



# Advanced Storage Technology



## **SILICONDRIVE™ WHITE PAPER** **SISMA™ TECHNOLOGY**

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## INTRODUCTION

SiliconDrive™ solid-state storage technology is specifically designed to meet the high performance, high reliability and multi-year product lifecycle requirements of Enterprise System OEMs in the netcom, military, industrial, interactive kiosk and medical markets. SiliconSystems key focus is on decreasing the total cost of storage ownership over the entire system deployment by creating technologies to minimize unscheduled downtime, maximize security for the OEM's software IP and to provide real-time feedback to enable the host system to manage its storage more effectively.

Applications requiring advanced levels of reliability and availability can employ SiliconSystems patent-pending SiSMART™ technology, which allows the host system to poll the SiliconDrive and receive real-time feedback as to the current usage. This allows the host to calculate projected remaining usable life and model the data transactions to ensure that the drive lasts throughout the scheduled deployment.

## BACKGROUND

### **SMART for Hard Drives**

The SMART (**S**elf-**M**onitoring **A**nalysis and **R**eporting **T**echnology) function was introduced in the ANSI standard group's release of the ATA-3 specification. The SMART technology is designed to act as an early warning system for pending problems with mechanical media such as hard disk drives (HDD). The integrated controller on the HDD works in conjunction with various sensors to monitor the HDD's performance and determines whether or not this performance is normal. The host system software can then poll the HDD using the SMART command and generate a flag to alert the user to a potential problem.

The theory behind this command is that HDD failures do not usually occur suddenly. Most failures result from issues that generally occur over time, such as the mechanics of the HDD spindle wearing out. The SMART feature was designed to monitor such issues, thereby limiting data loss and unscheduled system downtime.

### **Solid-State Drives**

SiliconDrives are solid-state storage solutions and as such don't have moving parts. Therefore, many of the parameters monitored by the SMART function for HDDs are not applicable. While solid-state drives do not mechanically wear out and are therefore preferred in environmentally robust and high duty cycle applications, there is still a concern about wearing them out by exceeding the endurance specification.

In much the same way a rechargeable battery loses its charge after several cycles, non-volatile solid-state storage components can lose their ability to retain data after tens of thousands of write/erase cycles. This is usually specified by component vendors as endurance. When a block loses its ability to retain data, or when data errors occur that cannot be corrected by the drive's ECC algorithm, the block is swapped with one from an available spare pool. When the spare blocks are exhausted and another error occurs, the solid-state drive will reach critical failure and will need to be replaced.

### **Eliminating Unscheduled Downtime**

There are two ways to eliminate unscheduled downtime: develop technologies to prevent the failures and increase drive endurance, or provide monitoring technology to warn the host system of impending issues. SiliconSystems has engineered technologies that accomplish both:

- PowerArmor™ eliminates drive corruption due to power disturbances  
(See **TB140C – SiliconSystems Patented PowerArmor Technology**)
- Solid-state storage management algorithms such as 6-Bit ECC and wear leveling over the entire SiliconDrive maximize the drive life and extend the write/erase endurance to well over 2M cycles per block.  
(See **WP401C – SiliconDrive Endurance**)

### **SiSMART**

SiSMART technology performs just as critical a function by acting as an early warning system for the host and by providing status on the percentage of drive usage relative to the endurance specification. The host can then set its threshold and can schedule preventative maintenance before the system goes down unexpectedly.

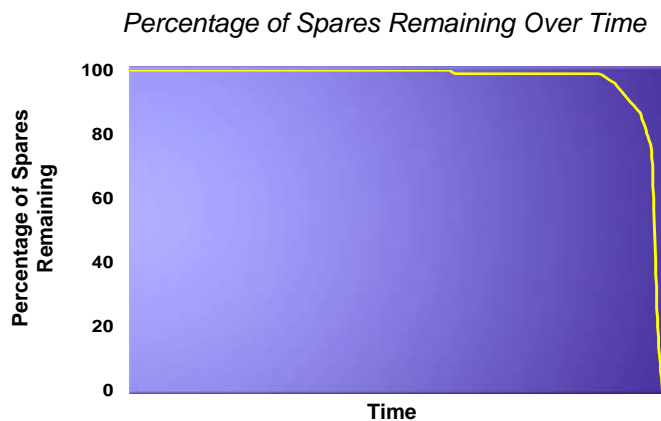
SiliconSystems designed the SiSMART feature to monitor the write/erase cycles of each block and the usage of spare blocks in SiliconDrive products. Monitoring both is essential in solid-state drives that use wear leveling to extend the life and endurance specification of the drive.

### **Monitoring Spares Only**

There is a significant consideration when only using spares to determine remaining usable life in a solid-state drive that does wear leveling. In order to understand this, a basic understanding of wear leveling is required.

Wear leveling is defined as the ability of the solid-state drive to map logical block addresses to different physical blocks. If done properly, wear leveling will evenly wear all of the blocks in the solid-state drive and all of the blocks should wear out at roughly the same time.

If a block wears out, it is replaced by a spare. Once the spares run out, the drive will cease to operate. Therefore, if all blocks wear out at roughly the same time, all of the spare blocks will be used up at roughly the same time. Figure 1 illustrates this concept. The solid-state drive has 100 percent of its spares available for most of the product life. Once spares start getting used, they get used up very quickly.



*Figure 1*

SiSMART can provide the remaining number of spares to the host system at any time. The host can then set its threshold and can take preventative action based on its own established set of criteria.

### **Monitoring Data Transactions for Each Block**

Most system designers require a better feedback methodology that yields meaningful data at any time during system operation. It is useful to understand when the application has reached the 10%, 20%, 50%, etc. point so the host system can more accurately flag any issues well in advance of when they are likely to occur (see Figure 2).

SiSMART goes well beyond only monitoring spares. In order to yield meaningful information at any point in time, SiSMART tracks and tabulates write/erase transactions for each block in the SiliconDrive. Based on this information and whenever requested by the host, SiSMART can calculate the percentage of drive life remaining. If the used percentage goes beyond a certain comfort zone, the drive can be replaced during the next scheduled maintenance period. Eliminating unscheduled maintenance calls can save Enterprise System OEMs tens to hundreds of thousands of dollars per year.

Percentage of SiliconDrive Used Over Time

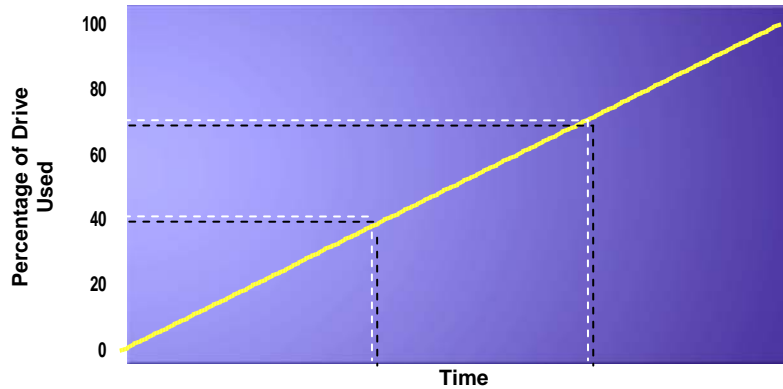


Figure 2

## Modeling System Usage

Another benefit of the feedback provided by SiSMART is the ability to perform storage usage modeling. It is very difficult for system designers to fully understand all data transactions between the host and the drive – especially if operating and file systems are used. SiSMART eliminates this uncertainty.

### **Example:**

*An OEM that manufactures enterprise edge routers uses SiSMART to model the data storage requirements of its system. The router is constantly logging data and write/erase endurance is a significant issue.*

*In order to properly size the SiliconDrive, the company had to review the data collection requirements. First, they needed to determine which parameters to monitor and how often to log those parameters. Next, they had to determine how long they wanted to deploy this product in the field - in this case five years.*

*The company had used flash cards in the past. Those flash cards had no feedback mechanism and the company felt it would need to double the size of the card to give them the required comfort level for meeting the five year deployment target. With SiSMART technology, the company deployed the capacity originally defined, resulting in an immediate cost savings.*

*The company tested the SiliconDrive in the field for six months. They brought the system back to their test lab and ran the SiSMART utility to determine drive usage. It turned out that the drive was less than 5% utilized, so the company not only felt comfortable with its current application, it found a new data reporting requirement and collected even more data – potentially giving them a competitive advantage in their market. They could upgrade their system and still feel confident in meeting the five year target.*

## SiSMART Utility

The SiSMART function stores and tabulates the following parameters for retrieval by the SiSMART utility:

Parameter	Description	Values
<b>SiSTAT</b>	Returns the write/erase statistics of each block	Integers
<b>SiWEAR</b>	Yields the percentage of wear over the entire SiliconDrive.	Decimal value representing a percentage. 1.02 = 1.02% of the drive used.
<b>SiSPARE</b>	Yields the number of spare sectors used and number of spares remaining	Integers

The SiSMART utility can run on Windows XP, Linux or DOS host systems. Other operating system support will be available in the second half of 2006. This executable utility can also be integrated into applications directly. Finally, software libraries and source code will be available under NDA to those customers who want to tailor this function to their unique requirements.

## SUMMARY

Traditional solid-state drives and flash cards did not incorporate any type of feedback mechanism and consequently were allowed to operate until they exceed the endurance specification and failed.

The ability to monitor write/erase endurance is analogous to monitoring fuel in an automobile. Having no monitoring solution is like driving the car without a fuel gauge. The system operates until it “runs out of gas.” Monitoring spares only is like having a light that comes on just before running out of gas. There may or may not be enough time “to get to a gas station” before the system fails. SiSMART monitoring technology is like having a complete fuel gauge. Preventative maintenance (“filling up”) well in advance of a failure ensures the system will operate properly and will not experience any unscheduled downtime.

## Related Document

*SiSMART User Guide*