GigaDevice Semiconductor Inc.

Arm[®] Cortex[®]-M4 32-bit MCU

应用笔记 AN029



目录

| 目录. | | 2 |
|-----|---------------|---|
| 图索 | 引 | 3 |
| 表索 | 引 | 4 |
| 1. | 前言 | 5 |
| 2. | 操作步骤 | 6 |
| 2.1 | 开启 FPU | 6 |
| 2.2 | 查看 FPU 是否开启成功 | 7 |
| 2.3 | 性能测试对比 | 7 |
| 2.4 | 开启 DSP | 9 |
| 3. | 版本历史 | |



图索引

| 图 2-1. | 使能 FPU | . 6 |
|--------|---------------------------|-----|
| 图 2-2. | 选择 303 or 403 型号并使能 FPU | . 6 |
| 图 2-3. | 添加相应的编译宏 | . 7 |
| 图 2-4. | 查看 FPU 是否开启 | . 7 |
| 图 2-5. | 性能测试对比 | . 8 |
| 图 2-6. | math.lib 文件 | . 9 |
| 图 2-7. | 需要的.h 文件 | . 9 |
| 图 2-8. | core_cm3.h 修改为 core_cm4.h | 10 |
| 图 2-9. | 修改芯片型号 | 10 |
| 图 2-10 | .添加相应的 Math 编译宏 | 11 |
| | | |



表索引

| 表 3-1. | 版本历史 | 12 | 2 |
|--------|------|----|---|
|--------|------|----|---|



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。



AN029 GD32F103 程序在 GD32F303 和 GD32F403 芯片上运行 DSP 指令集和 FPU

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

| syste | em_gd32f10x.c |
|-------|--|
| 178 | * @param None |
| 179 | * @retval None |
| 180 | */ retval |
| 181 | |
| 182 | void SystemInit (void) |
| 183 | |
| 184 - | ‡ifdef MATH 403 |
| 185 | // #if (_FPU_PRESENT == 1) && (_FPU_USED == 1) |
| 186 | SCB->CPACR = ((3UL << 10*2))(3UL << 11*2)); /* set CP10 and CP11 Full Access */ |
| 187 | // #endif |
| 188 | - #endlf |

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

| 🕅 Options for Target '403_Math' 🛛 🕹 | | | | | | | |
|--|------------------------------------|--|--|--|--|--|--|
| Device Target Output Listing User C/C++ Asm Linker Debug Utilities | | | | | | | |
| GigaDevice GD32F403VE 选择403的型号,同时使用FPU | | | | | | | |
| Xtal (MHz): 25.0 | | | | | | | |
| Operating system: None | Use Cross-Module Optimization | | | | | | |
| System-Viewer File (.Sfr): | ✓ Use MicroLIB ✓ Big Endian | | | | | | |
| SED/GD/GD32E4m/GD32E403 SEB | Floating Point Hardware: Use FPU | | | | | | |
| 31 D (d) (d) 321 400 (d) 321 400.51 (f) | | | | | | | |
| Read/Only Memory Areas | Read/Write Memory Areas | | | | | | |
| default off-chip Start Size Startup | default off-chip Start Size Nolnit | | | | | | |
| □ ROM1: □ 0 | □ RAM1: □ □ | | | | | | |
| □ ROM2: □ O | □ RAM2: □ □ | | | | | | |
| □ ROM3: ○ | RAM3: | | | | | | |
| on-chip | on-chip | | | | | | |
| IROM1: 0x8000000 0x80000 € | IRAM1: 0x20000000 0x18000 □ | | | | | | |
| IROM2: | IRAM2: | | | | | | |
| | | | | | | | |
| | | | | | | | |
| OK Cancel Defaults Help | | | | | | | |

3. 填写相应的编译宏定义



 \sim

GD32F103 程序在 GD32F303 和 GD32F403 芯片上运行 DSP 指令集和 FPU

图 2-3. 添加相应的编译宏

🔣 Options for Target 'GD32F10X_HD'

| | ~ |
|--|---|
| Device Target Output Listing User C/C++ Asm Linker Debug Vtilities | |
| Preprocessor Symbols | |
| Define: USE_STDPERIPH_DRIVER GD32F10X_CLFPU_PRESENTTARGET_FPU_VFP | |
| Undefine: | |

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][0]: E000E000, CID: B105E00D, PID: 000BB00C SCS-M7

ROMTb1[0][1]: E0001000, CID: B105E00D, PID: 003BB002 DWT

ROMTb1[0][2]: E0002000, CID: B105E00D, PID: 003BB001 ITM

ROMTb1[0][3]: E0000000, CID: B105E00D, PID: 003BB001 ITM

ROMTb1[0][4]: E0040000, CID: B105900D, PID: 003BB001 ITM

ROMTb1[0][5]: E0041000, CID: B105900D, PID: 003BB011 TPIU

ROMTb1[0][5]: E0041000, CID: B105900D, PID: 003BB011 TPIU

ROMTb1[0][5]: E0041000, CID: B105900D, PID: 003BB01 ITM

ROMTb1[0][5]: E0041000, CID: B105900D, PID: 0008B9A1 TPIU

ROMTb1[0][5]: E0041000, CID: B105900D, PID: 0000B9A1 TPIU

ROMTb1[0][5]: E0041000, CID: 00000000, PID: 0000B9A1 TPIU

ROMTb1[
```

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:

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```
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:





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_cortexM4I_math.lib(如 果是带浮点的需要选择 arm_cortexM4If_math.lib)

图 2-6. math.lib 文件

| 新加卷 (D:) ▶ Keil ▶ ARM ▶ CMSIS ▶ Li | b ▶ ARM | | ▼ \$ |
|------------------------------------|------------------|----------------|-------------|
| 工具(T) 帮助(H) | | | |
| 共享 ▼ 新建文件夹 | | | |
| 名称 | 修改日期 | 类型 | 大小 |
| 🛃 arm_cortexM0l_math.lib | 2012/10/24 11:07 | Altium Library | 10,364 KB |
| 🛃 arm_cortexM3l_math.lib | 2012/10/24 11:07 | Altium Library | 10,656 KB |
| 🚔 arm_cortexM4l_math.lib | 2012/10/24 11:07 | Altium Library | 10,822 KB |
| 🛃 arm_cortexM4lf_math.lib | 2012/10/24 11:07 | Altium Library | 10,905 KB |

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

| C Firmware CMSIS | | | ▼ * | MSIS |
|---------------------|-----------------|--------|----------------|------|
| 工具(T) 帮助(H) | | | | |
| 共享 ▼ 新建文件夹 | | | | : |
| 名称 | 修改日期 | 类型 | 大小 | |
| arm math.h | 2016/11/5 1:33 | H文件 | 247 KB | |
| 📋 core_cm0.h | 2016/11/5 1:33 | H 文件 | 36 KB | - |
| 📋 core_cm0plus.h | 2016/11/5 1:33 | H 文件 | 43 KB | |
| 📄 core_cm3.c | 2010/6/7 10:25 | C 文件 | 17 KB | |
| core cm3.h | 2016/11/5 1:33 | H 文件 | 102 KB | _ |
| 📄 core_cm4.h | 2016/11/5 1:33 | H 文件 | 112 KB | |
| core_cm4_simd.h | 2017/4/27 16:18 | H 文件 | 23 KB | |
| core_cmFunc.h | 2016/11/5 1:33 | H 文件 | 18 KB | |
| core_cminstr.n | 2010/11/3 1:55 | F 又(1+ | 20 ND | • |
| 📄 core_cmSimd.h | 2016/11/5 1:33 | H 文件 | 23 KB | |
| 📄 gd32f10x.h | 2015/3/23 9:59 | H 文件 | 699 KB | |
| 📄 system_gd32f10x.c | 2015/1/19 9:08 | C 文件 | 38 KB | |
| 📄 system_gd32f10x.h | 2015/1/19 9:08 | H文件 | 2 KB | |

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



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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

| Options for Target '303_Math' | × |
|--|-------|
| Options for Target '303_Math' Device Target Output Listing User C/C++ Asm Linker Debug Utilities Database: GigaDevice GD32F30x Devices ▼ Vendor: GigaDevice GigaDevice GD32F30x Devices ▼ Vendor: GigaDevice Device: GD32F303RG Core: ARM 32-bit Cortex-M4 Microcontroller, (120 MHz max) GD32F303CE GD32F303CG GD32F303CG GD32F303CG F GD32F303CG F GD32F303CG | |
| GD32F303CG GD32F303RC GD32F303RC GD32F303RG GD32F303RG GD32F303RG GD32F303RG GD32F303RK C GD32F303RK C GD32F303RK C GD32F303VC GD32F303VC GD32F303VC C GD32F303VC <li< td=""><td>= </td></li<> | = |
| OK Cancel Defaults H | elp |



AN029

■ GD32F103 程序在 GD32F303 和 GD32F403 芯片上运行 DSP 指令集和 FPU

图 2-10. 添加相应的 Math 编译宏

| Options for Target '303_Math' Device Target Output Listing Use | r C/C++ Asm Linker Debug | Vtilities | | |
|--|---|---|--|--|
| Preprocessor Symbols Define: USE_STDPERIPH_DRIVER Undefine: | GD32F10X_HD.MATH_3 | CM4 | | |
| Language / Code Generation Optimization: □ Optimize for Time □ Split Load and Store Multiple ▼ One ELF Section per Function | Strict ANSI C Enum Container always int Plain Char is Signed Read-Only Position Independent Read-Write Position Independent | Wamings: All Wamings Thumb Mode No Auto Includes | | |
| Include Paths \;\\Fimware\Peripherals\inc;\\Fimware\CMSIS Misc Controls Compiler control string -ccpu Cortex-M4 -D_MICROLIB -g -00apcs=interworksplit_sections -l\-l.\\Fimware \Peripherals\inc -l\\Fimware\CMSIS | | | | |
| 0K | Cancel Defaults | Help | | |



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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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