RT-Thread Nano 移植

NuMicro® 32 位元系列微控制器範例代碼介紹

文件資訊

應用簡述	本範例基於 BSP 中 GPIO_OutputInput 參考程式，介紹如何移植 RT-Thread Nano 並創建 2 個執行緒。
BSP 版本	M251_M252_M254_M256_M258_Series_BSP_CMSIS_V3.02.006
開發平台	NuMaker-M252SD V1.2

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1. 概述

本範例基於 BSP 中 GPIO_OutputInput 參考程式，介紹如何移植 RT-Thread Nano 並創建 2 個執行緒。執行緒 1 通過 GPIO 口，控制 LED 每 500 ms 閃爍一次；執行緒 2 通過 COM 埠，每 1000 ms 交替輸出“Hello”、“World”字樣。

1.1 原理

RT-Thread Nano 是一個精煉的硬即時內核，設計用於記憶體資源有限的系統。功能包括執行執行緒管理、執行緒間同步與通信、時鐘管理、中斷管理和記憶體管理等，這些功能使得 RT-Thread Nano 非常適合需要高性能即時控制的嵌入式系統。支持包括 Arm Cortex M0/M23/M3/M4/M7 以及 RISC-V 等多種 CPU 架構，對記憶體資源的佔用極小，最小只需要 3 K 位元組 Flash 和 1.2 K 位元組 RAM 情況下就可以運行。

本範例使用 M252SD2AE 晶片，包括 64 K 位元組 Flash，12 K 位元組 RAM，介紹如何移植 RT-Thread Nano 並創建管理 2 個執行緒。

1.2 執行結果

本範例代碼執行編譯和燒錄後，LED(PB14) 每 500 ms 閃爍一次，如圖 1-1 所示。

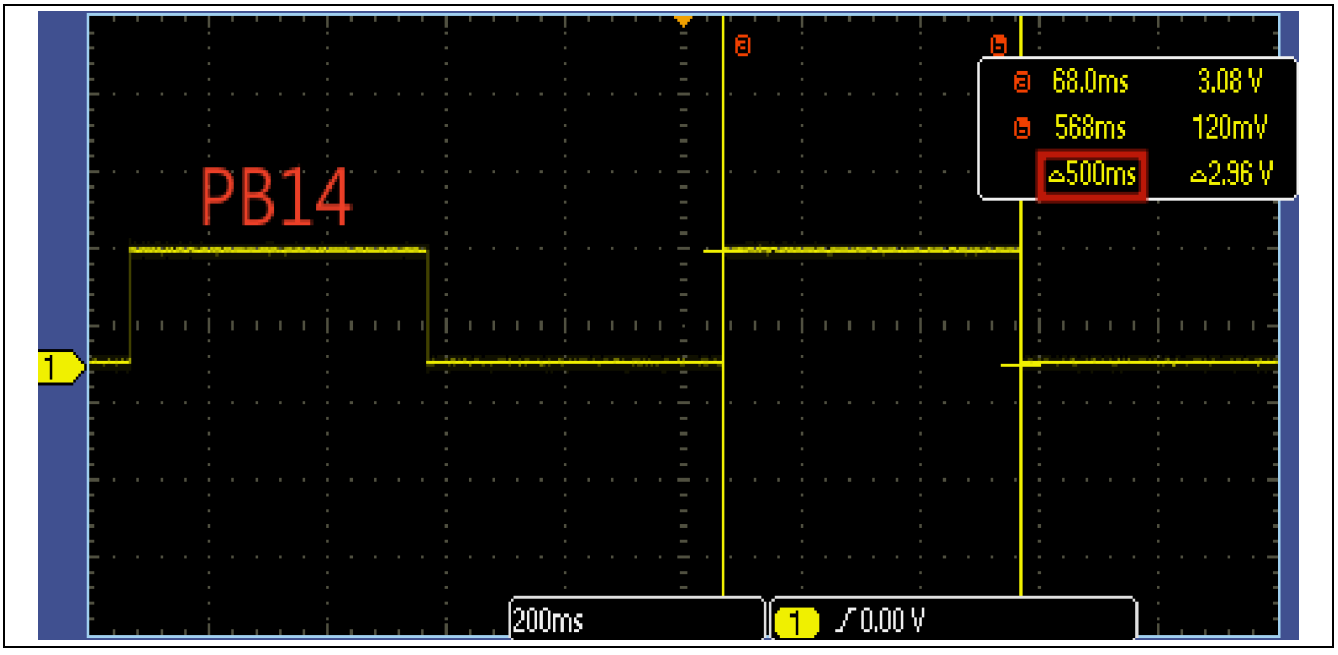


圖 1-1 執行編譯和燒錄結果

COM 埠列印消息如圖 1-2 所示。

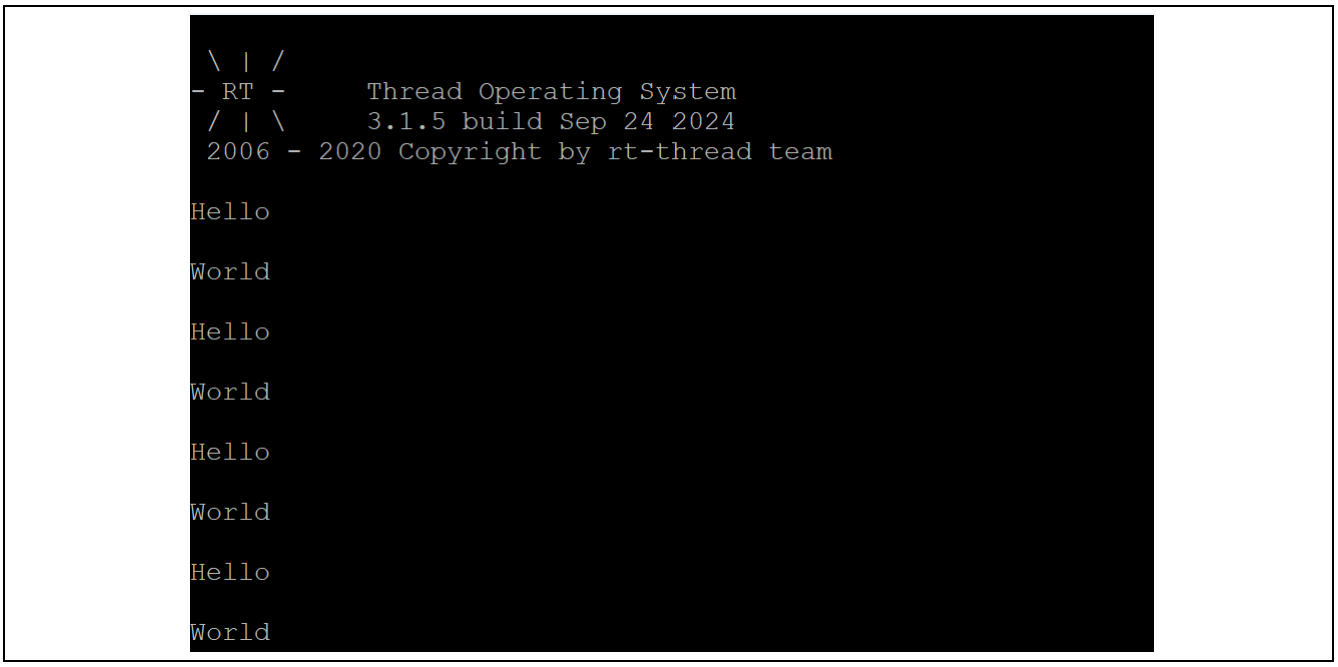


圖 1-2COM 埠列印消息

2. 代碼描述

2.1 下載 RT-Thread Nano 程式碼

單擊下面鏈接，在官網頁面下載 RT-Thread Nano 程式碼。

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

程式碼解壓後如下。

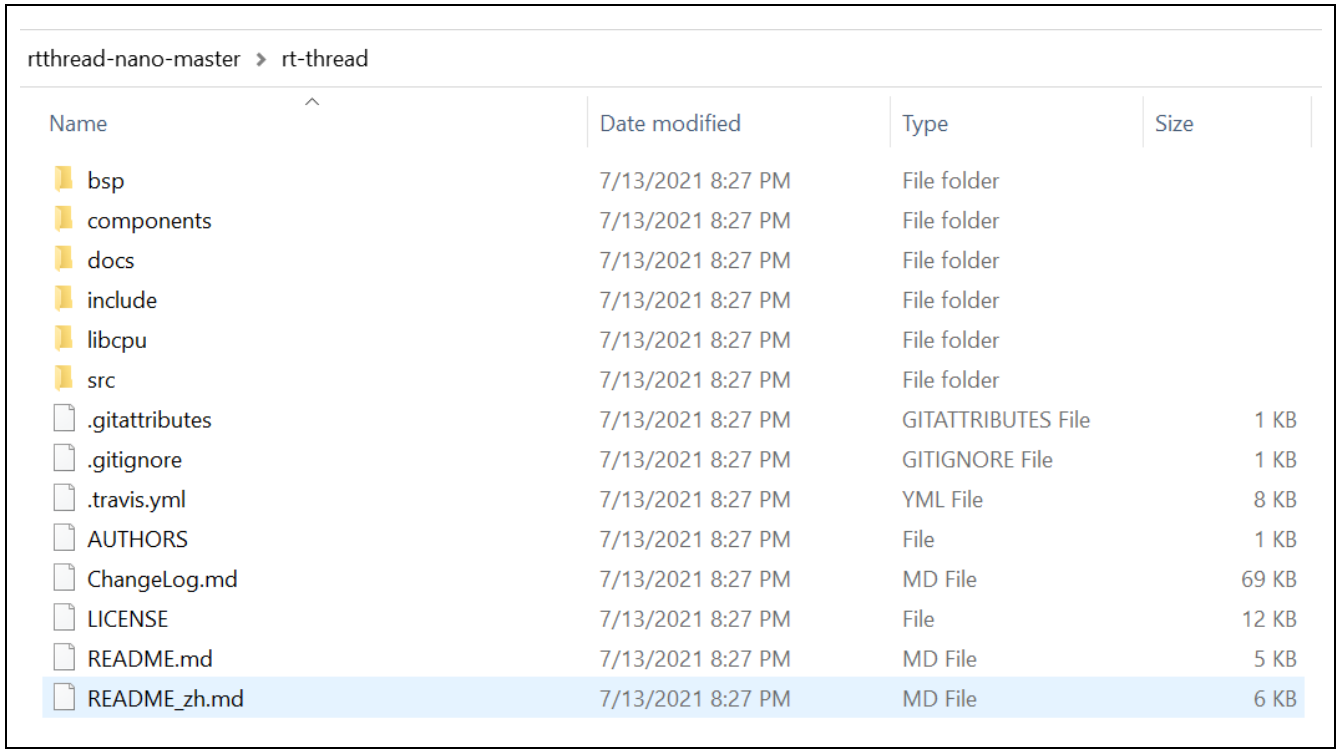


圖 2-1 rt-thread 檔案結構

2.2 拷貝 rt-thread 文件到 BSP 路徑下

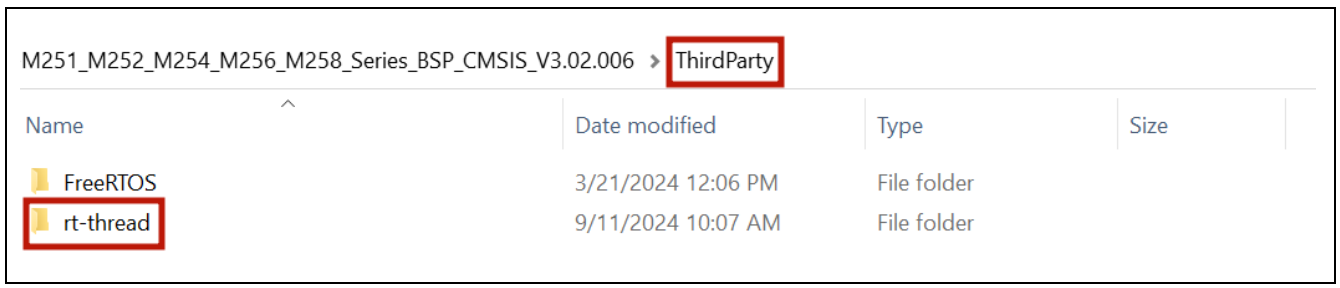


圖 2-2 rt-thread 存放路徑

2.3 新建 rt-thread 組

在專案中新建 rt-thread 組並添加相關源碼檔。

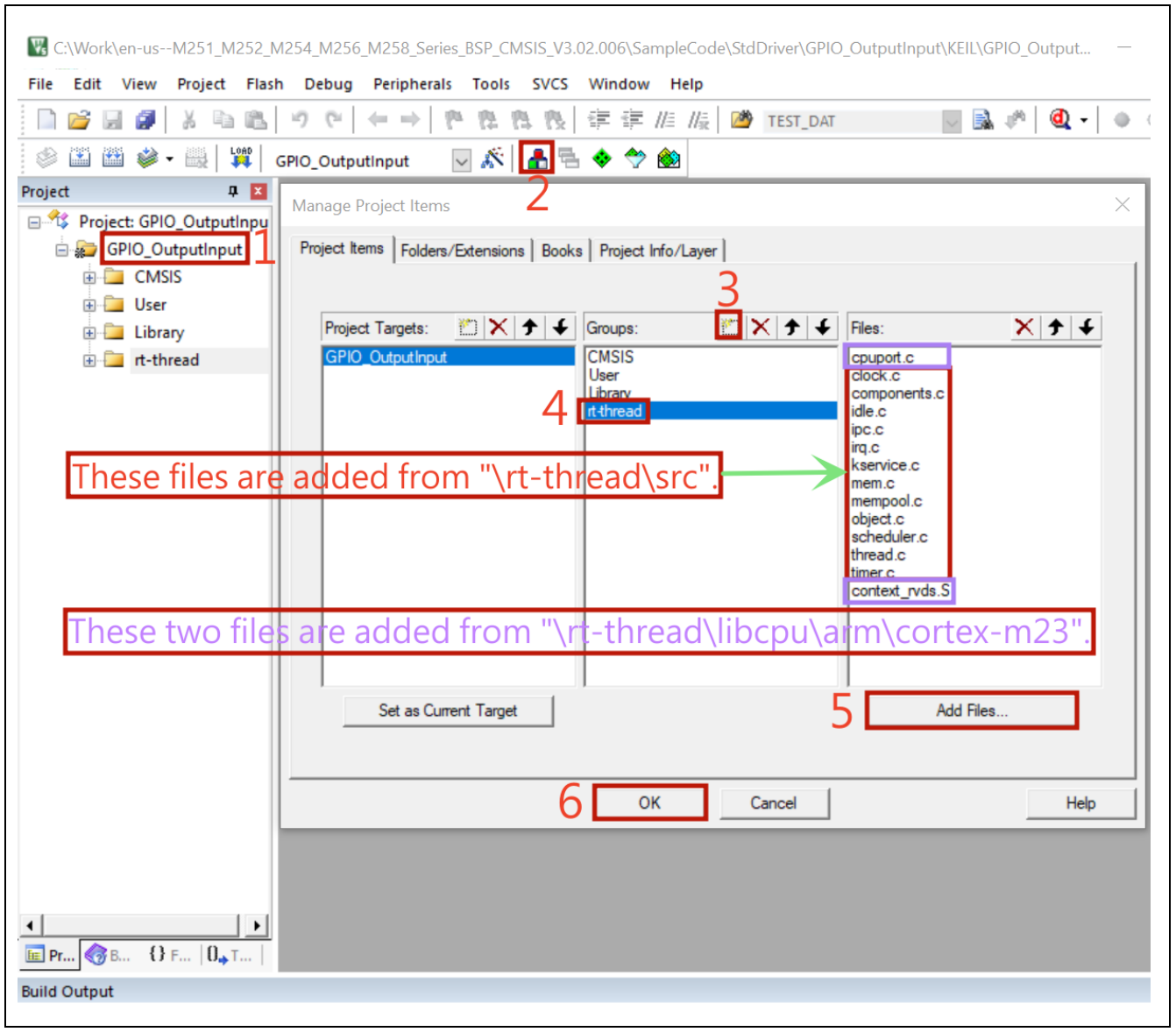


圖 2-3 新建 rt-thread 組並添加源碼檔

2.4 複製 *Board.c* 和 *rtconfig.h* 文件

先將 “\rt-thread\bsp_template\” 路徑下 *Board.c* 和 *rtconfig.h* 文件複製到 “\GPIO_OutputInput\” 路徑，然後將它們添加到 User 組。

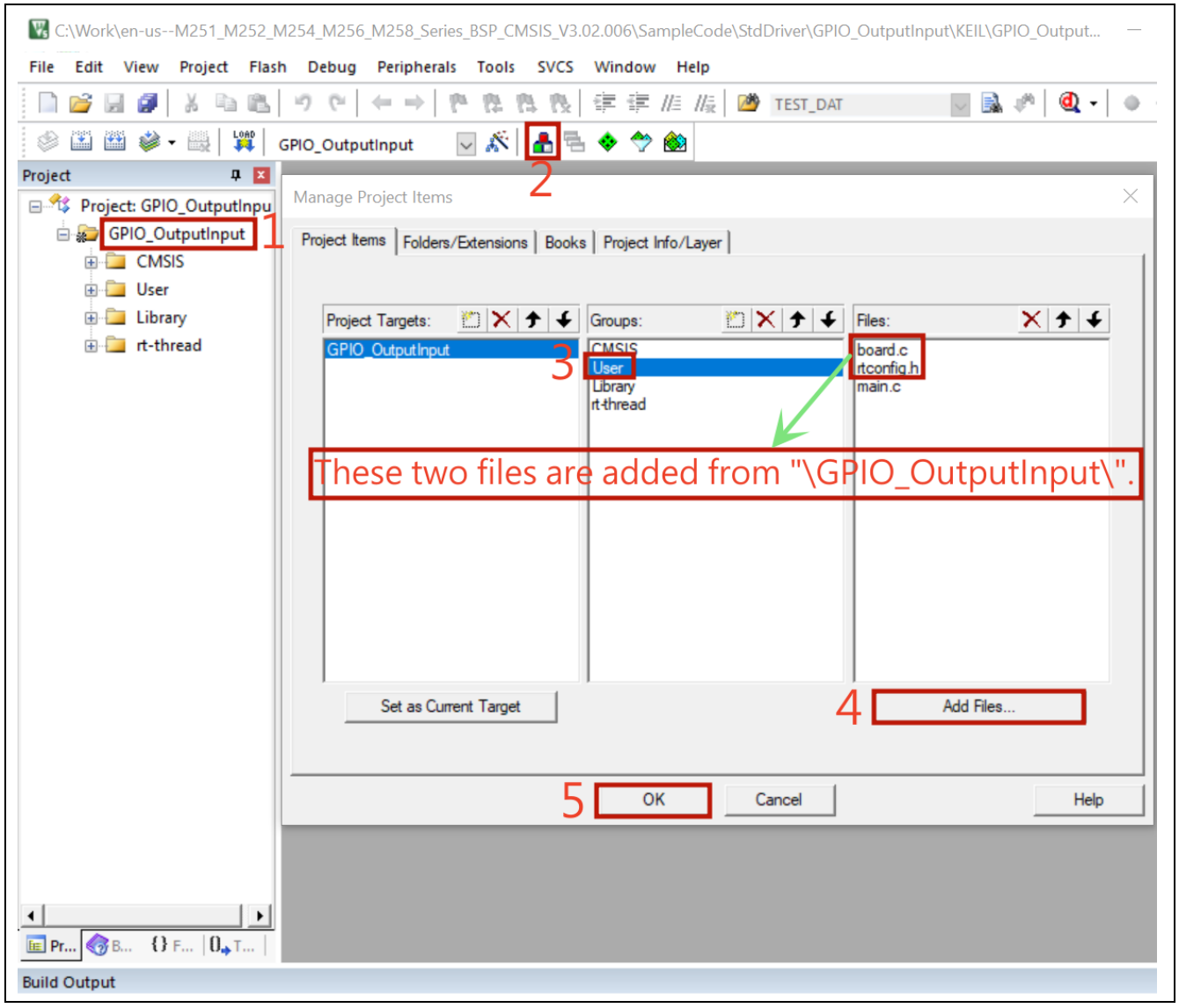


圖 2-4 添加文件到 User 組

2.5 修改專案選項 Include Paths

在專案選項中增加 rt-thread 文件 Include Paths。

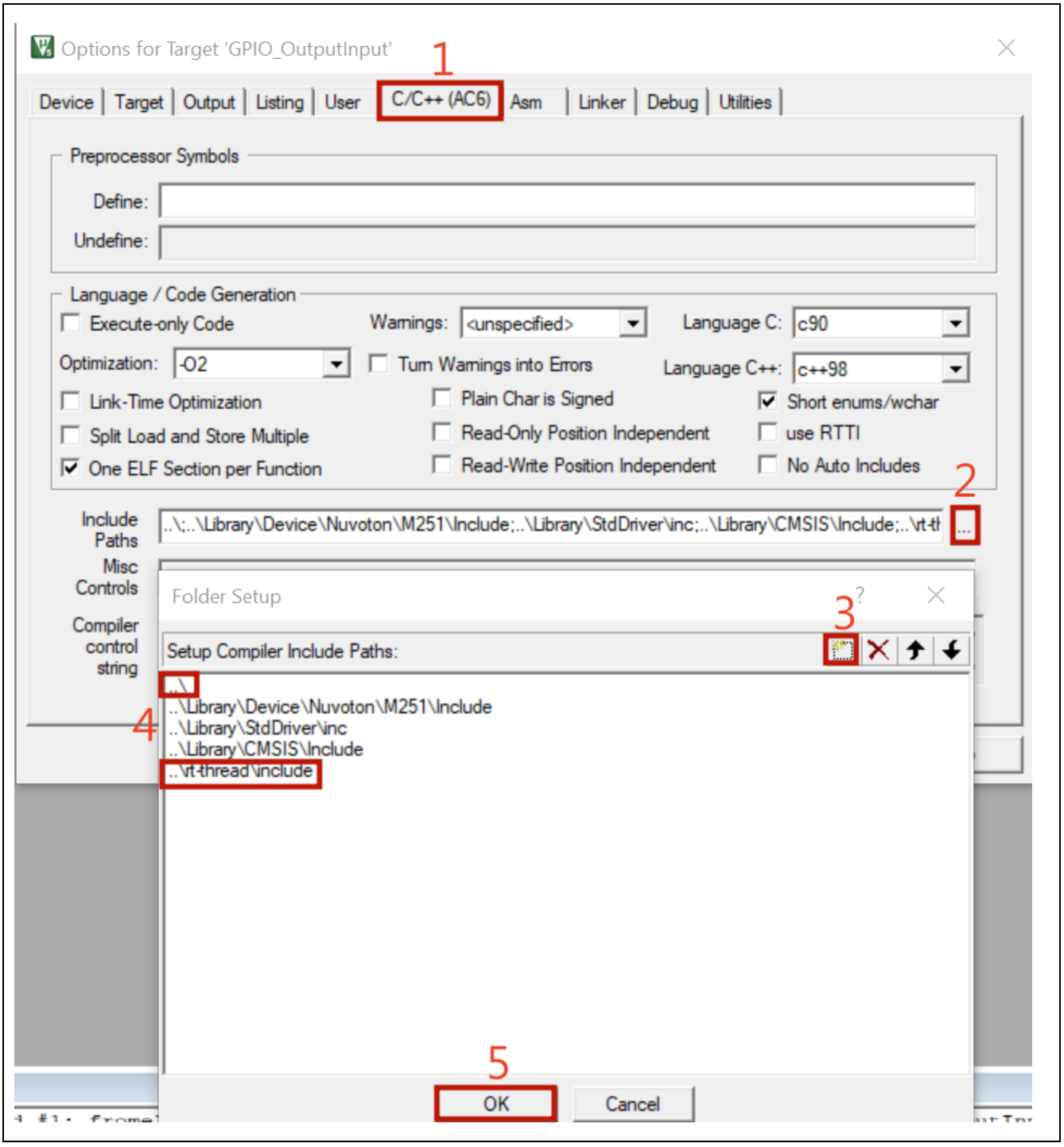


圖 2-5 增加 rt-thread 文件 Include Paths

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"
```

因為目標晶片 SRAM 最大 12 KB，需要將 #define RT_HEAP_SIZE (15*1024) 修改為 #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)
```

將原陣列及函式進行如下重定義，避免 non-word-aligned 風險。

```
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 函式下面新增 SysTick_Handler 函式。

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

在函式 rt_hw_board_init 中，先注釋第一行，然後增加系統初始化、系統內核時鐘更新、配置 SysTick 函式。

```
    //#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);
```

將 *main.c* 檔中 SYS_Init 函式複製到 *board.c* 文件。

在函式 uart_init 中，先注釋第一行，然後增加 UART 復位函式及傳輸速率設置函式。

```
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;
}
```

在函式 rt_hw_console_output 中，先注釋第一行，然後編寫 printf 函式。

```
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>
```

定義 2 個執行緒相關全部變數。

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

執行緒 1 函式設計。

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

執行緒 2 函式設計。

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

刪除 SYS_Init、UART0_Init 函式。

主函式 main 重新設計。

```
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

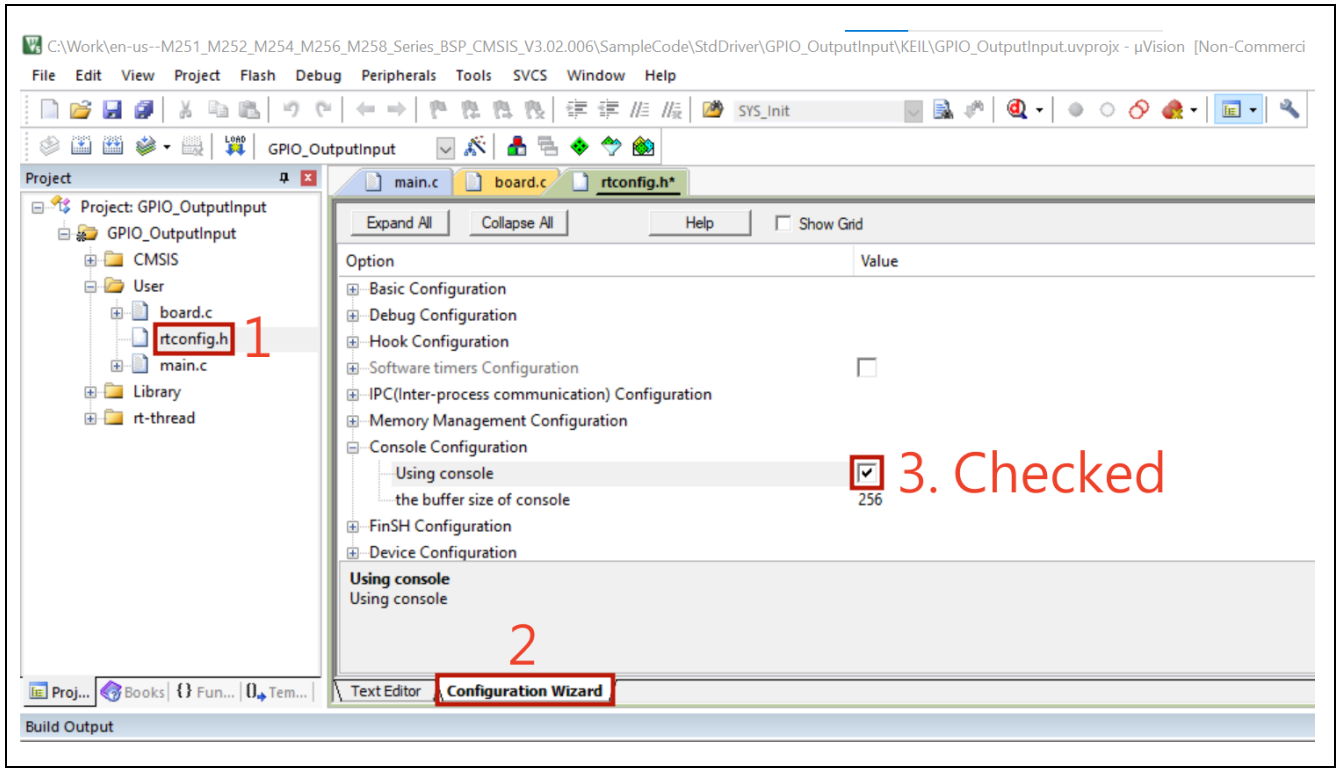
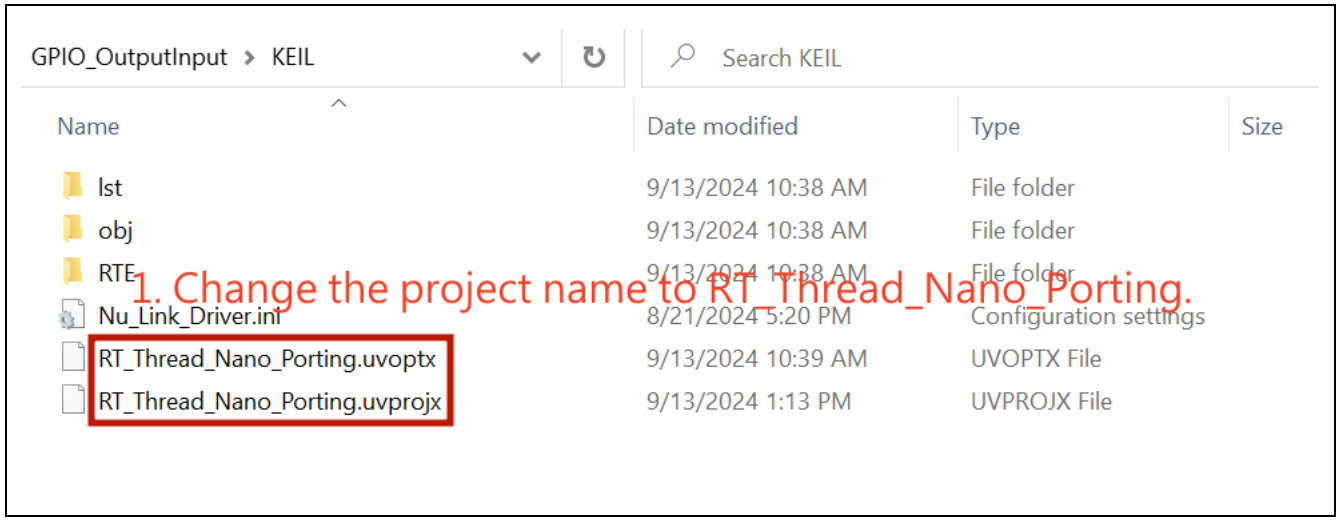


圖 2-6 配置 console

2.9 修改專案名

修改專案名為 RT_Thread_Nano_Porting。



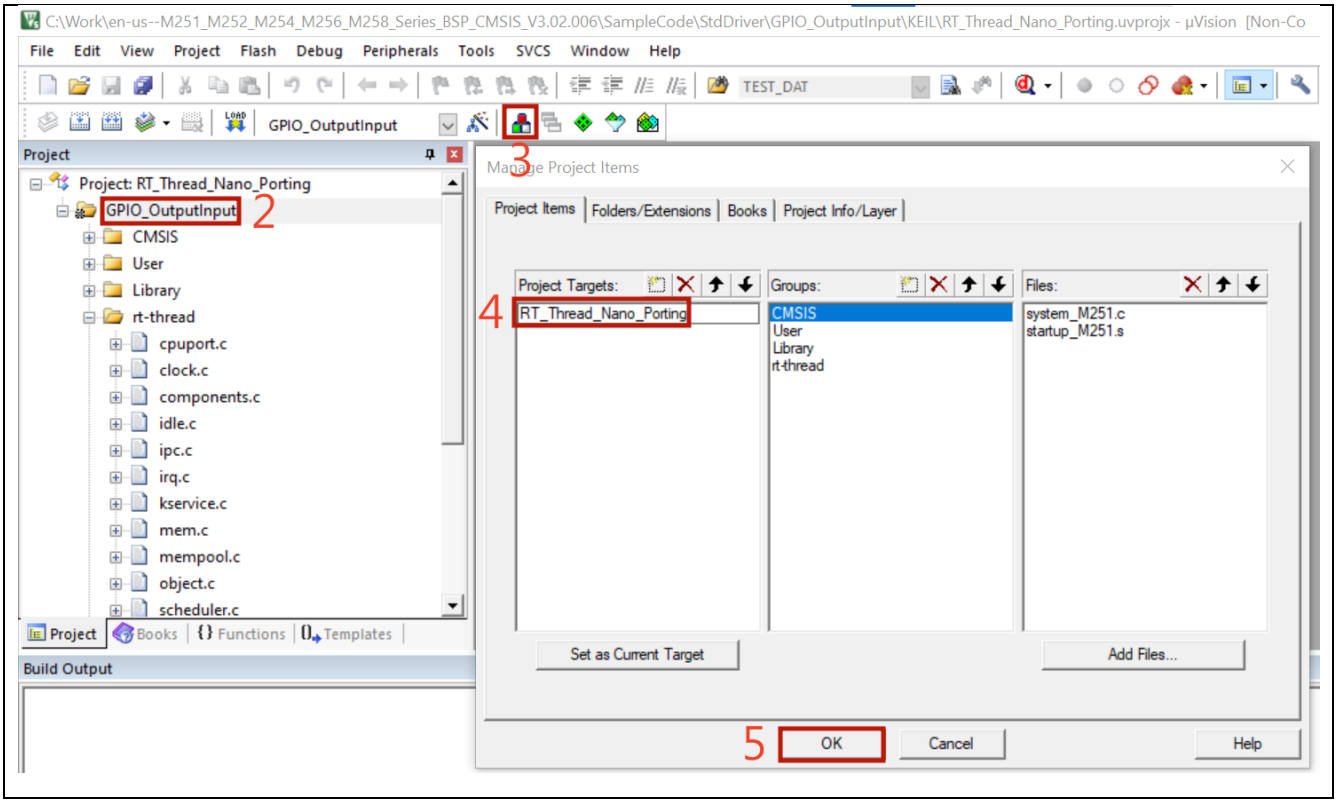


圖 2-7 修改專案名稱

2.10 修改各檔案名稱

對各檔案名稱進行相應修改，並刪除非必要文件。

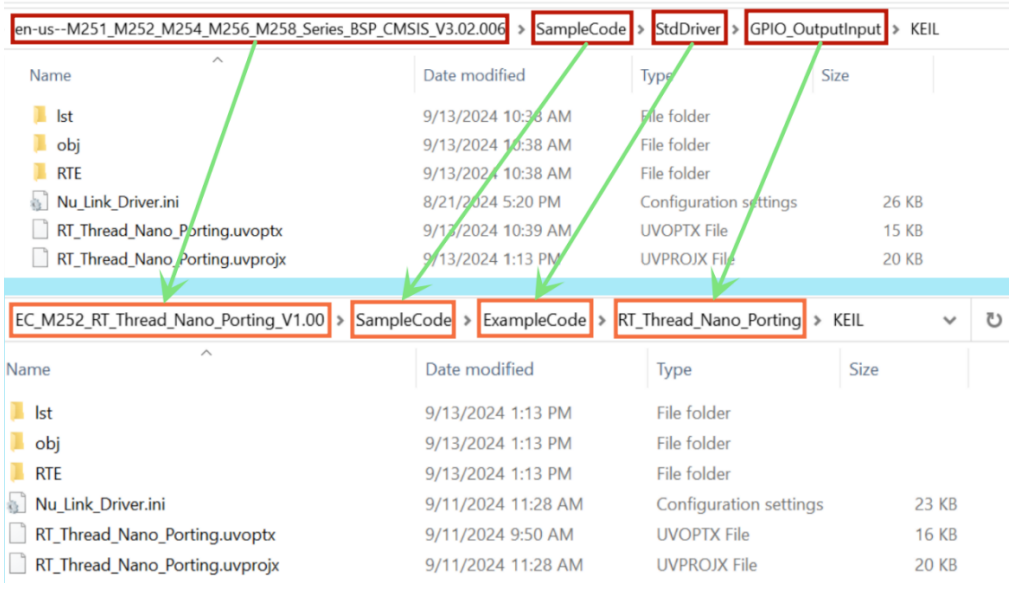


圖 2-8 修改各檔案名稱

3. 軟體與硬體需求

3.1 軟體需求

- BSP 版本
  - M251_M252_M254_M256_M258_Series_BSP_CMSIS_V3.02.00
- IDE 版本
  - Keil uVersion 5.36

3.2 硬體需求

- 電路元件
  - NuMaker-M252SD V1.2
- 線路示意圖
  - 通過設置 Nu-Link2-Me 上的指撥開關，啟用其 USB 轉 COM 埠功能。

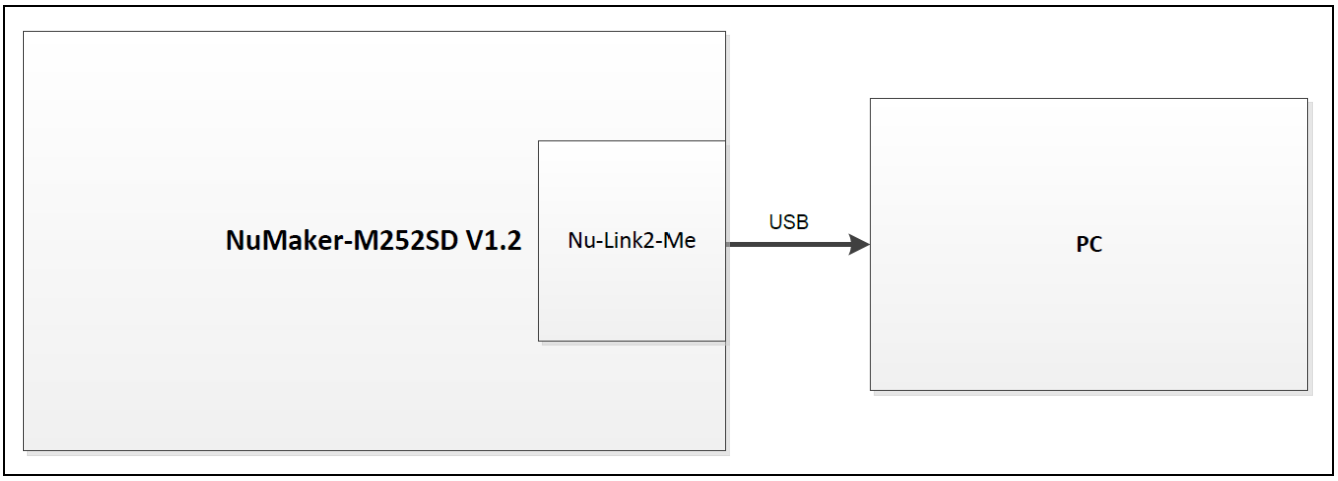


圖 3-1 線路示意圖

4. 目錄資訊

EC_M252_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

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 RT_Thread_Nano_Porting.uvprojx。
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
   - 執行代碼

6. 修訂紀錄

Date	Revision	Description
2024.10.08	1.00	初始發布。

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