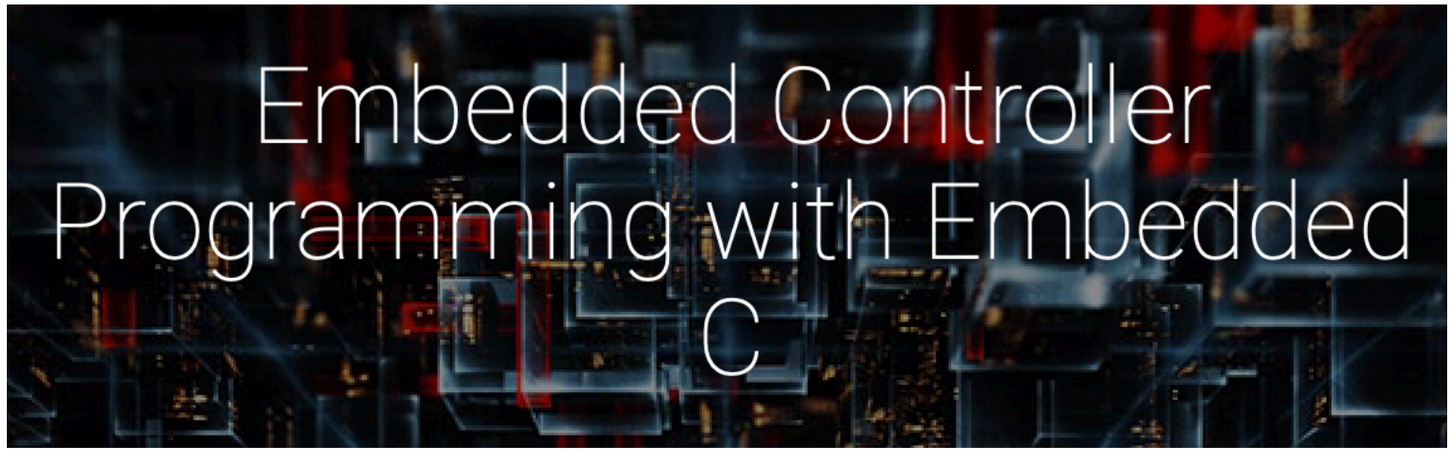

Lesson 2 - LL and Embedded C

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Contents

- Reference Info
- Concepts
- STM32CubeIDE and LL Code Generation
  - Blink LED using LL APIs
- File Tours

Reference Info

https://www.st.com/content/ccc/resource/technical/document/user_manual/63/a8/8f/e3/ca/a1/4c/84/DM00173145.pdf/files/DM00173145.pdf/jcr:content/translations/en.DM00173145.pdf

life.augmented

UM1884
User manual

Description of STM32L4/L4+ HAL and low-layer drivers

Introduction

STMCube™ is STMicroelectronics's original initiative to ease developers' life by reducing development efforts, time and cost. STM32Cube covers the STM32 portfolio.

STM32Cube Version 1.x includes:

- The STM32CubeMX, a graphical software configuration tool that allows generating C initialization code using graphical wizards.
- A comprehensive embedded software platform, delivered per series (such as STM32CubeL4 for STM32L4 series and STM32L4+ series)
  - The STM32Cube Hardware Abstraction Layer (HAL), an STM32 abstraction layer embedded software ensuring maximized portability across the STM32 portfolio. The HAL is available for all peripherals.
  - The low-layer APIs (LL) offering a fast light-weight expert-oriented layer which is closer to the hardware than the HAL. The LL APIs are available only for a set of peripherals.

Key Sections From Manual

Concepts

Introduction to LL and Embedded C

- **LL** = Low Layer Interface to Hardware
  - Fast and Lightweight
    - Better optimization, **Less Portability**
  - Expert -Oriented
    - **Require deep knowledge of MPU and peripherals**
- Closer to hardware than HAL
- Only for a subset of peripherals
  - Not provide for “complex” peripherals such as USB or SD/MMC
- **Strict ANSI C**
- Checked with CodeSonar Static Analysis tool
- Fully Documented and MIRSA-C 2004 Compliant

Features of LL Drivers Function to:

- Initialize peripherals
  - Based on parameters specified in data structures
- Fill data structures with initial reset values
- De-Initialize Peripherals
- Direct and atomic register access
- Independent from HAL
  - Can be used with or without HAL

Features of LL Drivers Function to:

- LL Drivers do not implement any processing
- LL Drivers do not need additional memory
- LL Drivers are all about **direct access to peripheral registers**

Low Layer Files

- No configuration file for LL
  - (Unlike HAL which uses configuration file to enable features)
- Include single include file
  - #include “stm32yyxx.h” (the STM32 CMSIS device file)
- stm32l4xx_ll_…
  - All filenames begin with the stm32l4xx_**ll**_… prefix
- Next several slides list specific LL files

stm32l4xx_ll_bus.h

- Core Bus Control
- Peripheral Clock Activation/Deactivation
- Example
  - LL_AHB2_GRP1_EnableClock

stm32l4xx_ll_cortex.h

- Cortex-M related register operations related to:
  - SysTick
    - LL_SYSTICK_xxxx
  - Low Power Mode
    - LL_LPM_xxxx

stm32l4xx_ll_system.h

- System related operations
  - LL_SYSCFG_xxx
  - LL_DBGMCU_xxx
  - LL_FLASH_xxx
  - LL_VREFBUF_xxx

stm32l4xx_ll_*PPP*.h/.c

- Peripheral Initialization Functions
  - LL_PPP_Init()
  - LL_PPP_StructInit()
  - LL_PPP_DeInit()

Note: *PPP* is replaced with specific peripheral, e.g. GPIO, SPI, etc.

stm32l4xx_ll_utils.h/.c

- Generic APIs
- Read of device unique ID and electronic signature
- Timebase and delay management
- System clock configuration

Common Initialization Functions

- **LL**_*PPP*_Init()
- **LL**_*PPP*_StructInit()
- **LL**_*PPP*_DeInit()

More info on the following slides

PPP is generic placeholder

LL_*PPP*_Init() Example

- initialize peripheral main features
- Example
  - ErrorStatus
    LL_*USART*_Init(
      USART_TypeDef *USARTx,
      LL_USART_InitTypeDef *USART_InitStruct)

LL_*PPP*_StructInit() Example

- Fill structures with init values
- Example
  - void **LL**_*USART*_StructInit(
    LL_USART_InitTypeDef *USART_InitStruct)

LL_*PPP*_DeInit() Example

- DeInit, i.e. restore to default reset values
- Example
  - ErrorStatus
    LL_*USART*_DeInit(
      USART_TypeDef *USARTx)

Additional LL Functions for Selected Peripherals

- **LL**_PPP_{Category}_Init()
  - **LL**_ADC_INJ_Init(…)
  - **LL**_RTC_TIME_Init(…)
  - **LL**_RTC_DATE_Init(…)
  - **LL**_TIM_IC_Init(…)
  - **LL**_TIM_ENCODER_Init(…)

LL Register Level Config Functions - Flags

- Get
    - **LL**_PPP_IsActiveFlag_BITNAME
- Clear
    - **LL**_PPP_ClearFlag_BITNAME

LL Register Level Config Functions - Interrupts

- Enable
  - **LL**_PPP_EnableIT_BITNAME
- Disable
  - **LL**_PPP_DisableIT_BITNAME
- Get
  - **LL**_PPP_IsEnabled_BITNAME

LL Register Level Config Functions - DMA

- Enable
  - **LL**_PPP_EnableDMAReq_BITNAME
- Disable
  - **LL**_PPP_DisableDMAReq_BITNAME
- Get
  - **LL**_PPP_IsEnabledDMAReq_BITNAME

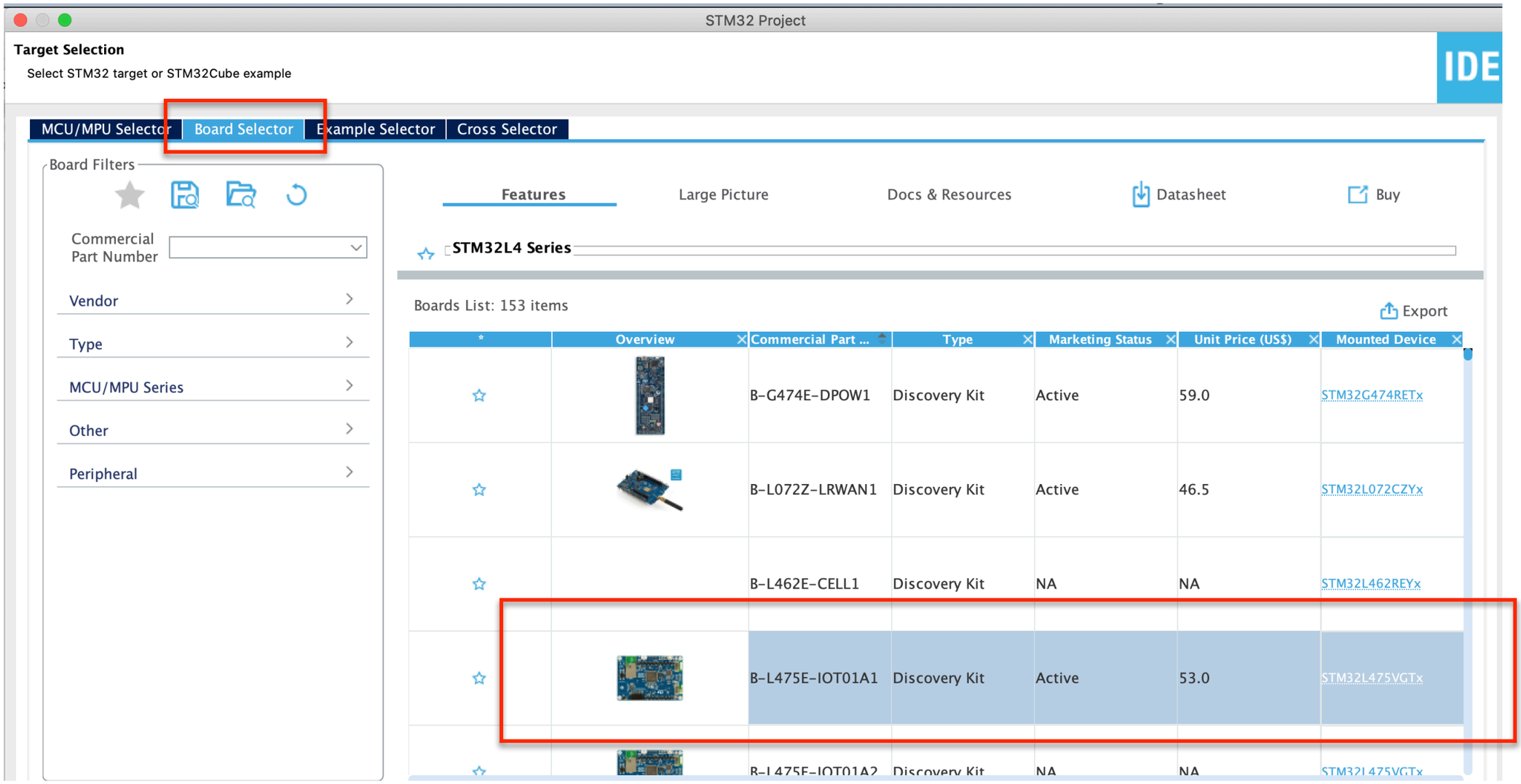
DMA = Direct Memory Access

Cohabiting of LL and HAL

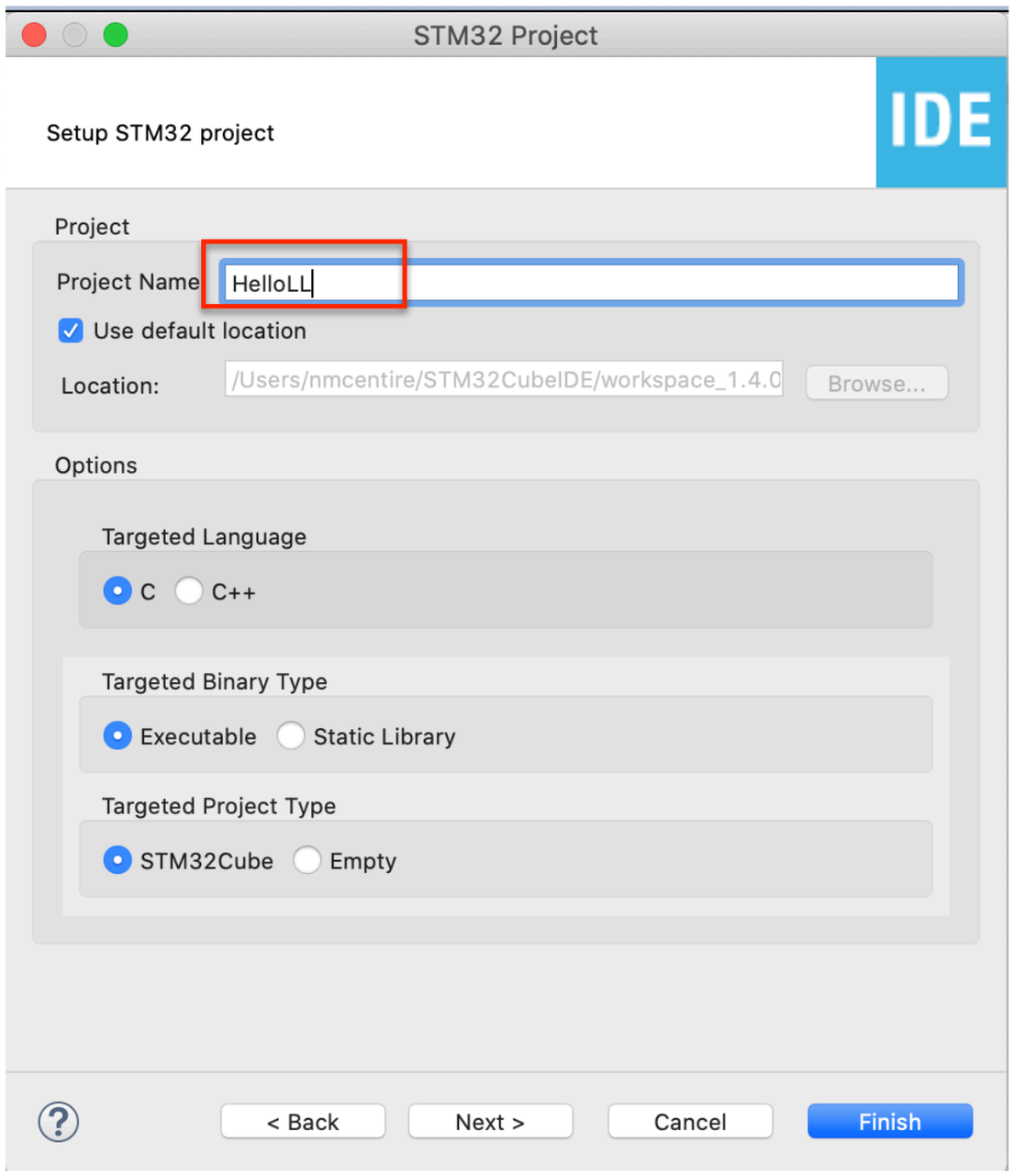
- **LL** can be used in:
  - Stand alone mode (no HAL)
    - HAL = Hardware Abstraction Layer
  - Combined with HAL (but not controlling same peripherals as HAL)
- NOTE: STM provides some examples of using LL and HAL - see **Examples_MIX** projects

STM32CubeIDE and Generation of LL Code

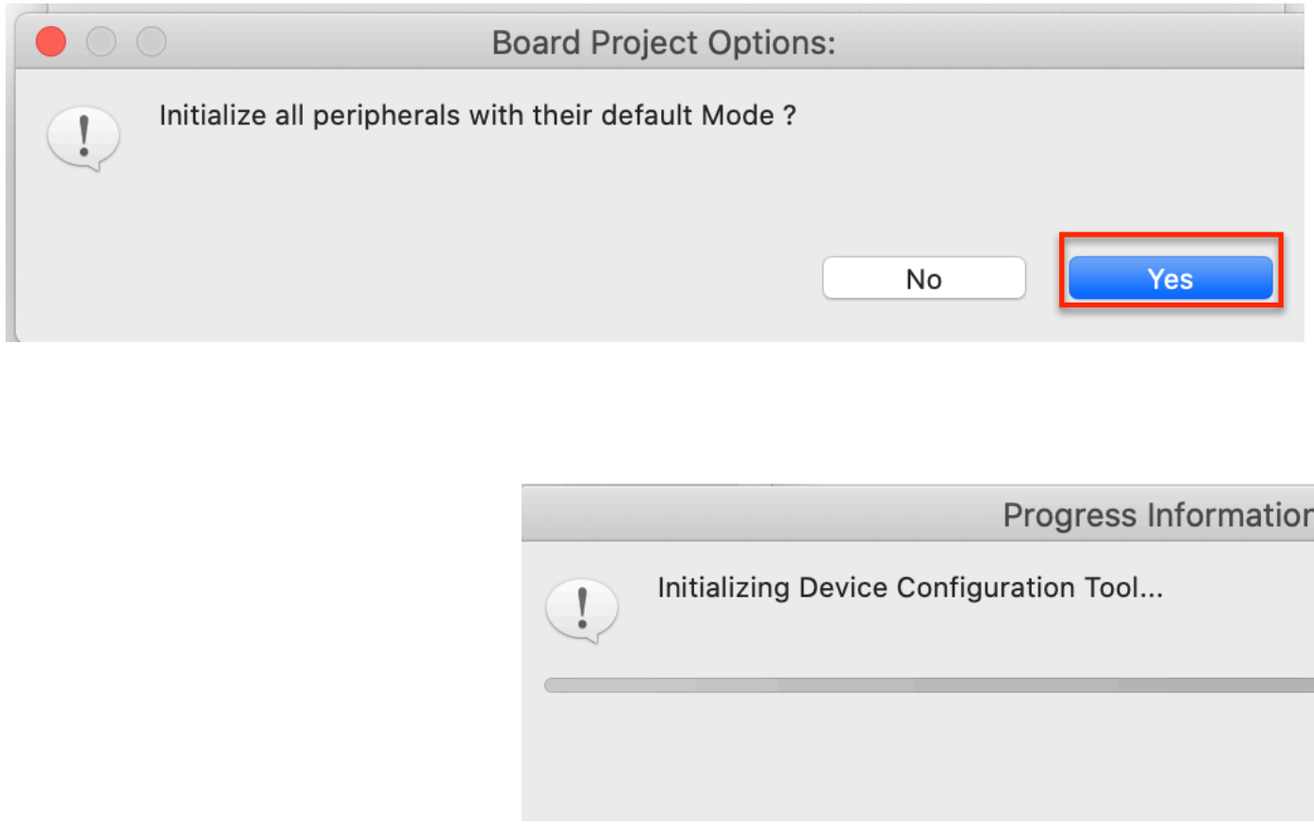
Step 1. Target Board Selector - B-L475-IOT01A1



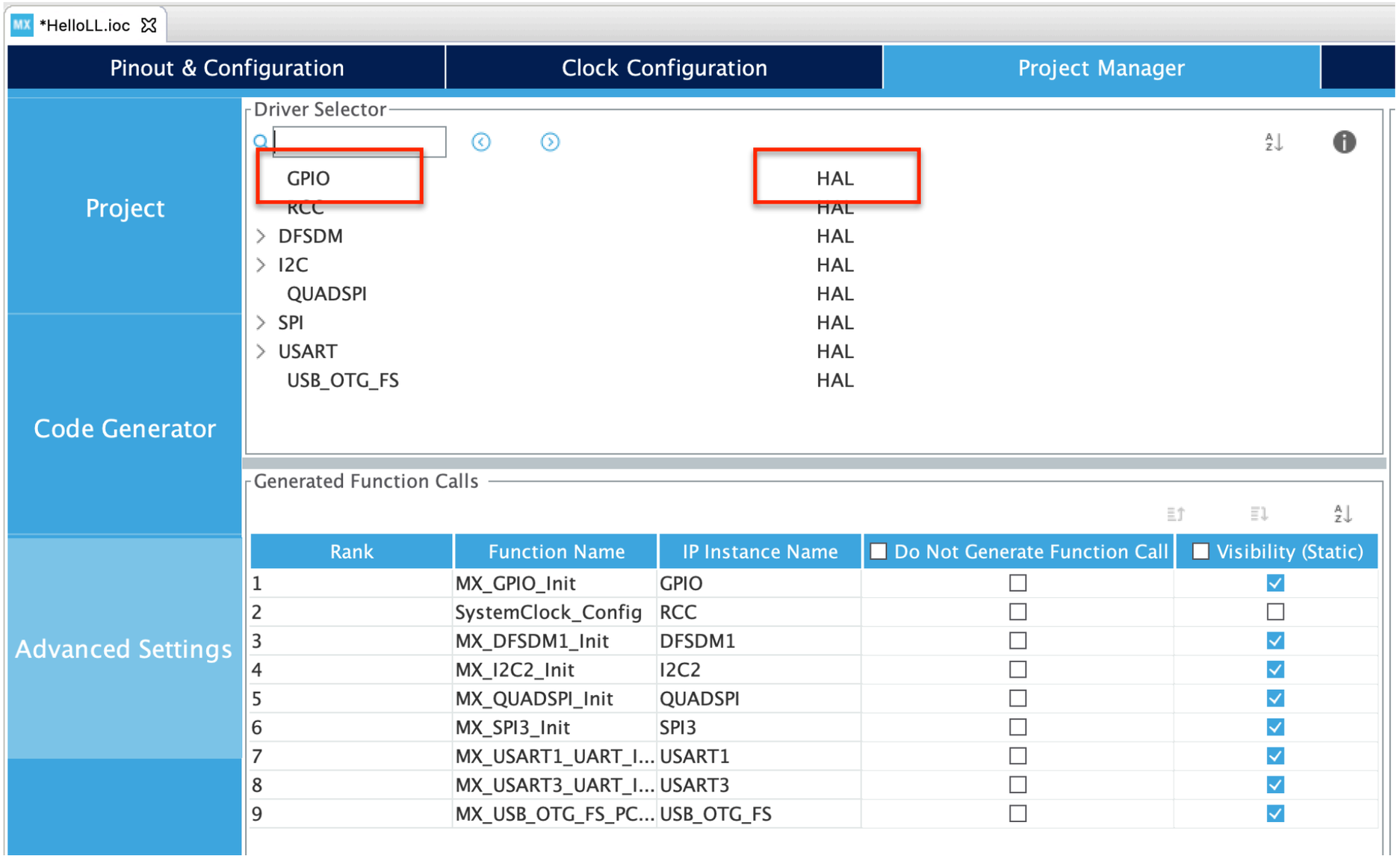
Step 2. HelloLL



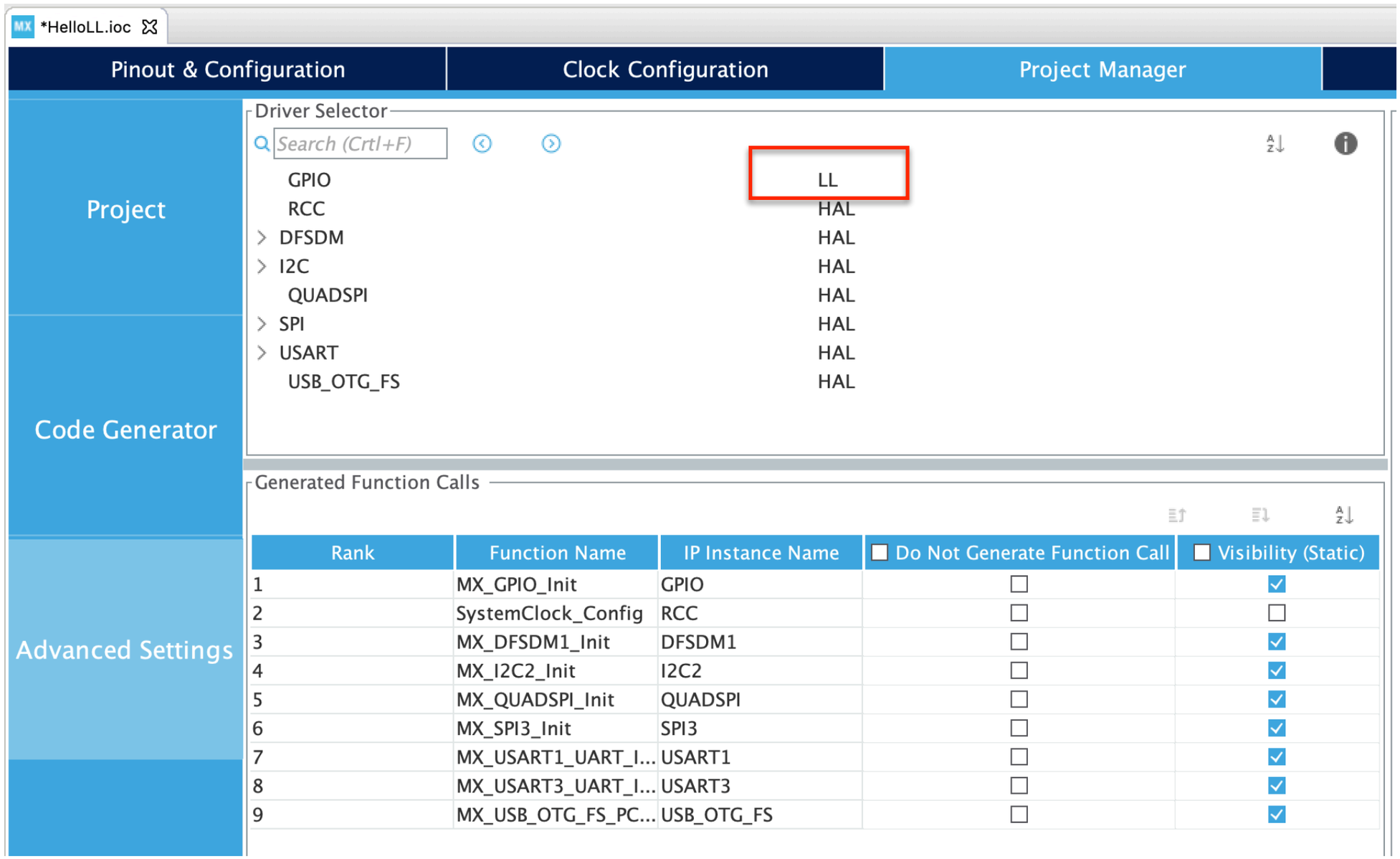
Step 3. Init all peripherals with their default mode



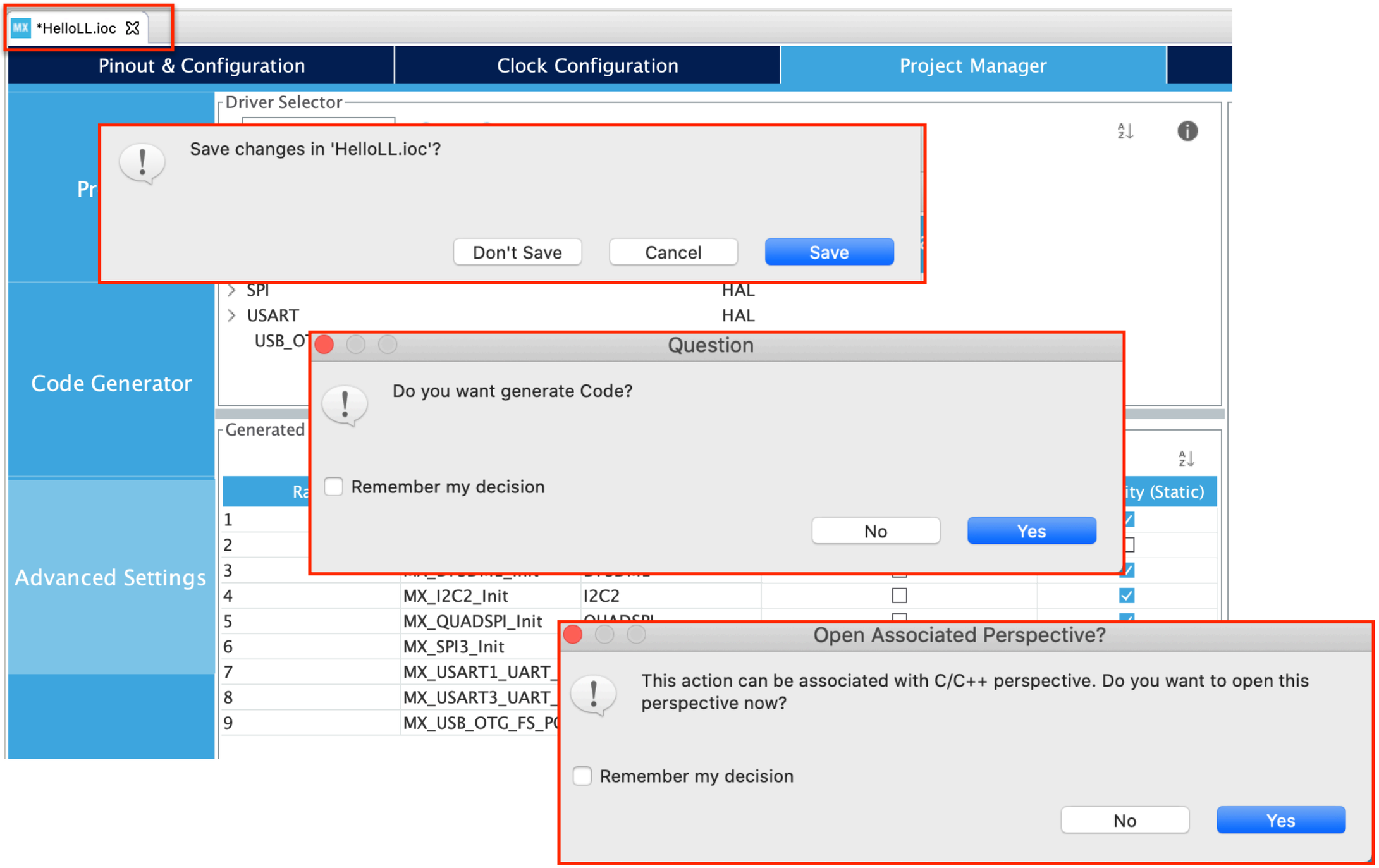
Step 4. Project Manager, Advanced Settings - Defaults



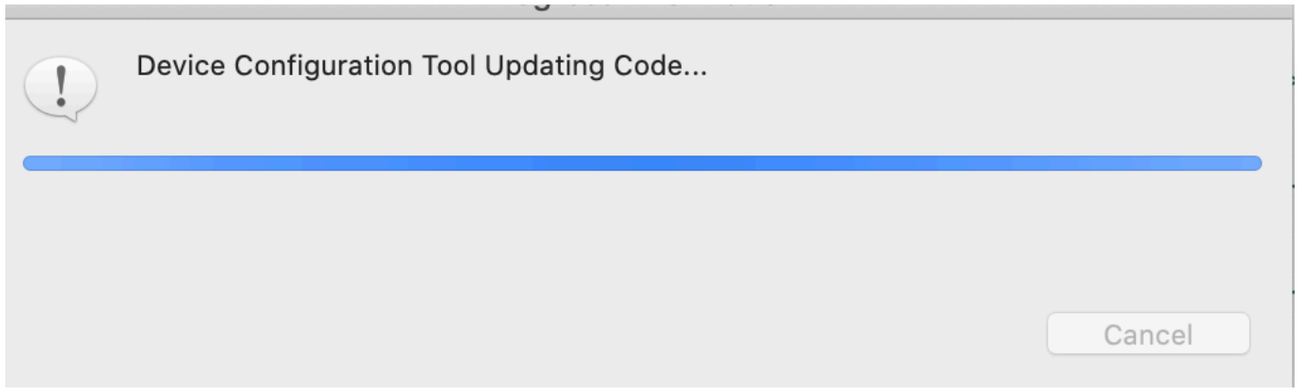
Step 4. Project Manager, Advanced Settings - Change to LL



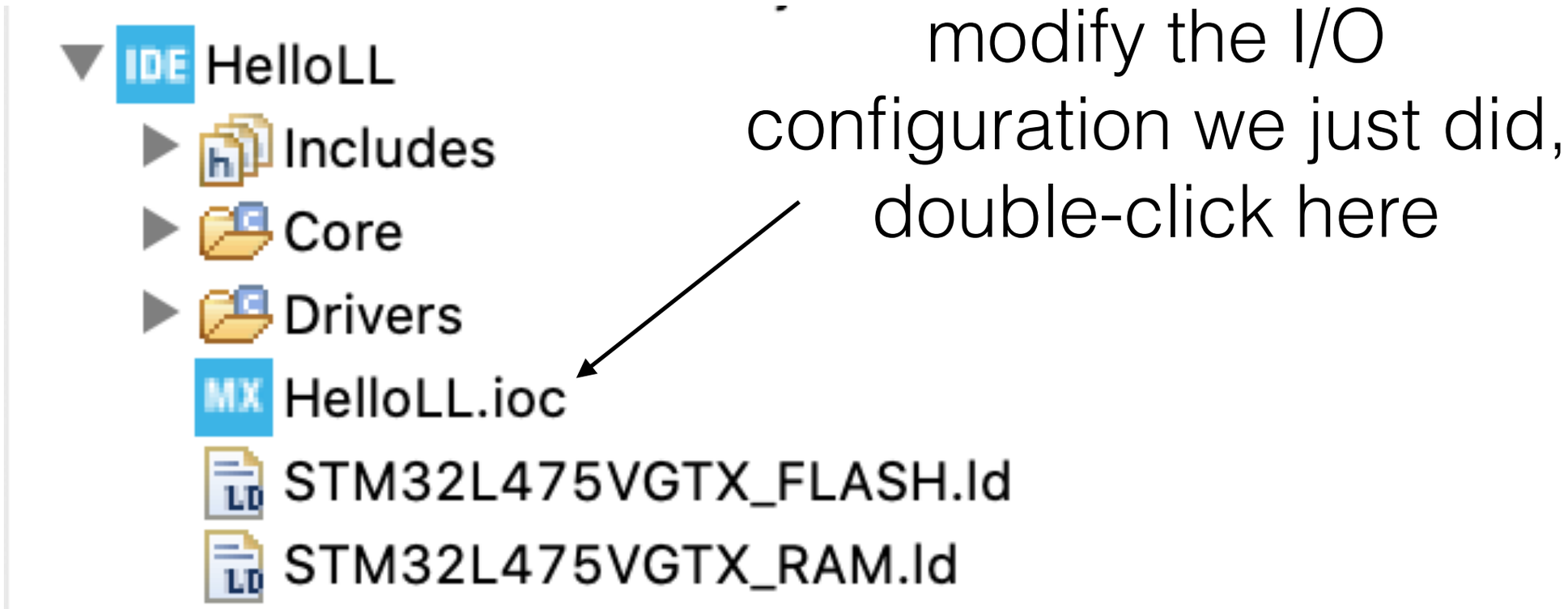
Step 5. Save Settings



Step 6. Wait for code generation



Step 7. Results



Step 8. main.c

You can safely edit code in the range
USER CODE BEGIN and USER CODE END
(will not be replaced if code regenerated)

```
1  /* USER CODE BEGIN Header */
2  /**
3    ******************************************************************************
4    * @file           : main.c
5    * @brief          : Main program body
6    ******************************************************************************
7    * @attention
8    *
9    * <h2><center>&copy; Copyright (c) 2020 STMicroelectronics.
10   * All rights reserved.</center></h2>
11   *
12   * This software component is licensed by ST under BSD 3-Clause license,
13   * the "License"; You may not use this file except in compliance with the
14   * License. You may obtain a copy of the License at:
15   *                        opensource.org/licenses/BSD-3-Clause
16   *
17   ******************************************************************************
18   */
19 /* USER CODE END Header */
```

Step 9. main.c

Be sure to place your additional Header files (e.g. #include <string.h>” Between the USER CODE BEGIN and USER_CODE_END sections

```
20  /* Includes ------------------------------
21  #include "main.h"
22
23  /* Private includes ----------------
24  /* USER CODE BEGIN Includes */
25
26  /* USER CODE END Includes */
27
```

Step 10. main.c

Your typedefs , #defines, macros

```
28 /* Private typedef -----------
29   /* USER CODE BEGIN PTD */
30
31   /* USER CODE END PTD */
32
33 /* Private define ------------
34   /* USER CODE BEGIN PD */
35   /* USER CODE END PD */
36
37 /* Private macro -------------
38   /* USER CODE BEGIN PM */
39
40   /* USER CODE END PM */
41
```

main.c

```
  */
int main(void)
{
  /* USER CODE BEGIN 1 */

  /* USER CODE END 1 */

  /* MCU Configuration--------------------------------------------------------*/

  /* Reset of all peripherals, Initializes the Flash interface and the Systick. */
  HAL_Init();

  /* USER CODE BEGIN Init */

  /* USER CODE END Init */

  /* Configure the system clock */
  SystemClock_Config();

  /* USER CODE BEGIN SysInit */

  /* USER CODE END SysInit */

  /* Initialize all configured peripherals */
  MX_GPIO_Init();
  MX_DFSDM1_Init();
  MX_I2C2_Init();
  MX_QUADSPI_Init();
  MX_SPI3_Init();
  MX_USART1_UART_Init();
  MX_USART3_UART_Init();
  MX_USB_OTG_FS_PCD_Init();
  /* USER CODE BEGIN 2 */

  /* USER CODE END 2 */

  /* Infinite loop */
  /* USER CODE BEGIN WHILE */
  while (1)
  {
    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
  }
  /* USER CODE END 3 */
```

Pre-written initialization code

Put your code here

main.c

```
/**
  * @brief GPIO Initialization Function
  * @param None
  * @retval None
  */
static void MX_GPIO_Init(void)
{
  LL_EXTI_InitTypeDef EXTI_InitStruct = {0};
  LL_GPIO_InitTypeDef GPIO_InitStruct = {0};

  /* GPIO Ports Clock Enable */
  LL_AHB2_GRP1_EnableClock(LL_AHB2_GRP1_PERIPH_GPIOE);
  LL_AHB2_GRP1_EnableClock(LL_AHB2_GRP1_PERIPH_GPIOC);
  LL_AHB2_GRP1_EnableClock(LL_AHB2_GRP1_PERIPH_GPIOA);
  LL_AHB2_GRP1_EnableClock(LL_AHB2_GRP1_PERIPH_GPIOB);
  LL_AHB2_GRP1_EnableClock(LL_AHB2_GRP1_PERIPH_GPIOD);

  /**/
  LL_GPIO_ResetOutputPin(GPIOE, M24SR64_Y_RF_DISABLE_Pin|M24SR64_Y_GPO_Pin|ISM43362_RST_Pin);

  /**/
  LL_GPIO_ResetOutputPin(GPIOA, ARD_D10_Pin|SPBTLE_RF_RST_Pin|ARD_D9_Pin);

  /**/
  LL_GPIO_ResetOutputPin(GPIOB, ARD_D8_Pin|ISM43362_BOOT0_Pin|ISM43362_WAKEUP_Pin|LED2_Pin
                          |SPSGRF_915_SDN_Pin|ARD_D5_Pin);
```

Notice use of LL_ APIs

Step 11. main.c

Use LL APIs to toggle LED

```
118     /* Infinite loop */
119     /* USER CODE BEGIN WHILE */
120     while (1)
121     {
122         LL_GPIO_TogglePin(LED2_GPIO_Port, LED2_Pin);
123
124         LL_mDelay(1000);
125
126       /* USER CODE END WHILE */
127
128       /* USER CODE BEGIN 3 */
129     }
130     /* USER CODE END 3 */
131   }
```

Step 12. main.c

Exploring implementation of LL_GPIO_TogglePin

```
1014    */
1015  __STATIC_INLINE void LL_GPIO_TogglePin(GPIO_TypeDef *GPIOx, uint32_t PinMask)
1016  {
1017    uint32_t odr = READ_REG(GPIOx->ODR);
1018    WRITE_REG(GPIOx->BSRR, ((odr & PinMask) << 16u) | (~odr & PinMask));
1019  }
1020
```

ODR = Output Direction Register

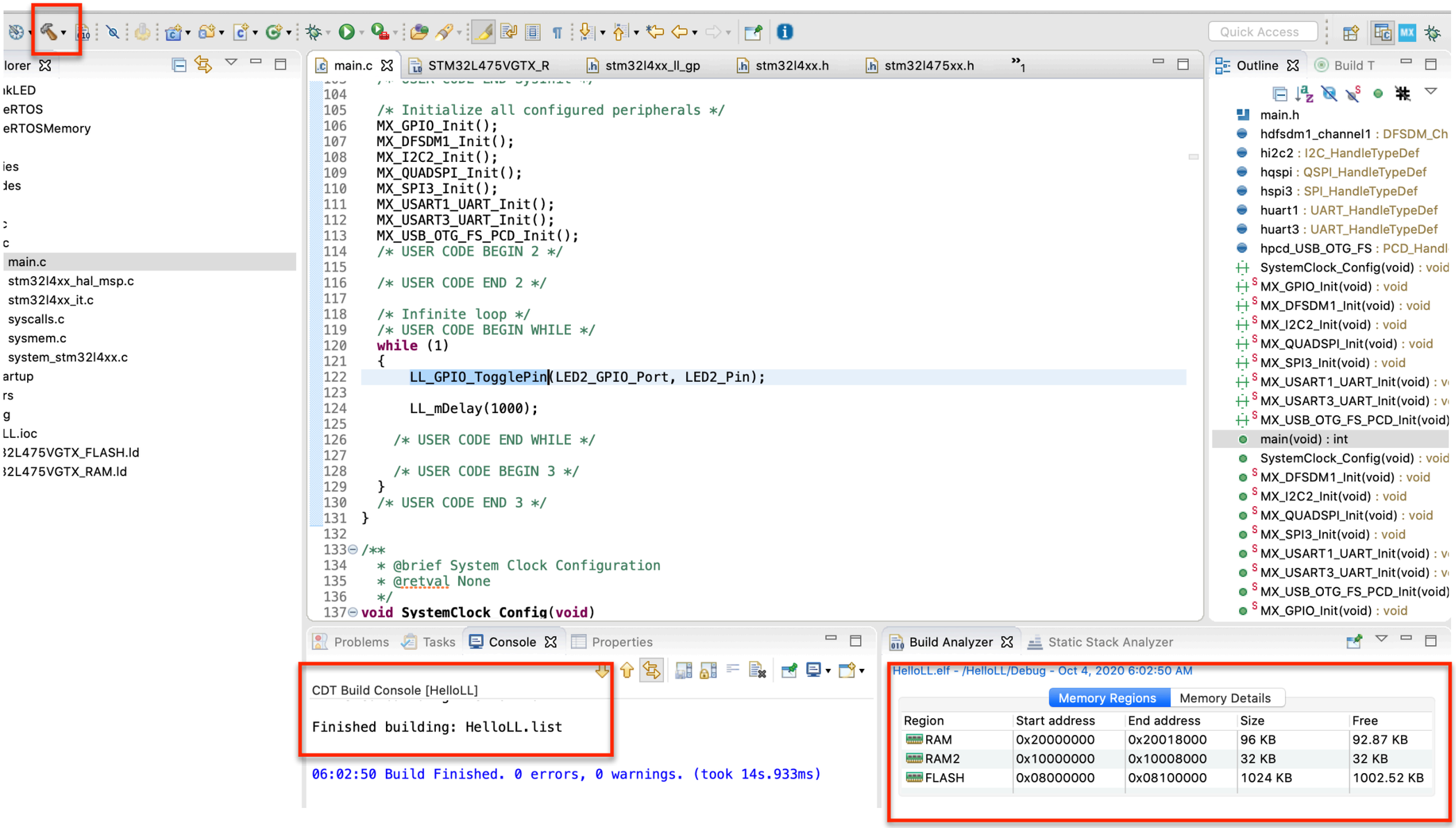
BSSR = Bit Set Reset Register

Step 13. main.c

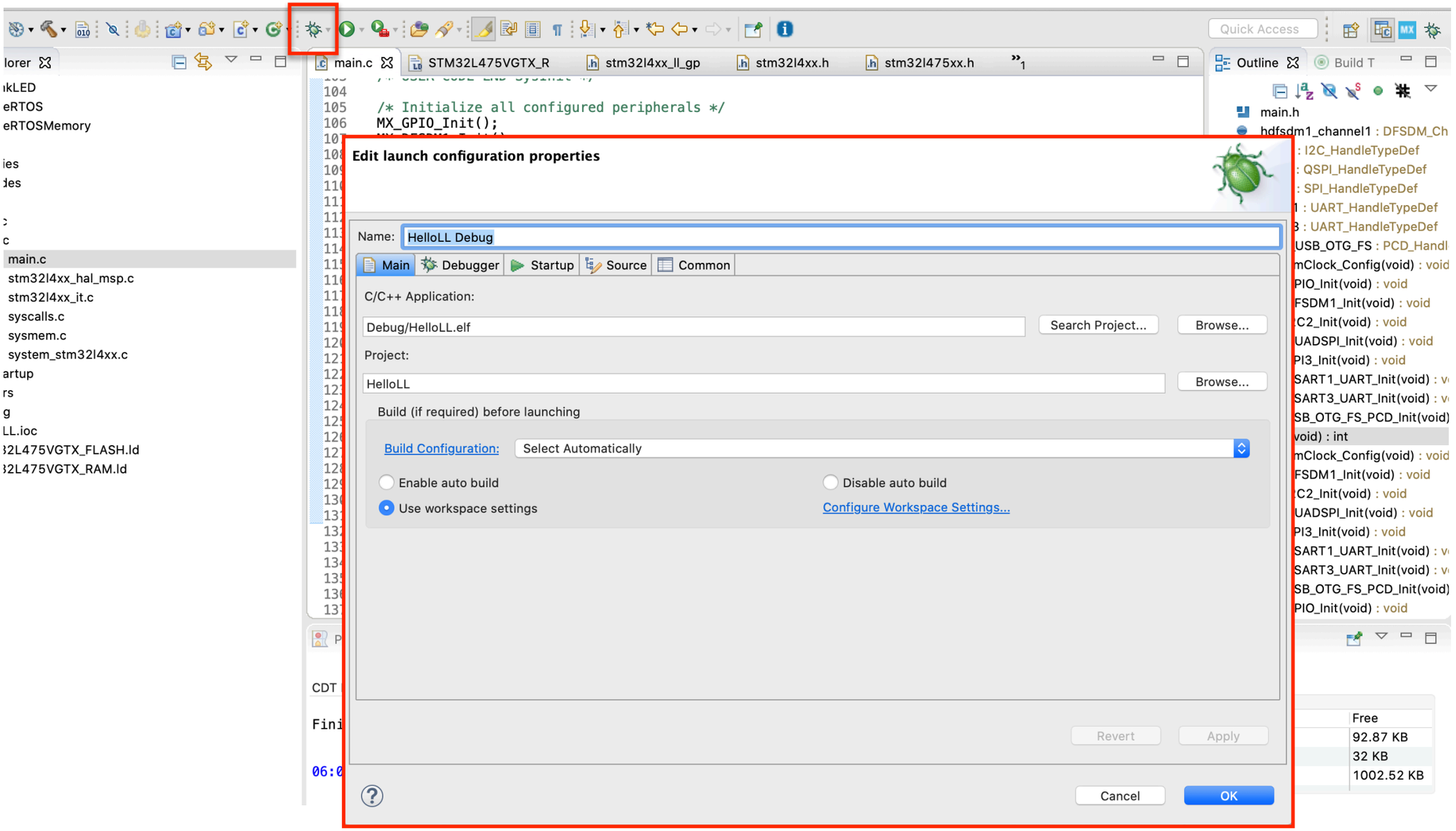
GPIO_TypeDef

```
527  /**
528    * @brief General Purpose I/O
529    */
530
531  typedef struct
532  {
533    __IO uint32_t MODER;       /*!< GPIO port mode register,               Address offset: 0x00      *
534    __IO uint32_t OTYPER;      /*!< GPIO port output type register,        Address offset: 0x04      *
535    __IO uint32_t OSPEEDR;     /*!< GPIO port output speed register,       Address offset: 0x08      *
536    __IO uint32_t PUPDR;       /*!< GPIO port pull-up/pull-down register,  Address offset: 0x0C      *
537    __IO uint32_t IDR;         /*!< GPIO port input data register,         Address offset: 0x10      *
538    __IO uint32_t ODR;         /*!< GPIO port output data register,        Address offset: 0x14      *
539    __IO uint32_t BSRR;        /*!< GPIO port bit set/reset  register,     Address offset: 0x18      *
540    __IO uint32_t LCKR;        /*!< GPIO port configuration lock register, Address offset: 0x1C      *
541    __IO uint32_t AFR[2];      /*!< GPIO alternate function registers,     Address offset: 0x20-0x24 *
542    __IO uint32_t BRR;         /*!< GPIO Bit Reset register,               Address offset: 0x28      *
543    __IO uint32_t ASCR;        /*!< GPIO analog switch control register,   Address offset: 0x2C     */
544
545  } GPIO_TypeDef;
546
```

Step 14. Build Code



Step 15. Run Code

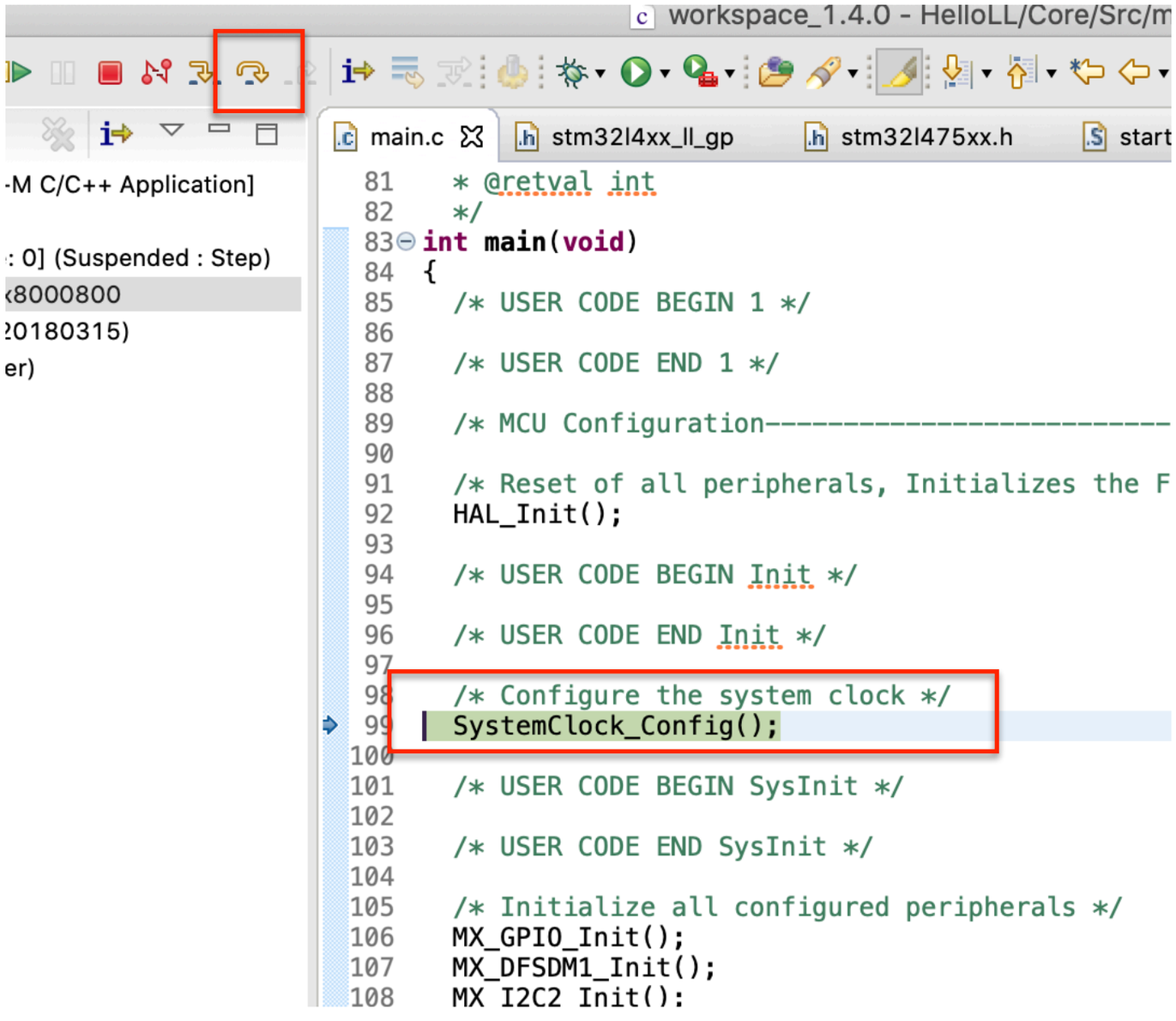


Step 16. Hit Breakpoint

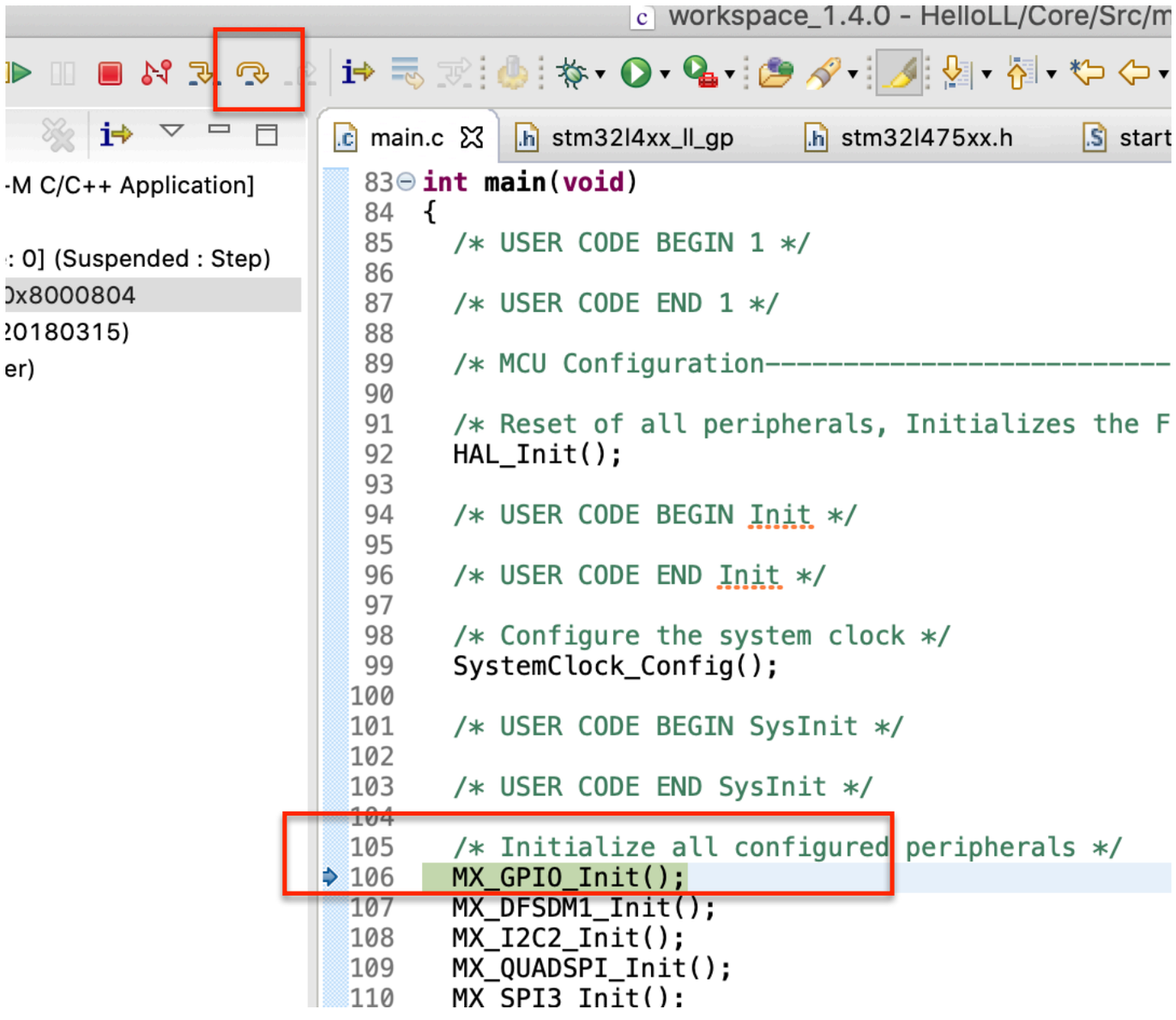
main.c | stm32l4xx_ll_gp | stm32l475xx.h | startup_stm32l4 | »3

```
81    * @retval int
82    */
83  int main(void)
84  {
85    /* USER CODE BEGIN 1 */
86
87    /* USER CODE END 1 */
88
89    /* MCU Configuration--------------------------------------------------------*/
90
91    /* Reset of all peripherals, Initializes the Flash interface and the Systick. */
92    HAL_Init();
93
94    /* USER CODE BEGIN Init */
95
96    /* USER CODE END Init */
97
98    /* Configure the system clock */
99    SystemClock_Config();
100
101   /* USER CODE BEGIN SysInit */
102
103   /* USER CODE END SysInit */
104
105   /* Initialize all configured peripherals */
106   MX_GPIO_Init();
107   MX_DFSDM1_Init();
108   MX_I2C2_Init();
109   MX_QUADSPI_Init();
110   MX_SPI3_Init();
111   MX_USART1_UART_Init();
112   MX_USART3_UART_Init();
113   MX_USB_OTG_FS_PCD_Init();
114   /* USER CODE BEGIN 2 */
```

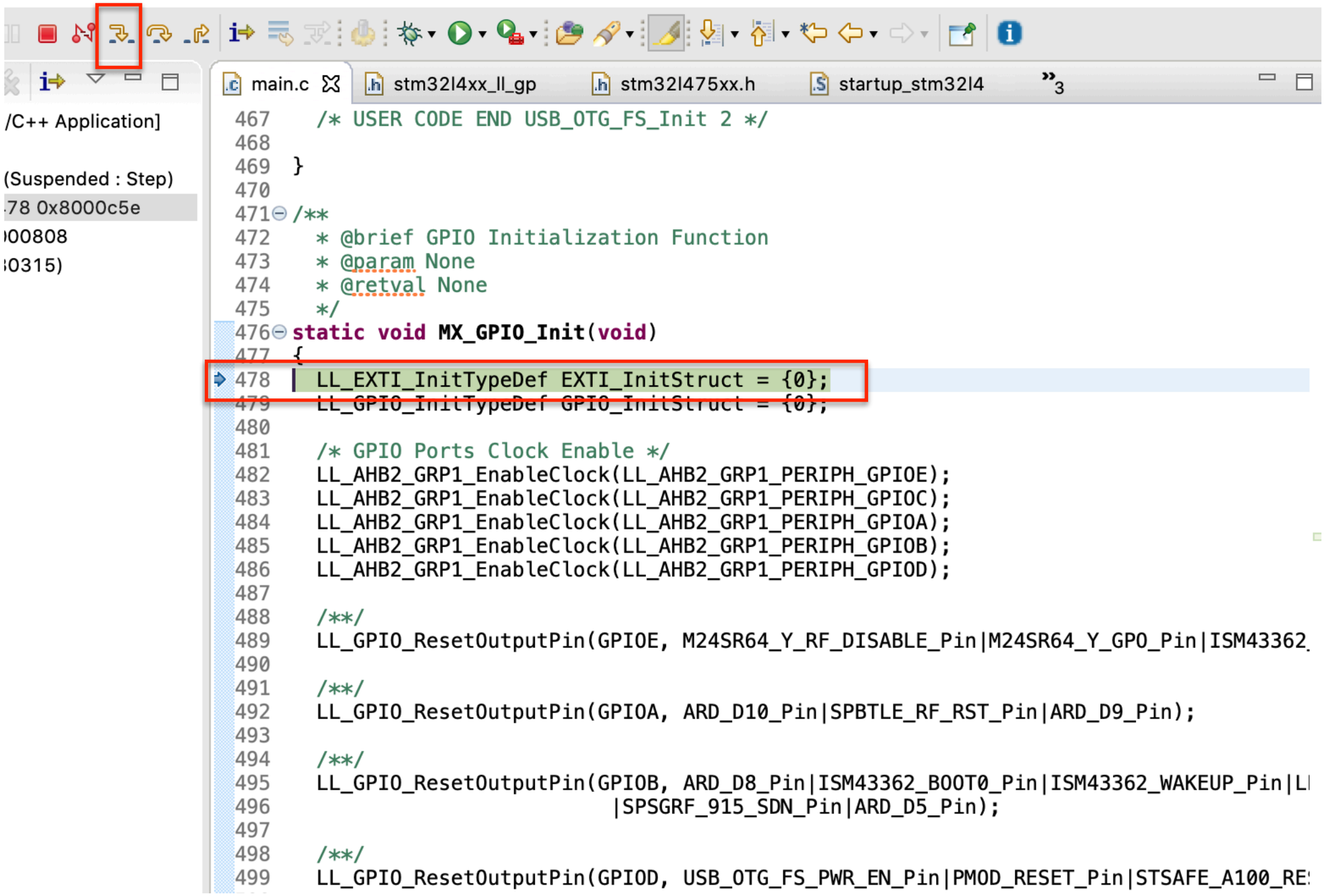
Step 17. Step Over



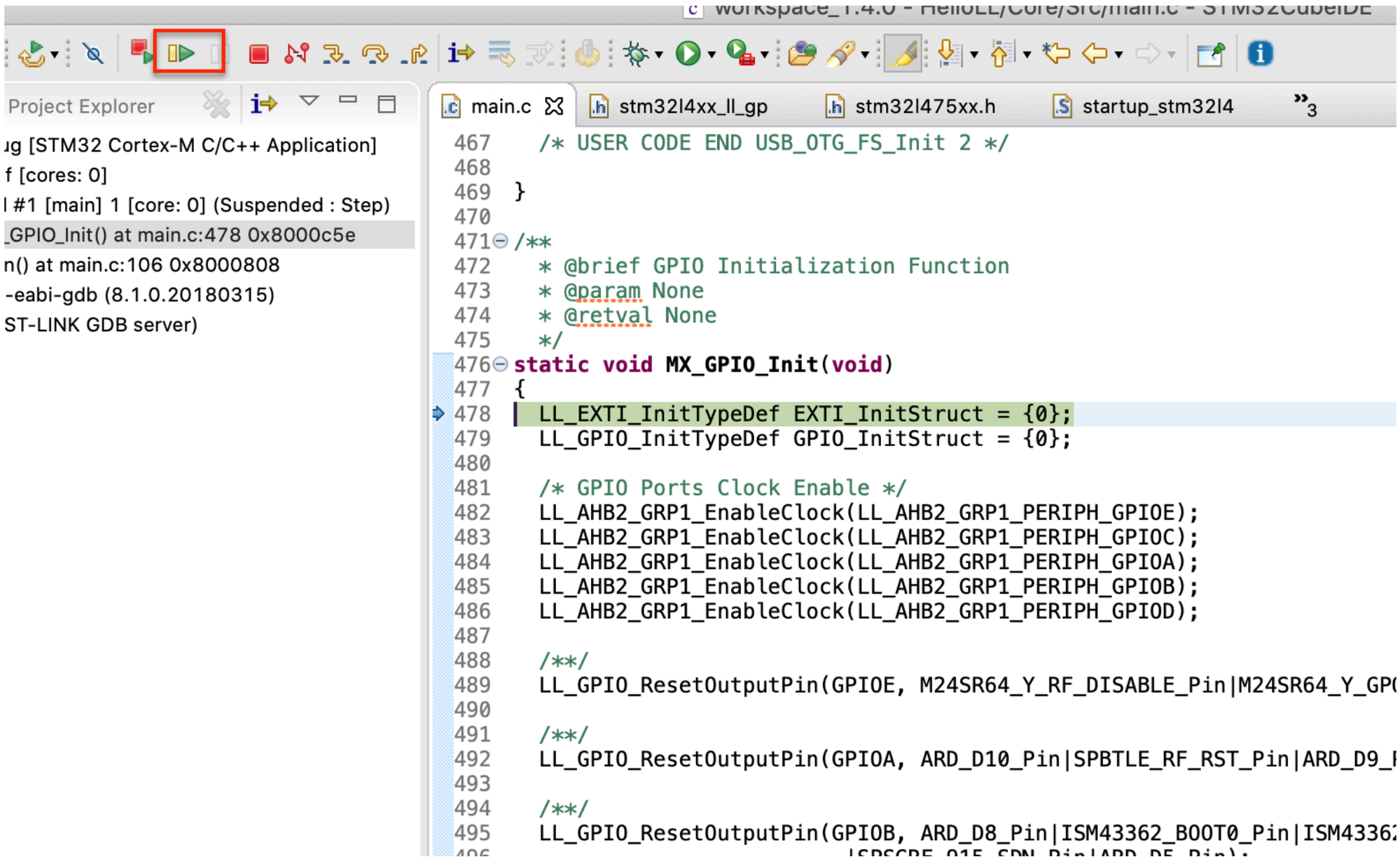
Step 18. Step Over Again



Step 19. Step **Into**

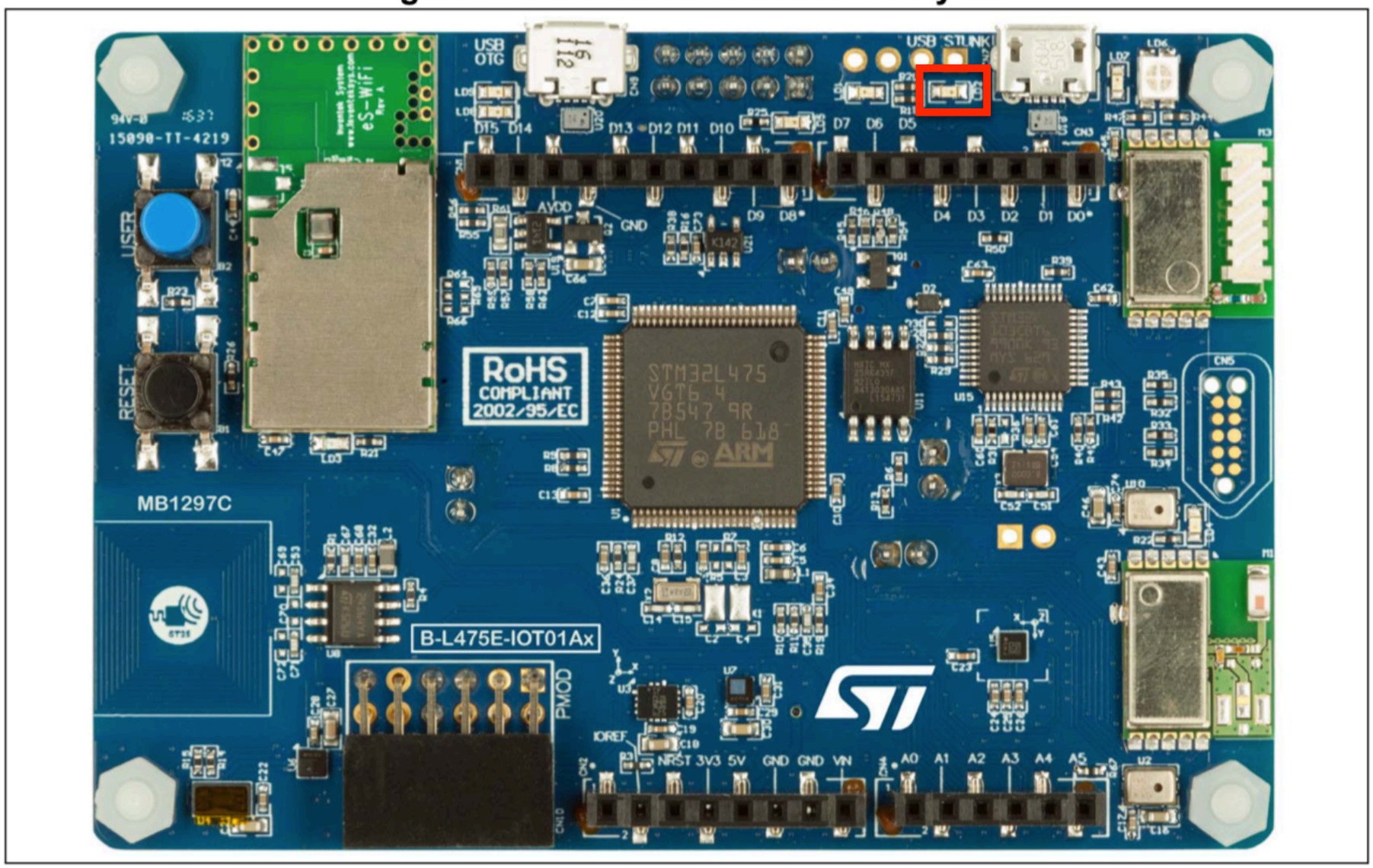


Step 20. **Resume**



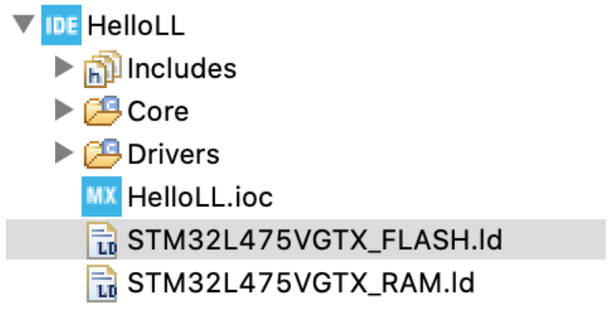
Results - Code Blinking LED use LL APIs

Figure 1. B-L475E-IOT01A Discovery kit

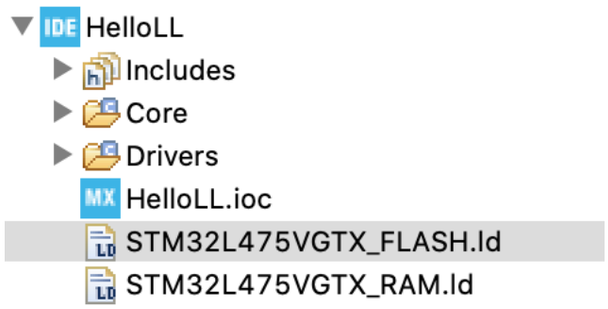


File Tour

Linker Scripts



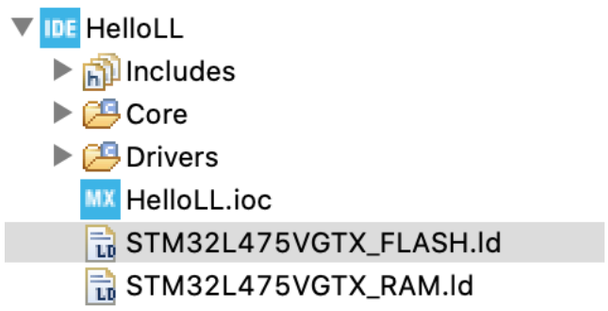
Step 1. Linker Script - Flash



main.c | STM32L475VGTX_FLASH.ld

```
/**
******************************************************************************
* @file      LinkerScript.ld
* @author    Auto-generated by STM32CubeIDE
*  Abstract     : Linker script for B-L475E-IOT01A1 Board embedding STM32L475VGTx Device from stm32l4 s
*                  1024Kbytes FLASH
*                  96Kbytes RAM
*                  32Kbytes RAM2
*
*          Set heap size, stack size and stack location according
*          to application requirements.
*
*          Set memory bank area and size if external memory is used
******************************************************************************
* @attention
```

Step 2. Linker Script - Flash



estack = end of stack

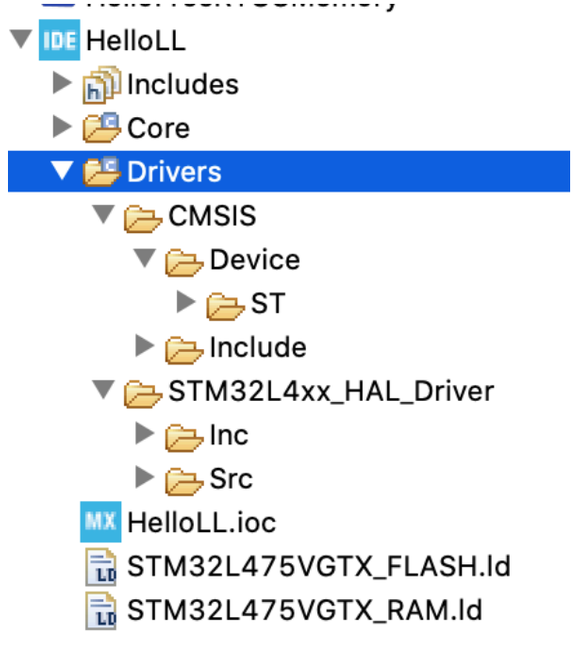
```
27
28 * Entry Point */
29 NTRY(Reset_Handler)
30
31 * Highest address of the user mode stack */
32 estack = ORIGIN(RAM) + LENGTH(RAM);    /* end of "RAM" Ram type memory */
33
34 Min_Heap_Size = 0x200 ;    /* required amount of heap  */
35 Min_Stack_Size = 0x400 ;   /* required amount of stack */
36
37 * Memories definition */
38 EMORY
39
40  RAM    (xrw)    : ORIGIN = 0x20000000,   LENGTH = 96K
41  RAM2    (xrw)    : ORIGIN = 0x10000000,   LENGTH = 32K
42  FLASH    (rx)    : ORIGIN = 0x8000000,   LENGTH = 1024K
43
44
```

Stack - push/pop as you make function calls

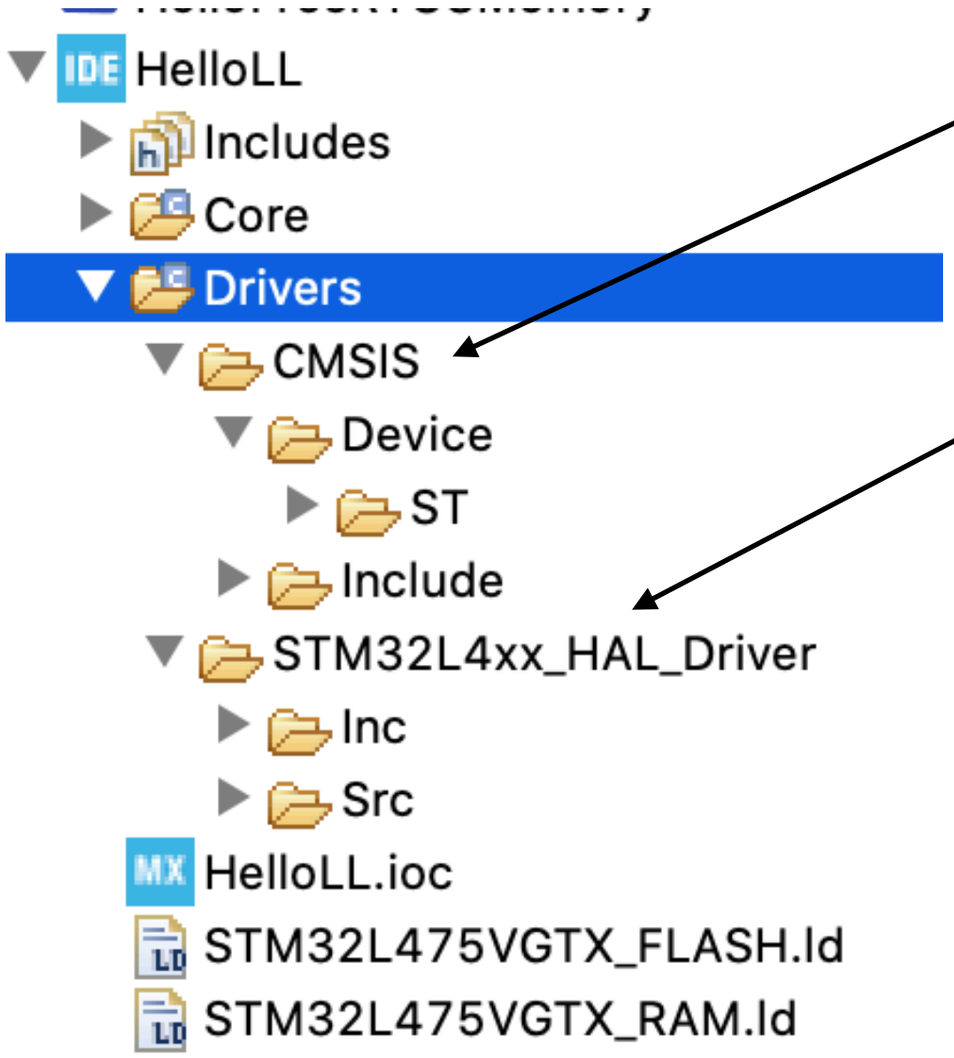
Heap - Dynamic Memory Allocation

File Tour

Driver Files



Step 1. Drivers



Cortext M
Software Interface Standard

HAL
Hardware Abstraction Layer

Inc
Include Files (.h)

Src
Source Files (.c)

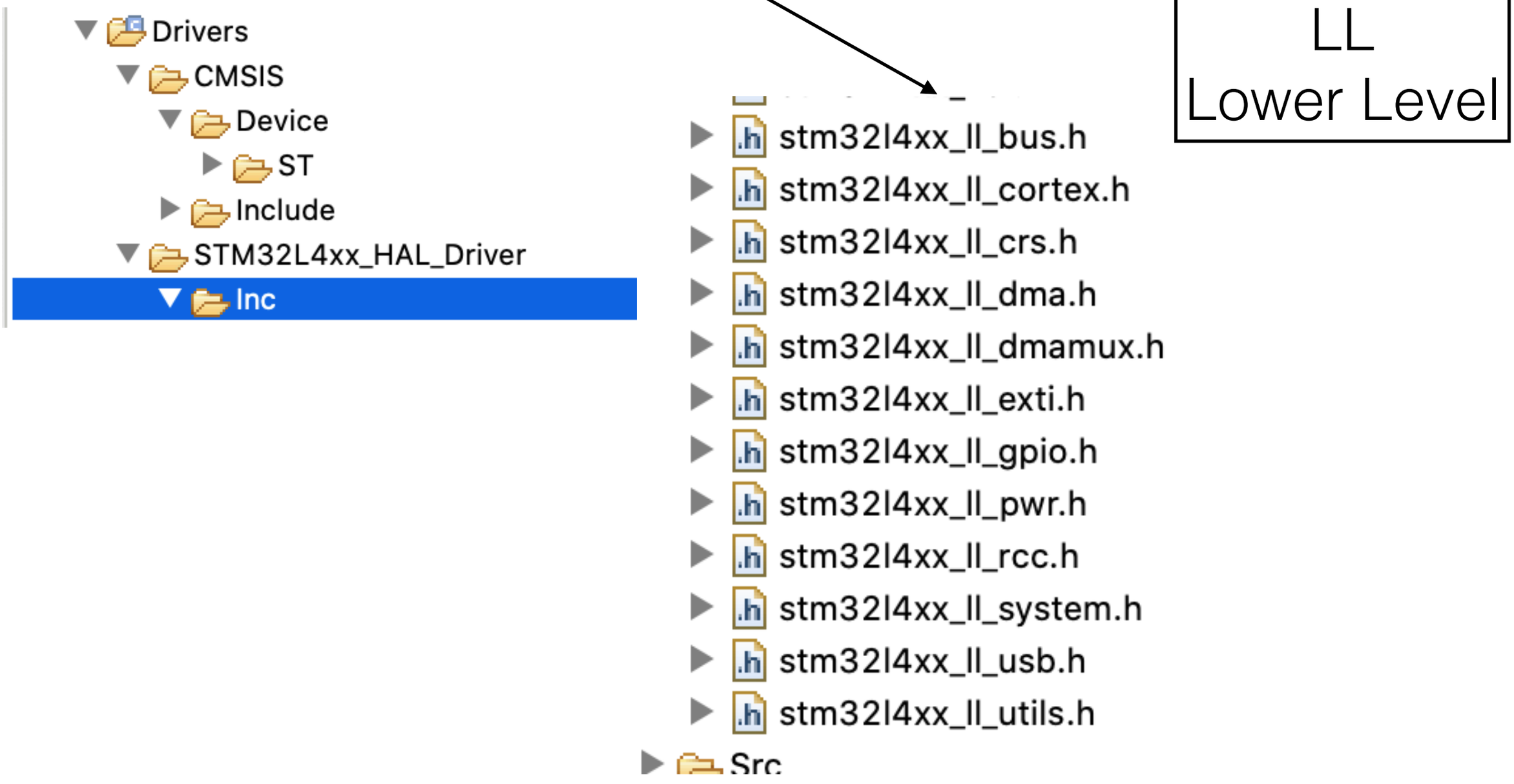
https://developer.arm.com/tools-and-software/embedded/cmsis

The **Cortex Microcontroller Software Interface Standard (CMSIS)** is a vendor-independent hardware abstraction layer for microcontrollers that are based on Arm® Cortex® processors. It defines generic tool interfaces and enables consistent device support. Its software interfaces simplify software re-use, reduce the learning curve for microcontroller developers, and improve time to market for new devices.

CMSIS provides interfaces to processor and peripherals, real-time operating systems, and middleware components. It includes a delivery mechanism for devices, boards, and software and enables the combination of software components from multiple vendors.

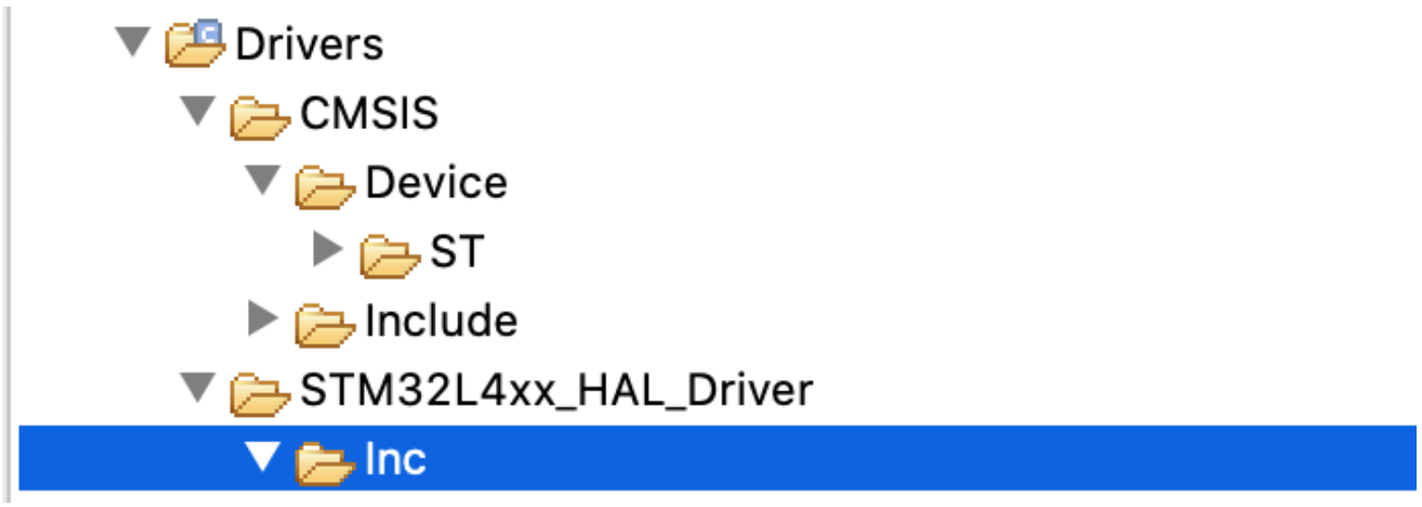
List of software packs » Parametric search for devices »

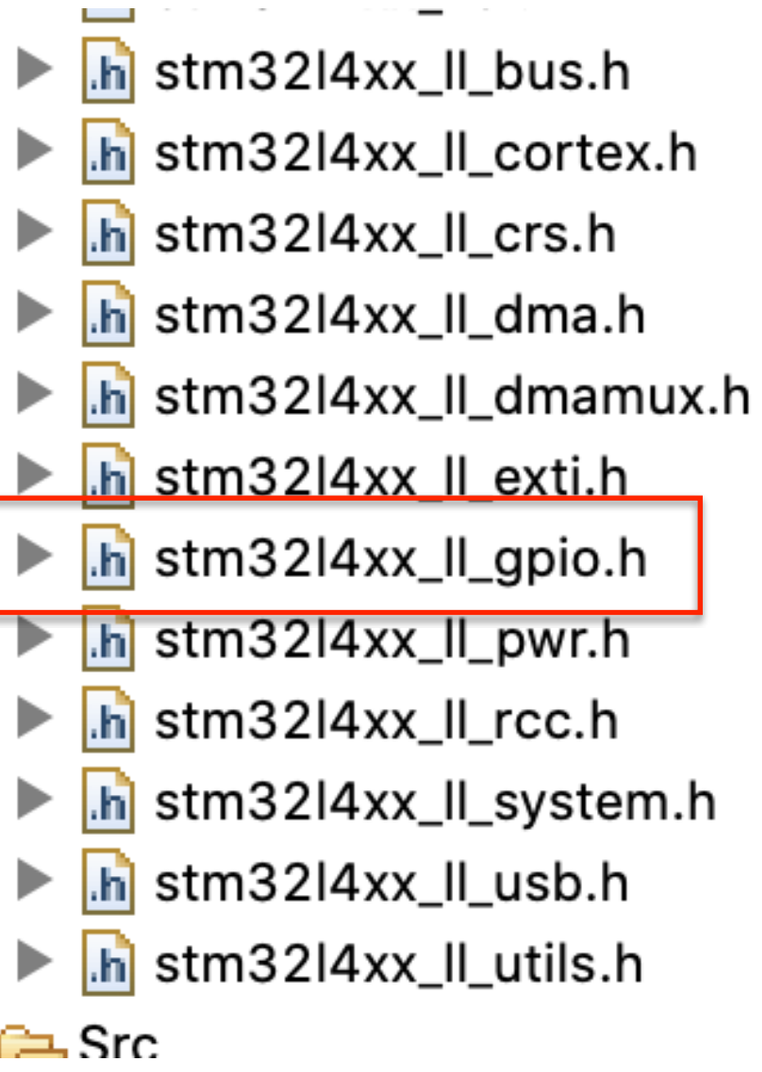
Step 3. LL Header Files



File Tour

Part 1





Step 1. stm32l4xx_ll_gpio.h

Automatic documentation generation
With **doxygen** tool

```
/**
  ******************************************************************************
  * @file    stm32l4xx_ll_gpio.h
  * @author  MCD Application Team
  * @brief   Header file of GPIO LL module.
  ******************************************************************************
  * @attention
  *
  * <h2><center>&copy; Copyright (c) 2017 STMicroelectronics.
  * All rights reserved.</center></h2>
  *
  * This software component is licensed by ST under BSD 3-Clause license,
  * the "License"; You may not use this file except in compliance with the
  * License. You may obtain a copy of the License at:
  *                        opensource.org/licenses/BSD-3-Clause
  *
  ******************************************************************************
  */
```

https://www.doxygen.nl/index.html

Step 2. stm32l4xx_ll_gpio.h

```
20  /* Define to prevent recursive inclusion -
21  #ifndef STM32L4xx_LL_GPIO_H
22  #define STM32L4xx_LL_GPIO_H
23
24  #ifdef __cplusplus
25  extern "C" {
26  #endif
27
28  /* Includes ------------------------------
29  #include "stm32l4xx.h"
30
```

Include this header file a single time

If compiling with C++ compiler, use C naming instead of C++ “mangled names” For this code

NOTE: Grayed out Means we are not using C++ compiler for this build

Step 3. stm32l4xx_ll_gpio.h

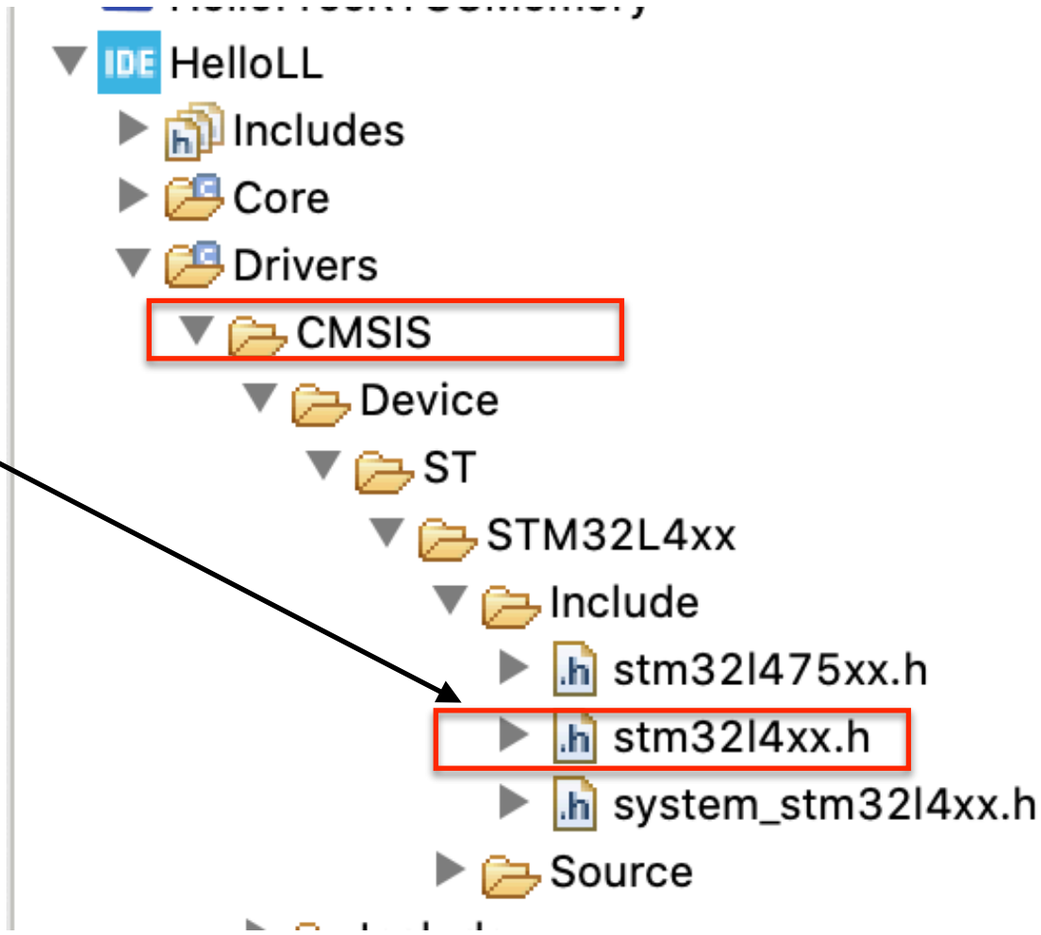
Include the remainder of this code only
if using GPIOA or GPIOB or …

```
34
35  #if defined (GPIOA) || defined (GPIOB) || defined (GPIOC) || defined (GPIOD) || defined (GPIOE)
36
```

Step 4. stm32l4xx_ll_gpio.h

Include file for CMSIS code common to all STM32L4 devices

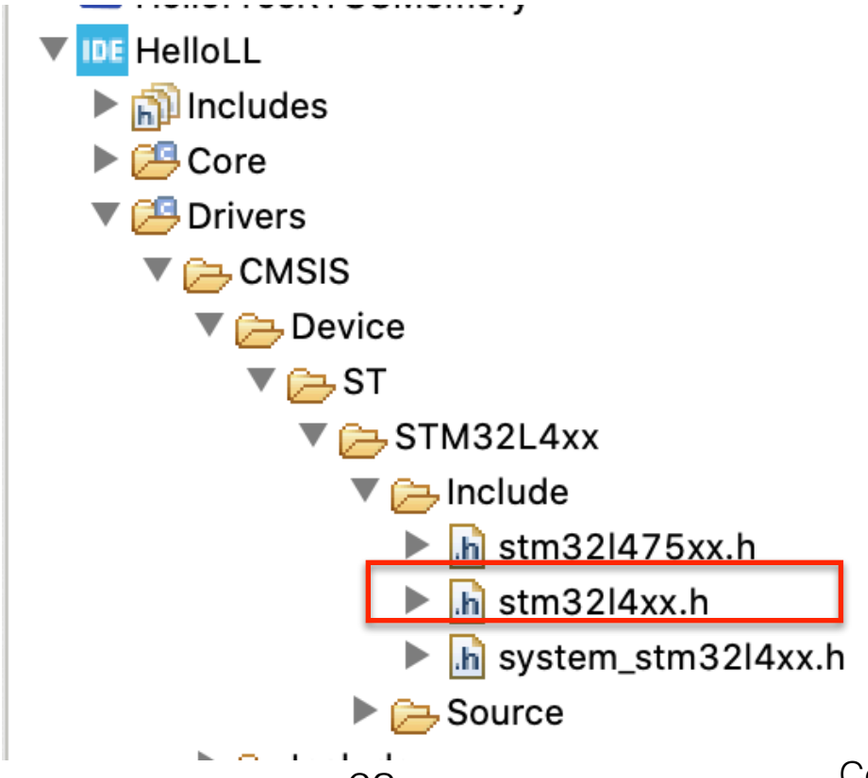
```
27
28  /* Includes ------------------------------
29  #include "stm32l4xx.h"
30
```



CMSIS
Cortex M
Software Interface Standard

File Tour

stm32l4xx.h



stm32l4xx.h
Part 1

```
/**
  ******************************************************************************
  * @file    stm32l4xx.h
  * @author  MCD Application Team
  * @brief   CMSIS STM32L4xx Device Peripheral Access Layer Header File.
  *
  *          The file is the unique include file that the application programmer
  *          is using in the C source code, usually in main.c. This file contains:
  *           - Configuration section that allows to select:
  *              - The STM32L4xx device used in the target application
  *              - To use or not the peripheral's drivers in application code(i.e.
  *                code will be based on direct access to peripheral's registers
  *                rather than drivers API), this option is controlled by
  *                "#define USE_HAL_DRIVER"
  *
```

stm32l4xx.h
Part 2

```
37
38  #ifndef __STM32L4xx_H
39  #define __STM32L4xx_H
40
41  #ifdef __cplusplus
42   extern "C" {
43  #endif /* __cplusplus */
44
```

Include this header file a single time

If compiling with C++ compiler, use C naming instead of C++ “mangled names” For this code

NOTE: Grayed out Means we are not using C++ compiler for this build

stm32l4xx.h
Part 3

```
49 /**
50   * @brief STM32 Family
51   */
52 #if !defined (STM32L4)
53 #define STM32L4
54 #endif /* STM32L4 */
55
```

If not defined,
Then define it.
Says we are using
The STM32L4 family

stm32l4xx.h
Part 4

```
55
56  /* Uncomment the line below according to the target STM32L4 device used in your
57     application
58   */
59
60  #if !defined (STM32L412xx) && !defined (STM32L422xx) && \
61      !defined (STM32L431xx) && !defined (STM32L432xx) && !defined (STM32L433xx) && !defined (ST
62      !defined (STM32L451xx) && !defined (STM32L452xx) && !defined (STM32L462xx) && \
63      !defined (STM32L471xx) && !defined (STM32L475xx) && !defined (STM32L476xx) && !defined (ST
64      !defined (STM32L496xx) && !defined (STM32L4A6xx) && \
65      !defined (STM32L4P5xx) && !defined (STM32L4Q5xx) && \
66      !defined (STM32L4R5xx) && !defined (STM32L4R7xx) && !defined (STM32L4R9xx) && !defined (ST
67    /* #define STM32L412xx */   /*!< STM32L412xx Devices */
68    /* #define STM32L422xx */   /*!< STM32L422xx Devices */
69    /* #define STM32L431xx */   /*!< STM32L431xx Devices */
70    /* #define STM32L432xx */   /*!< STM32L432xx Devices */
71    /* #define STM32L433xx */   /*!< STM32L433xx Devices */
72    /* #define STM32L442xx */   /*!< STM32L442xx Devices */
73    /* #define STM32L443xx */   /*!< STM32L443xx Devices */
```

We use STM32L475xx on Discovery Kit

stm32l4xx.h
Part 5

CMSIS Version Number is 01.07.00

```
105 /**
106   * @brief CMSIS Device version number
107   */
108 #define __STM32L4_CMSIS_VERSION_MAIN   (0x01) /*!< [31:24] main version */
109 #define __STM32L4_CMSIS_VERSION_SUB1   (0x07) /*!< [23:16] sub1 version */
110 #define __STM32L4_CMSIS_VERSION_SUB2   (0x00) /*!< [15:8]  sub2 version */
111 #define __STM32L4_CMSIS_VERSION_RC     (0x00) /*!< [7:0]  release candidate */
112 #define __STM32L4_CMSIS_VERSION        ((__STM32L4_CMSIS_VERSION_MAIN << 24)\
113                                        |(__STM32L4_CMSIS_VERSION_SUB1 << 16)\
114                                        |(__STM32L4_CMSIS_VERSION_SUB2 << 8 )\
115                                        |(__STM32L4_CMSIS_VERSION_RC))
116
```

stm32l4xx.h
Part 6

Pull in info specific to the MCU we are using

```
142   #include "stm32l452xx.h"
143 #elif defined(STM32L462xx)
144   #include "stm32l462xx.h"
145 #elif defined(STM32L471xx)
146   #include "stm32l471xx.h"
147 #elif defined(STM32L475xx)
148   #include "stm32l475xx.h"
149 #elif defined(STM32L476xx)
150   #include "stm32l476xx.h"
151 #elif defined(STM32L485xx)
```

stm32l4xx.h
Part 7

Types used throughout the code

```
186 typedef enum
187 {
188   RESET = 0,
189   SET = !RESET
190 } FlagStatus, ITStatus;
```

FlagStatus

```
192 typedef enum
193 {
194   DISABLE = 0,
195   ENABLE = !DISABLE
196 } FunctionalState;
```

FunctionalState

```
197 #define IS_FUNCTIONAL_STATE(STATE) (((STATE) == DISABLE) || ((STATE) == ENABLE))
```

```
199 typedef enum
200 {
201   SUCCESS = 0,
202   ERROR = !SUCCESS
203 } ErrorStatus;
```

ErrorStatus

stm32l4xx.h
Part 8

Macros used throughout the code

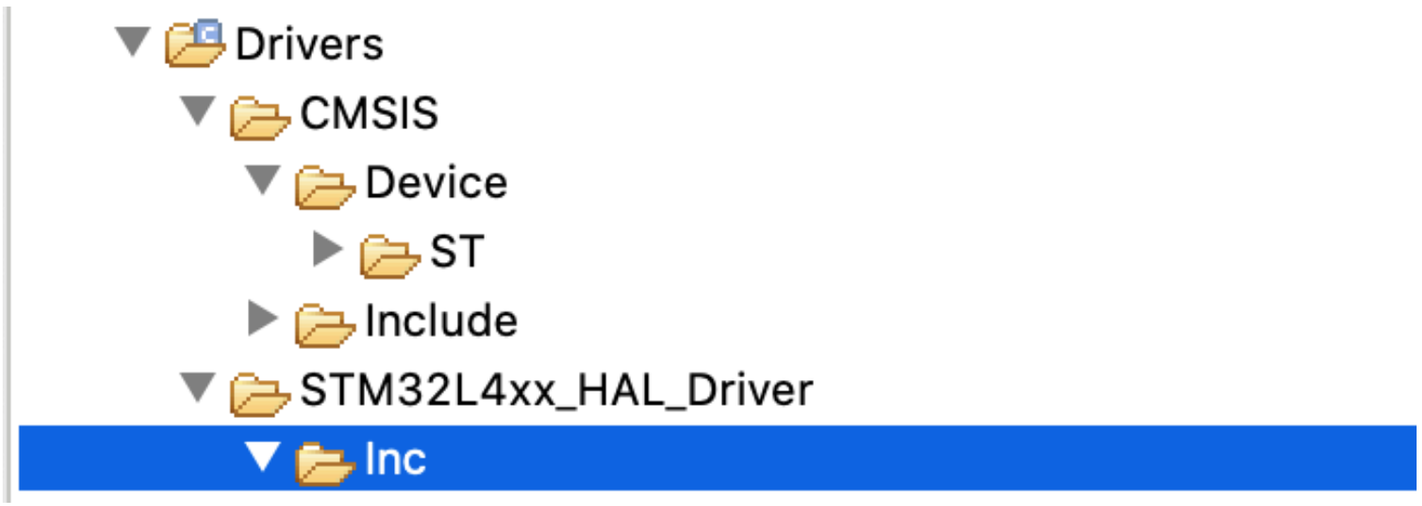
```
209
210 /** @addtogroup Exported_macros
211   * @{
212   */
213 #define SET_BIT(REG, BIT)     ((REG) |= (BIT))
214
215 #define CLEAR_BIT(REG, BIT)   ((REG) &= ~(BIT))
216
217 #define READ_BIT(REG, BIT)    ((REG) & (BIT))
218
219 #define CLEAR_REG(REG)        ((REG) = (0x0))
220
221 #define WRITE_REG(REG, VAL)   ((REG) = (VAL))
222
223 #define READ_REG(REG)         ((REG))
224
225 #define MODIFY_REG(REG, CLEARMASK, SETMASK)  WRITE_REG((REG), (((READ_REG(REG)) & (~(CLEARMASK))) | (S
226
227 #define POSITION_VAL(VAL)     (__CLZ(__RBIT(VAL)))
228
```

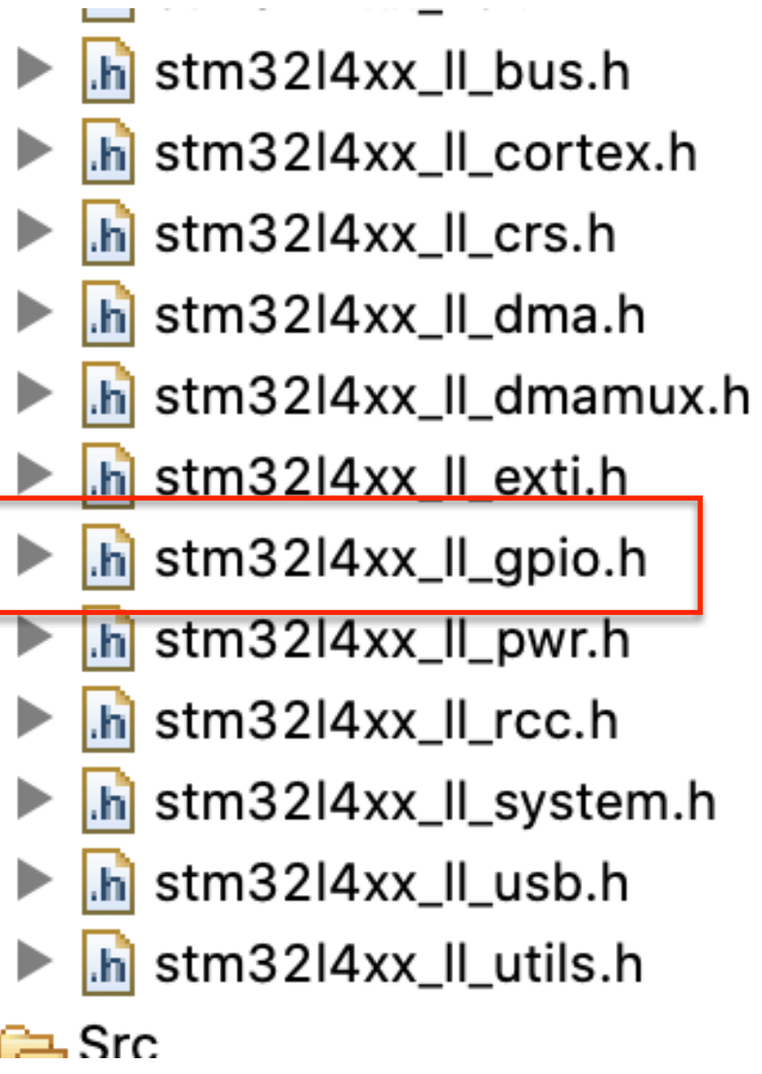
stm32l4xx.h
Part 9

If using HAL drivers

```
233
234 #if defined (USE_HAL_DRIVER)
235  #include "stm32l4xx_hal.h"
236 #endif /* USE_HAL_DRIVER */
```

File Tour Part 2





Step: View “Drivers/ STM32L4xx_HAL_Driver/Inc/ stm32l4xx_ll_gpio.h” - Part 1

```
******************************************************************************
* @file    stm32l4xx_ll_gpio.h
* @author  MCD Application Team
* @brief   Header file of GPIO LL module.
******************************************************************************
```

```
/* Define to prevent recursive inclusion -------------------------------------*/
#ifndef __STM32L4xx_LL_GPIO_H
#define __STM32L4xx_LL_GPIO_H

#ifdef __cplusplus
extern "C" {
#endif

/* Includes ------------------------------------------------------------------*/
#include "stm32l4xx.h"
```

Step: View “Drivers/ STM32L4xx_HAL_Driver/Inc/ stm32l4xx_ll_gpio.h” - Part 2

```
#if defined (GPIOA) || defined (GPIOB) || defined (GPIOC) || defined (GPIOD) || defined (GPIOE) ||
defined (GPIOF) || defined (GPIOG) || defined (GPIOH) || defined (GPIOI)
```

```
  */
/** MISRA C:2012 deviation rule has been granted for following rules:
  * Rule-18.1_d - Medium: Array pointer `GPIOx' is accessed with index [..,..]
  * which may be out of array bounds [..,UNKNOWN] in following APIs:
  * LL_GPIO_GetAFPin_0_7
  * LL_GPIO_SetAFPin_0_7
  * LL_GPIO_SetAFPin_8_15
  * LL_GPIO_GetAFPin_8_15
  */
```

Step: View “Drivers/ STM32L4xx_HAL_Driver/Inc/ stm32l4xx_ll_gpio.h” - Part 3

```
  */
typedef struct
{
  uint32_t Pin;          /*!< Specifies the GPIO pins to be configured.
                             This parameter can be any value of @ref GPIO_LL_EC_PIN */

  uint32_t Mode;         /*!< Specifies the operating mode for the selected pins.
                             This parameter can be a value of @ref GPIO_LL_EC_MODE.

                             GPIO HW configuration can be modified afterwards using unitary function @ref LL_GPIO_SetPinMode().*/

  uint32_t Speed;        /*!< Specifies the speed for the selected pins.
                             This parameter can be a value of @ref GPIO_LL_EC_SPEED.

                             GPIO HW configuration can be modified afterwards using unitary function @ref LL_GPIO_SetPinSpeed().*/

  uint32_t OutputType;   /*!< Specifies the operating output type for the selected pins.
                             This parameter can be a value of @ref GPIO_LL_EC_OUTPUT.

                             GPIO HW configuration can be modified afterwards using unitary function @ref LL_GPIO_SetPinOutputType().*/

  uint32_t Pull;         /*!< Specifies the operating Pull-up/Pull down for the selected pins.
                             This parameter can be a value of @ref GPIO_LL_EC_PULL.

                             GPIO HW configuration can be modified afterwards using unitary function @ref LL_GPIO_SetPinPull().*/

  uint32_t Alternate;    /*!< Specifies the Peripheral to be connected to the selected pins.
                             This parameter can be a value of @ref GPIO_LL_EC_AF.

                             GPIO HW configuration can be modified afterwards using unitary function @ref LL_GPIO_SetAFPin_0_7() and LL_GPIO_SetAFPin_8_15().*/

} LL_GPIO_InitTypeDef;
```

LL_GPIO_InitTypeDef

Step: View “Drivers/ STM32L4xx_HAL_Driver/Inc/ stm32l4xx_ll_gpio.h” - Part 4

```
/** @defgroup GPIO_LL_EC_PIN PIN
  * @{
  */
#define LL_GPIO_PIN_0                      GPIO_BSRR_BS0 /*!< Select pin 0 */
#define LL_GPIO_PIN_1                      GPIO_BSRR_BS1 /*!< Select pin 1 */
#define LL_GPIO_PIN_2                      GPIO_BSRR_BS2 /*!< Select pin 2 */
#define LL_GPIO_PIN_3                      GPIO_BSRR_BS3 /*!< Select pin 3 */
#define LL_GPIO_PIN_4                      GPIO_BSRR_BS4 /*!< Select pin 4 */
#define LL_GPIO_PIN_5                      GPIO_BSRR_BS5 /*!< Select pin 5 */
#define LL_GPIO_PIN_6                      GPIO_BSRR_BS6 /*!< Select pin 6 */
#define LL_GPIO_PIN_7                      GPIO_BSRR_BS7 /*!< Select pin 7 */
#define LL_GPIO_PIN_8                      GPIO_BSRR_BS8 /*!< Select pin 8 */
#define LL_GPIO_PIN_9                      GPIO_BSRR_BS9 /*!< Select pin 9 */
#define LL_GPIO_PIN_10                     GPIO_BSRR_BS10 /*!< Select pin 10 */
#define LL_GPIO_PIN_11                     GPIO_BSRR_BS11 /*!< Select pin 11 */
#define LL_GPIO_PIN_12                     GPIO_BSRR_BS12 /*!< Select pin 12 */
#define LL_GPIO_PIN_13                     GPIO_BSRR_BS13 /*!< Select pin 13 */
#define LL_GPIO_PIN_14                     GPIO_BSRR_BS14 /*!< Select pin 14 */
#define LL_GPIO_PIN_15                     GPIO_BSRR_BS15 /*!< Select pin 15 */
#define LL_GPIO_PIN_ALL                    (GPIO_BSRR_BS0 | GPIO_BSRR_BS1  | GPIO_BSRR_BS2  | \
                                            GPIO_BSRR_BS3  | GPIO_BSRR_BS4  | GPIO_BSRR_BS5  | \
                                            GPIO_BSRR_BS6  | GPIO_BSRR_BS7  | GPIO_BSRR_BS8  | \
                                            GPIO_BSRR_BS9  | GPIO_BSRR_BS10 | GPIO_BSRR_BS11 | \
                                            GPIO_BSRR_BS12 | GPIO_BSRR_BS13 | GPIO_BSRR_BS14 | \
                                            GPIO_BSRR_BS15) /*!< Select all pins */

/**
```

Step: View “Drivers/ STM32L4xx_HAL_Driver/Inc/ stm32l4xx_ll_gpio.h” - Part 5

```
/** @defgroup GPIO_LL_EC_MODE Mode
  * @{
  */
#define LL_GPIO_MODE_INPUT                   (0x00000000U) /*!< Select input mode */
#define LL_GPIO_MODE_OUTPUT                  GPIO_MODER_MODE0_0  /*!< Select output mode */
#define LL_GPIO_MODE_ALTERNATE               GPIO_MODER_MODE0_1  /*!< Select alternate function mode */
#define LL_GPIO_MODE_ANALOG                  GPIO_MODER_MODE0    /*!< Select analog mode */
/**
  * @}
  */

/** @defgroup GPIO_LL_EC_OUTPUT Output Type
  * @{
  */
#define LL_GPIO_OUTPUT_PUSHPULL              (0x00000000U) /*!< Select push-pull as output type */
#define LL_GPIO_OUTPUT_OPENDRAIN             GPIO_OTYPER_OT0 /*!< Select open-drain as output type */
/**
  * @}
  */

/** @defgroup GPIO_LL_EC_SPEED Output Speed
  * @{
  */
#define LL_GPIO_SPEED_FREQ_LOW               (0x00000000U) /*!< Select I/O low output speed    */
#define LL_GPIO_SPEED_FREQ_MEDIUM            GPIO_OSPEEDR_OSPEED0_0 /*!< Select I/O medium output speed
#define LL_GPIO_SPEED_FREQ_HIGH              GPIO_OSPEEDR_OSPEED0_1 /*!< Select I/O fast output speed
#define LL_GPIO_SPEED_FREQ_VERY_HIGH         GPIO_OSPEEDR_OSPEED0   /*!< Select I/O high output speed
/**
  * @}
  */
#define LL_GPIO_SPEED_LOW                    LL_GPIO_SPEED_FREQ_LOW
#define LL_GPIO_SPEED_MEDIUM                 LL_GPIO_SPEED_FREQ_MEDIUM
#define LL_GPIO_SPEED_FAST                   LL_GPIO_SPEED_FREQ_HIGH
#define LL_GPIO_SPEED_HIGH                   LL_GPIO_SPEED_FREQ_VERY_HIGH
```

Step: View “Drivers/ STM32L4xx_HAL_Driver/Inc/ stm32l4xx_ll_gpio.h” - Part 6

```
/** @defgroup GPIO_LL_EC_PULL Pull Up Pull Down
  * @{
  */
#define LL_GPIO_PULL_NO                      (0x00000000U) /*!< Select I/O no pull */
#define LL_GPIO_PULL_UP                      GPIO_PUPDR_PUPD0_0 /*!< Select I/O pull up */
#define LL_GPIO_PULL_DOWN                    GPIO_PUPDR_PUPD0_1 /*!< Select I/O pull down */
/**
  * @}
  */

/** @defgroup GPIO_LL_EC_AF Alternate Function
  * @{
  */
#define LL_GPIO_AF_0                         (0x0000000U) /*!< Select alternate function 0 */
#define LL_GPIO_AF_1                         (0x0000001U) /*!< Select alternate function 1 */
#define LL_GPIO_AF_2                         (0x0000002U) /*!< Select alternate function 2 */
#define LL_GPIO_AF_3                         (0x0000003U) /*!< Select alternate function 3 */
#define LL_GPIO_AF_4                         (0x0000004U) /*!< Select alternate function 4 */
#define LL_GPIO_AF_5                         (0x0000005U) /*!< Select alternate function 5 */
#define LL_GPIO_AF_6                         (0x0000006U) /*!< Select alternate function 6 */
#define LL_GPIO_AF_7                         (0x0000007U) /*!< Select alternate function 7 */
#define LL_GPIO_AF_8                         (0x0000008U) /*!< Select alternate function 8 */
#define LL_GPIO_AF_9                         (0x0000009U) /*!< Select alternate function 9 */
#define LL_GPIO_AF_10                        (0x000000AU) /*!< Select alternate function 10 */
#define LL_GPIO_AF_11                        (0x000000BU) /*!< Select alternate function 11 */
#define LL_GPIO_AF_12                        (0x000000CU) /*!< Select alternate function 12 */
#define LL_GPIO_AF_13                        (0x000000DU) /*!< Select alternate function 13 */
#define LL_GPIO_AF_14                        (0x000000EU) /*!< Select alternate function 14 */
#define LL_GPIO_AF_15                        (0x000000FU) /*!< Select alternate function 15 */
/**
```

Step: View “Drivers/ STM32L4xx_HAL_Driver/Inc/ stm32l4xx_ll_gpio.h” - Part 7

```
/* Exported macro ------------------------------------------------------------*/
/** @defgroup GPIO_LL_Exported_Macros GPIO Exported Macros
  * @{
  */

/** @defgroup GPIO_LL_EM_WRITE_READ Common Write and read registers Macros
  * @{
  */

/**
  * @brief  Write a value in GPIO register
  * @param  __INSTANCE__ GPIO Instance
  * @param  __REG__ Register to be written
  * @param  __VALUE__ Value to be written in the register
  * @retval None
  */
#define LL_GPIO_WriteReg(__INSTANCE__, __REG__, __VALUE__) WRITE_REG(__INSTANCE__->__REG__, (__VALUE__))

/**
  * @brief  Read a value in GPIO register
  * @param  __INSTANCE__ GPIO Instance
  * @param  __REG__ Register to be read
  * @retval Register value
  */
#define LL_GPIO_ReadReg(__INSTANCE__, __REG__) READ_REG(__INSTANCE__->__REG__)
/**
  * @}
  */
```

Step: View “Drivers/ STM32L4xx_HAL_Driver/Inc/ stm32l4xx_ll_gpio.h” - Part 8

```
/**
  * @brief  Write output data register for the port.
  * @rmtoll ODR          ODy           LL_GPIO_WriteOutputPort
  * @param  GPIOx GPIO Port
  * @param  PortValue Level value for each pin of the port
  * @retval None
  */
__STATIC_INLINE void LL_GPIO_WriteOutputPort(GPIO_TypeDef *GPIOx, uint32_t PortValue)
{
  WRITE_REG(GPIOx->ODR, PortValue);
}

/**
  * @brief  Return full output data register value for a dedicated port.
  * @rmtoll ODR          ODy           LL_GPIO_ReadOutputPort
  * @param  GPIOx GPIO Port
  * @retval Output data register value of port
  */
__STATIC_INLINE uint32_t LL_GPIO_ReadOutputPort(GPIO_TypeDef *GPIOx)
{
  return (uint32_t)(READ_REG(GPIOx->ODR));
}
```

Step: View “Drivers/ STM32L4xx_HAL_Driver/Inc/ stm32l4xx_ll_gpio.h” - Part 9

```
#if defined(USE_FULL_LL_DRIVER)
/** @defgroup GPIO_LL_EF_Init Initialization and de-initialization functions
  * @{
  */

ErrorStatus LL_GPIO_DeInit(GPIO_TypeDef *GPIOx);
ErrorStatus LL_GPIO_Init(GPIO_TypeDef *GPIOx, LL_GPIO_InitTypeDef *GPIO_InitStruct);
void        LL_GPIO_StructInit(LL_GPIO_InitTypeDef *GPIO_InitStruct);
```

Summary

- Reference Info
- Concepts
- STM32CubeIDE and LL Code Generation
  - Blink LED using LL APIs
- File Tours