

**GigaDevice Semiconductor Inc.**

**GD32A503/A513 系列 ECC 双位错误说明**

**应用笔记**

**AN175**

1.0 版本

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## 1. 简介

在进行写操作时，编码器会产生 ECC 码，和数据一起写入存储单元。在进行读操作时，解码器会对存储单元原始数据和 ECC 码进行解析及校验。ECC 可实现 1 个 bit 纠错及 2 个 bit 检错的功能，无法判断 2 个 bit 以上的错误。

该应用笔记介绍了 SRAM / flash 发生 ECC 双位错误时，常用处理办法。

## 2. ECC 双位错误产生的 NMI 中断

SRAM / Main flash / OTP 发生 ECC 双位错误后，程序会进入 NMI 中断。如果 NMI 中断处理函数不清除 ECC 标志位，会造成 NMI 中断持续触发，从而影响调试器连接。

建议处理方法：进入 NMI 中断后，记录 ECC 信息，设置查询标志，清除标志位。主程序中通过查询标志来判断是否产生了 ECC 错误，如果产生了错误再做进一步处理。

### 3. ECC 双位错误场景

#### 3.1. SRAM 的 ECC 双位错误

对未初始化的SRAM地址进行读操作，很可能会因为SRAM原始数据和ECC码不匹配而产生ECC双位错误。

处理方法：在SRAM读操作之前需要对可能被访问的SRAM地址进行初始化。推荐在启动文件中对所有SRAM地址进行初始化。

**图 3-1. SRAM 初始化**

```

Reset_Handler PROC
EXPORT Reset_Handler [WEAK]

LDR r0, =0x1FFF7E0
LDR r2, [r0]
LDR r0, =0xFFFF0000
AND r2, r2, r0
LSR r2, r2, #16
LSL r2, r2, #10
LDR r1, =0x20000000
MOV r0, #0x00
SRAM_INIT STM r1!, {r0}
SUBS r2, r2, #4
CMP r2, #0x00
BNE SRAM_INIT

IMPORT SystemInit
IMPORT __main
LDR R0, =SystemInit
BLX R0
LDR R0, =__main
BX R0
ENDP
    
```

在实际应用中，如果不希望复位后对全部的SRAM区域进行初始化，只初始化应用程序可能会访问的地址，则需要注意debug程序时IDE软件有可能访问到SRAM，当IDE访问到未初始化SRAM地址则会触发ECC错误。

#### 3.2. Flash 的 ECC 双位错误

绝大多数情况下，ECC错误是由于操作时电压低，断电或者复位导致，物理存储单元并没有实质性的损坏。FMC\_ECCCS寄存器中ECCADDR[14:0]记录了出错地址，擦除出错地址后可以继续使用，擦除后原有数据丢失。

**表 3-1. ECC 错误地址描述**

出错区域	错误标志	出错地址
Bank0	ECCDET	0x08000000 + ECCADDR[14:0] * 8
Bank1	ECCDET / BK1_ECC	0x08040000 + ECCADDR[14:0] * 8
Data flash	ECCDET / DF_ECC	0x08800000 + ECCADDR[14:0] * 8
System area	ECCDET / SYS_ECC	0x1FFFB000 + ECCADDR[14:0] * 8
Option bytes 0	ECCDET / OB0_ECC	0x1FFFF800 + ECCADDR[14:0] * 8

出错区域	错误标志	出错地址
(读 0x1FFFF80x)		
OTP	ECCDET / OTP_ECC	0x1FFF7000 + ECCADDR[14:0] * 8
EEPROM SRAM	EPECCDET	0x08C00000 + ECCADDR[14:0] * 8
选项字节 0	OB0ECCDET	/
选项字节 1	OB1ECCDET	/

**注意：**如果ECC双位错误发生在选项字节0或选项字节1加载时，ECCADDR[14:0]将不会记录出错地址。

如果Flash使用时间长，考虑到老化失效，如果擦除、编程后再进行读取很可能再次报错，这类出错地址不应继续使用。

### 3.2.1. Main flash / OTP 的 ECC 双位错误

如果main flash / OTP发生ECC错误，出错地址数据返回全F，程序将进入NMI中断，按NMI中断处理建议处理。

**注意：**OTP具有不可擦除的属性，在编程时要确保工作环境的正常稳定。

### 3.2.2. EEPROM 的 ECC 双位错误

如果EEPROM发生ECC错误，出错地址数据返回全F，程序不会进入NMI中断。

EEPROM ECC双位错误一般是由于操作EEPROM时断电或者复位导致，EEPROM ECC双位错误发生时，EPECCDET被置位。出现ECC双位错误意味着EEPROM数据不可靠，需要对EEPROM重新配置后再使用。

EPECCDET标志会在系统复位后被清除，也可能在复位后EEPROM数据重建过程中被再次置位。不管再次复位后是否为0，只要出现过EPECCDET置位的情况都需要重新配置EEPROM。

为及时捕捉EPECCDET置位信息，需要使能FMC ECC双位错误中断。可调用库函数fmc\_interrupt\_enable(FMC\_INT\_ECCDET);来使能双位错误中断。不可如此操作寄存器：FMC\_ECCCS |= FMC\_ECCCS\_ECCDETIE; 因为如果打开中断前就有EEPROMECC错误，那么或操作将对错误标志位写1，导致错误标志位清0。

打开中断后，需要在FMC中断中重新配置EEPROM。

**表 3-2. EEPROM 的 ECC 双位错误处理**

```

if(RESET != fmc_interrupt_flag_get(FMC_INT_FLAG_EPECCDET))
{
    fmc_interrupt_flag_clear(FMC_INT_FLAG_EPECCDET);
    fmc_unlock();
    ob_unlock();
    ob1_eeeprom_parameter_config(OB1CS_DF_32K_EF_32K, OB1CS_EPSIZE_4K);
    ob_reset();
}
    
```



### 3.3. OB0 / OB1 加载时产生的 ECC 双位错误

如果OB0 / OB1加载时发生ECC错误，出错地址数据返回全F，程序不会进入NMI中断。由于OB0 / OB1改写次数少，出现ECC双位错误基本可断定为非正常操作引起的错误，需要重新配置OB0 / OB1。

### 3.4. 总线从 0x1FFFF80x 读 OB0 时产生的 ECC 双位错误

当发生ECC双位错误时，出错地址数据返回全F，程序将进入NMI中断。由于OB0改写次数少，出现ECC双位错误基本可断定为非正常操作引起的错误，需要重新配置OB0。

## 4. 版本历史

表 4-1. 版本历史

版本号.	说明	日期
1.0	首次发布	2023 年 11 月 30 日

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