BG96 Flash Scrub

Application Note

LTE Module Series

Rev. BG96_Flash_Scrub_Application_Note_V1.1

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Status: Released

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About the Document

History

Revision	Date	Author	Description
1.0	2018-08-20	Matt YE	Initial
1.1	2018-09-27	Matt YE	1. Deleted AT+QSCRUBCFG="enable" command. 2. Added AT+QSCRUBCFG="scrubtime" command.

Contents

Table Index

1 Introduction

This document mainly introduces the Flash Scrub feature and also describes how to use Flash Scrub function of Quectel BG96 module.

2 General Overview

NAND Flash stores data (bits 0 and 1) in an array of memory cells made from floating gate transistors, and the reliability of these memory cells varies with respect to temperature. As temperature increases, the charge held in the memory cells deteriorates until the stored value is lost.

The following are NAND Flash limitations that should be handled in software such as the Flash Scrub feature:

- **Bad blocks and wear leveling**

  While writing a page or erasing a block, the NAND Flash blocks can become bad at runtime. This must be handled in the software by relocating the pages still held in the bad block to a new good block. Also, the software must use all the NAND Flash blocks equally (wear leveling) to get maximum usage from the NAND Flash.

- **Read disturb**

  Reading a NAND page can cause side effects to nearby memory cells in the same block, and excessive reads can eventually cause the memory cells to lose their charge and stored data value. The software must address this issue by avoiding excessive page reads.

- **Long-term data retention**

  Data stored in NAND Flash deteriorates over time (even when not used). The rate of deterioration increases rapidly as the temperature increases. The software must handle this by periodically relocating the NAND data from deteriorating NAND blocks to fresh, good NAND blocks.

3 How Flash Scrub Works

The Flash Scrub module periodically performs scrubbing by keeping track of the elapsed time since the module startup and initiating scrubbing when the scrub timer threshold is reached. For example, if a periodic Flash Scrub is configured to occur once every four months, then the Flash Scrub module ensures that one scrub occurs every four months.

All code partitions that require scrubbing are grouped together in the NAND Flash. At the end of the code partitions group, there is a new NAND partition, called the scrub partition. This scrub partition is larger than the biggest code partition and has extra blocks to accommodate bad blocks for 15 years of NAND Flash use.

When Flash Scrub starts, the scrub partition is continuously moving up and down one code partition at a time such that the code partition is written on fresh NAND blocks held by the scrub partition. The scrub partition takes over the old partition NAND blocks as illustrated in the example below.

1. In the NAND card shown in the figure below, TZ, RPM and QDSP partitions are grouped to do scrubbing.
2. The scrub partition is created at the end of these grouped partitions.
3. Start scrubbing by moving the QDSP partition to the end of the scrub partition.
4. Compute MD5-hash on the new partition and confirm that it matches the old one.
5. After moving, erase the old QDSP partition.
6. Repeat with the RPM partition and then with the TZ partition.
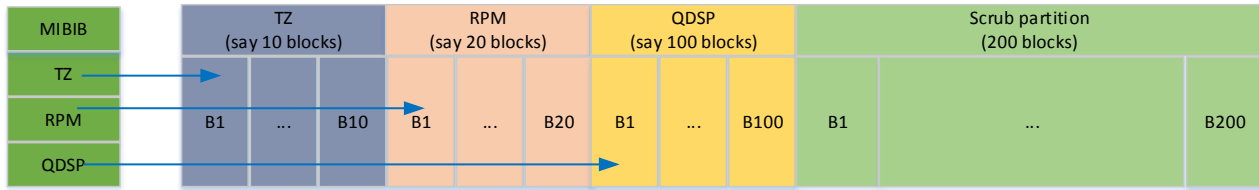
Copy the 100 blocks of QDSP partition to the end of Scrub partititon
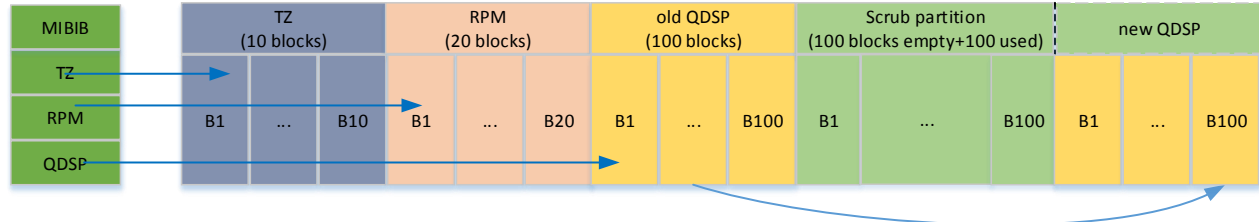
Update MIBIB to point new location
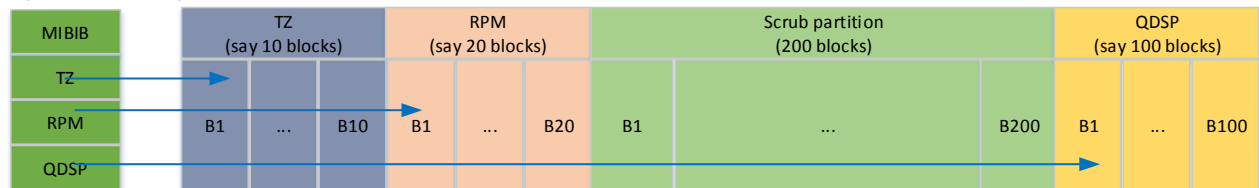
Now scrub partition gets back the 100 blocks and we can now do scrubbing for the next partition(RPM)

Figure 1: Flash Scrub for Code Partitions

4 Flash Scrub Related AT Commands

4.1. AT+QSCRUB   Start Flash Scrub

The command is used to start Flash Scrub.

AT+QSCRUB Start Flash Scrub	
Write Command **AT+QSCRUB=<mode>**	Response **OK** **+QSCRUB: "START"** **+QSCRUB: "END",<err>** If there is any error related to ME functionality: **+CME ERROR: <errcode>**
Read Command **AT+QSCRUB?**	Response **+QSCRUB: <scrubbing>** **OK**
Maximum Response Time	300ms
Reference	

Parameter

<mode>	Integer type. 1 Start Flash Scrub
<scrubbing>	Integer type. 0 Not in scrubbing 1 In scrubbing 2 Scrub not supported
<err>	Integer type. 0 means scrubbed successfully. Any other value means an error. Please refer to *Table 1* for details.
<errcode>	Integer type. The error code of operation. Please refer to *Table 2* for details.

Example

AT+QSCRUB=1 //Start Flash Scrub.
OK

+QSCRUB: "START"

+QSCRUB: "END",0

> **NOTE**
>
> It is recommended to perform Flash Scrub once every four months.

4.2. AT+QSCRUBCFG Flash Scrub Configurations

The command is used to configure Flash Scrub settings.

AT+QSCRUBCFG Flash Scrub Configurations	
Test Command **AT+QSCRUBCFG=?**	Response **+QSCRUBCFG: "scrubtime",<time>** **+QSCRUBCFG: "scrubdirection"** **OK**
Reference	

4.2.1. AT+QSCRUBCFG="scrubtime" Configure the Automatic Scrub Time

AT+QSCRUBCFG="scrubtime" Configure the Automatic Scrub Time	
Write Command **AT+QSCRUBCFG="scrubtime"[,<time>]**	Response When **<time>** is not omitted, configure the automatic scrub time: **OK** **+QSCRUB: "START"** **+QSCRUB: "END",<err>** When **<time>** is omitted, query the current setting: **+QSCRUBCFG: "scrubtime",<time>**

	OK If there is any error related to ME functionality: **+CME ERROR: <errcode>**
Maximum Response Time	300ms
Reference	

Parameter

<time>	Integer type. Timer value for the automatic periodic scrub. Range: 0 or [16,480]. Unit: week. 0　　　　Disable automatic scrub Others　　Timer value of automatic periodic scrub
<err>	Integer type. 0 means scrubbed successfully. Any other value means an error. Please refer to *Table 1* for details.
<errcode>	Integer type. The error code of operation. Please refer to *Table 2* for details.

Example

```
AT+QSCRUBCFG="scrubtime",16        //Enable Flash Scrub.
OK

AT+QSCRUBCFG="scrubtime"           //Query the current setting.
+QSCRUBCFG: "scrubtime",16

OK

+QSCRUB: "START"                   //16 weeks later, start flash scrub.

+QSCRUB: "END",0
```

NOTES

1. The command will be effective after restart.
2. The default automatic scrub time is 17 weeks (more accurately 124 days).

4.2.2. AT+QSCRUBCFG="scrubdirection" Query the Flash Scrub Direction

AT+QSCRUBCFG="scrubdirection" Query the Flash Scrub Direction	
Write Command **AT+QSCRUBCFG="scrubdirection"**	Response **+QSCRUBCFG: "scrubdirection",<direction>** **OK** If there is any error related to ME functionality: **+CME ERROR: <errcode>**
Maximum Response Time	300ms
Reference	

Parameter

<direction>	Integer type. Flash Scrub direction. 0 Reverse 1 Forward
<errcode>	Integer type. The error code of operation. Please refer to *Table 2* for details.

Example

AT+QSCRUBCFG="scrubdirection" **+QSCRUBCFG: "scrubdirection",1** **OK**	//Query the current scrub direction.

NOTES

1. The initial **<direction>** is 1 ("Forward"). If **AT+QSCRUB=1** or automatic scrub is executed, it will change into 0 ("Reverse").
2. Before download firmware by QFlash, please make sure **<direction>** is 1.
3. If **<direction>** is 0 and upgrading with DFOTA in such case, flash scrub will be executed automatically before upgrading.

5 Summary of Error Codes

Table 1: Summary of <err> Codes

<err>	Meaning
0	Scrubbed successfully
-1	Scrubbed too often
-2	Operation not permitted
-3	Writing file error
-4	Invalid parameter

Table 2: Summary of <errcode> Codes

<errcode>	Meaning
323	Invalid parameter
440	Flash Scrub not supported
441	Scrub is ongoing
442	DFOTA is ongoing

6 Appendix A References

Table 3: Terms and Abbreviations

Abbreviation	Description
DFOTA	Delta Firmware Upgrade Over-the-air
MIBIB	Multi-Image Boot Information Block
QDSP	Qualcomm Digital Signal Processor
RPM	Resource Power Manager
TZ	Trust Zone