Industrial Flash Storage Module

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Current Market Trends for Flash Storage

Application Types: Recently, data storage applications for Flash products have been extended for both daily use and at the workplace. From early digital cameras to cell phones, and now even in industrial applications, flash storage products have been included in a diverse range of applications. Due to the particular environmental requirements of the industrial market, flash memory, with its solid state and shock resistant features, has proved incredibly versatile as for example, a startup HDD, to setup OS, for software updates and as regular storage modules among others.

Application Demands: When using memory cards, users care most about stability, long life, speed, quality and data loss. Applications in industrial computing require even higher stability and reliability (for example, when used as system and data memory in public transportation applications) and will result in serious systemic problems if the memory card becomes damaged or critical data is lost without warning.

## Advantech's Techniques in SQFlash

1. NAND FLASH TECHNOLOGY

At present memory cards are mainly NAND Flash. To improve the capability, the semi-conductor factories have to use more advanced process technology to achieve this, lower the cost as well as keep the same size. The process technology has improved from the early 70/60 nm (2006), 50 nm (2007-2009), 40 nm (2009-2011) to 30 / 20 nm nowadays, and so has the capacity. However, this kind of process technology also increases the numbers of bad blocks within the flash, which are useless for data storage. Semi-conductor manufacturers have to record and mark these bad blocks during the previous test process so that bad blocks can be passed by. In addition, proofreading systems must be improved to prevent additional errors, so BBM and ECC systems are used to improve the stability of memory. The comparison of various SLC Flash types is as follows:

-	SLC Flash	
NAND Process	70/60/50 nm	40/30/20 nm
ECC Required	1 bit	4 bit
Erase Cycle	100K per block	
Data Retention	10 years	

BBM and ECC: BBM (Bad Block Management) is a system to manage and mark bad blocks. It will mark all the damaged blocks so as to prevent users from writing data into them and committing data loss. ECC (Error Correction Code) is a system to proofread written data. When there are bit data mistakes during the writing process, the system will correct them. Advantech SQFlash makes use of the BCD and ECC methods supporting up to 44-bits per 1 KB data. This method has stronger proofreading capability than the common RS code method, and can effectively avoid of data mistakes.

Reserve Block:
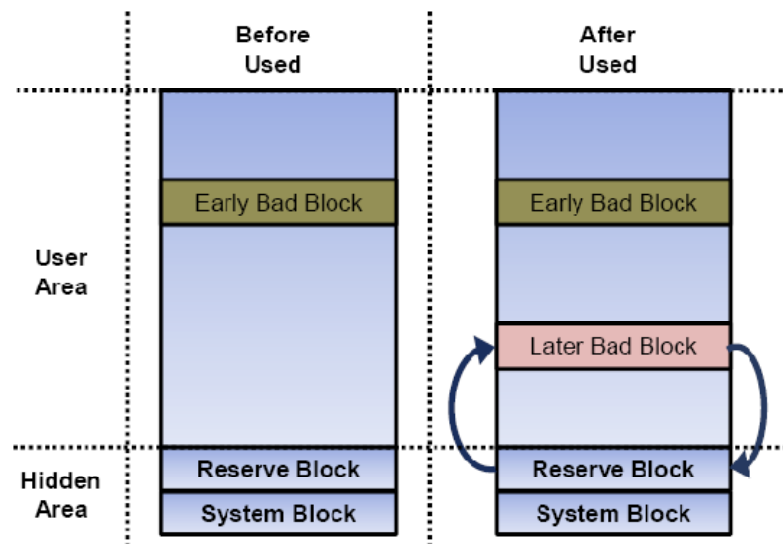
Early Bad Block:

The flash controller has detected this bad block. The bad block could be under 1% total.

User Area:

This area can be used normally.

Reserve Block:

The vendor of the controller will reserve about 4% space block for changing later bad blocks.

System Block:

This block has stored some information from controller IC.

Later Bad Block:

Detects damaged blocks during use.

2. WEAR LEVELING

When the memory cell of a NAND Flash is limited, a special flash management and control method will be applied. This will overcome and manage the memory period and times, and increase its service life. This method is called Wear Leveling. The following is the difference between Non-Wear Leveling and Wear Leveling.
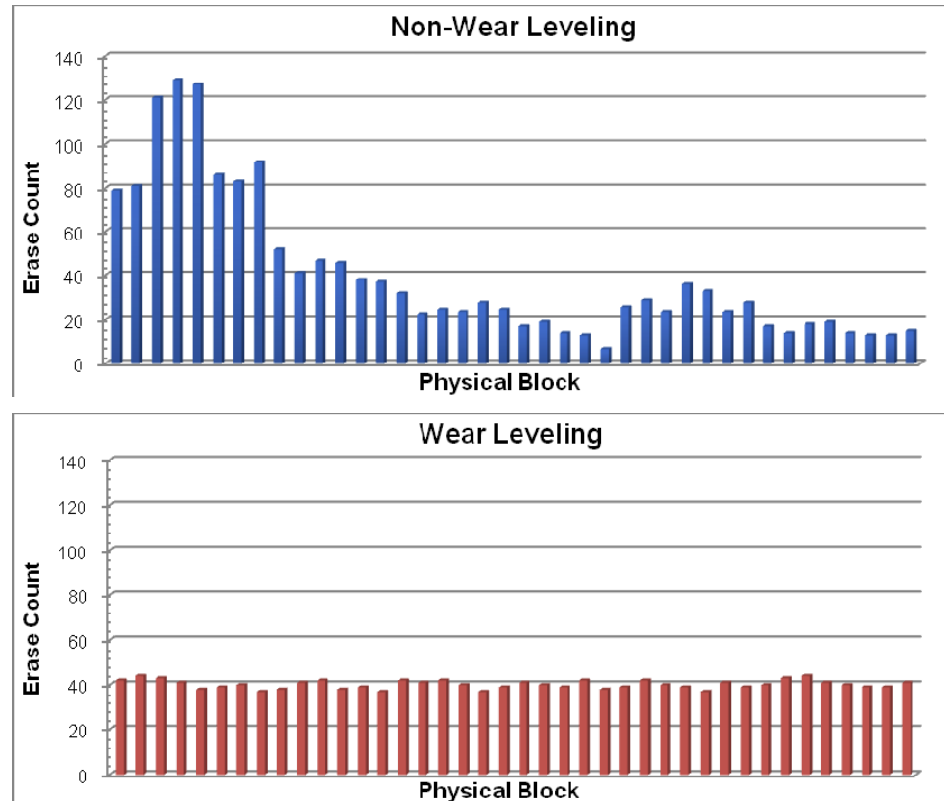
Seen from the Advantech SQFlash, within every memory block of NAND Flash, the Program / Erase Cycles are limited (SLC: 100,000 times; MLC: 3,000 times). If the data continues to be written into the same block when it reaches the maximum, then that block will be unable to be written to. But through Wear Leveling technology, the physical blocks will be transferred into it before the memory block is out of bound. The following figure gives a brief expression of it.

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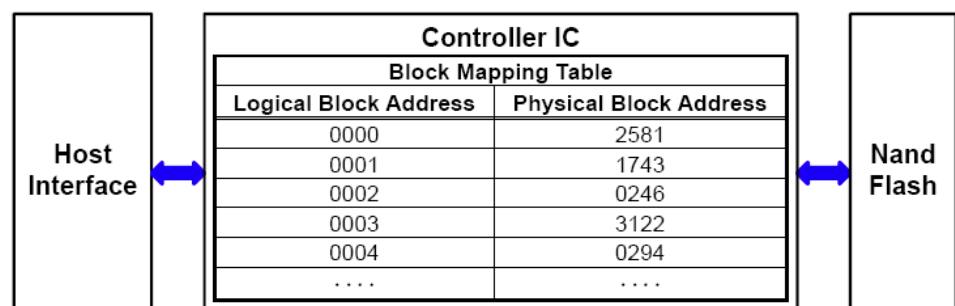
Endurance Field Test:
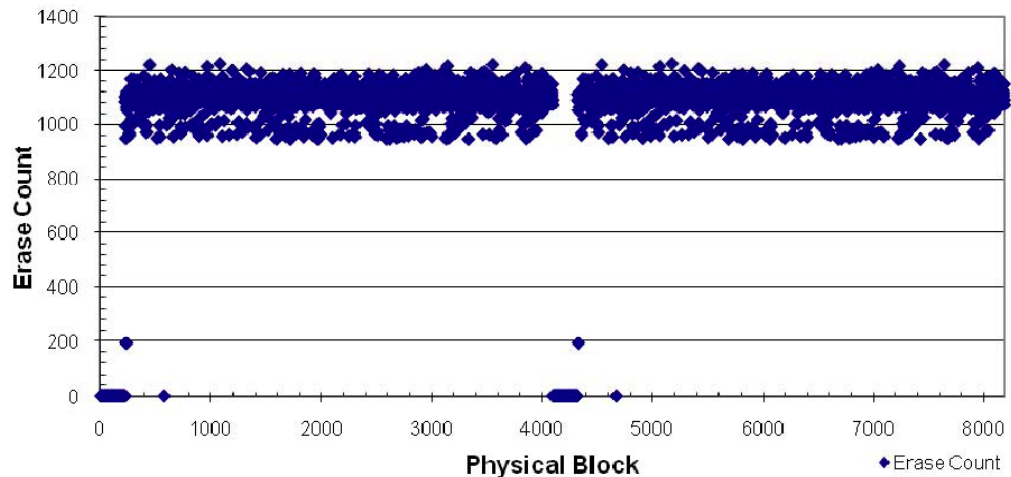
Sample Capacity: 4GB

Target life endurance: > 3 years

Test Period: 15 days

Full disk read/write cycles: 382 cycles

Total data flow: 1528 GB*

Average erase count = 1.1 K << 100 K

* Volume of data transferred by user (based on top laptop maker's estimation):

= 125 MB/hr * 10 hr/day * 365 days/year * 3 years

= 1368.75 GB

3. RELIABILITY

When using flash products, unavoidable conditions may occur, such as high/low temperatures, unstable voltage and vulnerable power supply, which may affect the reliability of the data. If the power suddenly goes down or surges when the machine is operating or the voltage is lower than the specification, then processing data and file information could get lost, even the memory device itself may get damaged. Therefore, in industrial applications, a stable OS and flash device is required so that the OS runs normally. And within Advantech SQFlash memory devices, just such a protection system exists.

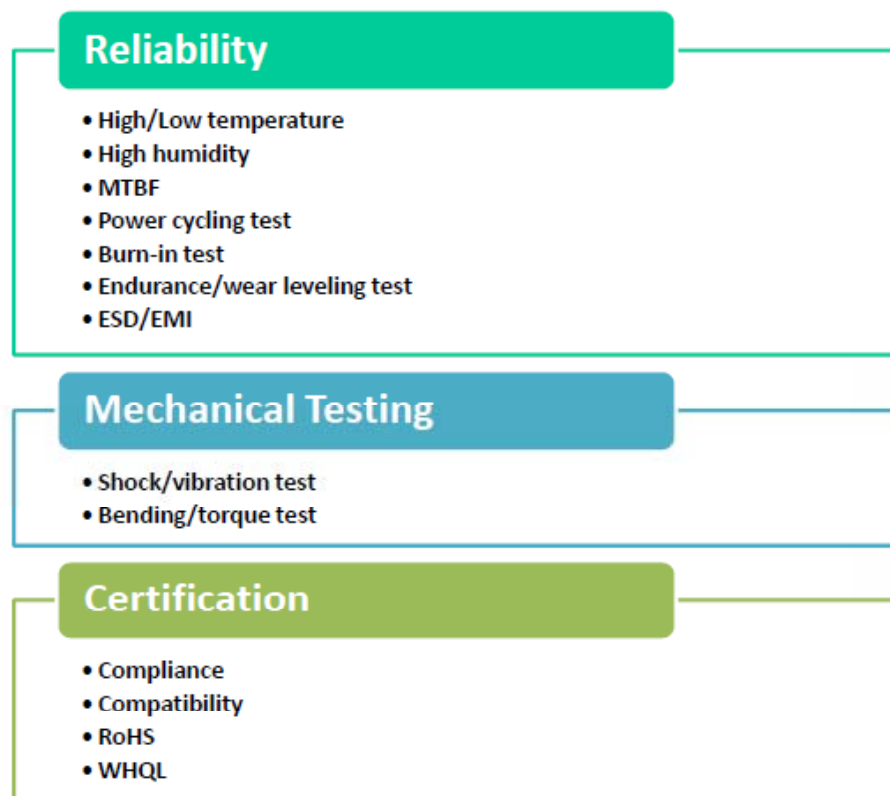*Advantech SQFlash Filed Test: Power Shutdown Cycle Time Testing*

Sample Capacity：4GB

Test Method：Dynamic Read/Write Test, Pattern Test, Random 5 Static Area Test.

Result：3,500 passes for each test before the CF card can be used.
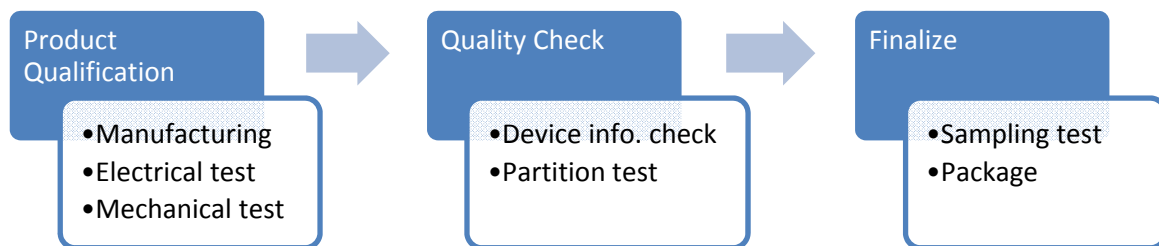
Qualification Plan of Product Development

With over a decade of experience in industrial computing, Advantech has proven to be capable of providing the most reliable, suitable, and updated solutions to the market. Flash modules are one of the key peripherals that are crucial to overall system performance and reliability. That is the reason why SQFlash, the Smart and Quality Flash Module, was introduced as the first choice for industrial grade flash products. Below are the qualification plans for SQFlash product development.

Reliability
- High/Low temperature
- High humidity
- MTBF
- Power cycling test
- Burn-in test
- Endurance/wear leveling test
- ESD/EMI

Mechanical Testing
- Shock/vibration test
- Bending/torque test

Certification
- Compliance
- Compatibility
- RoHS
- WHQL

Recent Advantech project with a major healthcare application provider in the US reveal the underlying elements that helped Advantech gain new orders and serviced customers better. This mini case shows how the sales process involves finding the right customer, developing and nurturing a partnership, understanding the customer's needs, the markets they compete in, and educating the customer on Advantech's capabilities and value added qualities.

QC Flow of Mass Production

Each SQFlash has been produced with a unique qualification flow, which has been developed based on years of experience.

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Product Qualification		Quality Check		Finalize	
• Manufacturing • Electrical test • Mechanical test	→	• Device info. check • Partition test	→	• Sampling test • Package	

The purpose of the test flow is to ensure the highest product quality and reliability from the material and manufacturing point of view. The qualification flows include: NAND test, Chamber Burn-in, Vibration Test and Thermal Cycling.

NAND TEST

NAND Test is conducted to ensure that all flash blocks can be programmed and erased correctly and the test guarantees the communication and functionality from controller to NAND flash.

CHAMBER BURN-IN

The purpose of this test is to ensure each product unit could be programmed and erased correctly as a system. The test guarantees the communication and functionality from host to NAND flash via controller.

VIBRATION TEST

For preventing any potentially weaker device unit after SMT and housing assembly. Vibration testing avoids DOA devices being shipped to customers.

THERMAL CYCLING

Since application environments vary, thermal cycling makes sure the flash module can read and write normally under different conditions. It is also a verification of mechanical strength that the device can physically cope with intense temperature changes.

Advantech's Pre-warning Software in SQFlash

Many memory devices in embedded applications are used to save data but also function as disks for the OS. Most users are blind to their operation and do not know when a memory device is wearing out, and often only remedies the problem after they have already been damaged. To cater to this demand, Advantech has developed a software package called SQFlash Utility, which can check the condition of the memory device at an early stage and inform users well in advance. When the life of the memory device is lower than the specified level, the software will warn users to backup and change to another device.

SQFlash Utility is a flash management software package that contains utilities and APIs 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 SQFlash Utility or implement functions into the application via the SQFlash API. A life-span detection mechanism can be designed from Life Endurance information.

SOFTWARE FEATURES

<u>Access Code:</u>
Once you type a valid access code with this utility, the system will keep a record and you won't need to type the access code next time.
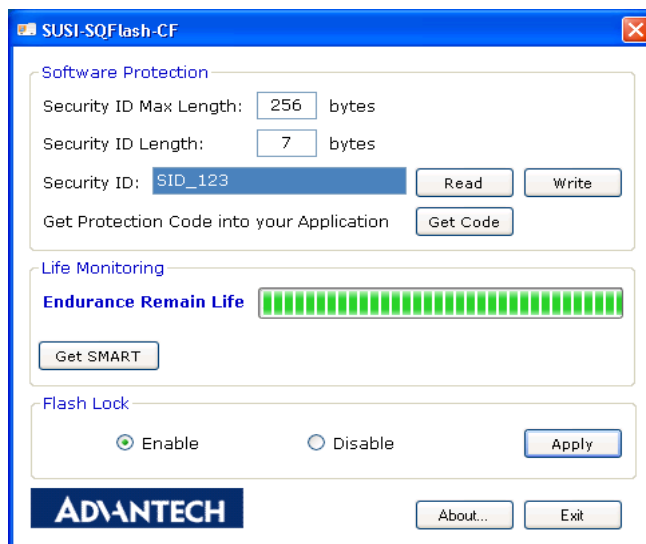
SQFlash Utility:

- Detects max and user-defined length of Security ID
- Reads or Writes Security ID into hidden area
- Sets protection code in application (C# sample)

Get SMART attribute:

Max Program - Max program and erase cycles in SQFlash.

Average Program - Average program and erase cycles in SQFlash.

Power On Time - Power on accumulated time.

ECC Count - Error correct code number of times counter.

Endurance Check - Endurance (%) of remaining life is the result of (Average P/E cycles) / (Max P/E cycles).

Conclusion

SSD and NAND Flash modules are one of the most popular storages today based on their high performance, good reliability and wide compatibility along with the properties of being highly vibration resistant and extremely low power consumption. Advantech SQFlash was designed with industrial operation in mind and provides highly

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reliable flash memory solutions with excellent compatibility, performance and security. Designing your application with SQFlash will decrease integration effort significantly and increase overall system stability.