Industrial Storage Modules- Advantech SQFlash GuaranteedFlush Technology

Reliability Enhancements for DRAM-Cache Structure Flash Drives

Author: Precyan Lee

E-mail: precyan.lee@advatech.com.tw

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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.

GuaranteedFlush Technology

Reliability Enhancements for DRAM-Cache Structure Flash Drives

DRAM (dynamic random-access memory) is a volatile memory with fast access time, frequently used as a temporary cache or buffer between a host controller and backend storage. In today's SSD (solid-state drive) designs, the utilization of DRAM cache (either internal or external) has become a common practice to boost overall SSD performance, especially on small file transfers. Apart from performance benefits, caching can also improve the endurance of SSDs by consolidating multiple small transfers before pushing them to NAND Flash, reducing the amount of block erase during the process. However, there is one major drawback of cache memory—it requires power to maintain the stored information in the DRAM. This raises concerns about data integrity under situations such as unstable power supply or even power failures.

During a proper system shutdown, the operating system would typically issue a STANDBY IMMEDIATE command to signal the SSD to prepare for system shutdown. This command provides enough time for the SSD controller to flush the data in the cache to NAND Flash, thereby preserving the data after the power is shutoff. However, during an abnormal power shutdown, incomplete user data and system metadata in cache may not be able to be transferred to NAND Flash. Thus, it is critical for SSD firmware to implement intelligent protection schemes to preserve data integrity in the event of unexpected power loss. Several new cache mechanism technologies have been implemented in the latest controller for SQFlash SATA Flash drives to better handle power-loss situations. These technologies will be introduced in following sections.

DRAM Cache Mechanism Overview

In the latest SATA SSD technologies, an external DRAM cache is required for better performance and endurance; this is also an essential design allowing SATA Flash drives to work with "*Fragment Writing Technology*" (Article available at www.advantech.com). Within the cache buffer, the amount of cache dedicated to user data is kept at a minimum (< 15% of total cache). The majority of the cache is used for system metadata, which is self-recovering during SSD reboot


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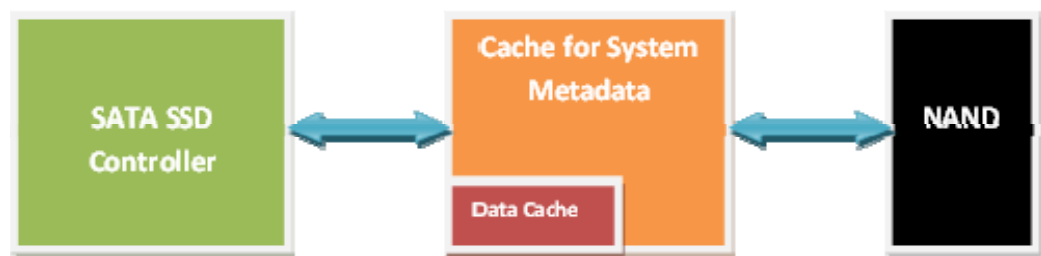
In most cases, the controller will send an acknowledgement (ACK) to the host for WRITE COMPLETE after the data is fully written to DRAM. However, data will not be 100% safe until it is "flushed" into NAND Flash, a non-volatile memory. This is the reason the ATA spec defined the FLUSH CACHE command[1] which is issued by the host following the write command to verify that the data has been fully committed to NAND. The caching technique used in the latest SQFlash SATA controller is called "write-through." In this technique, a write is done both to the cache and to the backend NAND Flash with a minimum of delay, and the controller will only send an ACK to the host when the flush is complete.

Flush Cache Command Workflow and Highlights

This example uses Windows operating system to illustrate how FLUSH CACHE is used to allow the OS to recover from a power-loss. During a file *Copy* task, the operating system breaks down the task into sub-tasks. The following graphic describes the general process flow:

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[1]FLUSH CACHE command is defined in the ATA specification as follows, "*The FLUSH CACHE command requests the device to flush the volatile write cache. If there is data in the volatile write cache, that data shall be written to the non-volatile media. This command shall not indicate completion until the data is flushed to the non-volatile media or an error occurs.*"
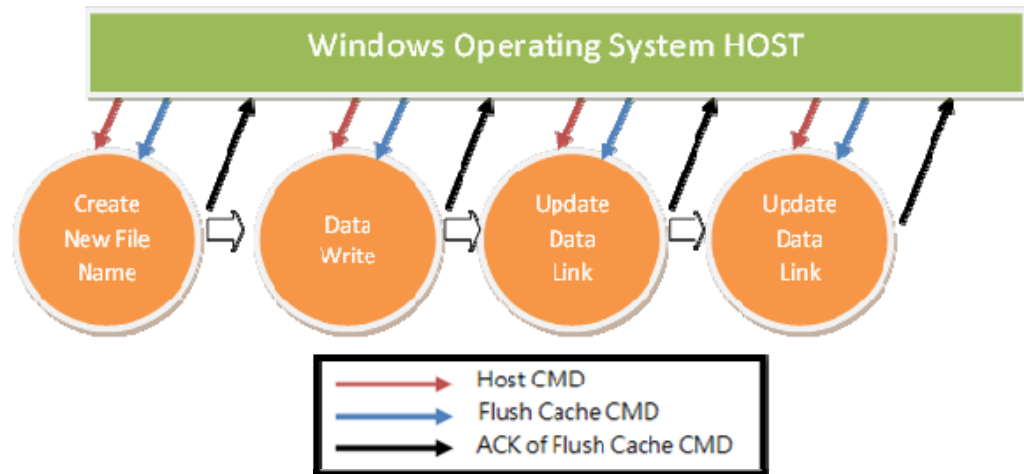
The flush command following each important stage of a given task allows the OS to re-build the system table and file system table (using CHKDSK for Windows, and FSCK for Linux) upon recovery from a power failure.

SMARTCACHEFLUSH

SQFlash SATA controllers utilize smart algorithms to reduce the amount of the data which resides in the external cache. SmartCacheFlush technology allows incoming host data to make a "pit stop" in cache and then be pushed into NAND storage immediately, barring bottlenecks on the Flash interface. If the interface backs up, the cache is organized and consolidated into groups before being written to improve the write amplification.

GUARANTEEDFLUSH

GuaranteedFlush technology has two implementations for device reliability:

1. An ACK will only be delivered to the host when the data is fully committed to the NAND media. Other solutions on the market may send an ACK to a flush command when the data is not yet committed to the NAND. Such an implementation gives a false-positive result of the data's integrity[2] and runs the risk of power failure issues.

2. Once the data is committed to the NAND media, the following page writes will not impact previously committed data. This is made possible by intelligently managing the pair-page of the MLC Flash.

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[2] Data is recognized in the block mapping table but is actually volatilized from DRAM during power failure.

Conclusion

The latest SQFlash SATA Flash drives utilize many hardware, firmware and performance improvements of DDR to minimize data flushing delay. Furthermore, the host and device initiated mechanisms introduced further guarantee data integrity on the firmware side to make sure Flash drives can always recover from power failures.

Not only does SQFlash provide great performance, Advantech is dedicated to continuously develop the security software which protects intellectual property. Advantech provides Flash Security ID to avoid applications being copied, Flash Lock which can detect corresponding platforms when accessed, and User Life Monitoring which can check the health of the flash. SQFlash are available in various interface. They can fulfill all kinds of applications, and they provide 3 years longevity and fixed specification support. Advantech SQFlash easily integrates into your application with decreased design effort, enhanced reliability and performance.

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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