



White Paper
July 2016

iSLC

A Cost-Effective Superior-MLC
Solution With Similar Performance,
Endurance and Reliability to SLC

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.

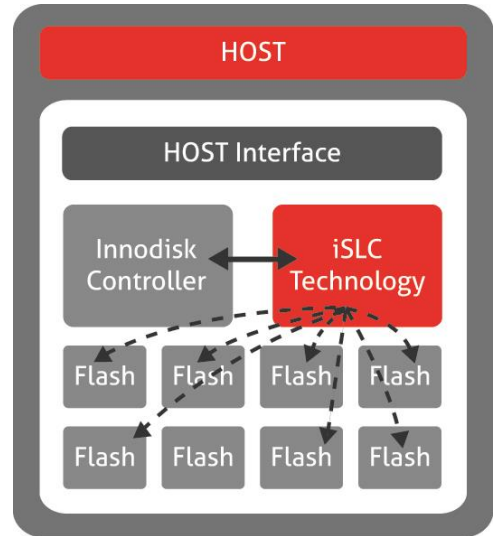


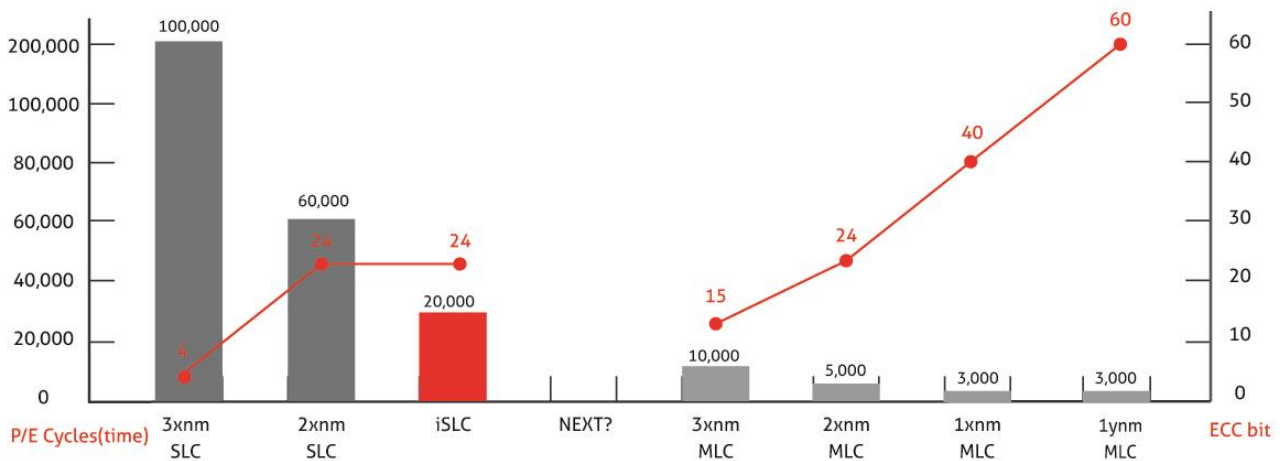
Table 1. Comparing SLC and MLC

	Program Page	Erase Block	P/E Cycle	ECC
SLC (24nm)	400µs	4ms	60K	24 bit/ 1024Bytes
MLC (15nm)	1400µs	5ms	3K	40 bit/ 1024Bytes

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 3Xnm to 2Xnm and 1Xnm, manufacturers require higher ECC capabilities to compensate for the decrease in reliability and endurance.

Figure 1 : MLC NAND Flash Trend

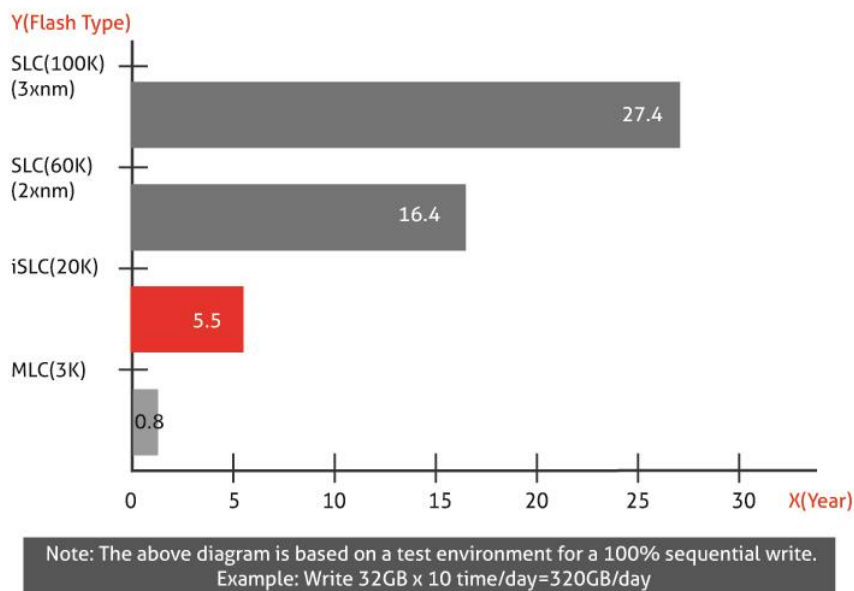


Innodisk has developed iSLC as a hybrid solution for those that require high-performance at a lower price point. Innodisk enhances superior MLC through screening and programming by our exclusive firmware. The firmware reprograms two bits per cell into one bit per cell, which increases the sensitivity of data 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 write 10 full disk per day throughout a 5.5 year lifespan while the MLC can only last for 0.8 year life. See Figure 2.

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

Figure 2: iSLC increase demands on endurance.

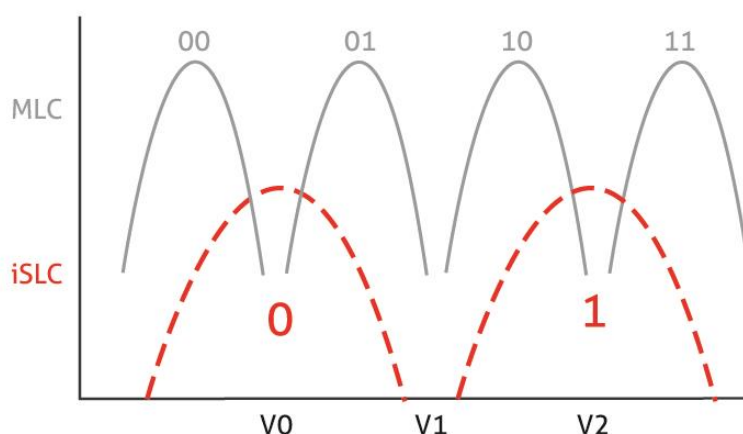


How iSLC Works

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.

Figure 3: iSLC firmware technology empower MLC



Testing Data

The average endurance in iSLC can surpass 20,000 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	16GB	16K	34,733	0	532
2	32GB	16K	22,797	0	657

Our tests show the error bits of iSLC are much lower than MLC. When Comparing the technology nodes of iSLC and MLC, 1xnm iSLC P/E cycle reached 20,000 times with error bits under 24 bits, while 1xnm MLC P/E cycle reached 3,000 times with error bits up to 40 bits. Table 3 shows ECC bits comparison between iSLC and MLC.

Table 3: ECC bits Comparison between iSLC and MLC

Flash Type	Capacity	Average Erase Count	ECC
iSLC	16GB	34,733	15 bits
MLC	32GB	22,797	40 bits

Write performance for iSLC NAND flash is about 10% slower than SLC NAND Flash while MLC NAND flash is approximately 50% slower than SLC NAND flash. This is a significant jump in performance over typical MLC solutions. See Table 4.

Table 4: Comparing the Write performance for SLC, iSLC and MLC on SATA III

Write (Max. MB/s)	1 CH	2 CH	4 CH
SLC	NA*	110	230
iSLC	50	100	230
MLC	20	40	140

*SLC starts with 2 channels.

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's 3IE3 series includes the following :

- 2.5" SATA SSD
- CFast
- mSATA
- SATA Slim
- ServerDOM
- M.2
- nanoSSD
- SATADOM

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, Innodisk's 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. Innodisk offers 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. Innodisk continually strives for innovation, while providing system integrators and end customers with the best service in the industry.

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The logo for Innodisk, featuring the word "innodisk" in white lowercase letters on a red rectangular background. A small red square is positioned above the top right corner of the main red rectangle.

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