White Paper

Innodisk iData Guard Technology for SSDs

Introduction

Data Integrity In the Event of Abnormal Power Failure in SSDs

Data integrity during an unexpected loss of power is a critical issue in industrial applications such as data recorders, enterprise data centers, medical devices, network appliances, etc. Innodisk's iData Guard is our patented Power Cycling DATA Management system, that ensures data integrity in case of a sudden power outage. Innodisk's iData Guard is comprised of a hardware and firmware power-down recovery algorithm that reduces the probability of data loss and corruption.

The Importance of iData Guard Data Protection

Solid-state drives (SSDs) are more robust than traditional HDDs; they are more engery efficient, have faster read/write/access times, and have longer MTBF. However, neither device can prevent an abnormal power failure. Systems may not always properly shutdown, in which case users may find their drives susceptible to data and file corruption. The programming operation in a flash-based SSD needs to be completed to ensure that the data is stored successfully. If the operation is stopped due to loss of power, there can be inconsistencies in the data; the page may not load successfully, and an ECC failure may occur. Innodisk iData Guard technology resolves this issue with a built-in low power detector (4V by 5V power-in; 2.9V by 3.3V power-in)on our SSDs, to check for a sudden loss of power. Once the low power detector is triggered, a safe power-down recovery algorithm is executed to help prevent data loss and ensure data integrity.

Innodisk SSDs: Handling a Power Failure

Innodisk iData Guard technology implements both hardware and firmware-based power failure protection. When the built-in power failure circuit detects an abnormal power failure, the SSD will not accept any new commands from the host. Our circuit design will ensure that the SSD has enough power for the last programing operation. If the input voltage is also unstable, our circuit will be triggered to prevent further data input to the NAND flash. See Figure 1 below.

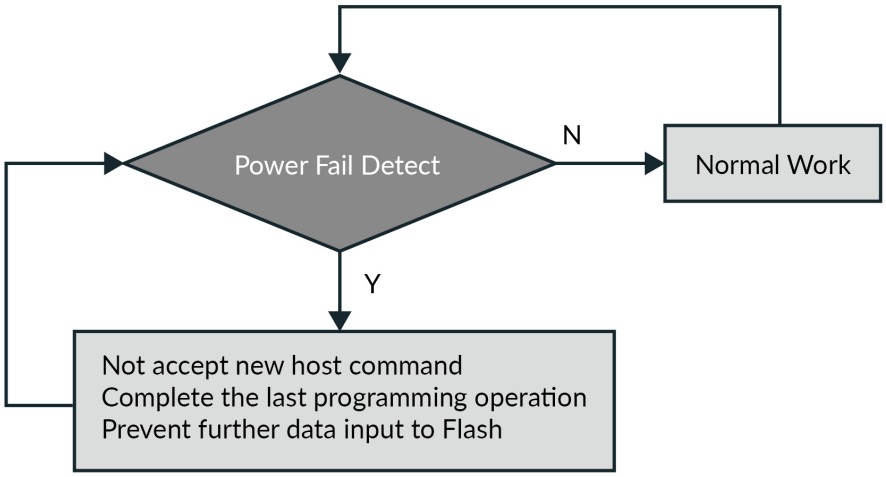

Figure 1: Power Failure Data Protection Block Diagram of Innodisk SSDs

When an unexpected power failure interrupts the page data access, the data operation stops and can cause data inconsistencies. Upon power restoration, the data will not load successfully, and an ECC failure will occur on the page. Innodisk's power-down recovery algorithm resolves this issue when power is restored to the drive. Our controller accesses each block in sequence, reading the logical address for table mapping to rebuild the original mapping table of the data. In addition, the firmware also merges the data of active blocks from before an abnormal power interruption into new active blocks. See Figure 2 below.

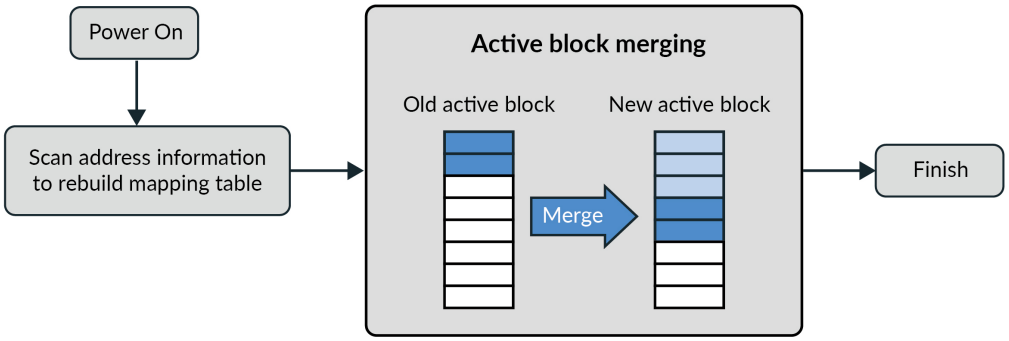

Figure 2: Power-down Recovery Algorithm Block Diagram of Innodisk SSDs

Innodisk's Power-Down Recovery Algorithm: How it Works

Innodisk's patented firmware executes table remapping to delete the corrupted data. A mapping table is also coded into the SSD's NAND Flash IC. This serves as a translation table between logical and physical addresses. Based on the instructions in the mapping table, the internal microprocessor translates logical addresses assigned by the host into different physical pages and blocks within the NAND Flash.

Using logical block addressing (LBA), the controller processes the LBA consistent with firmware information available in the spare blocks. Figure 3 shows the logical to physical address data translation.

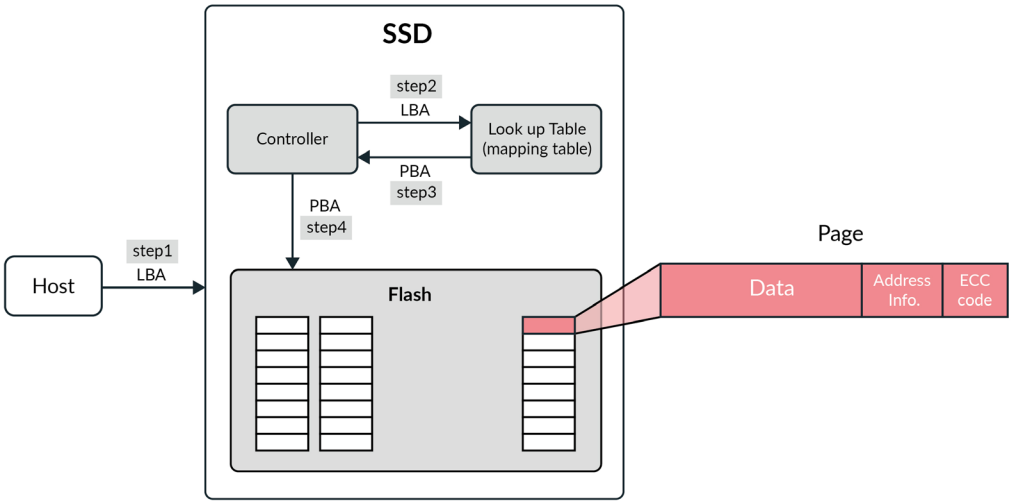

Figure 3: Logical to Physical Address Data Translation

Figure 4 illustrates a flow chart for rebuilding the mapping table after power is restored from an abnormal power failure.

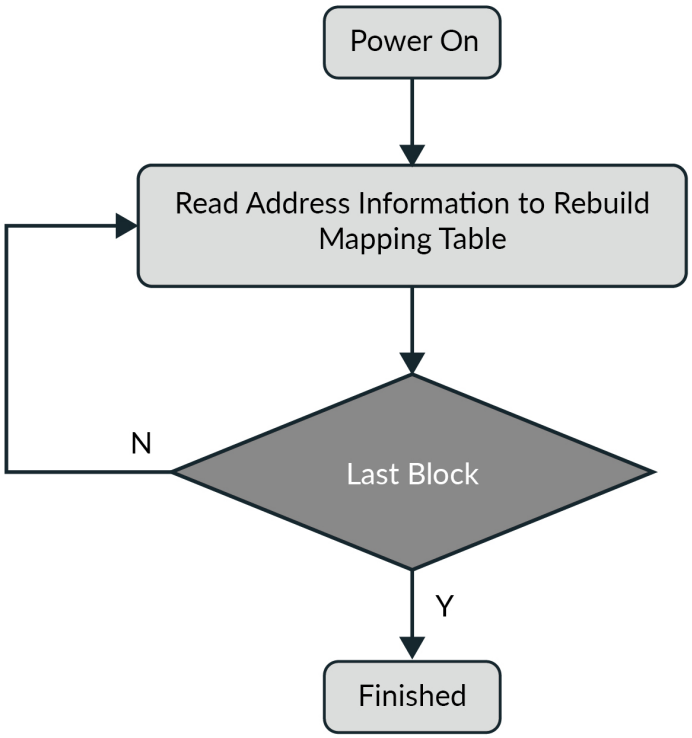

Figure 4: Mapping Table Rebuild Flow after Power On

Because an abnormal power interruption can lead to unexpected demage and disruptions in the block currently in operation, such incidents can undermine the accuracy and integrity of the data within the block. Consequently, the firmware combines the valid data from this block with new, stable blocks to ensure data accuracy and integrity. Figure 5 below provides a visual representation of this process.

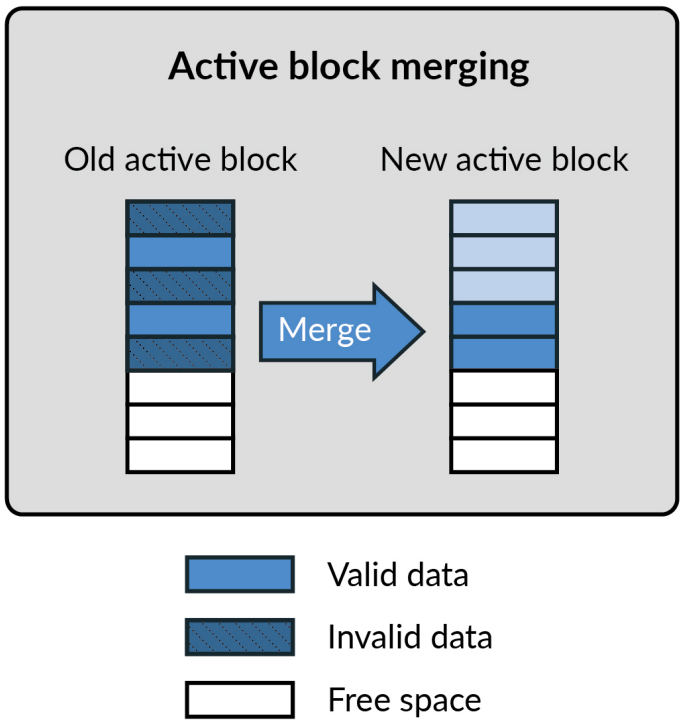

Figure 5: Data Block Merging

In Figure 5, if an abnormal power failure occurs during Page F3 data access, the data operation is stopped, resulting in data inconsistency. The data on Page F3 is not loaded successfully and an ECC failure occurs on that page. Innodisk's iData Guard resolves this issue by reading Page F3 and finding the ECC failure. Our controller then sends instructions to merge the valid data from the Data Block with data from the Free Block, to create a new entry in the New Data Block. Data from Page F0, F1 and F2 and data from Page D3 are collected and then sent to the last page in the New Data Block.

When the merge is completed, the New Data Block replaces the original block. Our controller then erases the data from the Data Block and the Free Block, and performs a garbage collection.

Conclusion

Innodisk iData Guard is a critical element to ensuring data integrity, and provides a reliable power failure protection to Innodisk's SSDs. Our circuit design enables a drive to complete the Power-Down Recovery Algorithm once the trigger detects low power. Innodisk has designed the iData Guard feature to aid in the prevention of data loss, and to protect our partner's data. Unexpected power loss may not be preventable, and data loss/ corruption doesn't have to be inevitable.

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