RTP 自我檢測程式庫

NuMicro® 64/32位系列微控制器範例代碼介紹

文件資訊

應用簡述	本範例程式為 MA35D1 的 Real Time Processor (RTP)之自我檢測程式庫，此程式庫實現了晶片的自我檢測功能，可以達成市場上所需要的安全要求，在晶片出現錯誤時，能夠即時檢測並使系統維持功能安全。
BSP 版本	MA35D1 Series RTP BSP CMSIS V3.00.001
開發平台	NuMaker-HMI-MA35D1-S1

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1. 概述

本範例為 MA35D1 的 Real Time Processor (RTP)之自我檢測程式庫(Self-Test Library, STL)，此程式庫提供了基本的系統檢測功能，如 CPU Register、Program Counter、Clock、Flash 和 SRAM 的自我檢測，在晶片出現錯誤時，能夠即時檢測並使系統維持功能安全，此外使用者還可以修改或增加到現有的應用程式中，以補足系統的安全需求，加速使用者開發和安全認證過程。

本範例程式實現 STL 所使用的方法和技術，提供使用者在應用程式的安全功能，最終仍必須由認證機構在應用系統級別進行驗證。

1.1 原理

軟體流程如圖 1-1 所示，程式主要分成兩個部分進行自我檢測，分別是 Startup Time Check 和 Run Time Check，兩個部分都會呼叫 STL 中的自我檢測程式，進行相對應的檢測項目。

Startup Time Check 僅會在系統剛開機時執行一次，確保程式的完整性，然後在 Main Loop 中，會不斷執行 Run Time Check 進行自我檢測，以確保系統在應用執行時，晶片的功能是正常的，能夠維持系統的安全。

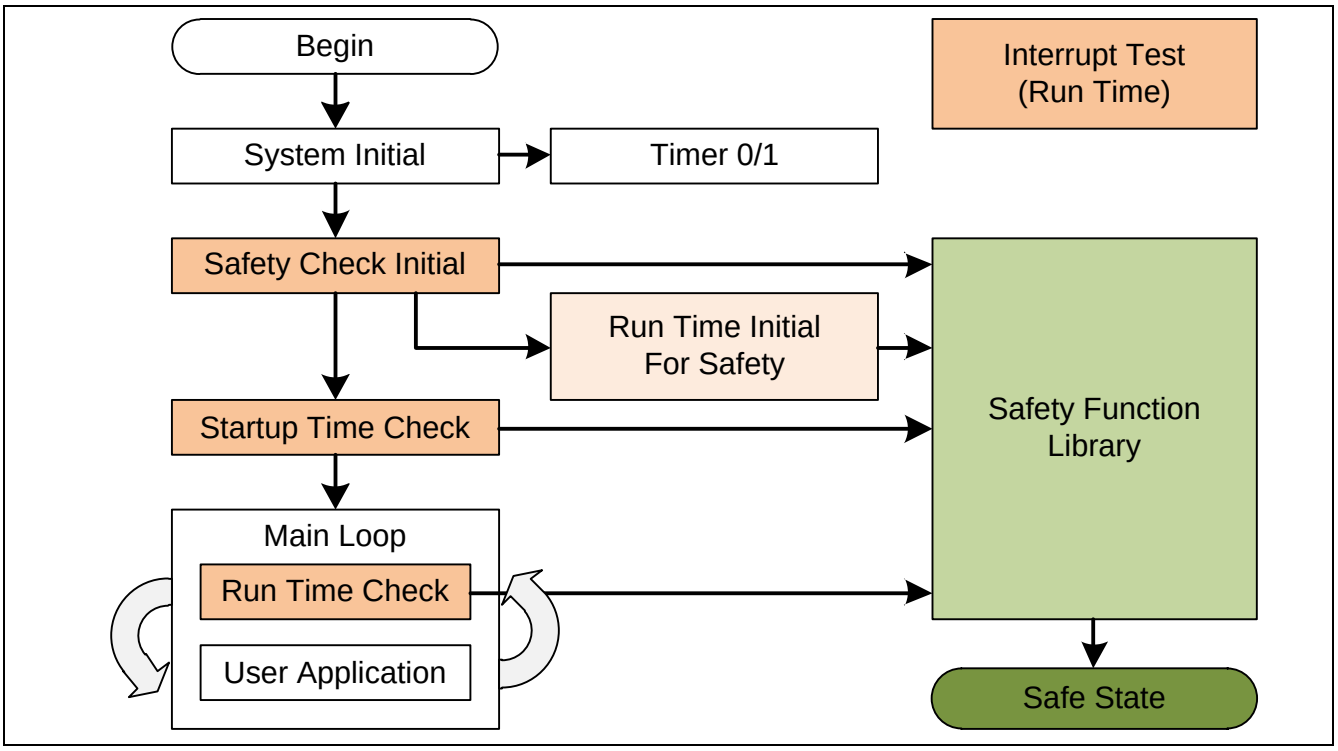

圖1-1 軟體流程圖

1.2 執行結果

程式正常執行時，會顯示各項檢測項目 Pass:

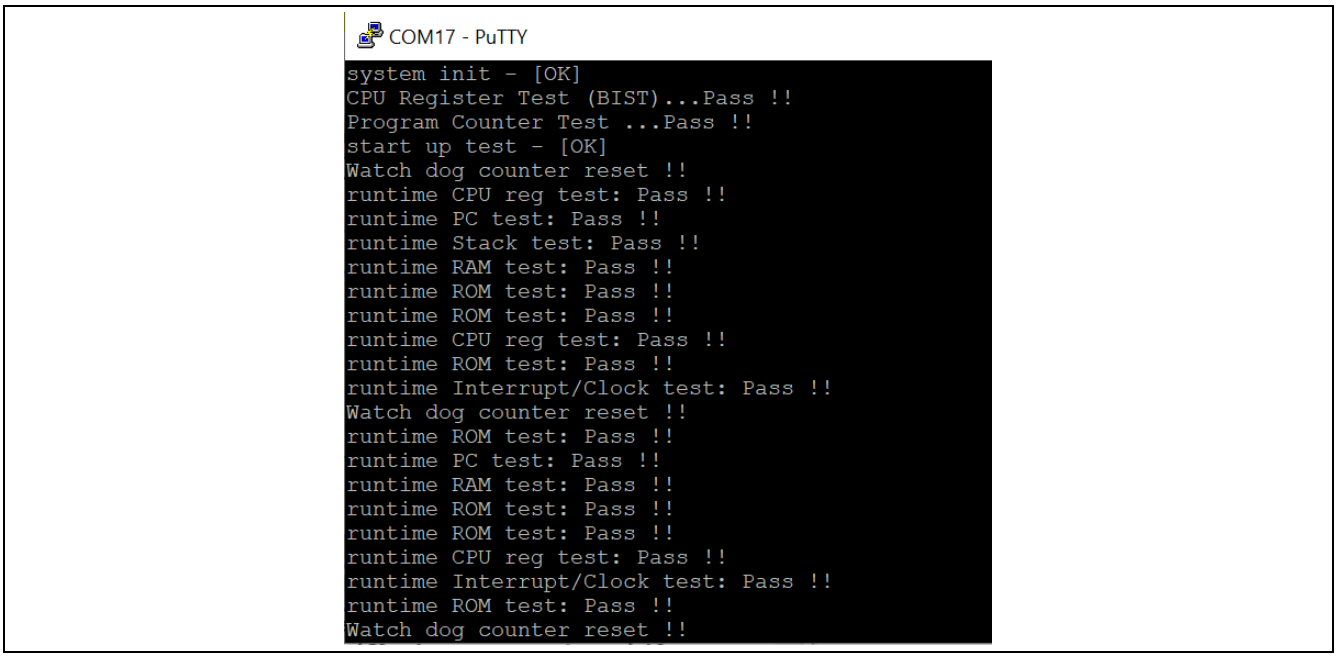

圖1-2 測試結果

當有檢測項目出現問題時，會顯示 Fail Code，使用者可以根據 Fail Code 確認出現錯誤的項目:

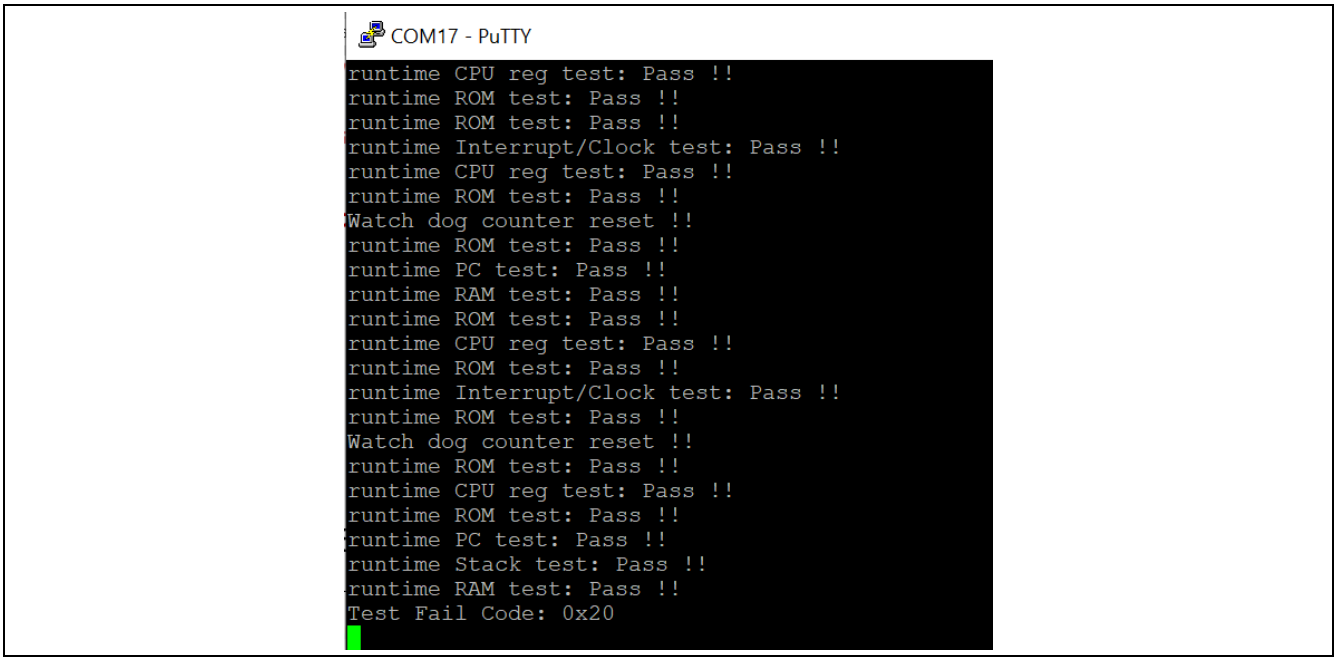

圖1-3 測試失敗案例

Fail Code 的對照表如下:

Test Functions Fails	Fail Code
CPU Register Test Fail	0x10
Program Counter Test Fail	0x14
Stack Test Fail	0x26
Interrupt Test Fail	0x18
Clock Test Fail	0x1C
Flash Test Fail	0x20
RAM Test Fail	0x25

表 1-1 Fail Code

2. 程式介紹

以下程式實現了章節 1.1 的架構。

```
int main(void)
{
    if(system_init())
        printf("system init - [FAIL]\n");
    else
        printf("system init - [OK]\n");

    /* To check if system has been reset by WDT time-out reset or not */
    if(WDT_GET_RESET_FLAG())
    {
        /* Clear WDT reset flag */
        WDT_CLEAR_RESET_FLAG();
        printf("*** System has been reset by WDT time-out event ***\n\n");
        while(1)
            WDT_RESET_COUNTER();
    }

    /* Test Lib Init */
    TESTLIB_INIT(UserErrorHandling, WatchDogReset);

    if(STARTUP_TESTS() != 1)
        printf("start up test - [FAIL]\n");
    else
        printf("start up test - [OK]\n");

    while (1){
        /* Run Time Execution Check */
        CHECK_RUNTIME_TESTS_EXECUTION();
        /* Run Time Test mainloop */
        RUNTIME_TESTS();
    }
}
```

在 Startup Test 中會呼叫的檢測項目如下:

```
uint8_t STARTUP_TESTS(void)
{
    uint8_t u8TestResult;
    /* CPU Registers Test */
    rt_printf("CPU Register Test (BIST)...");
    u8TestResult = Registers_Test(STARTUP);
    if(u8TestResult)
        rt_printf("Pass !!\n");
    else
        SAFE_STATE(CPU_TEST_FAIL);

    /* Program Counter Test */
    rt_printf("Program Counter Test ...");
```

```
    u8TestResult = ProgramCounter_Test();
    if(u8TestResult)
        rt_printf("Pass !!\n");
    else
        SAFE_STATE(PC_TEST_FAIL);

    return u8TestResult;
}
```

在 Runtime Test 中會呼叫的檢測項目如下:

```
void RUNTIME_TESTS(void)
{
    uint8_t u8TestResult;
    /* reset wdt */
    if(RunTimeTestExecution.WATCHDOG_RESET == 1) {
        u8TestResult = WatchDog_Reset();
        if(u8TestResult)
            rt_printf("Watch dog counter reset !!\n");
    }

    /* CPU Registers Test */
    if(RunTimeTestExecution.REGISTER_TEST == 1)
    {
        u8TestResult = Registers_Test(RUNTIME);
        if(u8TestResult)
            rt_printf("runtime CPU reg test: Pass !!\n");
        else
            SAFE_STATE(CPU_TEST_FAIL);
    }

    /* Program Counter Test */
    if(RunTimeTestExecution.PROGRAMCOUNTER_TEST == 1) {
        u8TestResult = ProgramCounter_Test();
        if(u8TestResult)
            rt_printf("runtime PC test: Pass !!\n");
        else
            SAFE_STATE(PC_TEST_FAIL);
    }

    /* Stack Overrun Test */
    if(RunTimeTestExecution.STACK_TEST == 1) {
        u8TestResult = Stack_Test();
        if(u8TestResult)
            rt_printf("runtime Stack test: Pass !!\n");
        else
            SAFE_STATE(STACK_TEST_FAIL);
    }

    /* RAM Test */
    if(RunTimeTestExecution.RAM_TEST == 1) {
        u8TestResult = RAM_Test(RUNTIME);
        if(u8TestResult)
            rt_printf("runtime RAM test: Pass !!\n");
```

```
        else
            SAFE_STATE(RAM_TEST_FAIL);
    }

    /* ROM Test */
    if(RunTimeTestExecution.ROM_TEST == 1) {
        u8TestResult = Flash_Test(RUNTIME);
        if(u8TestResult)
            rt_printf("runtime ROM test: Pass !!\n");
        else
            SAFE_STATE(FLASH_TEST_FAIL);
    }

    /* Interrupt/Clock test */
    if(RunTimeTestExecution.INTERRUPT_TEST) {
        u8TestResult = Interrupt_Clock_Test();
        if(u8TestResult)
            rt_printf("runtime Interrupt/Clock test: Pass !!\n");
        else
            SAFE_STATE(INTERRUPT_TEST_FAIL);
    }
}
```

3. 軟體與硬體需求

3.1 軟體需求

- BSP 版本
  - MA35D1 Series RTP BSP CMSIS V3.00.001
- IDE 版本
  - Keil uVersion 5.37

3.2 硬體需求

- NuMaker-HMI-MA35D1-S1
- 腳位連接示意圖

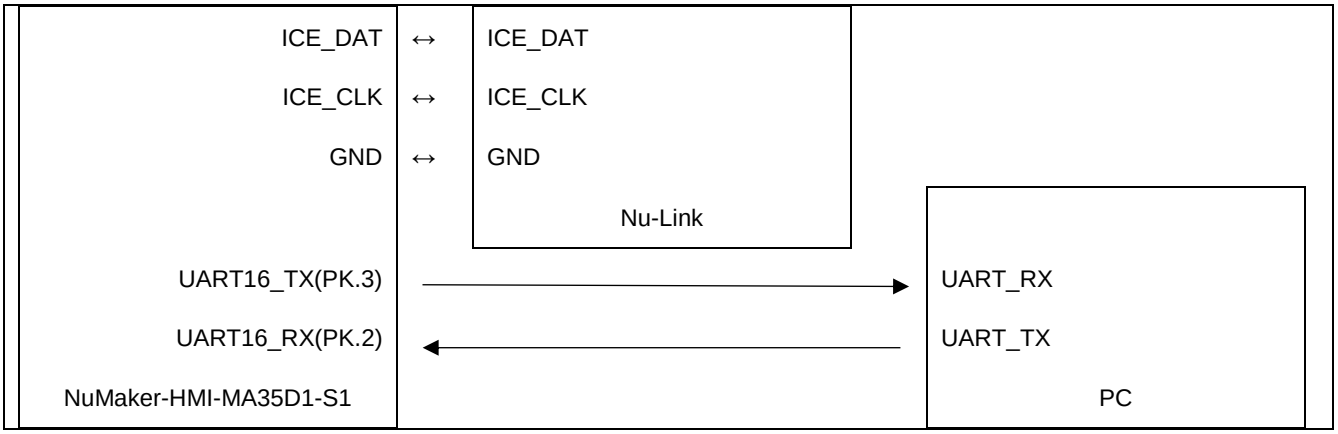

圖 3-1腳位連接示意圖

4. 目錄資訊

目錄架構如下所示。

EC_MA35D1_RTP_Self_Test_Library_V1.00	
Library	Sample code header and source files
CMSIS	Cortex® Microcontroller Software Interface Standard (CMSIS) by ARM® Corp.
Device	CMSIS compliant device header file
StdDriver	All peripheral driver header and source files
SampleCode	
ExampleCode	Source file of example code

圖 4-1 目錄資訊

5. 範例程式執行

1. 根據目錄資訊章節進入 ExampleCode 路徑中的 KEIL 資料夾，雙擊 *RTP_Self_Test_Library.uvproj*。
2. 進入編譯模式介面
   - 編譯
   - 下載代碼至記憶體
   - 進入 / 離開除錯模式
3. 進入除錯模式介面
   - 執行程式

詳細的 RTP Example Code 使用方式請參考使用手冊，下載連結如下:

https://www.nuvoton.com/resource-download.jsp?tp_GUID=UG1320221208093843 99

6. 修訂紀錄

Date	Revision	Description
2023.2.28	1.00	初始發布。

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