Embedded Multi-Media Card (eMMC)

Firmware Configurations

Application processors are a common choice for controlling embedded products due to their processing power, integrated peripherals, power saving features, and low cost. These processors typically rely on external flash storage devices such as embedded Multi-Media Card (eMMC). Embedded applications can have a variety of diverging requirements for flash storage to include performance, capacity, power consumption, usable device life and cost. The eMMC standard supports many features that can be customized to tailor the device to the specific embedded application requirements. In addition to these customizations, Kingston offers three different base firmware configurations for eMMC. These firmware configurations determine how data is stored within the NAND flash cells. This paper provides a description of each configuration along with advantages that help you choose which configuration would be best for your application.

Native Mode: With this firmware, the NAND flash cells are configured in their original (native) mode where each cell is typically divided into multiple energy levels to store more than one bit of data. For Multi-level Cell (MLC) NAND flash technology, each NAND cell is divided into 4 energy levels to store 2 bits per cell. The latest generations of NAND use a 3D structure with NAND cells organized into several layers. This technology has cells that are typically configured as 3 bit per cell (TLC), by dividing the cell into 8 energy levels. With this native mode configuration, maximum device capacity is achieved. Native mode firmware is best for applications that require: 1) consistent, uniform performance; 2) full device storage capacity while maximizing device life.

Pseudo Single Level Cell (pSLC): Both endurance and write performance can be boosted with a firmware that configures the NAND flash cells to two energy levels to store a single bit of data. This configuration will increase the device endurance substantially in addition to boosting write performance. Typically, pSLC mode endurance can be increased by a factor of ten over the native configuration. This is achieved due to higher signal to noise margin within the NAND flash cell. Since the pSLC cell only contains a single bit, the NAND cell can be programmed faster, resulting in faster device level write speed. Overall, device storage capacity is reduced with the pSLC configuration. Since TLC NAND will be reduced from 3 bits per cell to one, the overall storage capacity is reduced to one third of the original native storage capacity. When configuring MLC NAND to pSLC, storage capacity is reduced by one half of the original capacity since the cells are converted from two bits to one. The term "pseudo" is used to describe the single level cell configuration when the NAND flash was originally designed to support more than one bit per cell. In general, the pSLC configuration is a great choice for long life applications that will write substantial amount of data over the life of the product. Applications that need consistent, high write performance will also benefit from pSLC configuration.

Dynamic Boost: Applications that require high storage capacity typically will have the NAND configured in native mode. However, write performance can be improved for some situations with a hybrid configuration. In this configuration, the eMMC device will report the full native mode capacity. However, initially, the device will start in pSLC mode. While in pSLC mode, the device will achieve higher write speed. As the device capacity nears maximum utilization in pSLC mode, the device will start to convert NAND flash cells back to their native configuration. The Kingston Dynamic Boost configuration

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is sometimes referred to as Dynamic SLC, since the cells are initially in pSLC mode but are dynamically converted back to the native mode as more storage capacity is needed. The Dynamic Boost feature can lower the total amount of data that can be written to the device over its lifetime. Dynamic Boost is best for applications that require the maximum storage capacity that the device can support while providing increased write performance for improved user experience. For embedded applications that do not benefit from the boosted write performance, Kingston recommends using native mode firmware without Dynamic Boost. This will offer the highest total amount of data that can be written over the device life cycle while the NAND is in native mode configuration. Table 1 below summarizes the three different firmware configurations.

Firmware Configuration	Performance	Life (TBW)	Storage Capacity
Native Mode	Baseline/ Consistent	Baseline	Highest
Native Mode with Dynamic Boost	Improved	Less than Baseline	Highest
Pseudo Single Level Cell	Highest	Highest	Reduced by: 50% for MLC 66% for TLC

Table 1

In addition to the firmware configurations discussed in this paper, there are many additional ways that eMMC configurations can be tailored to support a particular embedded application. Many of these configurations can be performed in the field. Kingston can also support these custom configurations as well as preloading content directly from the Kingston factory. Contact your Kingston representative or visit www.kingston.com/embedded for more information.

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