

Avoiding premature failure of NAND Flash memory

In practice, the real lifetime of flash memory is dependent on a large number of parameters which are often not even mentioned in the data sheets from the manufacturers. This means that in real-life situations the flash memory used in your applications can fail earlier than expected. This risk can be minimised with lifetime tests carried out with the “altec SSD Life Test Tool”.

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History

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Introduction

Flash memory can be found these days nearly everywhere in modern IT technology and industrial electronics. It is used for example in high-performance servers, high availability storage clusters and very small industrial computers (embedded systems) and in modern consumer electronics devices. Correct functioning of these systems and the services they provide is often entirely dependent on whether the NAND flash memory which is used operates without errors. If the flash memory fails, then the respective application will also fail. This often has serious effects on the services provided or leads to considerably reduced functionality.

Even though flash memory is so-called “solid state” and functions without moving mechanical parts, flash memory storage wears out in practice as a result of write and erase cycles which take place during its normal, intended usage. In the data sheets from the manufacturers, the limited lifetime of flash memory resulting from write and delete cycles (P/E cycles, program/erase cycles) is often expressed with the parameter TBW (Terabytes written) or PTW (Petabytes written). Some manufacturers also quote the amount of data which can be written daily (GB written per day) for a specified duration or lifetime.

However, these parameters can only give you a rough point of reference when choosing suitable flash memory. They are not suitable for finding the best flash memory from the viewpoint of price and performance for a specific application. The data sheets cannot give a definite answer to the decisive and important question: “How long will the flash memory and/or the SSD last in practice?”. This is because the real lifetime is not only significantly affected by the specific write and erase scenario but also the temperature range with which the flash memory is operated. The lifetime is also affected by the structure size of the flash chips, the wear levelling strategy (unfortunately the wear levelling itself also “consumes” a significant number of P/E cycles), the internal design of the flash memory such as controller type, the type of cache and the actual firmware version etc.

Minimise the risk of premature failure of the flash memory you are using with a real lifetime test!

If you only choose the flash memory according to the data sheet and do not test it physically for its lifetime, you are running a risk that it will fail prematurely. Normally, the actual risk cannot be exactly predicted or calculated in advance because of the wide range of different factors which can play a role.

The “altec SSD Life Test Tool” is a reliable way of testing the actual lifetime of flash memory in a realistic environment with the specific write and erase profile of your own application. It is above all intended for development engineers and buyers who want to be certain of making the right choice of flash memory.

Information storage in flash memory cells

Flash memory cells store information when electrons tunnel through an insulating oxide layer to reach the so-called floating gate with the help of a high voltage (10 - 18 Volt) which is applied to the control gate. The electrical charge which is applied and then removed again from the floating gate causes the insulating oxide layer to degenerate more and more with an increase in the number of charge/discharge cycles. Finally, the oxide layer is so worn out that the charge which represents the stored bit of information drains away on its own.

A flash cell wears a little bit more with each write and erase cycle and thus has a very limited lifetime.

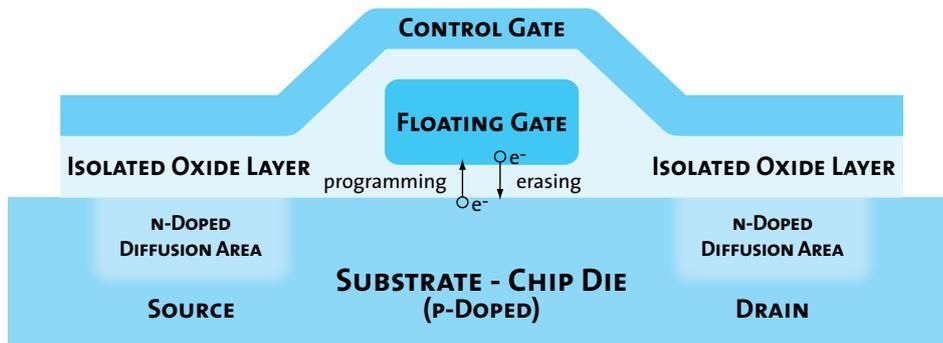


FIGURE 1:
SCHEMATIC VIEW OF A FLASH MEMORY CELL

The minimum time guaranteed by the manufacturer within which the information is correctly stored in the flash memory and no data loss has taken place due to drainage of the charge in the floating gate is called retention. Within the time scale of the specified retention, endurance refers to the ability of the flash memory to withstand significant functional degeneration of the oxide layer and the associated corruption of the stored data. The endurance is the maximum number of P/E cycles for each flash memory cell within which the manufacturer guarantees the specified retention.

With respect to retention and endurance, the problem nowadays is the significant reduction in the amount of charge applied to each memory cell and the reduced size of the oxide layer resulting from the smaller structure size of the chips. In addition, the smaller floating gates and insulation layers amplify non-linear effects at the ends of the specified temperature range which can impair the information which is stored.

Resulting from the continuous reduction of the structure size of the flash memory chips, 2-bit MLC and 3-bit MLC (TLC) NAND flash memory is now available on the market which sometimes only allows 1,000 P/E cycles (MLC) and/or only a few hundred P/E cycles (TLC) per flash memory cell before degradation. These are alarmingly low endurance values! The SLC NAND Flash memory which was nearly always used in the professional sector until a few years ago allows 100,000 P/E cycles – specially selected SLC chips can also reach > 1,000,000 P/E cycles. Up to a few years ago, typical 2-bit MLC Flash memory was still specified for 10,000 P/E cycles.

The retention and endurance of NVRAM is defined in JESD22-A117A, JESD47 (JEDEC). These days, data sheets usually specify the endurance for a retention of only 1 year. There is a direct relationship between endurance and retention, for example 100,000 endurance cycles for 1 year retention or 10,000 endurance cycles for 10 years retention.

These days, smaller semiconductor structures allow an increased chip yield and have allowed a continuous reduction of the price of flash memory. However, smaller structures also significantly reduce the usable lifetime (endurance) of the flash memory cells.

As a result of competitive cost pressure, there is an increased trend to use low price MLC flash with small structure sizes in the professional sector as well. This special flash memory technology which is also called Enterprise MLC (eMLC) was developed for low error rates and/or high endurance values (10,000 P/E cycles) and is meant to be very robust. However, despite it's specified 10,000 P/E cycles, eMLC only achieves the same endurance values which were "normal" for the MLC NAND Flash which was formerly manufactured with a significantly larger structure size. The better endurance values of modern eMLC compared to the currently common MLC with smaller structure sizes is not solely a result of further developed manufacturing methods at the chip level, but partly due to significantly more effort with error detection and/or correction than was common only a few years ago. In contrast to the impression one gets from the name eMLC, the number of P/E cycles is now significantly worse than "normal" MLC which was manufactured with larger structure sizes several years ago. This is mainly because the former flash chips, which were manufactured with larger structure sizes, were guaranteed for a much larger retention. Retentions of 10 years were common at that time, whereas nowadays the number of P/E cycles is typically only specified for a retention of 1 year.

	SLC	eMLC	MLC	TLC	MLC (old)
Typical process technology	> 40 nm	≈ 48 ... 32 nm	34 ... 24 nm	≈ 28 ... 20 (19) nm	> 50 nm
P/E cycles (retention min. 1 year)	1,000,000 ... 100,000	≈ 10,000	≈ 1000	« 1,000 (typ. ≈ 300)	(*)
P/E cycles (retention min. 3 years)	333,000 ... 33,000	≈ 3,300	≈ 333	« 333 (typ. ≈ 100)	(*)
P/E cycles (retention min. 5 years)	200,000 ... 20,000	≈ 2,000	≈ 200	« 200 (typ. ≈ 60)	(*)
P/E cycles (retention min. 10 years)	100,000 ... 10,000	≈ 1,000	≈ 100	« 100 (typ. ≈ 30)	10,000

(*) not specified

TABLE 1:
TYPICAL P/E CYCLES OF VARIOUS NAND FLASH TECHNOLOGIES COMPARE AGAINST TYPICAL RETENTION VALUES

A closer look at write and erase cycles

It is not possible to write to or erase specific, individual NAND flash memory cells on a flash chip. Internally, the separate flash memory cells are grouped together into pages of 2 to 16 kByte in size. A page is the smallest writable unit of a flash chip. In addition, the separate pages are grouped together into so-called erase blocks. An erase block is the smallest unit of data in the flash memory which can be erased. Depending on the internal structure of the flash chip, the size of the erase blocks typically vary between 16 kByte and 2 MByte.

However, it is likely that the sizes of the pages and erase blocks will continue to increase in future with a reduction of the structure size of the flash chips.

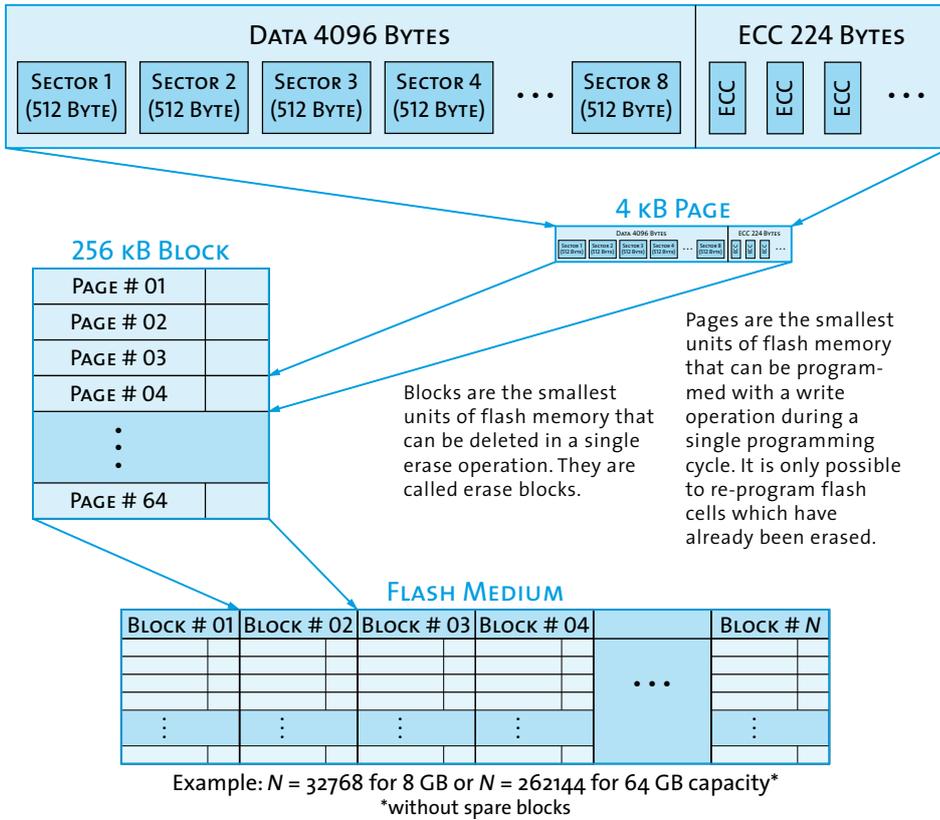


FIGURE 2-A:
SCHEMATIC STRUCTURE OF TYPICAL FLASH MEMORY

In practice, this subdivision into pages and erase blocks means that when writing a very small amount of data, considerably more flash cells must be written to than one would expect from the actual quantity of data to be changed. With a page size of 16 kByte and a data block of 4 kByte, four times more flash cells must be written to than required by the quantity of data – with data blocks of size 512 Byte, 32 times as many flash cells must be written to!

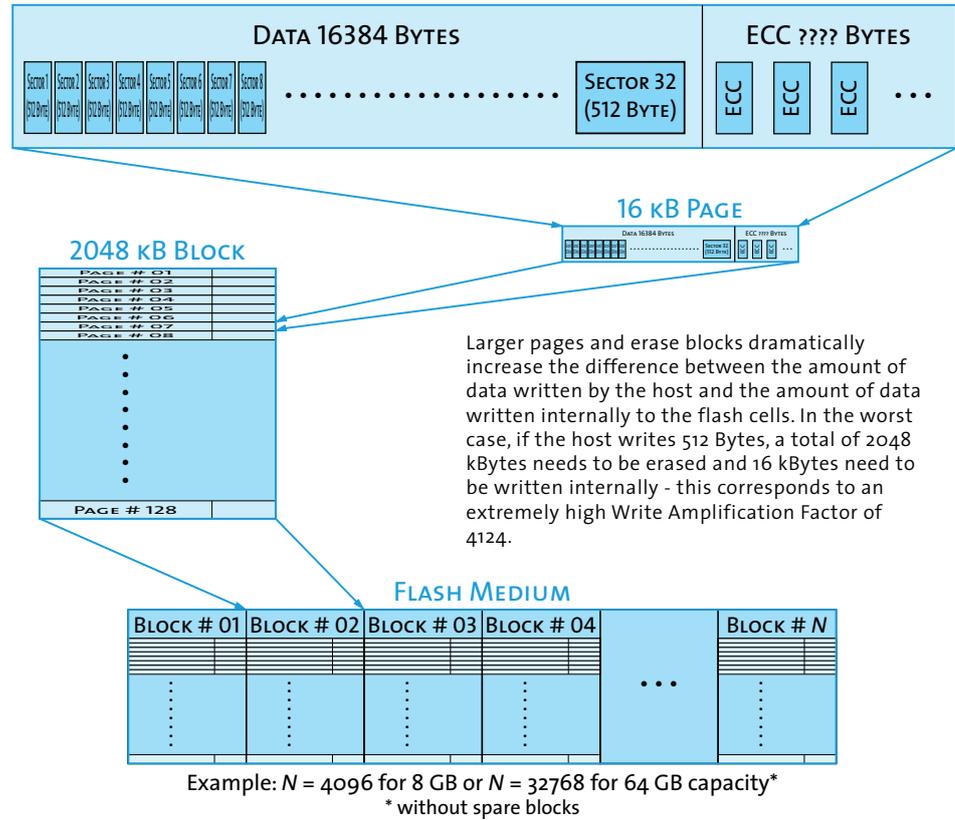
512 bytes correspond to one sector, the smallest data unit in a typical file system. Modern file systems also use sectors of 4 kByte in size.

However, this is only true if the flash media has enough empty pages which do not already contain data. If it is necessary to erase flash cells or pages before writing the new data, the amount of data to be written to the flash chip can increase again considerably. When writing relatively small amounts of data compare to the size of the pages and erase blocks, each write and erase cycle can result in a very large overhead of P/E cycles which can dramatically increase the wear of the individual flash cells on the chip. This overhead is called the Write Amplification Factor (WAF). The WAF is calculated as follows:

$$\text{Write Amplification Factor (WAF)} = \frac{\text{Data actually written to the flash cells}}{\text{Data which the application needs to write}}$$

An WAF of 1 would be ideal and means that if the application needs to write 1 MByte, only 1 MByte need to be written to the flash cells. If the flash cells already contain

data, the WAF is always larger than 1 because the old data must be erased before writing the new data.



Larger pages and erase blocks dramatically increase the difference between the amount of data written by the host and the amount of data written internally to the flash cells. In the worst case, if the host writes 512 Bytes, a total of 2048 kBytes needs to be erased and 16 kBytes need to be written internally - this corresponds to an extremely high Write Amplification Factor of 4124.

FIGURE 2-B:
SCHEMATIC DIAGRAM OF A HIGHLY INTEGRATED FLASH MEDIUM

The controller of the flash medium tries, sometimes with the help of intelligent caching mechanisms, to group together the separate write operations to the pages of the flash chip and also tries to minimise the number of erase cycles which are necessary. How this optimisation is done is generally unknown because it is a trade secret of the manufacturer. Accordingly, the exact lifetime of the flash medium can hardly be calculated from the parameters in the data sheet for endurance (TBW or PBW) and knowledge of the flash technology and structure (SLC, MLC, eMLC, TLC, structure size and organisation of the chips in the pages and erase blocks).

Only real lifetime tests can minimise the risk of premature failure of flash memory in real operation.

The solution is a practical test with the “altec SSD Life Test Tool” whether the flash medium or SSD to be evaluated functions reliably within the planned lifetime of the application. Above all with complex write and erase scenarios, the “altec SSD Life Test Tool” is the ideal evaluation tool because it allows you to define a stress profile to match the read/write scenario of your application. Furthermore, if the stress profile is not known, you can use the altec “USB Life Test Tool Traffic FlashDrive” to record the actual data operations of your application (read, write, erase) and create a real stress profile. You can then use the “altec SSD Life Test Tool” with the logged stress profile to evaluate the flash medium.

The risk due to flash memory lifetime

Flash memory in a wide range of different designs, whether as flash memory cards, SSD or USB storage modules are now an integral part of most modern IT technologies. There are many advantages of flash memory - insensitive to shock and vibration, low energy requirements and often a significantly higher performance than hard disks, for example from the viewpoint of speed and IOPs (Input/Output operations Per Second). However, flash memory also has a much higher cost per Gigabyte than hard disks. The biggest disadvantage of flash memory - the limited lifetime and/or the limited number of P/E cycles for flash cells - has been known to developers and buyers for a long time but they are reassured by the manufacturer's information presented on the data sheets. However, this can be the largest "minefield" in the whole evaluation process and/or for the completed product. This is because an incorrectly chosen flash memory module which fails before the planned lifetime of the application can result in considerable follow-up costs – even if you ignore the image loss for the equipment manufacturer.

IT technology is mainly considered to be a capital investment and is expected to last for several years. The ISO 9001 or BOM (Bill of Materials) generally provide enough safety to be able to guarantee the planned lifetime of the individual components. With the help of the appropriate parameters from the flash memory manufacturer, the buyer or developer can determine the theoretical lifetime of the flash memory used and can plan maintenance cycles and/or calculate the TCO (Total costs of ownership). However, since the real lifetime of flash memory is dependent on the specific write and erase scenario, the choice of the best flash memory for a particular application is difficult to make only using the theoretical parameters.

The possible risks are numerous. Premature failure of the flash memory normally means that a functional error will take place within the application. In the case of embedded or industrial applications, this often means that an entire part of the plant will fail. Mobile radio systems, servers or network services fail or are only available with a reduced performance until the faulty flash memory is replaced. In addition to unplanned costs for spare parts replacement and repairs, claims for compensation may also be incurred. In single cases, the extra costs may be limited, but if a series of failures occur the costs can rise astronomically.

If the buyer and developer purchase higher-value and thus more expensive flash memory, the risk due to premature failure can be reduced but often not minimised. In addition, it is questionable whether the higher costs bear a meaningful relationship to the expected benefits and do not solely result in a disproportionate increase of the price of the final product. In the worst case, the increased cost means that the finished product cannot be sold in the planned market segment due to price competition from other suppliers.

Despite the superiority of the main technical parameters, the limited lifetime of flash memory can be a risk for the reliability of applications which use this memory.

Flash memory which is not ideally suitable for the application has a negative effect on the finished product.

Only a few years ago, it was possible with relatively simple calculations to determine the expected lifetime of flash memory. Formulas from flash memory manufacturers such as the following generally present a good starting point to calculate the theoretical lifetime:

$$\text{Lifetime} = \frac{\text{Endurance Rating} * \text{capacity in GB} * (0.0325) * 1024}{\text{Write IOPS} * \text{file size in kB} * \text{Write Amplification Factor} * \text{Duty Cycle}}$$

Endurance Rating – number of P/E cycles for the flash cell in thousands see table 1

Capacity in GB – capacity using the binary system (2ⁿ instead of 10ⁿ)

0.0325 – constant to convert from the endurance rating to 1000 cycles, to convert from kB to GB and for the number of seconds in one year

1024 – constant to convert from kB to MB

Write IOPS – number of write input/output cycles per second (determined by measuring in the application or a theoretical value)

File size in kB – the file size which is used to measure the Write IOPS or a theoretical value

Write Amplification Factor (WAF) – the relationship between the amount of data written to the flash memory cells to the amount of data written by the application (host).

Duty cycle – the percentage ratio of write cycles to the sum of read cycles and idle cycles.

Example: An application processes data measured by sensors and saves a 2 kB file 15 times per second (write IOPS) . The application thus writes a data quantity of 2,592,000 kByte per day to the flash memory, in other words 2,47 MByte. The data is then further processed and the “duty cycle” is 25% . It is planned to use MLC flash memory (endurance rating = 10) of 4 GB storage capacity.

$$\text{Lifetime} = \frac{10 * 4 * (0.0325) * 1024}{15 * 2 * 32 * 25\%} = 5,546 \text{ years}$$

The manufacturer’s data on the lifetime of flash memory produced with a large structure size typically includes a safety margin. The capacity of the flash memory can be doubled if you want to allow an additional safety margin or if the results of the calculation appear to be only just sufficient. This generally leads to a doubling of the lifetime, but increases the product price of the due to the more expensive flash memory.

In the above example where the calculated lifetime of the flash memory is only just sufficient for a planned usage time of the hardware of five years, doubling the size of the MLC flash memory to 8 GB would lead to a calculated lifetime of well above 10 years.

An alternative is the use of smaller flash memory chips with 1 GB capacity based on SLC NAND technology – the endurance rating is then 100 instead of 10 (assuming that the other parameters are the same).

$$\text{Lifetime} = \frac{100 * 1 * (0.0325) * 1024}{15 * 2 * 32 * 25\%} = 13.866 \text{ years}$$

However, write and erase scenarios are unfortunately typically more complex in practice. If we stay with the original example - the processing and storage of sensor data by an application - this could lead to the following stress profile:

	Size of the files written by the application in kByte										
	0.5	1	2	4	8	16	32	64	...	512	1024
w r i t e IOPS	45	23	15	18	5	32	6	22	...	0.25	1

TABLE 2:
MORE COMPLEX STRESS PROFILE 1

If detailed stress profiles like this are available, with a little more work it is relatively easy to calculate whether a particular type of flash memory is suitable for the intended application or not – provided that all of the necessary parameters are available from the manufacturer. Unfortunately that is often not the case or only some of the parameters are known. Parameters from the manufacturers such as TBW (PBW and/or GB written per day) are not sufficient to be able to calculate whether the flash memory is really suitable.

Currently, the data sheet parameters specified by flash memory manufacturers only contain lifetime values which are valid for standardised write and erase profiles.

Assuming that the size of the files written are 1024 kByte and with one write IOPS (see above table), the amount of data written by the host (i.e. the application) is around 85 GByte per day. It is further assumed that the erase block size is known and is 1024 kByte. With these assumptions, the WAF is initially 1 at the beginning, when the flash memory does not yet contain any data. However, if it is necessary to first delete blocks from the flash memory, the WAF increases to 2. This is nearly always the case after the flash memory has been used for a short period. Accordingly, the amount of data written internally to the flash memory is 170 GByte instead of 85 GByte per day.

The following table shows the amount of user data written by the application (host) in 24 hours and the amount of data that the flash memory controller must write internally in order to be able to write this amount of user data. The manufacturer’s data sheet states that the page size of the flash memory is 8 kByte and the erase block size is 1024 kB.

	Amount of data written by the application in kByte										
	0.5	1	2	4	8	16	32	64	...	512	1024
write IOPS	45	23	15	18	5	32	6	22	...	0.25	1
WAF	2048	1024	512	256	128	64	32	16	...	4	2
Amount of user data written by the host in 24 hours in Gigabyte (rounded)											
	1.8	1.9	2.5	5.9	3.3	42.2	15.8	116	...	10.5	84.4
Amount of data written internally "worst case" in Gigabyte (rounded)											
	3686	1945	1280	1510	422	2700	505	1856	...	42	169

TABLE 3:
MORE COMPLEX STRESS PROFILE 2

The total amount of user data written by the host in 24 hours is thus around 285 GByte. In contrast, the total amount of data written internally to the flash media as a result of the WAF is around 13,937 GB (13.6 TByte) – 49 times more than this!

When specifying the LDE, some manufacturers refer to the profiles which have been defined as typical by BAPCo: Professional ≈ 90 GBW/week, student ≈ 37 GBW/week and personal ≈ 37 GBW/week. It is questionable whether these profiles are suitable for your own applications, since they are intended to represent typical Windows users.

With this example, the flash cells of flash memory with a specified endurance of several hundred TBW (LDE, Long Term Data Endurance) would be completely worn out within only a few days due to the resulting large number of P/E cycles. High-value flash media with e.g. 500 TBW and with the above stress profile and the amount of data written internally would be so worn out after about 37 days that it would soon fail completely. If instead you calculate the expected lifetime from the amount of user data written by the host (285 GB for 500 TBW), the theoretical lifetime is about 1800 days, i.e. 5 years. This calculated, theoretical lifetime is a lot closer to that which one would expect from modern flash media. Unfortunately, this result is nowadays often not achievable.

The big difference between the two values is because the host does not write to the flash media in a 1:1 relationship, but the controller of the flash media optimises each of the write cycles to keep the WAF as small as possible and to minimise the number of unnecessary P/E cycles. Due to the cache in front of the memory, the caching and wear levelling algorithms implemented in the controller firmware and also partly due to data compression, the real WAF in practical operation can remain quite low. Which of these mechanisms has been implemented at all by the manufacturer and the design effectiveness of the implementation in the controller firmware and how effective these measures are in practice with different stress profiles is unfortunately a trade secret.

Starting with the above example, where the user data of the stress profile based on a data quantity of 500 TBW indicates that the probable lifetime of the flash medium will be 5 years, there is clearly a large risk that the flash media may reach its end of life much earlier than this. Exactly how much earlier or whether the expected lifetime will be reached in practice can only be determined reliably with a lifetime test using a stress profile which matches the usage environment.

Lifetime test with the “altec SSD Life Test Tool”

The “altec SSD Life Test Tool” was specially developed to test the actual lifetime of flash media in a practical environment for its suitability for a specific application. It can also be used to test whether the flash medium functions reliably within the planned lifetime of the application. This is not only essential to demonstrate the operational reliability of the application, but also allows a comparison of flash media versions with different price performance ratio, in order to determine the ideal data storage for the application.

The “altec SSD Life Test Tool” is a reliable aid for testing already existing applications too. For example, following an update of the controller firmware, it can be used to make sure that the update will not have a negative effect on the lifetime of the flash memory. It is quite often the case during product development and evaluation of an application that the manufacturer of the flash memory releases various firmware updates which are meant to correct errors which have been found. If the firmware corrections result (unwittingly) in a reduction of the lifetime of the flash memory in an application which is already on the market, this represents an additional risk for the reliability and planned lifetime of the application. The “altec SSD Life Test Tool” can be used to minimise the risks with respect to liability, warranty and compensation claims.

Flash memory normally tends to wear out fairly slowly as a result of the P/E cycles over a period of time. The “altec SSD Life Test Tool” is able to accelerate the wearing processes like a kind of time lapse. The “altec SSD Life Test Tool” is configured with a stress profile in tabular form which specifies the individual Write IOPS for a range of different block sizes. In addition, you can specify the planned or expected lifetime. The “altec SSD Life Test Tool” is started after connecting the flash medium to be tested with the test computer. It then writes test patterns to the flash medium using the Write IOPS and block size combinations configured in the stress profile. This process is repeated until the “altec SSD Life Test Tool” has determined that the planned lifetime has been reached or the flash medium has failed before the planned lifetime.

If the appropriate stress profiles are already known, they can be represented in the form shown in “Table 2: More complex stress profile 1”, entered in the software and used for the test. In addition, altec has developed the hardware tool “USB Life Test Tool Traffic FlashDrive” for process computers and embedded systems and/or all applications with dynamic data requirements. This test hardware is used by the application for a limited testing period as data storage during real life or laboratory tests instead of the flash medium to be used in the final product. The microcontroller in the “USB Life Test Tool Traffic FlashDrive” logs the Write IOPS generated by the application for each of the block sizes. After waiting for a statistically relevant logging duration, the write cycles can be read out of the USB tool and a tabular stress profile can be made for the “altec SSD Life Test Tool”.

Firmware updates of flash memory can be a blessing and a curse at the same time – in the case of flash memory which is already being used for your applications, an additional lifetime test of the updated flash memory can reduce the risk of premature failure.

The „altec Life Test Tool” lets you determine the lifetime of test memory using any kind of stress profile as required.

Reduce risks and costs by using comparable lifetime tests

For the first time, test results from the “altec SSD Life Test Tool” can be used for the direct comparison of the real price/performance ratio of various flash media products which are suitable for your application. Nowadays, the flash memory market features an enormous number of different manufacturers with very different product lines.

The use of alternative flash media types due to an improved price performance ratio can increase the risk of premature failure since practical experience of the real lifetime is not available. The “altec Life Test Tool” can minimise this risk and help to reduce costs.

It is quite common that an application developer or manufacturer remains faithful to a particular flash memory supplier due to good experience made with their products in the past. This faithfulness is not always ideal from the business viewpoint with respect to the real price/performance ratio. The faithfulness to the supplier is often justified in that the lifetime of the previously used flash memory was accurately known for the respective application. It is understandable that the lifetime is a particularly important parameter since a premature failure of the flash memory can result in unexpected high follow-up costs and have a negative effect on the company’s image. Accordingly, there is often a resistance to change to another flash manufacturer, even if an alternative supplier of flash memory appears to have a better price/performance ratio than the previous supplier. After all, there are initially only the parameters in the data sheets which seem to show a better price/performance ratio. Up to now, it was quite difficult to verify these parameters, particularly in respect of the actual lifetime of alternative flash memory.

For the first time, the “altec SSD Life Test Tool” allows a reliable comparison with an acceptable amount of effort and allows you to benefit from commercial advantages without undergoing an incalculable risk for the planned lifetime of the application.

Practical example

For the purpose of direct comparison, two alternative products were chosen according to the data sheets in addition to the existing flash media which had been used for many years. Several samples were ordered for evaluation and to make a lifetime test with the “altec SSD Life Test Tool”.

The application is a planned further development of an existing product, and sufficient practical experience is known from previous versions. According to the customer’s performance specifications, the new version should be suitable for an operating period of at least 7 years. A maintenance contract will be signed with the customer for a period of 2 years and 36 hours response time. The first scheduled maintenance is free of charge to the customer because a guarantee period of 3 years was agreed. The application will be marketed and installed by the customer throughout Europe.

Based on the planned sales, the customer initially ordered 2,500 units and expects to order 1,500 units per quarter in the future. The customer has calculated the market saturation throughout Europe to be reached with 20,000 and expects an active marketing phase of 3 years. The developer and manufacturer of the application wants to check whether the previously used flash memory A will function reliably within the planned lifetime of the product. In addition to that, the customer would like to improve the sales margin and wants to test 2 alternative types of flash memory for suitability.

Flash memory A with price index 100

The former flash memory product which had been used for many years is an embedded USB 2.0 module with 32 GB capacity, based on MLC NAND flash chips with 40 nm structure size, TBW value unknown. The exact number of P/E cycles in normal operation are also unknown – the data sheet states a minimum of 10,000 P/E cycles. The guarantee period is 3 years.

The manufacturer and/or distributor of the USB module offers to calculate the lifetime of the flash module. The result of this calculation showed that, just like in the previous version of the application, the flash memory must be replaced during every second scheduled maintenance. Doubling the capacity of the memory, which would have doubled the lifetime, was rejected since this would significantly increase the price of the USB module and it can be expected in future that the overall price for flash memory will drop further.

Alternative flash memory B with price index 85

An embedded USB 2.0 module with 32 GB capacity, based on eMLC NAND flash chips with 24 nm structure size. The lifetime is specified as 120 TBW, the number of P/E cycles is not specified (assumed range >2,500 ... < 5,000 P/E cycles). The guarantee period is 2 years.

Alternative flash memory C with price index 180

An embedded USB 2.0 module with 16 GB capacity, based on SLC NAND flash chips with 50 nm structure size. The lifetime is specified as 540 GBW per day for 5 years, the number of P/E cycles is specified as > 100,000. The guarantee period is 5 years.

“altec SSD Life Test Tool” test results with an application-specific stress profile and an planned application life of 5 years

Flash memory A: The test was stopped after 4.3 years because the flash media no longer accepted any write operations.

Flash memory B: The test was stopped after 2.4 years because the flash media no longer accepted any write operations.

Flash memory C: Succeeded in the test. In a follow-up test, a lifetime of 12.3 years was determined.

Based on the test results with the “altec SSD Life Test Tool”, the developers decided to choose the flash memory C. Decisive for the decision was the very long lifetime of flash memory C under real conditions despite the significantly higher price. It was no longer necessary to replace the flash memory during the scheduled maintenance. The component costs during production increased as a result of the more expensive and higher quality flash module, but the cost of the scheduled maintenance dropped significantly without having a negative influence on the reliability and the planned overall lifetime of the application. On the contrary, flash memory C was shown to be the most suitable product and reduced the TCO of the application. Some of the reduced maintenance costs can be passed on by the developers to the customer and resulted in an additional competitive advantage.

Conclusion

The use of modern flash memory systems which are nowadays manufactured with small chip structures is not without risks with respect to unpredictable failures. The data sheet parameters of the flash memory manufacturers can be a good starting out point for identifying flash memory products which could be suitable for the planned application. However, the data sheet parameters do not give a detailed answer to the question of the actual lifetime of the flash memory under real conditions. Accordingly, in order to minimise the risk of a premature failure it is necessary to make lifetime tests of pre-fabricated and currently available flash memory before use or before starting to manufacture the application.

The “altec SSD Life Test Tool” is the ideal system for testing the lifetime of flash memory under real conditions and for comparing flash memory products which appear to be suitable for the application. The results obtained with the “altec SSD Life Test Tool” are an important contribution to the reliability of the application and allow a reliable assessment of the real lifetime. In addition, the test results of the “altec SSD Life Test Tool” make it easier to estimate the overall costs (TCO) of the planned application when using different types of flash memory. The tests results allow a real comparison of the price/performance ratio, while avoiding hidden risks, which only become apparent during the later lifetime of the application, leading to premature failure of the flash memory.

In addition to manually entering the stress profile, you can also log the stress profile dynamically in your application directly during real (laboratory) operation using the hardware tool “USB Life Test Tool Traffic FlashDrive”. After completing the logging, the “altec SSD Life Test Tool” can read the stress profile from the “USB Life Test Tool Traffic FlashDrive” and use it for a subsequent lifetime test of the flash memory. These tools allow you to collect real stress profiles from real operation of the application with an acceptable amount of effort. This was previously very difficult to do and could only be done by a few specialised companies.

The “altec SSD Life Test Tool” together with the “USB Life Test Tool Traffic FlashDrive” already minimises the risk of premature failure in operation due to unsuitable choice of flash memory during the assessment phase of an application. The risks of unexpected failure, expensive guarantee repairs or financial compensation, unscheduled maintenance and additional purchasing costs can be minimised. At the same time, the total cost of ownership (TCO) can be reduced and the operational reliability of the application can be increased.

Please contact the altec sales team if you want to use the “altec SSD Life Test Tool” and the “USB Life Test Tool Traffic FlashDrive” to be on the safe side in future and to avoid premature failures of flash memory.

Contact

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For more than 25 years, altec ComputerSysteme has been developing and manufacturing custom solid state solutions for the military, avionic/aerospace and nautical applications, the offshore sector, automotive, (heavy) industry etc. Certified QS processes to ISO 9001 guarantee the highest quality, reliability and long life of our products. Whether you are looking for solutions for rapid storage, redundant systems, systems with special protection against unauthorised access or manipulation of the stored data or other special requirements – altec’s qualified team of engineers can solve practically any data storage problem that you may have.