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1. **Introduction**

GD32F3xx and GD32F403 with Cortex-M4 kernel are launched by GD in recent years. These two series products can run 103 program directly. But the 103 program doesn’t have the DSP instruction set. Is there a way to let the users to use the DSP instruction set and FPU when the program is based on 103? The answer is yes. The detailed method is show as below.

2. **Operation steps**

The following steps use Keil4 as an example, and the configuration method of Keil5 is exactly the same.

2.1 **Turn on FPU**

The 303 and 403 series have the FPU function. Some particular configuration need to be set as below.

1. Enable FPU before executing code

   **Figure 2-1. Enable FPU**

   ```c
   void SystemInit (void)
   ```

2. Select 303 or 403 model and use FPU
GD32F103 program runs DSP instruction set and FPU on chips GD32F303 and GD32F403

3. Fill in the corresponding compilation macro definition.

**Figure 2-3. Add the corresponding compilation macro**

Note: GD32F10X_CL must be configured for F403, and F303 and F103 must be the same.

### 2.2 Check whether the FPU is turned on successfully

In the JLINK debugging control interface, enter the command:

```
mem32 0xE000ED88 1
```

See the following figure for detailed operation. After entering the command, 00f00000 indicates that the FPU has been turned on. If it is 00000000, it indicates that the FPU has not been turned on.

**Figure 2-4. Check whether the FPU is turned on**
2.3 Performance test comparison

Compile the code, then the performance of M4 can be tested on 103 code.

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

    /* configure systick */
    systick_config();
    /* initialize 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);
        }
    }
}
```
GD32F103 program runs DSP instruction set and FPU on chips GD32F303 and GD32F403

```c
printf("\r\ni = %f", i);
while(RESET == gd_eval_key_state_get(KEY_WAKEUP)) {
    ...
}
```

Grab the pin waveform of LED3 with the logic analyzer and check the calculation time of floating-point operation. The following is the test comparison between opening FPU and not opening FPU:

**Figure 2-5. Comparison of performance test**

![Image of comparison test]

If FPU is not enabled, a floating-point multiplication takes 640ns, and only 160ns after FPU is enabled.

### 2.4 Turn on DSP

1. Copy math.lib from the MDK path and add to the project. The specific document is `arm_cortexM4l_math.lib`. (If the FPU is used, `arm_cortexM4lf_math.lib` will be selected.)

   **Figure 2-6. math.lib file**

   ![Image of math.lib file]

2. Copy the corresponding .H file to the project. The `core_cm4.h` file is needed if DSP is used.
3. Change the core_cm3.h to core_cm4.h in gd32f10x.h file.

**Figure 2-8. Core_cm3.h changed to core_cm4.h**

4. Modify the selection of the MCU model. 303 select the corresponding 303 model, 403 select the corresponding 403 model and the corresponding Math compilation macro.
Figure 2-9. Modify the chip model

Figure 2-10. Add the corresponding Math compilation macro
GD32F103 program runs DSP instruction set and FPU on chips GD32F303 and GD32F403
3. Revision history

Table 3-1. Revision history

<table>
<thead>
<tr>
<th>Revision No.</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Initial Release</td>
<td>Apr.30, 2021</td>
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