swissbit®

EM-20 e•MMC Production State Awareness (PSA)

White Paper

BU: Flash Products
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Content

1 Overview

The Swissbit EM-20 e·MMC product is an industry compatible solution following the JEDEC e·MMC 5.0 Standard (JESD84-B50).

With the JEDEC spec 5.0 a feature called "Production State Awareness (PSA)" has been introduced in order to allow pre-loading of data onto the e·MMC and a successive reflow process without corrupting the pre-loaded data.

The document is valid for following EM-20 part numbers:

Density	Part Number	Temp. Range	Flash Technology
8GB	SFEM008GB1EA1T0-I-GE-111-STD	-40°C to 85°C	MLC NAND Flash
16GB	SFEM016GB1EA1T0-I-GE-111-STD		
32GB	SFEM032GB1EA1T0-I-LF-111-STD		
64GB	SFEM064GB1EA1T0-I-HG-111-STD		

2 MLC and SLC mode retention

The data retention of NAND flash technology is very temperature sensitive. Exposure to high temperature degrades the data content stored in NAND flash and may cause high bit failure rate up to unreadable content.

e·MMC products are BGA balled managed flash components that are designed for integration an PCB balls through a reflow soldering process. The reflow process applies high temperature up to 260°C to the BGA package and causes a strong reduction in the charge distribution of the NAND cell.

In most cases the e·MMC will be used in MLC mode (2 bit data per cell with 4 different charge level distributions).

After data upload the potential information in the NAND cell is well distinguishable and the bit failure rate is low. (see Fig 1)

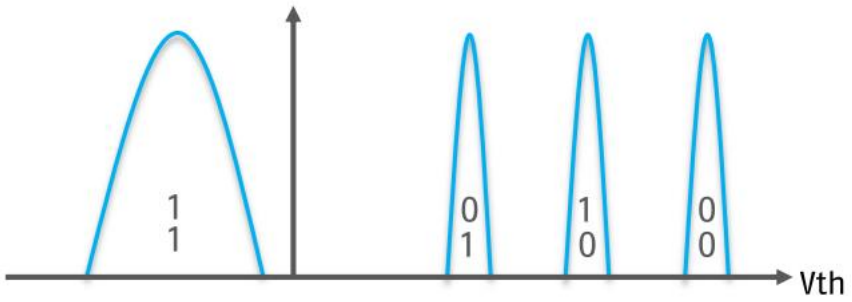

Fig. 1) MLC mode charge distribution after data upload

After the reflow process the charge distribution in the cells experience a differently strong degradation, resulting in potentially overlapping bit coding. (See Fig 2, red areas)

This could result in pages with high bit error rate or even uncorrectable data.

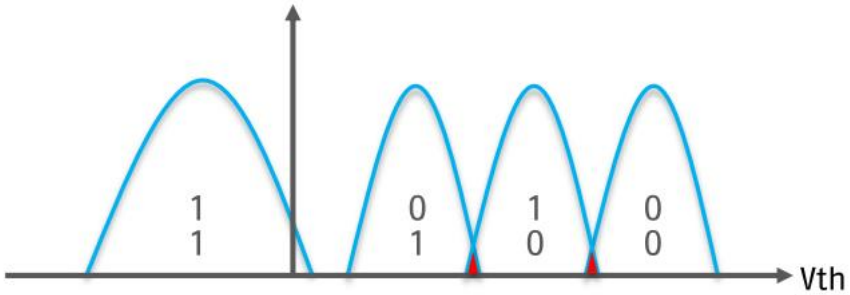

Fig. 2) MLC mode after reflow process with uncorrectable information

One way to overcome this limitation is to use the e·MMC in reliable mode when being programmed. In reliable mode only the strong bit of the MLC cell is used which has a much higher retention and has distinguishable charge distributions even after a reflow process.

Fig 3. shows the bit coding when only the strong bit is used and Fig 4. the distribution after degradation by the reflow process.

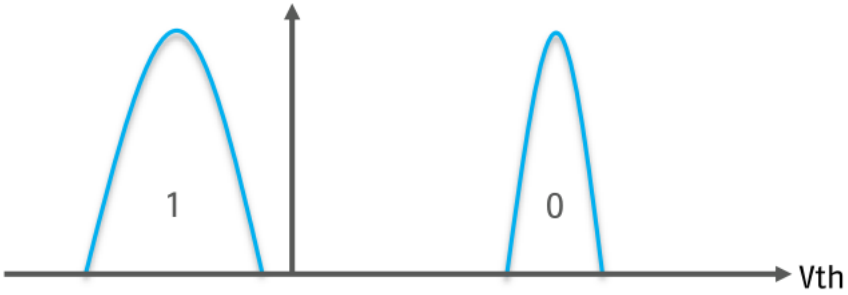

Fig. 3) Reliable (SLC) mode charge distribution after data upload

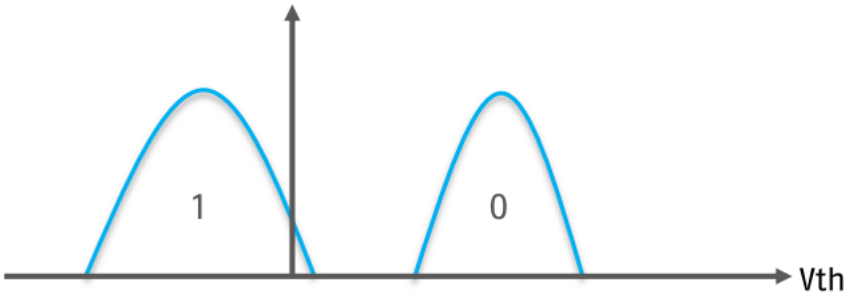

Fig. 4) Reliable (SLC) mode charge distribution after reflow process.

The diagrams show the degradation process also happening to SLC mode, but there is still enough gap to identify reliably the programmed data.

Uploading data in SLC mode is the solution to overcome the degradation effect caused by the solder process. EM-20 configured in reliable mode has this SLC mode as native operation type. The limitation to this is that the usable capacity in SLC mode is only half of the MLC capacity.

The Production State Awareness overcomes this limitation by offering an automated way to switch between SLC upload and MLC operating mode.

3 Production State Awareness

As discussed in the previous chapter it is desirable to upload data in the pre-solder process in SLC mode.

The EM-20 offers 2 configuration registers to control this process:

PRODUCT_STATE_AWARENESS_ENABLEMENT:	turns PSA on
PRE_LOADING_DATA_SIZE:	defines the range of capacity reserved for upload data, maximum ½ of the MLC capacity.
PRODUCTION_STATE_AWARENESS:	Controls the different states of EM-20 production 0x0 = normal MLC mode operation 0x1 = pre soldering, ready for upload 0x2 = pre soldering, post writes

After enabling the PSA and defining the upload data size the EM-20 should be set in "PRE-SOLDERING_WRITES" state. This will cause all following writes to happen in SLC mode.
The maximum data capacity that can be used in this mode is ½ of the MLC capacity due to the fact that only one of the two bits per cell are used.

The respective bits need to be set by the host controller of the upload tool.

Once all data has been uploaded the host controller or tester needs to set the state to "PRE_SOLDERING_POST_WRITES" to freeze the data. No further writes are allowed beyond this point.

The EM-20 is now ready for the soldering process and integration into a host system.

Once the host system powers up, the BIOS or device driver needs to switch the PSA status to NORMAL. In this mode the controller and firmware will operate the NAND flash in MLC mode.
Depending on the upload data size it may be necessary that each 2 SLC pages are merged into one MLC page to free up empty pages. Over time the SLC mode is fully converted into MLC storage.

For optimized performance the SLC mode is maintained until the limitation of free pages forces a merge into MLC.

In NORMAL state the full capacity of the EM-20 in MLC mode is available.

The implementation of PRODUCTION_STATE_AWARENESS enables up to 3 reflow soldering passes of the EM-20. It is recommended though to limit the storage time between the reflow passes.

4 Document History

Table 1: Document Revision History

Date	Revision	Details
16-Jun-2017	1	Initial release