition, when the connector to an SD or CF card is used in harsh conditions for a long period of time, its performance can be impaired, resulting in reduced data-transfer performance, or even

complete failure. Products for industrial-grade applications also need to be able to handle shocks. Embedded products which use a BGA SSD perform much better when exposed to shock and vibration than an SD or CF card.

Another factor in the embedded computing market is that industrial PC (IPC) vendors face enormous competitive pressure which risks suppressing their revenue from their COM product lines. To raise or maintain profit, IPC manufacturers devote great effort to the integration of products which add value, in part by embedding on the COM board components which might previously have been external, plug-in devices. Storage is one of the most vital onboard elements of an embedded computing system: IPC vendors are always looking for opportunities to add value to their products' storage provision.

For instance, vendors today are selecting BGA SSD products which offer advanced safety and stability design features which protect the user's core operating system and data. This ensures the data cannot easily be corrupted or deleted – a capability which gives the COM product a valuable new selling point, and the vendor an important competitive edge.

Specialized data protection technologies in FerriSSD products

This requirement to maintain the integrity of stored data is true of many implementations of the COM format, in applications such as industrial manufacturing systems, smart medical imaging platforms, digital display boards, entertainment and broadcasting, and military equipment. This calls for the use of secure data storage systems which will prevent the risk of unpredictable errors or data loss.

The need for data protection, security and reliability may be met by taking advantage of the FerriSSD's set of dedicated features and technologies:

End-to-End Data Path Protection

FerriSSDs incorporate full data error detection with recovery engines to provide enhanced data integrity throughout the entire Host-to-NAND-to-Host data path. The FerriSSD data recovery algorithm can effectively detect any error in the SSD data path, including hardware (i.e. ASIC) errors, firmware errors, and memory errors arising in SRAM, DRAM or NAND(see Figure 1).
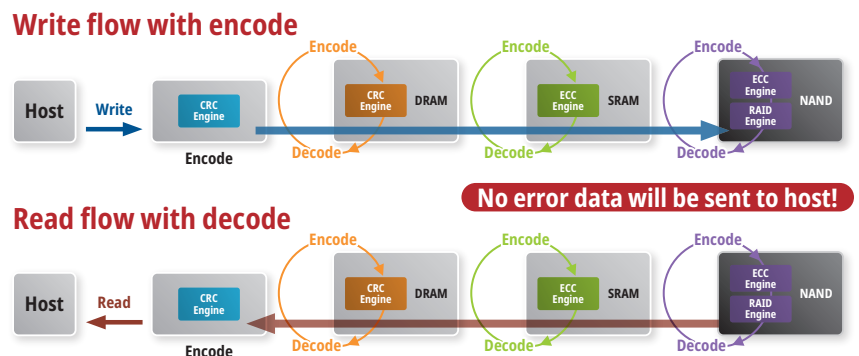

Figure 1: End-to-end data path protection ensures the data transportation points inside the SSD are completely free of errors

Why is it that, when there is an error within the data, FerriSSD's data recovery algorithm is immediately able to detect it? The main reason is that once the data is written, a parity set is produced. When this batch of data is to be read, FerriSSD will, once again, calculate its parity. If the former parity does not match with the latter, it will pass an error flag to the host for appropriate recovery processing. By comparison, conventional SSDs pass faulty data to the host without an error flag, exacerbating the initial problem by failing to alert the host to the need for error recovery processing.

Active Protection: 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 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 (see Figure 2).
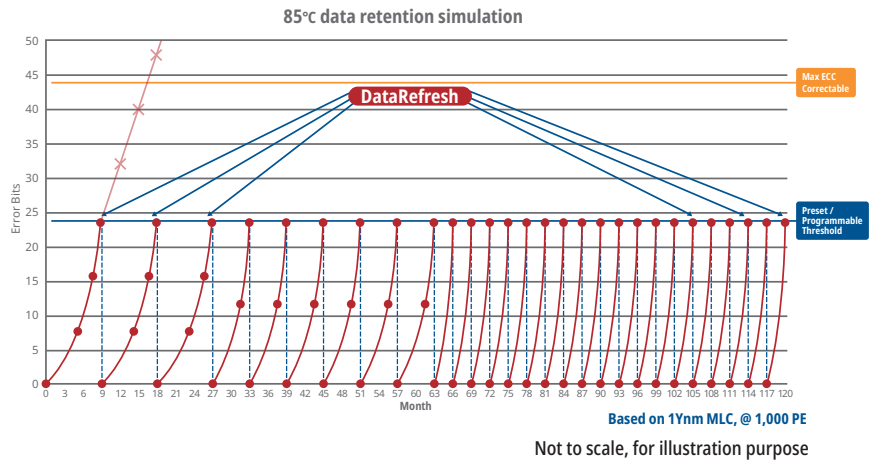

Figure 2: IntelligentScan & DataRefresh functions can detect high-risk factors before the data is lost

Passive Protection: Using NANDXtend® Parity to Correct 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 (see Figure 3).
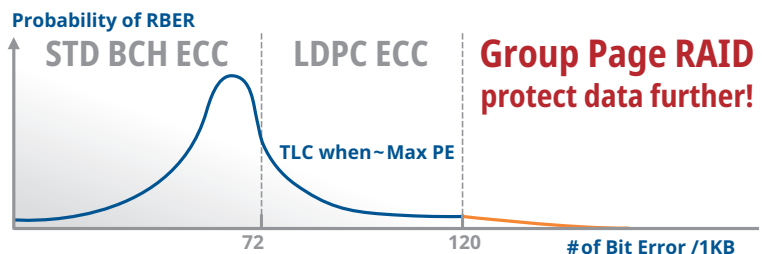

Figure 3: Silicon Motion's patented NANDXtend is able to add to the reliability of SSD products

User Data Protection

Silicon Motion is deeply invested in strengthening data security to counter the risk of hacking. It does not only apply its own methods or follow public data protection regulations in the market (such as Full Disk Encryption/ TCG Opal 2.0) as its operational benchmark. Clients with a higher need for sensitive data protection often worry that public data protection regulations are easily hackable. They prefer to create their own security protection
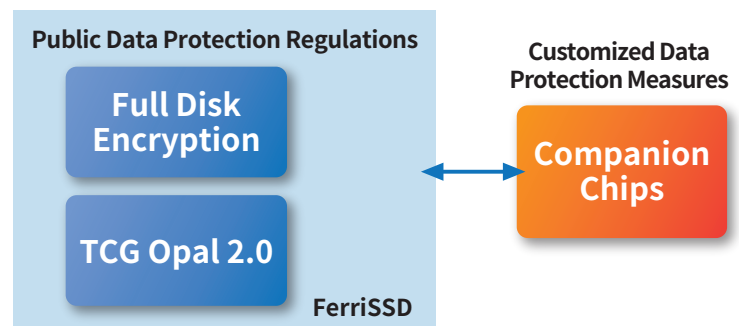

Figure 4: Customized companion chips are added to enhance the safety of sensitive data

measures, such as the addition of a personalized auxiliary chip (see Figure 4). This controls the flow of communication and cooperation with FerriSSD, authorizing the storage device to accept, receive, or send data while maintaining complete security.

Robust Firmware Protection with Secure Digital Signature

FerriSSD supports secure digital signature verification systems. This function is identical to the addition of Silicon Motion's security passphrases for client equipment. When the firmware is being updated, it allows for involved parties to go through a password verification process using FerriSSD's algorithm to produce a set of verification codes which are inaccessible to hackers (see Figure 5). If hackers create a malicious program to force a firmware update in the end product, it is unable to produce the verification code and the malicious update attempt fails.

Figure 5: FerriSSD maintains boot security via secured digital signature

100% Assessment to Ensure Low dPPM

COM manufacturers require a wide operating temperature range of -40°C to 85°C. Before FerriSSD products ship from the warehouse, a strict temperature test takes place as specified by clients (see Figure 6). This results in very low dPPM rates, in line with client requirements for very high reliability.

In summary, the lowering of NAND costs, the rise in demand for data stability and data protection, along with COM vendors' increasing desire to integrate high-value products in to the COM board, mean that the BGA SSD has become a favorite product in today's COM market. This is especially true of SSD products which include data protection and storage reliability features.

Figure 6: To reach the lowest dPPM, FerriSSD products are subject to a strict temperature test

The inclusion of end-to-end data path protection and active/passive protection for users' data and of firmware offers great benefits in embedded computing systems.

Silicon Motion's FerriSSD has now established itself as the ideal storage component for embedded computing modules through its implementation of comprehensive temperature testing and the resultant low dPPM rates. FerriSSD storage is now the preferred choice for COM products for military, transportation, medical, entertainment, networking, industrial automation, and many other applications.
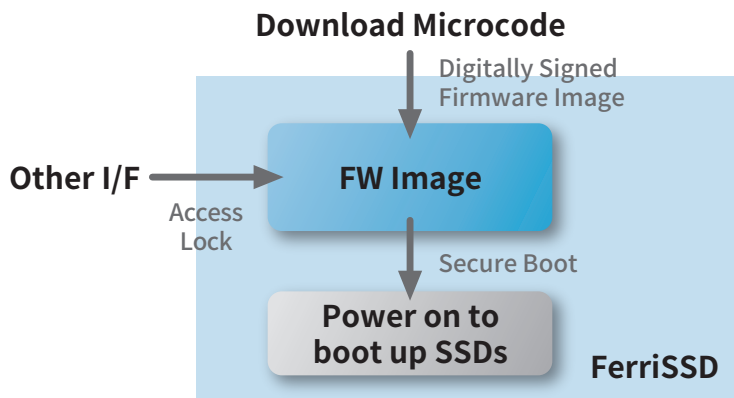
For more information about Ferri Family, please go to
www.siliconmotion.com or send email to **ferri@siliconmotion.com**

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