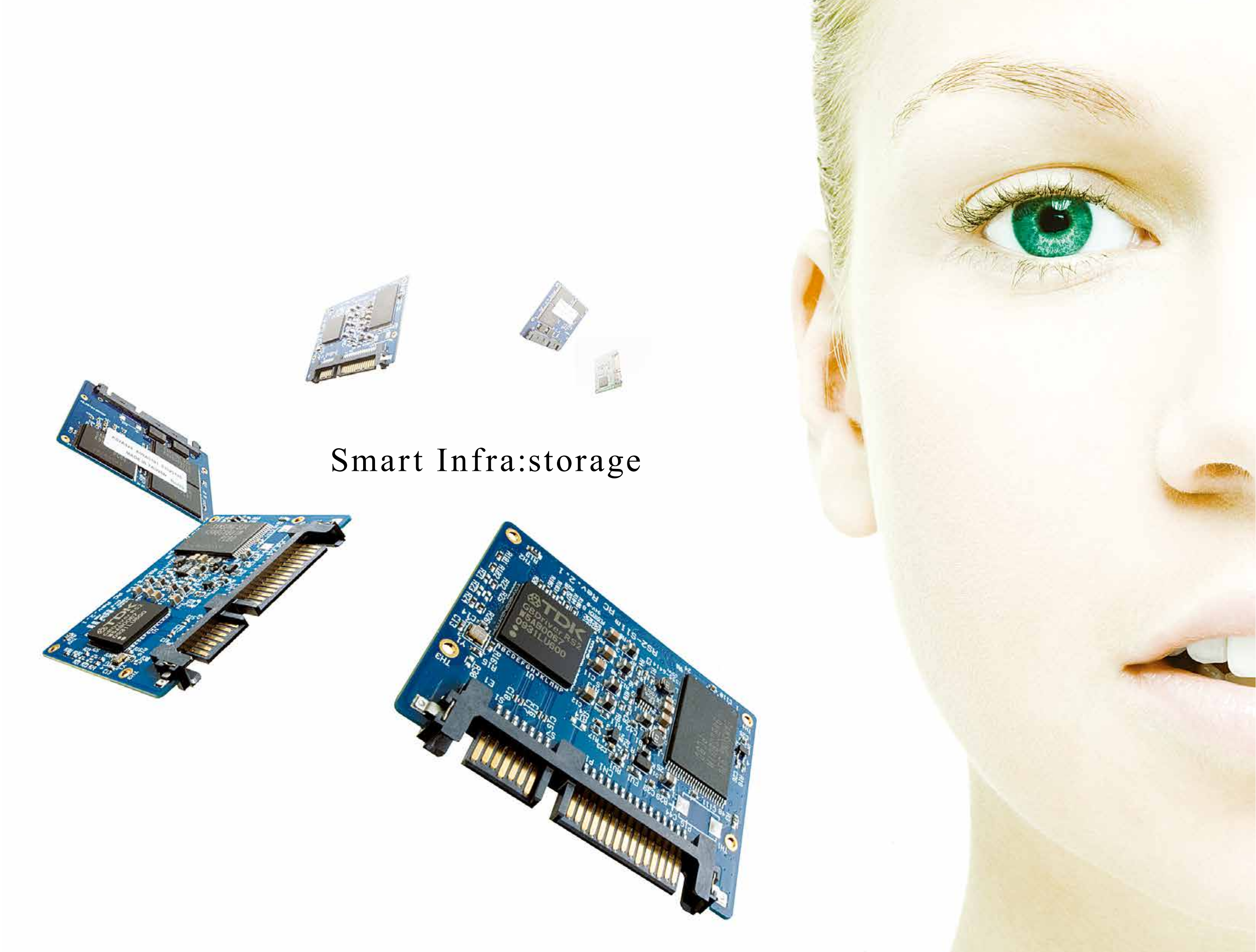
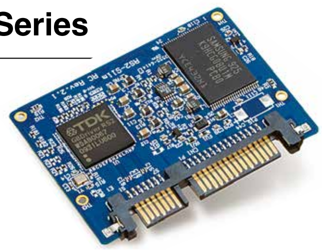


TECH JOURNAL

Half Slim SSD With Serial ATA 3 Gbps SHG2A Series

SHG2A series



SMART Storage Solution for Industrial Application

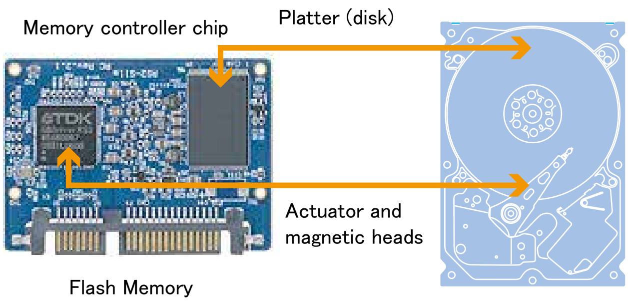
More and more notebook computers nowadays are using SSD (Solid State Drives) instead of HDD (Hard Disk Drives) for storage. This trend has in fact started with industrial equipment, where it has progressed even further. SSDs are storage devices that make use of flash memory. Unlike HDDs, there are no mechanical or moving parts, which makes SSDs ideal for machine tools and other equipment subject to high levels of vibrations and shocks. However, the design of memory management and control in SSDs requires a high degree of technical sophistication. Because the number of times flash memory can be programmed (erased) has a limit, the performance of the memory controller chip has a significant bearing on SSD endurance and performance. The GBDriver (GreenByte Driver) series of memory controllers from TDK have been evolving through 10 years track records in the industrial equipment sector where high reliability is required. TDK SSDs using advanced GBDriver are increasingly found not only in industrial equipment but also in a wide range of other Green IT infrastructure applications including Smart Grid and Cloud Computing.

Cheaper Flash Memory Prompts Drastic Expansion of SSD Market

An SSD is a device that combines flash memory chips, a memory controller, and peripheral circuitry on a printed circuit board. Some modular type SSDs are designed to be directly embedment, while others come in a package with the same form factor as a hard disk drive. They also use the same interface as a HDD and therefore make replacement quick and simple.

When correlating the functional parts of SSD and HDD devices, one could say that the flash memory which stores data in the SSD corresponds to the platter (disk) in the HDD, while the SSD memory controller chip that controls the read and write process corresponds to the actuator that positions the magnetic heads of the HDD. Because the SSD has no mechanical parts, it can handle considerable levels of vibrations and shock. Other advantages over hard disk drives include small dimensions, light weight, fast startup, and low power consumption. Previously, a major drawback was the higher cost of semiconductor-based storage. However, since about 2006, the price of flash memory has continued to drop, and the market for SSDs has in turn expanded considerably. This has now made SSD a viable proposition also for use in notebook computers. Besides SSDs, flash memory is also used in USB sticks which are highly popular as removable storage, and in CompactFlash™ and other memory cards found in digital cameras and similar products. The following section gives an overview of how flash memory works and what its special features are.

Comparison of SSD and HDD

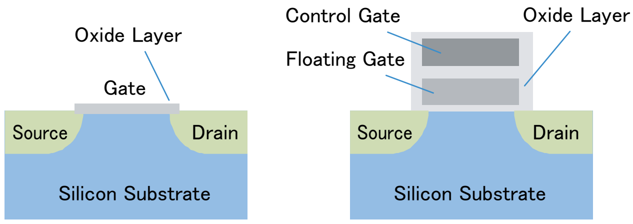


How Does Flash Memory Store Data?

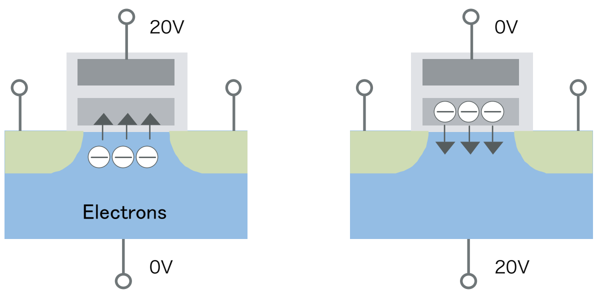
The development of flash memory is based on the same MOS-FET technology that is widely used for IC and LSI chips. A MOS-FET is a special kind of field effect transistor (FET). On a silicon substrate comprising P-type and N-type semiconductor areas, a thin oxide layer (silicon dioxide dielectric layer) is formed, and metal electrodes called source, drain, and gate are created. This is indicated by the MOS acronym which stands for "Metal, Oxide, Semiconductor." The current flowing between the source and the drain is controlled by the gate voltage, similar to a sluice gate controlling a flow of water.

Flash memory uses a dual gate construction, with a floating gate positioned between the MOS-FET gate and the insulating layer. Because the floating gate is normally completely covered by the oxide layer, it acts as an insulator. But when a voltage is applied to the upper control gate, a so-called tunnel current (by a process known as Fowler-Nordheim Tunneling) flows through the insulating layer, causing an electric charge to accumulate at the floating gate. This is the write operation of the flash memory. The reverse process, namely applying a voltage to the silicon substrate and thereby releasing the accumulated charge at the floating gate, is the erase operation of the flash memory.

MOS-FET and flash memory construction



《MOS-FET》 《Flash Memory》



《Write operation》
A voltage applied to the control gate causes a tunnel current to flow through the oxide layer, thereby injecting electrons into the floating gate.

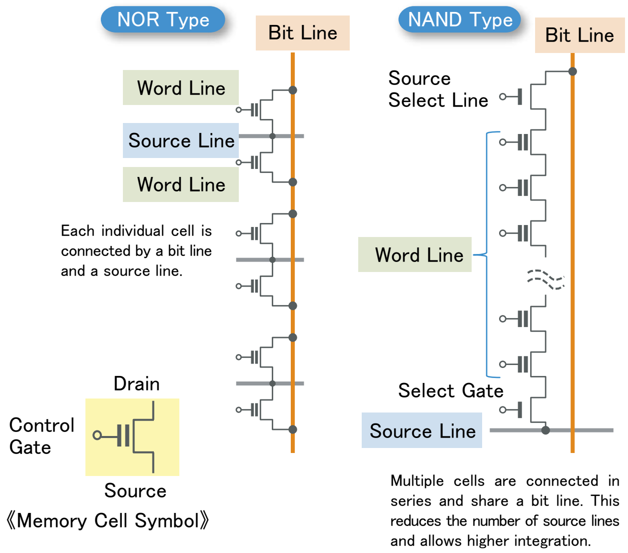
《Erase operation》
A voltage applied to the silicon substrate releases the electrons accumulated at the floating gate.

NAND Type More Suited to High Integration Than NOR Type

A flash memory chip comprises a very large number of MOS-FET memory cells with floating gates, arranged in a tessellated pattern on a silicon wafer. The cells are linked by so-called word lines, bit lines, and source lines. There are two types of flash memory, namely the NOR type and NAND type, which employ the same basic cell structure but differ in the way these lines are connected. In a NOR type chip, the source line and bit line are connected individually to each cell, which makes it possible to perform write operations in 1-bit units.

By contrast, in a NAND type chip, multiple cells are connected in series between the source line and bit line. The width of each connecting line is only on the order of several tens of nanometers, but since the cells themselves are extremely small, the lines require a comparatively large amount of space in a NOR type chip where each cell has its own source line connection. A NAND type chip on the other hand allows higher integration because a source line is shared by multiple cells.

Cell construction in NOR type and NAND type flash memory (partial view)



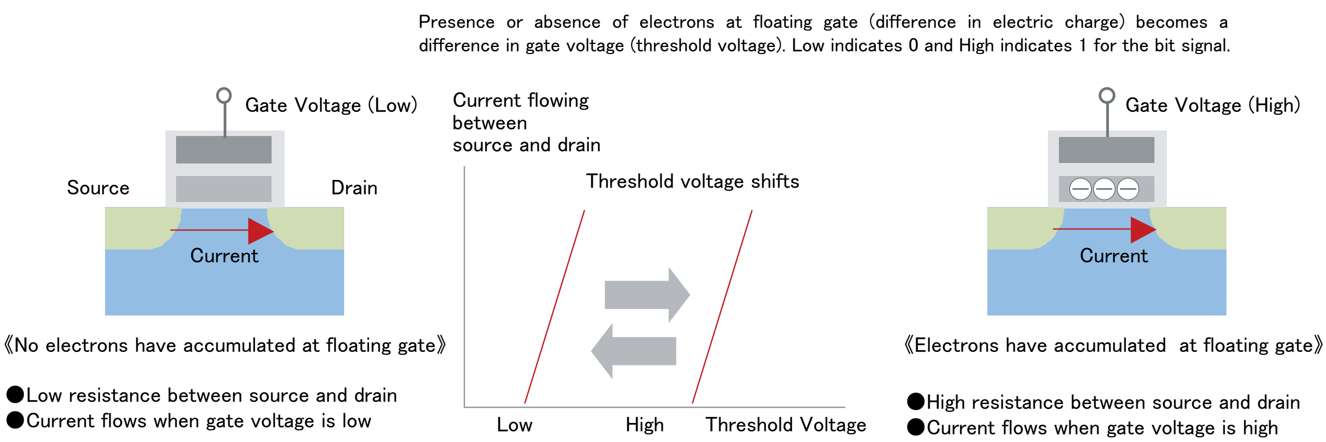
How Data Are Read From a NAND Type Flash Memory Cell

The quantity of the electric charge accumulated at the floating gate is used to determine whether data has been written to a cell. The detection is performed by applying a voltage to the linking lines of the cell.

If no charge has accumulated at the floating gate, the resistance between source and drain is low, causing a current to flow between the source and drain already when a low voltage is applied to the control gate. Conversely, if a charge has accumulated at the floating gate, the resistance between source and drain is high, so that no current flows between source and drain until the voltage at the control gate reaches a certain higher level. This voltage is called the threshold voltage, and whether it is low or high is used to determine whether the bit signal for the cell is 0 or 1. This is the principle by which a flash memory is read. Because the floating gate is covered by the insulating layer, the accumulated charge, and thereby the data written to the cell, is retained also when the power supply is interrupted. Therefore this kind of memory is called "nonvolatile."

To increase storage capacity, the threshold voltage can be divided into several levels. A cell that stores only 1 bit (2 levels) is called a SLC (Single Level Cell), while a cell that stores 2 bits (4 levels) or more is called a MLC (Multi Level Cell).

Reading data from a NAND flash memory cell

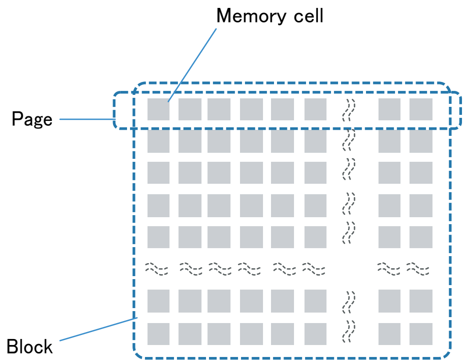


NAND Flash Memory Has an Upper Limit to Number of Program (Erase) Operations

NAND type flash memory is a useful and popular data storage medium, but there is a risky side to it as well. Because a high number of cells share a source line, the writing operation is performed in "page" units that consist of multiple cells. Erasing is performed in "blocks" which are made up of multiple pages. Therefore when a page is to be rewritten, the entire block to which the page belongs first has to be temporarily stored elsewhere, then the block is erased, the target data are rewritten, and finally stored in an empty block. Because the entire block has to be erased even for rewriting a single bit, an error could lead to the loss of the entire data of the block.

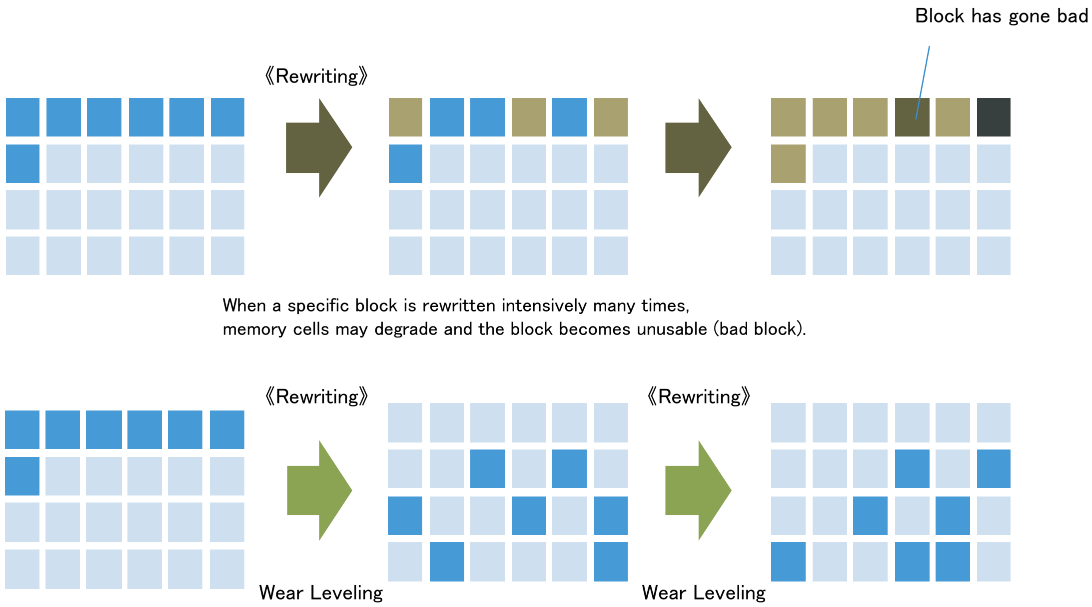
With an HDD, as long as there is no failure of mechanical or circuit parts, data on the platter (disk) can be rewritten for an almost unlimited number of times. With an SSD on the other hand, the number of possible rewrite operations has an upper limit. With single level cells, this limit is about 50,000 times, while it is even lower with multi level cells. The reason for this limitation is due to the fact that the tunnel current that passes the oxide layer of the floating gate gradually degrades the layer. When rewrite operations are carried out intensively on a specific block, the block may become unusable and give errors, which leads to a decrease in storage capacity of the flash memory. The controller chip in the SSD therefore has an important role to play in preventing possible problems.

☐ Flash memory cells, pages, and blocks



The NAND type flash memory performs writing in page units and erasing in block units. Because erasing affects a wide range of data in one quick operation, the memory is called a "flash" memory.

☐ Wear leveling by controller chip (conceptual diagram)

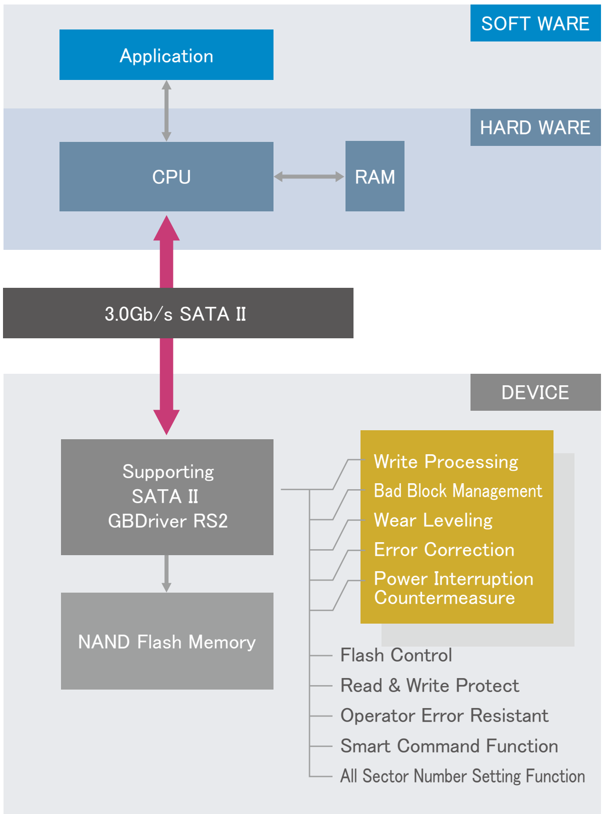


Based on a special algorithm, the controller chip distributes the rewrite operation so that it is not focused on a specific block.

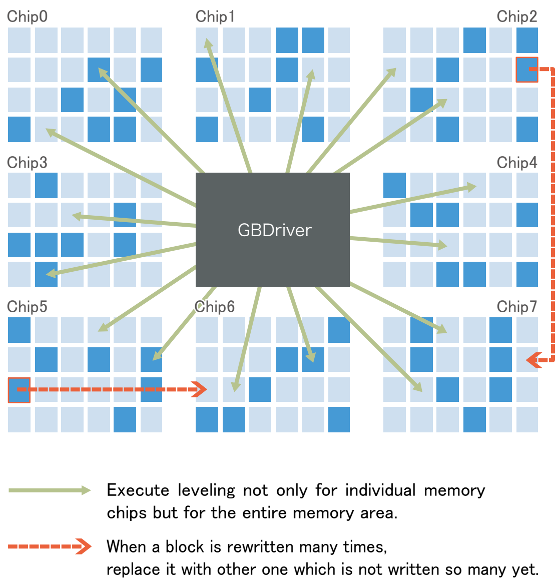
Wear Leveling Using Proprietary TDK Algorithm

The memory controller IC serves to control the data read/write operation between the flash memory cells of the SSD. Because there is a endurance limit to the number of flash memory program (erase) operations, a technique called wear leveling is employed. This involves a diversification of write operations so that they are not concentrated on a specific block. Consequently, the wear on the cells is evened out (leveled). Wear leveling is a basic technology for SSD devices, but its effectiveness depends largely on the algorithm that is used for controlling and spreading the rewrite operations.
A special algorithm developed in-house by TDK enables highly accurate and finely tuned control to achieve superior results. It is incorporated in the renowned "GBDriver" (GreenByte Driver) memory controller chip for NAND type flash memory. The chip also incorporates robustl error correction functions (ECC) and is designed to prevent errors occurring due to power interruptions. The auto recovery function is able to automatically restore data affected by so-called read disturb errors that can occur during repeated data read operations. The end result is superb reliability.
SSD devices are implementing higher storage capacities by incorporating multiple flash memory chips. An important and innovative feature of TDK's GBDriver is the fact that it is able to perform leveling over multiple memory chips (Global Static Wear Leveling, “TDK Smart Swap”). This dramatically improves the program (erase) count of installed flash memory. TDK GBDriver,as well as CompactFlash cards and SSDs incorporating the GBDriver have earned highest praise from the industry, thanks to their highly advanced leveling technology.

System Example With GBDriver



Global Static Wear Leveling Over Entire Memory Area (“TDK Smart Swap”)



TDK Smart Swap Technology of TDK GBDriver not only executes wear leveling for individual memory chips, it also features highly sophisticated leveling for the entire memory area (Global Static Wear Leveling). This results in drastically higher rewrite limits for the installed flash memory.

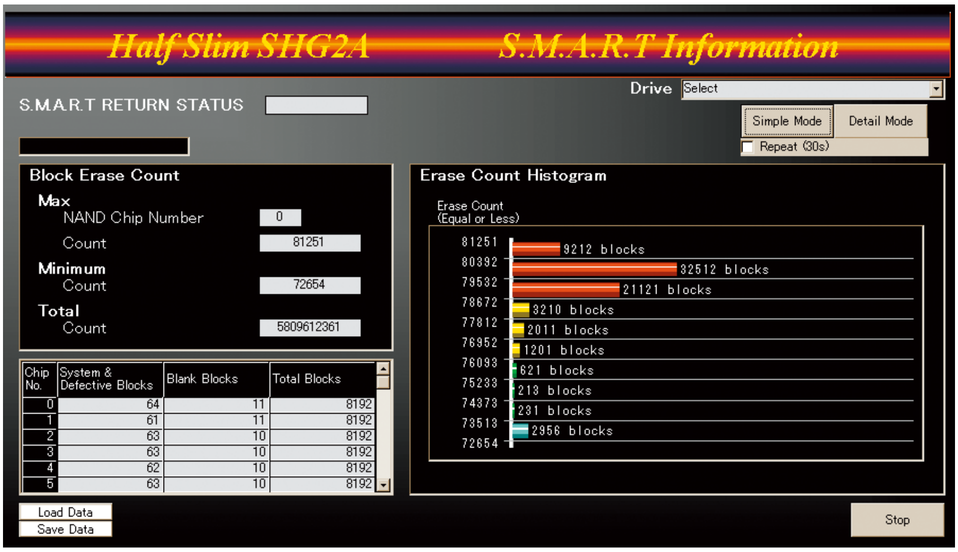
Downloadable SSD Life Monitor Software "TDK SMART"

Since being first introduced to the market in the year 2000, the GBDriver series from TDK has shipped a cumulative total of 55 million units. Along with the growing capacity of flash memory, the TDK GBDriver also has evolved in significant ways. Currently, the main product lines are the SATA compliant RS series and the PATA compliant RA series.

The newly introduced "Half Slim SSD SHG2A Series" is a further miniaturized (one half the size of a 1.8 inch HDD) SATA II compliant, high performance SSD module (max. 32 GB) incorporating the GBDriver RS2.

The SSD SHG2A series also supports the service life diagnosis program SMART (Self-Monitoring & Analysis Reporting Technology). This SSD Life Monitor Software “TDK SMART” monitors the number of program (erase) operations of the flash memory in TDK CompactFlash cards or SSDs and calculates the estimated service life in real time, based on the actual system environment. (The software can be downloaded from the TDK web site.)

☐ SSD Life Monitor Software "TDK SMART"



Monitors number of program (erase) counts of TDK CompactFlash cards or SSDs (SMART ON compatible models) and calculates estimated service life in real time.

Covered Information

1. Program (erase) count for most frequently erased block
2. Program (erase) count for least frequently erased block
3. Program (erase) count for all blocks (10-stage histogram)
4. Total Program (erase) count for all blocks of CF / SSD
5. Number of flash memory chips mounted in CF / SSD and total number of blocks

SSD Solutions Gaining Importance through Increasing IT Infrastructure Applications

The Half Slim type SSD SHG2A series not only are replacing HDDs in many industrial applications, they are also suitable for various other sectors of society. Because SSDs are highly impervious against shocks and vibrations, they are ideal HDD storage replacements in automotive equipment such as car navigation systems and drive recorders, as well as for railway carriage equipment. SSDs are also used in areas where high reliability is paramount, such as medical equipment, testing and analyzing instruments, ATMs, and POS systems.

In terms of security, the incorporation of AES 128 bit encryption is another advantage. Data stored in the flash memory can be reliably protected from unauthorized access. Because the encrypted data are unreadable if retrieved without decryption, unwanted data alterations and security leaks can be prevented, and personal information remains secure. For these reasons, SSDs are increasingly used in financial institutions, for ATM systems, electronic patient records, and similar sensitive applications.

The reduction in flash memory costs means that the price per storage unit for SSDs is now only a few times higher than for HDDs. On the other hand, the storage density of HDDs is increasing drastically. A likely scenario for the near future therefore is diversification. Data centers will store data that are only infrequently rewritten on magnetic tapes and optical discs, data that are frequently rewritten on HDDs, and data for which reliable high-speed access is required on SSDs. This will allow efficient handling of the respective kinds of data.

TDK has always been at the forefront of innovation in storage technology, whether it is magnetic tapes, optical discs, or HDD magnetic heads. With the development of the proprietary GBDriver memory controller chip, the company now is a world leader in SSD technology as well. Smart Grid, Cloud Computing and other developments that will shape the IT infrastructure of society in the future demand storage solutions that will see SSD come into its own. SSD products from TDK incorporating the GBDriver are ideally poised for this challenge, because they offer a perfect balance of high capacity, low power requirements, long service life, and fast access speeds.

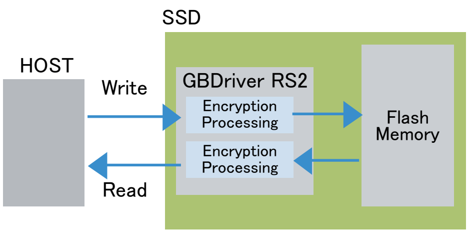
Features and application areas of Half Slim type SSD modules

Long Service Life
Proprietary algorithm developed by TDK implements static wear leveling over entire memory area.

Space Saving Design
One half the size of a 1.8 inch HDD

Resistance Against Shocks and Vibrations
Shock resistance 1500 G (non-operating)
Vibration resistance 15 G (operating)

Encryption Function
AES 128 bit encryption built in



Data are stored in memory in encrypted form. If data are retrieved without proper decryption, they will be unreadable, thereby preventing unauthorized alteration or information leaks.

【[Factory Automation / Measuring Applications】
NC tools, semiconductor manufacturing equipment, sequencers and PLC, FA panel computers, etc.

【Automotive and Rail Transport Applications】
Car navigation systems, drive recorders, digital tachographs, railway carriage equipment, automated turnstile systems, etc.

【Disaster Prevention / Security】
Crime prevention and disaster prevention equipment, monitoring camera systems, digital signage, security authentication systems, etc.

【Medical Equipment】
Diagnostic imaging equipment, medical computers, electronic patient records, analysis and measurement devices, etc.

【Distribution】
POS terminals, kiosk terminals, RFID systems, etc.

【Office Automation】
Multi-function printers (MFP), electronic whiteboards, business projectors, etc.

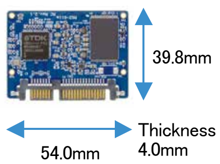
【IT】
Thin client computers, green IT equipment, embedded CPU boards, data servers, etc.

【Communications / Broadcasting】
Next-generation LTE Super3G mobile phone servers, routers, etc.

【Financial Sector】
Bank ATMs, Internet-based trading systems at securities companies, etc.

【Smart Grid】
Smart meters, power controllers, etc.

【Games and Amusement】
Arcade game machines, etc.



High Reliability
Powerful error correction function (ECC expandable to max. 15 bits per sector), power supply protection circuitry built in.
Complete prevention of data corruption errors in case of power supply interruption.

High-Speed Access
Read 95MB/s
Write 40MB/s

Service Life Diagnosis Tool
"TDK SMART" monitors rewrite counts and expected service life in real time.
* Program can be downloaded from TDK web site.

Major Features

1. **Employed TDK SSD Controller GBDriver® RS2. (Designed by us and domestically-manufactured)**
2. **Employed 4KB/page SLC NAND type flash memory. (High-speed, high-durability, and domestically-manufactured.)**
3. **Compatible with Serial ATA Standard Rev.2.6 (Gen 1:1.5Gbps/Gen 2: 3.0Gbps).**
4. **Equipped with 15bit/512Byte ECC (BCH).**
5. **Reinforced power fail tolerance. (Equipped with rewinding function)**
6. **Equipped with power backup circuit.**
7. **Equipped with TDK global Static Wear leveling function. (TDK SMART SWAP)**
8. **Equipped with AES 128bit (Advanced Encryption Standard) encryption function (CBC mode)**
9. **SSD life monitor software (TDK SMART) is included.**
10. **Optional functions**
11. **Solution support**

Specifications

Series		Serial ATA 3Gbps Half slim SSD RS2 series
Model		SHG2A series
Data capacity		1GB/2GB/4GB/8GB/16GB/32GB
Form factor		Half Slim Type SSD
Memory type		SLC(single level cell) NAND type flash memory (4KByte/Page)
Controller		TDK GBDriver RS2
Interface		Serial ATA Revision 2.6
Transfer mode		SATA Gen1: 1.5Gbps, Gen2: 3.0Gbps
Transfer speed*	Read (max.)	95MByte/sec
	Write (max.)	40MByte/sec
Error check and correction (ECC)		15bit/512Byte
Endurance		Effective blocks×50,000 times (e.g. 16GB Half Slim : 3.1 billion times)
Vibration resistance		15G (Operating)
Shock resistance		1,500G (Non operating)
Ambient operating temperature		0 to +70°C [–40 to +85°C Industrial Option]
Ambient storage temperature		–25 to +85°C [–40 to +85°C Industrial Option]
Operating/storage humidity		0 to 90(%)RH [Non condensation]
Power supply voltage		5V±10%
Conformed standards		CE/FCC/VCCI
Environmental specifications		RoHS compliant

* In 4ch Interleaved mode, measured by CrystalDiskMark 3.0.
The speed may vary depending on the actual use environment/conditions.

2015.08.07