

An Innodisk White Paper
March 2013

iSLC

A Cost-Effective Superior-MLC solution
With Similar Performance, Endurance
and Reliability To SLC

Revision History

Date	Version	Information
2013.3.22	1.0	First Release

Introduction

This white paper presents Innodisk's iSLC technology as a cost-effective flash solution that increases the performance, reliability, and endurance of MLC NAND flash.

The lower premium that MLC commands over SLC is the trade-off many users take while sacrificing performance and reliability.

The main difference between SLC and MLC is the number of bits stored in each NAND cell. SLC stores 1 bit of data per cell, while MLC stores 2 bits per NAND cell. This allows SLC to be more fault-tolerant than MLC, while supporting more write cycles per cell. SLC flash can provide longer endurance and is a perfect choice for high-end applications. More key differences between SLC and MLC include Read, Write and Erase times, Program/Erase (P/E) cycles, and handling of errors bits. See Table 1.

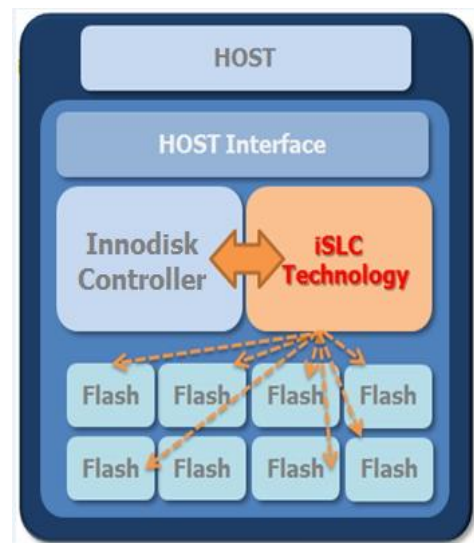


Table 1. Comparing SLC andMLC

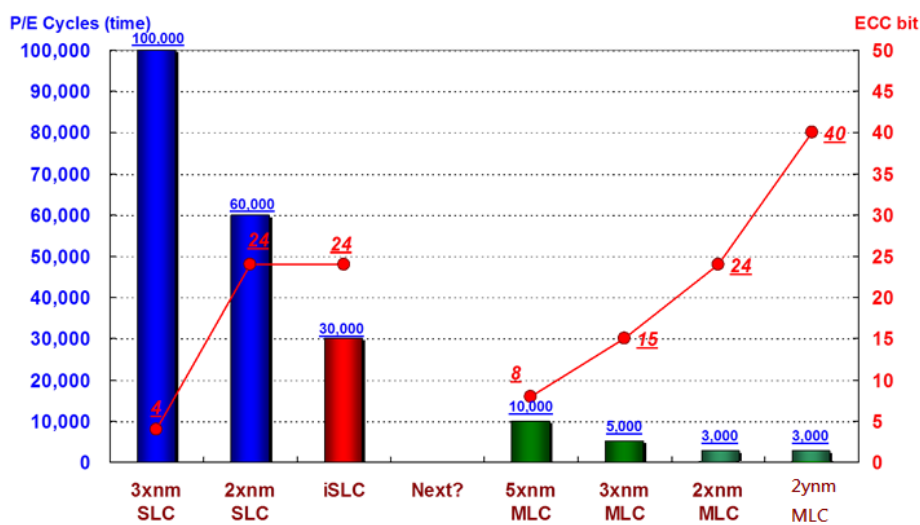
	Read page	Erase Block	P/E Cycle	ECC
SLC(5xnm)	25us	1.5ms	100K	1 Bit/ 512
SLC(4xnm)	25us	2ms	100K	1 Bit/ 512
SLC(3xnm)	25us	0.7ms	100K	4 Bit/ 512
SLC(2xnm)	35us	0.7ms	100K	8 Bit/ 512
MLC(3xnm)	50us	3ms	5K	24 Bit/ 1K
MLC(2xnm)	75us	4ms	3K	24 Bit/ 1K

Since SLC NAND flash is more reliable and has longer endurance than MLC, so it is the ideal solution for the industrial and enterprise applications. However, due to economic pricing, MLC flash has been a

very attractive, though concerns over performance and endurance still remain.

MLC's popularity was driven mainly by price. This has lead MLC NAND manufacturers to create larger capacities at better cost efficiency. The trade-off is a decrease in reliability and endurance seen below. As NAND flash technology shrinks from 4Xnm to 2Xnm and 1Xnm, manufacturers require higher ECC capabilities to compensate for the decrease in reliability and endurance.

Figure 1: MLC NAND flash trend

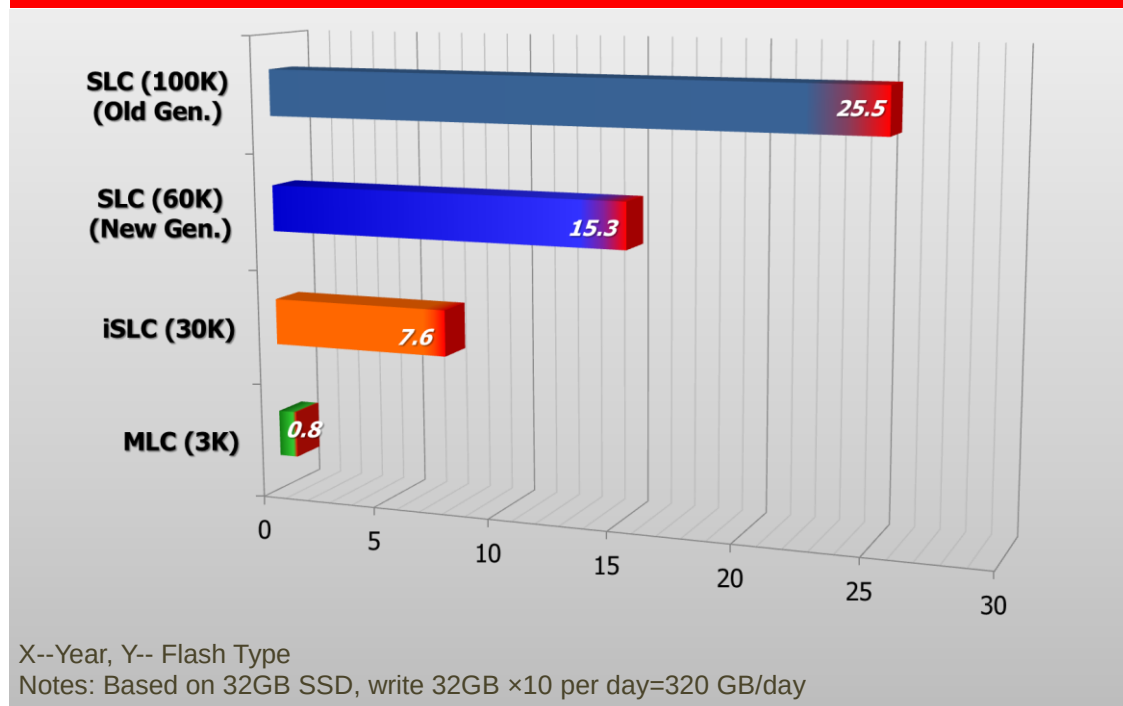


Innodisk has developed iSLC as a hybrid solution for those that require high-performance at a lower price point. Innodisk enhances superior MLC through screening and programming by our exclusive firmware. The firmware reprograms two bits per cell into one bit per cell, which increases the sensitivity of delta between each level. This practice enables the NAND flash to perform similar to an SLC Flash based solution

Innodisk's iSLC is designed to overcome this inherent deficiency in MLC NAND flash due to ever increasing demands on performance and endurance. With our iSLC technology, a 32GB capacity drive can sustain 10 full disk write. See Figure 2 below.

iSLC offers an improvement over endurance of MLC to further suit the needs of industrial SSD applications such as Industrial PC (IPC), kiosks, Point-of-Sale (POS) systems, embedded systems, and servers.

Figure 2: iSLC increase demands on endurance.

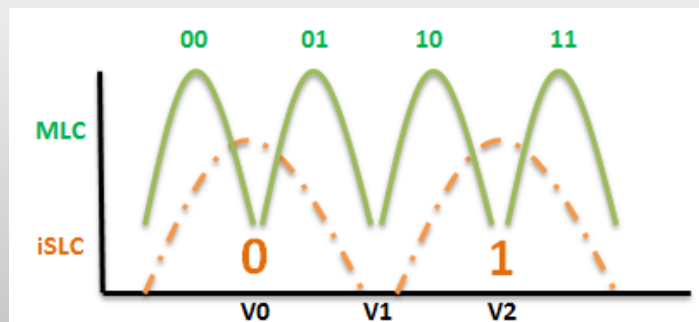


How iSLC Works

As stated, the purpose of iSLC is to increase the SSD's lifespan, and keep costs down by finding the right balance between Performance, Price, Capacity, Endurance and Reliability – in other words, performing as close as possible to SLC flash, but costing as close as possible to MLC flash. How is this accomplished?

Innodisk uses specially designed, in-house firmware to force the MLC flash to act as SLC flash. Each SLC cell holds 1 bit – 1 or 0 – while MLC holds 2 bits – 00, 01, 10, 11. iSLC mimics SLC by only holding 1 bit in each NAND cell. See figure 3. This firmware tweak essentially allows the flash to perform close to that of SLC flash. This also increases endurance and data retention levels of the MLC NAND Flash. See figure 3 below.

Figure 3: iSLC firmware technology empower MLC



V = Voltage

Testing Data

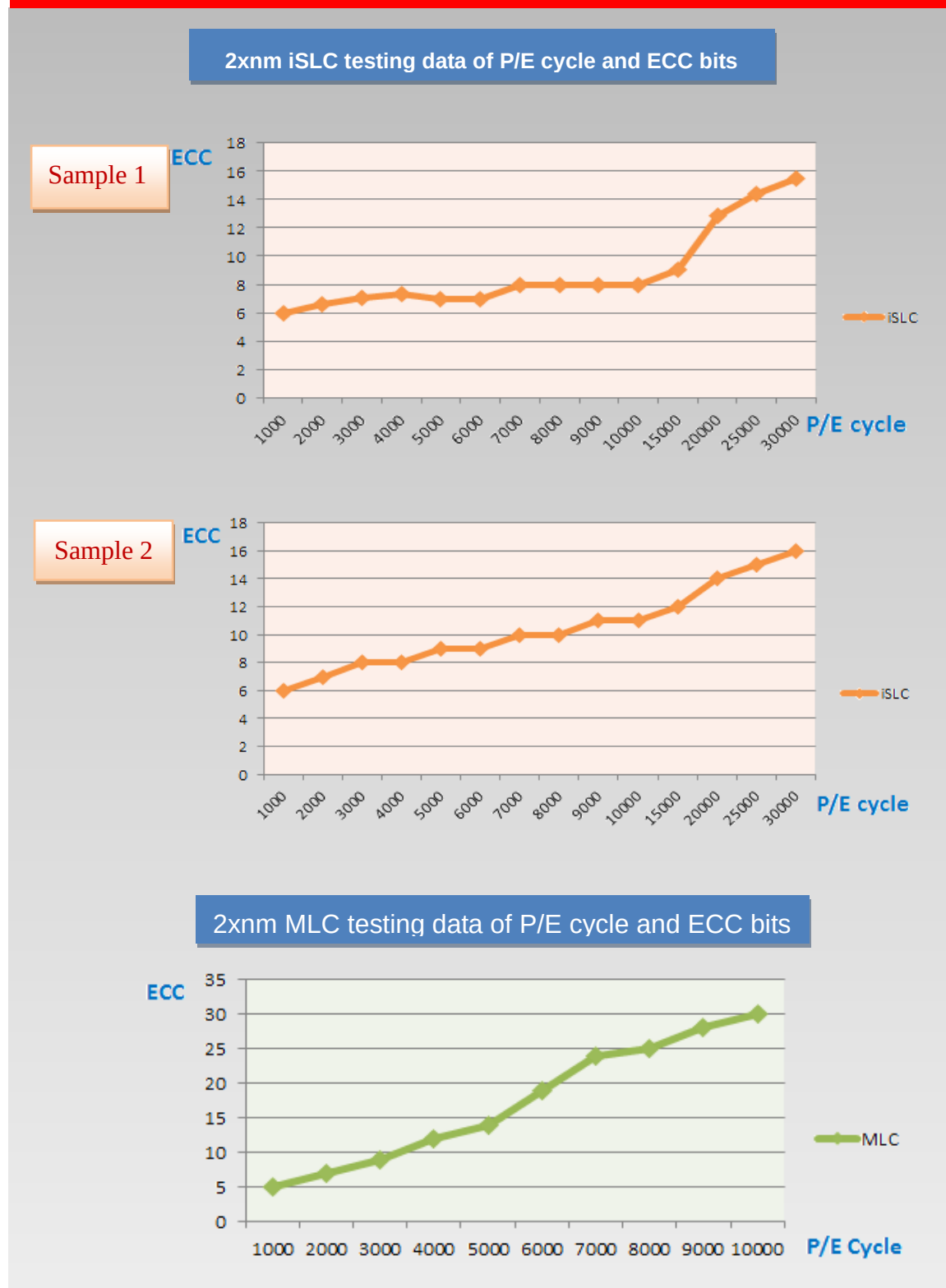
The average endurance in iSLC can surpass 30,000 Program/Erase (P/E) cycles, which increases the lifespan of the drive over MLC Flash. Internal tests have been conducted at Innodisk Headquarters for a period of time without any device failure. Table 2 shows a non-stop burn test with measured variables.

Table 2: non-stop burn test with measured variables

Sample	Capacity	Page Size	Average Erase Count	Error	Total Data Written(TBW)
1	8GB	4K	30,000	0	92
2	8GB	4K	30,011	0	92

Our tests show the error bits of iSLC are much lower than MLC. When Comparing the technology nodes of iSLC and MLC, 2xnm iSLC P/E cycle reached 30,000 times with error bits under 16 bits, while 2xnm MLC P/E cycle reached 10,000 times with error bits higher than 30 bits. Figure 4 shows that iSLC decreases the error bits significantly.

Figure 4: Comparison the ECC bits for iSLC and MLC



Write performance for iSLC NAND flash is about 15% slower than SLC NAND Flash while MLC NAND flash is 50% slower than SLC NAND flash. This is a significant jump in performance over typical MLC solutions. See Figure 5.

Figure 5: Comparing the Write performance for SLC, iSLC and MLC on SATA II

Write(Max. MB/s)	1	2	4	8
SLC	25	65	130	220
iSLC	20	50	125	200
MLC	7	11	50	80

Conclusion

iSLC offers a cost-effective way for industrial applications to perform at a high capacity while still keeping tight control on expenditures. Kiosks, POS and other embedded IPC applications require reliability and endurance but might not always need to operate at the top end of the technological spectrum as far as cost and performance criteria are concerned. iSLC flash is perfectly suited to find that sweet spot in industrial flash applications.

Innodisk SSD series that incorporate iSLC flash technology

Innodisk's 2IE series, including 2.5" SATA SSD 、CFast 、mSATA 、SATA Slim 、SATADOM-QH 、SATADOM-QV 、SATADOM-QVL

About us

Innodisk is a worldwide leading provider of data storage and memory module solutions for industrial and mission-critical applications. Leveraging in-house engineering and R&D expertise with a keen insight on industry trends, our solid-state drive (SSD) technologies provide enhanced, vertically-integrated data storage solutions. Our advanced flash-based data storage and DRAM memory solutions meet stringent aerospace and defense application requirements, and are also widely used in industrial applications and embedded systems. We offer customized solutions, from unique form factors to special firmware designs, and our support team of hardware, software and firmware engineers is always ready to tailor the right solution to each customer's needs. At Innodisk, we continually strive to innovate and provide system integrators and end customers with the best service in the industry.

For more information on our product line, technologies and applications, please visit www.Innodisk.com.