RTP 自我检测程序库

NuMicro® 64/32位系列微控制器范例代码介绍

文件信息

应用简述	本范例代码为 MA35D1 的 Real Time Processor (RTP)之自我检测程序库，此程序库实现了芯片的自我检测功能，可以达成市场上所需要的安全要求，在芯片出现错误时，能够实时检测并使系统维持功能安全。
BSP 版本	MA35D1 Series RTP BSP CMSIS V3.00.001
开发平台	NuMaker-HMI-MA35D1-S1

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1. 概述

本范例为 MA35D1 的 Real Time Processor (RTP)之自我检测程序库(Self-Test Library, STL)，此程序库提供了基本的系统检测功能，如 CPU Register、Program Counter、Clock、Flash 和 SRAM 的自我检测，在芯片出现错误时，能够实时检测并使系统维持功能安全，此外用户还可以修改或增加到现有的应用程序中，以补足系统的安全需求，加速使用者开发和安全认证过程。

本范例程序实现 STL 所使用的方法和技术，提供用户在应用程序的安全功能，最终仍必须由认证机构在应用系统级别进行验证。

1.1 原理

软件流程如图 1-1 所示，程序主要分成两个部分进行自我检测，分别是 Startup Time Check 和 Run Time Check，两个部分都会调用 STL 中的自我检测程序，进行相对应的检测项目。

Startup Time Check 仅会在系统刚开机时执行一次，确保程序的完整性，然后在 Main Loop 中，会不断执行 Run Time Check 进行自我检测，以确保系统在应用执行时，芯片的功能是正常的，能够维持系统的安全。

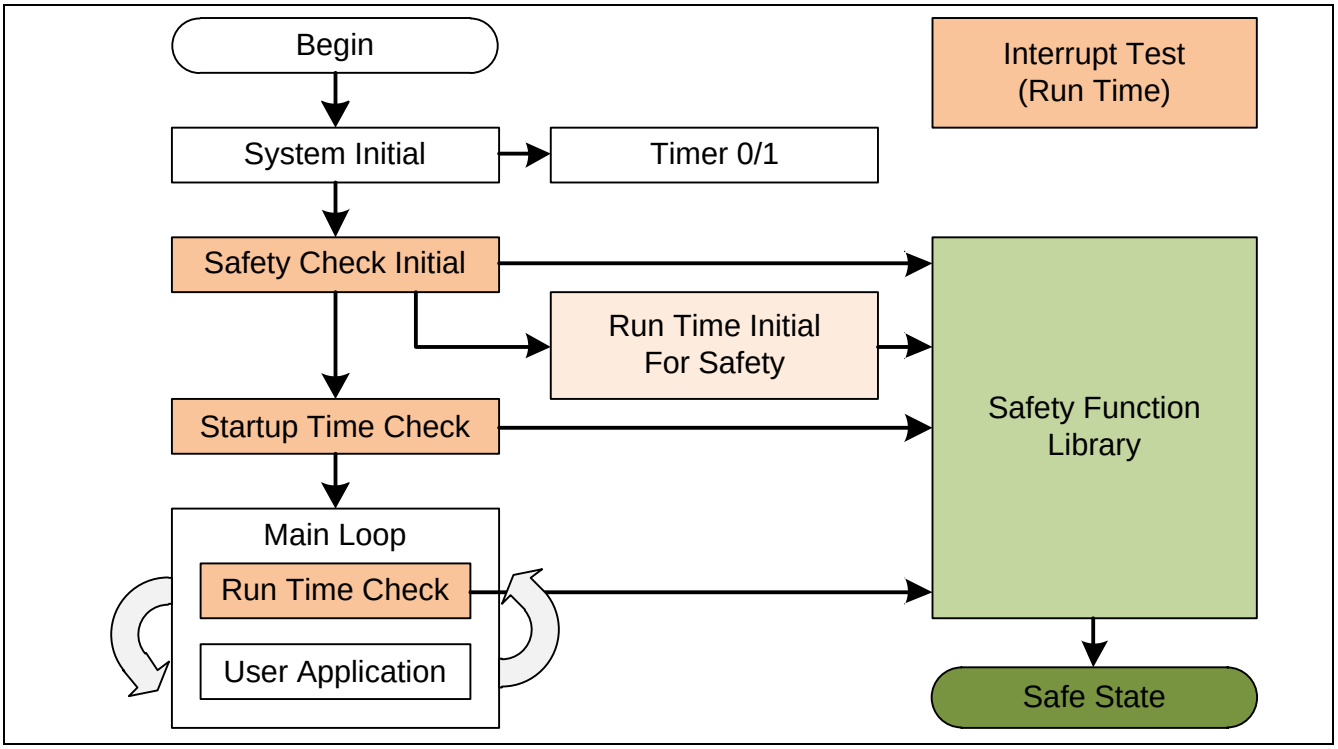

图1-1 软件流程图

1.2 执行结果

程序正常执行时，会显示各项检测项目 Pass:

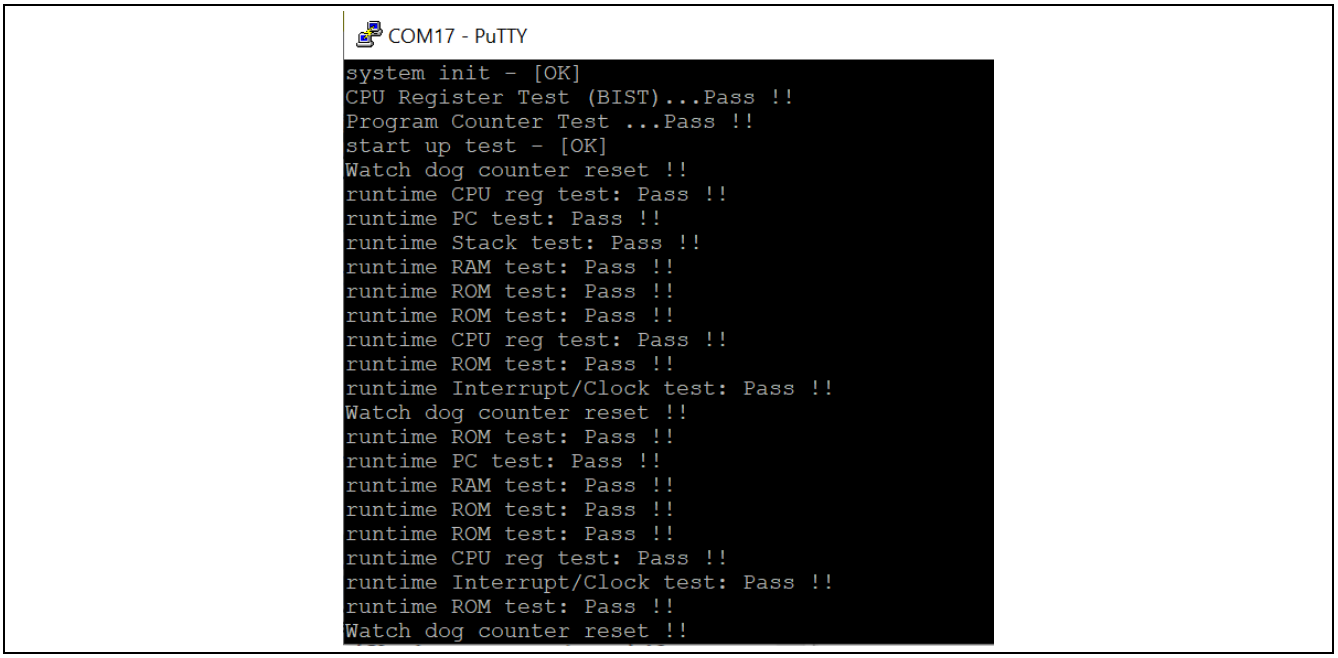

图 1-2 测试结果

当有检测项目出现问题时，会显示 Fail Code，用户可以根据 Fail Code 确认出现错误的项目:

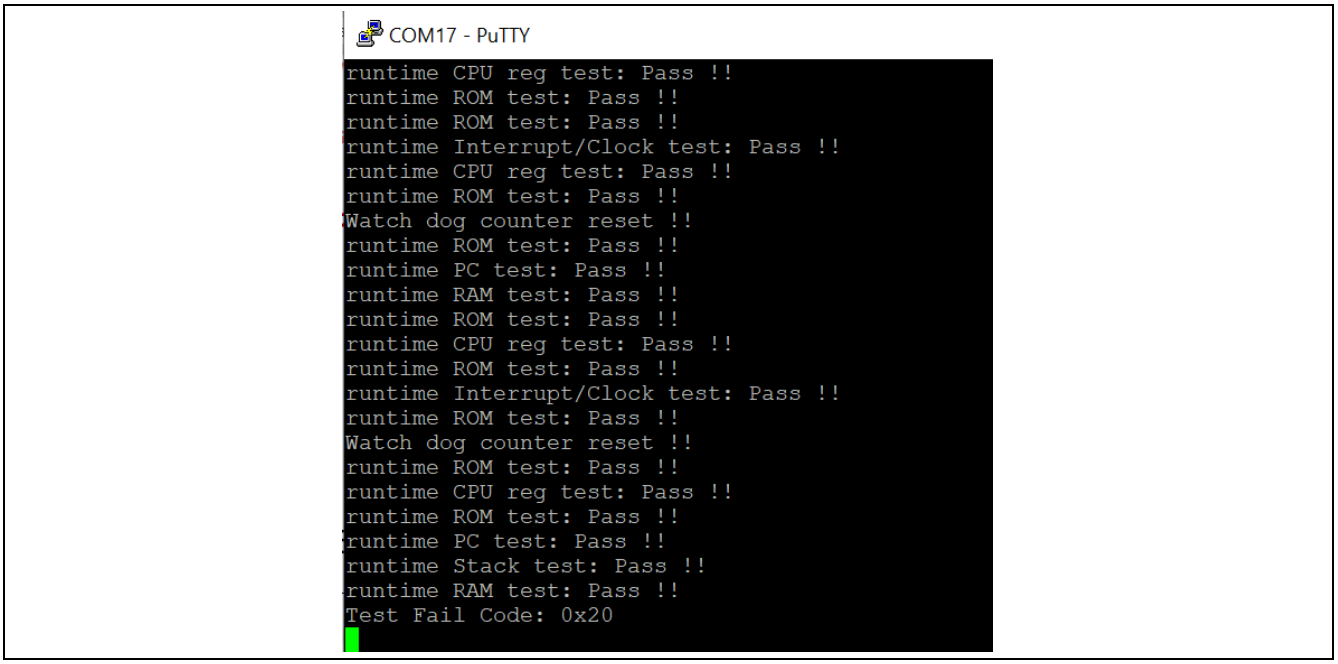

图 1-3 测试失败案例

Fail Code 的对照表如下:

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. 程序介绍

以下程序实现了章节 1.1 的架构。

```
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 中会调用的检测项目如下:

```
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 中会调用的检测项目如下:

```
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. 软件与硬件需求

3.1 软件需求

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

3.2 硬件需求

- NuMaker-HMI-MA35D1-S1
- 脚位连接示意图

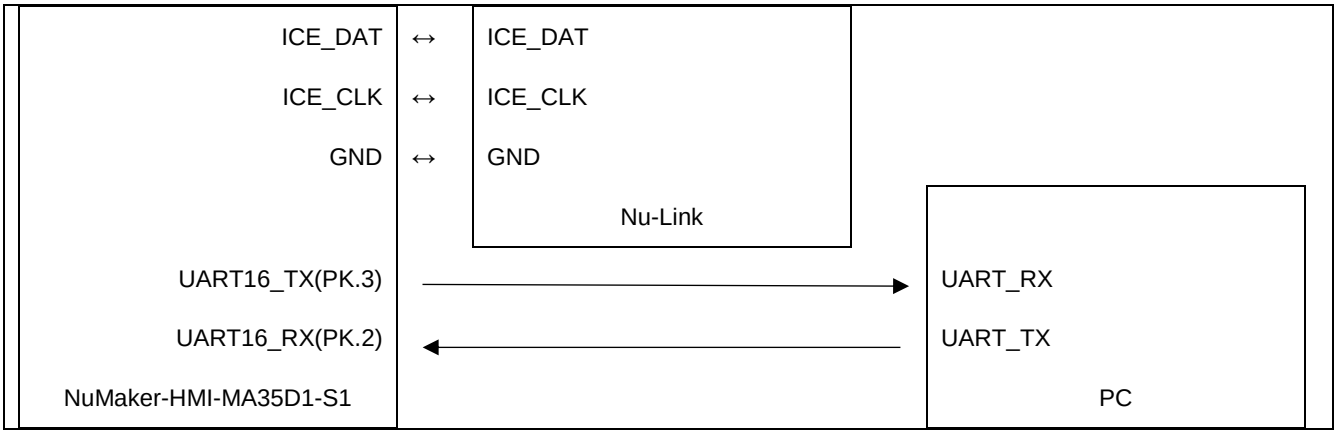

图 3-1脚位连接示意图

4. 目录信息

目录架构如下所示。

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

图 4-1 目录信息

5. 范例程序执行

1. 根据目录信息章节进入 ExampleCode 路径中的 KEIL 文件夹，双击 *RTP_Self_Test_Library.uvproj*。
2. 进入编译模式接口
   - 编译
   - 下载代码至内存
   - 进入 / 离开除错模式
3. 进入除错模式接口
   - 执行代码

详细的 RTP Example Code 使用方式请参考使用手册，下载连结如下:

https://www.nuvoton.com/resource-download.jsp?tp_GUID=UG132022120809384399

6. 修订纪录

Date	Revision	Description
2023.2.28	1.00	初始发布。

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