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Technical White Paper

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Industrial Storage Modules- SQFlash Fragment Writing Technology

Advanced Block Management to Enhance Endurance and Performance of Flash Drive

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Advantech SQFlash

Flash memory is a non-volatile storage memory that can be digitally programmed/re-programmed and erased. As technology continuously advances, the demands for greater density and better flash memory performance increase as well. These days, flash memory is no longer a component that resides only in your computer – It also performs as a media and photo album, or a filing cabinet that stores all your personal or business data.

SQFlash are Advantech's industrial storage modules designed for embedded users with higher compatibility, performance, and reliability in mind, also with 3 years longevity and fixed specification support that is most asked for by embedded customers. SQFlash comes in various interfaces including CompactFlash & CFast, 2.5" PATA & SATA SSD, PATA DOM, SATA DOM and USB DOM. And for security, features have been implemented at firmware and application levels in order to decrease customers' integration effort, and increase the reliability of our Flash modules.

Fragment Writing Technology

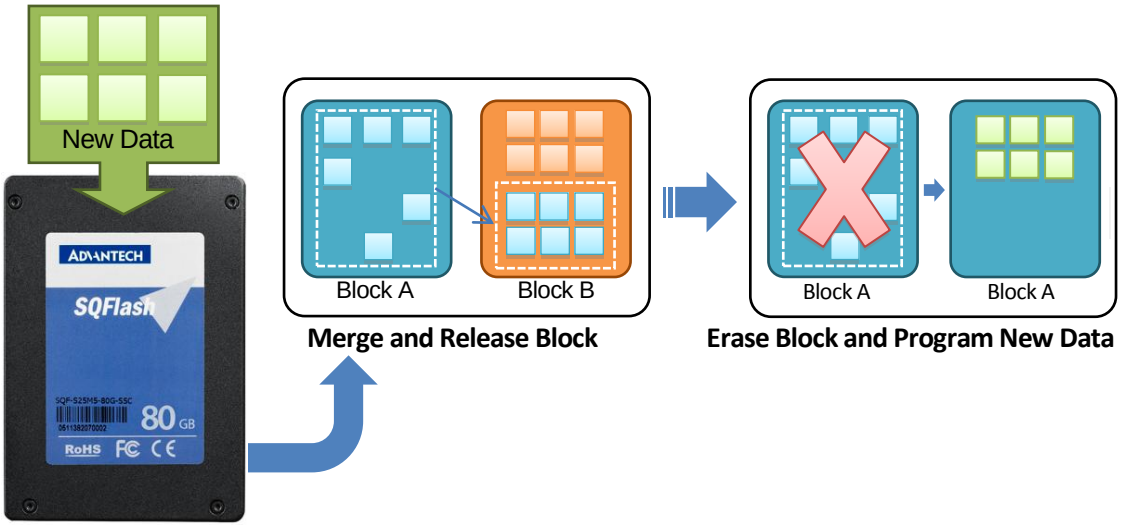
Advanced Block Management to Enhance Endurance and Performance of Flash Drive

A "block" is a basic process unit in any flash IC; every program or erase command in a flash drive is normally executed at the block level. The most essential task for a NAND flash controller, called "block management", is to rearrange user data into proper blocks and generate a block address table to convert low-level block information into readable data for the OS level. Therefore, the endurance and performance of a NAND flash module relies heavily on the block management approach conducted by the NAND flash controller.
The most common and mature block management mechanism is wear-leveling, which helps to deliver write and erase commands evenly into blocks in flash IC, thus prolonging flash drive life spans. Wear-leveling is widely adopted in NAND flash applications and its algorithm is key knowledge for every NAND flash controller IC designer. This white paper will focus on a new block management algorithm adopted by SQFlash SATA products. This is the latest NAND flash-to-SATA controller which enhances flash drive endurance.

Traditional Block Writing Mechanism

Each block will be erased before it is ready for accept new writing command

As mentioned above, the wear-leveling mechanism allows flash drive blocks to bear read-write cycles equally. The data, however, can be processed only in minimum units of one block; an expected conclusion is that there will be no empty blocks left after a period of use when every block has been programmed, i.e., written, at least once. The following figure shows how a flash drive programs new data.



If the new data input is assigned to fill in Block A while Block A is already occupied with active data, this data must first be merged with another block[1] so Block A can be erased for programming new data. As a result, each time the disk is programmed with new data there must be an extra erase count on at least one block. In the worst case, data programming in the flash drive is completely random, and every block is erased continuously despite most of the disk space being free.

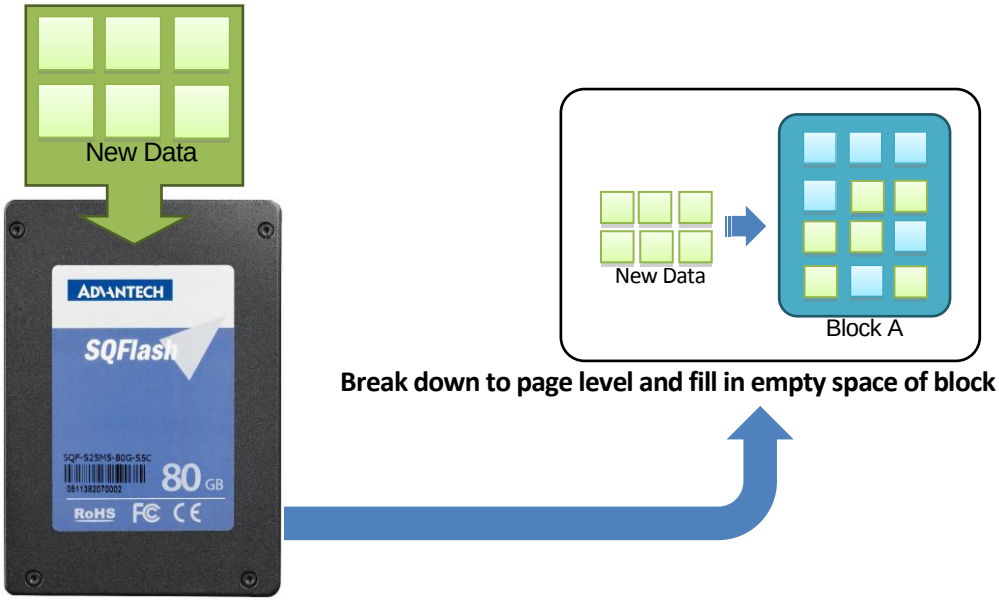
Fragment Writing Technology

Block will only be erased if it is fully occupied

In traditional block management, the minimum unit for both program and erase is the block. Even if the block is only slightly occupied, there's no way to avoid a block erase if new data is to be written to it. The erase command is a factor known to reduce flash IC lifespan. Moreover, it's also a major cause of performance degradation. So the idea of Fragment Writing Technology is to manage blocks more efficiently and reduce the frequency of the erase command.

Fragment Writing Technology is achieved by doing page writing, which is a sub-block level behavior, and the minimum write unit is broken down into pages instead of whole blocks. On the other hand, as long as the block still has empty pages, it can still be programmed with data without erasing data in advance.

[1] The merge process normally leverages spare blocks. Data in both Block A and the original Block B will be duplicated into a spare block and the spare block will be swapped with the original Block B as the new Block B.



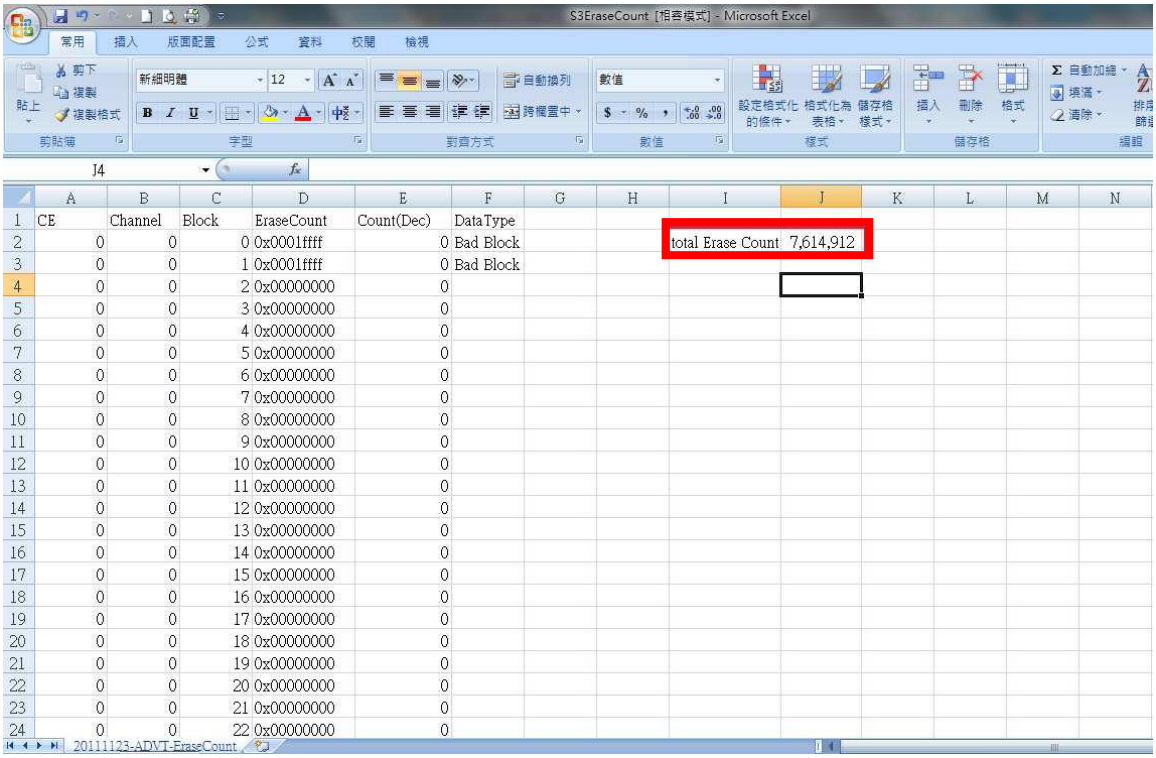
The flow, as shown above, is much simpler than in the traditional mechanism. When new data needs to be programmed, it will be broken down into pages and filled into available pages in a block that might already written with other data, meaning a fully occupied block need not be erased.

ENDURANCE ENHANCEMENT

The following test demonstrates the difference in endurance between SATA flash drives with and without Fragment Writing Technology. Two otherwise equal drives are tested by running 33 to 35 cycles of a data patterns consisting of 173 random read / write[2]. As the results below, with Fragment Writing Technology, the erase count is much lower than that of a flash drive employing only the traditional mechanism.

	Normal Algorithm	Fragment Writing Technology
Erase Cycles Count	7,614,912	1,909,863
Time Consumed	142 minutes 44 seconds	23 minutes 49 seconds

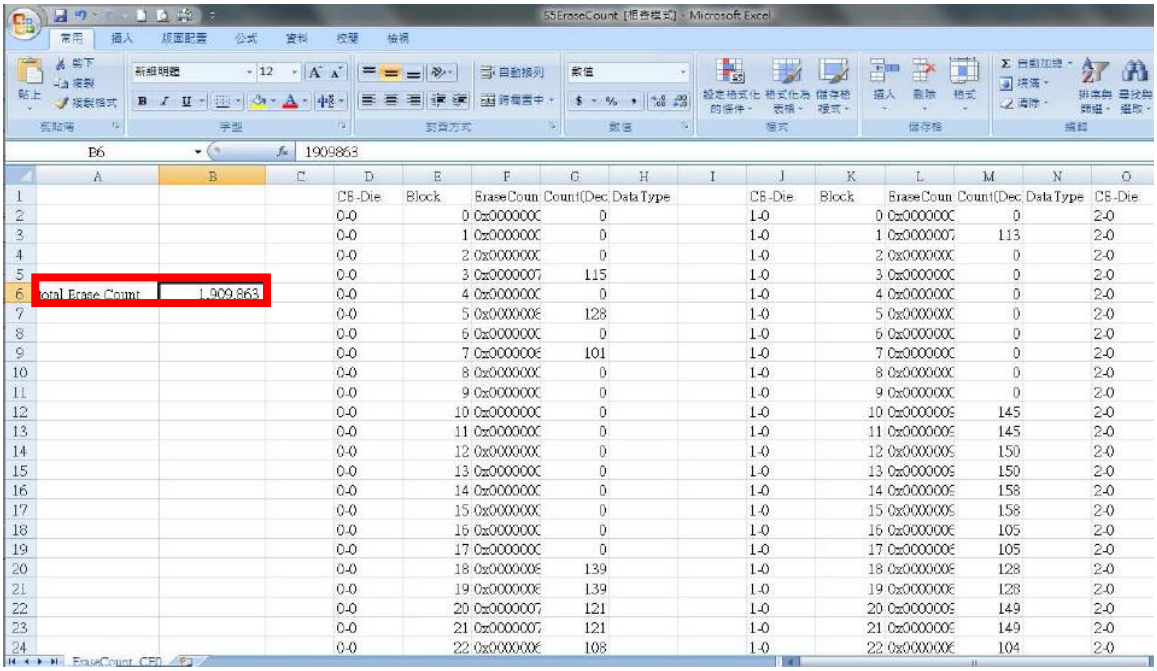
[2] The total size of these 173 files is 13.6GB and is consisting with 4 sizes of random data: 4MB, 5MB, 758MB, and 2.9GB.



CE	Channel	Block	EraseCount	Count(Dec)	DataType
0	0	0	0x0001ffff	0	Bad Block
0	0	1	0x0001ffff	0	Bad Block
0	0	2	0x00000000	0	
0	0	3	0x00000000	0	
0	0	4	0x00000000	0	
0	0	5	0x00000000	0	
0	0	6	0x00000000	0	
0	0	7	0x00000000	0	
0	0	8	0x00000000	0	
0	0	9	0x00000000	0	
0	0	10	0x00000000	0	
0	0	11	0x00000000	0	
0	0	12	0x00000000	0	
0	0	13	0x00000000	0	
0	0	14	0x00000000	0	
0	0	15	0x00000000	0	
0	0	16	0x00000000	0	
0	0	17	0x00000000	0	
0	0	18	0x00000000	0	
0	0	19	0x00000000	0	
0	0	20	0x00000000	0	
0	0	21	0x00000000	0	
0	0	22	0x00000000	0	

total Erase Count 7,614,912

Test result of SSD with normal algorithm



CS-Die	Block	EraseCount	Count(Dec)	DataType	CS-Die	Block	EraseCount	Count(Dec)	DataType	CS-Die
0-0	0	0x000000	0		1-0	0	0x000000	0		2-0
0-0	1	0x000000	0		1-0	1	0x000000	113		2-0
0-0	2	0x000000	0		1-0	2	0x000000	0		2-0
0-0	3	0x000000	115		1-0	3	0x000000	0		2-0
0-0	4	0x000000	0		1-0	4	0x000000	0		2-0
0-0	5	0x000000	128		1-0	5	0x000000	0		2-0
0-0	6	0x000000	0		1-0	6	0x000000	0		2-0
0-0	7	0x000000	101		1-0	7	0x000000	0		2-0
0-0	8	0x000000	0		1-0	8	0x000000	0		2-0
0-0	9	0x000000	0		1-0	9	0x000000	0		2-0
0-0	10	0x000000	0		1-0	10	0x000000	145		2-0
0-0	11	0x000000	0		1-0	11	0x000000	145		2-0
0-0	12	0x000000	0		1-0	12	0x000000	150		2-0
0-0	13	0x000000	0		1-0	13	0x000000	150		2-0
0-0	14	0x000000	0		1-0	14	0x000000	158		2-0
0-0	15	0x000000	0		1-0	15	0x000000	158		2-0
0-0	16	0x000000	0		1-0	16	0x000000	105		2-0
0-0	17	0x000000	0		1-0	17	0x000000	105		2-0
0-0	18	0x000000	139		1-0	18	0x000000	128		2-0
0-0	19	0x000000	139		1-0	19	0x000000	128		2-0
0-0	20	0x000000	121		1-0	20	0x000000	149		2-0
0-0	21	0x000000	121		1-0	21	0x000000	149		2-0
0-0	22	0x000000	108		1-0	22	0x000000	104		2-0

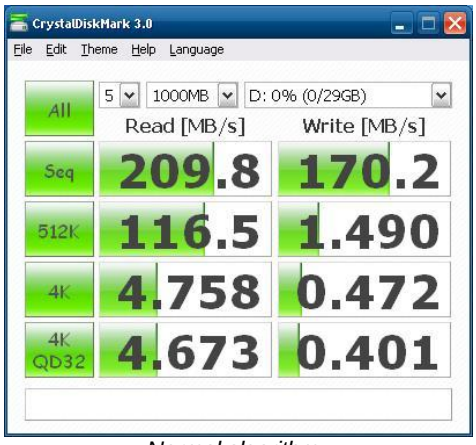
otal Erase Count 1,909,863

Test result of SSD with Fragment Writing Technology

PERFORMANCE ENHANCEMENT

Since the frequency of the erase command is significantly reduced, especially when the flash drive is mostly processing random data. As the test above, the total time consuming is much

lower while applying Fragment Writing Technology. This can also be proved with 512K and 4K random access test result as shown below; the writing performance is dramatically higher with Fragment Writing Technology.



Normal algorithm

Fragment Writing Technology

Performance Test Result

Conclusion

Data patterns tends to be random rather than sequential in the majority of industrial applications, while a flash drive is mostly utilized as an OS drive or for log storage. The benefit of fragment writing is especially evident since performance is boosted and the lifespan of the flash drive can be significantly extended.

SQFlash Offering

Advantech is dedicated to continuously develop the security software which protects intellectual property. Advantech provides SUSI-SQFlash software package is a flash management package that contains utilities and API to access and configure Advantech flash storage. It supports Software Protection (Security ID Read/Write) and Life Monitoring (S.M.A.R.T.) features. A product key protected package provides users with a safe environment which not only protects the application itself but also prevents Security ID being read without the same product key while writing. The S.M.A.R.T. attribute contains Max/Average Program and Erase Cycles, Power On Time, ECC count and Life Endurance utilities. Users can monitor directly via the SUSI-SQFlash utility or implement functions into the application via the SUSI-SQFlash API. A life-span detection mechanism can be designed from the Life Endurance information.

About Advantech SQFlash- An Industrial Storage Modules with Secure Management

Advantech SQFlash is an industrial storage modules, designed for embedded users with high performance, compatibility and reliability. It also develop security software directly combine with storage modules, provide a safety and reliability application environments. Learn more about SQFlash, please visit http://www.advantech.com/embcore/industrialstoragemodules.aspx

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