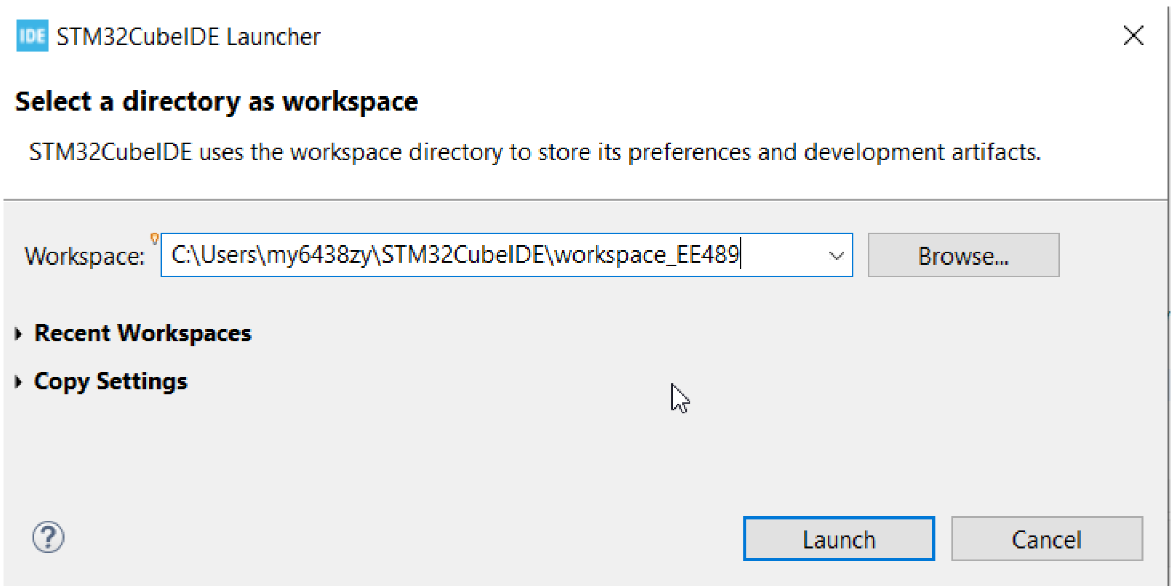
Real-time Embedded Systems Lab Manual

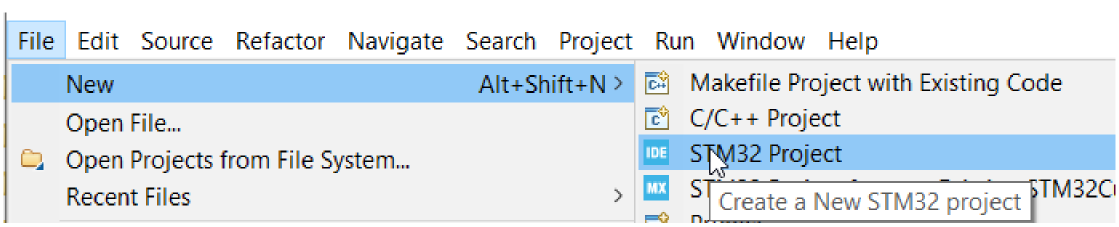
Thread Management in FreeRTOS – Part 1

1. Creating a new STM32 IDE project

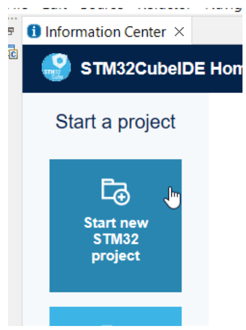
a. Starting STM32Cube IDE. This IDE first displays the ***STM32CubeIDE Launcher*** dialog with workspace selection. The first time the IDE is started, it presents a default location and workspace name. Any newly created project is stored in this workspace. The workspace is created if it does not yet exist. For example, the workspace is set as *C:\Users\xxxx\STM32CubeIDE\workspace_EE489* (xxxx could be your starID). Then, click **Launch**.



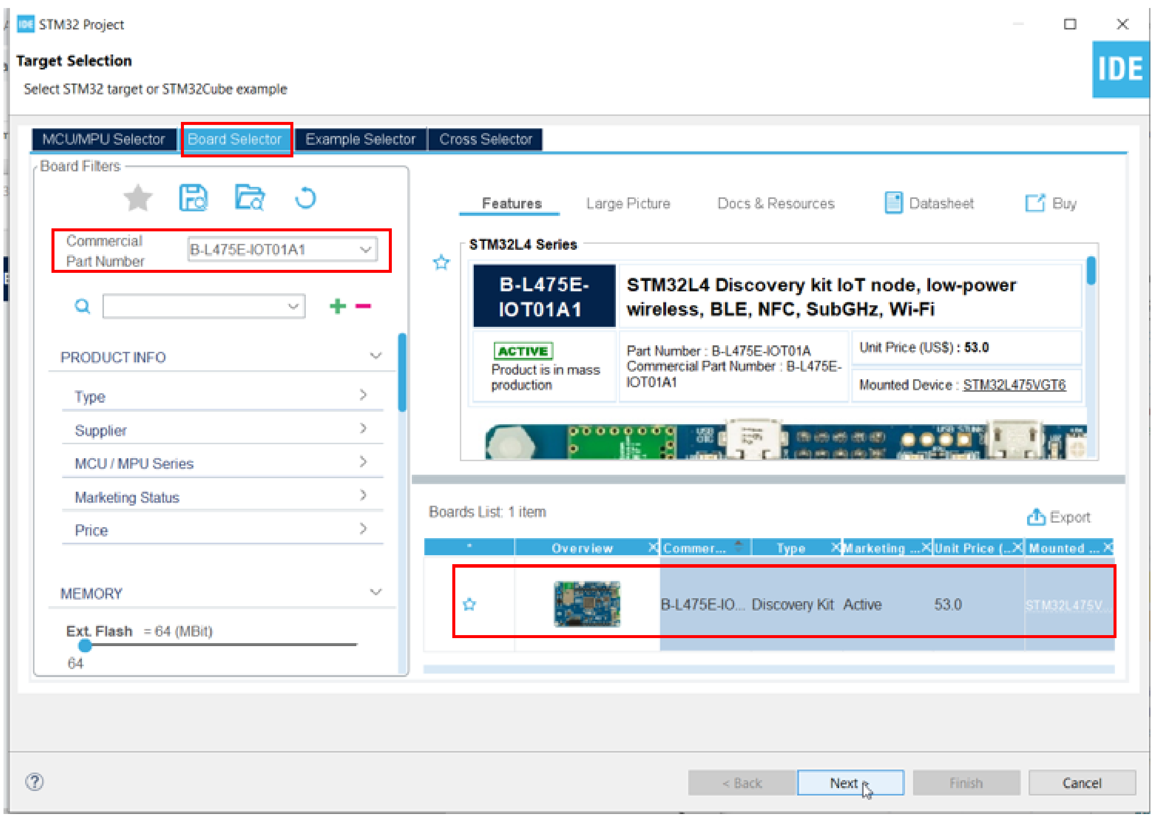
b. Select **File >> New >> STM32 Project**.



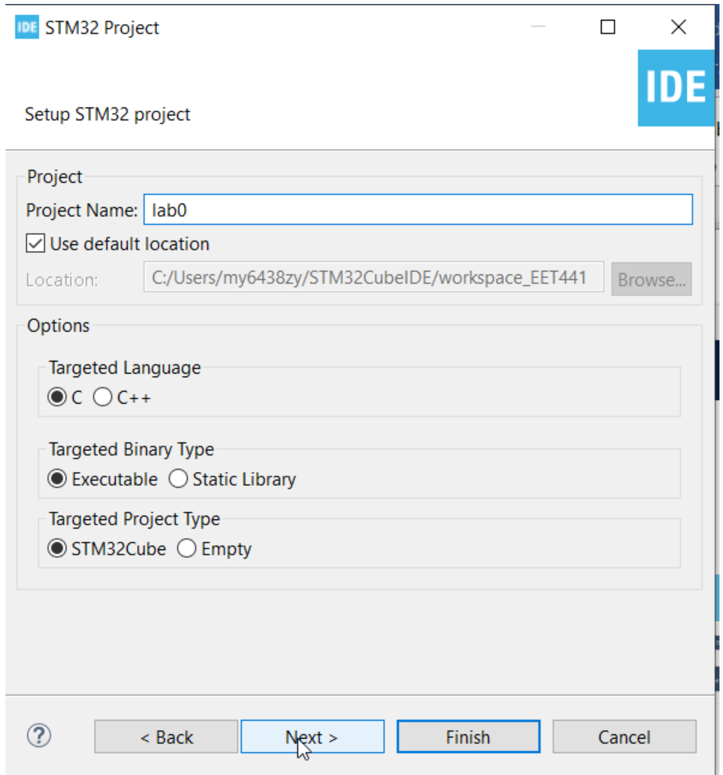
Alternatively, you could also start a new project by clicking the "**Start New STM32 project**" icon on the "**Information Center**" page, as shown below.



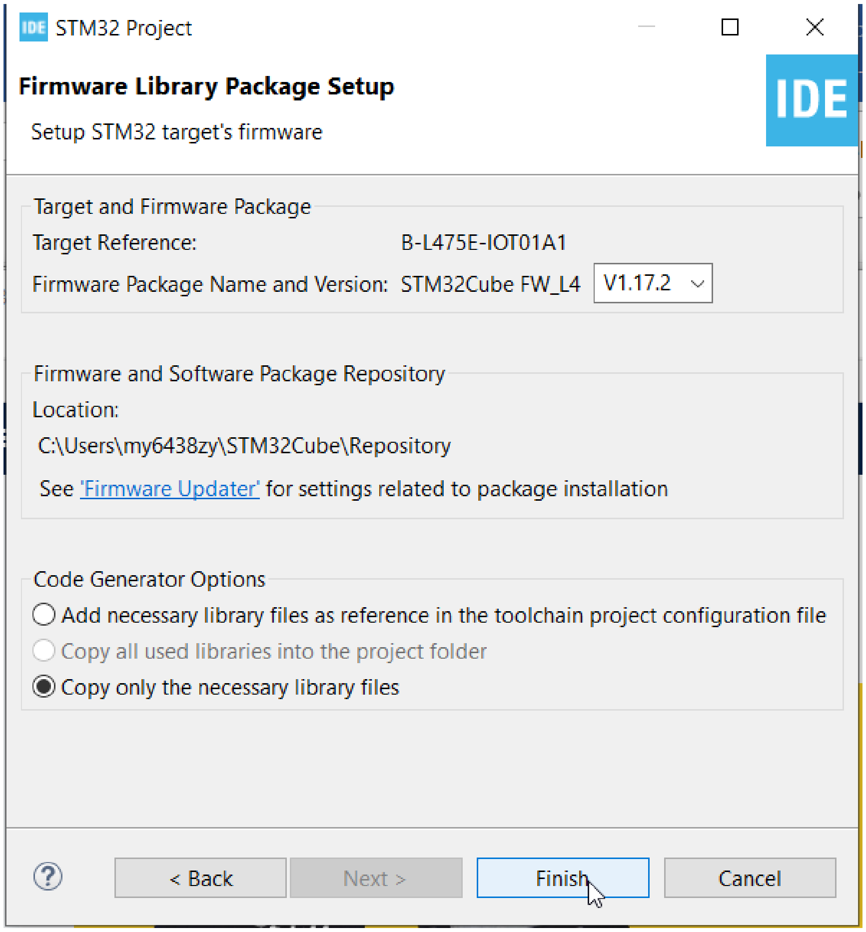
c. On the **Target Selection** window, select the **Board Selector** tab. Then, select B-L475E-IOT01A from the drop-down list under *the Commercial Part Number* search panel.
On the right-bottom of this window, Select B-L475E-IOT01A among the boards list that meet the search requirements specified before (only one board is listed here), and Click the **Next >** button at the bottom.



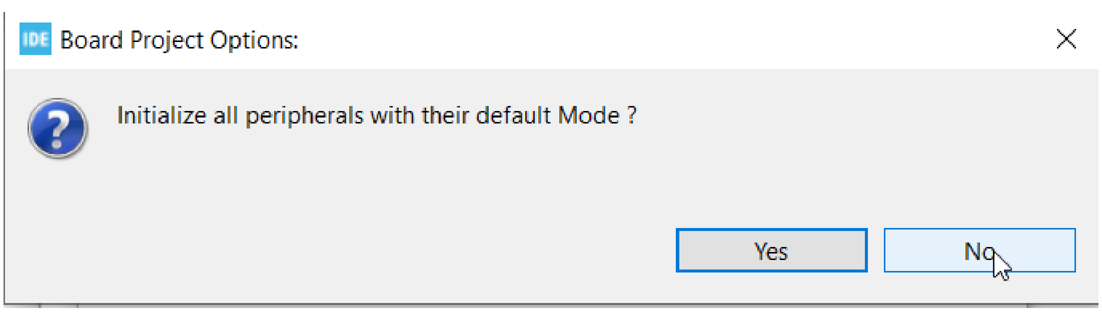
d. The *Project setup* page opens. Enter a project name, i.e. lab0, and leave the settings for the project in the dialog boxes as default. Then click Next >.



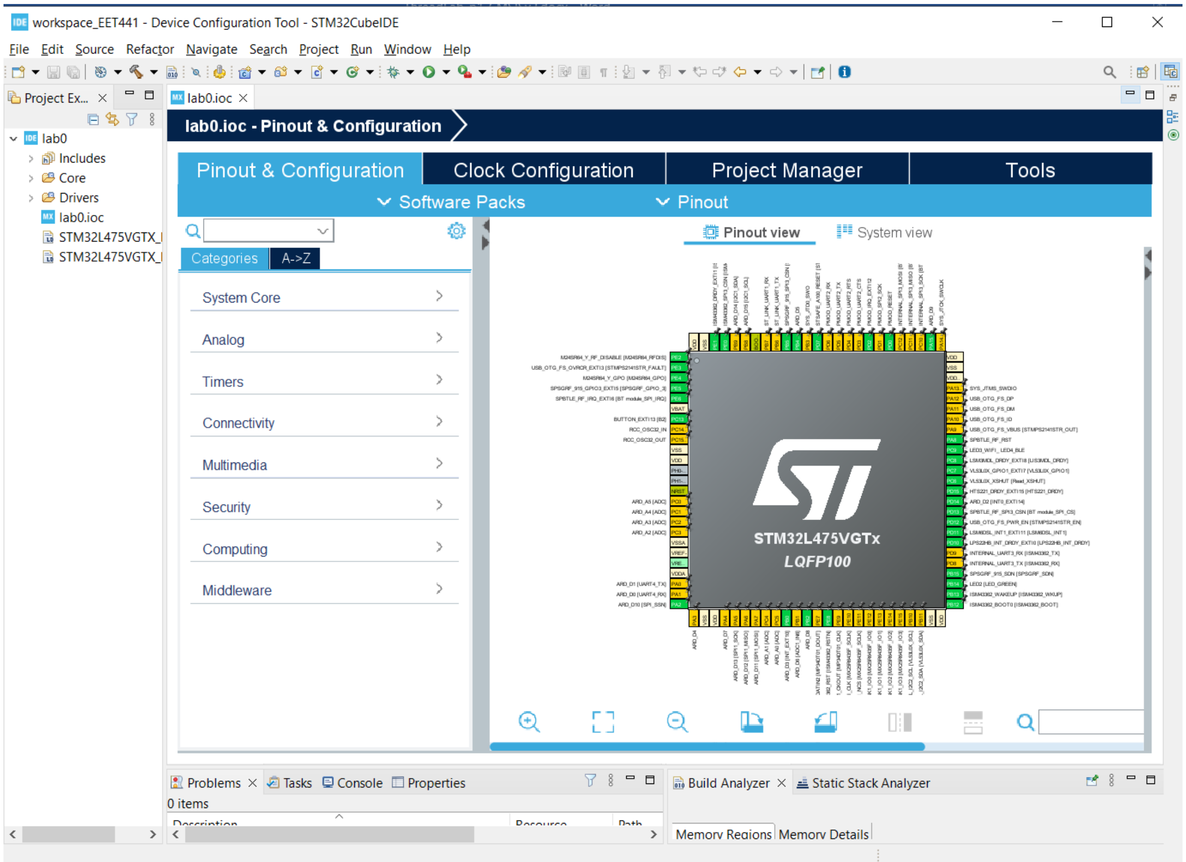
e. The *Firmware Library Package Setup* page opens. In this page, it is possible to select the STM32 Cube firmware package to use when creating the project. For this lab, the default settings are used. Press **Finish** to create the project.



f. Answer **No** when prompted to **initialize all peripherals in their default mode** as we do not want to initialize all peripherals, but only the ones that we use.

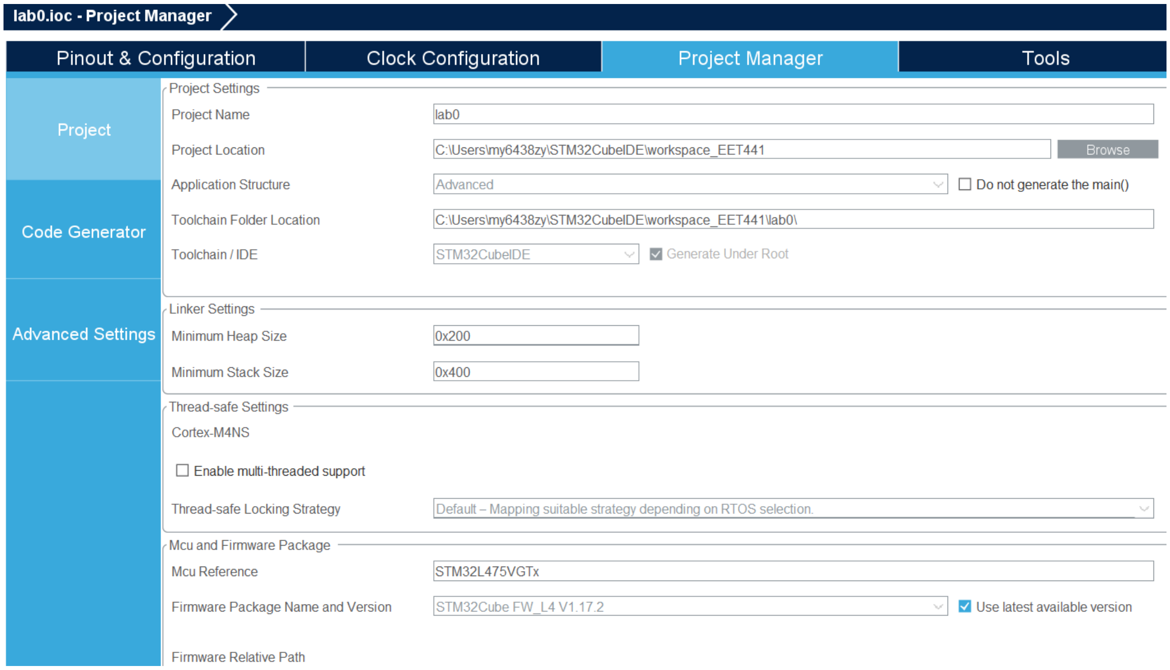


g. When the project is created, it is listed in the ***Project Explorer*** view with some of the folders and files it contains. The *lab0.ioc* contains the configuration settings and is opened in the STM32CubeMX editor.
The editor includes tabs for *Pinout & configuration*, *Clock configuration*, *Project manager* and *Tools*.

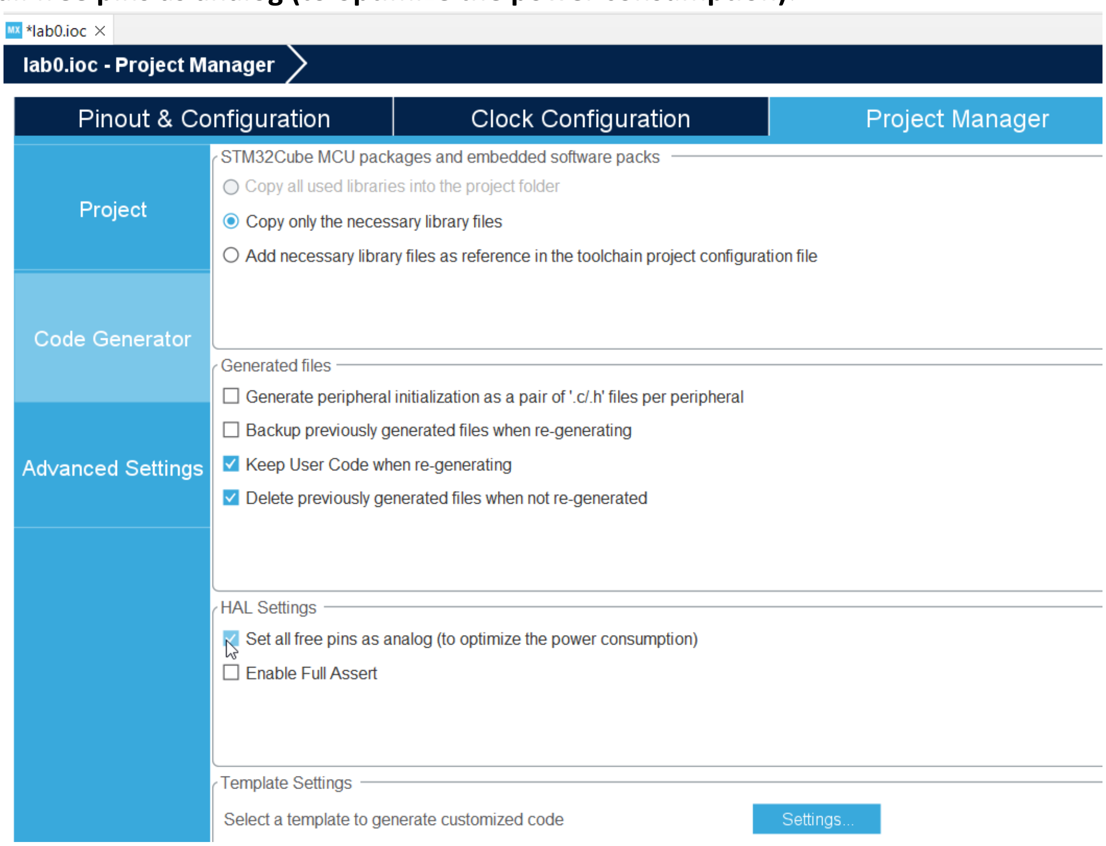


2. **Opening the Project Manager view**

a. Select the “Project” tab on the left side. Leave all the settings as default.



b. Select the “Code Generator” tab on the left side. Optionally, under **HAL settings**, check **set all free pins as analog (to optimize the power consumption)**.

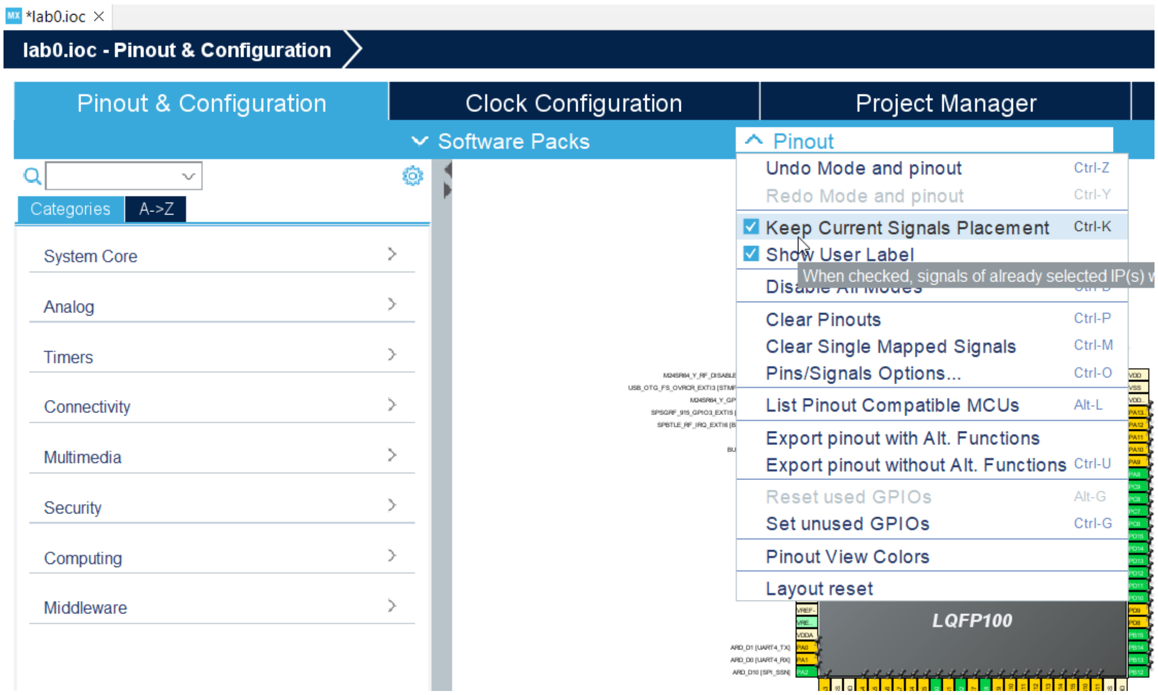


3. Opening the Clock Configuration view

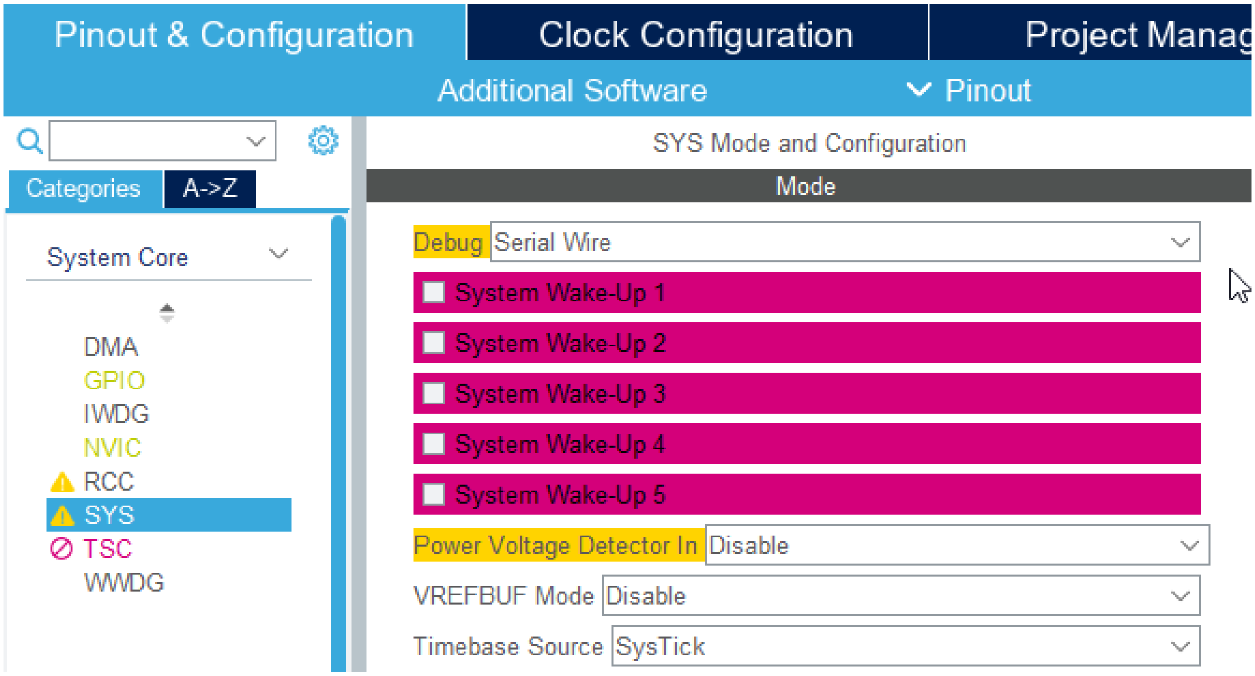
In this view, keep the default settings of clock. No change is needed.

4. Opening the Pinout&Configuration view

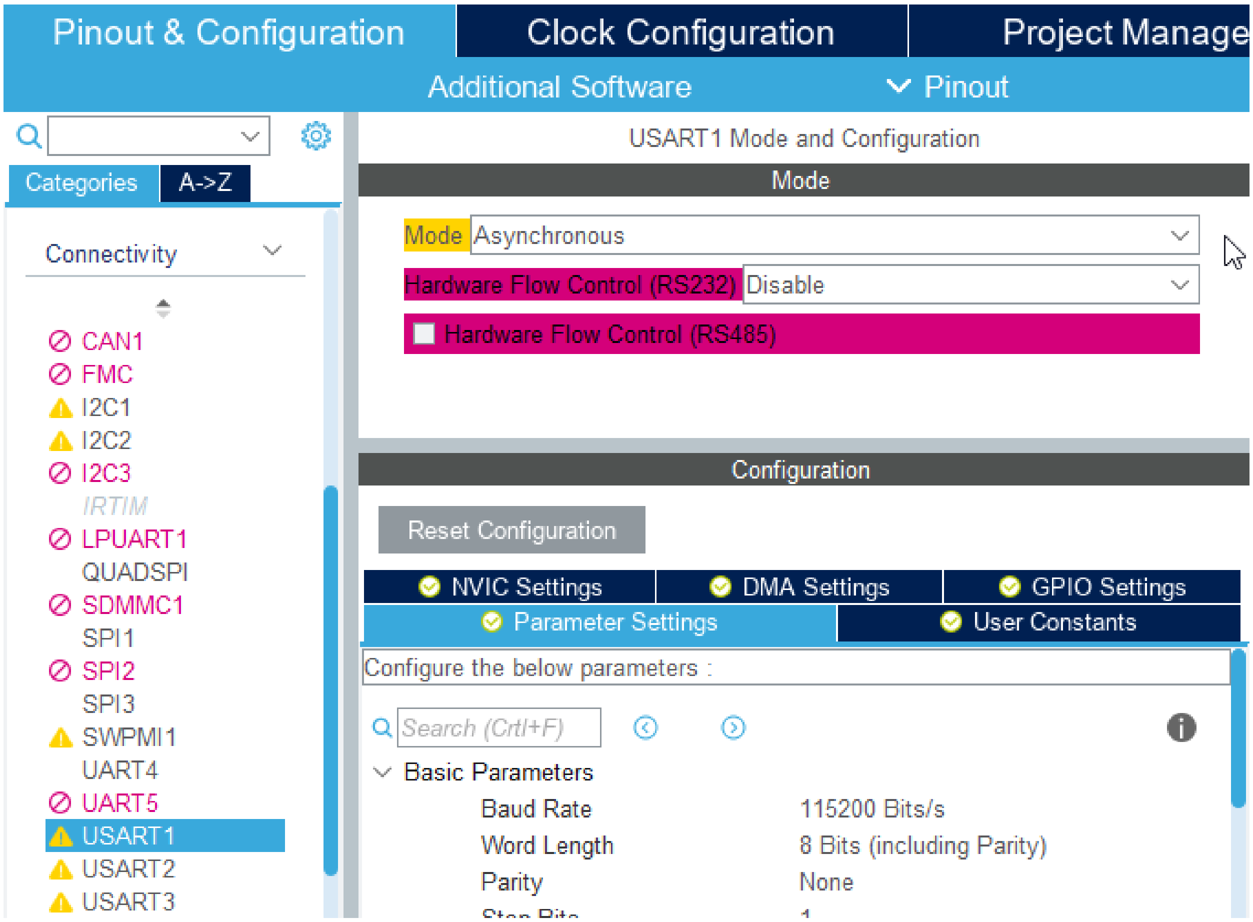
a. By default, the **Pinout** view shows. Since the MCU pin configurations must match the B-L475E-IOT01A board, enable *Pinout>>Keep Current Signals Placement* to maintain the peripheral function allocation to a given pin. **This step is optional.**



b. Select the category ***System Core >> SYS***, configure its **Debug** mode as *Serial Wire*; keep the default setting of **Timebase Source** as SysTick.

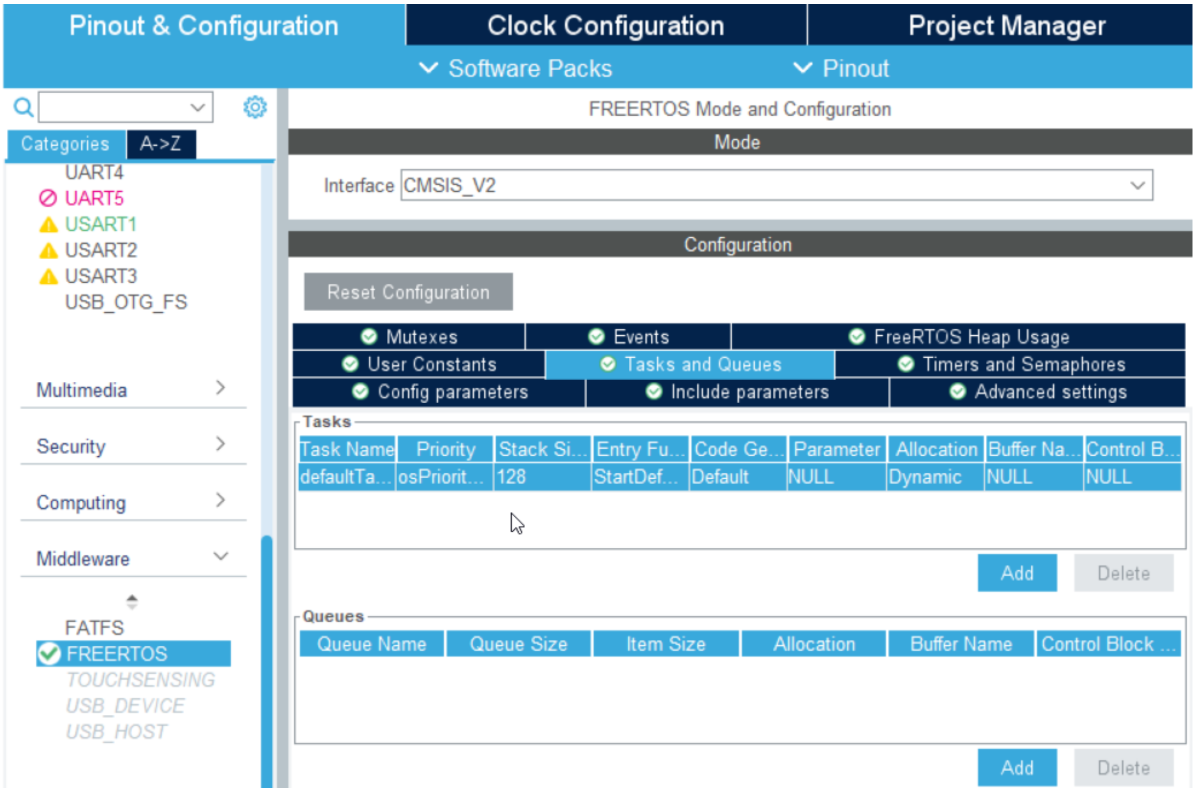


c. Select the category ***Connectivity >> USART1***, configure its **Mode** to *Asynchronous*. (USART1 shares the same pins as ST-LINK). Keep the rest mode and configuration parameters as default. This enables sending and receiving messages between PC and the board via USART1.

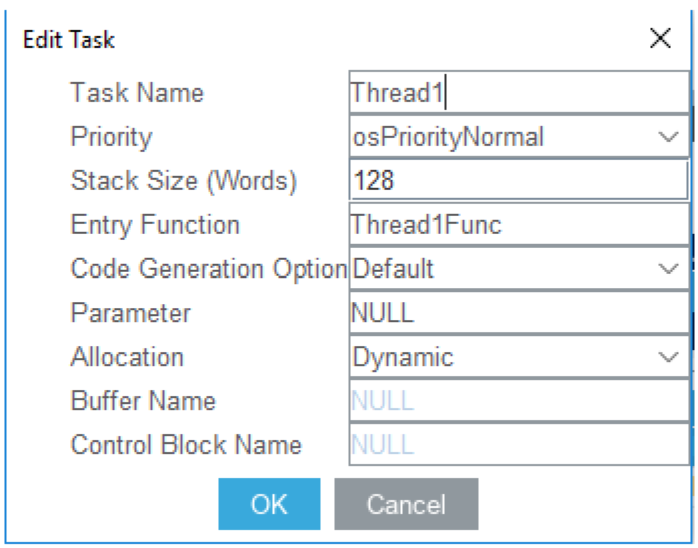


5. Configuring the Middleware FreeRTOS

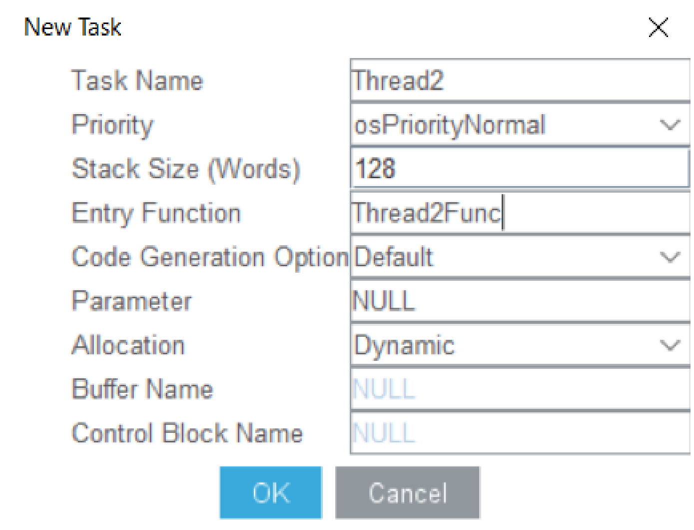
a. Select *Middleware>>FREERTOS*, On the **Mode** panel, select ***CMSIS_V2*** *Interface* to enable *FreeRTOS*;



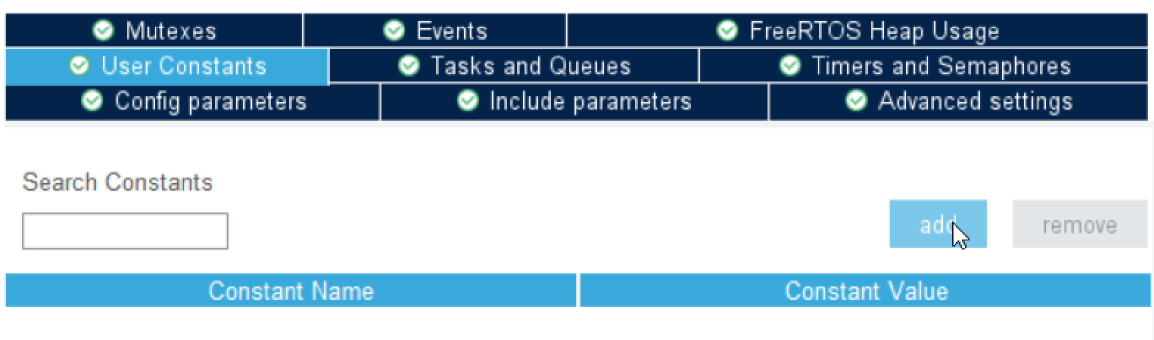
b. On the **Configuration** panel at the bottom, select the tab ***Tasks and Queues***. A default task is already under Tasks tab, which could be edited, but not deleted.
Double click the default task to open the **Edit Task** window. Change ***Task Name*** and ***Entry Function*** as below.

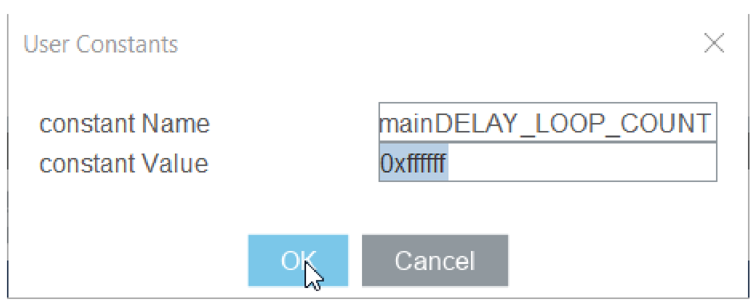


c. Then, click the **Add** button to add a new task; Change ***Task Name*** and ***Entry Function*** as *Thread2* and *Thread2Func* respectively, and set its **Priority** also as **osPriorityNormal**.



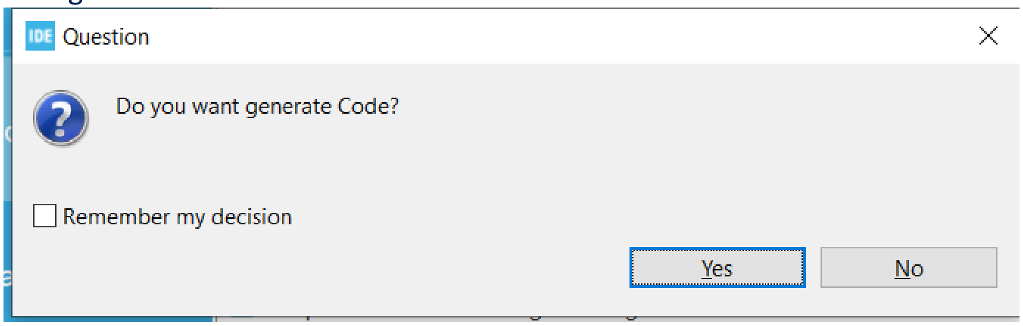
Create a constant variable by selecting the “User Constants” tab, click “add” to enter a constant name “mainDELAY_LOOP_COUNT”, and constant Value “0xffffff”.



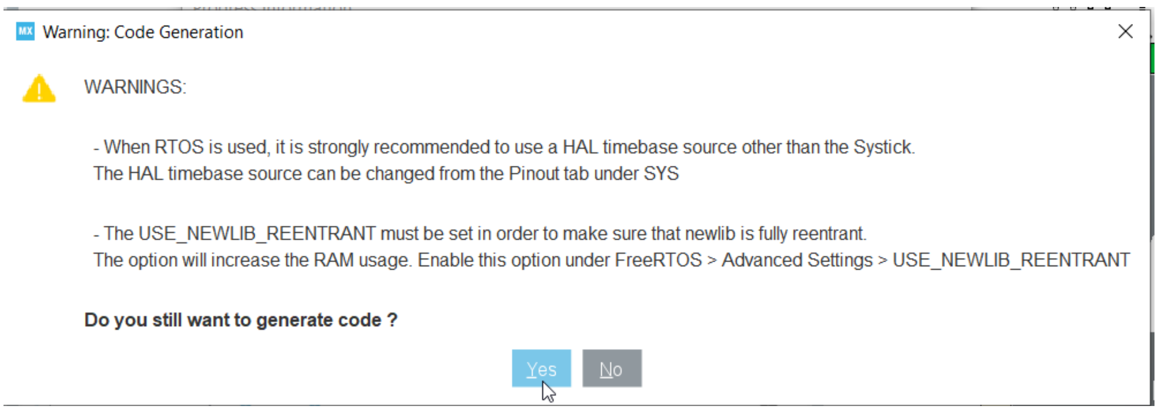


6. Generating Code

a. When changes are made in the STM32CubeMX editor, the .ioc file in the tab is marked as changed. When the file is saved, a dialog opens asking *"Do you want to generate Code?"*, making it easy to generate new code in the project that supports the new device configuration. Click Yes.

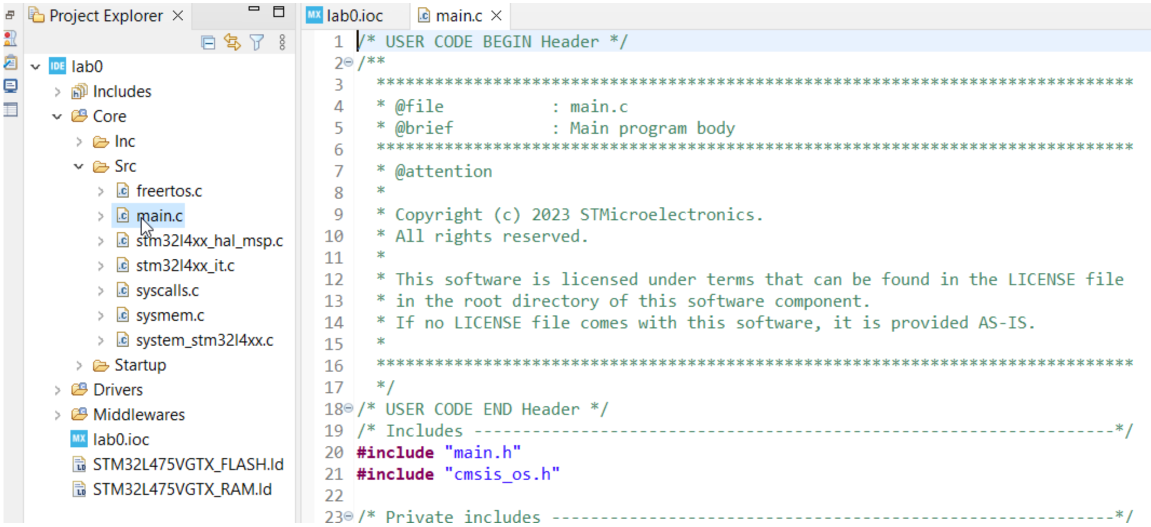


b. You may get a warning pop-up window about using sysclk as time base. You could just click "yes" to ignore it.



7. Editing the code in CubeIDE.

a. Open main.c file in the editor window.



b. Between /* USER CODE BEGIN 0 */ and /* USER CODE END 0 */, define the functions: putchUSART1() and putsUSART1().

```
void putchUSART1 (char ch)
{
  /* Place your implementation of fputc here */
  /* e.g. write a character to the serial port and Loop until the end of
transmission */
  while (HAL_OK != HAL_UART_Transmit(&huart1, (uint8_t *) &ch, 1, 30000))
  {
    ;
  }
}

void putsUSART1 (char* ptr)
{
   while(*ptr)
   {
         putchUSART1(*ptr++);
   }
}
```

```c
/* USER CODE BEGIN 0 */
void putchUSART1 (char ch)
{
  /* Place your implementation of fputc here */
  /* e.g. write a character to the serial port and Loop until the end of transmission */
  while (HAL_OK != HAL_UART_Transmit(&huart1, (uint8_t *) &ch, 1, 30000))
  {
    ;
  }
}

void putsUSART1 (char* ptr)
{
    while(*ptr)
    {
        putchUSART1(*ptr++);
    }
}
/* USER CODE END 0 */
```

c. Between /* USER CODE BEGIN 2 */ and /* USER CODE END 2 */ in the main() function, Add the statement as below

```c
putsUSART1("\n\rFreeRTOS Lab 0\n\r");
```

```c
  /* Initialize all configured peripherals */
  MX_GPIO_Init();
  MX_USART1_UART_Init();
  /* USER CODE BEGIN 2 */
  putsUSART1("\n\rFreeRTOS Lab 0\n\r");
  /* USER CODE END 2 */
```

d. Find the generated *Thread1Func()* function and edit it as below. Comment out the line

osDelay(1);

for this lab as we will define a continuous task (always ready to run), not a periodic task.

```c
/* USER CODE END Header_Thread1Func */
void Thread1Func(void *argument)
{
  /* USER CODE BEGIN 5 */
    volatile unsigned long ul;
  /* Infinite loop */
  for(;;)
  {
      putsUSART1("\n\rThread 1 is running.\n\r");

      for(ul = 0; ul < mainDELAY_LOOP_COUNT; ul++)
      {}

   // osDelay(1);
  }
  /* USER CODE END 5 */
}
```

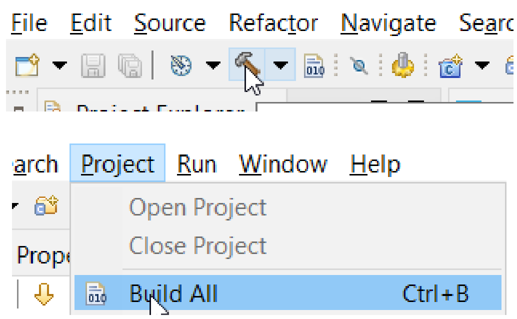
e. Edit the Thread2Func() function in the similar way. The only difference is the string for display.

```
putsUSART1("\n\rThread 2 is running.\n\r");
```

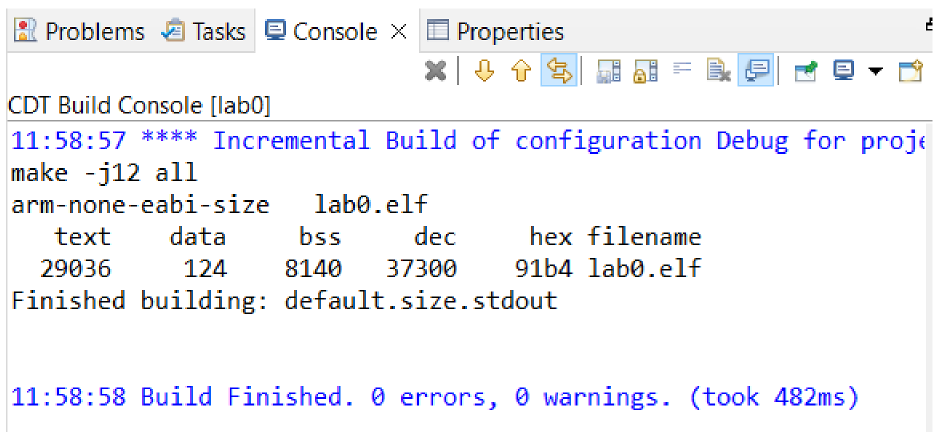
```
/* USER CODE END Header_Thread2Func */
void Thread2Func(void *argument)
{
  /* USER CODE BEGIN Thread2Func */
    volatile unsigned long ul;
  /* Infinite loop */
  for(;;)
  {
      putsUSART1("\n\rThread 2 is running.\n\r");

          for(ul = 0; ul < mainDELAY_LOOP_COUNT; ul++)
          {}
   // osDelay(1);
  }
  /* USER CODE END Thread2Func */
}
```

8. Build and debug the project in CubeIDE.

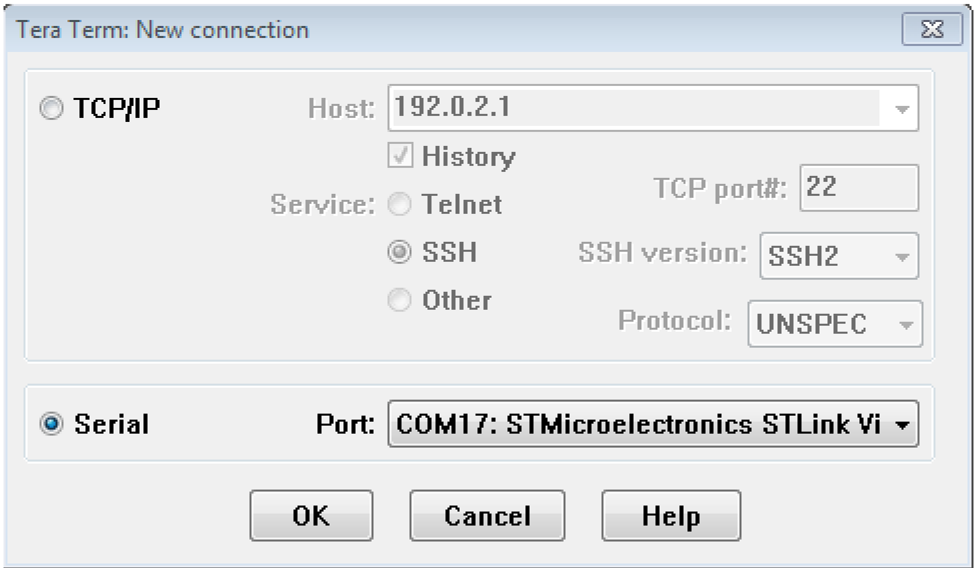
a. Click the Build button on the menu bar, or Select Project >> Build all target files as below.



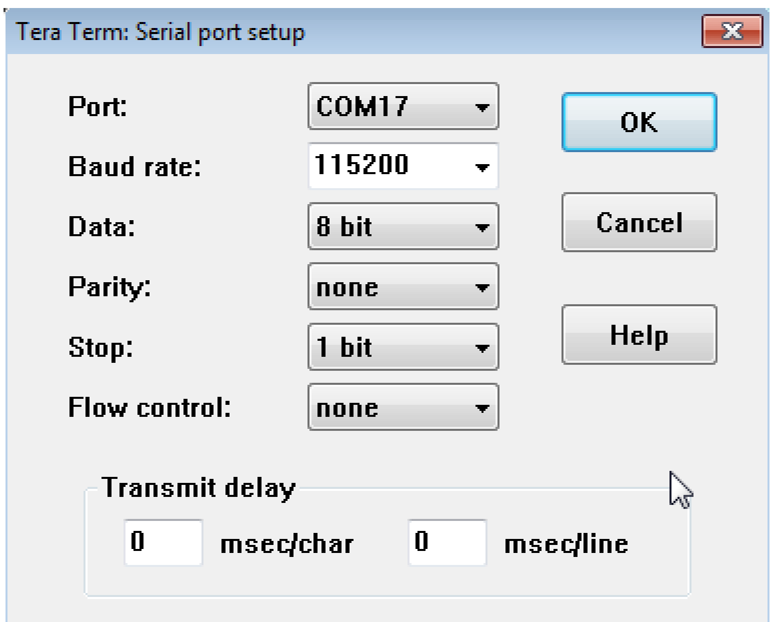
b. You should get the following outputs without errors from the **Console** window.



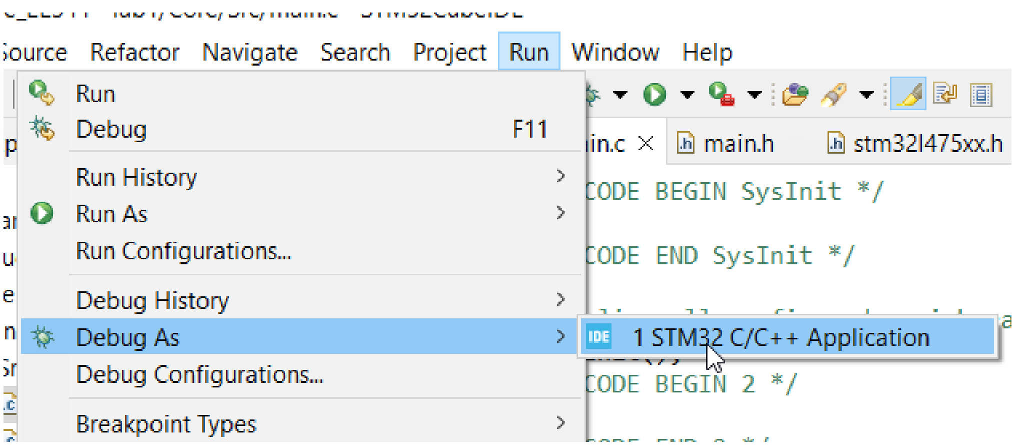
c. Open the Tera Term window. On the popup *New Connection* window, Select *Serial >> COMXX: STMicroelectronics STLink Virtual COM port* from the drop down *Port* list.



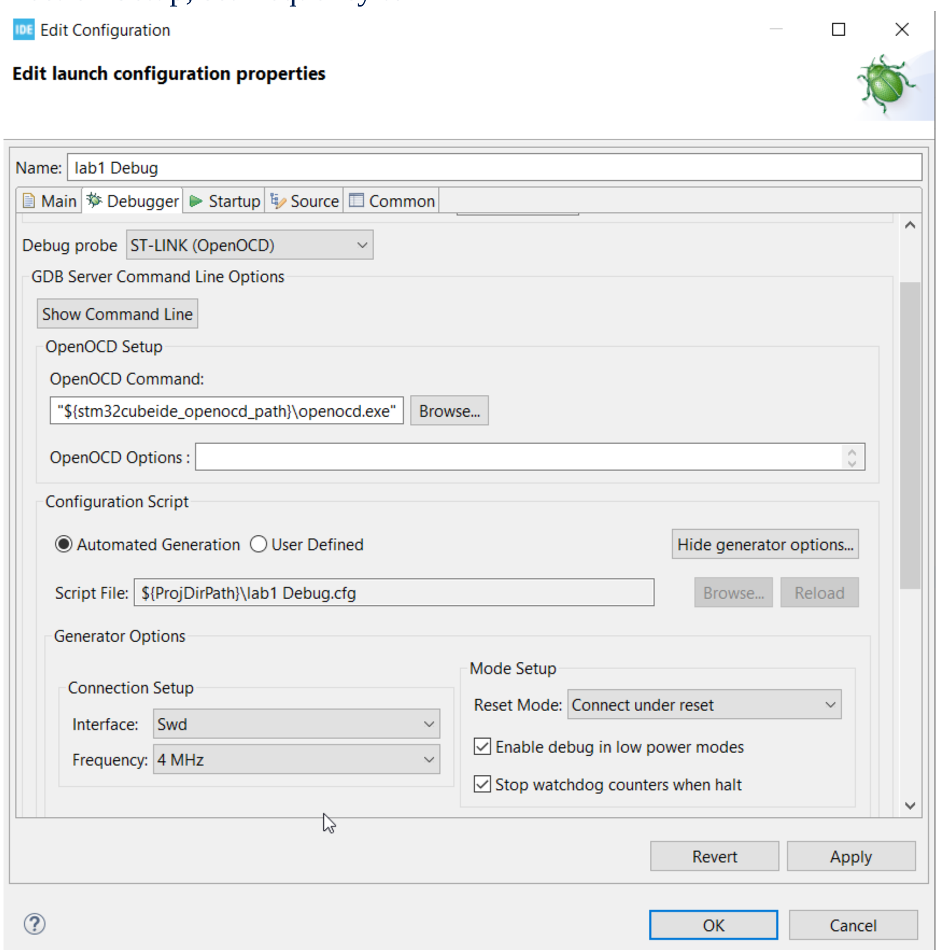
d. Configure *Setup>> Serial Port…*. Select *Baud rate* as 115200, click OK.



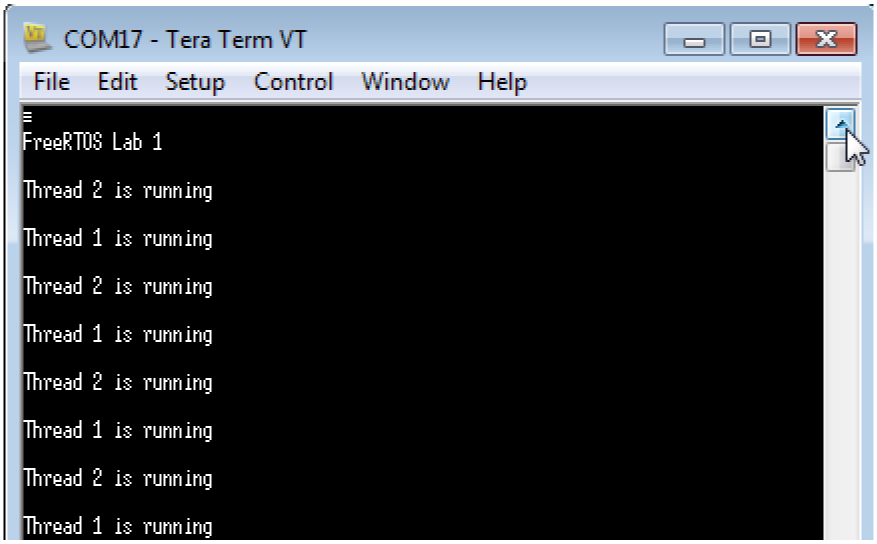
e. Debug the project by selecting **Run >> Debug As >> STM32C/C++ Application**
The CubeIDE window enters the debug perspective.



f. The Debug Configuration window pops up if the board is connected. Under *Debug probe*, choose **ST-LINK(OpenOCD)**.
Under Connection Setup, set frequency to 4MHz.



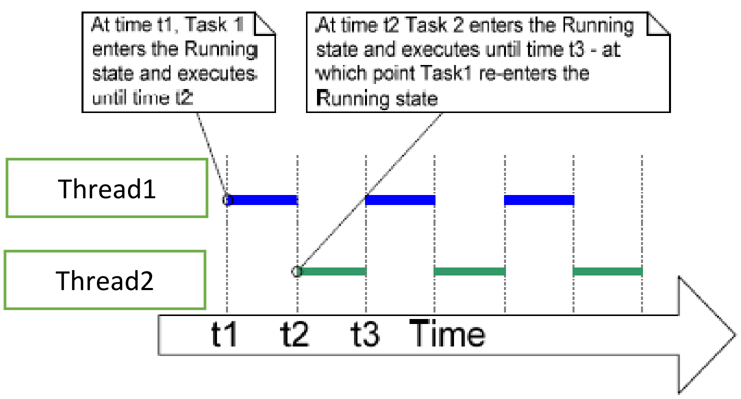
g. Click OK to start debugging.
h. The tera term window will display the following strings to show that thread 1 and 2 with the same priority are running in the round robin manner.



Summary

This demonstrates the steps of creating two simple threads and then starting threads executing. The threads simply print out a string periodically, using a null loop to create a period delay. Both threads functions are identical except for the string that they print.

Both Thread1 and Thread2 are running at the same priority, and so share CPU time on the single processor. Their actual execution pattern should be as the following.



The arrow along the bottom of the above figure shows the passing of time from time t1 onwards. The colored lines show which thread is running at each point in time.

Exercise: It is also possible to create a thread within another thread. So, let's try to create Thread1 from main(), and then create Thread2 from within Thread1.

- Move the statement of creating Thread2Func instance in main() into Thread2 immediately before the infinite *for(;;)* loop.
- Rebuild and execute the project.

```
  /* creation of Thread2 */
  Thread2Handle = osThreadNew(Thread2Func, NULL, &Thread2_attributes);

```

```
/* USER CODE END Header_Thread1Func */
void Thread1Func(void *argument)
{
  /* USER CODE BEGIN 5 */
    volatile unsigned long ul;

    /*
     * Move the Thread2 instance creation to here.
     * */

  /* Infinite loop */
  for(;;)
  {
      putsUSART1("\n\rTHread 1 is running. \n\r");

      for(ul = 0; ul < mainDELAY_LOOP_COUNT; ul++)
      {}

    //osDelay(1);
  }
  /* USER CODE END 5 */
}
```

Thus, Thread2 would not get created until the scheduler had been started. Please compare the output produced by the modified example with the one from the original example and check if they would be same.