GigaDevice Semiconductor Inc.

Arm® Cortex®-M4 32-bit MCU

应用笔记

AN029

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1. 前言

GD32F30x 和 GD32F403 都是 GD 近年推出的 Cortex M4 核的产品，这几个系列的产品比较特殊，能够直接运行 F103 的程序，但是原本 F103 的程序是不带 DSP 指令集的，是否有办法可以让客户使用 F103 的程序，然后又可以使用 DSP 指令集和 FPU 功能呢？答案是有的，下面就请看详细的做法。

2. 操作步骤

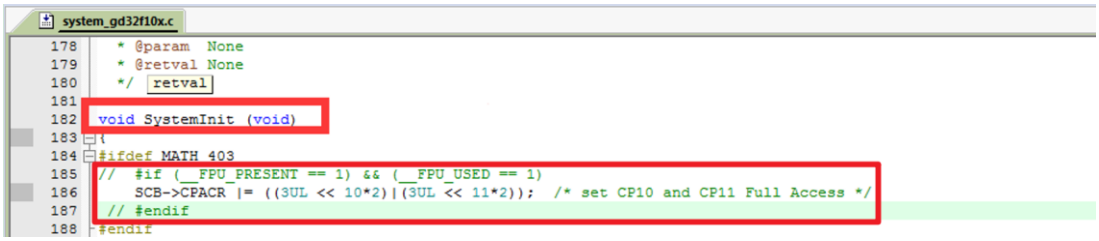
以下操作步骤使用 Keil4 作为示例，Keil5 的配置方法完全一致。

2.1 开启 FPU

303 和 403 均带有 FPU，所以针对 FPU 需要做如下配置：

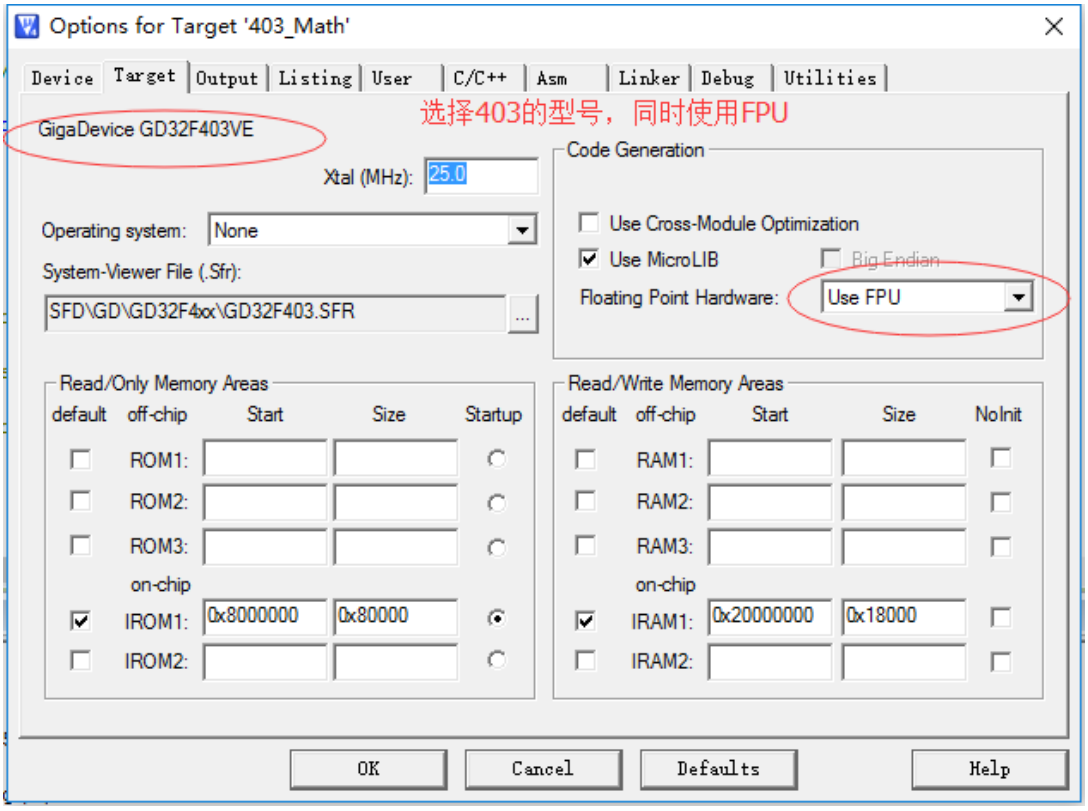
1. 在执行代码之前使能 FPU

图 2-1. 使能 FPU



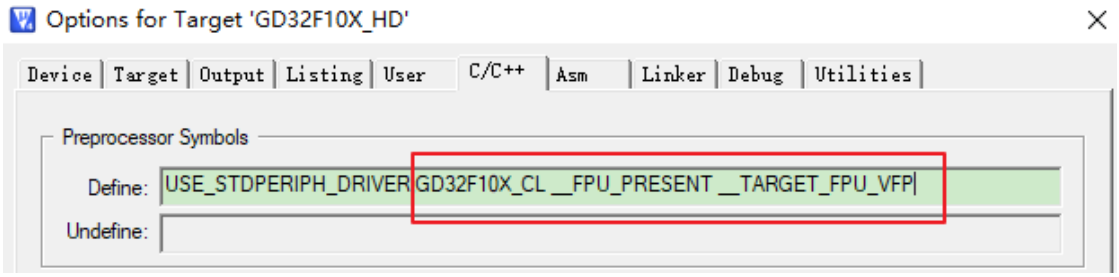
2. 选择 403 的型号，同时使用 FPU

图 2-2. 选择 303 or 403 型号并使能 FPU



3. 填写相应的编译宏定义

图 2-3. 添加相应的编译宏



注意：F403 的需要配置 GD32F10X_CL，F303 和 F103 保持一致。

2.2 查看 FPU 是否开启成功

在 Jlink 调试控制界面下，输入命令：

mem32 0xE000ED88 1

详细操作参见下图，输入命令后得到 00F00000，说明 FPU 已经开启，如果是 00000000 说明 FPU 没有开启。

图 2-4. 查看 FPU 是否开启

```
  T) cJTAG
TIF>swd
Specify target interface speed [kHz]. <Default>: 4000 kHz
Speed>
Device "GD32F303RE" selected.


Connecting to target via SWD
Found SW-DP with ID 0x2BA01477
Scanning AP map to find all available APs
AP[1]: Stopped AP scan as end of AP map has been reached
AP[0]: AHB-AP (IDR: 0x24770011)
Iterating through AP map to find AHB-AP to use
AP[0]: Core found
AP[0]: AHB-AP ROM base: 0xE00FF000
CPUID register: 0x410FC241. Implementer code: 0x41 (ARM)
Found Cortex-M4 r0p1, Little endian.
FPUnit: 6 code (BP) slots and 2 literal slots
CoreSight components:
ROMTb1[0] @ E00FF000
ROMTb1[0][0]: E000E000, CID: B105E00D, PID: 000BB00C SCS-M7
ROMTb1[0][1]: E0001000, CID: B105E00D, PID: 003BB002 DWT
ROMTb1[0][2]: E0002000, CID: B105E00D, PID: 002BB003 FPB
ROMTb1[0][3]: E0000000, CID: B105E00D, PID: 003BB001 ITM
ROMTb1[0][4]: E0040000, CID: B105900D, PID: 000BB9A1 TPIU
ROMTb1[0][5]: E0041000, CID: 00000000, PID: 00000000 ???
Cortex-M4 identified.
J-Link>mem32 0xE000ED88 1
E000ED88 = 00F00000
J-Link>
```

2.3 性能测试对比

编译相关代码，至此就能够直接在 103 的代码上测试 M4 的性能了，测试代码如下：

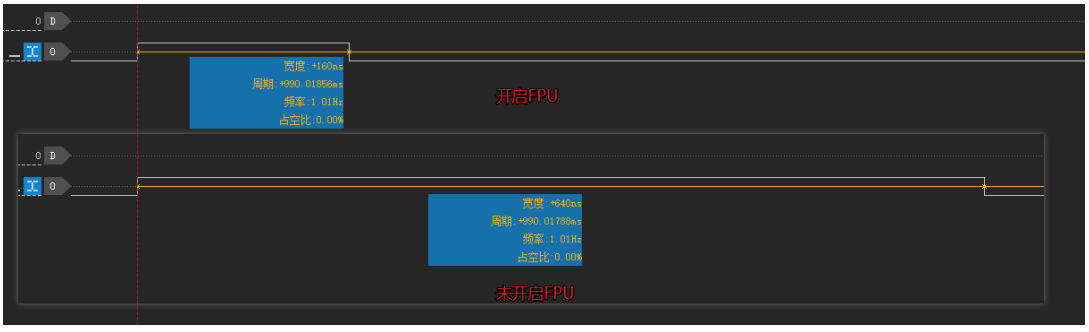
```
int main(void)
{
    float i;
    float m = 2.5f;
    float n = 4;

    /* configure systick */
    systick_config();
    /* initilize the LEDs, USART and key */
    gd_eval_led_init(LED2);
    gd_eval_led_init(LED3);
    gd_eval_led_init(LED4);
    gd_eval_com_init(EVAL_COM0);
    gd_eval_key_init(KEY_WAKEUP, KEY_MODE_GPIO);

    while(1){
        if(RESET == gd_eval_key_state_get(KEY_WAKEUP)){
            gd_eval_led_on(LED3);
            i = m * n;
            gd_eval_led_off(LED3);
            printf("\r\ni = %f", i);
            while(RESET == gd_eval_key_state_get(KEY_WAKEUP));
        }
    }
}
```

用逻辑分析仪抓取 LED3 的引脚波形，查看浮点运算的计算时间，如下是开启 FPU 和不开启 FPU 的测试对比：

图 2-5. 性能测试对比

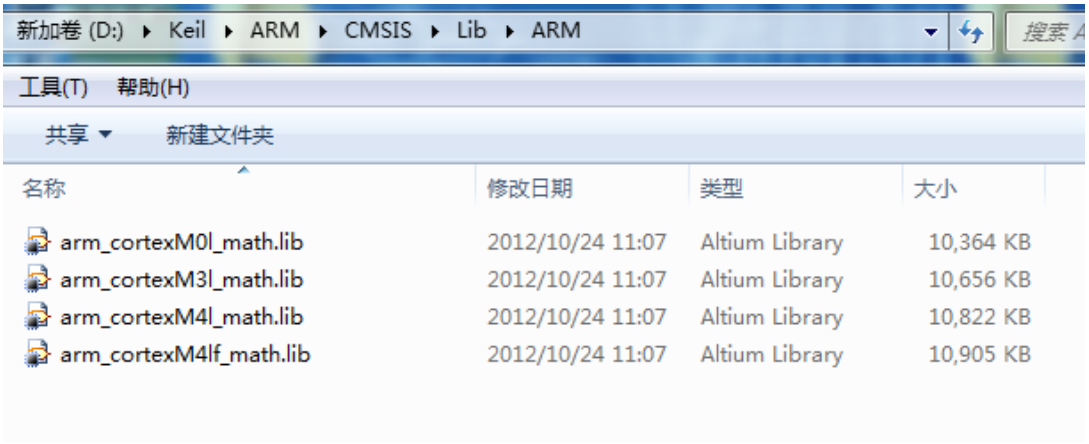


未开启 FPU，一个浮点乘法需要 640ns，开启之后仅需 160ns。

2.4 开启 DSP

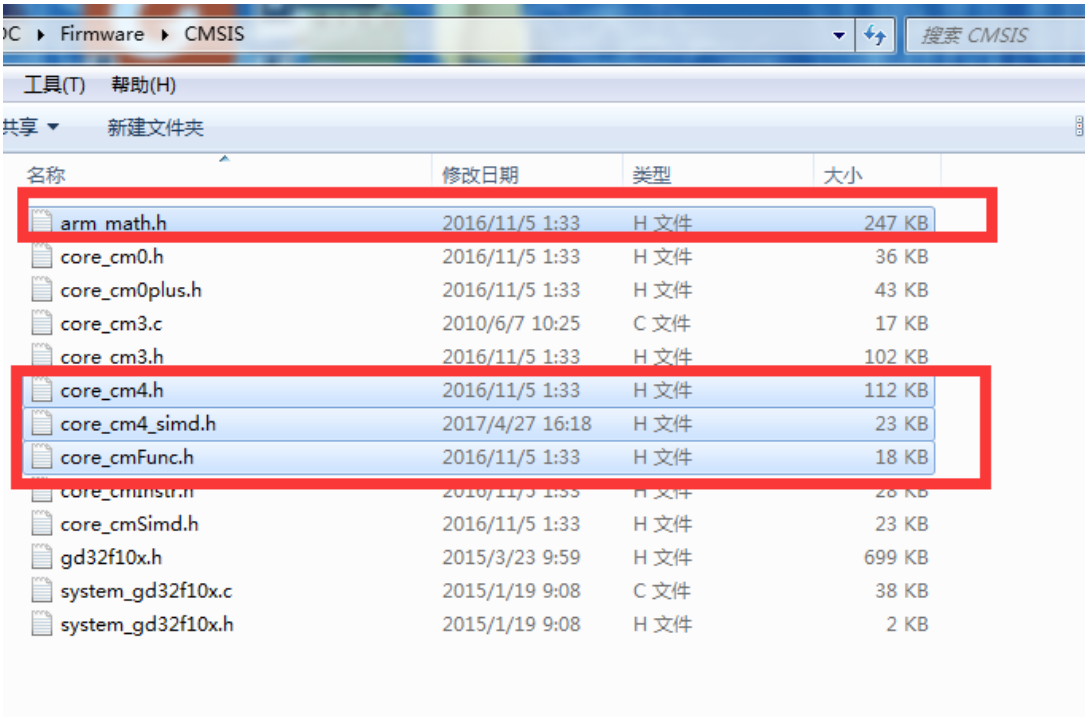
1、从 MDK 路径下拷贝 math.lib，并添加到工程里面，具体文件为 arm_cortexM4l_math.lib（如果是带浮点的需要选择 arm_cortexM4lf_math.lib）

图 2-6. math.lib 文件



2、拷贝相应的.h 文件到工程内部，使用 dsp 需要使用 core_cm4.h

图 2-7. 需要的.h 文件



3、将 gd32f10x.h 里面的 core_cm3.h 修改为 core_cm4.h

图 2-8. core_cm3.h 修改为 core_cm4.h

gd32f10x.h

```
328 #include "core_cm3.h"
329 #include "system_GD32F10X.h"
330 #include <stdint.h>
331
332 /** @addtogroup Exported_types
333   * @{
334   */
```

4、修改工程的型号选择，303 选择相应的 303 型号，403 选择相应的 403 型号，并添加相应的 Math 编译宏

图 2-9. 修改芯片型号

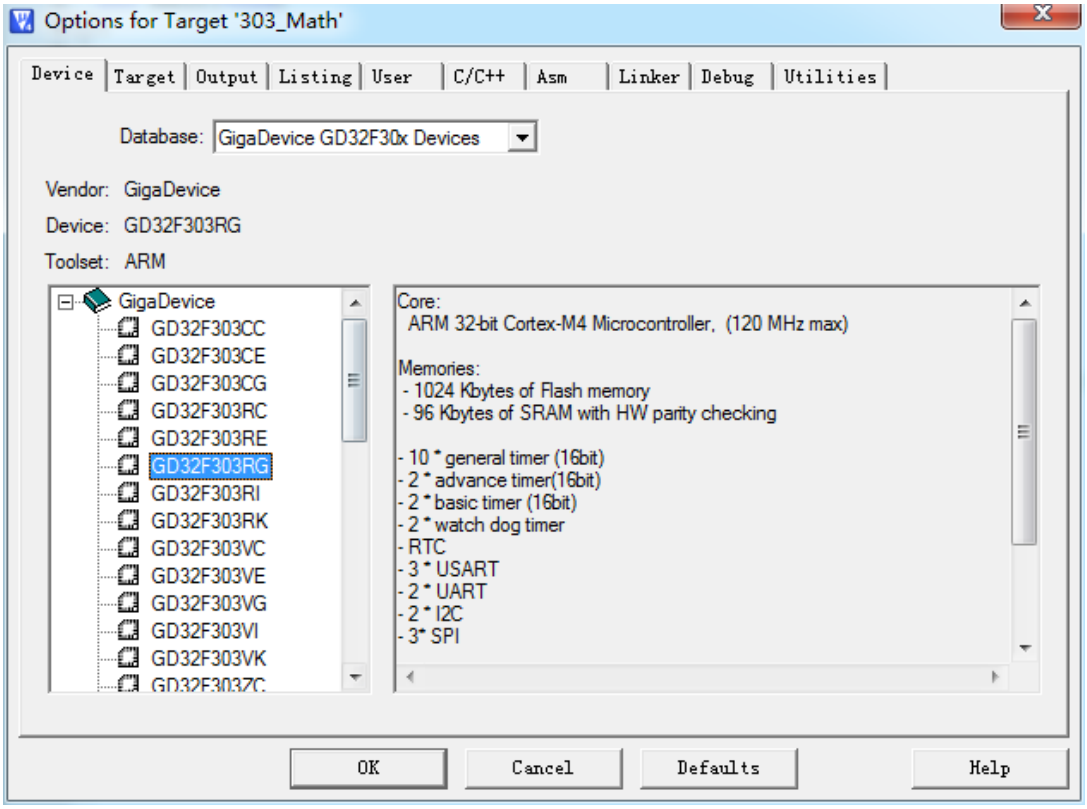
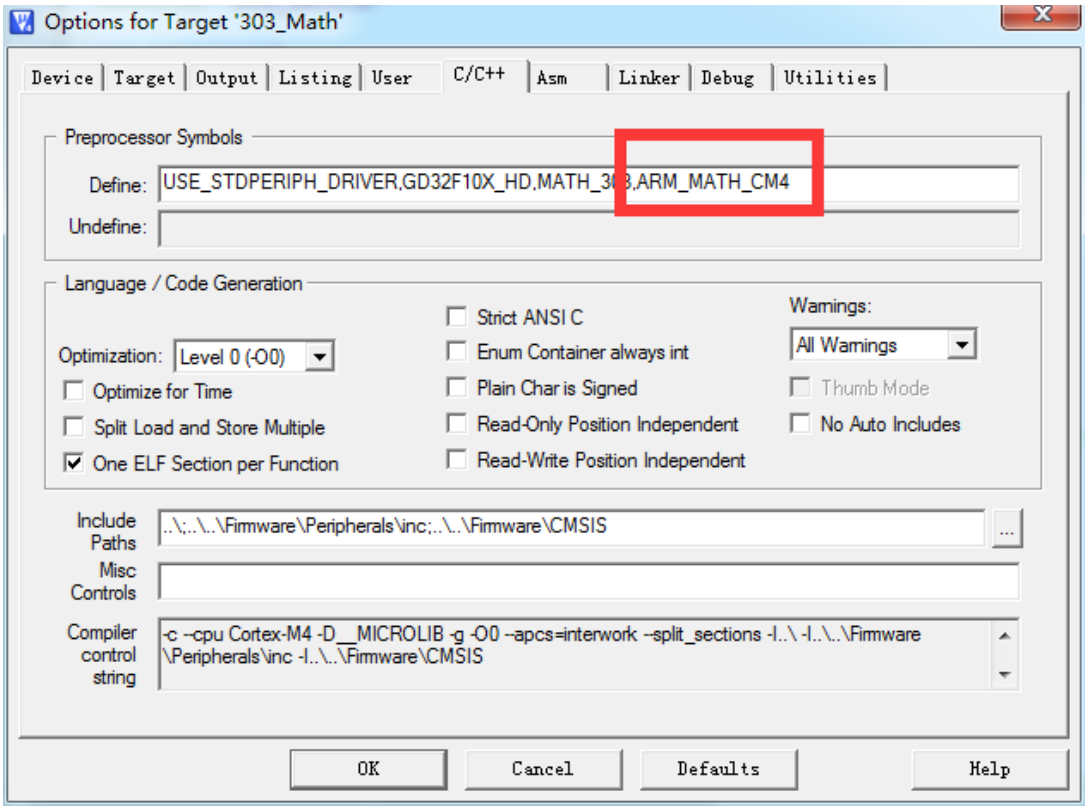


图 2-10. 添加相应的 Math 编译宏



3. 版本历史

表 3-1. 版本历史

版本号.	描述	日期
1.0	首次发布	2021 年 04 月 30 日

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