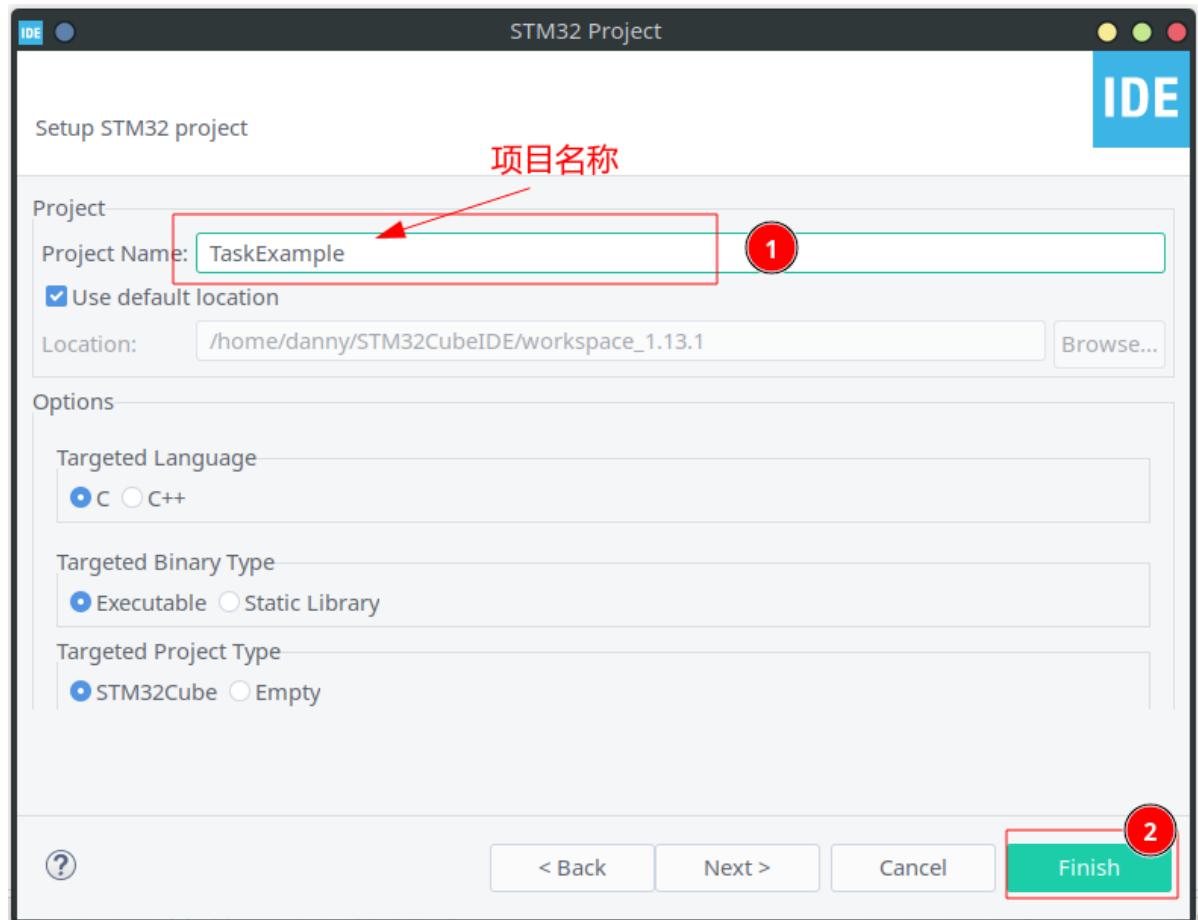
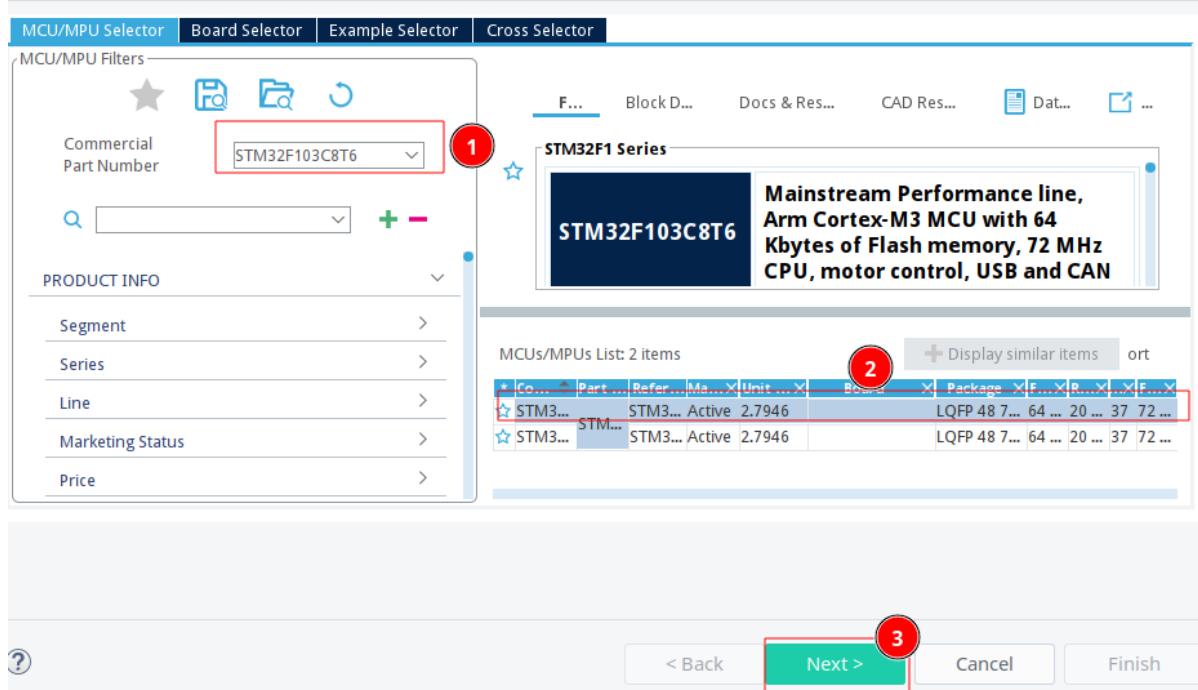


# 1. 新建带FreeRTOS的项目

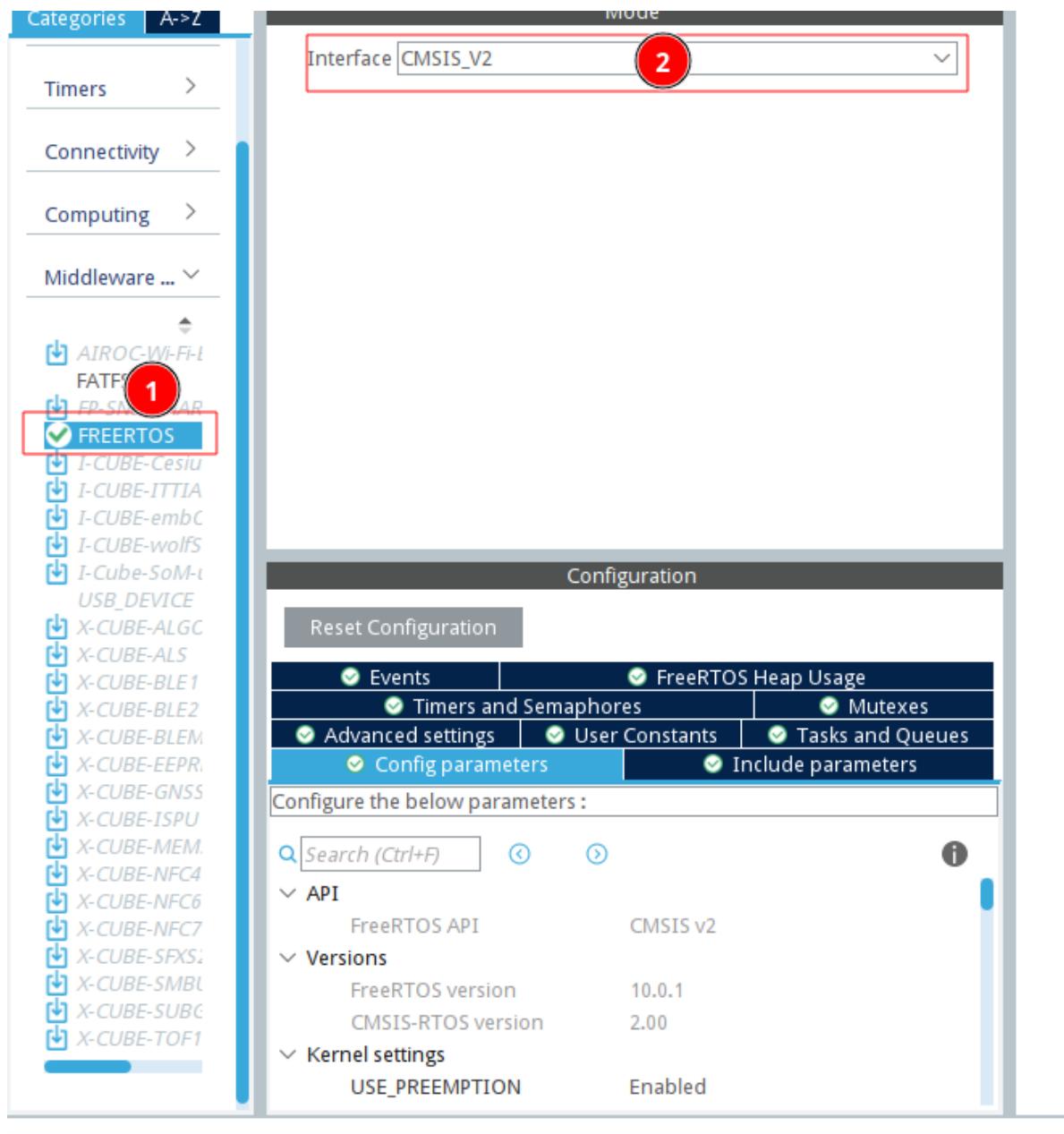
## 1.1. 建立项目

File->New->STM32 Project

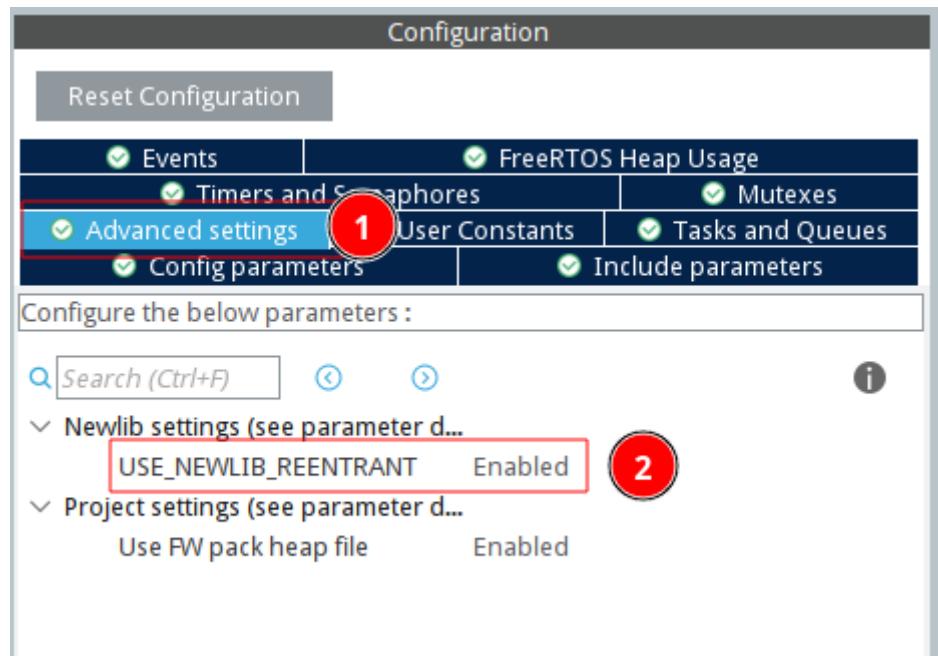


## 1.2. 配置项目

首先启用FreeRTOS支持，使用CMSIS\_V2接口。



在Advanced settings 中打开 NEWLIB 的支持。



设置系统滴答的时钟源以及调试方式。

The screenshot shows the Pinout & Configuration interface. On the left, a sidebar lists peripheral categories: System Core, Analog, Timers, RTC, TIM1, TIM2, TIM3, and TIM4. The 'SYS' category is selected and highlighted with a red box and a red circle labeled 1.

The main area is titled 'SYS Mode and Configuration'. It includes the following settings:

- Mode: Debug (highlighted with a red circle labeled 2) - dropdown menu currently set to 'Serial Wire'.
- System Wake-Up
- Timebase Source: TIM1 (highlighted with a red circle labeled 3) - dropdown menu currently set to 'TIM1'.

At the bottom, a warning message is displayed: **⚠ Warning: This peripheral has no parameters to be configured.**

因为代码量比较多，最好为每个外设设置独立的文件。

The screenshot shows the STM32Cube IDE Project Manager interface. At the top, there are tabs for 'Pinout & Configuration', 'Clock Configuration', and 'Project Manager' (which is highlighted with a red box and has a red number '1' in a circle). The 'Project' tab is selected, showing options for library copying: 'Copy all used libraries into the project folder' (radio button), 'Copy only the necessary library files' (radio button selected), and 'Add necessary library files as reference in the toolchain project configuration file'. Below this is the 'Code Generator' section (highlighted with a red box and has a red number '2'), which includes 'Generated files' settings. One setting, 'Generate peripheral initialization as a pair of '.c/.h' files per peripheral' (checkbox checked), is highlighted with a red box and has a red number '3'. Other settings include 'Backup previously generated files when re-generating', 'Keep User Code when re-generating', and 'Delete previously generated files when not re-generated'. The 'Advanced Settings' tab is also visible.

保存后生成代码框架

最后设置使用printf可以使用浮点。

Project->Properties

The screenshot shows the 'Properties' dialog for a project. The left sidebar lists categories: Resource, Builders, C/C++ Build (highlighted with a red box and has a red number '1'), Build Variables, Environment, Logging, Settings (highlighted with a red box and has a red number '2'), C/C++ General, CMSIS-SVD Settings, Project References, and Run/Debug Settings. The main area is titled 'Settings' with a 'Configuration: Debug [ Active ]' dropdown and a 'Manage Configurations...' button. Below is a tab bar with 'Tool Settings' (highlighted with a red box and has a red number '3'), Build Steps, Build Artifact, Binary Parsers, and Error Parsers. The 'Tool Settings' tab is active, showing the 'MCU Toolchain' section. It includes fields for MCU (STM32F103C8Tx), Board (genericBoard), Floating-point unit (None), Floating-point ABI (Software implementation (-mfloat-abi=single)), Instruction set (Thumb2), and Runtime library (Reduced C (-specs=nano.specs)). Under 'MCU Settings' (highlighted with a red box and has a red number '4'), there is a checkbox 'Use float with printf from newlib-nano (-u \_printf\_float)' (checked) and another checkbox 'Use float with scanf from newlib-nano (-u \_scanf\_float)' (unchecked). At the bottom right are 'Cancel' and 'Apply and Close' buttons.

## 2. 事件标志组的使用

请参考书上333页的讲解。

这里使用两个按钮都同时按过后才能点亮灯作为例子；如果只按了一个按钮不会点亮灯；两个按钮的先后顺序没关系；也就是说这是一个AND关系。

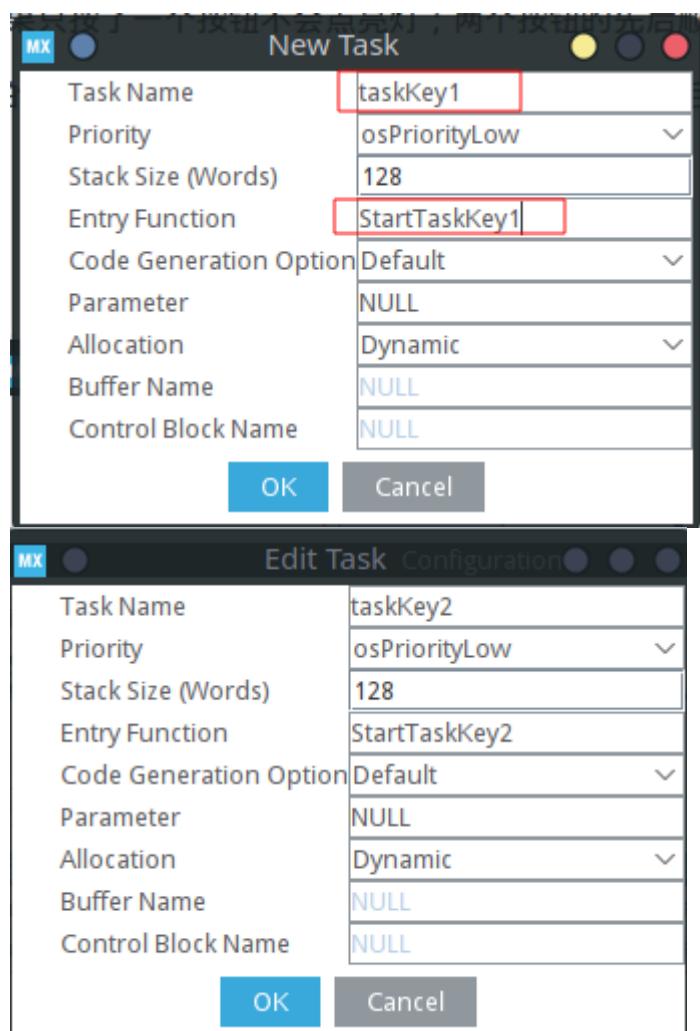
为了简单，我们并不做太多的操作，只是在一个按钮按下时候设置信号而已。当点灯的任务执行完点灯后，清除标志。

### 2.1. 环境配置

这里的配置都在IDE中配置完成，并不涉及代码

## 2.1.1. 按键线程

建立两个线程，定时检查按钮。



## 2.1.2. 按键配置

设置按键方式为输入，设置label为 KEY1 和 KEY2。需要在GPIO中设置两个端口的上拉（其中有个端口有外部上拉，我记不住了，就两个都设置了，也不影响）。

The screenshot shows the STM32CubeMX software's configuration interface. On the left, there is a sidebar with categories like System Core, Analog, Timers, Connectivity, Computing, and Middleware. Under System Core, 'GPIO' is selected and highlighted with a red circle labeled '1'. In the main area, the 'GPIO' tab is active, showing a table of pins. The table has columns for Pin Name, Signal on Pin, GPIO output, GPIO mode, GPIO Pull-up, Maximum, User Label, and Modified. Two rows are present: PB12 and PB13. Both rows have 'n/a' in the first three columns and 'Input mode' in the fourth column. The 'Modified' column for both rows has a checked checkbox, which is highlighted with a red circle labeled '2'. Below the table, there is a configuration panel for PB13, showing options for GPIO mode (set to 'Input mode'), GPIO Pull-up/Pull-down (set to 'Pull-up'), and User Label ('KEY2').

Pin Name	Signal on Pin	GPIO output	GPIO mode	GPIO Pull-up	Maximum	User Label	Modified
PB12	n/a	n/a	Input mode	Pull-up	n/a	KEY1	<input checked="" type="checkbox"/>
PB13	n/a	n/a	Input mode	Pull-up	n/a	KEY2	<input checked="" type="checkbox"/>

### 2.1.3. LED灯配置

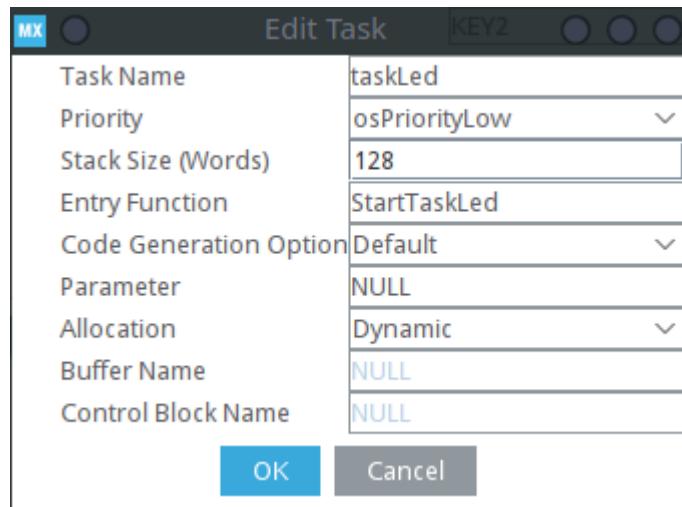
使用红色灯PB0端口设置成输出，并设置label为LED。

This screenshot shows the same configuration interface as the previous one, but with a different focus. The table now highlights the row for PB0, which is set to 'Output Pu...' mode and has 'Low' as its current value. The 'Modified' column for PB0 also has a checked checkbox. The other pins PB12 and PB13 remain in their previous state.

Pin Name	Signal on Pin	GPIO output	GPIO mode	GPIO Pull-up	Maximum	User Label	Modified
PB0	n/a	Low	Output Pu...	No pull-up	Low	LED	<input checked="" type="checkbox"/>
PB12	n/a	n/a	Input mode	Pull-up	n/a	KEY1	<input checked="" type="checkbox"/>
PB13	n/a	n/a	Input mode	Pull-up	n/a	KEY2	<input checked="" type="checkbox"/>

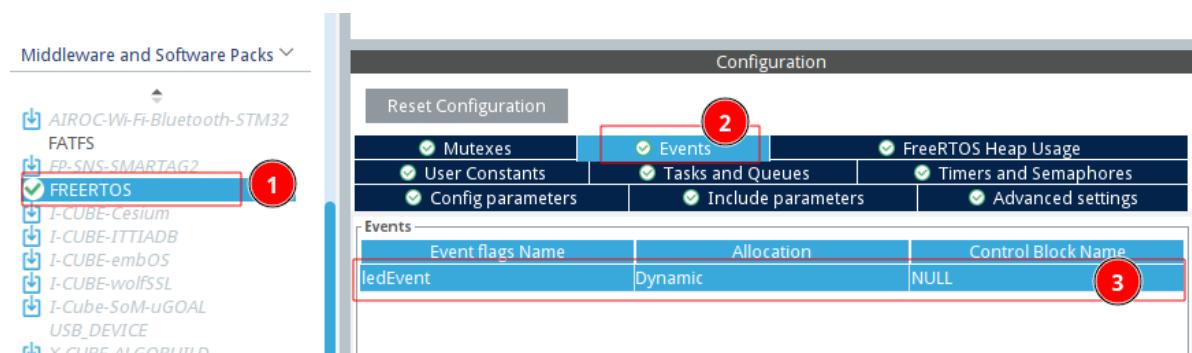
### 2.1.4. LED控制线程

建立一个LED控制线程



## 2.1.5. 事件标志组

书上是通过代码的方式建立事件标志组的，代码有些问题。这里直接使用配置的方式建立事件标志组。



## 2.2. 代码解析

IDE已经为我们生成了代码框架，接下来看看主要的代码块在什么位置。

### 2.2.1. 代码框架

GPIO的端口常量定义在main.h 的大约 60 行：

```
#define LED_Pin GPIO_PIN_0
#define LED_GPIO_Port GPIOB
#define KEY1_Pin GPIO_PIN_12
#define KEY1_GPIO_Port GPIOB
#define KEY2_Pin GPIO_PIN_13
#define KEY2_GPIO_Port GPIOB
```

这里定义了我们的三个IO的port和pin，到时候需要使用。

在 freertos.c 大约67行定义了事件标志组的变量：

```
/* Definitions for ledEvent */
osEventFlagsId_t ledEventHandle;
const osEventFlagsAttr_t ledEvent_attributes = { .name = "ledEvent" };
```

在大约87行的MX\_FREERTOS\_Init 初始化函数中对线程以及事件标志进行初始化：

```
void MX_FREERTOS_Init(void) {
    /* USER CODE BEGIN Init */
```

```

/* USER CODE END Init */

/* USER CODE BEGIN RTOS_MUTEX */
/* add mutexes, ... */
/* USER CODE END RTOS_MUTEX */

/* USER CODE BEGIN RTOS_SEMAPHORES */
/* add semaphores, ... */
/* USER CODE END RTOS_SEMAPHORES */

/* USER CODE BEGIN RTOS_TIMERS */
/* start timers, add new ones, ... */
/* USER CODE END RTOS_TIMERS */

/* USER CODE BEGIN RTOS_QUEUES */
/* add queues, ... */
/* USER CODE END RTOS_QUEUES */

/* Create the thread(s) */
/* creation of defaultTask */
defaultTaskHandle = osThreadNew(StartDefaultTask, NULL,
                               &defaultTask_attributes);

/* creation of taskKey1 */
taskKey1Handle = osThreadNew(StartTaskKey1, NULL, &taskKey1_attributes);

/* creation of taskKey2 */
taskKey2Handle = osThreadNew(StartTaskKey2, NULL, &taskKey2_attributes);

/* creation of taskLed */
taskLedHandle = osThreadNew(StartTaskLed, NULL, &taskLed_attributes);

/* USER CODE BEGIN RTOS_THREADS */
/* add threads, ... */
/* USER CODE END RTOS_THREADS */

/* Create the event(s) */
/* creation of ledEvent */
ledEventHandle = osEventFlagsNew(&ledEvent_attributes);

/* USER CODE BEGIN RTOS_EVENTS */
/* add events, ... */
/* USER CODE END RTOS_EVENTS */

}

```

在freertos.c中有三个自定义的线程，可以在IDE的Outline中比较方便的看到：

- StartTaskKey1(void\*) : void
- StartTaskKey2(void\*) : void
- StartTaskLed(void\*) : void

这三个函数就是具体的线程任务，我们看看其中的一个，其他三个都是类似的。

```
/* USER CODE BEGIN Header_StartTaskKey1 */
/**
 * @brief Function implementing the taskKey1 thread.
 * @param argument: Not used
 * @retval None
 */
/* USER CODE END Header_StartTaskKey1 */
void StartTaskKey1(void *argument) {
    /* USER CODE BEGIN StartTaskKey1 */
    /* Infinite loop */
    for (;;) {
        osDelay(1);
    }
    /* USER CODE END StartTaskKey1 */
}
```

## 2.2.2. 添加代码

我们需要在两个按键的线程中读取按键的状态，当按钮被按下后，设置相应的事件标志位；在后在LED线程中等待相应的标志位，等待选项设置成 osFlagsWaitAll，表示当所有的事件被设置后才相应。

实验中采用第0位和第1位作为事件标志。

两个按键线程的代码分别是：

```
/* USER CODE BEGIN Header_StartTaskKey1 */
/**
 * @brief Function implementing the taskKey1 thread.
 * @param argument: Not used
 * @retval None
 */
/* USER CODE END Header_StartTaskKey1 */
void StartTaskKey1(void *argument) {
    /* USER CODE BEGIN StartTaskKey1 */
    /* Infinite loop */
    for (;;) {
        osDelay(10);
        if (!HAL_GPIO_ReadPin(KEY1_GPIO_Port, KEY1_Pin))
            osEventFlagsSet(ledEventHandle, 0x01);
    }
    /* USER CODE END StartTaskKey1 */
}
```

```
/* USER CODE BEGIN Header_StartTaskKey2 */
/**
 * @brief Function implementing the taskKey2 thread.
 * @param argument: Not used
 * @retval None
 */
/* USER CODE END Header_StartTaskKey2 */
void StartTaskKey2(void *argument) {
```

```

/* USER CODE BEGIN StartTaskKey2 */
/* Infinite loop */
for (;;) {
    osDelay(10);
    if (!HAL_GPIO_ReadPin(KEY2_GPIO_Port, KEY2_Pin))
        osEventFlagsSet(ledEventHandle, 0x02);
}
/* USER CODE END StartTaskKey2 */
}

```

使用一个死循环去循环检测按钮，每次检测的间隔是10个系统滴答（10ms，因为系统滴答的频率是1000）。注意，这里必须使用osDelay函数！

如果检测到按键被按下，设置事件标志组的标志。按键1设置第0位，因此是0x01；按键2设置第1位，因此是0x02。

LED线程等待标志位：

```

/* USER CODE BEGIN Header_StartTaskLed */
/**
 * @brief Function implementing the taskLed thread.
 * @param argument: Not used
 * @retval None
 */
/* USER CODE END Header_StartTaskLed */
void StartTaskLed(void *argument) {
    /* USER CODE BEGIN StartTaskLed */
    /* Infinite loop */
    for (;;) {
        osEventFlagsWait(ledEventHandle, 0x03, osFlagsWaitAll, osWaitForever);
        HAL_GPIO_TogglePin(LED_GPIO_Port, LED_Pin);
    }
    /* USER CODE END StartTaskLed */
}

```

因为第0位和第1位都设置后的位掩码对应的数字是0x03，这样当检测到两个标志都设置后才对LED进行翻转。如果osEventFlagsWait等待到事件满足条件后，会清空相应的事件标志。

### 2.2.3. 实验效果

单按一个按钮LED并不会进行状态转换，按一个后（可以释放），再按第二个后，LED的状态翻转。