RT-Thread Nano 移植

NuMicro® 32 位系列微控制器范例代码介绍

文件信息

应用简述	本范例基于 BSP 中 GPIO_OutputInput 参考程序，介绍如何移植 RT-Thread Nano 并创建 2 个线程。
BSP 版本	M251_M252_M254_M256_M258_Series_BSP_CMSIS_V3.02.006
开发平台	NuMaker-M252SD V1.2

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1. 概述

本范例基于 BSP 中 GPIO_OutputInput 参考程序，介绍如何移植 RT-Thread Nano 并创建 2 个线程。线程 1 通过 GPIO 口，控制 LED 每 500 ms 闪烁一次；线程 2 通过串口，每 1000 ms 交替输出 “Hello”、“World”字样。

1.1 原理

RT-Thread Nano 是一个精炼的硬实时内核，设计用于内存资源有限的系统。功能包括线程管理、线程间同步与通信、时钟管理、中断管理和内存管理等，这些功能使得 RT-Thread Nano 非常适合需要高性能实时控制的嵌入式系统。支持包括 Arm Cortex M0/M23/M3/M4/M7 以及 RISC-V 等多种 CPU 架构，对内存资源的占用极小，最小只需要 3 KB Flash 和 1.2 KB RAM 情况下就可以运行。

本范例使用 M252SD2AE 芯片，包括 64 KB Flash，12 KB RAM，介绍如何移植 RT-Thread Nano 并创建管理 2 个线程。

1.2 执行结果

本范例代码执行编译和烧录后，LED(PB14) 每 500 ms 闪烁一次，如图 1-1 所示。

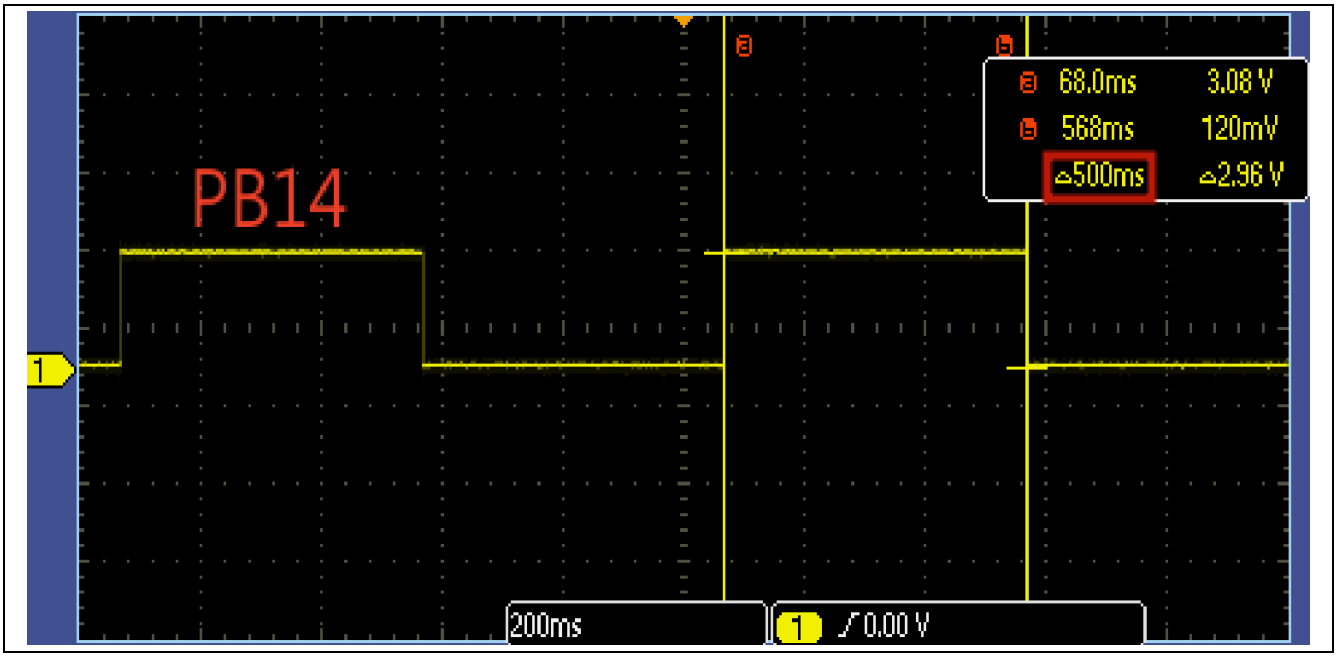


图 1-1 执行编译和烧录结果

串口打印消息如图 1-2 所示。

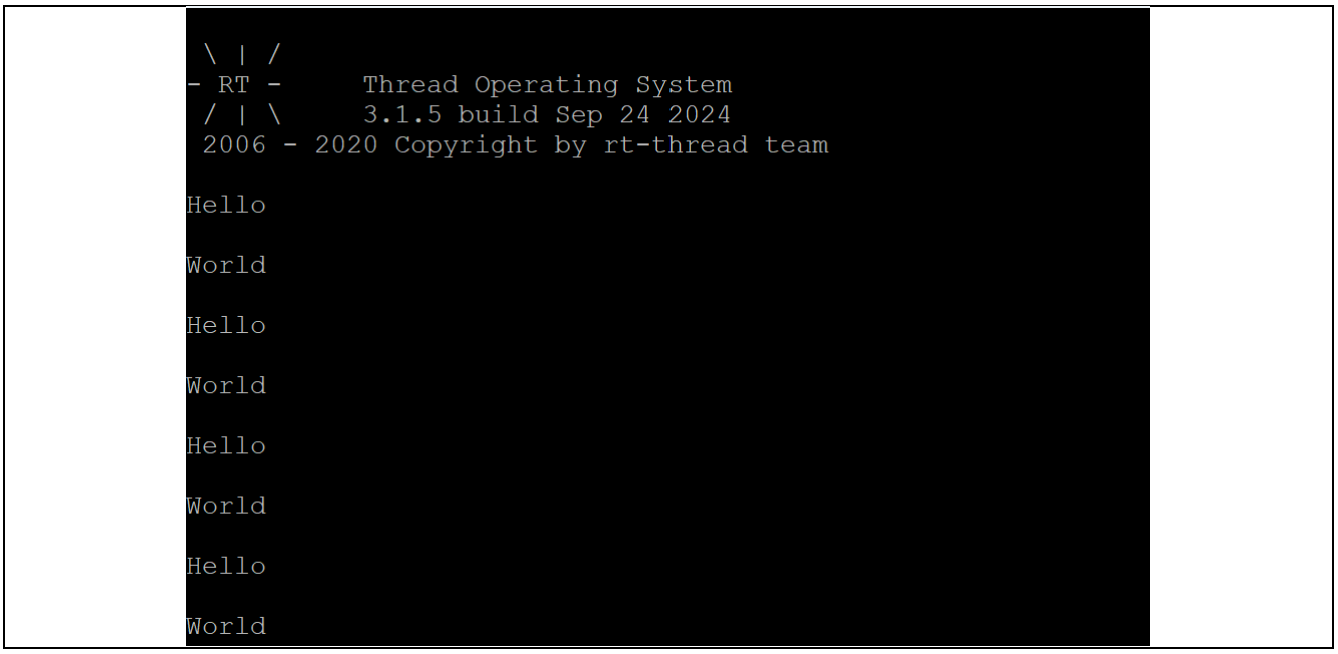


图 1-2 串口打印消息

2. 代码描述

2.1 下载 RT-Thread Nano 源码

单击下面链接，在官网页面下载 RT-Thread Nano 源码。

https://www.rt-thread.org/document/site/#/rt-thread-version/rt-thread-nano/an0038-nano-introduction

源码解压后如下。

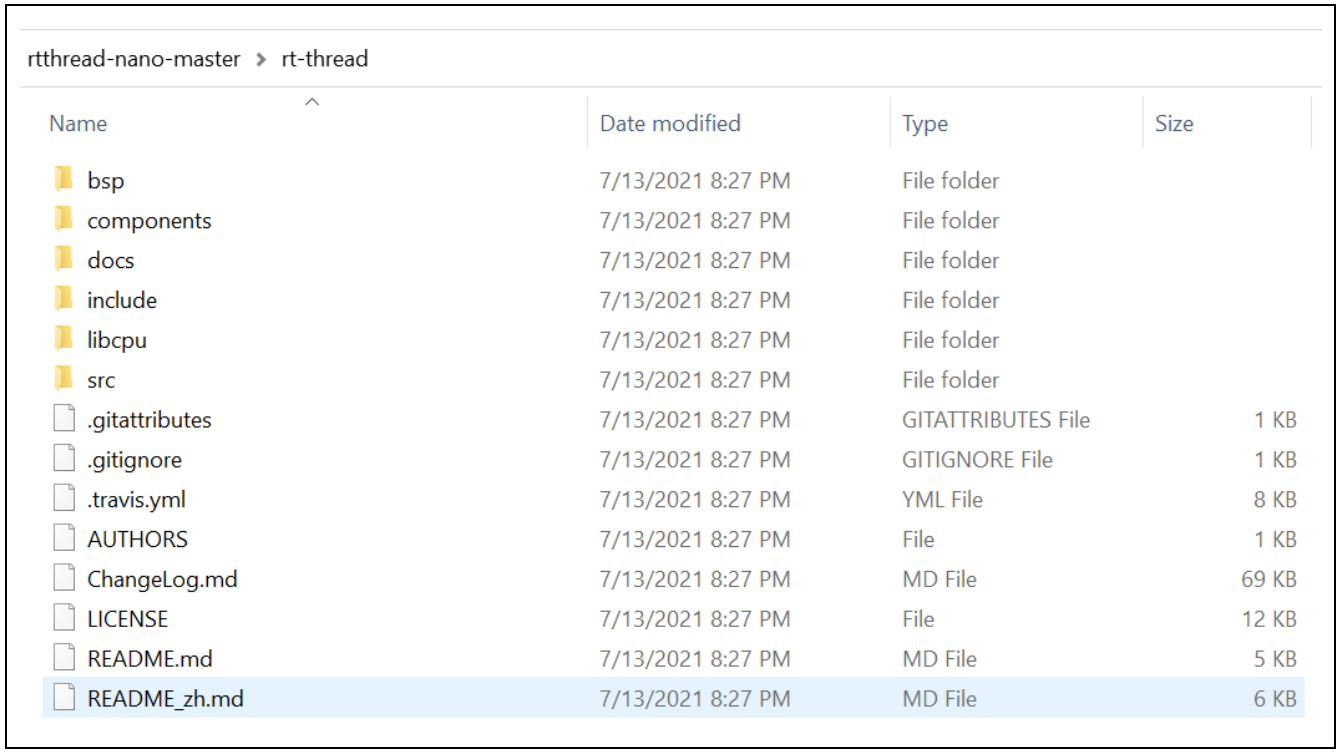


图 2-1 rt-thread 文件结构

2.2 拷贝 rt-thread 文件到 BSP 路径下

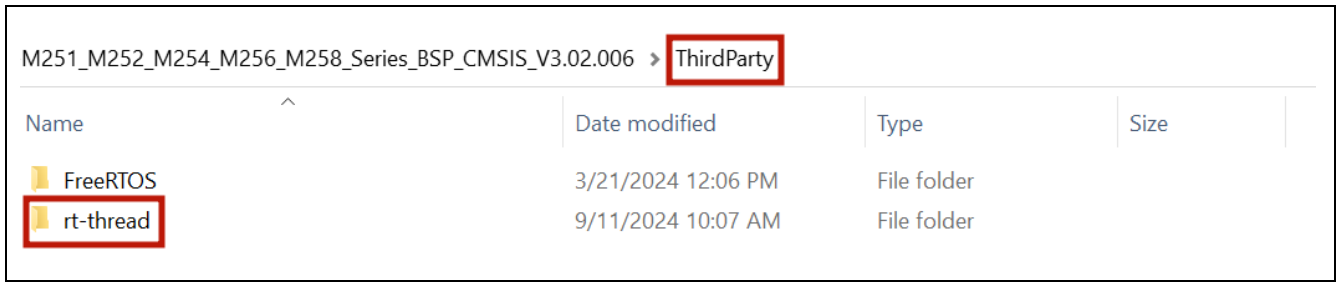


图 2-2 rt-thread 存放路径

2.3 新建 rt-thread 组

在工程中新建 rt-thread 组并添加相关源码文件。

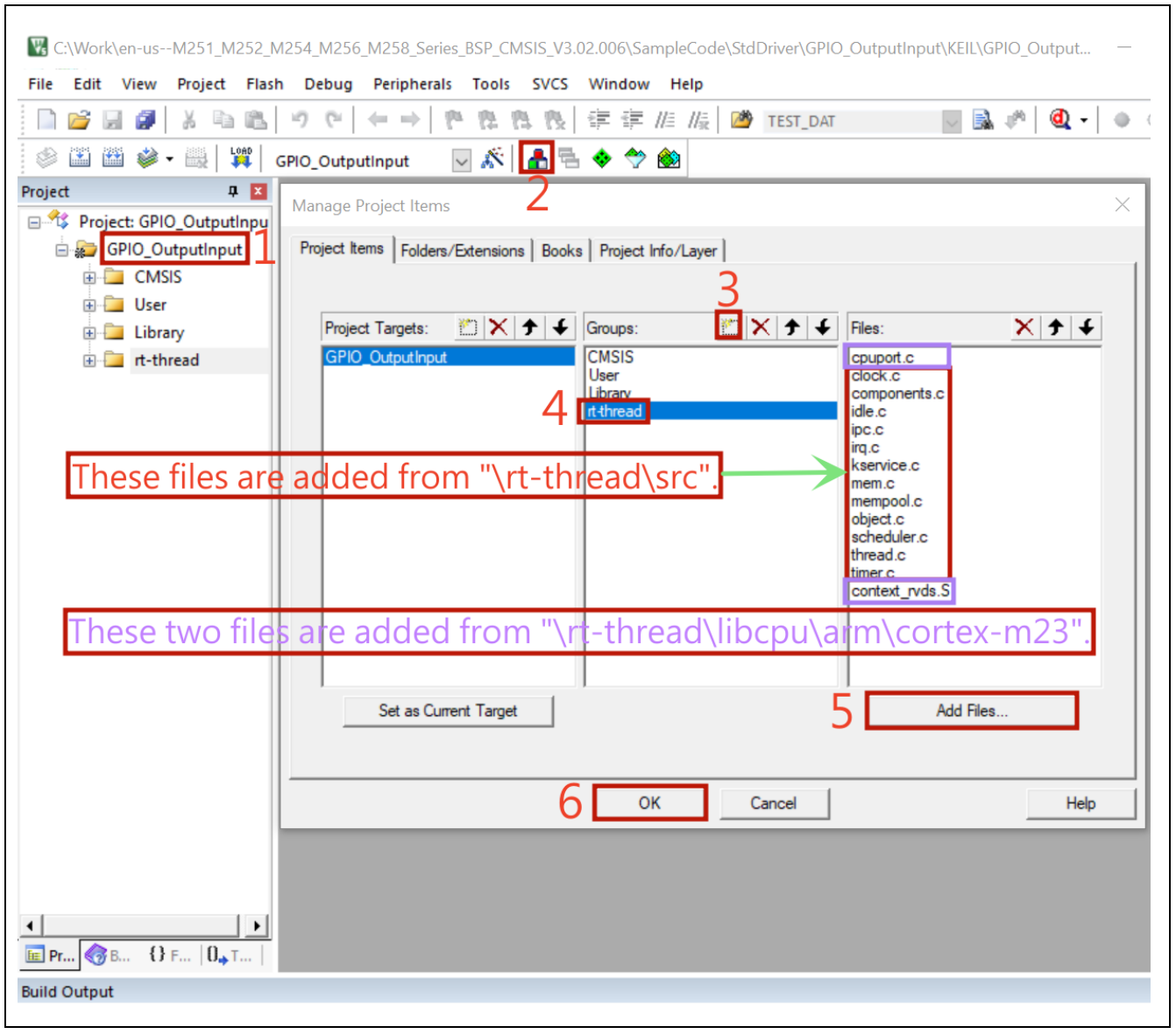


图 2-3 新建 rt-thread 组并添加文件

2.4 复制 Board.c 和 rtconfig.h 文件

将 “\rt-thread\bsp_template\” 路径下 *Board.c* 和 *rtconfig.h* 文件复制到 “\GPIO_OutputInput\ ” 路径，然后将它们添加到 User 组。

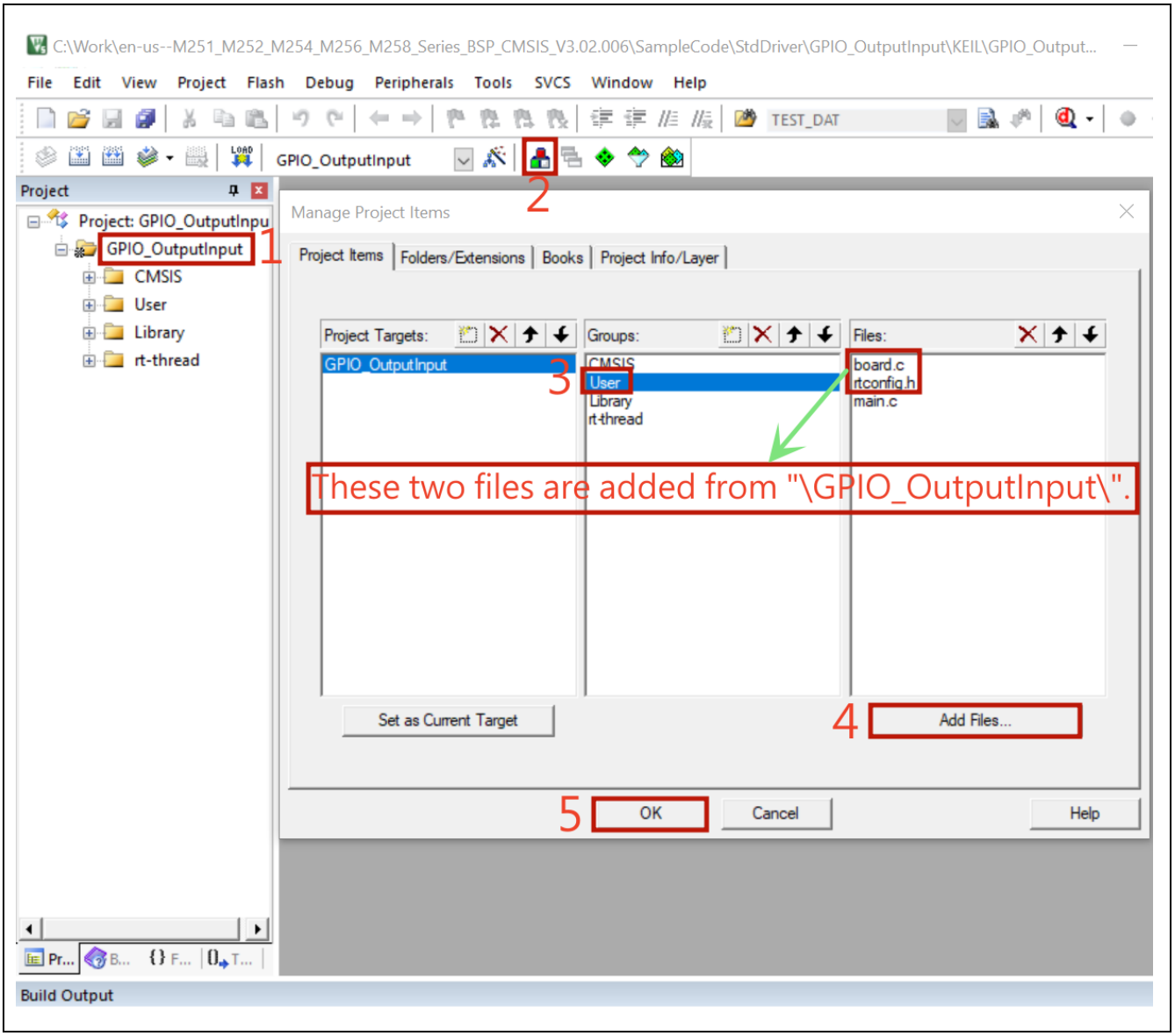


图 2-4 添加文件到 User 组

2.5 修改工程选项 Include Paths

在工程选项中增加 rt-thread 文件 Include Paths。

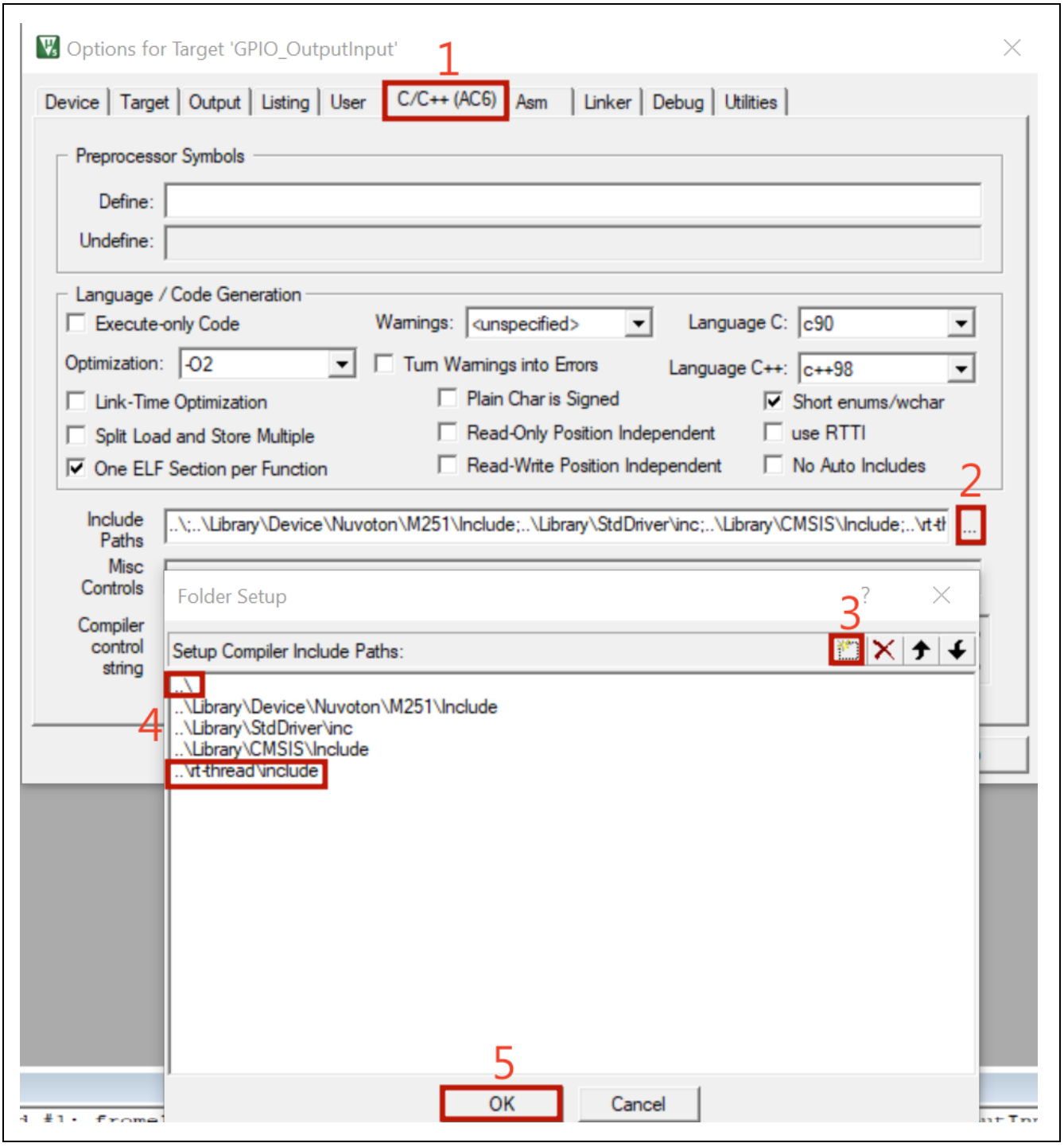


图 2-5 增加 rt-thread 文件 Include Paths

2.6 修改 *board.c* 文件

文件中新增包含 *NuMicro.h*、*stdio.h*。

```
#include <rthw.h>
#include <rtthread.h>
```

```
#include <stdio.h>
#include "NuMicro.h"
```

因为目标芯片 SRAM 最大 12 KB，需要将 #define RT_HEAP_SIZE (15*1024) 修改为 #define RT_HEAP_SIZE (4*1024)。

```
/*
 * Please modify RT_HEAP_SIZE if you enable RT_USING_HEAP
 * the RT_HEAP_SIZE max value = (sram size - ZI size), 1024 means 1024 bytes
 */
#define RT_HEAP_SIZE (4*1024)
```

将原数组及函数进行如下重定义，避免 non-word-aligned 风险。

```
static rt_uint32_t rt_heap[RT_HEAP_SIZE/sizeof(rt_uint32_t)];

RT_WEAK void *rt_heap_begin_get(void)
{
    return (void *)rt_heap;
}

RT_WEAK void *rt_heap_end_get(void)
{
    return (void *)((rt_uint32_t)rt_heap + sizeof(rt_heap));
}
```

在 rt_os_tick_callback 函数下面新增 SysTick_Handler 函数。

```
void SysTick_Handler(void)
{
    rt_os_tick_callback();
}
```

在函数 rt_hw_board_init 中，先注释第一行，然后增加系统初始化、系统内核时钟更新、配置 SysTick 函数。

```
    //#error "TODO 1: OS Tick Configuration."
    /*
     * TODO 1: OS Tick Configuration
     * Enable the hardware timer and call the rt_os_tick_callback function
     * periodically with the frequency RT_TICK_PER_SECOND.
     */
    /* System Init */
    SYS_UnlockReg();
    SYS_Init();
    SYS_LockReg();

    /* System Clock Update */
    SystemCoreClockUpdate();

    /* System Tick Configuration */
    SysTick_Config(SystemCoreClock / RT_TICK_PER_SECOND);
```

将 *main.c* 文件中 SYS_Init 函数复制到 *board.c* 文件。

在函数 uart_init 中，先注释第一行，然后增加 UART 复位函数及波特率设置函数。

```
static int uart_init(void)
{
    //#error "TODO 2: Enable the hardware uart and config baudrate."
    /* Reset UART module */
    SYS_ResetModule(UART0_RST);

    /* Configure UART0 and set UART0 baud rate */
    UART_Open(UART0, 115200);

    return 0;
}
```

在函数 rt_hw_console_output 中，先注释第一行，然后编写 printf 函数。

```
void rt_hw_console_output(const char *str)
{
    //#error "TODO 3: Output the string 'str' through the uart."
    printf("%s", str);
}
```

2.7 修改 main.c 文件

文件中新增加包含 *rtthread.h*。

```
#include "stdio.h"
#include "NuMicro.h"
#include <rtthread.h>
```

定义 2 个线程相关全部变量。

```
static struct rt_thread blink_thread;
static char blink_thread_stack[256];
static struct rt_thread print_thread;
static char print_thread_stack[256];
```

线程 1 函数设计。

```
void blink_thread_entry(void *parameter)
{
    while (1)
    {
        PB14 = 1;
        rt_thread_mdelay(500);
        PB14 = 0;
        rt_thread_mdelay(500);
    }
}
```

线程 2 函数设计。

```
void print_thread_entry(void *parameter)
{
    while (1)
    {
        rt_kprintf("\nHello\n");
        rt_thread_mdelay(1000);
        rt_kprintf("\nWorld\n");
        rt_thread_mdelay(1000);
    }
}
```

删除 SYS_Init、UART0_Init 函数。

主函数 main 重新设计。

```
int main(void)
{
    rt_err_t ret;

    /* Configure PB.14 as Output mode */
    GPIO_SetMode(PB, BIT14, GPIO_MODE_OUTPUT);

    /* Create thread 1 */
    ret = rt_thread_init(&blink_thread,
                         "led blink",
                         blink_thread_entry,
                         RT_NULL,
                         &blink_thread_stack[0],
                         sizeof(blink_thread_stack),
                         RT_THREAD_PRIORITY_MAX-2,
                         20);

    if (ret == RT_EOK)
    {
        /* After the thread 1 is created successfully, start the thread 1 */
        rt_thread_startup(&blink_thread);
    }

    /* Create thread 2*/
    ret = rt_thread_init(&print_thread,
                         "print info",
                         print_thread_entry,
                         RT_NULL,
                         &print_thread_stack[0],
                         sizeof(print_thread_stack),
                         RT_THREAD_PRIORITY_MAX-3,
                         20);

    if (ret == RT_EOK)
    {
        /* After the thread 2 is created successfully, start the thread 2 */
        rt_thread_startup(&print_thread);
```

```
        }

        return 0;
    }
```

2.8 修改 *rtconfig.h* 文件

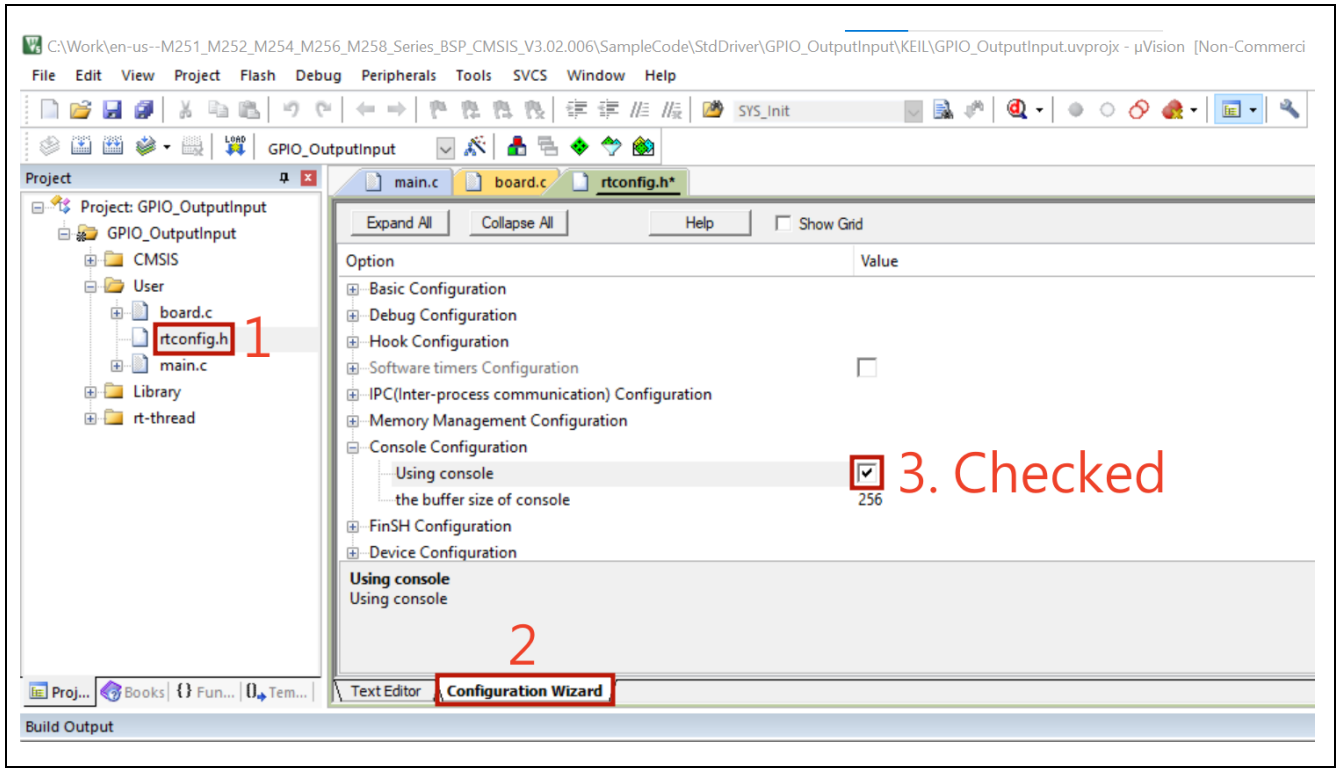
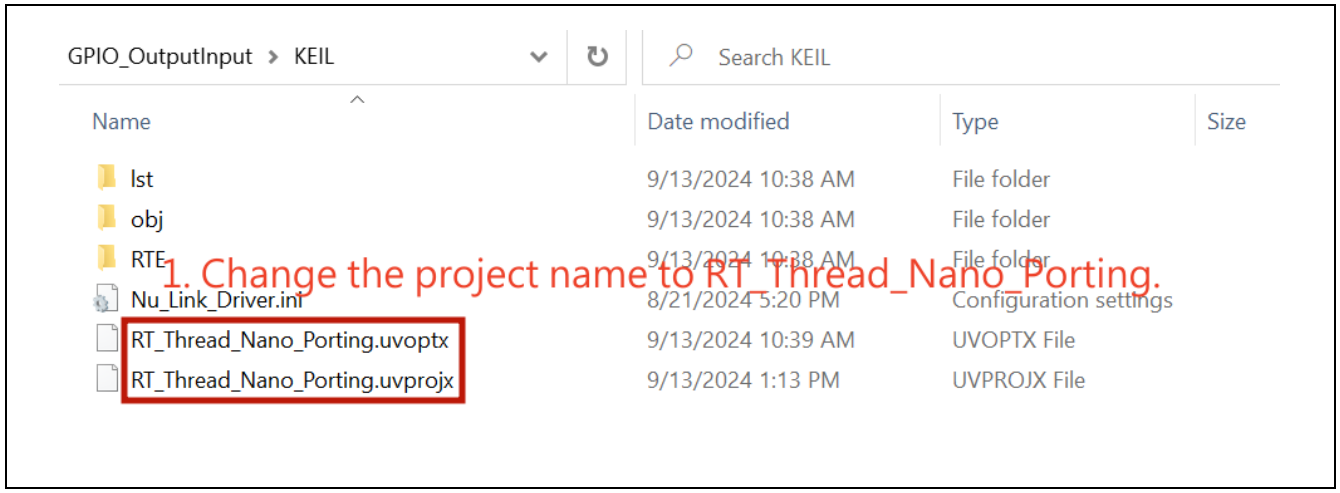


图 2-6 配置 console

2.9 修改工程名

修改工程名为 RT_Thread_Nano_Porting



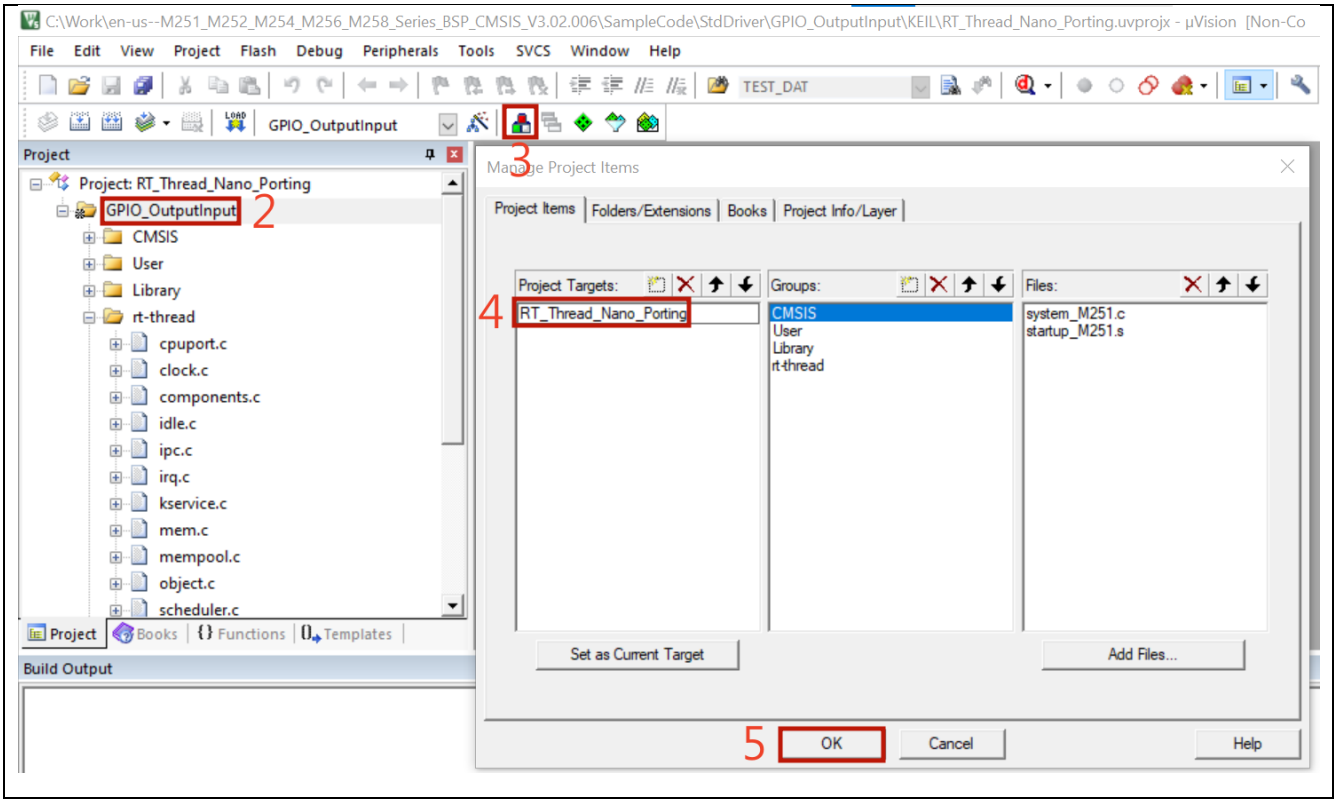


图 2-7 修改工程名称

2.10 修改各文件名称

对各文件名称进行相应修改，并删除非必要文件。

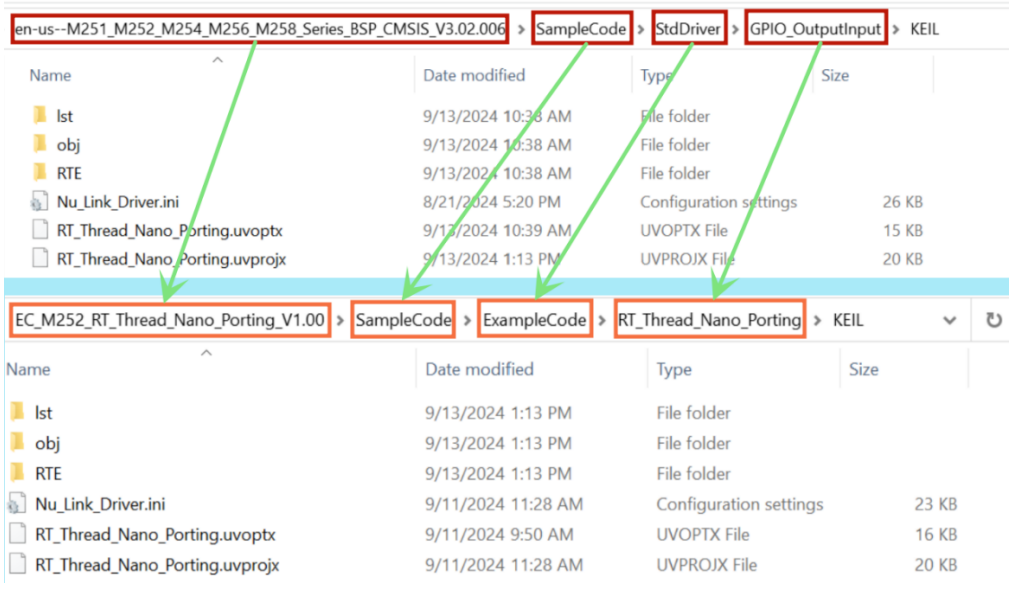


图 2-8 修改各文件名称

3. 软件与硬件需求

3.1 软件需求

- BSP 版本
  - M251_M252_M254_M256_M258_Series_BSP_CMSIS_V3.02.006
- IDE 版本
  - Keil uVersion 5.36

3.2 硬件需求

- 电路组件
  - NuMaker-M252SD V1.2
- 线路示意图
  - 通过设置 Nu-Link2-Me 上的拨码开关，使能其 USB 转串口功能。

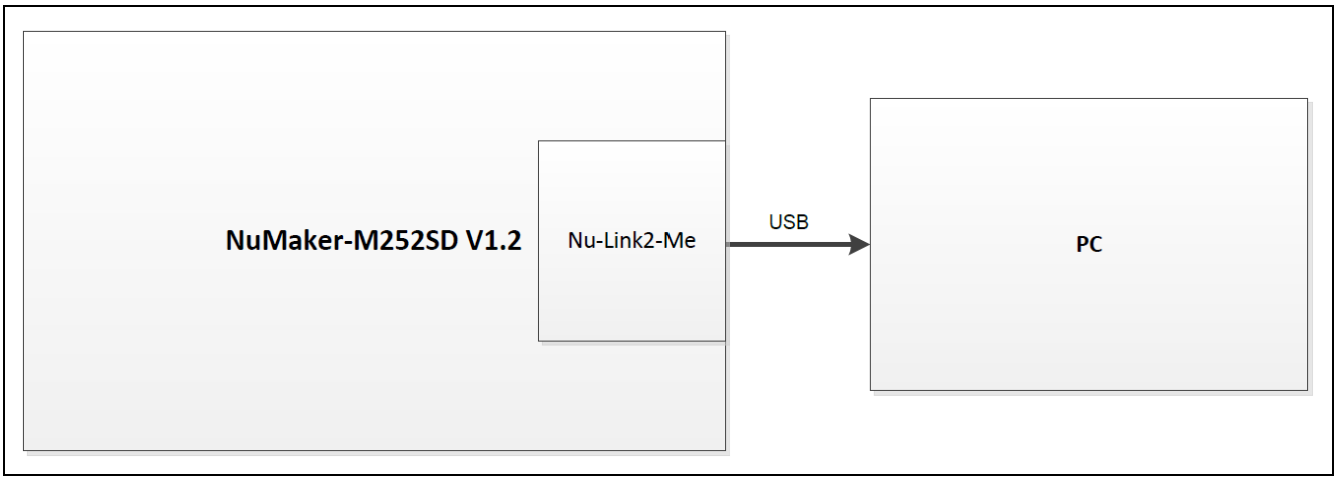


图 3-1 线路示意图

4. 目录信息

EC_252_RT_Thread_Nano_Porting_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
ThirdParty	
rt-thread	Source file of RT-Thread Nano code
SampleCode	
ExampleCode	
Project	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 RT_Thread_Nano_Porting.uvprojx。
2. 进入编译模式界面
   - 编译
   - 下载代码至内存
   - 进入 / 离开仿真模式
3. 进入仿真模式界面
   - 执行代码

6. 修订纪录

Date	Revision	Description
2024.10.08	1.00	初始发布。

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