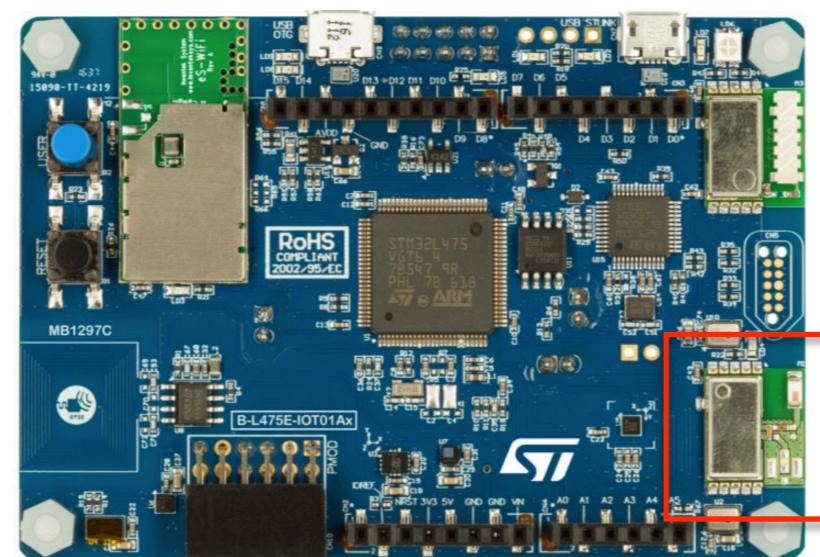


Embedded Systems Hardware Interfacing

BLE

Norman McEntire



Contents

- BLE compared to Wi-Fi
- BLE Concepts
- BLE Data Sheet
- Schematics - BLE on STM32L Discovery Kit for IoT
- Hands-On Project - BLE

References

- <https://en.wikipedia.org/wiki/Bluetooth>
- https://en.wikipedia.org/wiki/Bluetooth_Low_Energy
- https://en.wikipedia.org/wiki/Bluetooth_stack
- <https://www.bluetooth.com>
- <https://www.st.com/en/wireless-transceivers-mcus-and-modules/spbtle-rf.html>
- https://www.usb.orghttps://www.st.com/resource/en/schematic_pack/b-l475e-iot01ax_sch.zip
- https://www.st.com/resource/en/user_manual/dm00347848-discovery-kit-for-iot-node-multichannel-communication-with-stm32l4-stmicroelectronics.pdf
- <https://www.st.com/resource/en/datasheet/stm32l475vg.pdf>

BLE Compared to Wi-Fi

- Both have IEEE Standards
 - Wi-Fi - 802.11
 - BLE - 802.15.1 (but no longer maintained)
- Both are ISM (Industrial Scientific Medical) Bands
 - Wi-Fi - 2.4GHz and 5Ghz
 - BLE - 2.4GHz
- Range
 - Wi-Fi - Local Area Networks - 100 meters
 - BLE - Personal Area Networks - 10 meters

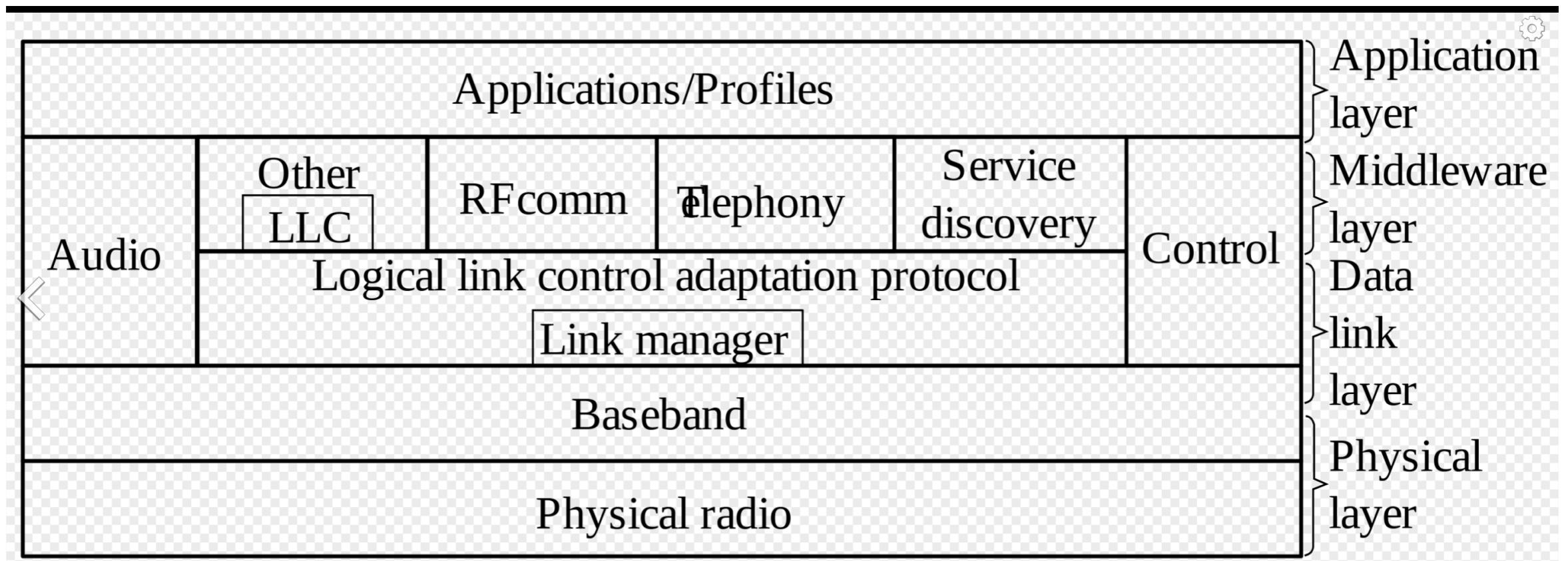
BLE Versions

	<ul style="list-style-type: none">6 Specifications and features<ul style="list-style-type: none">6.1 Bluetooth 1.0 and 1.0B6.2 Bluetooth 1.16.3 Bluetooth 1.26.4 Bluetooth 2.0 + EDR6.5 Bluetooth 2.1 + EDR6.6 Bluetooth 3.0 + HS<ul style="list-style-type: none">6.6.1 Ultra-wideband
BLE starts w/ 4.0 (Bluetooth Smart)	<ul style="list-style-type: none">6.7 Bluetooth 4.06.8 Bluetooth 4.16.9 Bluetooth 4.26.10 Bluetooth 56.11 Bluetooth 5.16.12 Bluetooth 5.2

BLE Concepts

- BLE - Bluetooth Low Energy
 - Sometimes called Bluetooth 4
 - Sometimes called Bluetooth Smart
- BLE makes it easy to get your embedded designs working with mobile devices
 - iPhone, Android, Tablets
 - Laptops

BLE Block Diagram



L2CAP = Logical Link Control and Adaptation Protocol

GAP

- Generic Access Profile
 - Makes your device visible
 - Controls Advertising and Connections
- GAP Defines Two Roles
 - Peripheral - the peripheral that connects to a central device
 - Central - the device (e.g. mobile phone) that allows peripherals to connect

Advertising

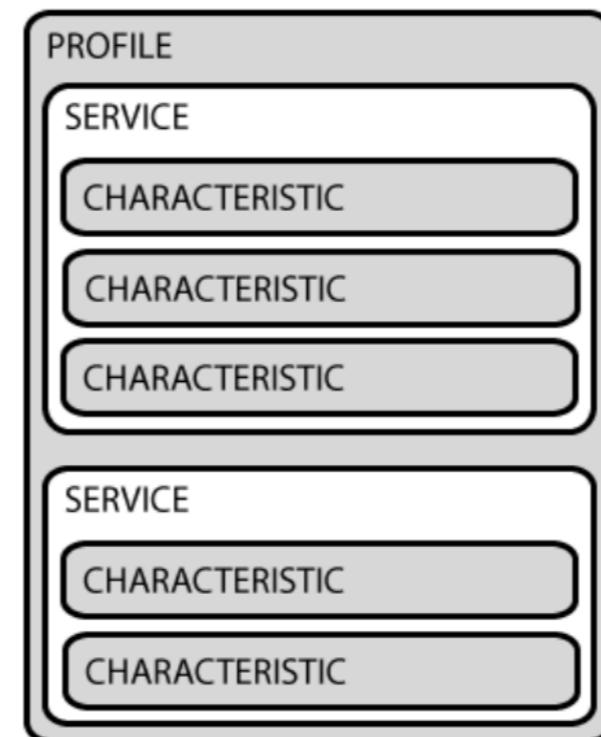
- Two Options to send out advertising with GAP
 - Advertising Data Payload
 - Mandatory
 - Scan Response Payload
 - Optional
 - Both can contain up to 31 bytes of data

Advertising Only Devices

- Some BLE devices can be advertising only
 - No need to connect to device - it simply sends out info (e.g. temperature)

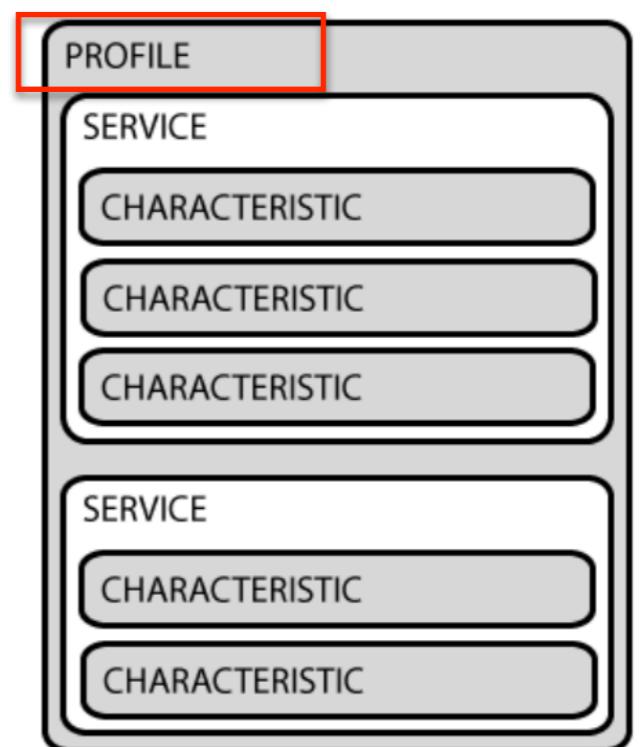
GATT

- Generic Attribute Profile
 - Defines how two BLE devices transfer data using
 - **Profiles**
 - **Services**
 - **Characteristics**



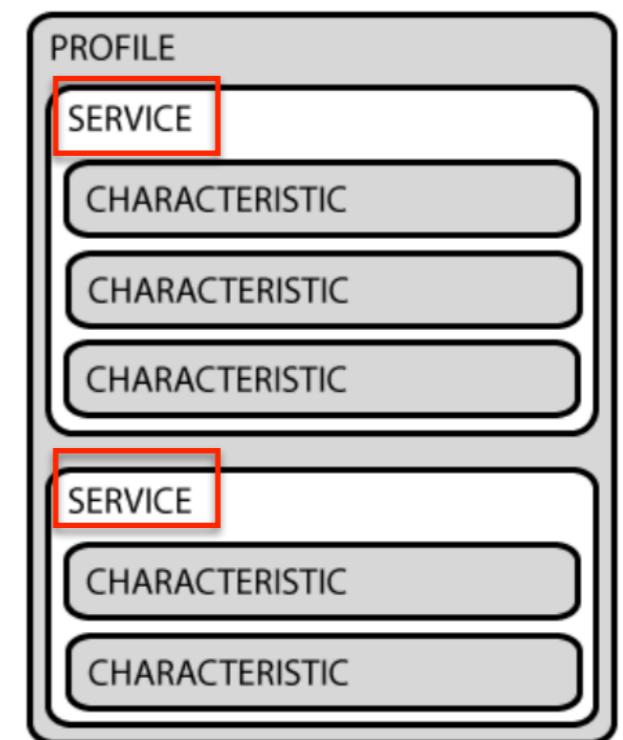
Profile

- Predefined *collection* of services
 - Defined by Bluetooth SIG
 - Or defined by your design
- Example: Heart Rate Profile



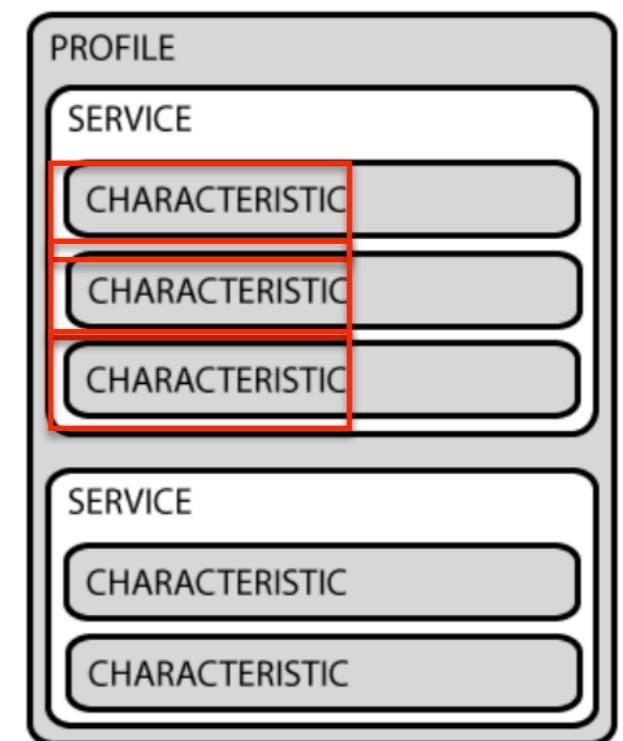
Service

- Breaks profiles into logical entities
- A service can have one or more characteristics



Characteristic

- A single data point
 - Example:
 - Heart Rate - UUID of 0x2A37



<https://www.bluetooth.com/specifications/gatt/>

Profile Specification		Version	Status	Adoption Date	Informative documents
ANP	Alert Notification Profile	1.0	Active	13 Sep 2011	N/A
ANS	Alert Notification Service	1.0	Active	13 Sep 2011	N/A
AIOP	Automation IO Profile	1.0	Active	14 Jul 2015	N/A
AIOS	Automation IO Service	1.0	Active	14 Jul 2015	N/A
BAS	Battery Service	1.0	Active	27 Dec 2011	N/A
BCS	Body Composition Service	1.0	Active	21 Oct 2014	N/A
BLP	Blood Pressure Profile	1.0.1	Active	21 Jan 2019	BLP_1.0.1_shovel.pdf
BLS	Blood Pressure Service	1.0	Active	25 Oct 2011	N/A
BMS	Bond Management Service	1.0	Active	21 Oct 2014	N/A
BSP	Binary Sensor Profile	1.0	Active	02 Jul 2019	N/A
BSS	Binary Sensor Service	1.0	Active	02 Jul 2019	N/A
CGMP	Continuous Glucose Monitoring Profile	1.0.1	Active	15 Dec 2015	N/A

CHP	BR/EDR Connection Handover Profile	1.0	Active	11 Aug 2020	N/A
CPP	Cycling Power Profile	1.1	Active	03 May 2016	N/A
CPS	Cycling Power Service	1.1	Active	03 May 2016	N/A
CSCP	Cycling Speed and Cadence Profile	1.0	Active	21 Aug 2012	N/A
CSCS	Cycling Speed and Cadence Service	1.0	Active	21 Aug 2012	N/A
CTS	Current Time Service	1.1	Active	07 Oct 2014	N/A
DIS	Device Information Service	1.1	Active	29 Nov 2011	N/A
EMP	Emergency Profile	1.0	Active	02 Jul 2019	N/A
EMCS	Emergency Configuration Service	1.0	Active	02 Jul 2019	N/A
ESP	Environmental Sensing Profile	1.0	Active	18 Nov 2014	N/A
ESS	Environmental Sensing Service	1.0	Active	18 Nov 2014	N/A
FMP	Find Me Profile	1.0	Active	21 Jun 2011	N/A
FTMP	Fitness Machine Profile	1.0	Active	14 Feb 2017	N/A
FTMS	Fitness Machine Service	1.0	Active	14 Feb 2017	N/A

GLS	Glucose Service	1.0	Active	10 Apr 2012	N/A
HIDS	HID Service	1.0	Active	27 Dec 2011	N/A
HOGP	HID over GATT Profile	1.0	Active	27 Dec 2011	N/A
HPS	HTTP Proxy Service	1.0	Active	06 Oct 2015	N/A
HRP	Heart Rate Profile	1.0	Active	12 Jul 2011	N/A
HRS	Heart Rate Service	1.0	Active	12 Jul 2011	N/A
HTP	Health Thermometer Profile	1.0	Active	24 May 2011	N/A
HTS	Health Thermometer Service	1.0	Active	24 May 2011	N/A
IAS	Immediate Alert Service	1.0	Active	21 Jun 2011	N/A
IDP	Insulin Delivery Profile	1.0	Active	24 Jul 2018	N/A
IDS	Insulin Delivery Service	1.0	Active	24 Jul 2018	N/A
IPS	Indoor Positioning Service	1.0	Active	19 May 2015	N/A
IPSP	Internet Protocol Support Profile	1.0	Active	16 Dec 2014	N/A

Heart Rate Service

BLUETOOTH® DOC	Date / Year-Month-Day 2011-07-12	Approved Adopted	Revision V10r00	Document No HRS_SPEC
Prepared By MED WG	E-mail Address med-feedback@bluetooth.org			N.B.

HEART RATE SERVICE

Heart Rate Service

3 Service Characteristics

The following characteristics are exposed in the Heart Rate Service. Unless otherwise specified, only one instance of each characteristic is permitted within this service.

Characteristic Name	Requirement	Mandatory Properties	Optional Properties	Security Permissions
Heart Rate Measurement	M	Notify		None.
Heart Rate Measurement Client Characteristic Configuration descriptor	M	Read, Write		None.
Body Sensor Location	O	Read		None.
Heart Rate Control Point	C.1	Write		None.

Table 3.1: Heart Rate Service characteristics

C.1: Mandatory if the Energy Expended feature is supported, otherwise excluded.

Notes:

- Security Permissions of “None” means that this service does not impose any requirements.
- Properties not listed as Mandatory or Optional are Excluded.

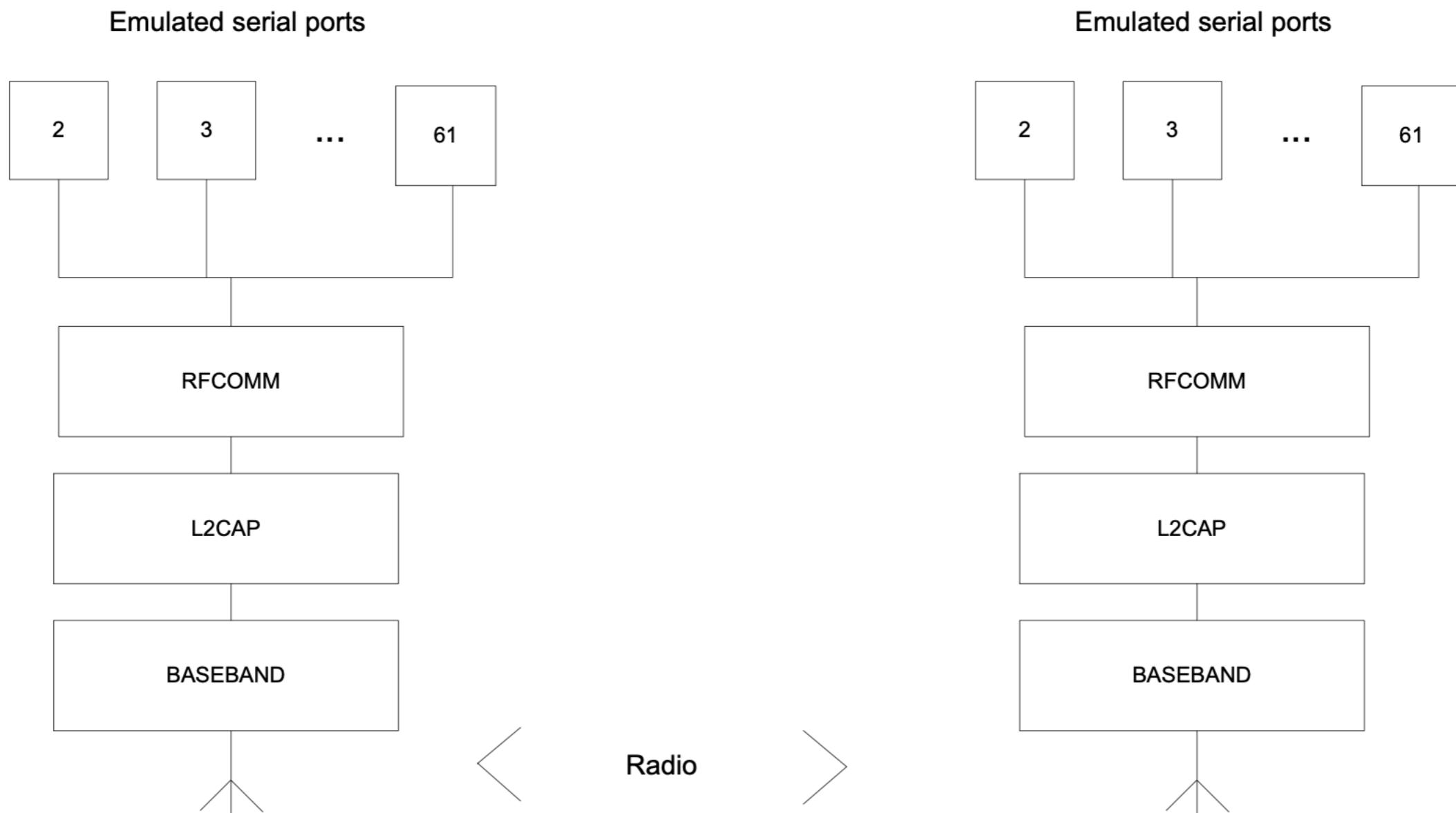
RFCOM

BLUETOOTH® DOC	Date / Year-Month-Day 2012-11-06	Approved Adopted	Revision V12	Document No RFCOMM_SPEC
Prepared By BARB	E-mail Address Barb-main@bluetooth.org			N.B.

RFCOMM WITH TS 07.10

Serial Port Emulation

RFCOM



L2CAP

- Logical Link Control and Adaptation Protocol
- Multiplex multiple logical connections between two devices

SM

- Streaming Mode
 - Simple mode with no retransmission or flow control
 - Unreliable L2CAP channel

BLE Example

<https://www.adafruit.com/product/4078>



**nRF52840 Bluetooth
Low Energy Module
with USB - MDBT50Q-
1MV2**

PRODUCT ID: 4078

BLE Example

<https://www.adafruit.com/product/2269>

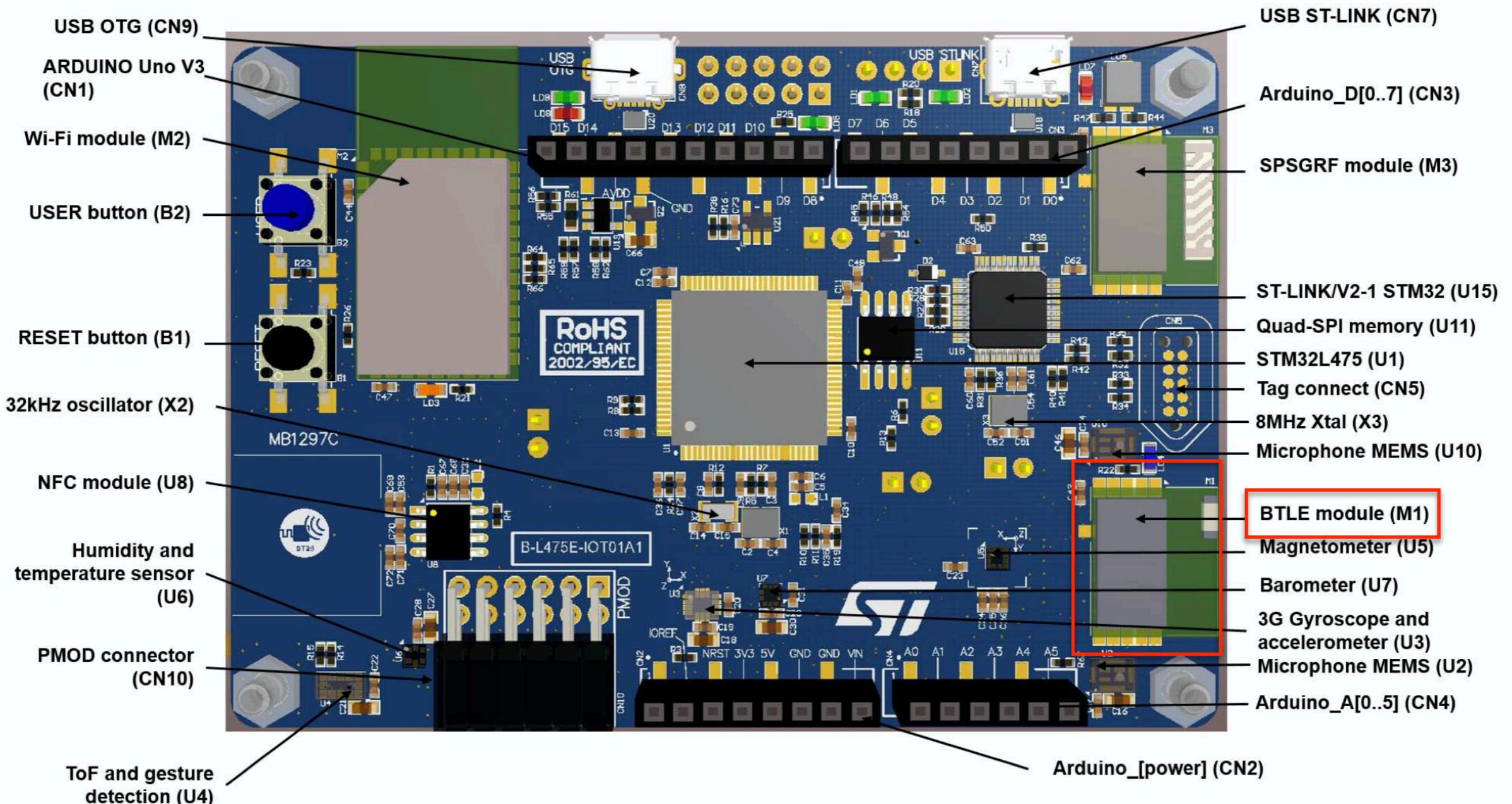


Bluefruit LE Sniffer - Bluetooth Low Energy (BLE 4.0) - nRF51822 - Firmware Version 2

PRODUCT ID: 2269

Interested in learning how Bluetooth Low Energy works down to the packet level? Debugging your own BLE hardware, and trying to spot where something is going wrong? Or maybe you're writing a custom application for your phone or tablet that needs to talk to existing BLE hardware, but you...

Bluetooth Example Discovery Kit



Data Sheet

Figure 13. SPBTLE-RF module



<https://www.st.com/en/wireless-transceivers-mcus-and-modules/spbtle-rf.html>

SPBTLE-RF NRND Not recommended for new designs!

Very low power module for Bluetooth Smart v4.1



SPBTLE-RF

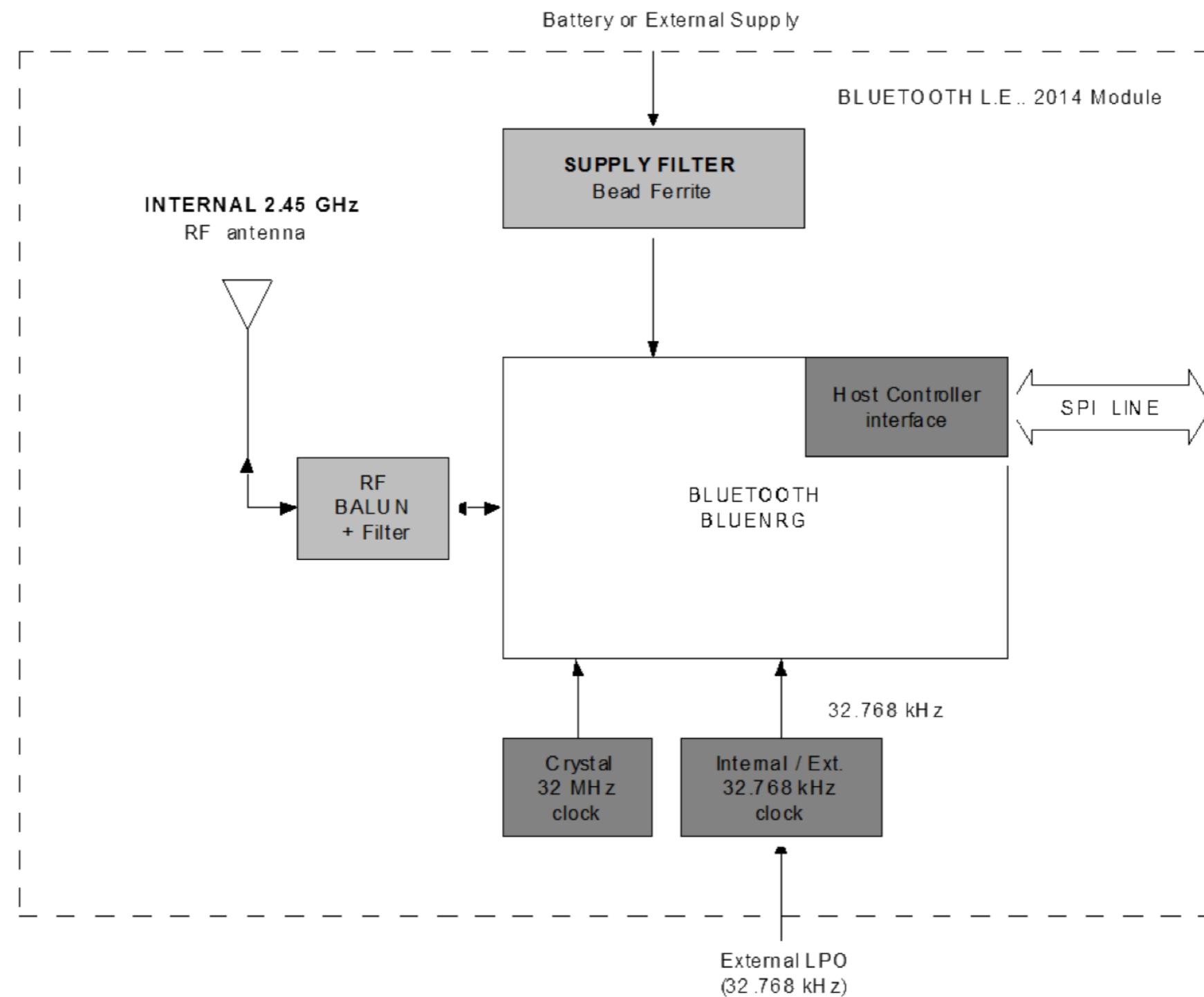
Very low power network processor module for Bluetooth® low energy v4.1

Datasheet - production data

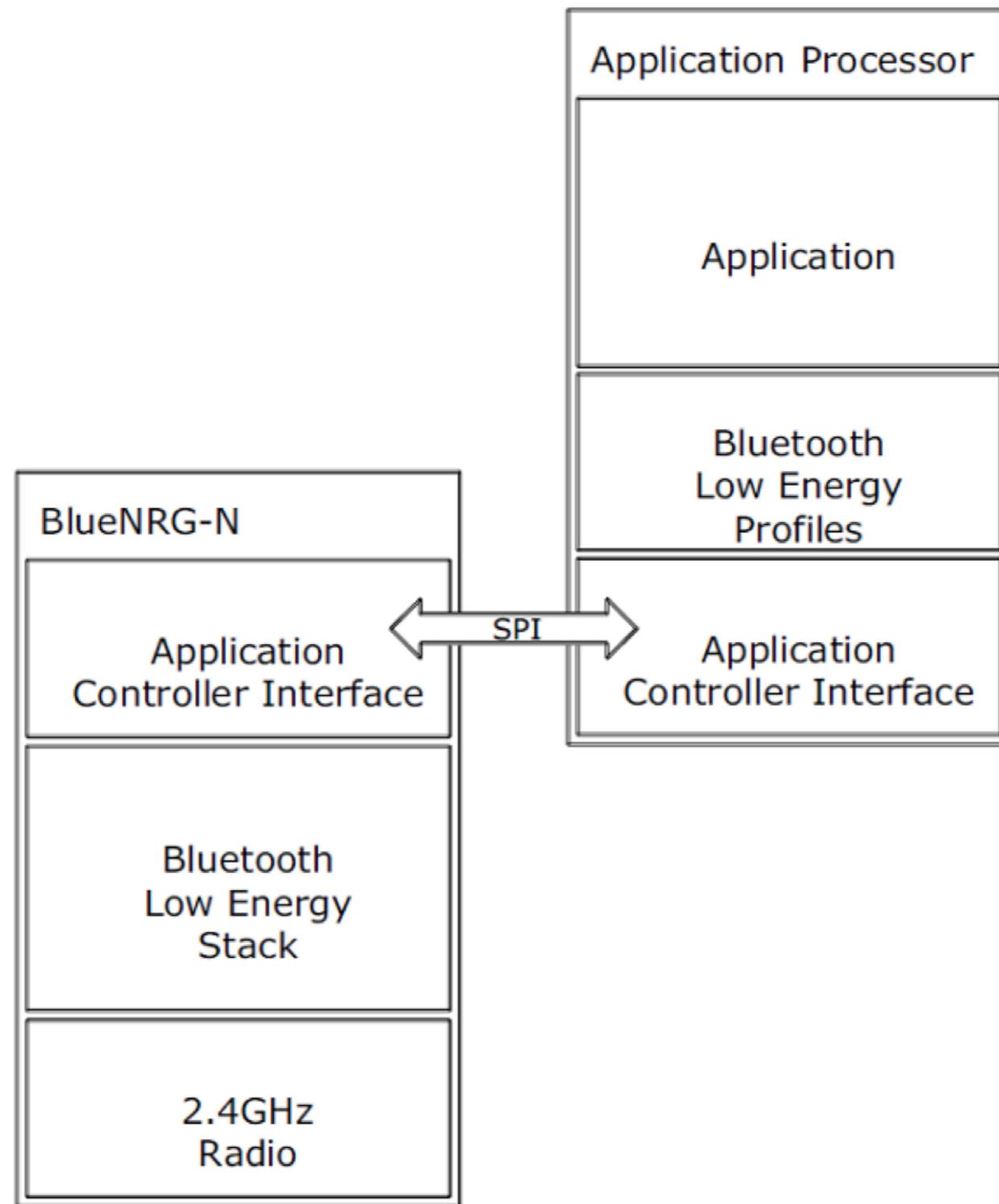
Features

- Bluetooth v4.1 compliant
 - Supports master and slave modes
 - Multiple roles supported simultaneously
- Embedded Bluetooth low energy protocol stack
 - GAP, GATT, SM, L2CAP, LL, RFPHY
- Bluetooth low energy profiles provided separately
- Bluetooth radio performance:
 - Embedded ST BlueNRG-MS
 - Tx power: + 4 dBm
 - Rx sensitivity: - 88 dBm
 - Provides up to 92 dB link budget with excellent link reliability
- Host interface
 - SPI, IRQ, and RESET
 - On-field stack upgrading available via SPI
- AES security co-processor
- Certification
 - CE qualified
 - FCC, IC modular approval certified
 - TCFI EC

Block Diagram - View 1

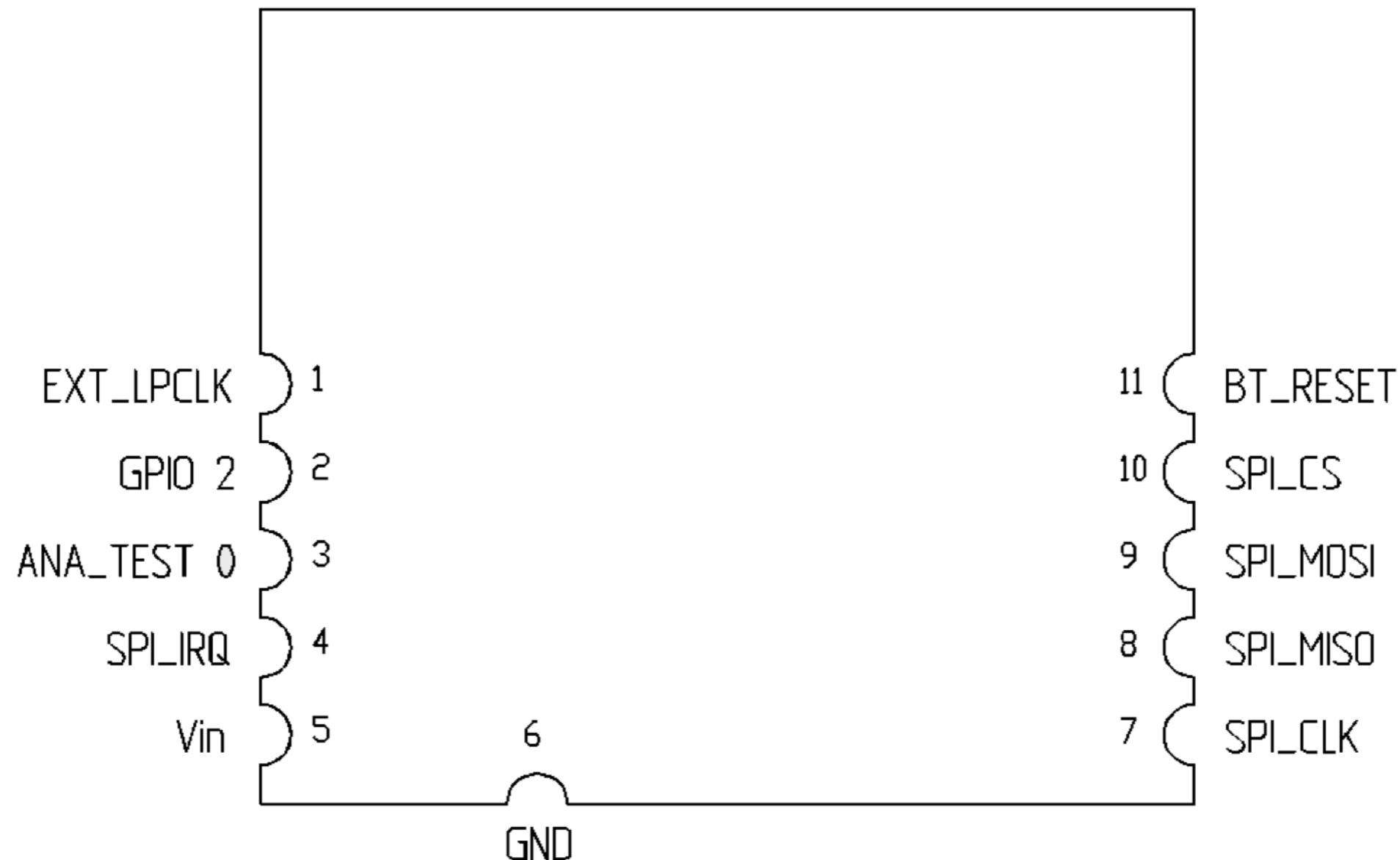


Block Diagram - View 2



Pin Connection

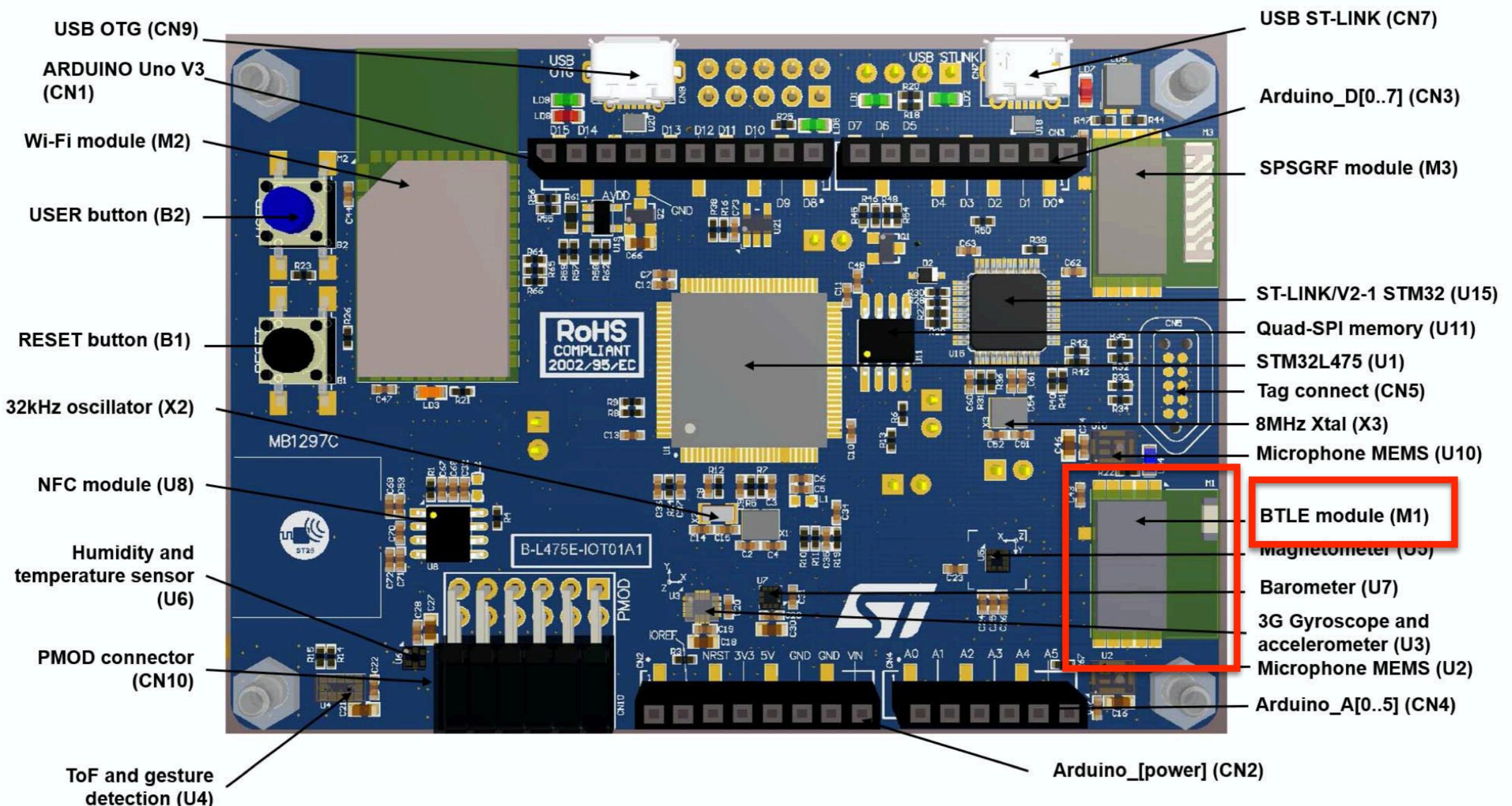
TOP VIEW



User Manual

STM32L Discovery Kit IoT Node

Use of BTLE



SPBTLE-RF Module

Figure 13. SPBTLE-RF module



User Manual

7.11.1 Bluetooth (V4.1 compliant) SPBTLE-RF module

The ST SPBTLE-RF module (M1) is implemented on top side of the STM32L4 Discovery kit for IoT node board.

The SPBTLE-RF is an easy to use Bluetooth smart master/slave network processor module, compliant with Bluetooth V4.1. The SPBTLE-RF B-Smart module supports multiple roles simultaneously, and it can act at the same time as Bluetooth Smart sensor and hub device.

The entire Bluetooth Smart stack and protocol are embedded into the SPBTLE-RF B-Smart module. The external host application processor, where the application resides, is connected to the SPBTLE-RF B-Smart module through a standard SPI interface (SPI3 of STM32L475VGT6).

SPBTLE-RF Features

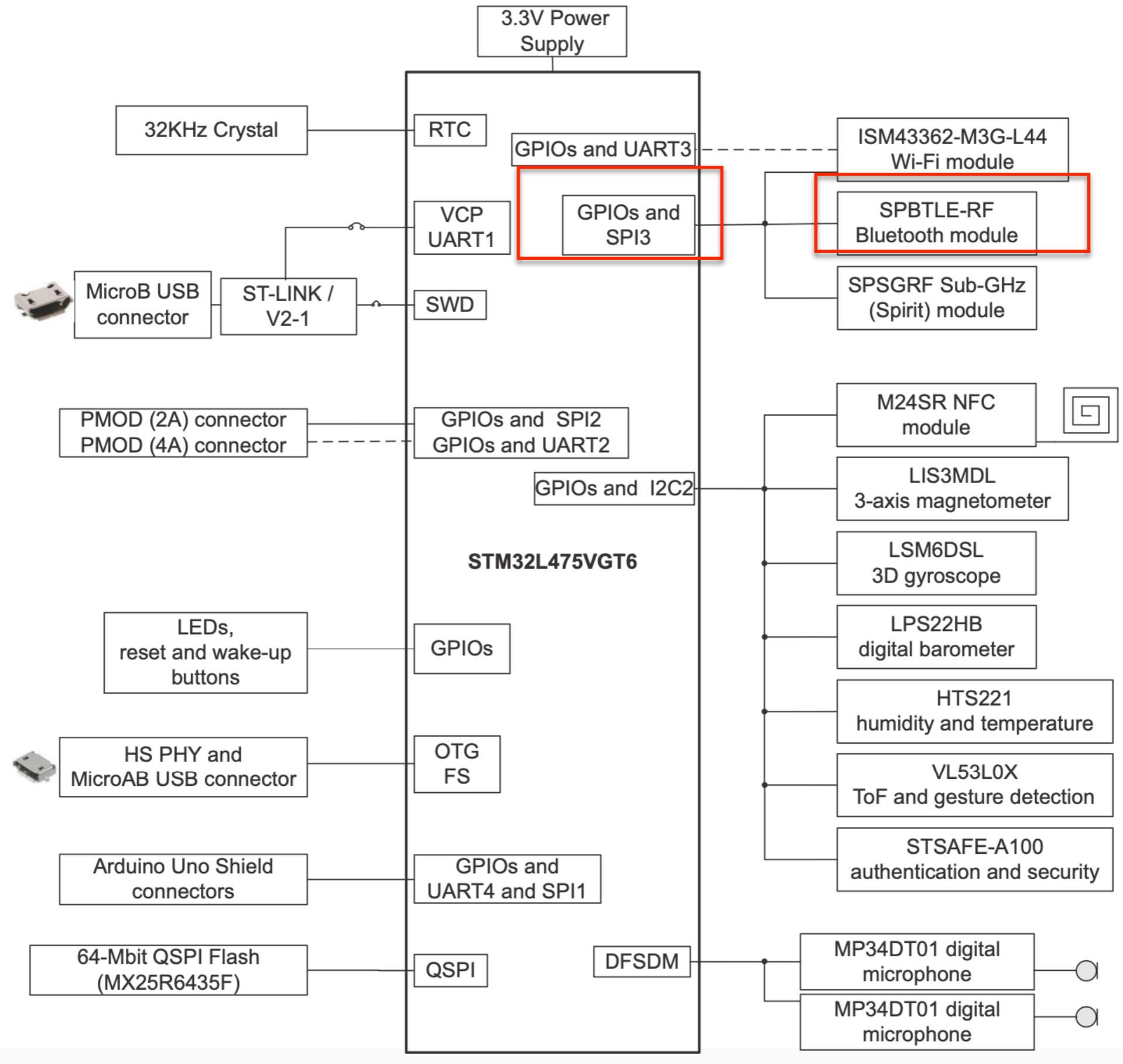
The main features of the ST SPBTLE-RF module are listed below.

- Bluetooth V4.1 compliant (supports master and slave modes, multiple roles supported simultaneously)
- Embedded Bluetooth low-energy protocol stack (GAP, GATT, SM, L2CAP, LL, RFPHY)
- Bluetooth low-energy profiles provided separately
- Bluetooth radio performance:
- Embedded ST BlueNRG-MS
- Tx power: +4 dBm
- Host interface SPI, IRQ, and RESET On-field stack upgrading available via SPI.
- Certification: CE qualified, FCC, IC modular approval certified, BQE qualified
- On-board chip antenna

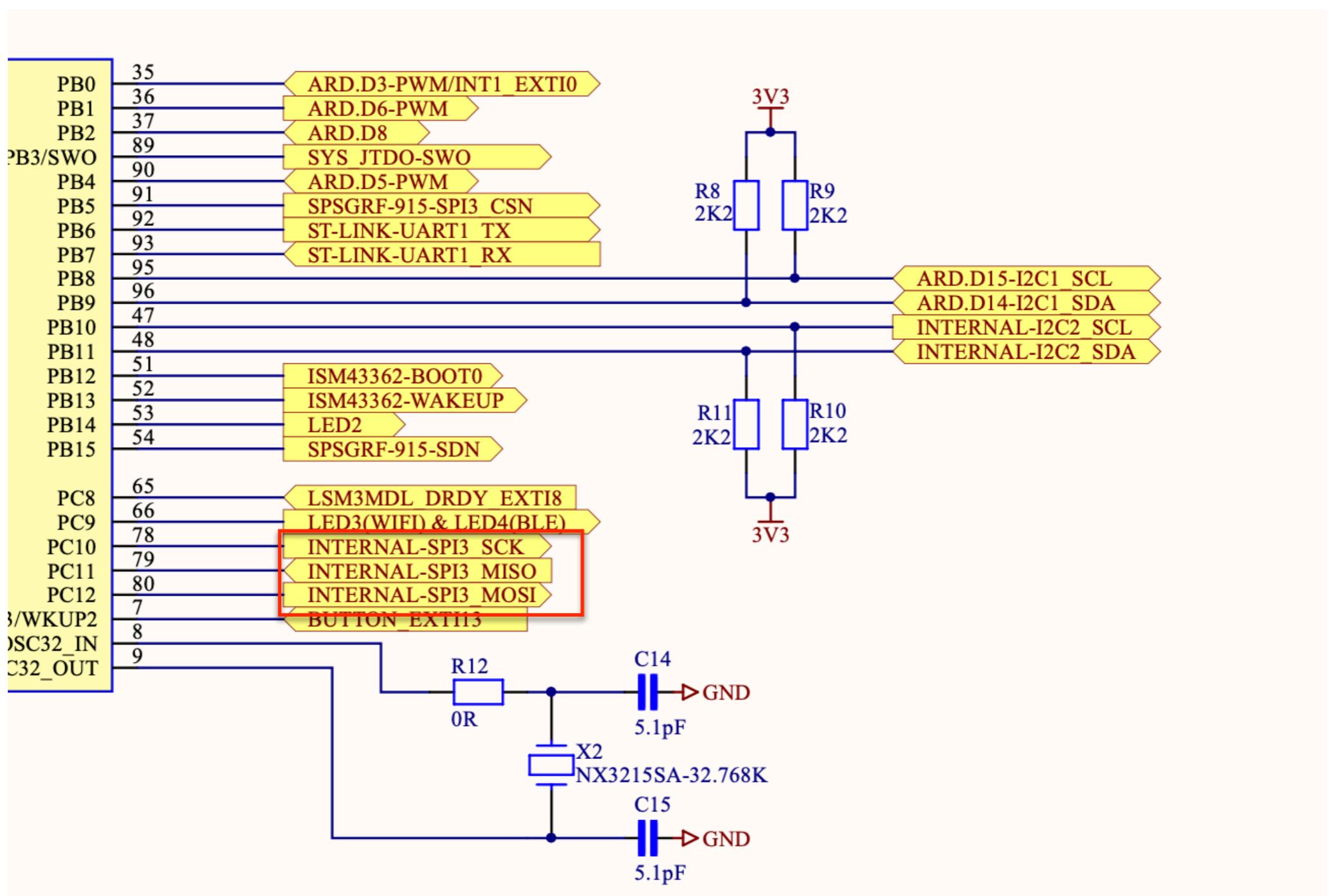
Schematics

STM324L Discovery Kit

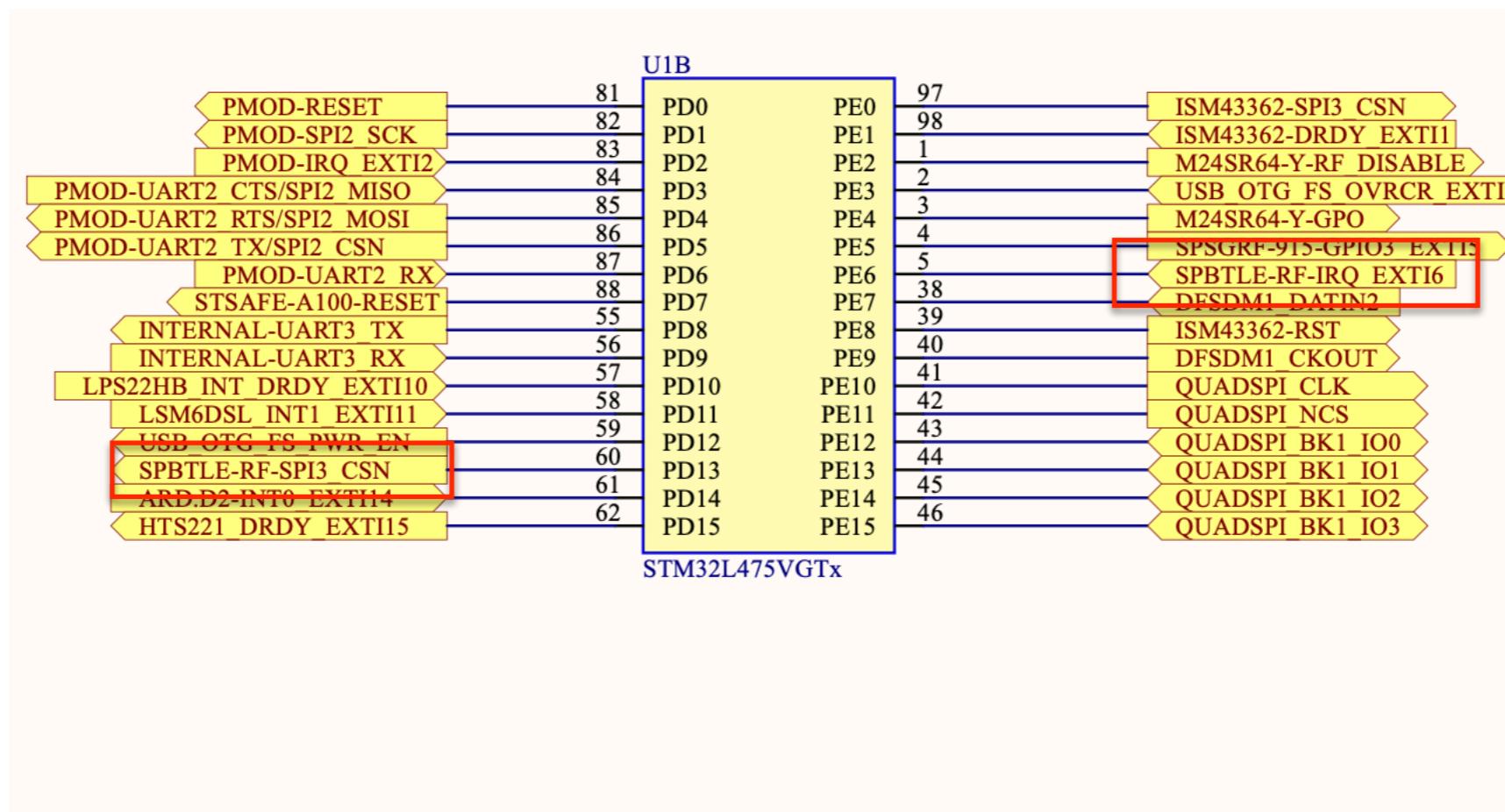
IoT Node



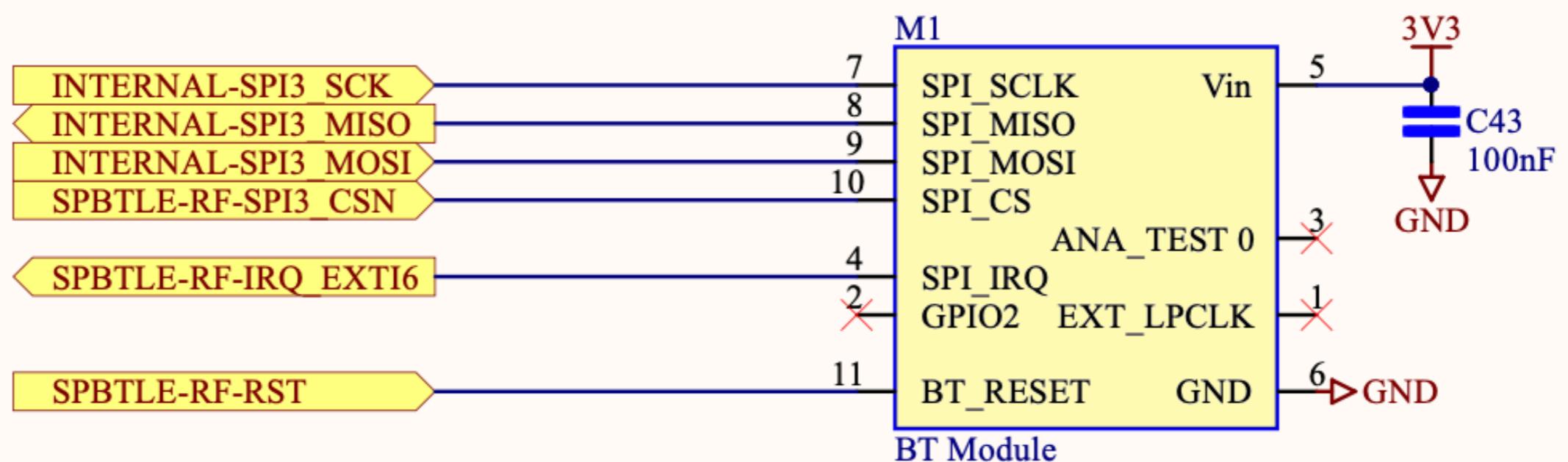
STM32L475



STM32L475



SPBT-RF



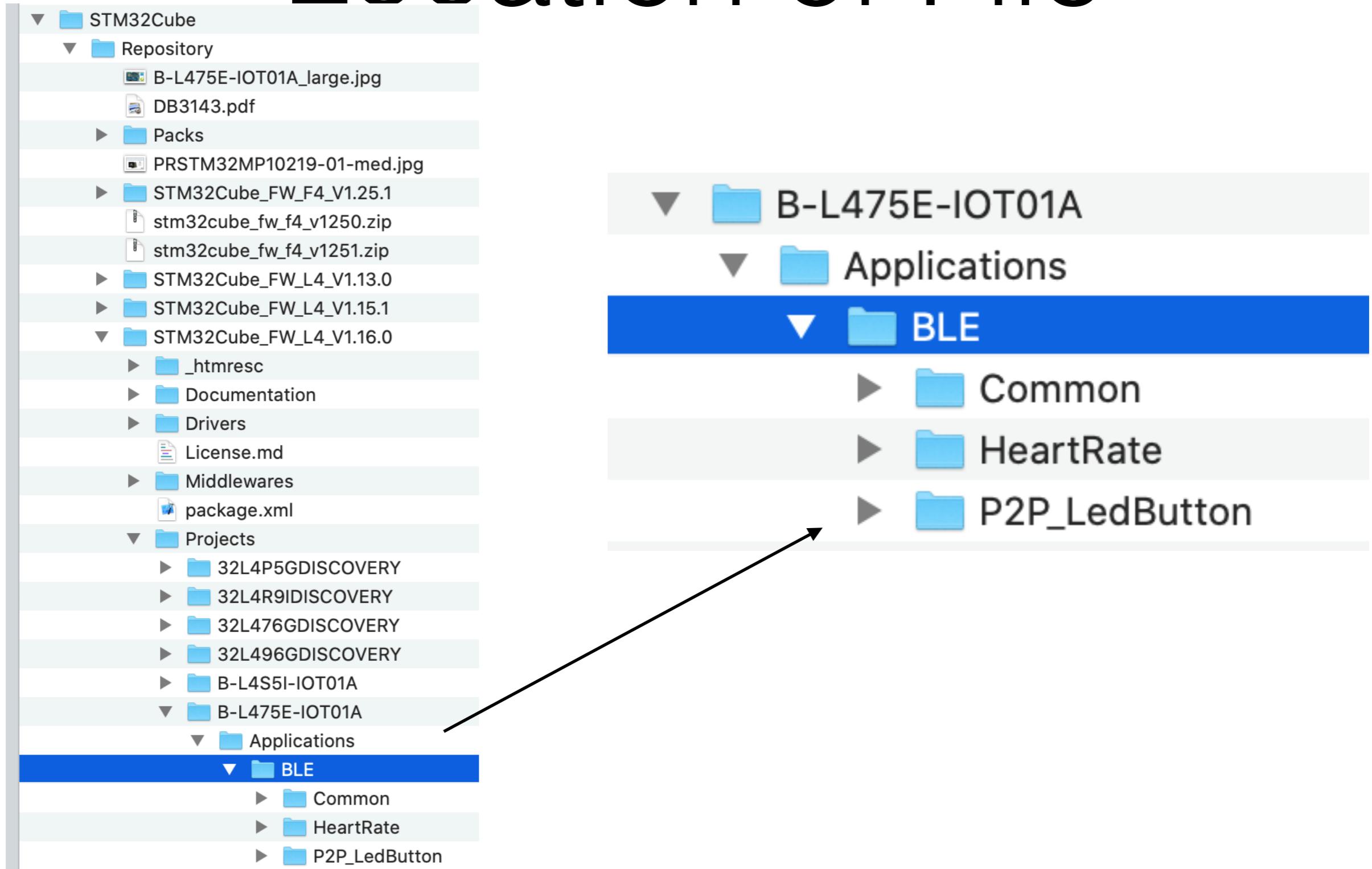
BLE Hands-On Project

BLE Hands-On Project

Overview

- The goal of this project is to give you hands-on experience with adding BLE to your device
 - Use the Middleware included with STMCubeIDE
 - To confirm your experience, you will create a **PDF document** that you will submit for grading
 - The PDF document will capture the major steps you perform to complete this project
 - See example PDF posted with assignment for example PDF format

Location of File



P2P_LedButton README

This example aims at demonstrating point-to-point communications using the BLE component.

Two STM32 B-L475E-IOT01A Discovery boards are used: one acting as GATT client, the other as GATT server.

The two boards needs to be compiled with different code by changing the #definitions in config.h

```
#define LB_CLIENT 0/1 /*1 = Device is GAP Central & GATT Client */  
#define LB_SERVER 1/0 /*1 = Device is GAP Peripheral & GATT Server */
```

Once the code is downloaded on the two STM32 B-L475E-IOT01A Discovery boards and executed, the modules are initialized. The slave device (GAP Peripheral) starts advertising, the master device (GAP Central) scans and automatically connects to the slave at power up. ST proprietary Led Button service is implemented on the slave device with Led Characteristics & Button Characteristics (GATT Server). Once connected, the Master Device(GATT Client) start to discover the remote services and Characteristics. The above phase takes some seconds, after that period when pressing the User button on one board the service allows toggling the Led on the other board. The User button can be pressed independently on the GATT Client or on the GATT Server.

To summarise:

```
*1* User presses User Button on GATT Server  
*2* Server ----- GATT Notification -----> Client  
*3* LED LD1 Toggles on GATT Client
```

or

```
*1* User presses User Button on GATT Client  
*2* Client ----- GATT Write command -----> Server  
*3* LED LD1 Toggles on GATT Server
```

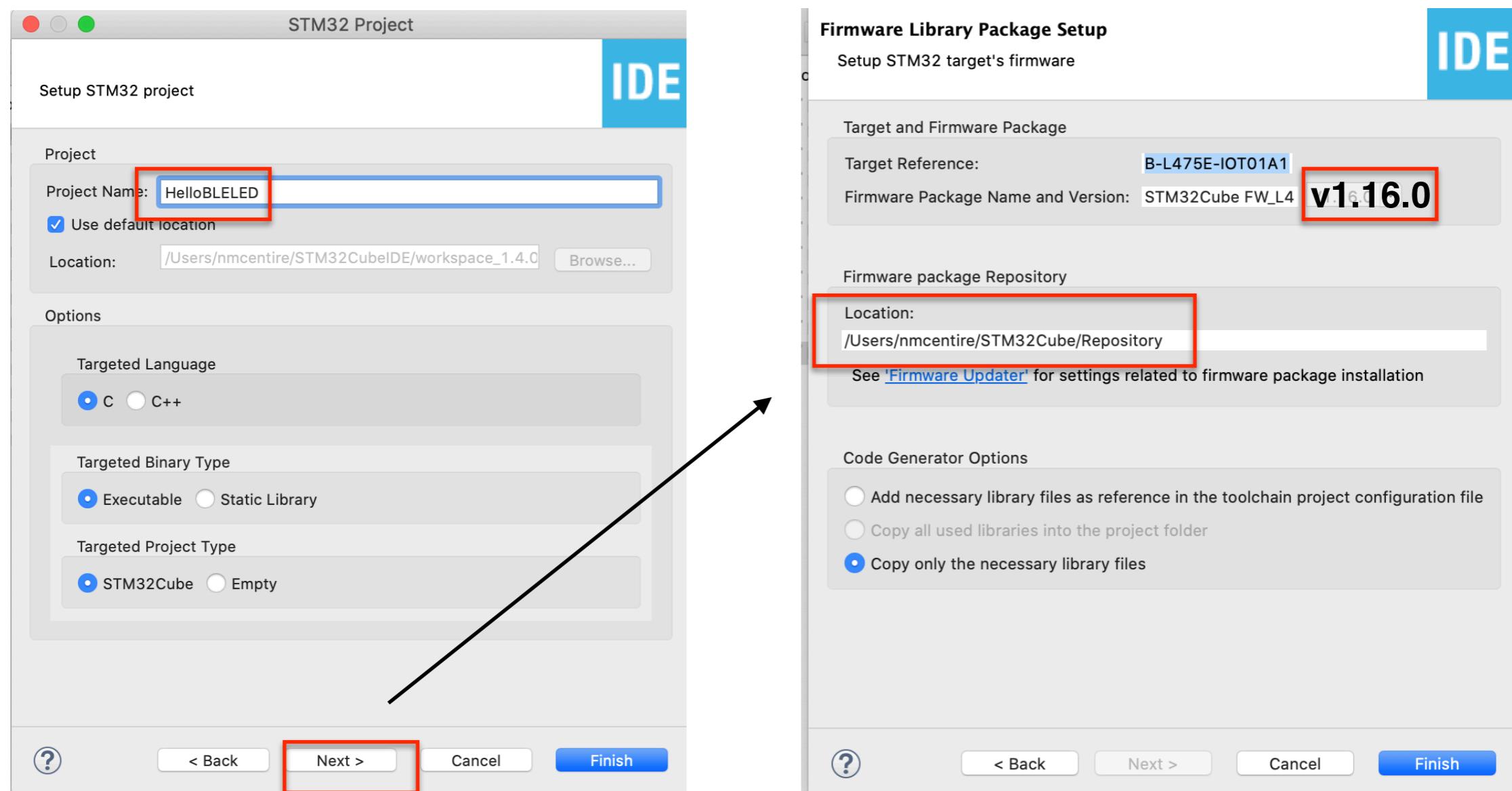
NOTE: We will build GATT Server (Central)

P2P_LedButton README

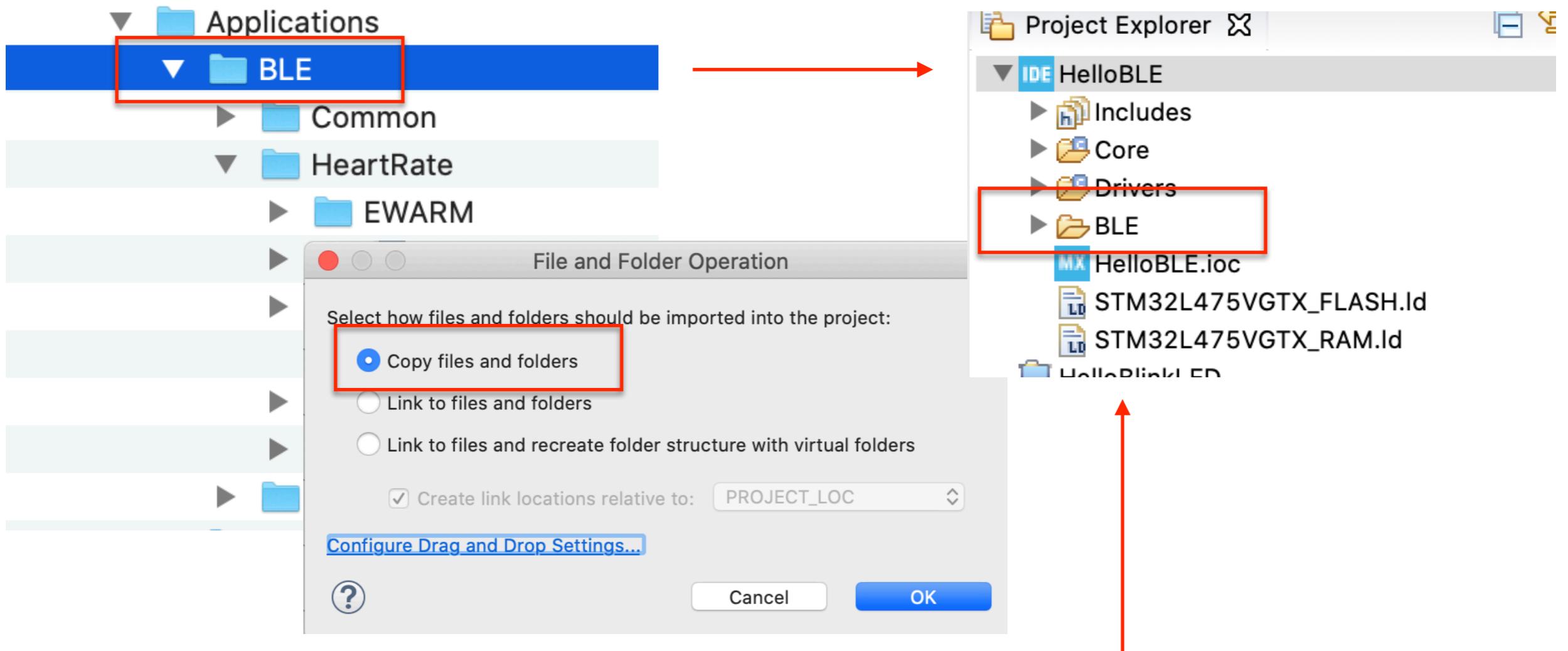
Part 2

- BLE/P2P_LedButton/Src/main.c	Main Program
- BLE/P2P_LedButton/Src/system_stm32l4xx.c	STM32L4xx system clock configuration file
- BLE/P2P_LedButton/Src/stm32l4xx_it.c	STM32 interrupt handlers
- BLE/P2P_LedButton/Src/lb_demo.c	P2P main Led Button application
- BLE/P2P_LedButton/Src/lb_client_app.c	P2P Client Led Button application
- BLE/P2P_LedButton/Src/lb_server_app.c	P2P Server Led Button application
- BLE/P2P_LedButton/Inc/config.h	Application configuration file
- BLE/P2P_LedButton/Inc/stm32l4xx_hal_conf.h	HAL configuration file
- BLE/P2P_LedButton/Inc/stm32l4xx_it.h	STM32 interrupt handlers header file
- BLE/P2P_LedButton/Inc/lb_demo.h	Exported files and function of lb_demo.c
- BLE/P2P_LedButton/Inc/lb_client_app.h	Exported files and function of lb_client_app.c
- BLE/P2P_LedButton/Inc/lb_server_app.h	Exported files and function of lb_server_app.c
- BLE/Common/	These files are Common also to other applic/examples then P2P_LedButton (e.g. to Heart
- BLE/Common/ble_core/**	BlueNRG-MS Bluetooth Low Energy device driver
- BLE/Common/ble_services/**	GATT services according to BLE spec
- BLE/Common/debug/**	Code useful for debugging (DBG should be activated in config.h)
- BLE/Common/tl/**	HCI layer and SPI protocol
- BLE/Common/hw/**	HW board and device dependencies (SPI pins, timeserver, low power)
- BLE/Common/utilities/**	Scheduler, memory/queue/fifo/list management, otp, etc

Create New Project (And Find Location of Repository)

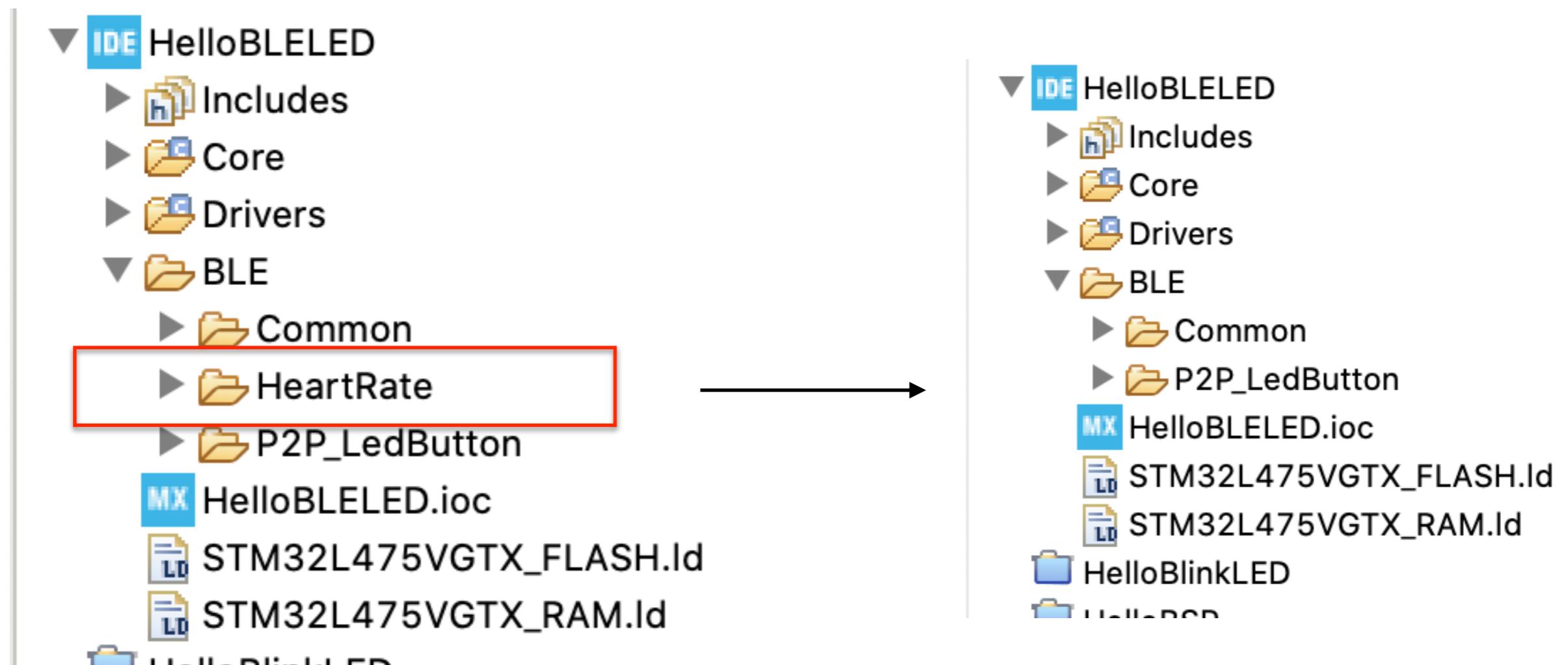


BLE Folder Drag/Drop (COPY FILES)

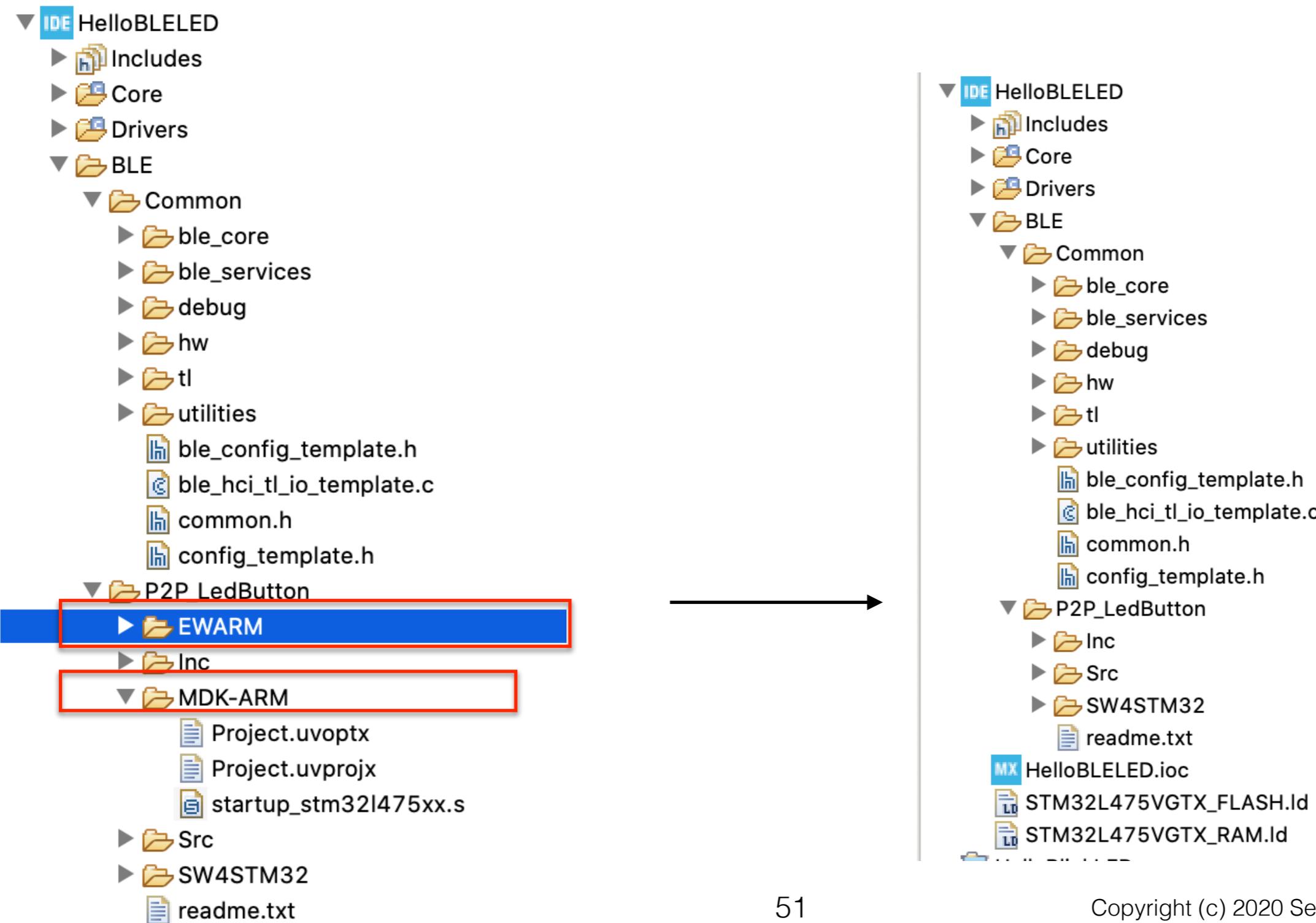


NOTE: Notice BLE Folder at top level with Core and Drivers

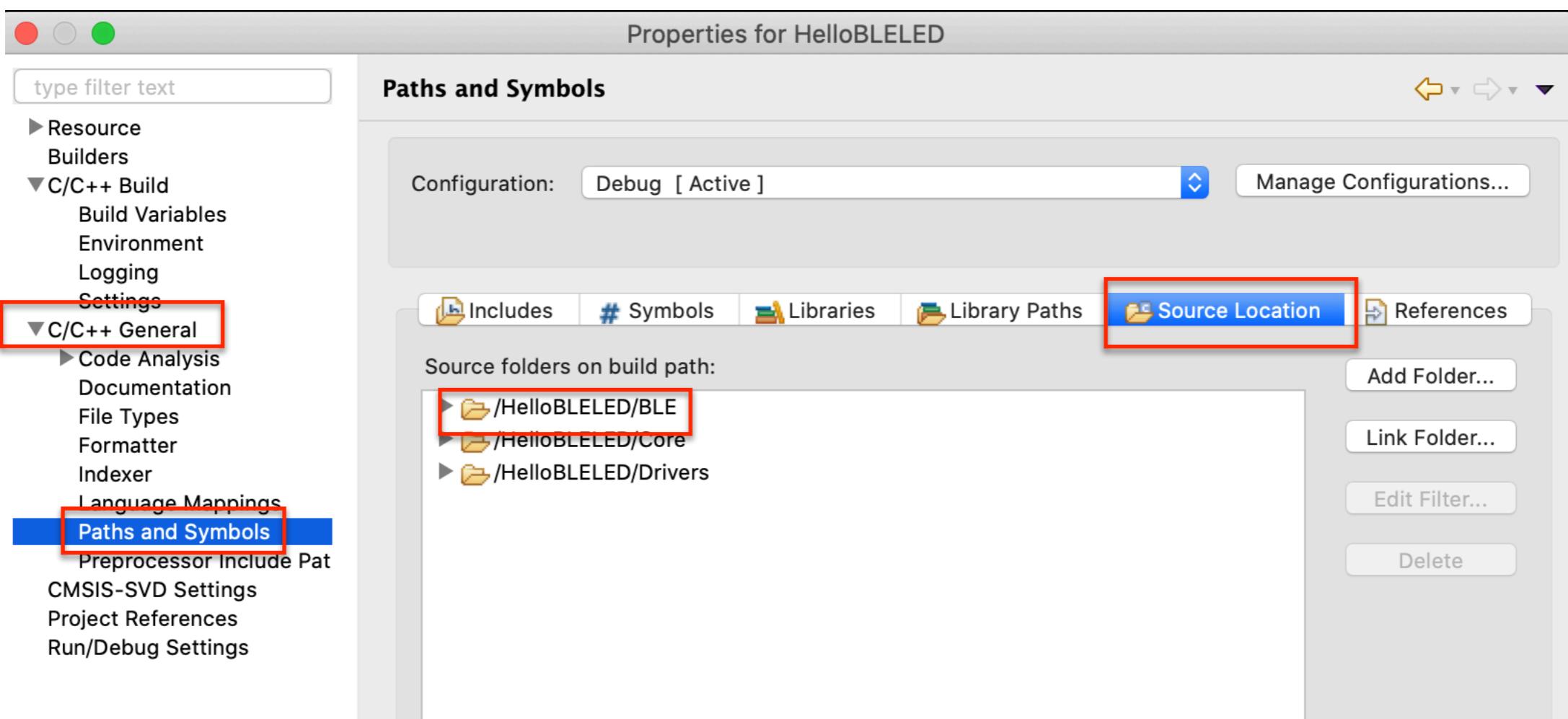
Delete HeartRate Folder



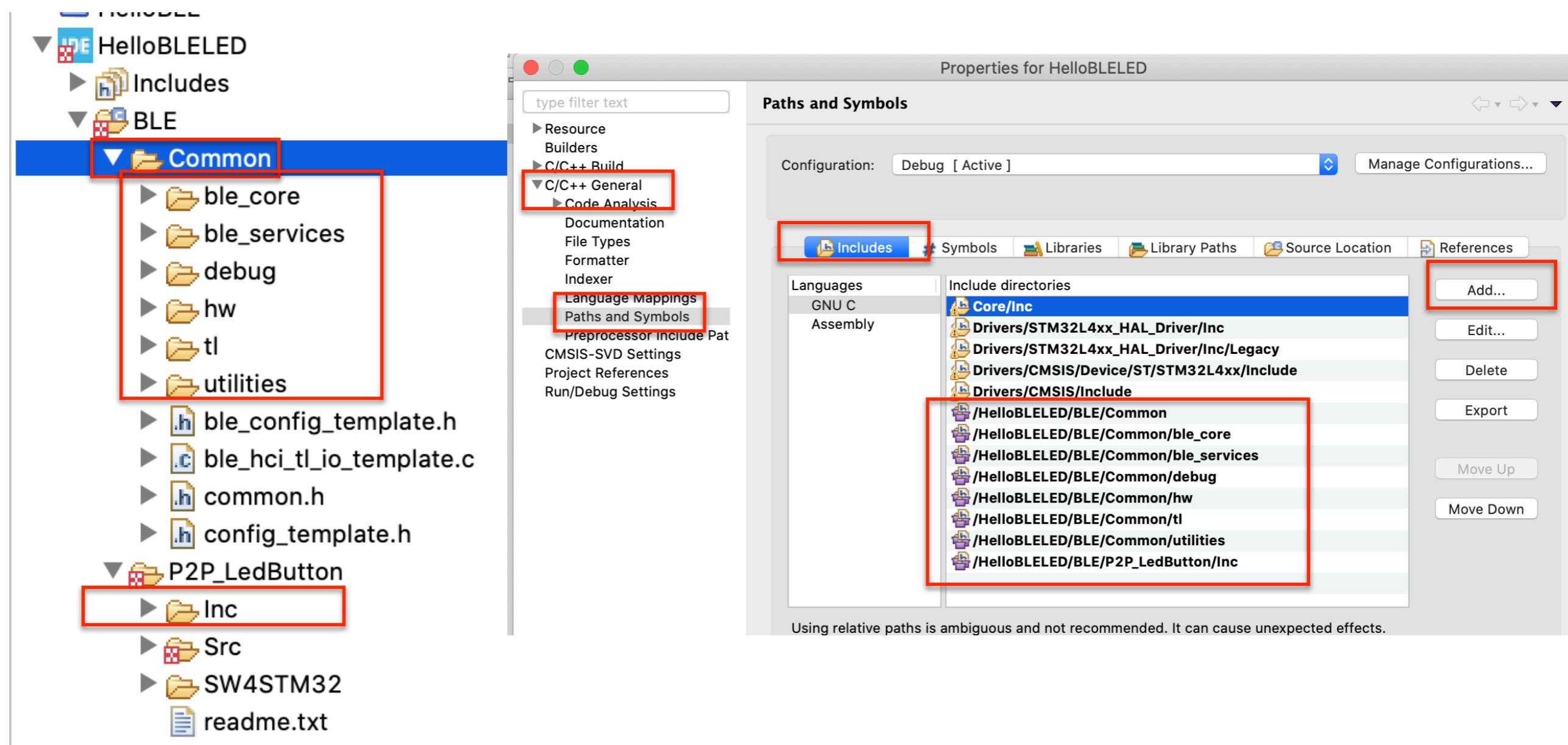
Delete EWARM Folder and MDK-ARM Folder



Add BLE to Source Path



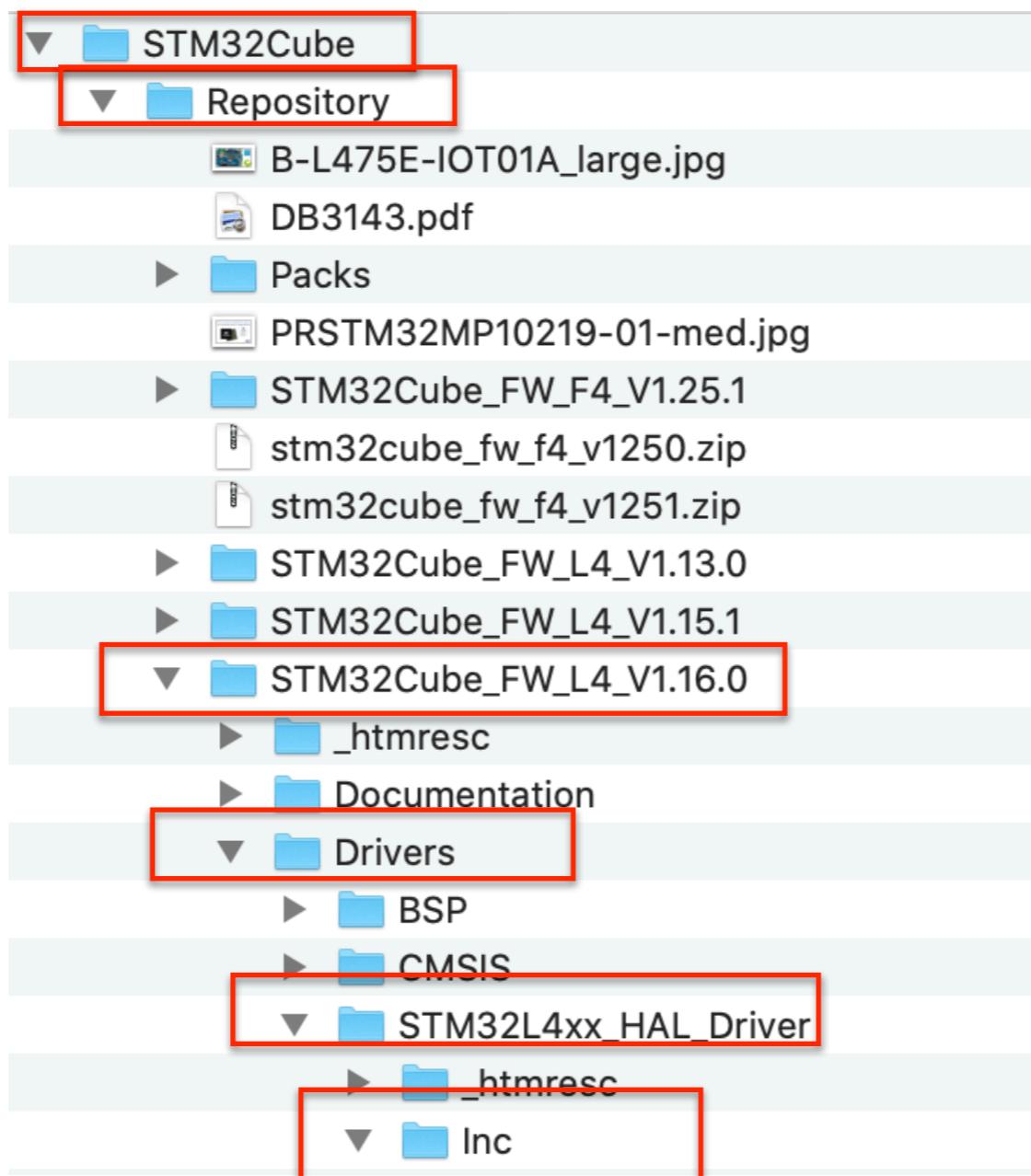
Add Include Paths To Project Properties



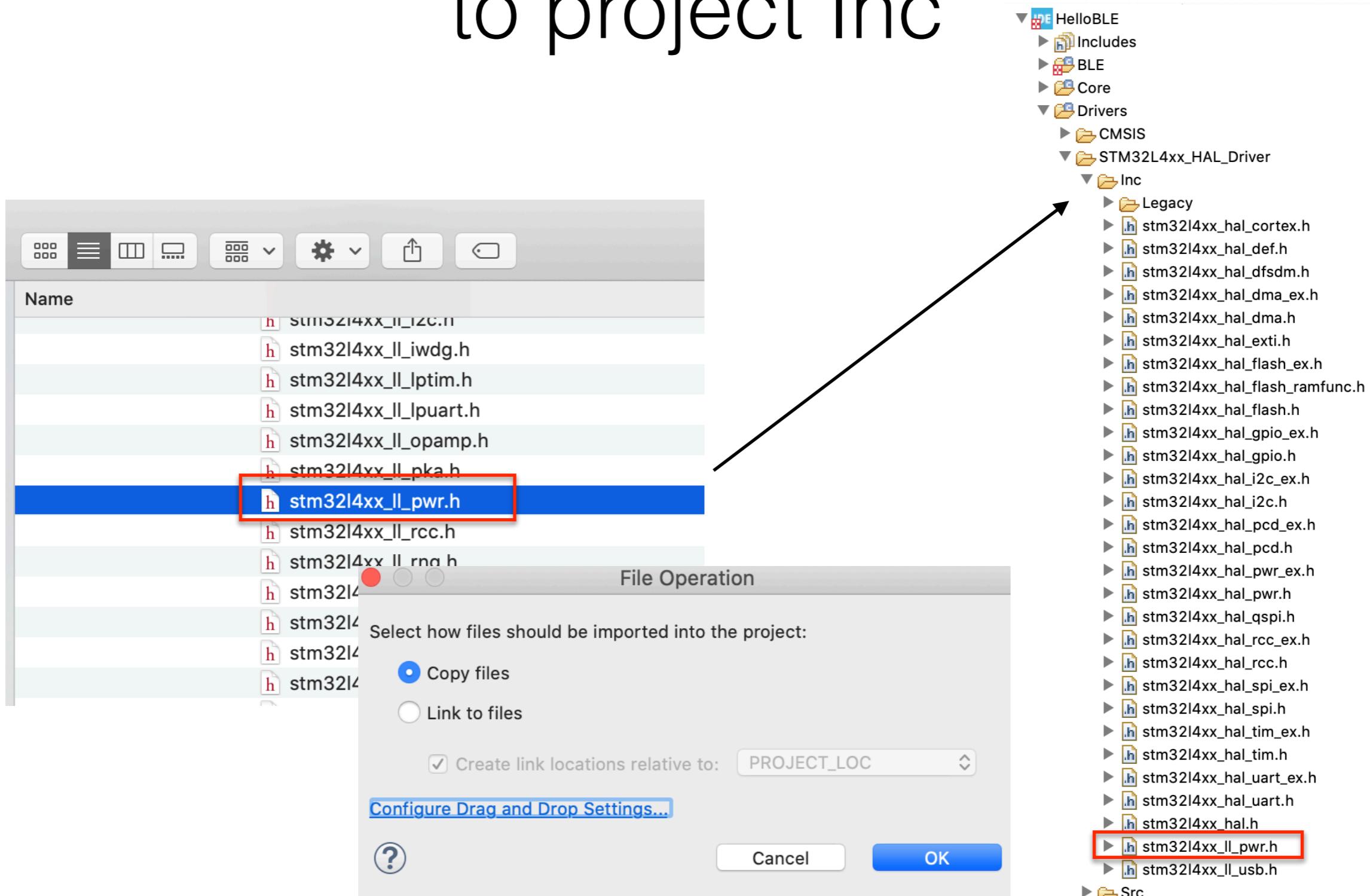
Attempt to Build Missing Header File stm32l4xx_ll_pwr.h

```
arm-none-eabi-gcc "../Core/Src/system_stm32l4xx.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../Core/Inc -I../Di
arm-none-eabi-gcc "../BLE/P2P_LedButton/Src/lb_client_app.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../Core/:
In file included from /Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/BLE/P2P_LedButton/Inc/config.h:28:0,
                  from /Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/BLE/Common/common.h:35,
                  from ../BLE/P2P_LedButton/Src/lb_client_app.c:22:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/BLE/Common/hw.h:30:10: fatal error: stm32l4xx_ll_pwr.h: No such file or directory
 #include "stm32l4xx_ll_pwr.h"
                                         ^
compilation terminated.
make: *** [BLE/P2P_LedButton/Src/subdir.mk:33: BLE/P2P_LedButton/Src/lb_client_app.o] Error 1
make: *** Waiting for unfinished jobs....
"make -j3 all" terminated with exit code 2. Build might be incomplete.
```

Where to find needed header files



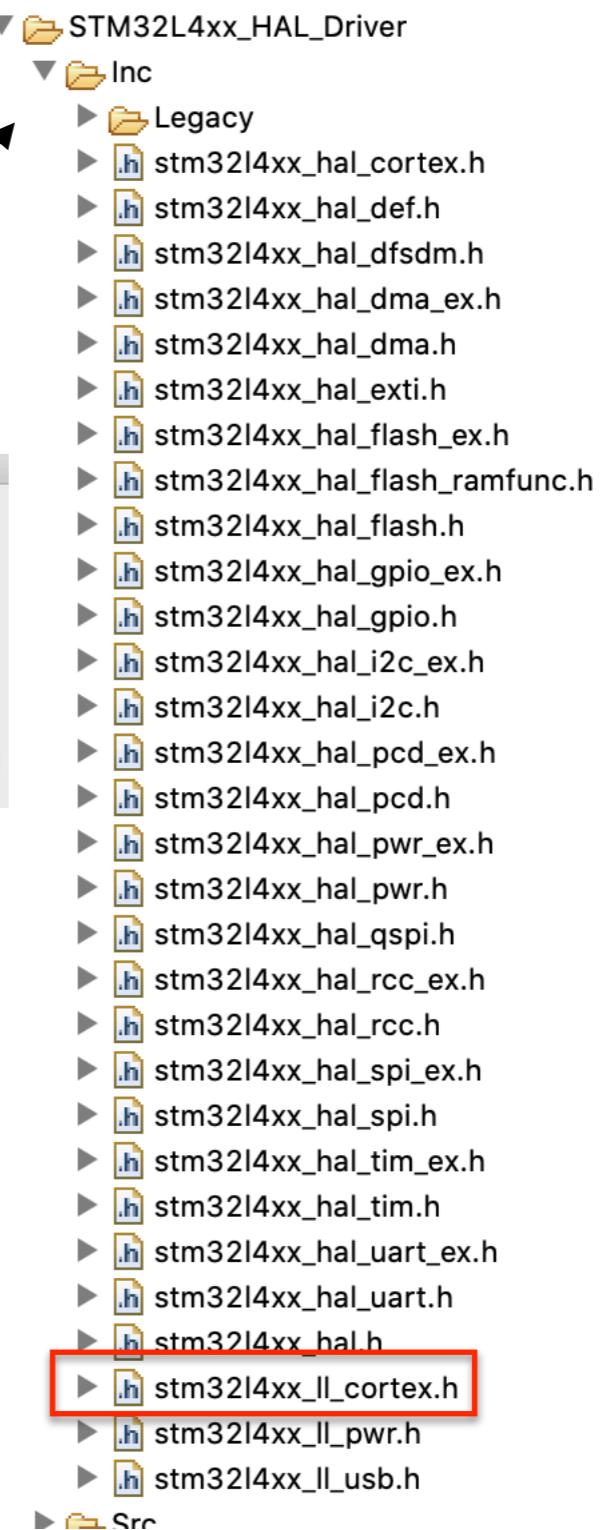
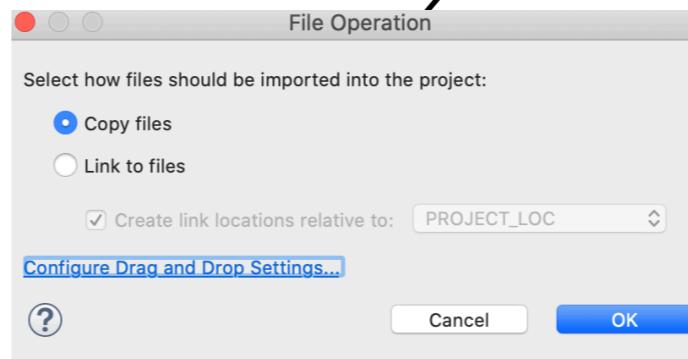
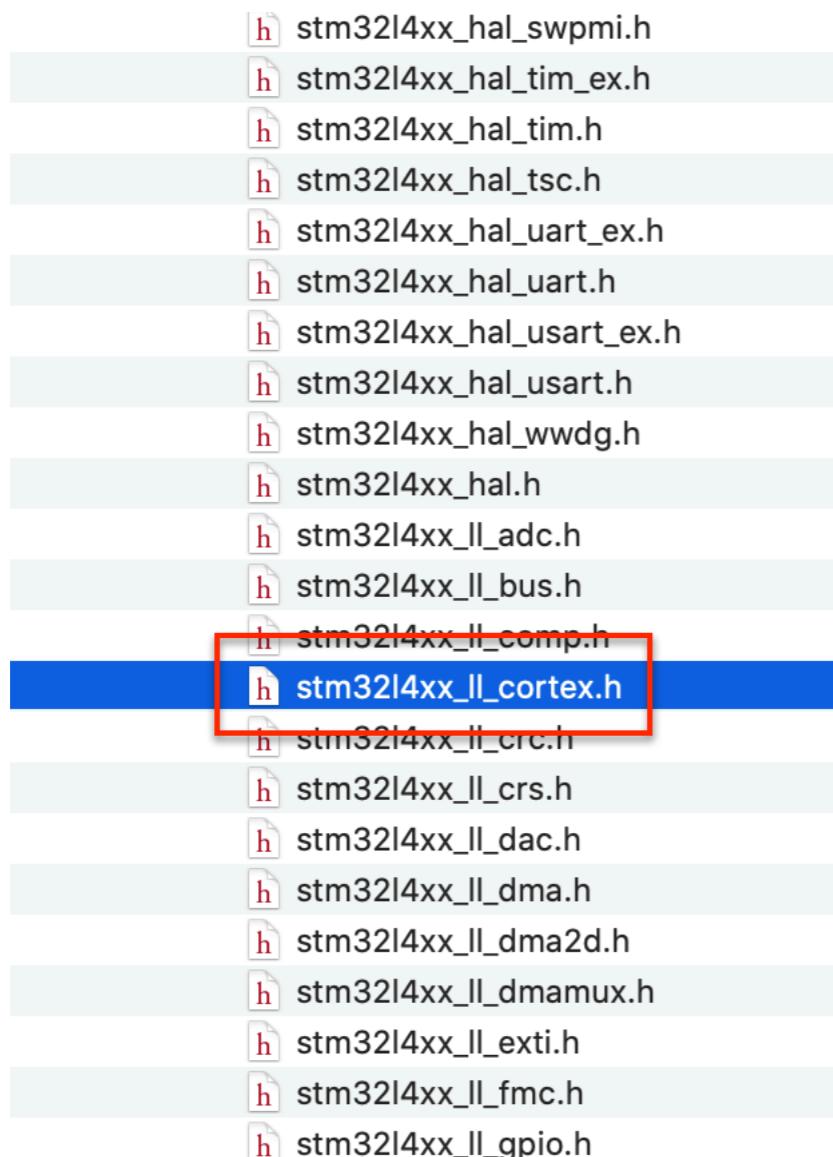
Copy Missing stm32l4xx_ll_pwr.h file to project \Inc



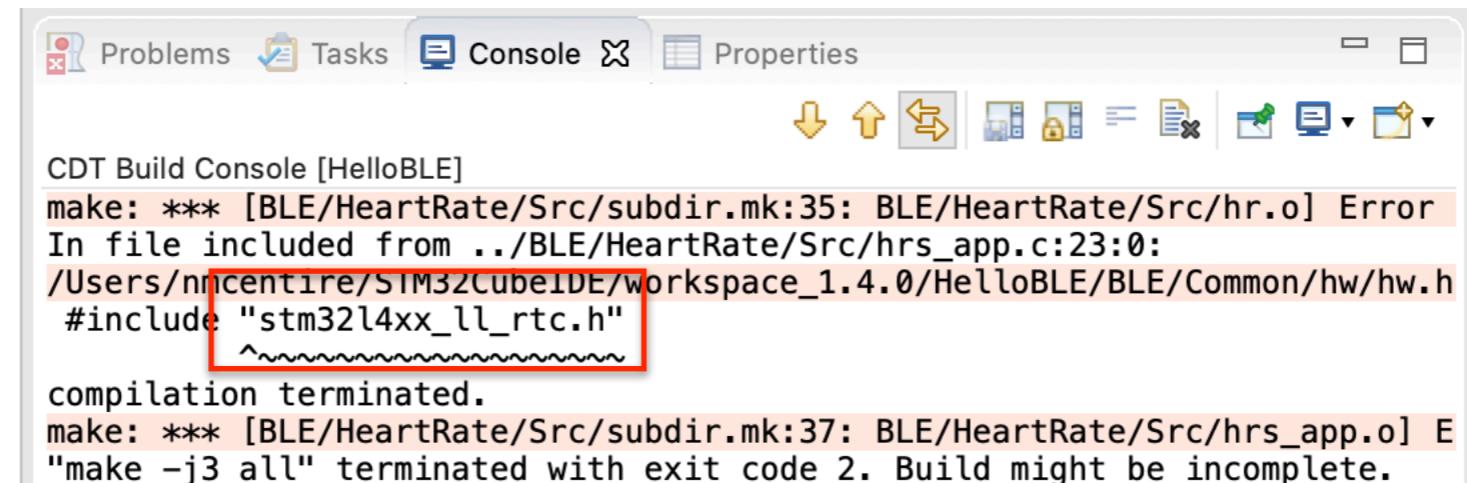
Attempt to Build Missing Header File stm32l4xx_ll_cortex.h

```
CDT Build Console [HelloBLELED]
06:58:38 **** Incremental Build of configuration Debug
make -j3 all
arm-none-eabi-gcc ".../BLE/P2P_LedButton/Src/lb_client_a
arm-none-eabi-gcc ".../BLE/P2P_LedButton/Src/lb_demo.c"
arm-none-eabi-gcc ".../BLE/P2P_LedButton/Src/lb_server_a
In file included from /Users/nmcentire/STM32CubeIDE/wor
              from /Users/nmcentire/STM32CubeIDE/wor
              from ../BLE/P2P_LedButton/Src/lb_clie
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLEL
#include "stm32l4xx_ll_cortex.h"
^~~~~~
compilation terminated.
In file included from /Users/nmcentire/STM32CubeIDE/wor
              from /Users/nmcentire/STM32CubeIDE/wor
```

Copy Missing stm32l4xx_ll_cortex.h file to project \Inc



Attempt to build

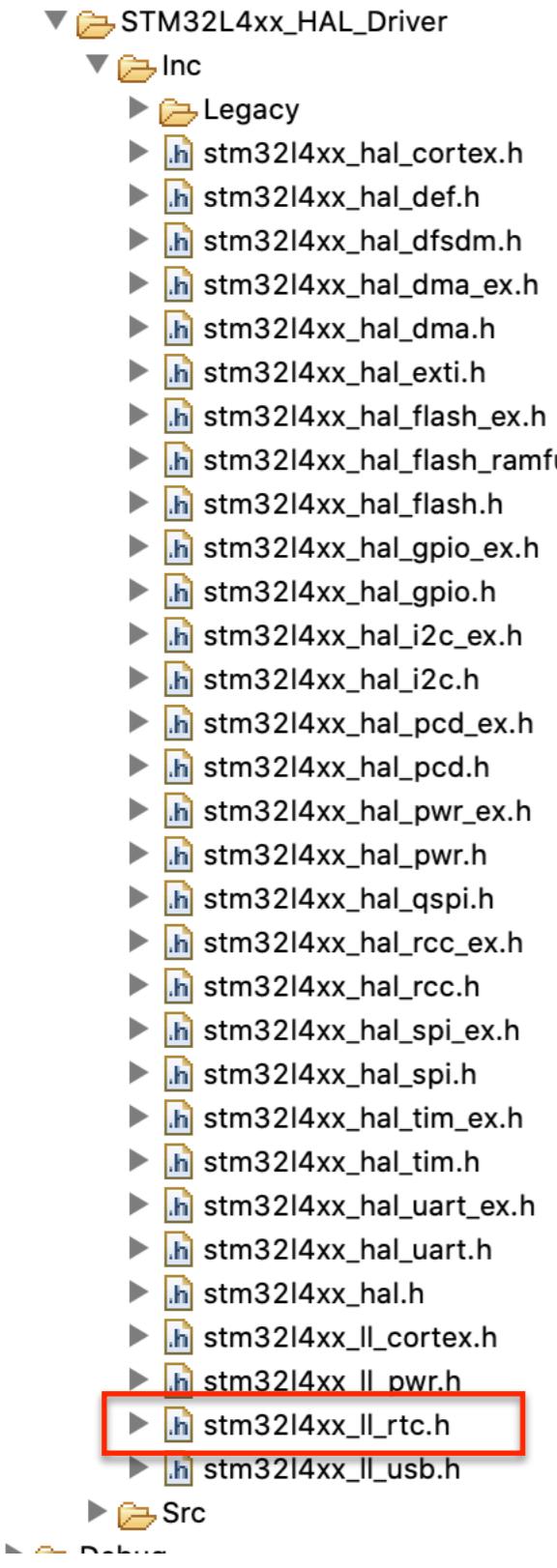


The screenshot shows the Eclipse CDT Build Console window titled "CDT Build Console [HelloBLE]". The console output is as follows:

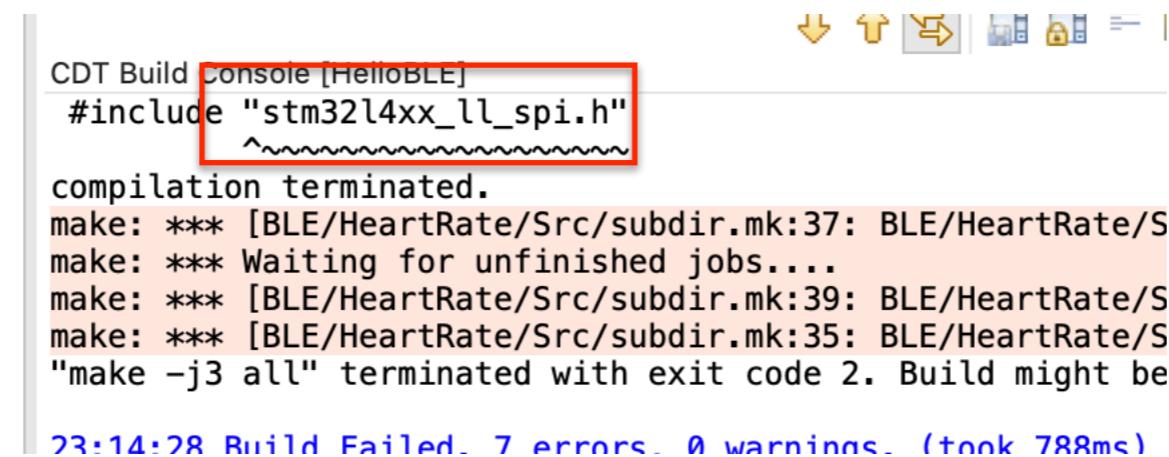
```
make: *** [BLE/HeartRate/Src/subdir.mk:35: BLE/HeartRate/Src/hr.o] Error
In file included from ../BLE/HeartRate/Src/hrs_app.c:23:0:
/Users/nncentire/SIM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h
#include "stm32l4xx_ll_rtc.h"
^~~~~~
compilation terminated.
make: *** [BLE/HeartRate/Src/subdir.mk:37: BLE/HeartRate/Src/hrs_app.o] E
"make -j3 all" terminated with exit code 2. Build might be incomplete.
```

A red box highlights the line "#include "stm32l4xx_ll_rtc.h"" in the error message, specifically pointing to the opening brace of the include statement.

Copy File



Attempt to build

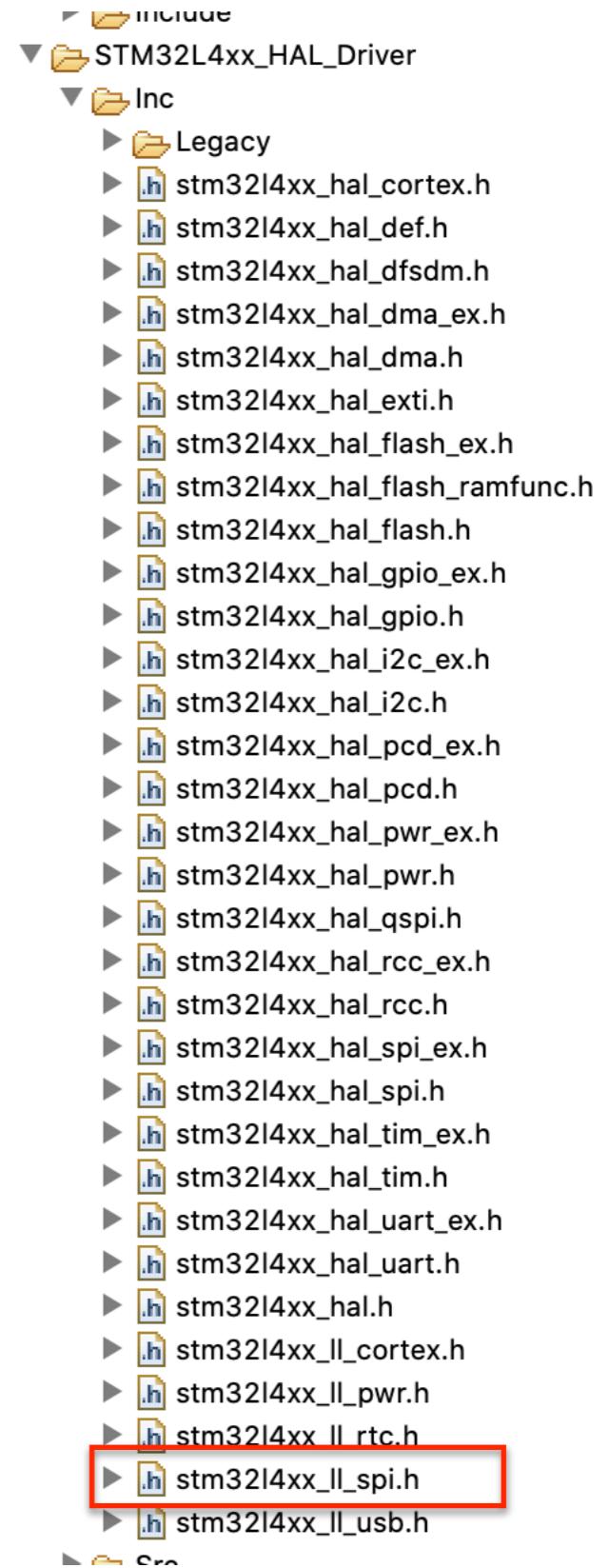
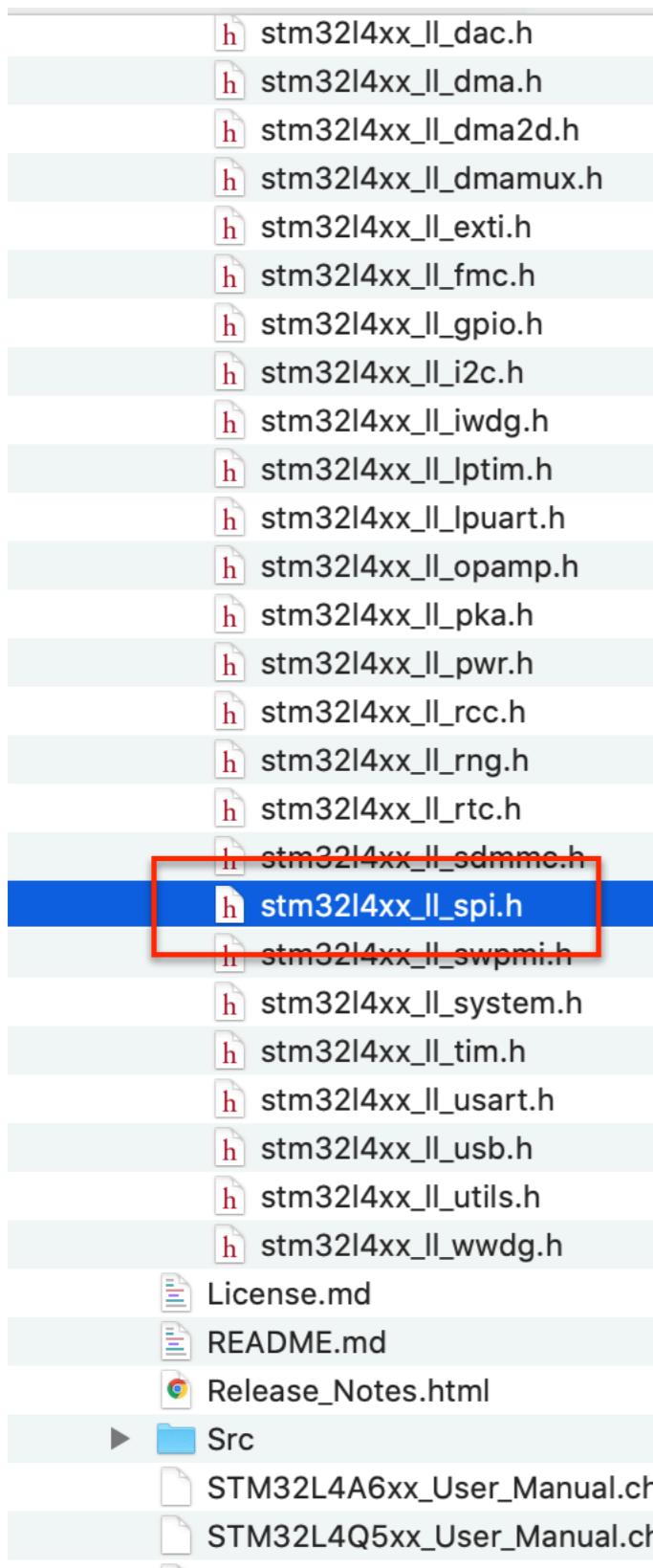


The screenshot shows a CDT Build Console window titled "Console [HelloBLE]". The console output is as follows:

```
CDT Build Console [HelloBLE]
#include "stm32l4xx_ll_spi.h"
compilation terminated.
make: *** [BLE/HeartRate/Src/subdir.mk:37: BLE/HeartRate/S
make: *** Waiting for unfinished jobs....
make: *** [BLE/HeartRate/Src/subdir.mk:39: BLE/HeartRate/S
make: *** [BLE/HeartRate/Src/subdir.mk:35: BLE/HeartRate/S
"make -j3 all" terminated with exit code 2. Build might be
23:14:28 Build Failed. 7 errors, 0 warnings. (took 788ms)
```

The line `#include "stm32l4xx_ll_spi.h"` is highlighted with a red box and a wavy underline, indicating a syntax error.

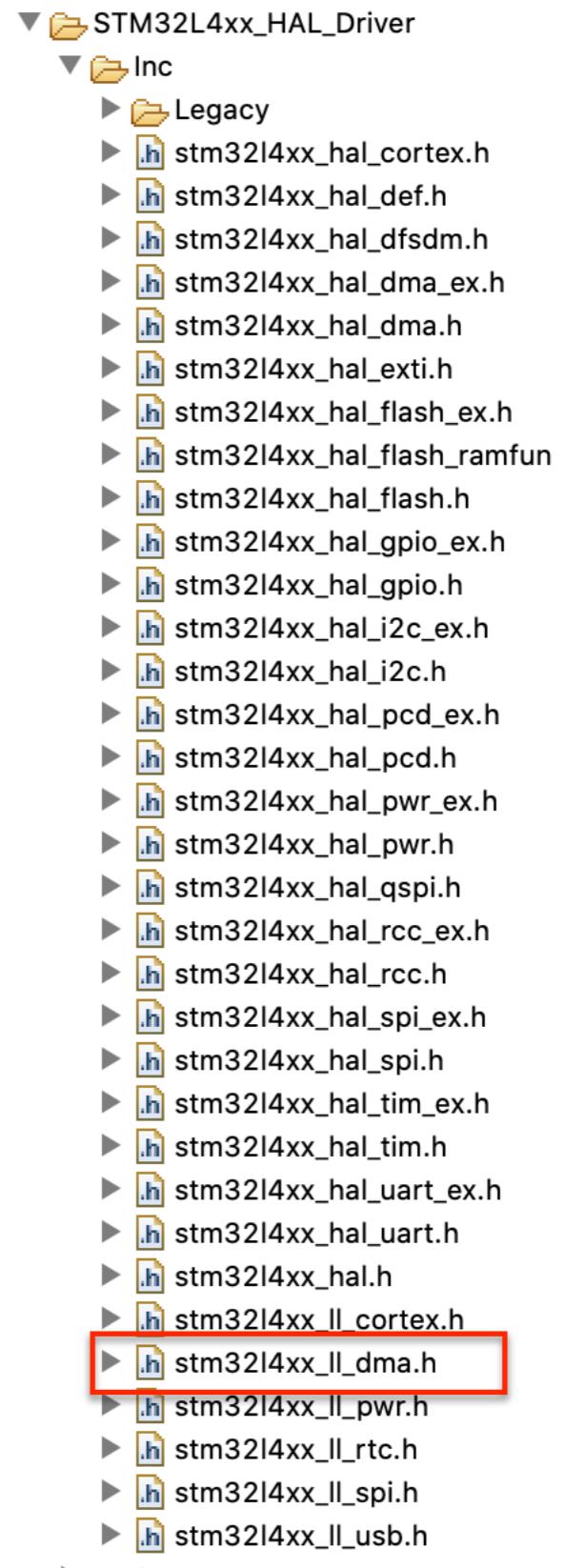
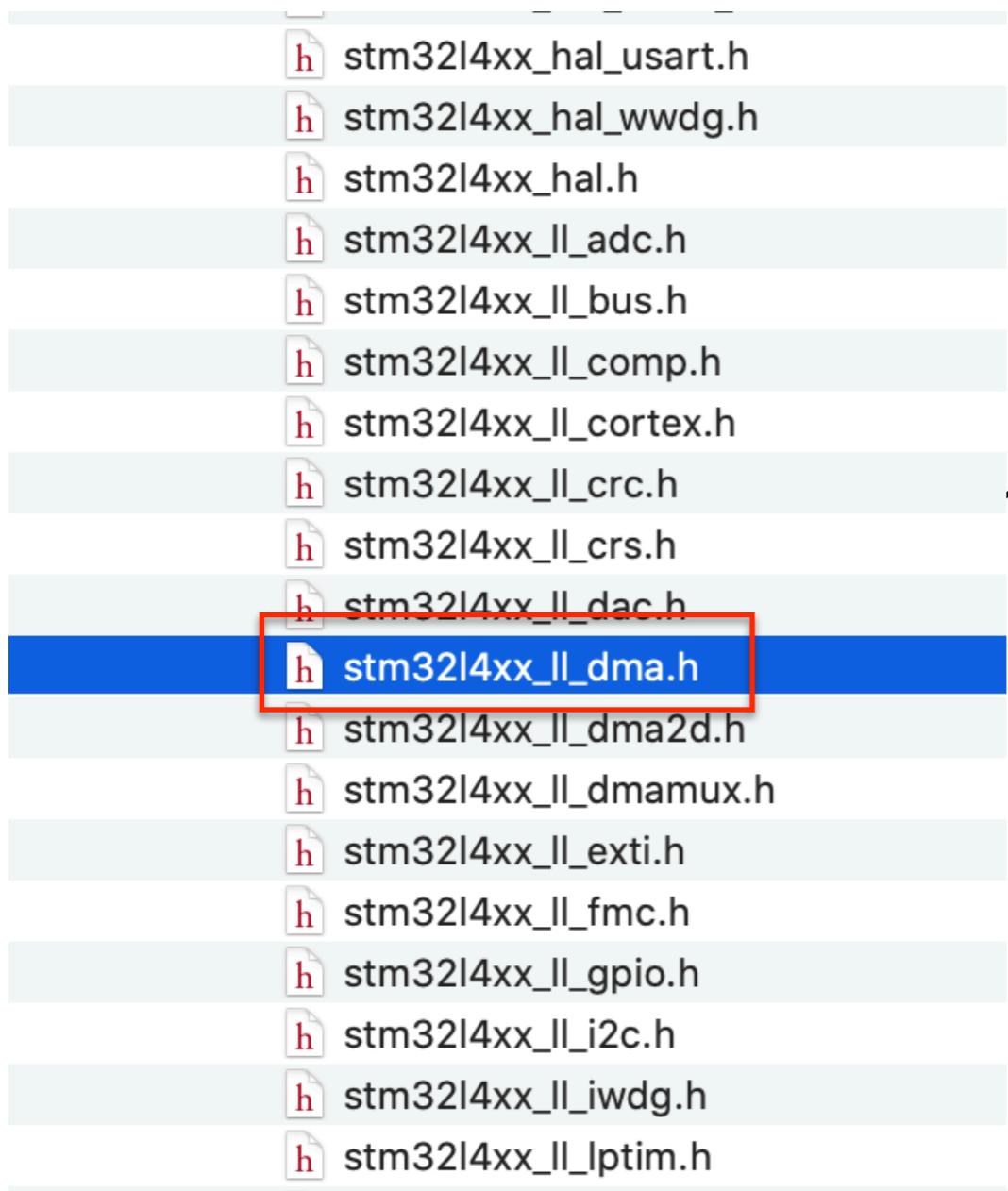
Copy File



Attempt to build

```
CDT Build Console [HelloBLELED]
07:08:05 **** Incremental Build of configuration Debug
make -j3 all
arm-none-eabi-gcc ".../BLE/P2P_LedButton/Src/lb_client.c"
arm-none-eabi-gcc ".../BLE/P2P_LedButton/Src/lb_demo.c"
arm-none-eabi-gcc ".../BLE/P2P_LedButton/Src/lb_server.c"
In file included from /Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/main.c:1:
                  from /Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/lb_client.c:1:
                  from .../BLE/P2P_LedButton/Src/lb_client.c:1:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/lb_client.c: In function 'void lbClientInit()':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/lb_client.c:14:10: warning: #include "stm32l4xx_ll_dma.h"
#include "stm32l4xx_ll_dma.h"
~~~~~
compilation terminated.
In file included from /Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/main.c:1:
                  from /Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/lb_client.c:1:
                  from .../BLE/P2P_LedButton/Src/lb_client.c:1:
```

Copy File

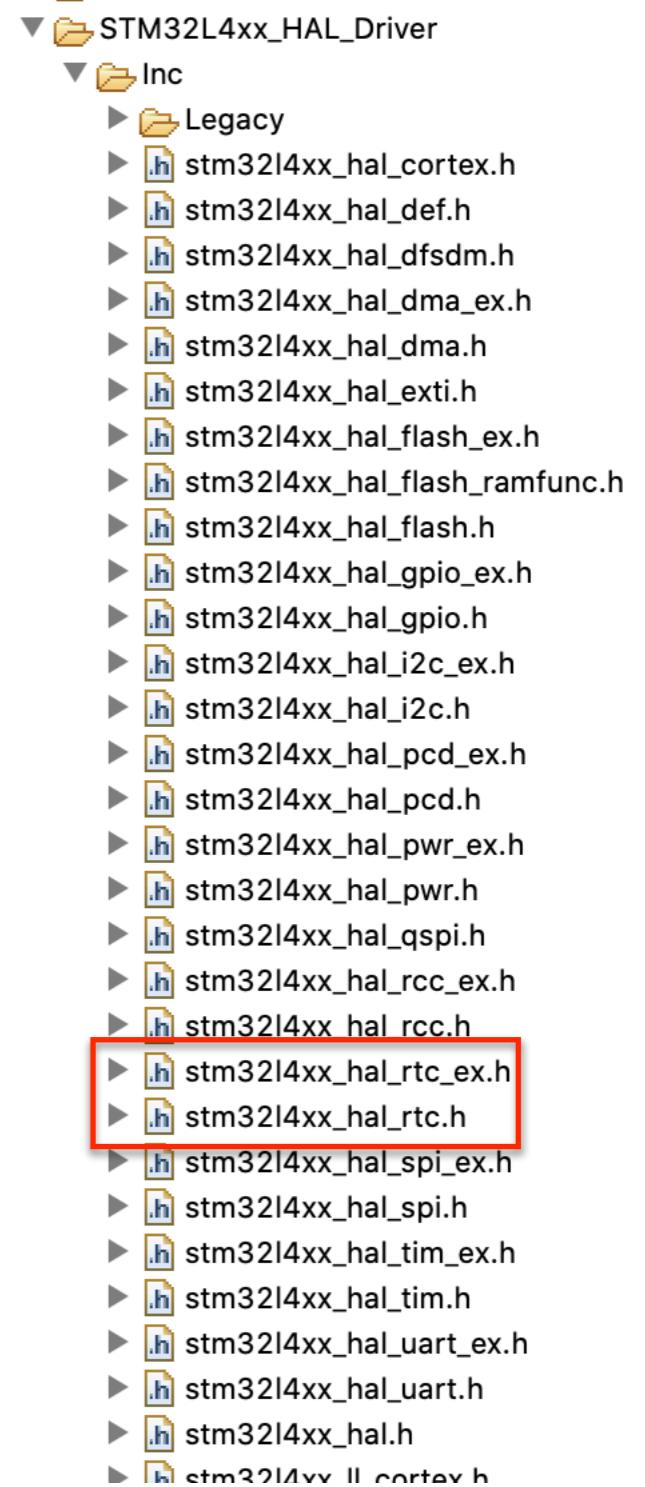
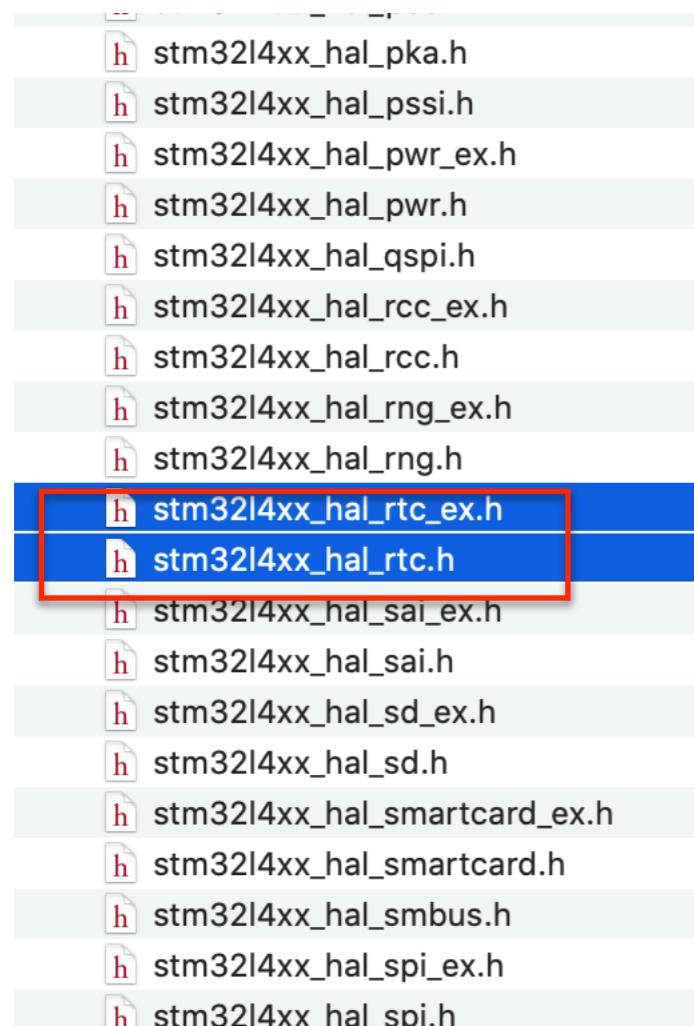


Attempt Build

```
CDT Build Console [HelloBLE]
23:39:07 **** Incremental Build of configuration Debug for project HelloBLE ****
make -j3 all
arm-none-eabi-gcc "../BLE/HeartRate/Src/hr.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../Core/
arm-none-eabi-gcc "../BLE/HeartRate/Src/hrs_app.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../
arm-none-eabi-gcc "../BLE/HeartRate/Src/main.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../Cor
In file included from ../BLE/HeartRate/Src/hrs_app.c:23:0:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h:97:51: error: unknown type name 'RTC_HandleTypeDef'; di
  void HW_TS_Init(HW_TS_InitMode_t TimerInitMode, RTC_HandleTypeDef *hrtc);
                           ^~~~~~
                           I2C_HandleTypeDef
In file included from ../BLE/HeartRate/Src/main.c:22:0:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h:97:51: error: unknown type name 'RTC_HandleTypeDef'; di
  void HW_TS_Init(HW_TS_InitMode_t TimerInitMode, RTC_HandleTypeDef *hrtc);
                           ^~~~~~
                           I2C_HandleTypeDef
../BLE/HeartRate/Src/main.c:47:8: error: unknown type name 'RTC_HandleTypeDef'
  static RTC_HandleTypeDef hrtc;  /* DTC handler declaration */

```

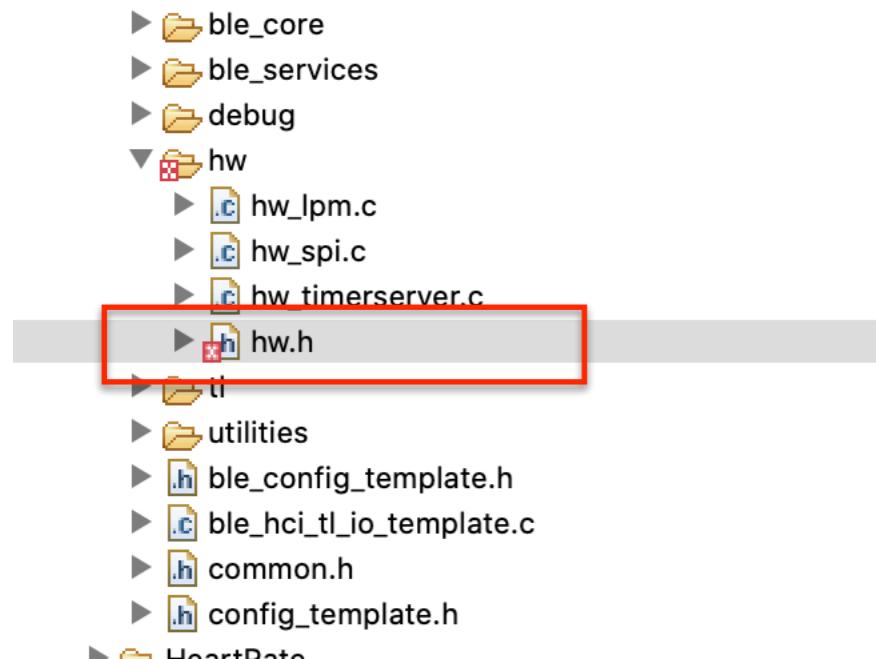
Copy TWO Files



Attempt Build

```
CDT Build Console [HelloBLE]
23:39:07 **** Incremental Build of configuration Debug for project HelloBLE ****
make -j3 all
arm-none-eabi-gcc "../BLE/HeartRate/Src/hr.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../Core/
arm-none-eabi-gcc "../BLE/HeartRate/Src/hrs_app.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../
arm-none-eabi-gcc "../BLE/HeartRate/Src/main.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../Cor
In file included from ../BLE/HeartRate/Src/hrs_app.c:23:0:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h:97:51: error: unknown type name 'RTC_HandleTypeDef'; di
  void HW_TS_Init(HW_TS_InitMode_t TimerInitMode, RTC_HandleTypeDef *hrtc);
                                         ^~~~~~
                                         I2C_HandleTypeDef
In file included from ../BLE/HeartRate/Src/main.c:22:0:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h:97:51: error: unknown type name 'RTC_HandleTypeDef'; di
  void HW_TS_Init(HW_TS_InitMode_t TimerInitMode, RTC_HandleTypeDef *hrtc);
                                         ^~~~~~
                                         I2C_HandleTypeDef
../BLE/HeartRate/Src/main.c:47:8: error: unknown type name 'RTC_HandleTypeDef'
  static RTC_HandleTypeDef hrtc;  /* DTC handler declaration */
                                         ^~~~~~
```

Edit Header file to add HAL RTC



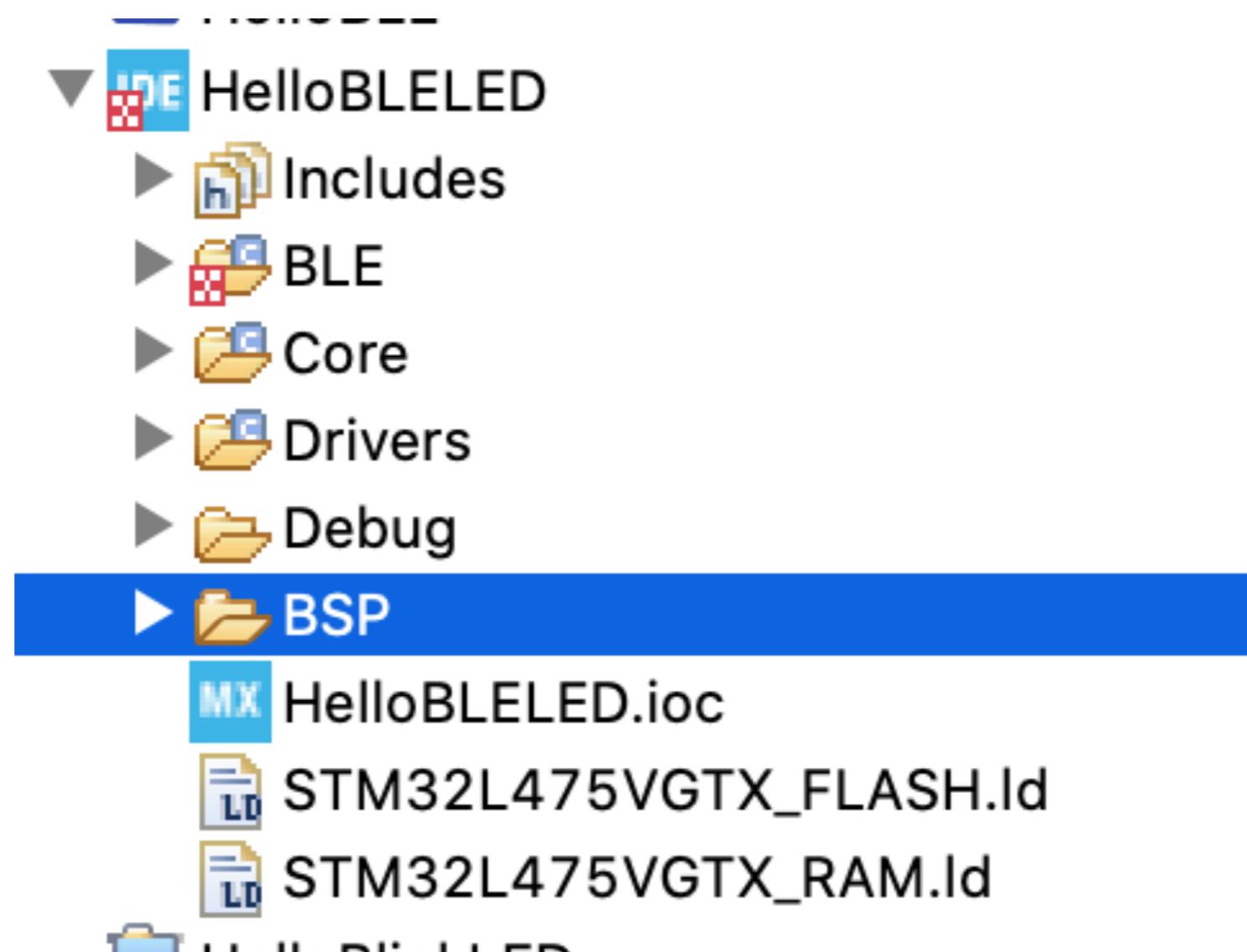
```
23 //-----  
24 #ifdef __cplusplus  
25 extern "C" {  
26 #endif  
27  
28 /* Includes -----  
29 #include "stm32l4xx.h"  
30 #include "stm32l4xx_ll_pwr.h"  
31 #include "stm32l4xx_ll_cortex.h"  
32 #include "stm32l4xx_ll_rtc.h"  
33 #include "stm32l4xx_ll_spi.h"  
34 #include "stm32l4xx_ll_dma.h"  
35  
36 #include "stm32l4xx_hal_rtc.h" //For RTC_HandleTypeDef|  
37  
38  
39
```

Attempt Build

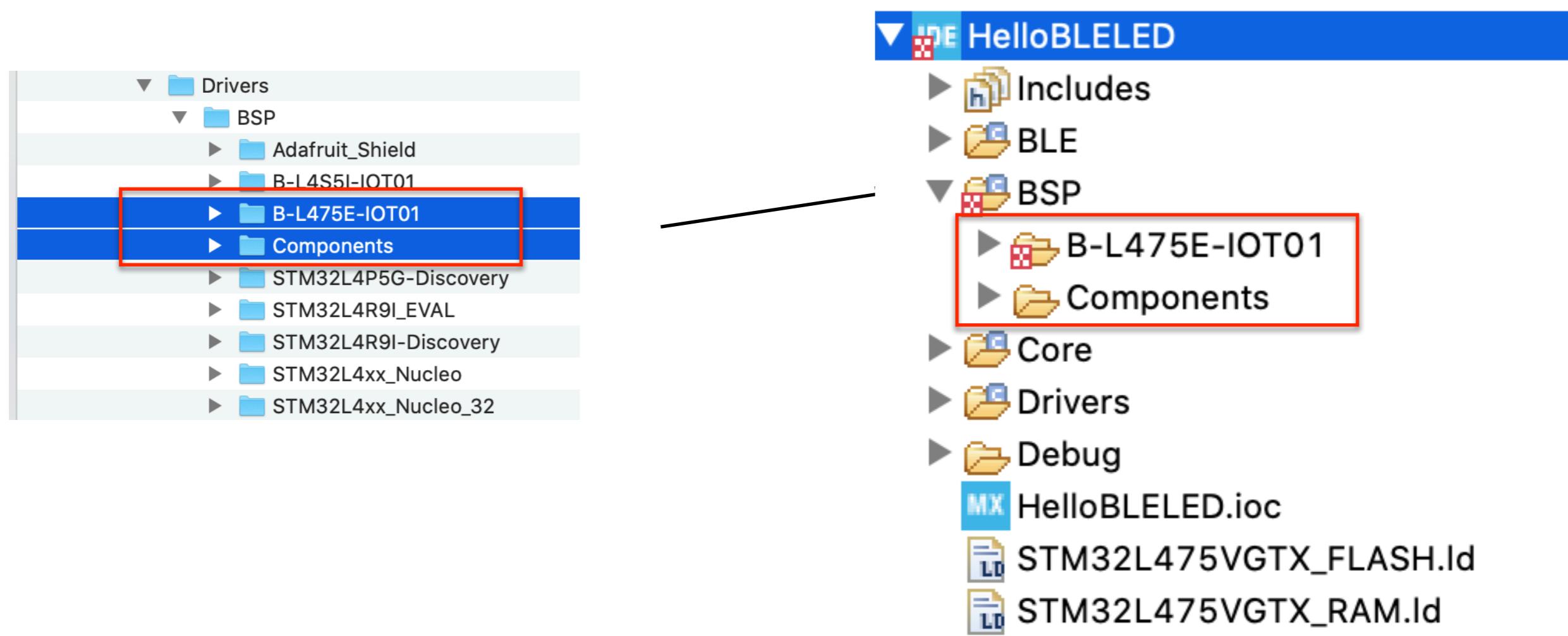
```
arm-none-eabi-gcc ".../BLE/P2P_LedButton/Src/lb_client_app.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG  
arm-none-eabi-gcc ".../BLE/P2P_LedButton/Src/lb_demo.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG  
arm-none-eabi-gcc ".../BLE/P2P_LedButton/Src/lb_server_app.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG  
.../BLE/P2P_LedButton/Src/lb_demo.c:36:10: fatal error: stm32l475e_iot01.h: No such file or directory  
#include "stm32l475e_iot01.h"  
~~~~~  
compilation terminated.  
make: *** [BLE/P2P_LedButton/Src/subdir.mk:35: BLE/P2P_LedButton/Src/lb_demo.o] Error 1  
make: *** Waiting for unfinished jobs....  
.../BLE/P2P_LedButton/Src/lb_server_app.c:30:10: fatal error: stm32l475e_iot01.h: No such file or directory  
#include "stm32l475e_iot01.h"  
~~~~~  
compilation terminated.  
.../BLE/P2P_LedButton/Src/lb_client_app.c:31:10: fatal error: stm32l475e_iot01.h: No such file or directory  
#include "stm32l475e_iot01.h"  
~~~~~  
compilation terminated.  
make: *** [BLE/P2P_LedButton/Src/subdir.mk:37: BLE/P2P_LedButton/Src/lb_server_app.o] Error 1  
make: *** [BLE/P2P_LedButton/Src/subdir.mk:33: BLE/P2P_LedButton/Src/lb_client_app.o] Error 1  
"make -i3 all" terminated with exit code 2. Build might be incomplete.
```

From the board support package

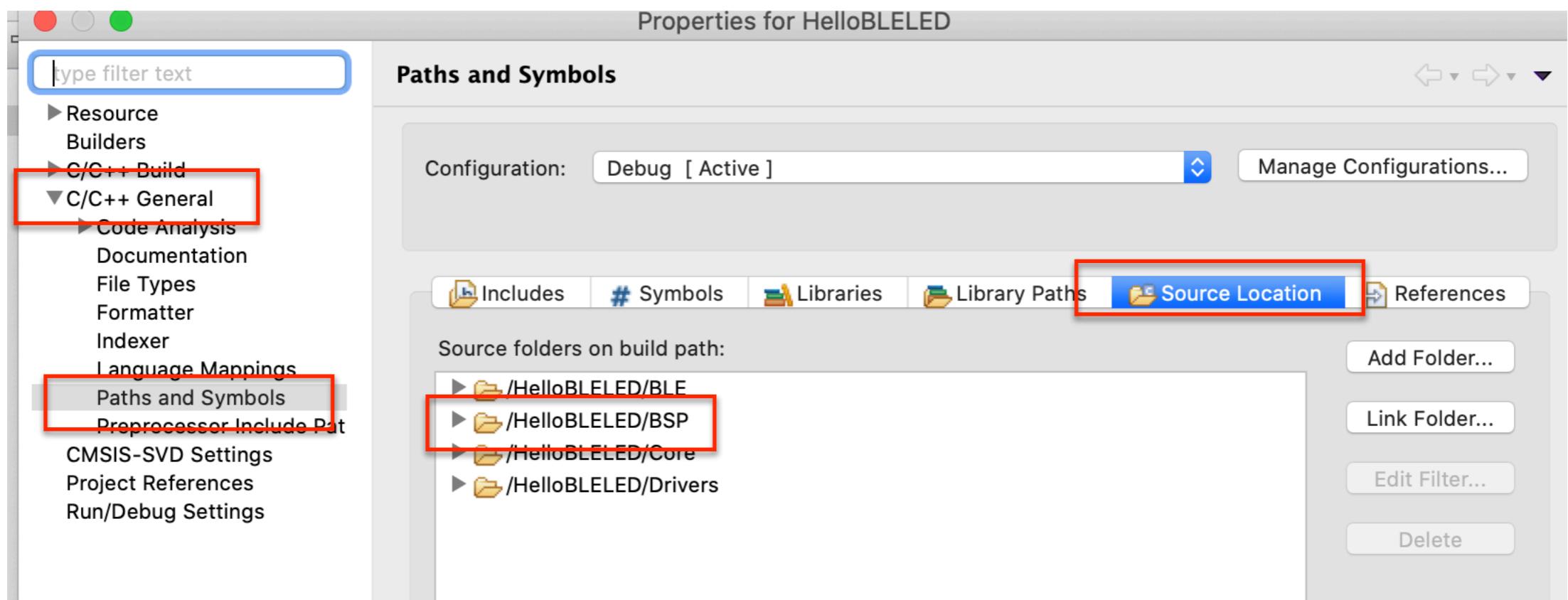
Add BSP Folder To Project



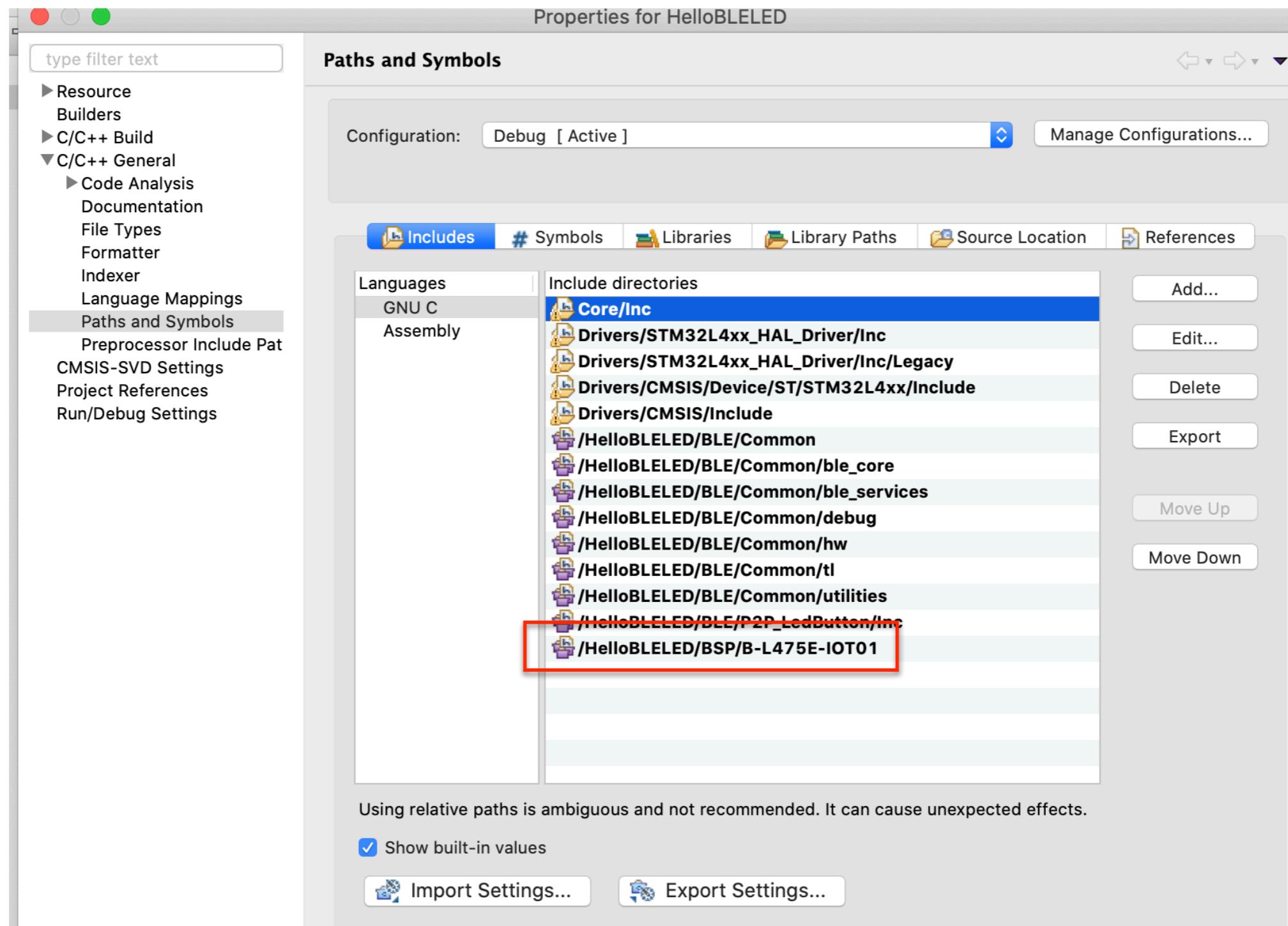
Copy TWO Folder Contents to Project



Add Source Location



Add Include Path



Attempt Build

```
... - - - ^  
./BLE/Common/ble_services/svc_ctl.c:154:18: note: in expansion of macro 'SVCCTL_GAP_DEVICE_NAME_LENGTH'  
    SVCCTL_GAP_DEVICE_NAME_LENGTH,  
    ^~~~~~  
In file included from /Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/BLE/Common/ble_core/ble_lib.h:35:0,  
    from ../BLE/Common/ble_services/svc_ctl.c:28:  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/BLE/Common/ble_core/bluenrg_gap_aci.h:103:12: note: expected 'uint1  
tBleStatus aci_gap_init(uint8_t role,  
    ^~~~~~  
./BLE/Common/ble_services/svc_ctl.c:152:5: error: too many arguments to function 'aci_gap_init'  
    aci_gap_init(role,  
    ^~~~~~  
In file included from /Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/BLE/Common/ble_core/ble_lib.h:35:0,  
    from ../BLE/Common/ble_services/svc_ctl.c:28:  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/BLE/Common/ble_core/bluenrg_gap_aci.h:103:12: note: declared here  
tBleStatus aci_gap_init(uint8_t role,  
    ^~~~~~  
make: *** [BLE/Common/ble_services/subdir.mk:33: BLE/Common/ble_services/svc_ctl.o] Error 1  
make: *** Waiting for unfinished jobs....
```

Notice Function Prototype is inside #ifdef

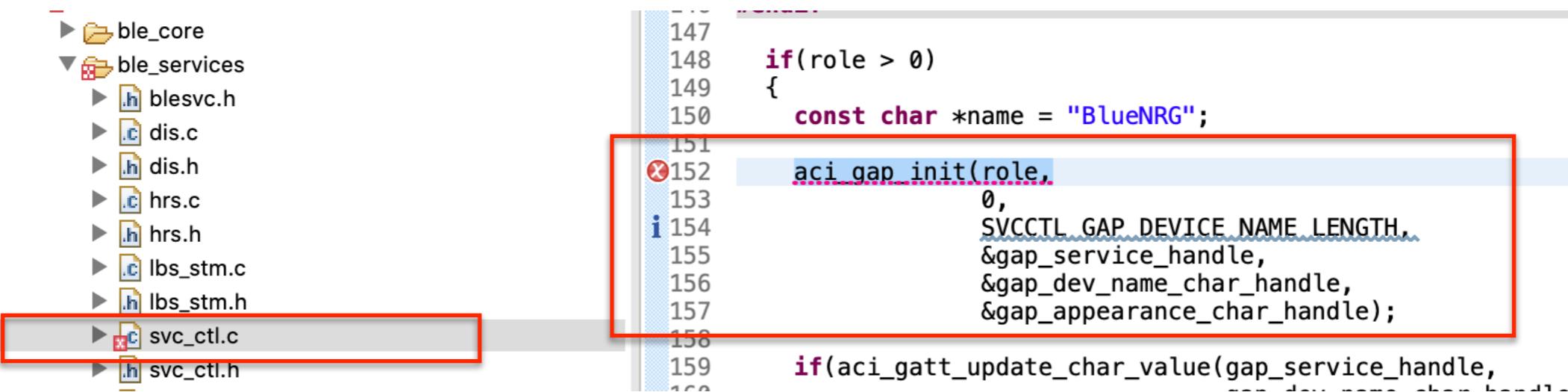
```
30
31 #if BLUENRG_MS
32 // @cond BLUENRG_MS
33 /**
34 * @brief Initialize the GAP layer.
35 * @note Register the GAP service with the GATT.
36 * All the standard GAP characteristics will also be added:
37 * @li Device Name
38 * @li Appearance
39 * @li Peripheral Preferred Connection Parameters (peripheral role only)
40 * @code
41
42 * @param role Bitmap of allowed roles: see @ref gap_roles "GAP roles".
43 * @param privacy_enabled Enable (1) or disable (0) privacy.
44 * @param device_name_char_len Length of the device name characteristic
45 * @param[out] service_handle Handle of the GAP service.
46 * @param[out] dev_name_char_handle Device Name Characteristic handle
47 * @param[out] appearance_char_handle Appearance Characteristic handle
48 * @retval tBleStatus Value indicating success or error code.
49 */
50 tBleStatus aci_gap_init(uint8_t role, uint8_t privacy_enabled,
51                         uint8_t device_name_char_len,
52                         uint16_t* service_handle,
53                         uint16_t* dev_name_char_handle,
54                         uint16_t* appearance_char_handle);
55
56 /**
57 * @param role One of the allowed roles: @ref GAP_PERIPHERAL_ROLE
58 * @param[out] service_handle Handle of the GAP service.
59 * @param[out] dev_name_char_handle Device Name Characteristic handle
60 * @param[out] appearance_char_handle Appearance Characteristic handle
61 * @retval tBleStatus Value indicating success or error code.
62 */
63
64 tBleStatus aci_gap_init(uint8_t role, uint8_t privacy_enabled,
65                         uint8_t device_name_char_len,
66                         uint16_t* service_handle,
67                         uint16_t* dev_name_char_handle,
68                         uint16_t* appearance_char_handle);
69
70 // @endcond
71 #else
72
73 // BLE
74 // Common
75 // ble_core
76 // ble_lib.h
77 // ble_status.h
78 // bluenrg_aci_const.h
79 // bluenrg_gap_aci.c
80 // bluenrg_gap_aci.h
81 // bluenrg_gap.h
82 // bluenrg_gatt_aci.c
83 // bluenrg_gatt_aci.h
84 // bluenrg_gatt_server.h
85 // bluenrg_hal_aci.c
86 // bluenrg_hal_aci.h
```

5-Params

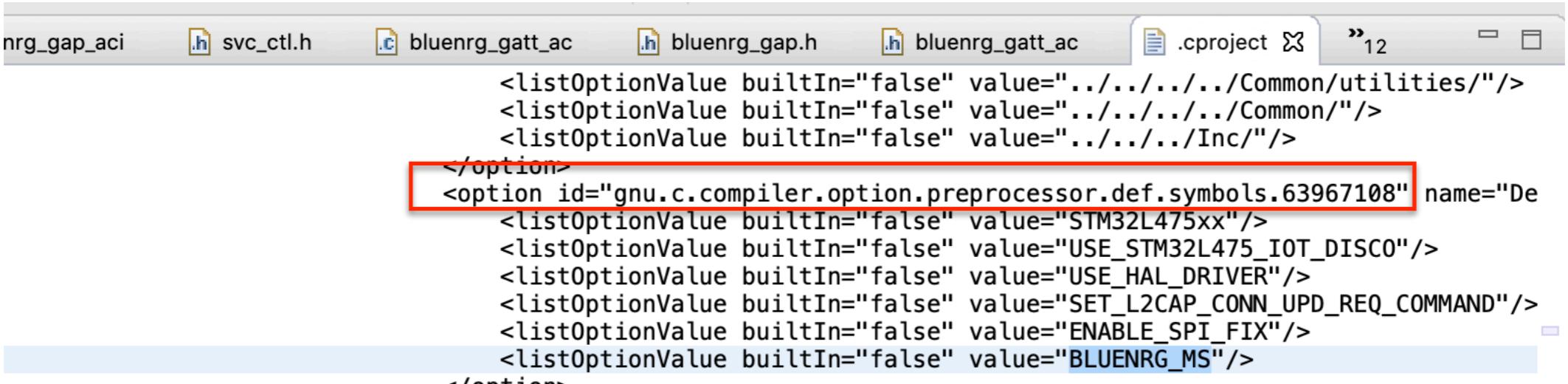
```
93 *
94 * PRINTF("aci_gatt_update_char_value failed.\n");
95 *
96 * @endcode
97 * @param role One of the allowed roles: @ref GAP_PERIPHERAL_ROLE
98 * @param[out] service_handle Handle of the GAP service.
99 * @param[out] dev_name_char_handle Device Name Characteristic handle
100 * @param[out] appearance_char_handle Appearance Characteristic handle
101 * @retval tBleStatus Value indicating success or error code.
102 */
103 BleStatus aci_gap_init(uint8_t role,
104                         uint16_t* service_handle,
105                         uint16_t* dev_name_char_handle,
106                         uint16_t* appearance_char_handle);
107 // @endcond
108 endif
```

4-Params

5-Param Version Used By Code



Value of BLUENRG_MS set to false

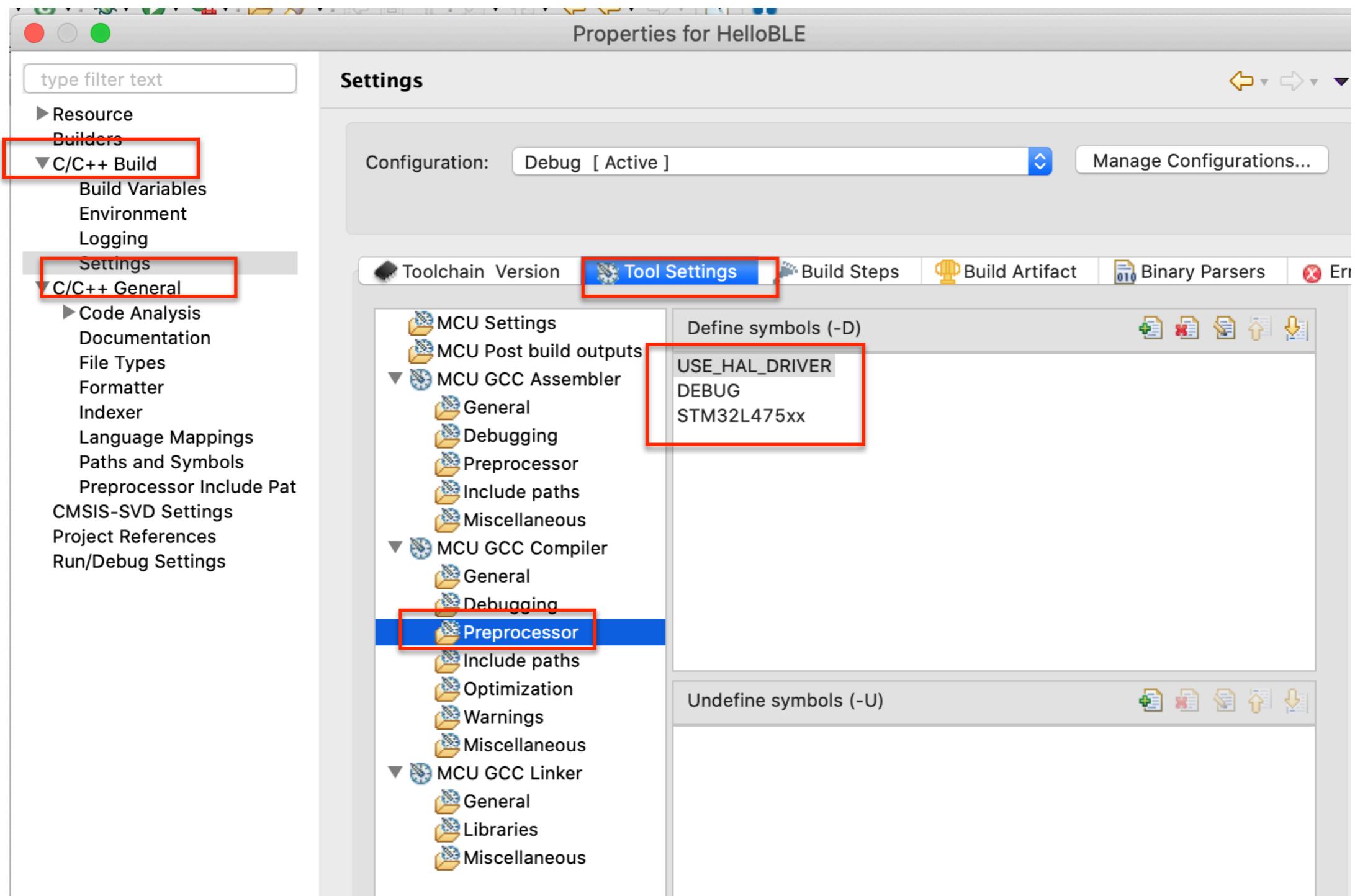


The screenshot shows a code editor window with several tabs at the top: nrg_gap_aci, svc_ctl.h, bluenrg_gatt_ac (selected), bluenrg_gap.h, bluenrg_gatt_ac, .cproject, and »12. The main content area displays XML-like configuration options. A red box highlights the following line:

```
<option id="gnu.c.compiler.option.preprocessor.def.symbols.63967108" name="De
<listOptionValue builtIn="false" value="STM32L475xx"/>
<listOptionValue builtIn="false" value="USE_STM32L475_IOT_DISCO"/>
<listOptionValue builtIn="false" value="USE_HAL_DRIVER"/>
<listOptionValue builtIn="false" value="SET_L2CAP_CONN_UPD_REQ_COMMAND"/>
<listOptionValue builtIn="false" value="ENABLE_SPI_FIX"/>
<listOptionValue builtIn="false" value="BLUENRG_MS"/>
```

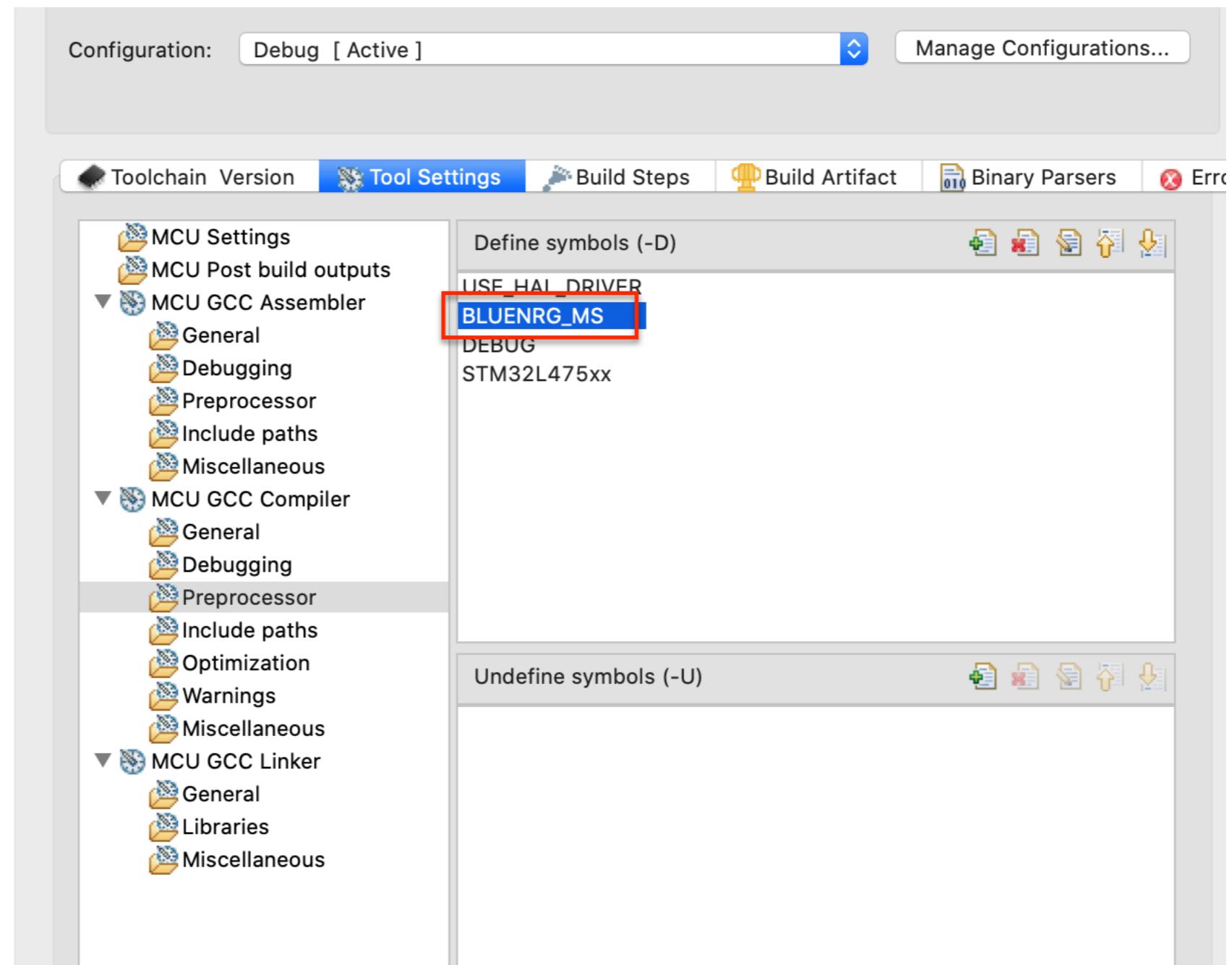
The line containing "BLUENRG_MS" is highlighted with a blue background.

Original Values



Add Value

▶ C/C++ General
CMSIS-SVD Settings
Project References
Run/Debug Settings



Attempt Build

```
arm-none-eabi-gcc ".../BLE/Common/ble_core/hci_le.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DBLUENRG_
.../BLE/Common/ble_core/bluenrg_l2cap_aci.c:16:10: fatal error: hal_types.h: No such file or directory
#include "hal_types.h"
^~~~~~
compilation terminated.
make: *** [BLE/Common/ble_core/subdir.mk:39: BLE/Common/ble_core/bluenrg_l2cap_aci.o] Error 1
make: *** Waiting for unfinished jobs....
.../BLE/Common/ble_core/hci_le.c:19:10: fatal error: hal_types.h: No such file or directory
#include "hal_types.h"
^~~~~~
compilation terminated.
make: *** [BLE/Common/ble_core/subdir.mk:41: BLE/Common/ble_core/hci_le.o] Error 1
"make -j3 all" terminated with exit code 2. Build might be incomplete.
```

Look for hal_types.h

```
Normans-MacBook-Air-674:workspace_1.4.0 nmcentire$ find . | grep hal_types  
./HelloBLE/BLE/Common/ble_core/bluenrg_private_hal_types.h
```

NOTE: Did not find hal_types.h but
did find bluenrg_private_hal_types.h

Edit include files

- ▶ bluenrg_gatt_server.h
- ▶ bluenrg_hal_aci.c
- ▶ bluenrg_hal_aci.h
- ▶ bluenrg_l2cap_aci.c
- ▶ bluenrg_l2cap_aci.h
- ▶ bluenrg_private_hal_types.h
- ▶ compiler.h
- ▶ hci_const.h
- ▶ hci_le.c
- ▶ hci_le.h
- ▶ hci_tl_io.h
- ▶ link_layer.h

```
18 //ORIGINAL #include "hal_types.h"
19 #include "bluenrg_private_hal_types.h"
20 #include "osal.h"
21 #include "ble_status.h"
22 //ORIGINAL #include "hal.h"
23 #include "stm32l4xx_hal.h"
24 #include "hci_const.h"
25 #if (STM == 1)
26 #include "gp_timer.h"
27#endif
28
29
30 #define MIN(a,b) ((a) < (b) )? (a) : (b)
31 #define MAX(a,b) ((a) > (b) )? (a) : (b)
```

Attempt Build

```
CDT Build Console [HelloBLELED]
09:19:44 *** Incremental Build of configuration Debug for project HelloBLELED ***
make -j3 all
arm-none-eabi-gcc "../BLE/Common/ble_core/bluenrg_l2cap_aci.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DBLUENRF52840
arm-none-eabi-gcc "../BLE/Common/ble_core/hci_le.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DBLUENRF52840
arm-none-eabi-gcc "../BLE/Common/ble_core/osal.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DBLUENRF52840
./BLE/Common/ble_core/bluenrg_l2cap_aci.c:16:10: fatal error: hal_types.h: No such file or directory
 #include "hal_types.h"
 ^~~~~~
```

Edit Include Files

The image shows a code editor interface with a file tree on the left and a code editor on the right.

File Tree:

- ▶ **.h** bluenrg_gap.h
- ▶ **.c** bluenrg_gatt_aci.c
- ▶ **.h** bluenrg_gatt_aci.h
- ▶ **.h** bluenrg_gatt_server.h
- ▶ **.c** bluenrg_hal_aci.c
- ▶ **.h** bluenrg_hal_aci.h
- bluenrg_l2cap_aci.c** (highlighted with a red box)
- ▶ **.h** bluenrg_l2cap_aci.h

Code Editor:

```
15  
16 //ORIGINAL #include "hal_types.h"  
17 #include "bluenrg_private_hal_types.h"  
18 #include "osal.h"  
19 #include "ble_status.h"  
20 //ORIGINAL #include "hal.h"  
21 #include "stm32l4xx_hal.h"  
22 #include "osal.h"  
23 #include "hci_const.h"
```

Attempt Build

```
▶ .h ble_lib.h
▶ .h ble_status.h
▶ .h bluenrg_aci_const.h
▶ .c bluenrg_gap_aci.c
▶ .h bluenrg_gap_aci.h
▶ .h bluenrg_gap.h
▶ .c bluenrg_gatt_aci.c
▶ .h bluenrg_gatt_aci.h
▶ .h bluenrg_gatt_server.h
▶ .c bluenrg_hal_aci.c
▶ .h bluenrg_hal_aci.h
▶ .c bluenrg_l2cap_aci.c
▶ .h bluenrg_l2cap_aci.h
▶ .h bluenrg_private_hal_types.h
▶ .h compiler.h
▶ .h hci_const.h
▶ .c hci_le.c
▶ .h hci_le.h
```

```
33 ⊕ int hci_reset()
34 {
35     struct hci_request_rq;
36     uint8_t status;
37
38     Osal_MemSet(&rq, 0, sizeof(rq));
39     rq.ogf = OGF_HOST_CTL;
40     rq.ocf = OCF_RESET;
41     rq.rparam = &status;
42     rq.rlen = 1;
43
44     if (hci_send_req(&rq, FALSE) < 0)
45         return BLE_STATUS_TIMEOUT;
46
47     return status;
48 }
```

```
50 ⊕ int hci_disconnect(uint16_t handle, uint8_t reason)
51 {
52     struct hci_request_rq;
53     disconnect_cp cp;
```

Find where struct hci_request defined

```
./HelloBLELED/ble/ble.h:115:1: error: conflicting types for 'struct hci_request' definition
Normans-MacBook-Air-674:workspace_1.4.0 nmcentire$ grep -r 'struct hci_request' ./HelloBLELED/
./HelloBLELED//BLE/Common/ble_core/bluenrg_hal_aci.c:    struct hci_request rq;
./HelloBLELED//BLE/Common/ble_core/bluenrg_hal_aci.c:    struct hci request rq;
./HelloBLELED//BLE/Common/ble_core/hci_t1_io.h:struct hci_request {
./HelloBLELED//BLE/Common/ble_core/hci_t1_io.h:int32_t hci_send_req(struct hci_request *r, uint8_t async);
./HelloBLELED//BLE/Common/ble_core/bluenrg_l2cap_aci.c:    struct hci_request rq;
./HelloBLELED//BLE/Common/ble_core/bluenrg_l2cap_aci.c:    struct hci_request rq;
```

Add Header File

The image shows a file browser on the left and a code editor on the right. In the file browser, several files are listed, including ble_lib.h, ble_status.h, bluenrg_aci_const.h, bluenrg_gap_aci.c, bluenrg_gap_aci.h, bluenrg_gap.h, bluenrg_gatt_aci.c, bluenrg_gatt_aci.h, bluenrg_gatt_server.h, bluenrg_hal_aci.c, bluenrg_hal_aci.h, bluenrg_l2cap_aci.c, bluenrg_l2cap_aci.h, bluenrg_private_hal_types.h, compiler.h, hci_const.h, hci_le.c, and hci_le.h. The file hci_le.c is highlighted with a red box. In the code editor, a C code snippet is shown with line numbers 21 through 42. Lines 21 to 28 are standard includes. Line 29 is a comment //Added. Line 30 is the new include statement #include "hci_tl_io.h", which is also highlighted with a red box. Lines 31 to 42 define the hci_reset() function.

```
21 #include "osal.h"
22 #include "ble_status.h"
23 //ORIGINAL #include "hal.h"
24 #include "stm32l4xx_hal.h"
25 #include "hci_const.h"
26 #if (STM == 1)
27 #include "gp_timer.h"
28#endif
29
30 //Added
31 #include "hci_tl_io.h"
32
33 #define MIN(a,b) ((a) < (b) ? (a) : (b))
34 #define MAX(a,b) ((a) > (b) ? (a) : (b))
35
36 int hci_reset()
37 {
38     struct hci_request rq;
39     uint8_t status;
40
41     Osal_MemSet(&rq, 0, sizeof(rq));
42     rq.ogf = OGF_HOST_CTL;
```

Attempt Build

```
CDT Build Console [HelloBLELED]
09:29:51 **** Incremental Build of configuration Debug for project HelloBLELED ****
make -j3 all
arm-none-eabi-gcc ".../BLE/Common/ble_core/hci_le.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAI
arm-none-eabi-gcc ".../BLE/Common/ble_hci_tl_io_template.c" -mcpu=cortex-m4 -std=gnu11 -g3 -I
.../BLE/Common/ble_hci_tl_io_template.c:25:1: error: unknown type name 'int32_t'
    int32_t hci_send_req(struct hci_request *r, uint8_t async)
    ^~~~~~
.../BLE/Common/ble_hci_tl_io_template.c:25:45: error: unknown type name 'uint8_t'
    int32_t hci_send_req(struct hci_request *r, uint8_t async)
    ^~~~~~
make: *** [BLE/Common/subdir.mk:18: BLE/Common/ble_hci_tl_io_template.o] Error 1
make: *** Waiting for unfinished jobs....
"make -j3 all" terminated with exit code 2. Build might be incomplete.
```

Add Include File

```
3  * @file    hci_tl_io_template.c
4  * @author   MCD Application Team
5  * @brief    This lower API is imposed by the MI
6  ****
7  * @attention
8  *
9  * <h2><center>&copy; Copyright (c) 2017 STMicroelectronics
10 * All rights reserved.</center></h2>
11 *
12 * This software component is licensed by ST under
13 * the "License"; You may not use this file except
14 * in compliance with the License. You may obtain a copy of the License at
15 * http://www.st.com/SLA0048
16 *
17 ****
18 */
19
20 // Added
21 #include <stdint.h>
22
23 /* Function prototypes -----
24
25 /* HCI send request: generic API imposed by MW
26 /* transport layer depends by the applic, e.g.
27
28 int32_t hci_send_req(struct hci_request *r, uint8_t
29 {
30     return 0;
31 }
```

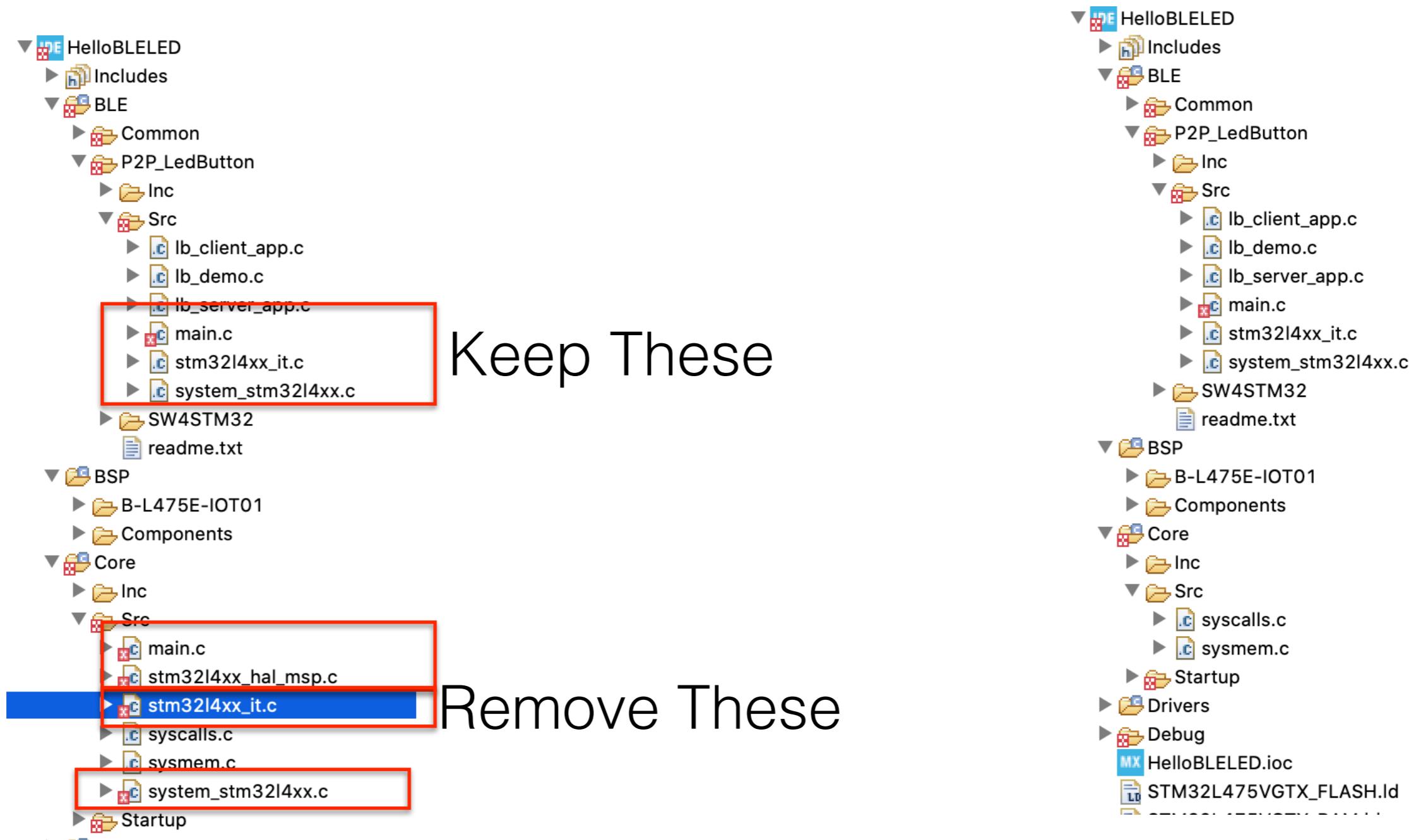
Attempt Build Multiple Definitions

```
CDT Build Console [HelloBLELED]
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/./Core/Src/stm32l4xx_it.c:183: multiple definition of `SysTick_Handler'
BLE/P2P_LedButton/Src/stm32l4xx_it.o:/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/./BLE/P2P_LedButton/Src/stm32l4xx_it.c:138: first defined here
Core/Src/stm32l4xx_it.c: In function `EXTI9_5_IRQHandler':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/./Core/Src/stm32l4xx_it.c:204: multiple definition of `EXTI9_5_IRQHandler'
BLE/P2P_LedButton/Src/stm32l4xx_it.o:/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/./BLE/P2P_LedButton/Src/stm32l4xx_it.c:166: first defined here
Core/Src/stm32l4xx_it.o: In function `EXTI15_10_IRQHandler':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/./Core/Src/stm32l4xx_it.c:221: multiple definition of `EXTI15_10_IRQHandler'
BLE/P2P_LedButton/Src/stm32l4xx_it.o:/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/./BLE/P2P_LedButton/Src/stm32l4xx_it.c:177: first defined here
Core/Src/system_stm32l4xx.o:/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/./Drivers/CMSIS/Device/ST/STM32L4xx/Include/system_stm32l4xx.h:58: multiple definitions of `AHBProcsTable'
BLE/P2P_LedButton/Src/system_stm32l4xx.o:/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/./Drivers/CMSIS/Device/ST/STM32L4xx/Include/system_stm32l4xx.h:58: multiple definition of `AHBProcsTable'
```

Note: stm32l4xx_it.c appears two Places. This is source of error

it = interrupt

Remove Duplicates

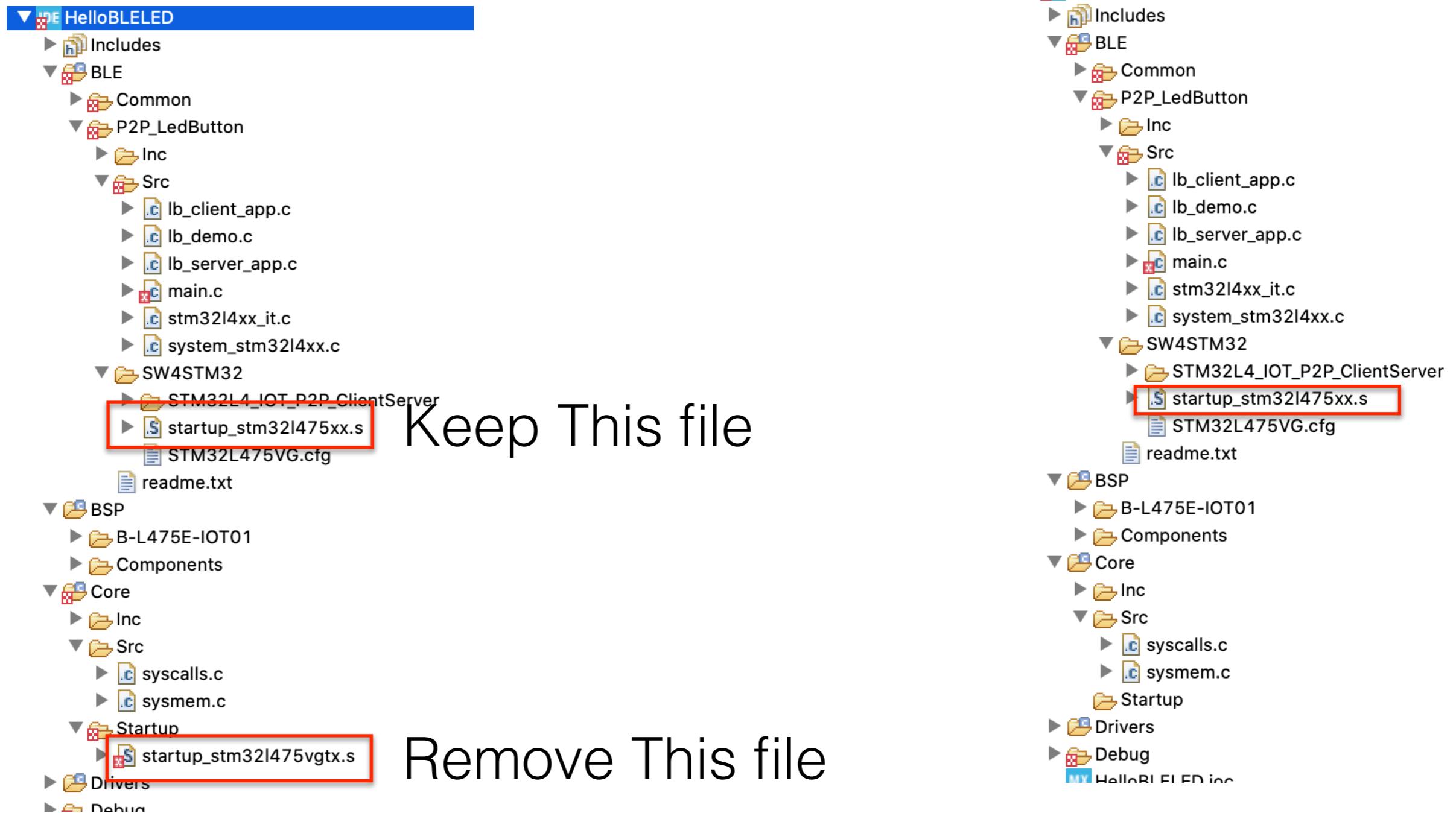


Attempt Build

```
09:40:57 *** Incremental Build of configuration Debug for project HelloBLELED ***
make -j3 all
arm-none-eabi-gcc -o "HelloBLELED.elf" @"objects.list"  -mcpu=cortex-m4 -T"/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/STM32L475VGTX_FLASH.ld" --sp
BLE/Common/tl/tl_ble_hci.o: In function `hci_send_req':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/./BLE/Common/tl/tl_ble_hci.c:268: multiple definition of `hci_send_req'
BLE/Common/ble_hci_tlv_io_template.o:/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/./BLE/Common/ble_hci_tlv_io_template.c:29: first defined here
Core/Startup/startup_stm32l475vgtx.o:(.isr_vector+0x0) multiple definition of `g_pfnVectors'
BLE/P2P_LedButton/SW4STM32/startup_stm32l475xx.o:(.isr_vector+0x0): first defined here
Core/Startup/startup_stm32l475vgtx.o: In function `FPU_IRQHandler':
```

NOTE: Need to remove multiple copies of startup code

Remove Multiple Versions of Startup Code



Attempt Build

```
09:46:43 **** Incremental Build of configuration Debug for project HelloBLELED ****
make -j3 all
arm-none-eabi-gcc -o "HelloBLELED.elf" @"objects.list"  -mcpu=cortex-m4 -T"/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/STM32L475VGTX_FLASH.ld" ---
BLE/Common/tl/tl_ble_hci.o: In function `hci_send_req':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/Common/tl/tl_ble_hci.c:268: multiple definition of `hci_send_req'
BLE/Common/ble_hci_tl_io_template.o:/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/Common/ble_hci_tl_io_template.c:29: first defined here
BLE/Common/ble_services/hrs.o: In function `HearRate_Event_Handler':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/Common/ble_services/hrs.c:123: undefined reference to `HRS_Notification'
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/Common/ble_services/hrs.c:155: undefined reference to `HRS_Notification'
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/Common/ble_services/hrs.c:160: undefined reference to `HRS_Notification'
BLE/Common/hw/hw_timerserver.o: In function `HW_TS_Init':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/Common/hw/hw_timerserver.c:600: undefined reference to `LL_EXTI_EnableRisingTrig_0_31'
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/Common/hw/hw_timerserver.c:601: undefined reference to `LL_EXTI_EnableIT_0_31'
BLE/P2P_LedButton/Src/main.o: In function `main':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/P2P_LedButton/Src/main.c:92: undefined reference to `LL_RCC_IsActiveFlag_PINRST'
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/P2P_LedButton/Src/main.c:104: undefined reference to `LL_RCC_ForceBackupDomainReset'
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/P2P_LedButton/Src/main.c:106: undefined reference to `LL_RCC_ReleaseBackupDomainReset'
BLE/P2P_LedButton/Src/main.o: In function `Init_RTC':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/P2P_LedButton/Src/main.c:204: undefined reference to `HAL_RTCEx_EnableBypassShadow'
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0/HelloBLELED/Debug/../../BLE/P2P_LedButton/Src/main.c:214: undefined reference to `HAL_RTC_Init'
collect2: error: ld returned 1 exit status
make: *** [makefile:84: HelloBLELED.elf] Error 1
"make -j3 all" terminated with exit code 2. Build might be incomplete.
```

Issue 1: Multiple definitions of hci_send_req

Issue 2: undefined references

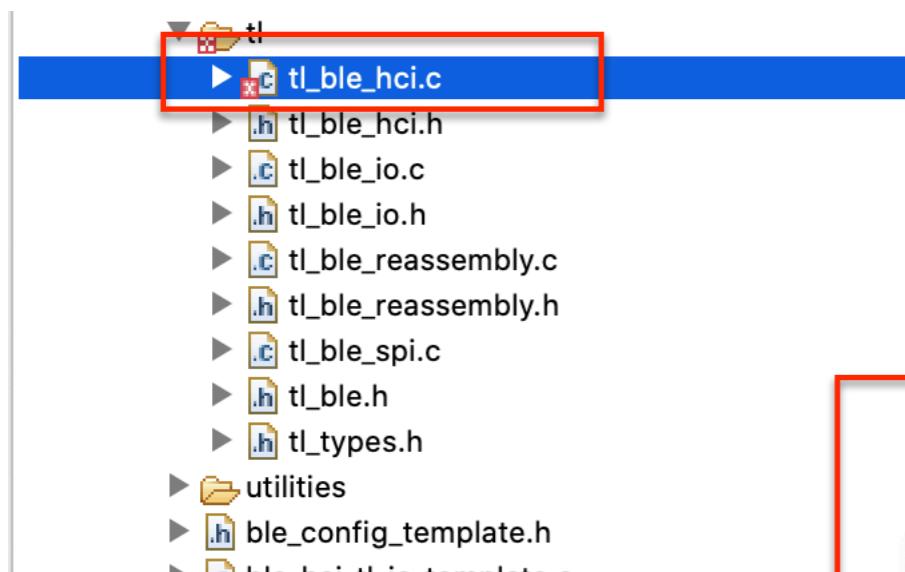
Multiple Definitions Issue

```
:t HelloBLELED ****

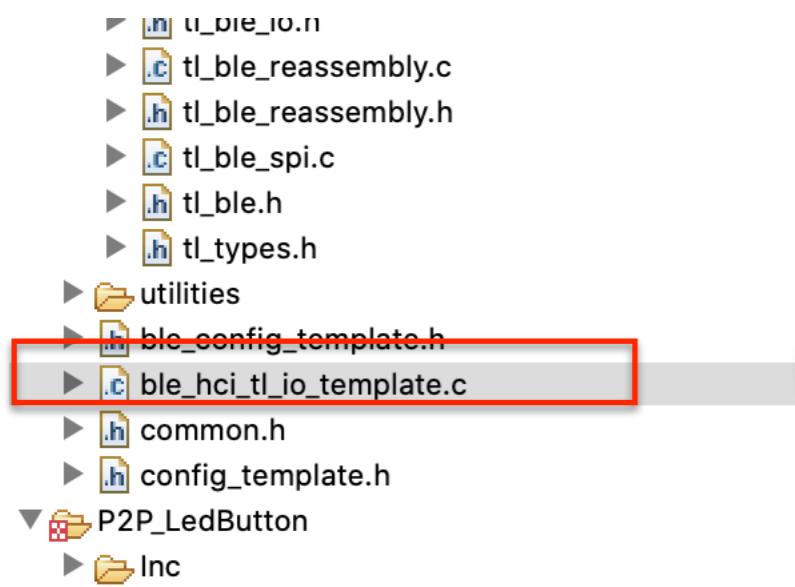
ortex-m4 -T"/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/STM32L475VGTX_FLASH.ld" --:

./BLE/Common/tl/tl_ble_hci.c:268: multiple definition of `hci_send_req'
E/workspace_1.4.0/HelloBLELED/Debug/./BLE/Common/ble_hci_tl_io_template.c:29: first defined here

```

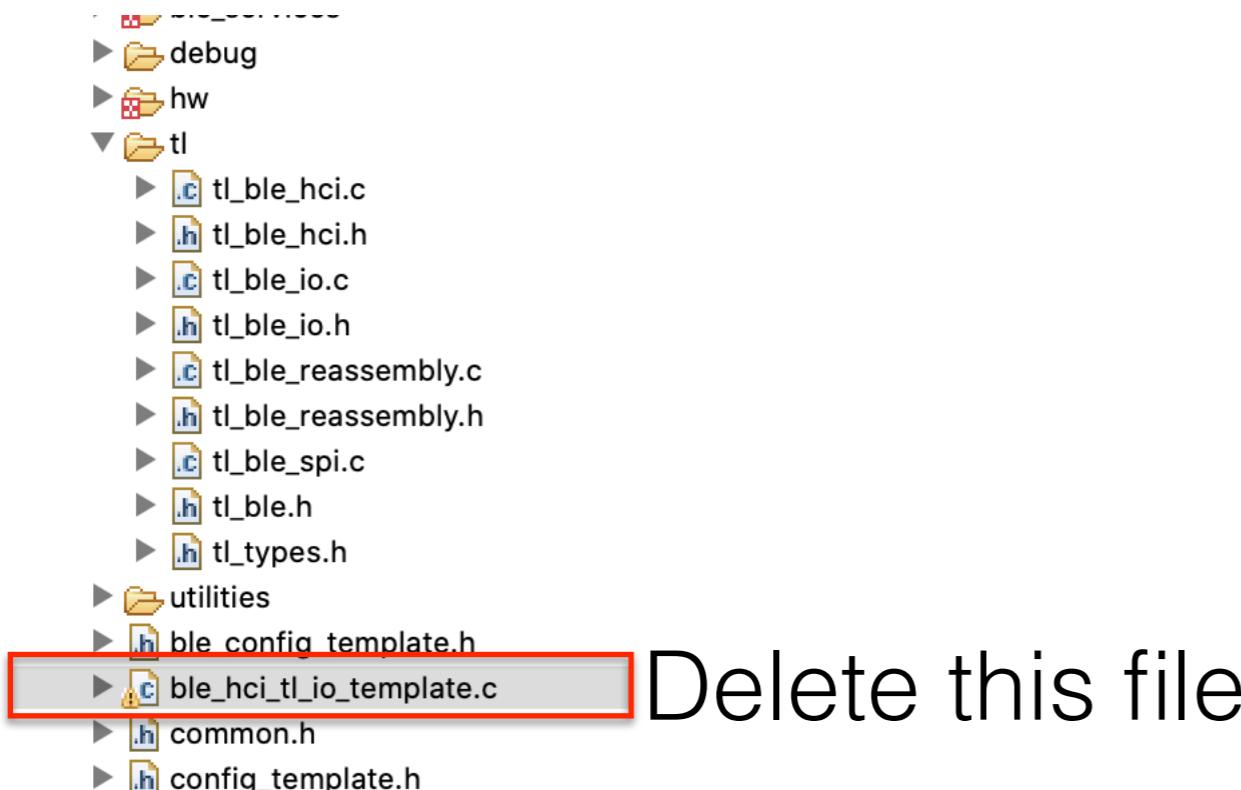


```
256     pCmdBuffer->cmdserial.cmd.plen = plen;
257     memcpy( pCmdBuffer->cmdserial.cmd.payload, param, plen );
258
259     TL_BLE_SendCmd();
260
261     return;
262 }
263
264
265
266 /* This API is imposed by the MW */
267 int32_t hci_send_req(struct hci_request *r, uint8_t async)
268 {
269     return ( TL_BLE_HCI_SendCmd( (TL_BLE_HCI_Cmd_t *)r ) );
multiple definition of `hci_send_req'
```



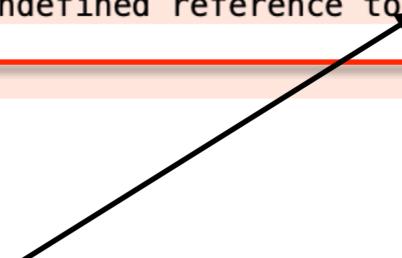
```
1/ ****
18 */
19
20 // Added
21 #include <stdint.h>
22
23 /* Function prototypes -----
24
25 /* HCI send request: generic API imposed by MW to the lower layers
multiple definition of `hci_send_req' depends by the applic, e.g.: spi, ipcc, etc
27
28 int32_t hci_send_req(struct hci_request *r, uint8_t async)
29 {
30     return 0;
31 }
```

Remove Template File



Linking Errors

```
error: undefined reference to 'HRS_Notification'  
error: undefined reference to 'HRS_Notification'  
error: undefined reference to 'HRS_Notification'  
error: undefined reference to 'LL_EXTI_EnableRisingTrig_0_31'  
error: undefined reference to 'LL_EXTI_EnableIT_0_31'  
error: undefined reference to 'LL_RCC_IsActiveFlag_PINRST'  
error: undefined reference to 'LL_RCC_ForceBackupDomainReset'  
error: undefined reference to 'LL_RCC_ReleaseBackupDomainReset'  
error: undefined reference to 'HAL_RTCEx_EnableBypassShadow'  
error: undefined reference to 'HAL_RTC_Init'  
[!] Error 1  
[!] Error 2. Build might be incomplete.
```

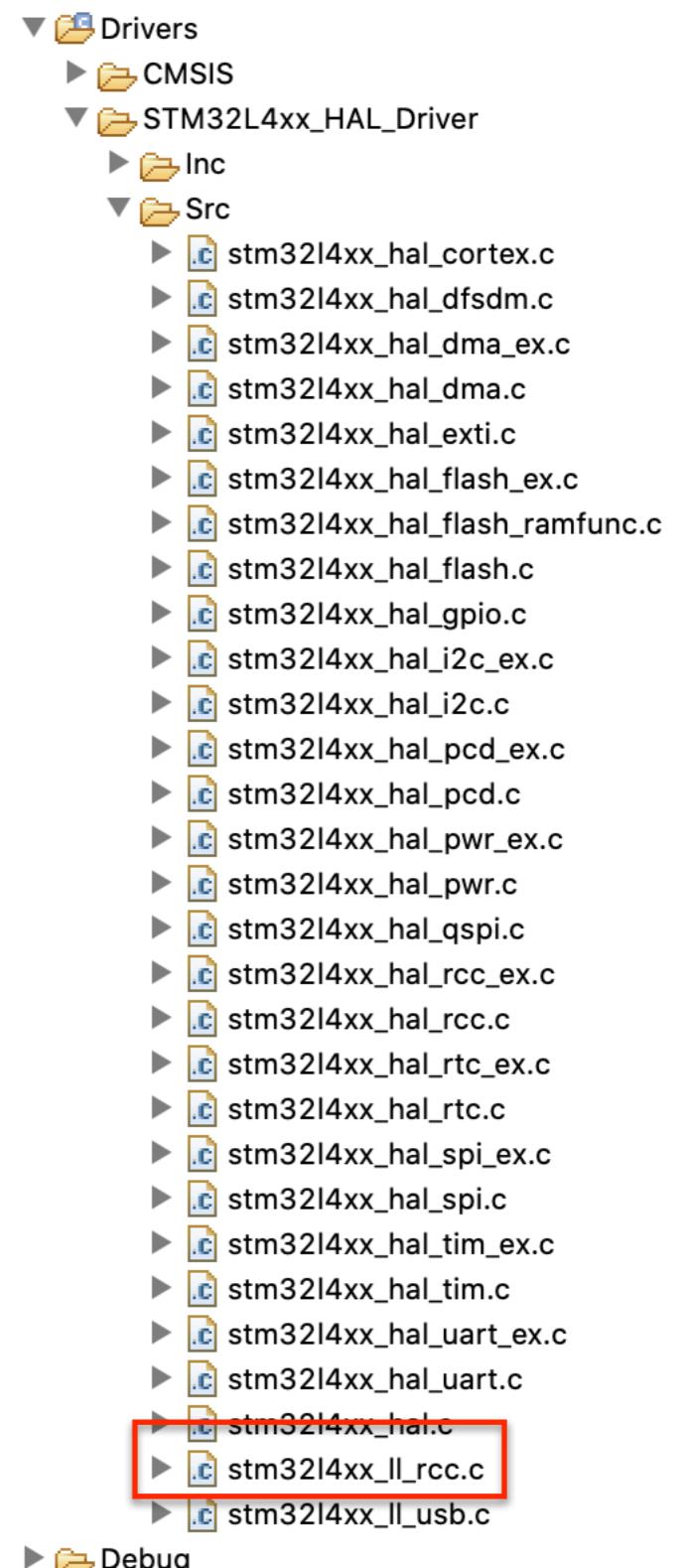
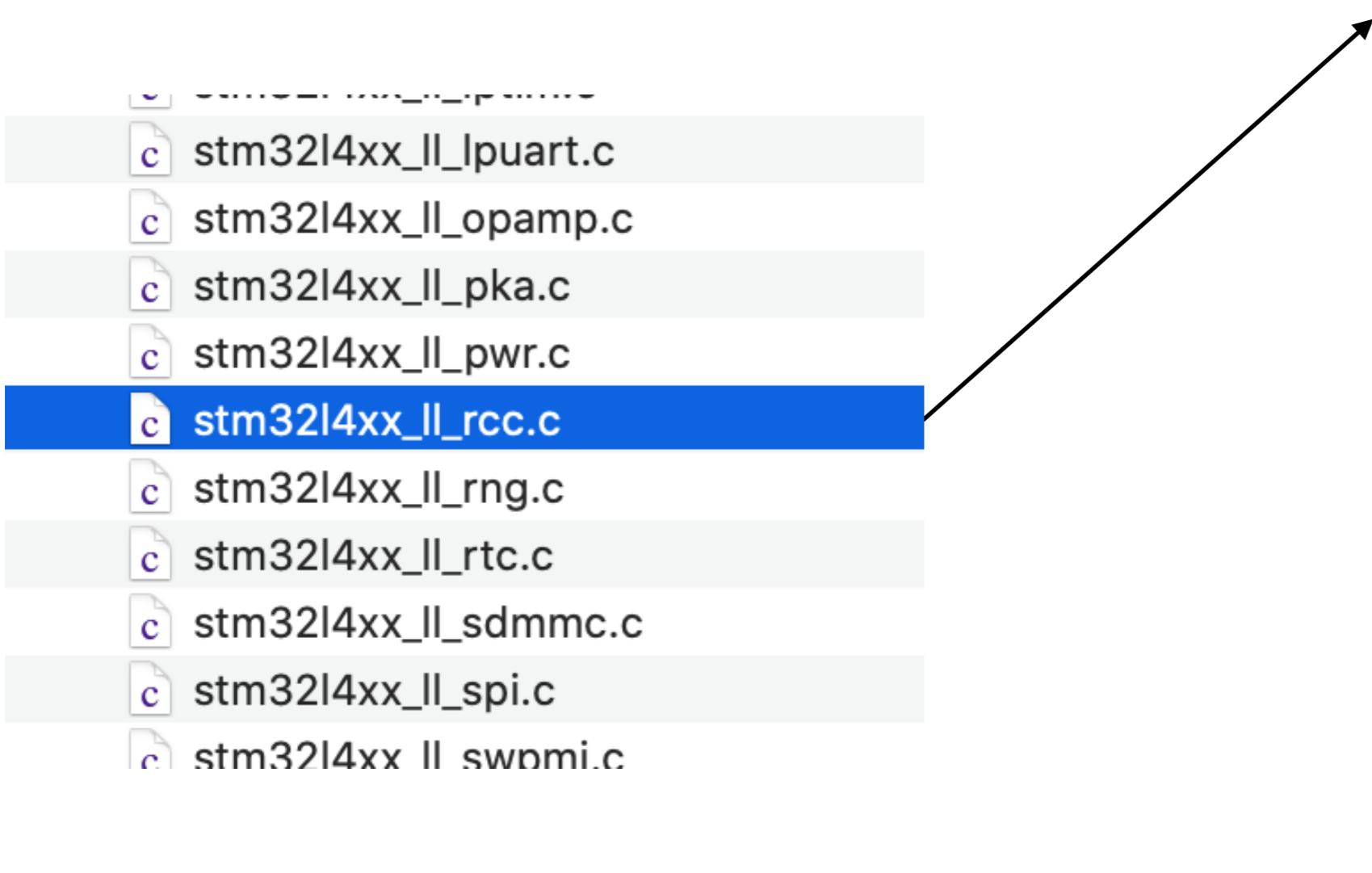


Missing HAL_RTC and LL_RCC .c files
(we added .h files but not .c files)

Copy Files



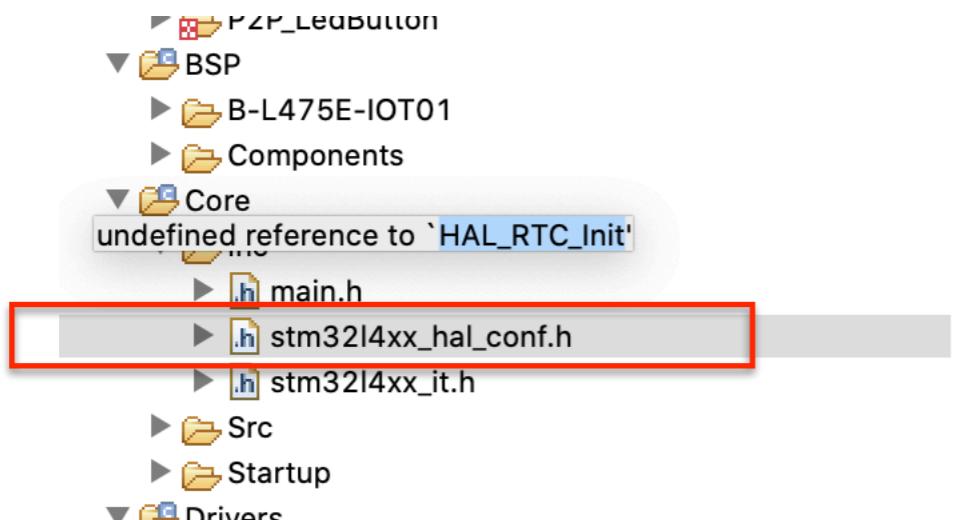
Copy Files



Search for HAL_RTC_Init

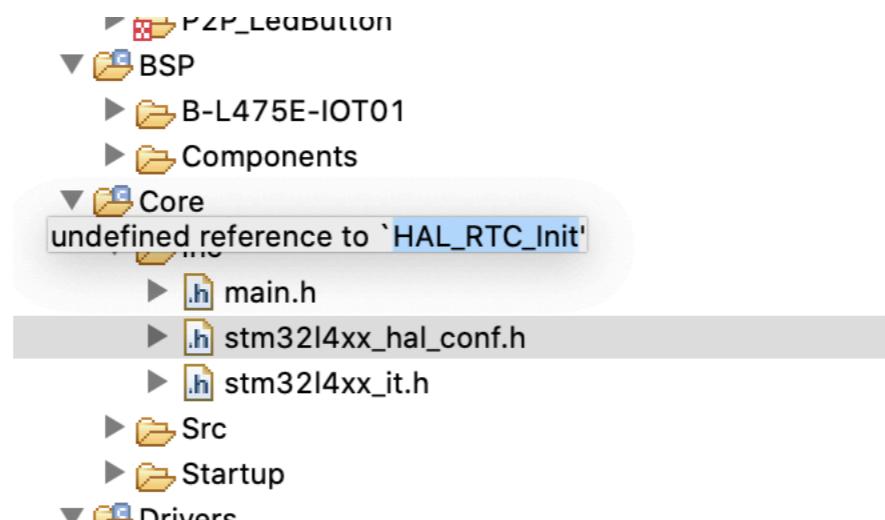
```
grep: HelloBLELED.: No such file or directory
Normans-MacBook-Air-674:workspace_1.4.0 nmcentire$ grep -r HAL_RTC_Init HelloBLELED/
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Inc/stm32l4xx_hal_rtc.h:HAL_StatusTypeDef HAL_RTC_Init(RTC_
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc.c:           format using the HAL_RTC_Ir
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc.c: By default, after the @ref HAL_RT
state is HAL_RTC_STATE_RESET,
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc.c: in the @ref HAL_RTC_Init()/@ref t
hen these calmultiple definition of `hci_send_req'
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc.c: If not, MspInit or MspDeInit are
_Init()/@ref HAL_RTC_DeInit()
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc.c: or @ref HAL_RTC_Init() function.
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc.c:HAL_StatusTypeDef HAL_RTC_Init(RTC_
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc_ex.c:           format using the HAL_RTC
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc_ex.c:           To output the selected R
_RTC_Init() function.
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc_ex.c:           (+) STM32L412xx and STM32L4
TC tamper configuration, you have to call HAL_RTC_Init() in order to
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc_ex.c:           (+) STM32L412xx and STM32L4
ling these functions you have to call HAL_RTC_Init() in order to
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc_ex.c:           HAL_RTC_Init() function.
HelloBLELED//Drivers/STM32L4xx_HAL_Driver/Src/stm32l4xx_hal_rtc_ex.c:           HAL_RTC_Init() function.
HelloBLELED//BLE/P2P_LedButton/Src/main.c: HAL_RTC_Init(&hrtc);
Binary file HelloBLELED//Debug/BLE/P2P_LedButton/Src/main.o matches
Normans-MacBook-Air-674:workspace_1.4.0 nmcentire$
```

RTC Module Not Enabled



```
67 /*#define HAL_QSPI_MODULE_ENABLED */  
68 #define HAL_QSPI_MODULE_ENABLED  
69 /*#define HAL RNG MODULE_ENABLED */  
70 #define HAL_RTC_MODULE_ENABLED */  
71 /*#define HAL_SAI_MODULE_ENABLED */  
72 /*#define HAL_SD_MODULE_ENABLED */  
73 /*#define HAL_SMBUS_MODULE_ENABLED */  
74 /*#define HAL_SMARTCARD_MODULE_ENABLED */  
75 #define HAL_SPI_MODULE_ENABLED  
76 /*#define HAL_SRAM_MODULE_ENABLED */  
77 /*#define HAL_SWPMI_MODULE_ENABLED */  
78 /*#define HAL_TIM_MODULE_ENABLED */  
79 /*#define HAL_TSC_MODULE_ENABLED */  
80 /*#define HAL_VREF_MODULE_ENABLED */
```

Change to this.



```
62  /*#define HAL_OPAMP_MODULE_ENABLED */  
63  /*#define HAL_OSPI_MODULE_ENABLED */  
64  /*#define HAL_OSPI_MODULE_ENABLED */  
65  #define HAL_PCD_MODULE_ENABLED  
66  /*#define HAL_PKA_MODULE_ENABLED */  
67  /*#define HAL_QSPI_MODULE_ENABLED */  
68  #define HAL_QSPI_MODULE_ENABLED  
69  /*#define HAL_RNG_MODULE_ENABLED */  
70  #define HAL_RTC_MODULE_ENABLED  
71  /*#define HAL_SAI_MODULE_ENABLED */  
72  /*#define HAL_SD_MODULE_ENABLED */  
73  /*#define HAL_SMBUS_MODULE_ENABLED */  
74  /*#define HAL_SMARTCARD_MODULE_ENABLED */  
75  #define HAL_SRT_MODULE_ENABLED
```

Attempt Build

```
arm-none-eabi-gcc "../BLE/Common/ble_core/bluenrg_l2cap_aci.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DBLUENRG_MS -DDEBUG -DSTM32L475xx -c -I../Core  
arm-none-eabi-gcc "../BLE/Common/ble_core/hci_le.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DBLUENRG_MS -DDEBUG -DSTM32L475xx -c -I../Core/Inc -I../D  
arm-none-eabi-gcc -o "HelloBLELED.elf" @objects.list" -mcpu=cortex-m4 -T"/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/STM32L475VGTX_FLASH.ld"  
BLE/Common/ble_services/hrs.o: In function `HearRate_Event_Handler':  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/ble_services/hrs.c:123: undefined reference to `HRS_Notification'  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/ble_services/hrs.c:155: undefined reference to `HRS_Notification'  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/ble_services/hrs.c:160: undefined reference to `HRS_Notification'  
BLE/Common/hw/hw_timerserver.o: In function `HW_TS_Init':  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/hw/hw_timerserver.c:600: undefined reference to `LL_EXTI_EnableRisingTrig_0_31'  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/hw/hw_timerserver.c:601: undefined reference to `LL_EXTI_EnableIT_0_31'  
BLE/P2P_LedButton/Src/main.o: In function `main':  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/P2P_LedButton/Src/main.c:92: undefined reference to `LL_RCC_IsActiveFlag_PINRST'  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/P2P_LedButton/Src/main.c:104: undefined reference to `LL_RCC_ForceBackupDomainReset'  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/P2P_LedButton/Src/main.c:106: undefined reference to `LL_RCC_ReleaseBackupDomainReset'  
collect2: error: ld returned 1 exit status  
make: *** [makefile:82: HelloBLELED.elf] Error 1  
"make -j3 all" terminated with exit code 2. Build might be incomplete.
```

HAL_RTC errors resolved.
Next to resolve LL_RCC errors.

Add Header File

The image shows a file explorer on the left and a code editor on the right. The file explorer lists several header files and source files. A red box highlights the 'main.c' file in the 'Src' folder. The code editor shows the content of 'main.c' with a specific line highlighted by a red box.

File Explorer:

- lb_client_app.h
- lb_demo.h
- lb_server_app.h
- stm32l4xx_hal_conf.h
- stm32l4xx_it.h
- Src
 - lb_client_app.c
 - lb_demo.c
 - lb_server_app.c
 - main.c**
 - stm32l4xx_it.c
 - system_stm32l4xx.c
- SW4STM32
- readme.txt

Code Editor (main.c):

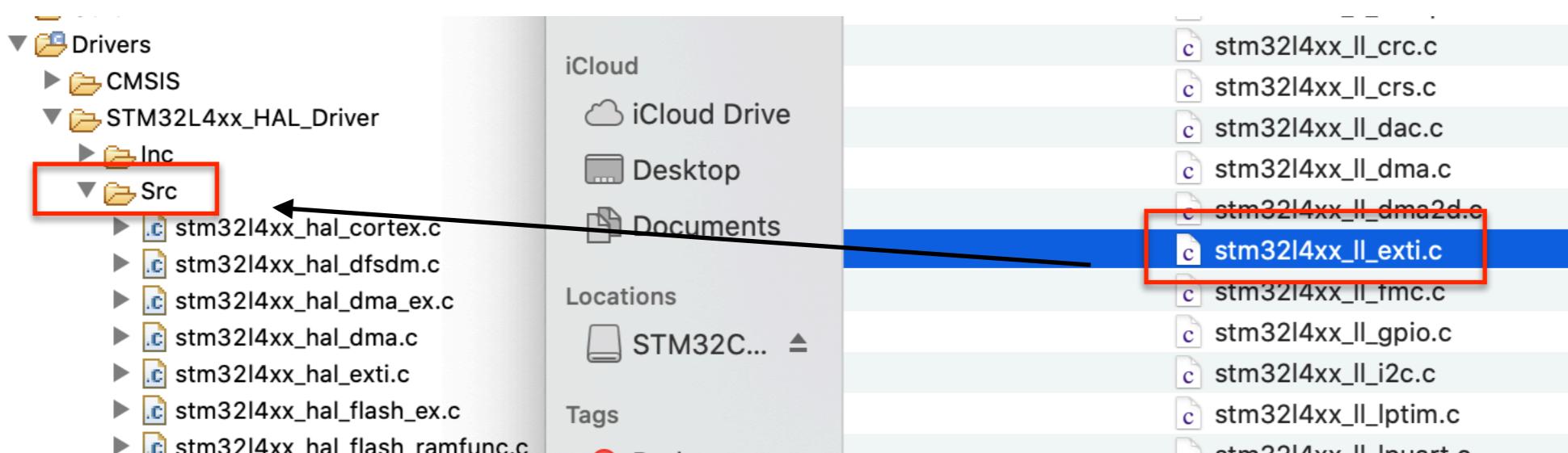
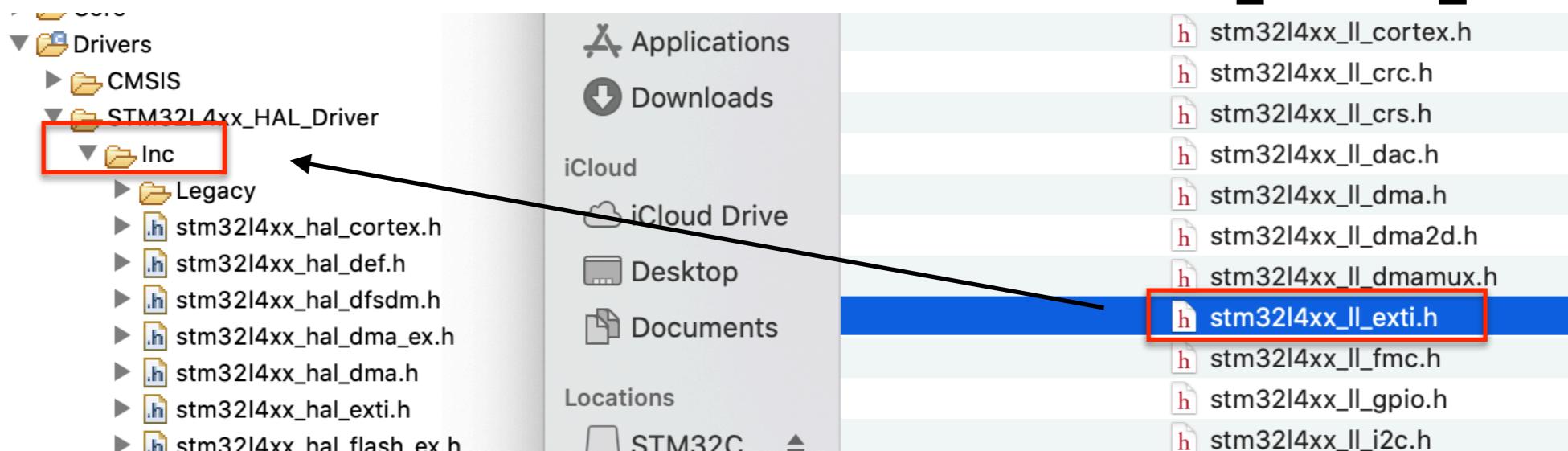
```
28 #include "tl_types.h"
29 #include "tl_ble_reassembly.h"
30 #include "tl_ble_hci.h"
31 #include "lb_server_app.h"
32 #include "stm32l475e_iot01.h"
33
34 #include "stm32l4xx_ll_rcc.h" // Line 34, highlighted with a red box
35
36
37 /**
38 * In order to support the Standby M
39 * In the STM32L4, the SRAM2 is used
40 * The section below identified the
41 * This section is mapped in the SRA
42 * All variables which content shall
multiple definition of `hci_send_req'
43 * The same section could be defined
44 * and will then be mapped in the SRAM2 in the
45 *
```

Attempt Build

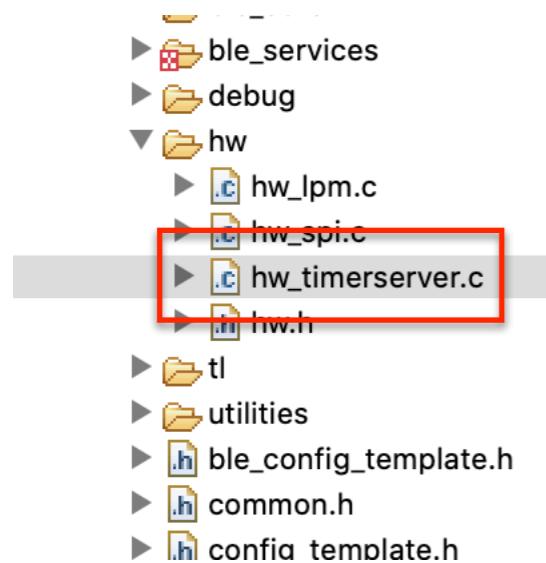
```
gcc ..../BLE/P2P_LedButton/Src/main.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DBLUENRG_MS -DDEBUG -DSTM32L475xx -c -I..../Core/Inc -I..../Dri
gcc -o "HelloBLELED.elf" "@objects.list" -mcpu=cortex-m4 -T"/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/STM32L475VGTX_FLASH.ld" --
_services/hrs.o: In function `HearRate_Event_Handler':
re/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/ble_services/hrs.c:123: undefined reference to `HRS_Notification'
re/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/ble_services/hrs.c:155: undefined reference to `HRS_Notification'
re/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/ble_services/hrs.c:160: undefined reference to `HRS_Notification'
hw_timerserver.o: In function `HW_TS_Init':
re/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/hw/hw_timerserver.c:600 undefined reference to `LL_EXTI_EnableRisingTrig_0_31'
re/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/hw/hw_timerserver.c:601 undefined reference to `LL_EXTI_EnableIT_0_31'
r: ld returned 1 exit status
efile:82: HelloBLELED.elf] Error 1
terminated with exit code 2. Build might be incomplete.
```

Copy Files

stm32l4xx_ll_exti.[hc]



Add Header File



```
15  * http://www.st.com/SLA004
16  *
17  ****
18  */
19
20 /* Includes -----
21 #include "common.h"
22 #include "hw.h"
23
24 #include "stm32l4xx_ll_exti.h"
25
26 /* Private typedef -----
27 @typedef enum
28 {
29     TimerID_Free,
```

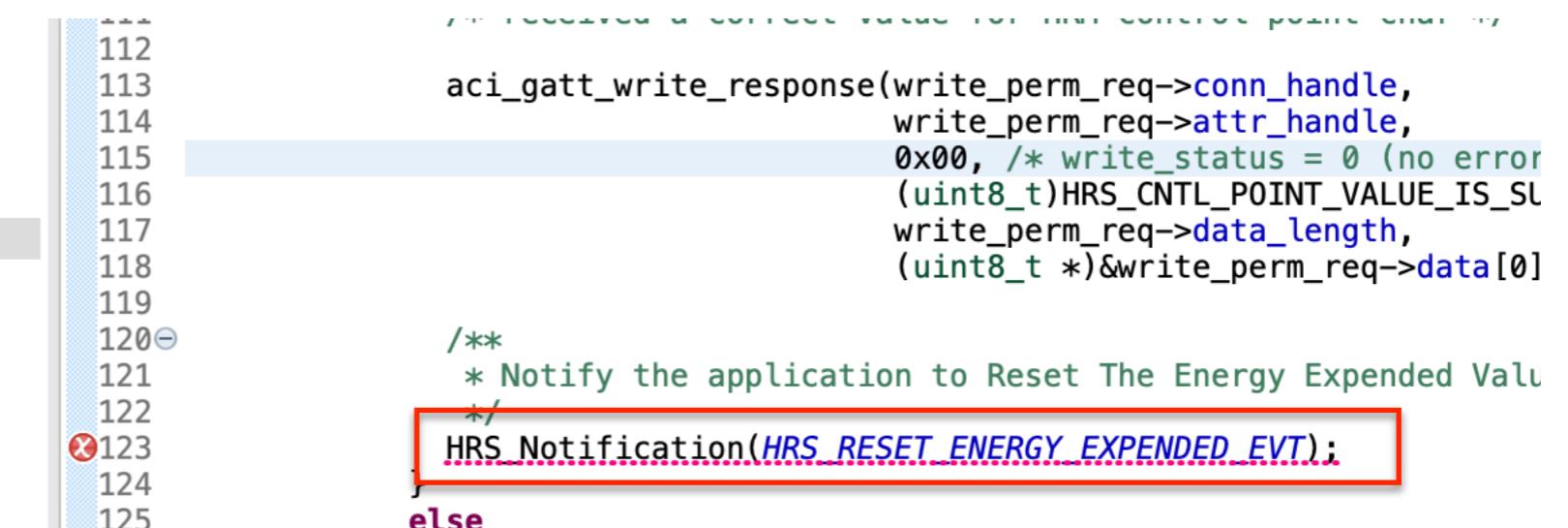
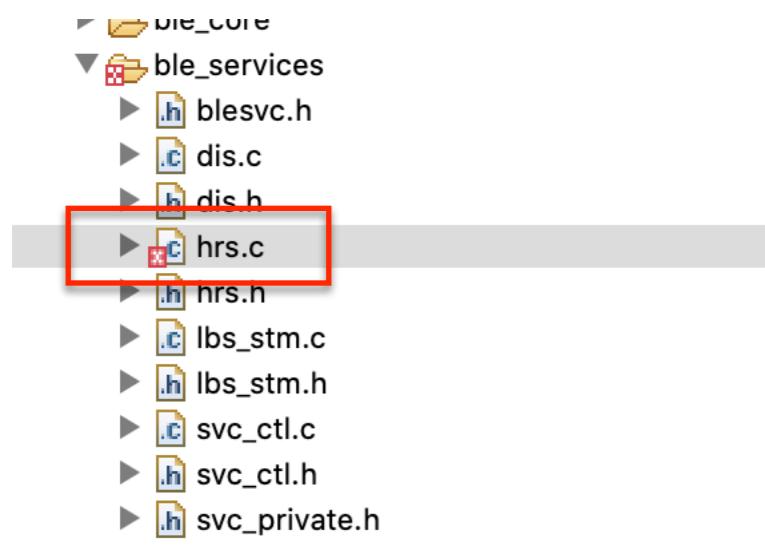
Attempt Build

```
CDT Build Console [HelloBLELED]
11:13:35 **** Incremental Build of configuration Debug for project HelloBLELED ****
make -j3 all
arm-none-eabi-gcc "../BLE/Common/hw/hw_timerserver.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DBLUENRG_MS -DDEBUG -DSTM32L475xx -c -I../Co
arm-none-eabi-gcc -o "HelloBLELED.elf" @"objects.list" -mcpu=cortex-m4 -T"/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/STM32L475VGTX_
BLE/Common/ble_services/hrs.o: In function `HearRate_Event_Handler':
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/ble_services/hrs.c:123: undefined reference to `HRS_Notification'
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/ble_services/hrs.c:155: undefined reference to `HRS_Notification'
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLELED/Debug/../BLE/Common/ble_services/hrs.c:160: undefined reference to `HRS_Notification'
collect2: error: ld returned 1 exit status
make: *** [makefile:82: HelloBLELED.elf] Error 1
"make -j3 all" terminated with exit code 2. Build might be incomplete.

11:13:37 Build Failed. 4 errors, 0 warnings. (took 1s.948ms)
```

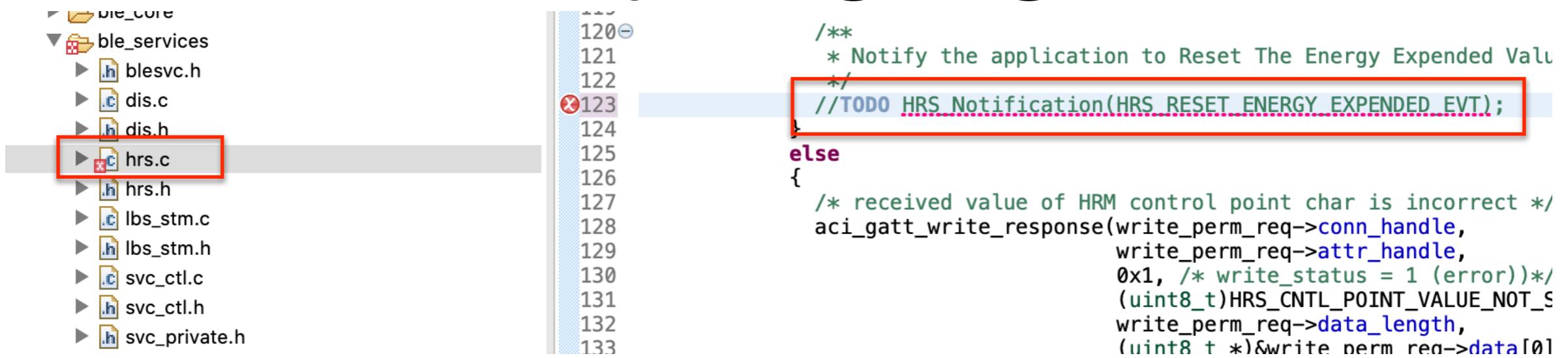
No code for HRS_Notification!

```
[Normans-MacBook-Air-674:workspace_1.4.0 nmcentire]$ grep -r HRS_Notification HelloBLELED/
HelloBLELED//BLE/Common/ble_services/hrs.h: void HRS_Notification(HRS_NotCode_t notification);
HelloBLELED//BLE/Common/ble_services/hrs.c:           HRS_Notification(HRS_RESET_ENERGY_EXPENDED_EVT);
HelloBLELED//BLE/Common/ble_services/hrs.c:           HRS_Notification(HRS_NOTIFICATION_ENABLED);
HelloBLELED//BLE/Common/ble_services/hrs.c:           HRS_Notification(HRS_NOTIFICATION_DISABLED);
Binary file HelloBLELED//Debug/BLE/Common/ble_services/hrs.o matches
```

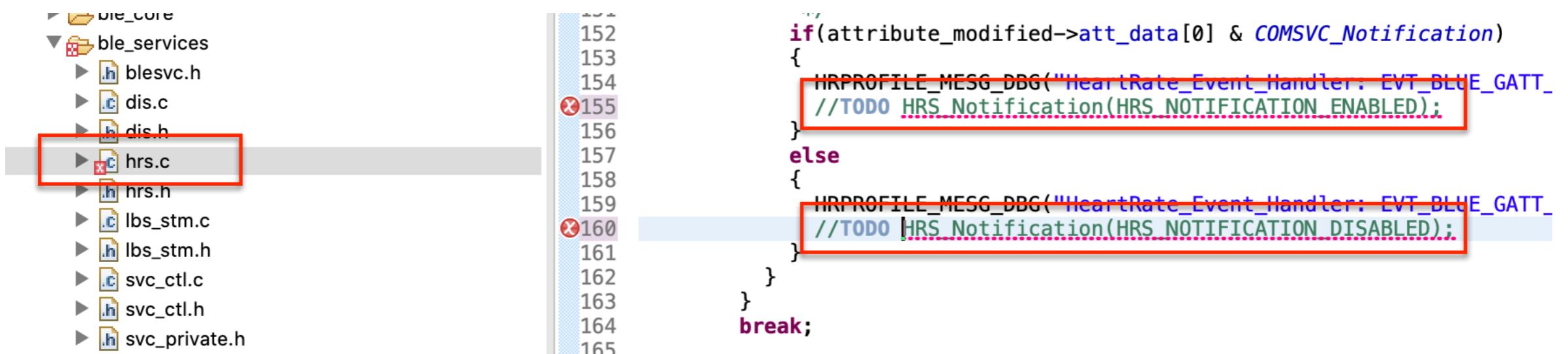


```
112
113
114
115 aci_gatt_write_response(write_perm_req->conn_handle,
116                               write_perm_req->attr_handle,
117                               0x00, /* write_status = 0 (no error)
118                               (uint8_t)HRS_CNTL_POINT_VALUE_IS_SL
119                               write_perm_req->data_length,
120                               (uint8_t *)&write_perm_req->data[0]
121
122 /**
123 * Notify the application to Reset The Energy Expended Value
124 */
125 HRS_Notification(HRS_RESET_ENERGY_EXPENDED_EVT);
```

For now comment out code With TODO



```
120    /**
121     * Notify the application to Reset The Energy Expended Value
122     */
123 //TODO HRS_Notification(HRS_RESET_ENERGY_EXPENDED_EVT);
124
125 else
126 {
127     /* received value of HRM control point char is incorrect */
128     aci_gatt_write_response(write_perm_req->conn_handle,
129                             write_perm_req->attr_handle,
130                             0x1, /* write_status = 1 (error) */
131                             (uint8_t)HRS_CNTL_POINT_VALUE_NOT_SUPPORTED);
132     write_perm_req->data_length,
133     (uint8_t *)write_perm_req->data[0];
}
```



```
152
153
154
155 if(attribute_modified->att_data[0] & COMSVC_Notification)
156 {
157     HRP PROFILE_MESG_DBG("HeartRate_Event_Handler: EVT_BLUE_GATT_NOTIFICATION");
158 //TODO HRS_Notification(HRS_NOTIFICATION_ENABLED);
159 }
160 else
161 {
162     HRP PROFILE_MESG_DBG("HeartRate_Event_Handler: EVT_BLUE_GATT_NOTIFICATION");
163 //TODO HRS_Notification(HRS_NOTIFICATION_DISABLED);
164 }
165 break;
```

FINALLY!

```
CDT Build Console [HelloBLELED]
    text      data      bss      dec      hex filename
  25260        32     4304    29596    739c HelloBLELED.elf
Finished building: default.size.stdout

Finished building: HelloBLELED.bin

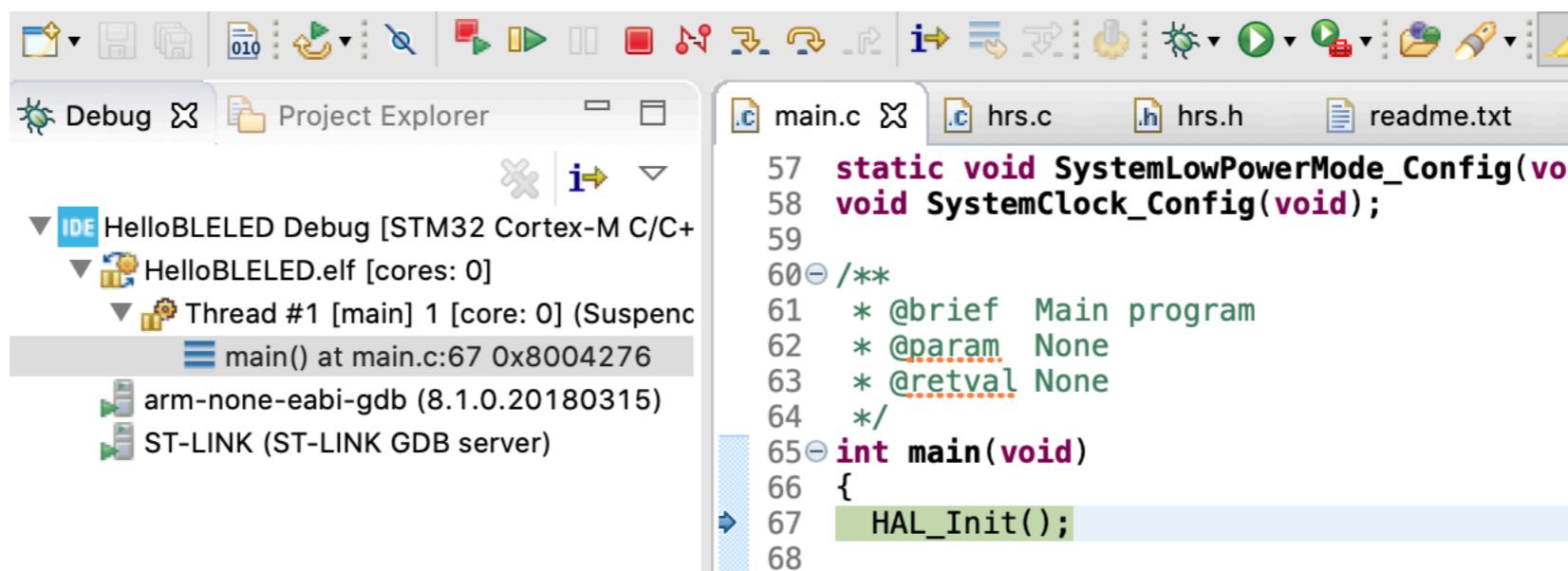
Finished building: HelloBLELED.list

11:28:23 Build Finished. 0 errors, 0 warnings. (took 2s.75ms)
```

Default Code Runs As Server (Central)

```
--  
43@ *****/  
44 * LB CONFIGURATION //Routeur or End Dev 1 or End Dev 2  
45 *****/  
46  
47 #define LB_CLIENT 0 /*1 = Device is GAP Central & GATT Client */  
48 #define LB_SERVER 1 /*1 = Device is GAP Peripherique & GATT SERVER*/  
49
```

Start Code Running



The screenshot shows a debugger interface with the following details:

- Project Explorer:** Shows a project named "HelloBLELED" with a sub-project "HelloBLELED.elf" containing a thread "Thread #1 [main]".
- Code Editor:** Displays the "main.c" file with the following code:

```
57 static void SystemLowPowerMode_Config(void);
58 void SystemClock_Config(void);
59
60 /**
61 * @brief Main program
62 * @param None
63 * @retval None
64 */
65 int main(void)
66 {
67     HAL_Init();
```
- Status Bar:** Shows the line numbers 57 through 68.

Heart Rate Monitor

Heart Rate ReadMe

This application shows how to use BLE component for HeartRate profile application.

The STM32 B-L475E-IOT01A Discovery board acts as GATT server.

Once the code is downloaded on the STM32 B-L475E-IOT01A Discovery board and executed, the modules are initialized and the device starts advertising.

The user needs an application (running for example on smartphone) in order to act as GATT client.

ST provides the following application (STM32 BLE Profiles):

<https://play.google.com/store/apps/details?id=com.stm.bluetoothlevalidation>

Tip:

To quickly download and launch the "STM32 BLE Profiles" application the NFC tag can be used.

By executing the NFC example (available in /Applications/NFC/WrAARtoRunBLEapp/) the NFC EEPROM is programmed (and it remains programmed) such that, each time the smartphone approaches the NFC antenna, the "STM32 BLE Profiles" application is automatically launched on the smartphone.

The user should activate Bluetooth Smart, execute such application, and SCAN for Bluetooth devices.

The device HR_L475_IoT will be detected.

The user should connect the smartphone to the STM32 B-L475E-IOT01A.

The presence of HeartRate profile should be detected by the smartphone application.

The user should click on the Heart Rate profile (this depends on the smartphone application used).

In general any smartphone application should allow the user to see the heart Rate measurement.

STM32 BLE Profiles smartphone application displays and expresses them in BPM (beat per minute).

In this example HR_L475_IoT Discovery sends dummy values each second.

The STM32 B-L475E-IOT01A example supports the full feature of Heart Rate Service as from specification

https://www.bluetooth.com/specifications/gatt/viewer?attributeXmlFile=org.bluetooth.service.heart_rate.xml
i.e. it provides other information like the sensor location and by writing 0x1 to the Heart Rate Control point the Energy Expanded field is reset.

STM32 BLE Profiles smartphone application does not support these options but other smartphone applications can be found on the internet and used to test these features.

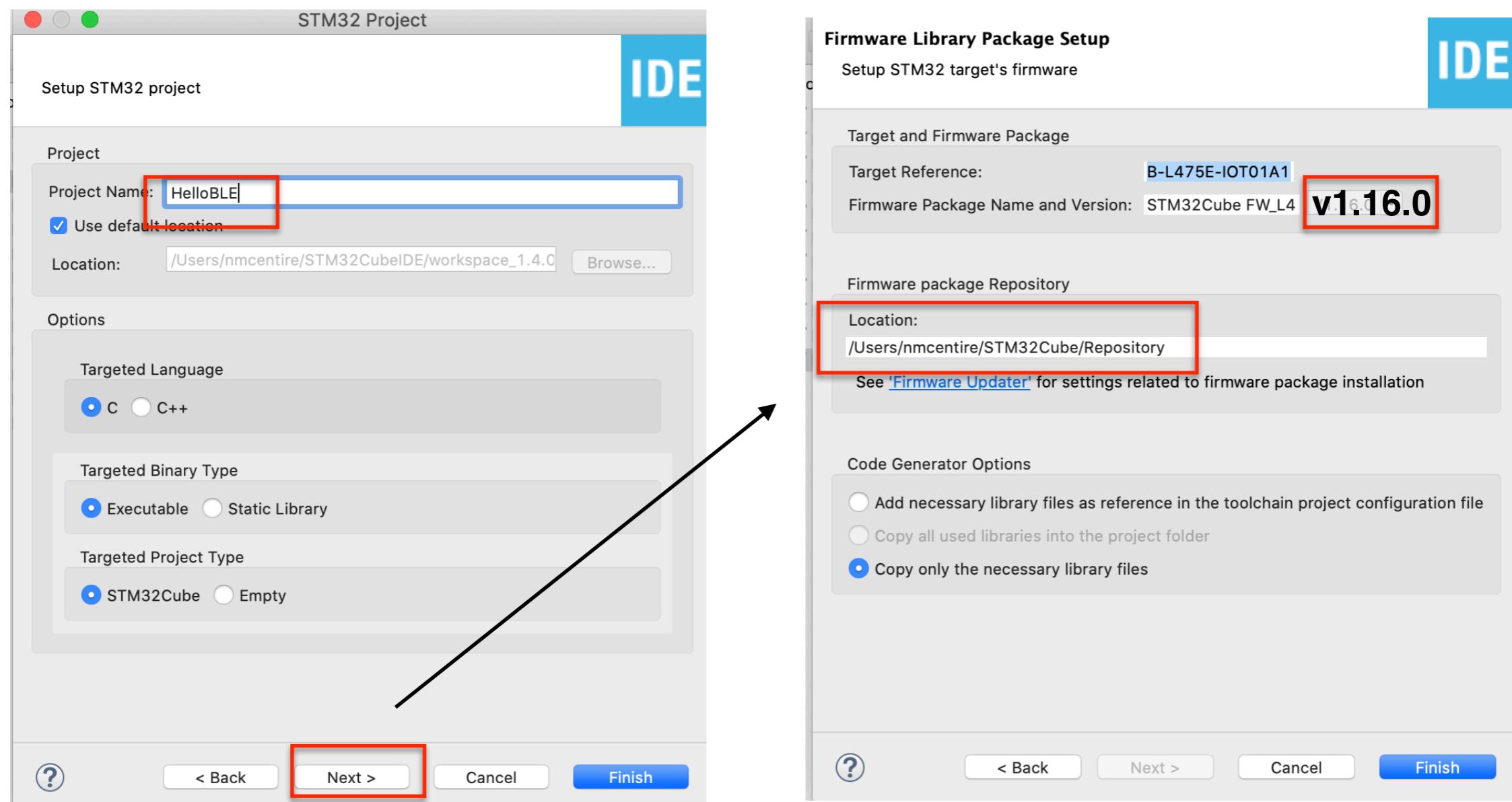
Heart Rate README

Part 2

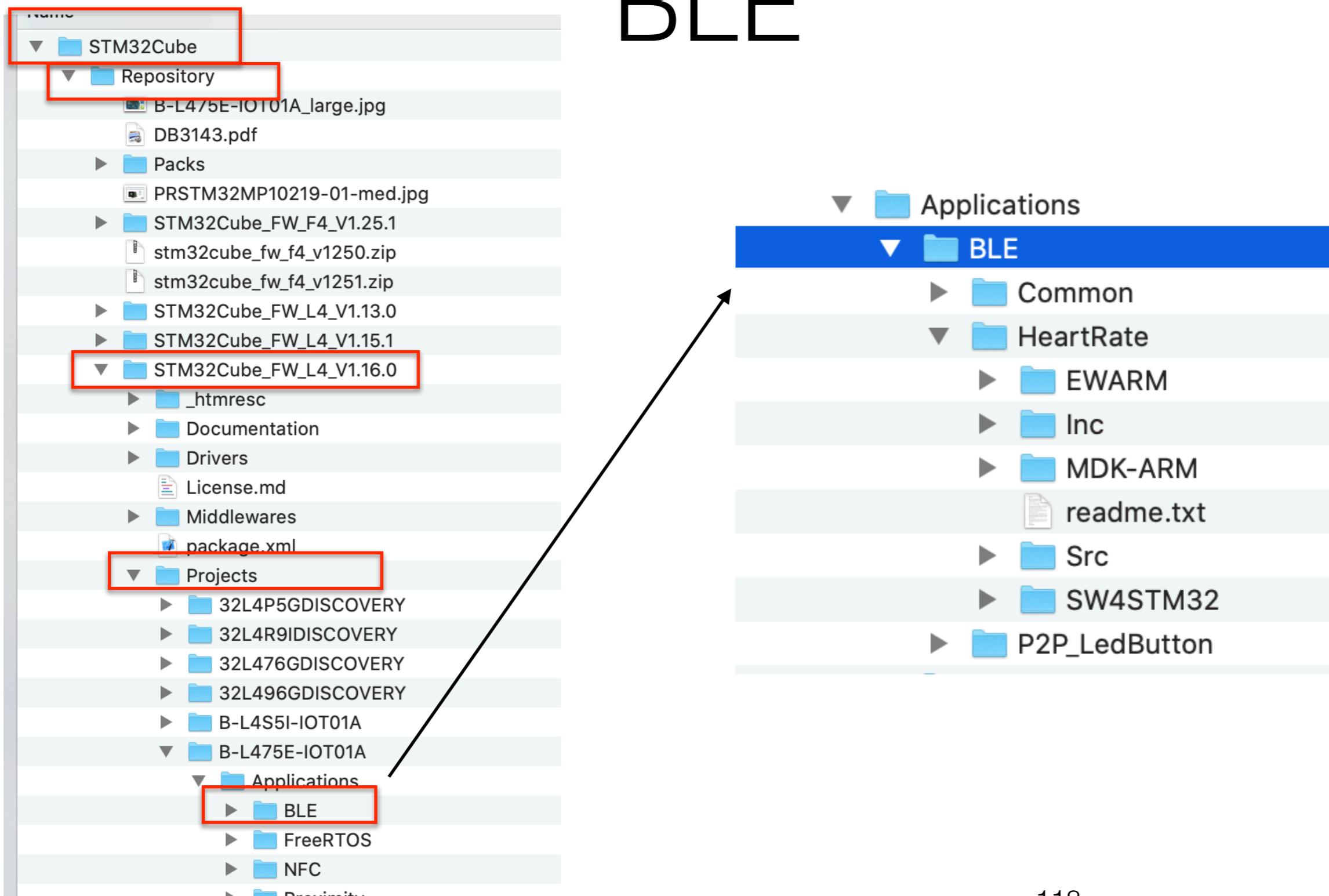
- BLE/HeartRate/Src/main.c
- BLE/HeartRate/Src/system_stm32l4xx.c
- BLE/HeartRate/Src/stm32l4xx_it.c
- BLE/HeartRate/Src/hr.c
- BLE/HeartRate/Src/hrs_app.c
- BLE/HeartRate/Src/dis_app.c
- BLE/HeartRate/Inc/config.h
- BLE/HeartRate/Inc/stm32l4xx_hal_conf.h
- BLE/HeartRate/Inc/stm32l4xx_it.h
- BLE/HeartRate/Inc/hr.h
- BLE/HeartRate/Inc/hrs_app.h
- BLE/HeartRate/Inc/dis_app.h
- BLE/Common/
- BLE/Common/ble_core/*.*
- BLE/Common/ble_services/*.*
- BLE/Common/debug/*.*
- BLE/Common/tl/*.*
- BLE/Common/hw/*.*
- BLE/Common/utilities/*.*

Main Program
STM32L4xx system clock configuration file
STM32 interrupt handlers
Heart Rate application
Heart Rate Service Application
Device Information Service Application
Application configuration file
HAL configuration file
STM32 interrupt handlers header file
Exported files and function of hr.c
Exported files and function of hrs_app.c
Exported files and function of dis_app.c
These files are Common also to other applic/examples then HeartRate
BlueNRG-MS Bluetooth Low Energy device driver
GATT services according to BLE spec
Code useful for debugging (DBG should be activated in config.h)
HCI layer and SPI protocol
HW board and device dependencies (SPI pins, timeserver, low power)
Scheduler, memory/queue/fifo/list management, otp, etc

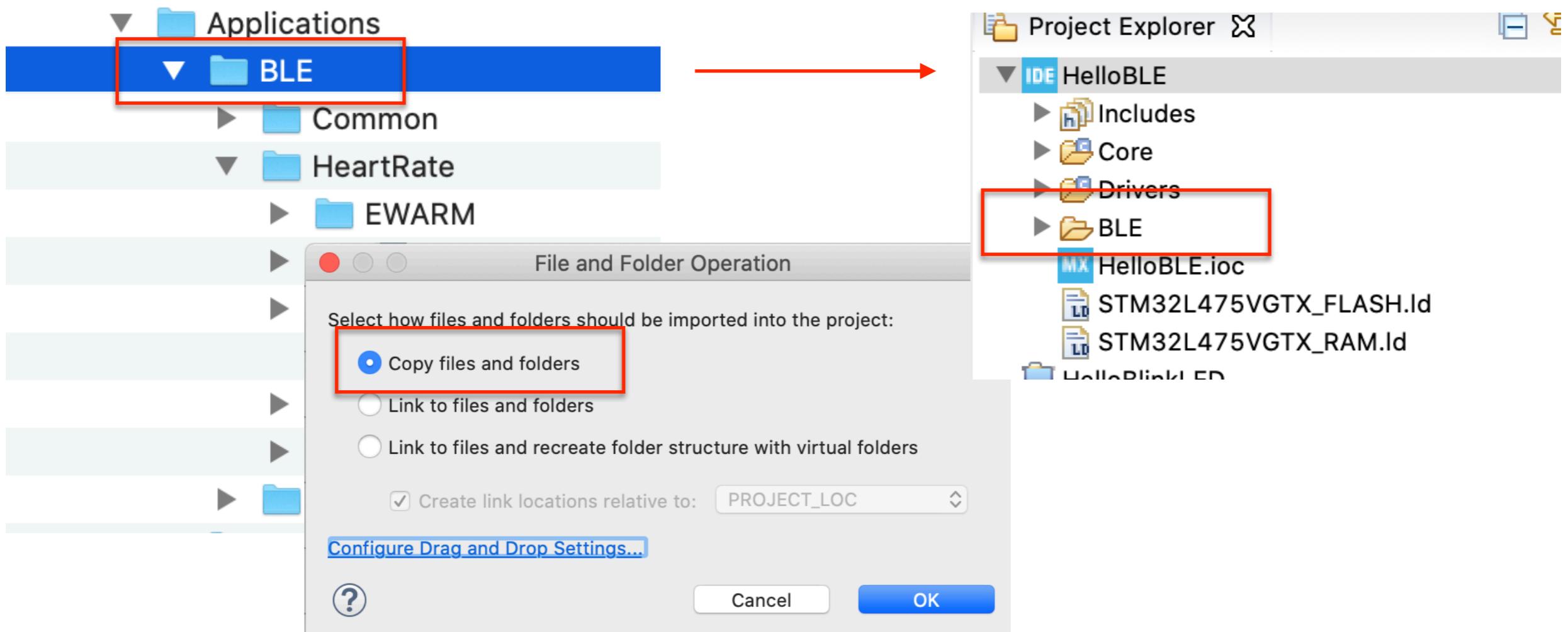
Create New Project (And Find Location of Repository)



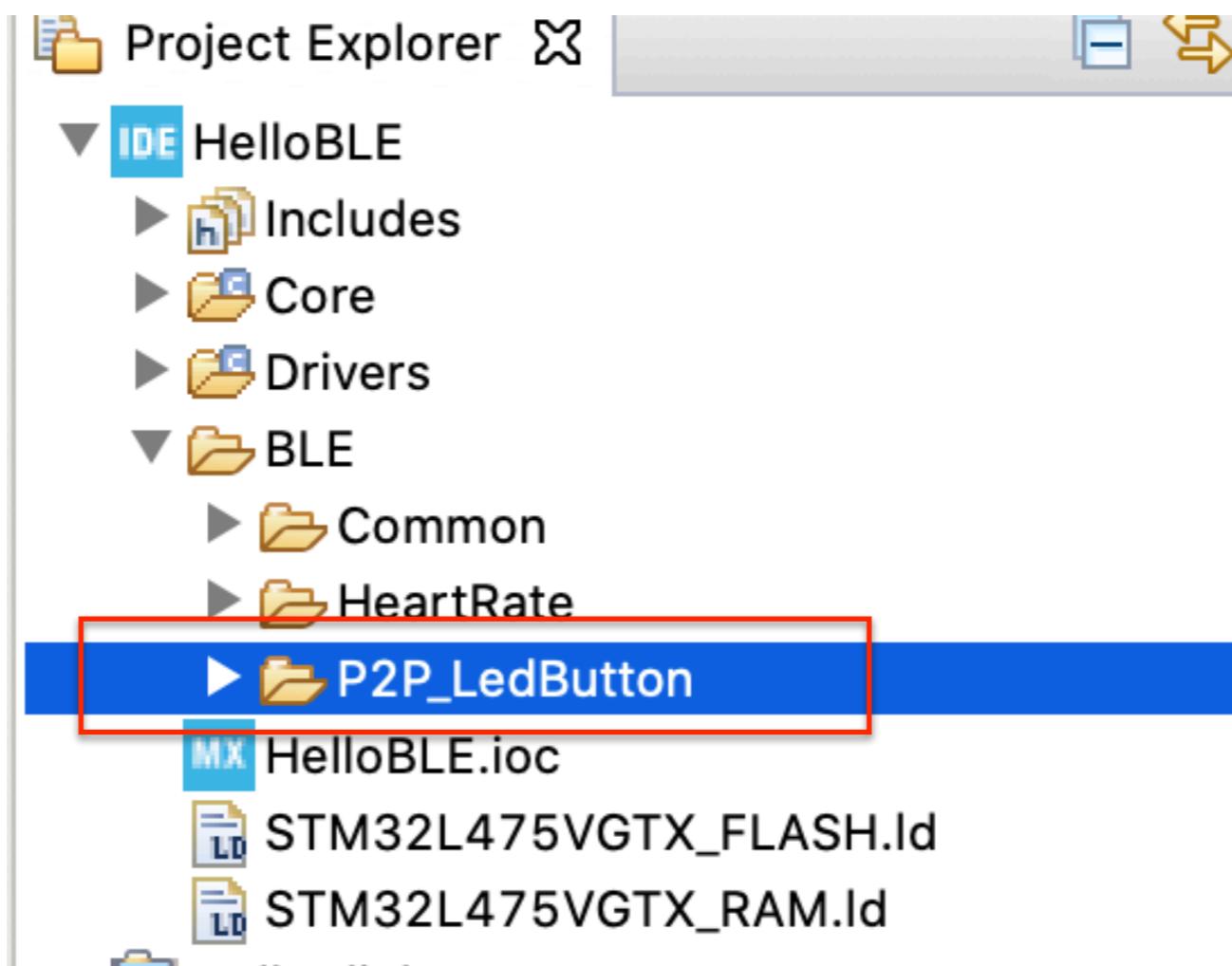
Projects/B-L475E-IOT01A/ BLE



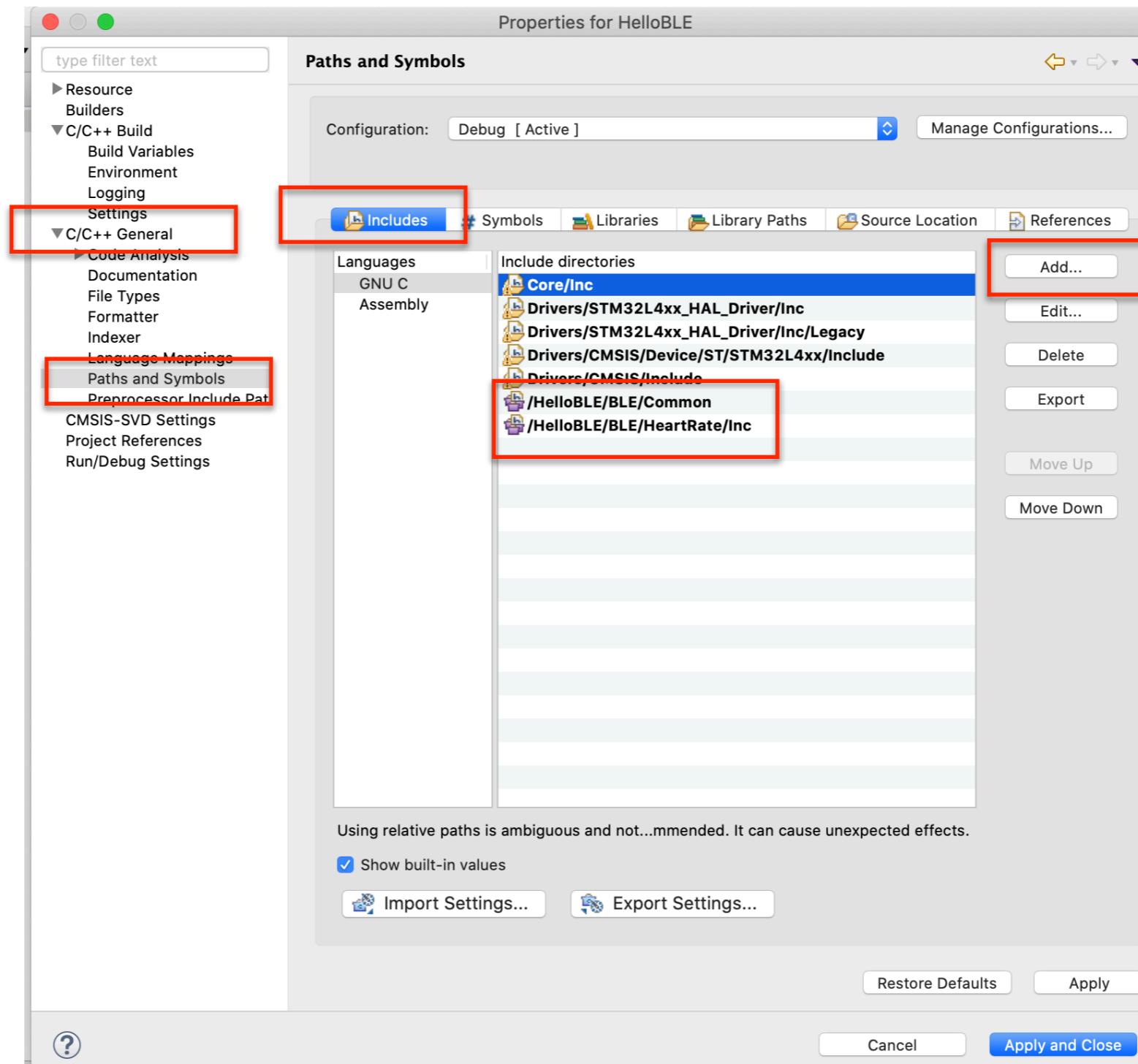
BLE Folder Drag/Drop (COPY FILES)



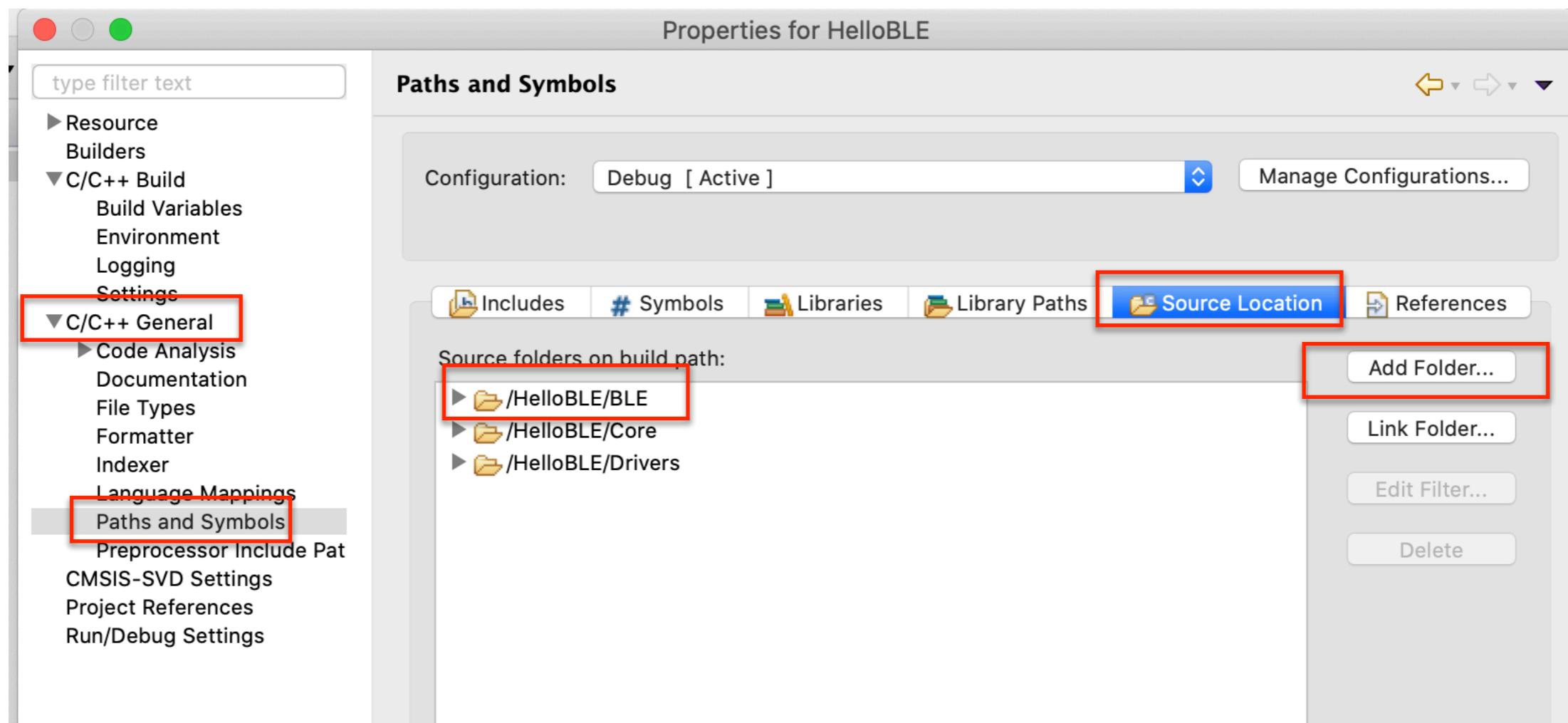
Delete P2P_LedButton Folder



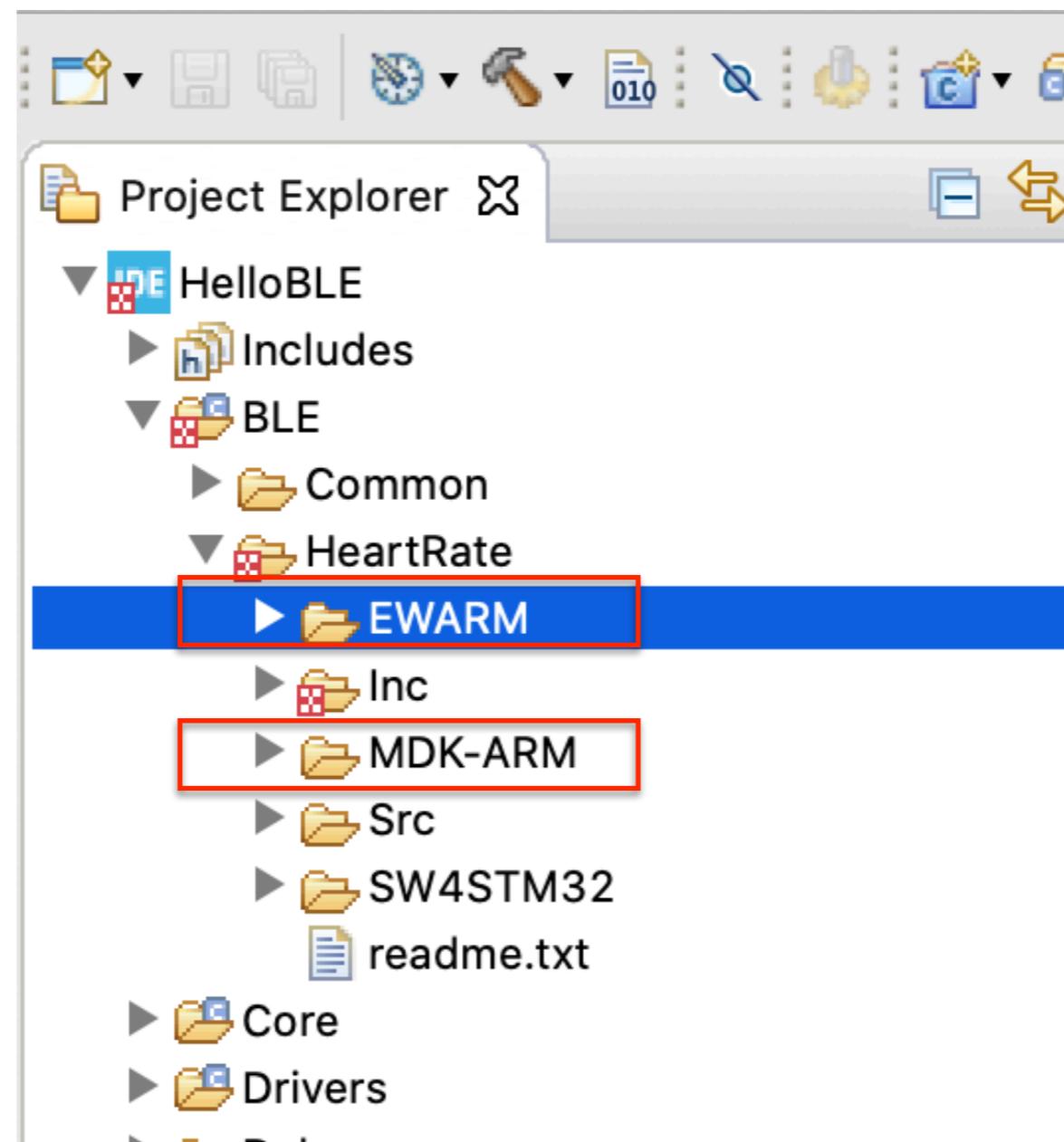
Add Include Paths To Project Properties



Add Source Paths To Project Properties

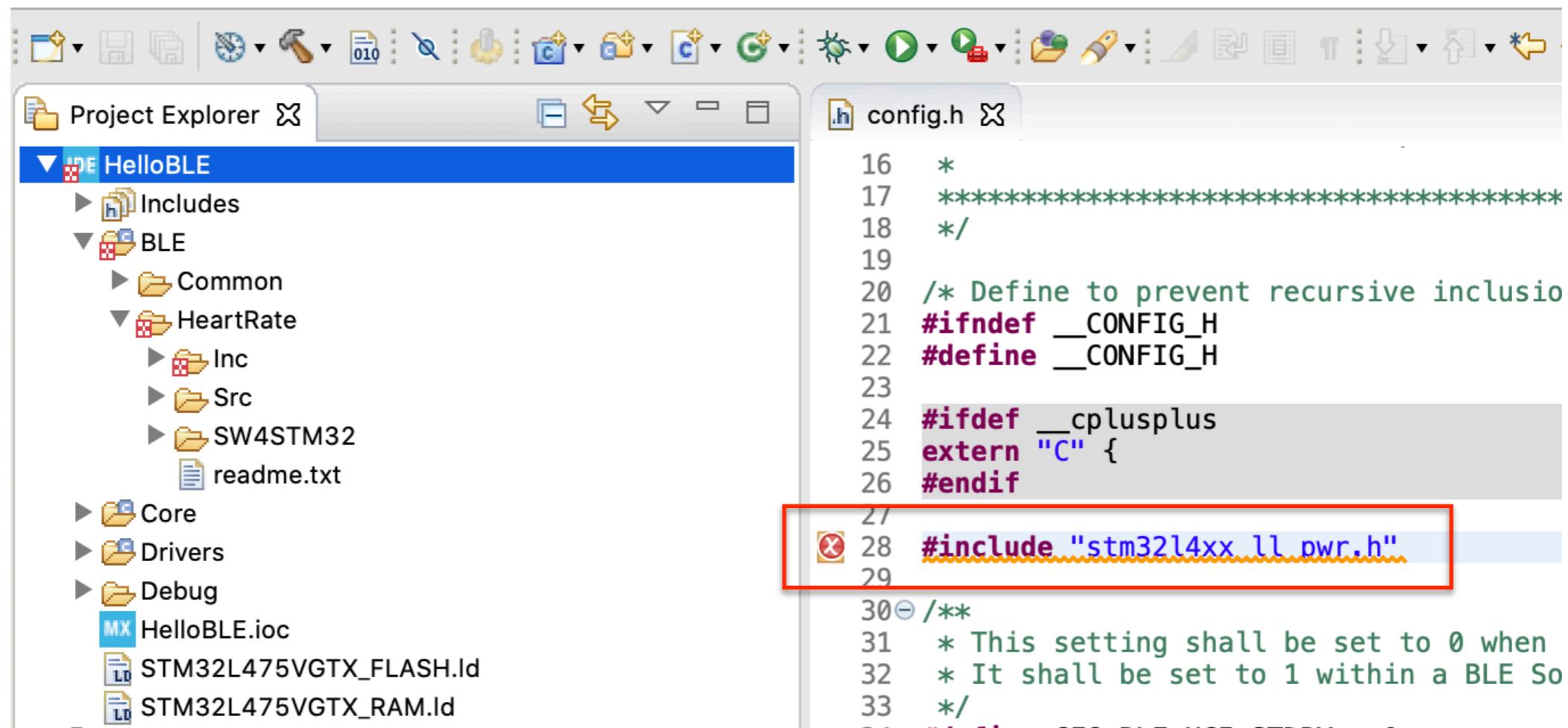


Delete Folders EWARM and MDK-ARM



First Build Attempt

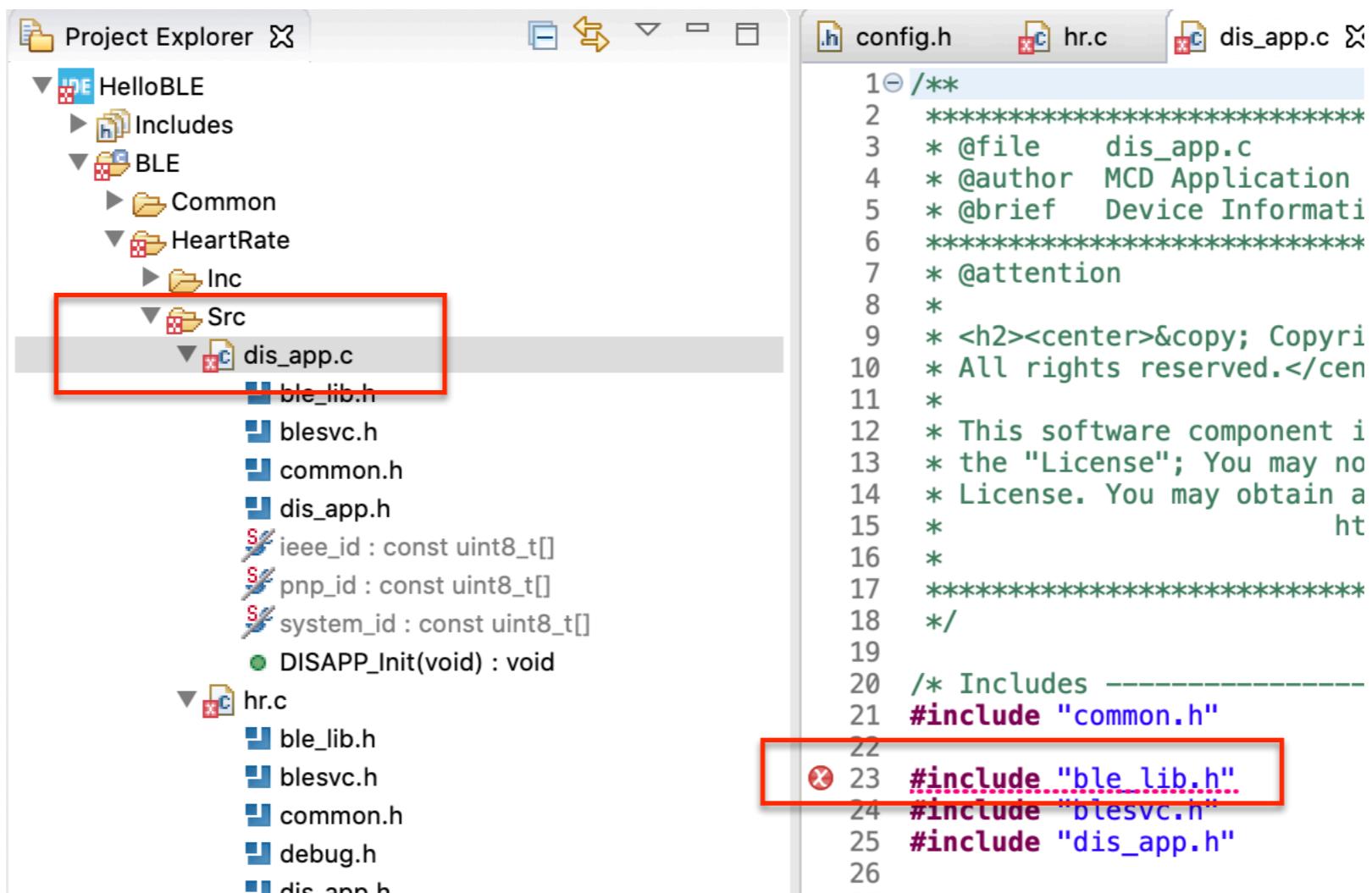
Missing LL Power



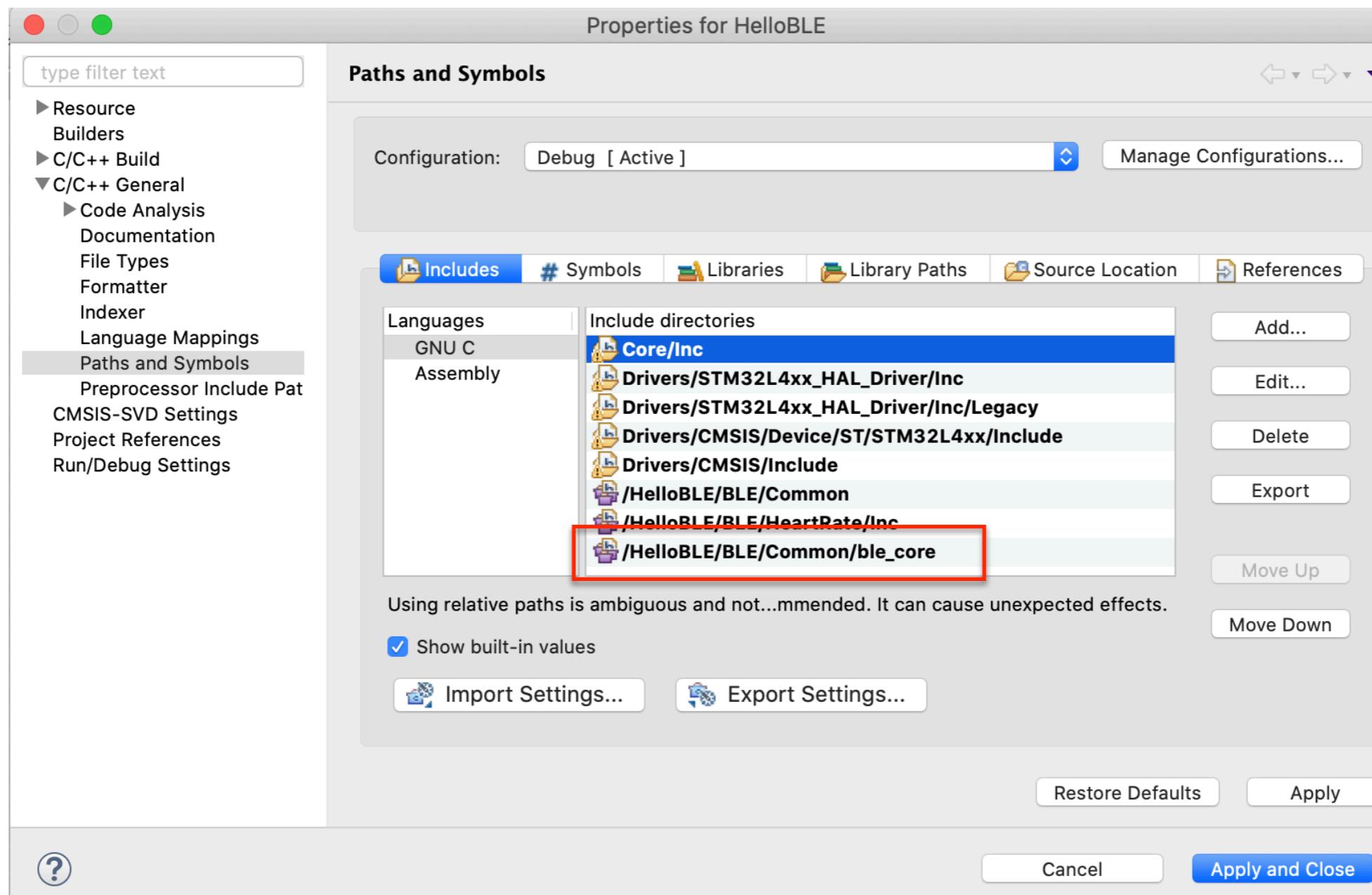
Drag Missing LL file to project



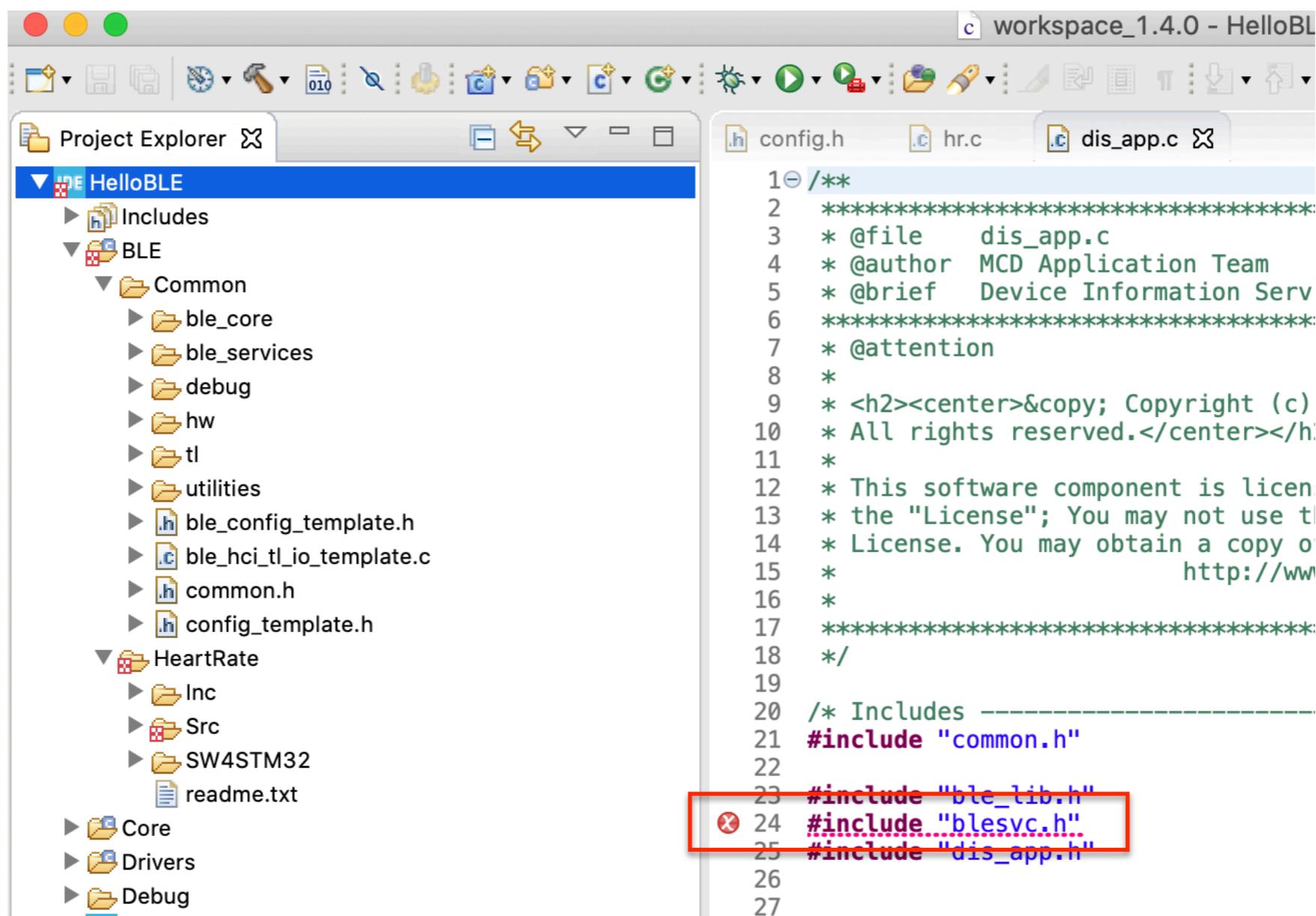
Attempt to build, observe error



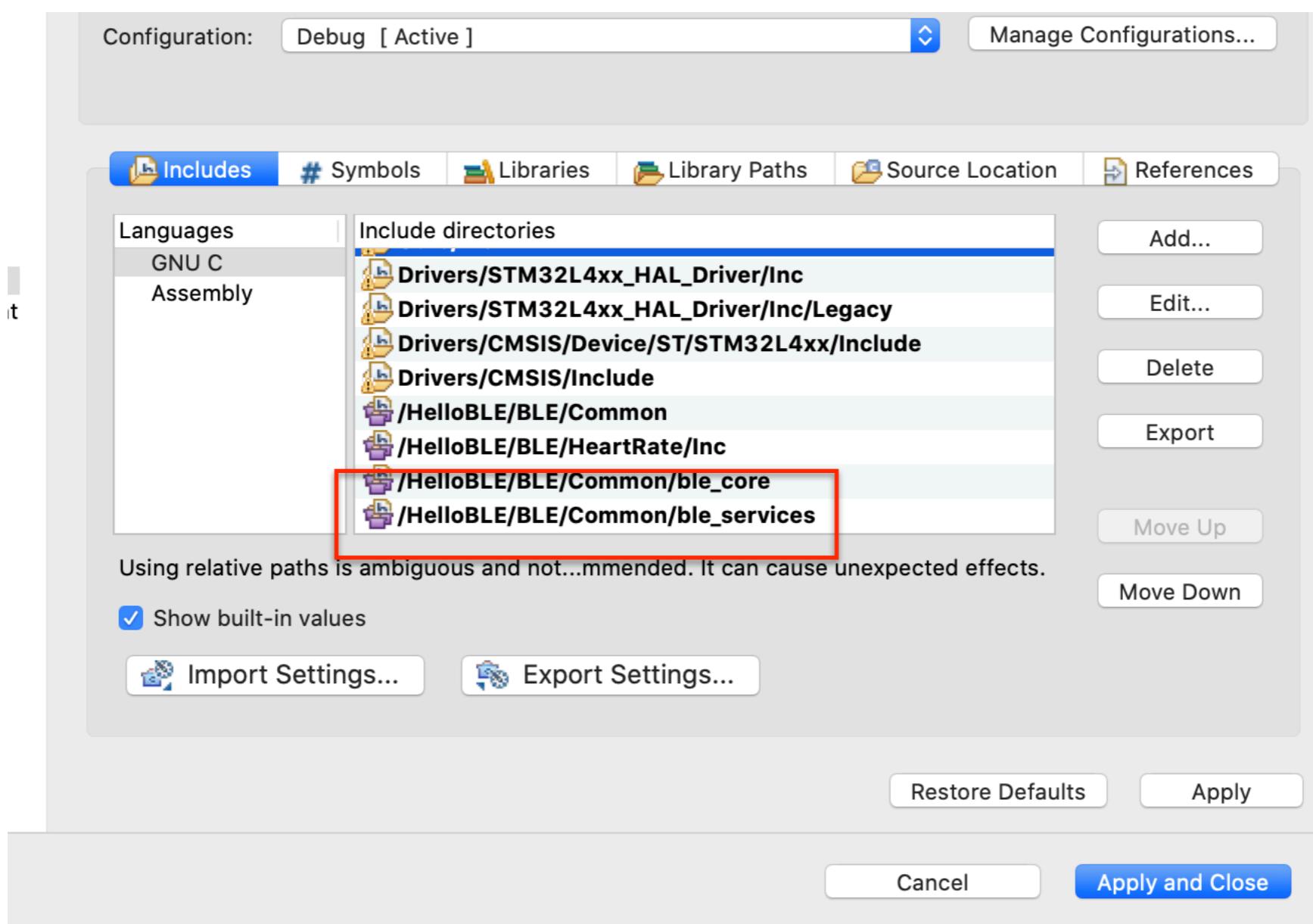
Add BLE/Common/ble_core to path



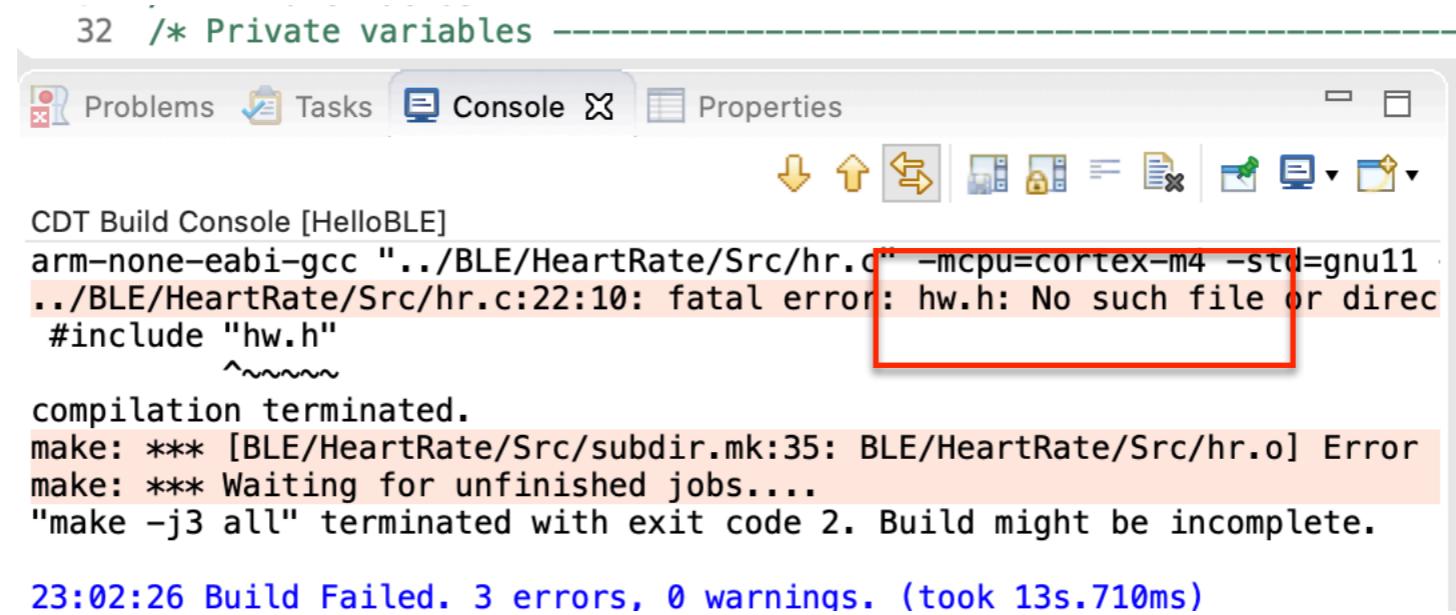
Attempt to build



Add BLE/Common/ ble_services to path



Attempt to build

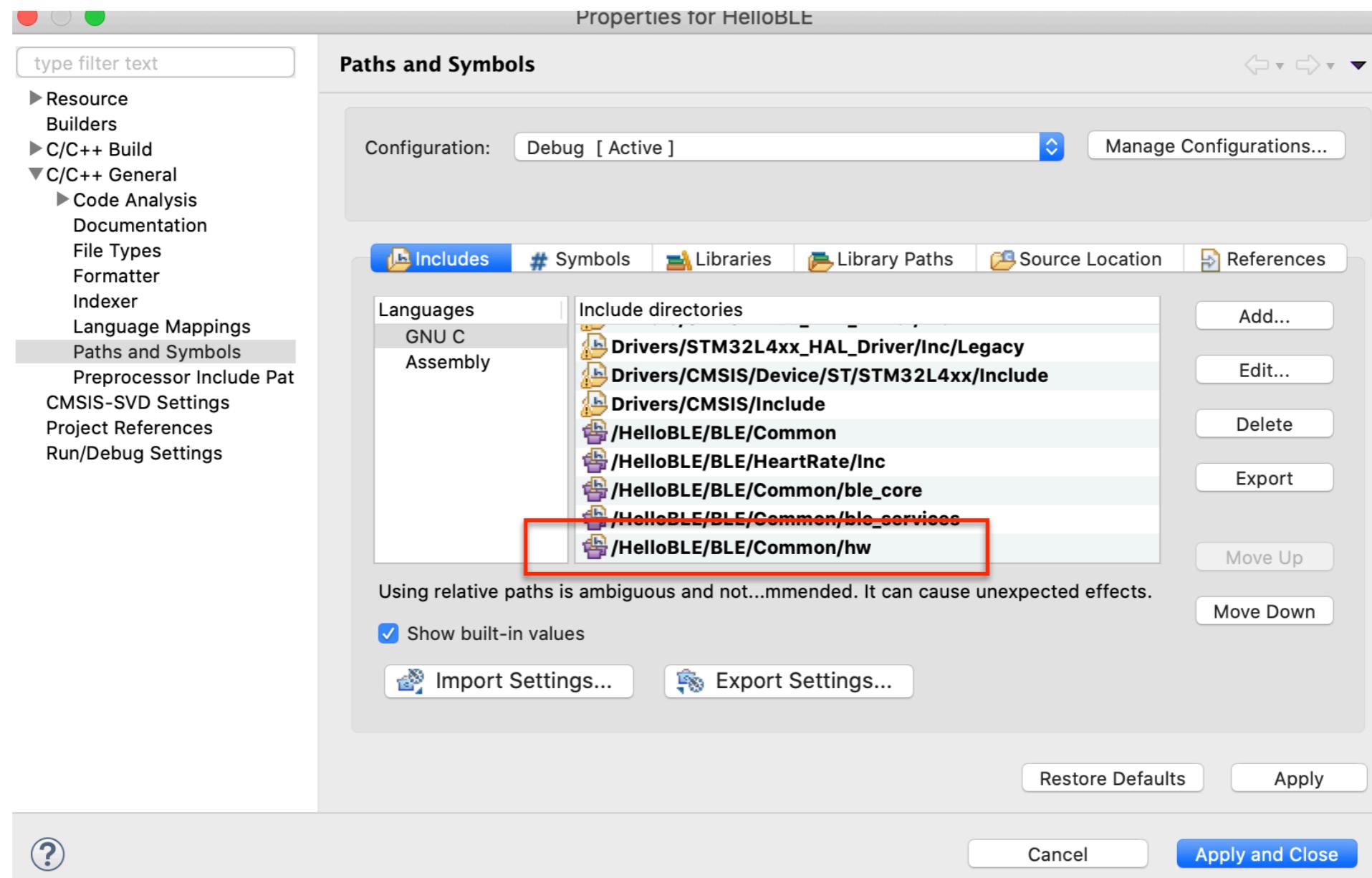


The screenshot shows a CDT Build Console window titled "CDT Build Console [HelloBLE]". The console output is as follows:

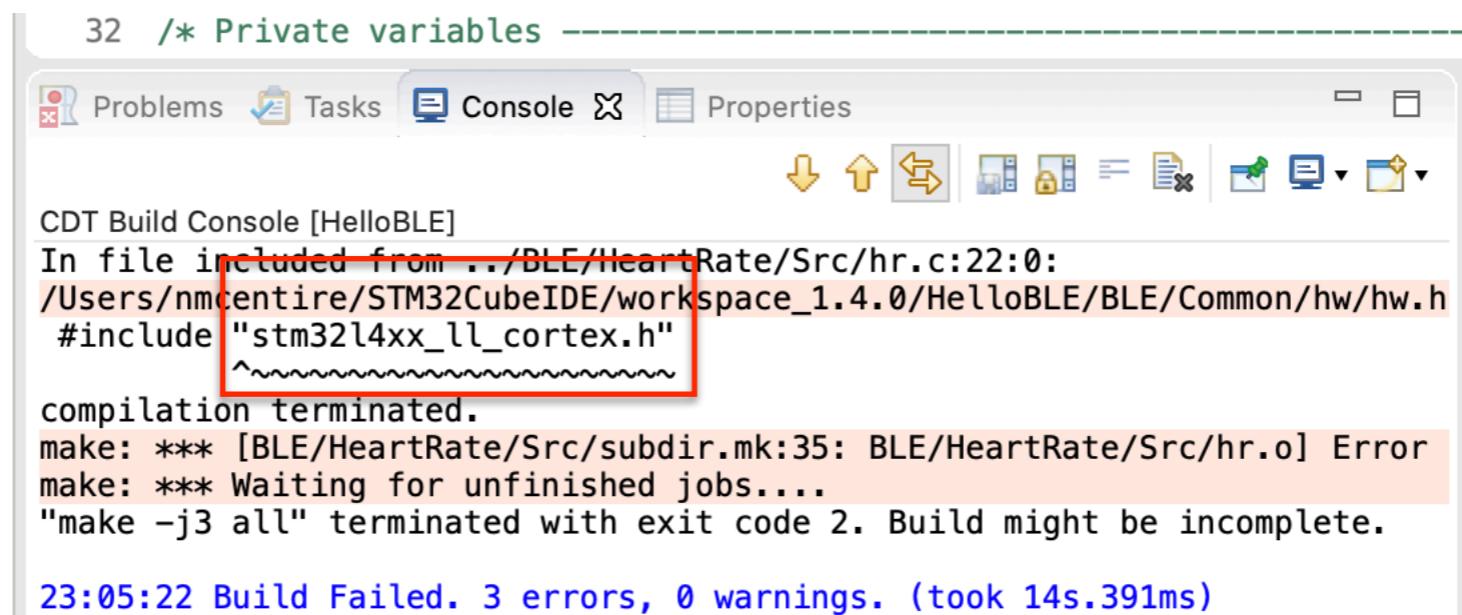
```
32 /* Private variables -----  
arm-none-eabi-gcc ".../BLE/HeartRate/Src/hr.c" -mcpu=cortex-m4 -std=gnu11  
.../BLE/HeartRate/Src/hr.c:22:10: fatal error: hw.h: No such file or direc  
#include "hw.h"  
           ^~~~~~  
compilation terminated.  
make: *** [BLE/HeartRate/Src/subdir.mk:35: BLE/HeartRate/Src/hr.o] Error  
make: *** Waiting for unfinished jobs....  
"make -j3 all" terminated with exit code 2. Build might be incomplete.  
  
23:02:26 Build Failed. 3 errors, 0 warnings. (took 13s.710ms)
```

A red box highlights the error message "No such file or directory" in the output.

Add BLE/Common/hw to path



Attempt to build



The screenshot shows the STM32CubeIDE CDT Build Console window. The title bar says "32 /* Private variables". The tabs at the top are "Problems", "Tasks", "Console" (which is selected), and "Properties". Below the tabs is a toolbar with icons for download, upload, copy, paste, and others. The main area of the console displays the following text:

```
CDT Build Console [HelloBLE]
In file included from ../BLE/HeartRate/Src/hr.c:22:0:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h
#include "stm32l4xx_ll_cortex.h"
^~~~~~
compilation terminated.
make: *** [BLE/HeartRate/Src/subdir.mk:35: BLE/HeartRate/Src/hr.o] Error
make: *** Waiting for unfinished jobs....
"make -j3 all" terminated with exit code 2. Build might be incomplete.

23:05:22 Build Failed. 3 errors, 0 warnings. (took 14s.391ms)
```

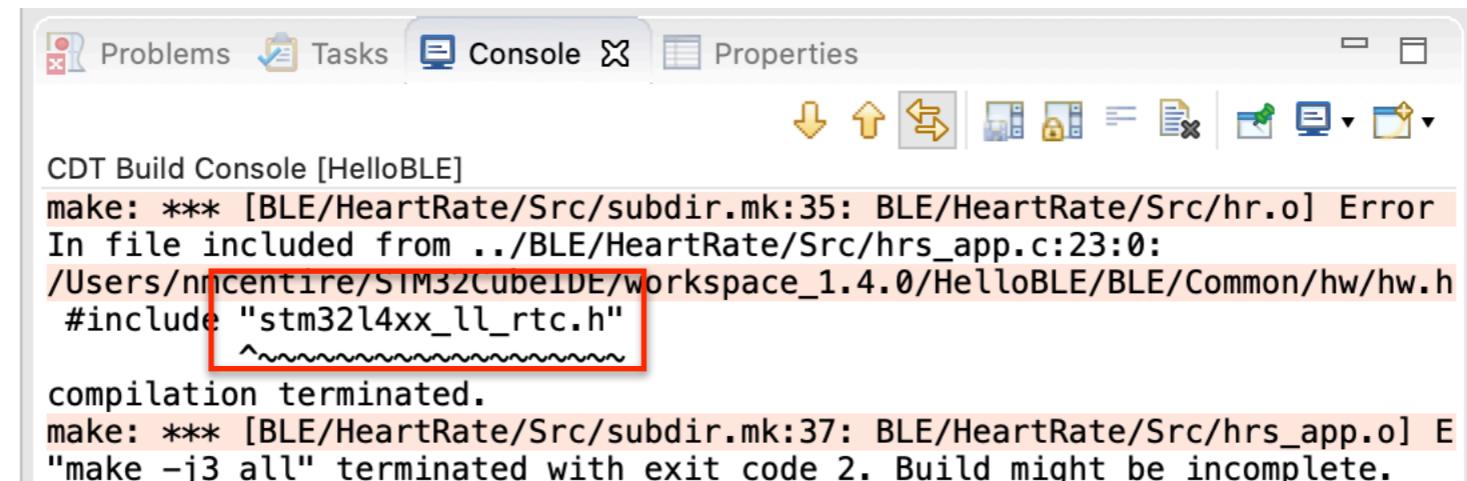
A red box highlights the line "#include "stm32l4xx_ll_cortex.h"" in the error message.

Copy File

stm32l4xx_hal_swpmi.h
stm32l4xx_hal_tim_ex.h
stm32l4xx_hal_tim.h
stm32l4xx_hal_tsc.h
stm32l4xx_hal_uart_ex.h
stm32l4xx_hal_uart.h
stm32l4xx_hal_usart_ex.h
stm32l4xx_hal_usart.h
stm32l4xx_hal_wwdg.h
stm32l4xx_hal.h
stm32l4xx_ll_adc.h
stm32l4xx_ll_bus.h
stm32l4xx_ll_comp.h
stm32l4xx_ll_cortex.h
stm32l4xx_ll_crc.h
stm32l4xx_ll_crs.h
stm32l4xx_ll_dac.h
stm32l4xx_ll_dma.h
stm32l4xx_ll_dma2d.h
stm32l4xx_ll_dmamux.h
stm32l4xx_ll_exti.h
stm32l4xx_ll_fmc.h
stm32l4xx_ll_gpio.h

STM32L4xx_HAL_Driver
 Inc
 Legacy
 stm32l4xx_hal_cortex.h
 stm32l4xx_hal_def.h
 stm32l4xx_hal_dfsdm.h
 stm32l4xx_hal_dma_ex.h
 stm32l4xx_hal_dma.h
 stm32l4xx_hal_exti.h
 stm32l4xx_hal_flash_ex.h
 stm32l4xx_hal_flash_ramfunc.h
 stm32l4xx_hal_flash.h
 stm32l4xx_hal_gpio_ex.h
 stm32l4xx_hal_gpio.h
 stm32l4xx_hal_i2c_ex.h
 stm32l4xx_hal_i2c.h
 stm32l4xx_hal_pcd_ex.h
 stm32l4xx_hal_pcd.h
 stm32l4xx_hal_pwr_ex.h
 stm32l4xx_hal_pwr.h
 stm32l4xx_hal_qspi.h
 stm32l4xx_hal_rcc_ex.h
 stm32l4xx_hal_rcc.h
 stm32l4xx_hal_spi_ex.h
 stm32l4xx_hal_spi.h
 stm32l4xx_hal_tim_ex.h
 stm32l4xx_hal_tim.h
 stm32l4xx_hal_uart_ex.h
 stm32l4xx_hal_uart.h
 stm32l4xx_hal.h
 stm32l4xx_ll_cortex.h
 stm32l4xx_ll_pwr.h
 stm32l4xx_ll_usb.h
 Src

Attempt to build

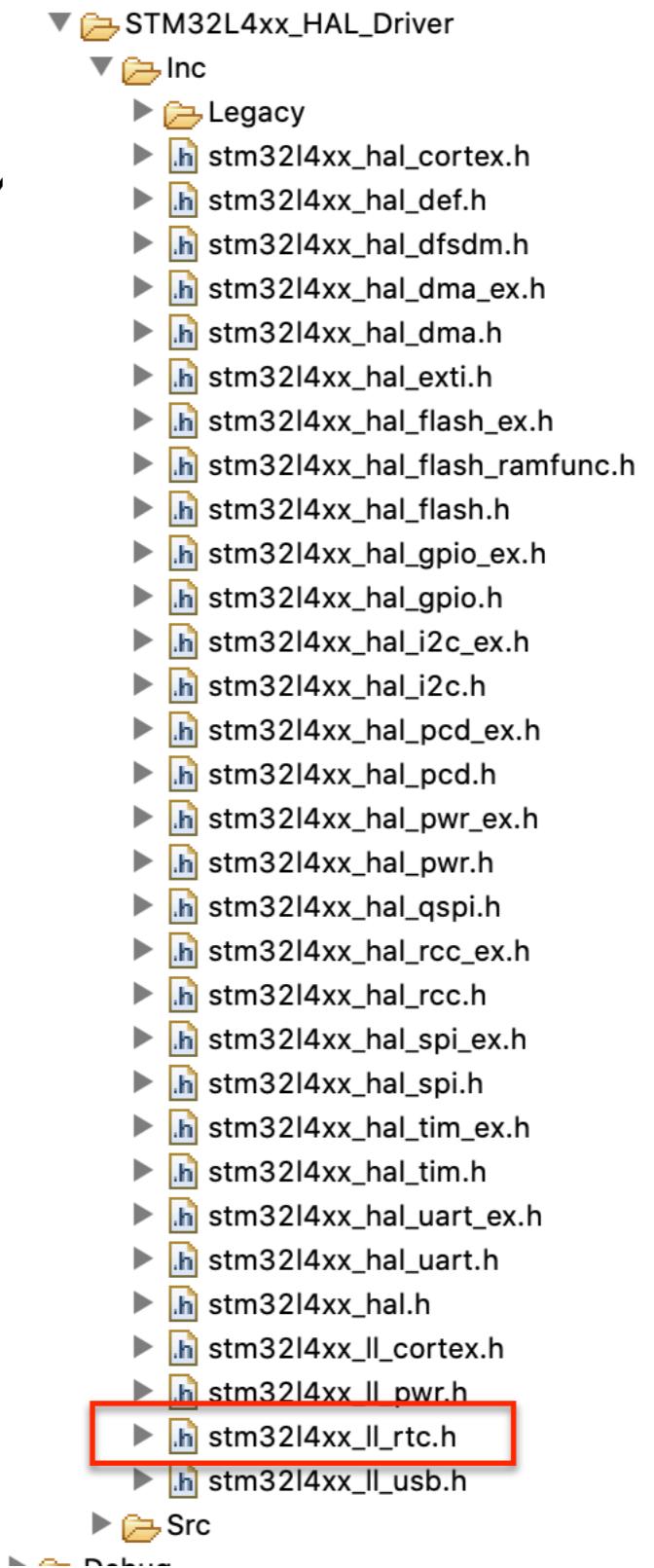
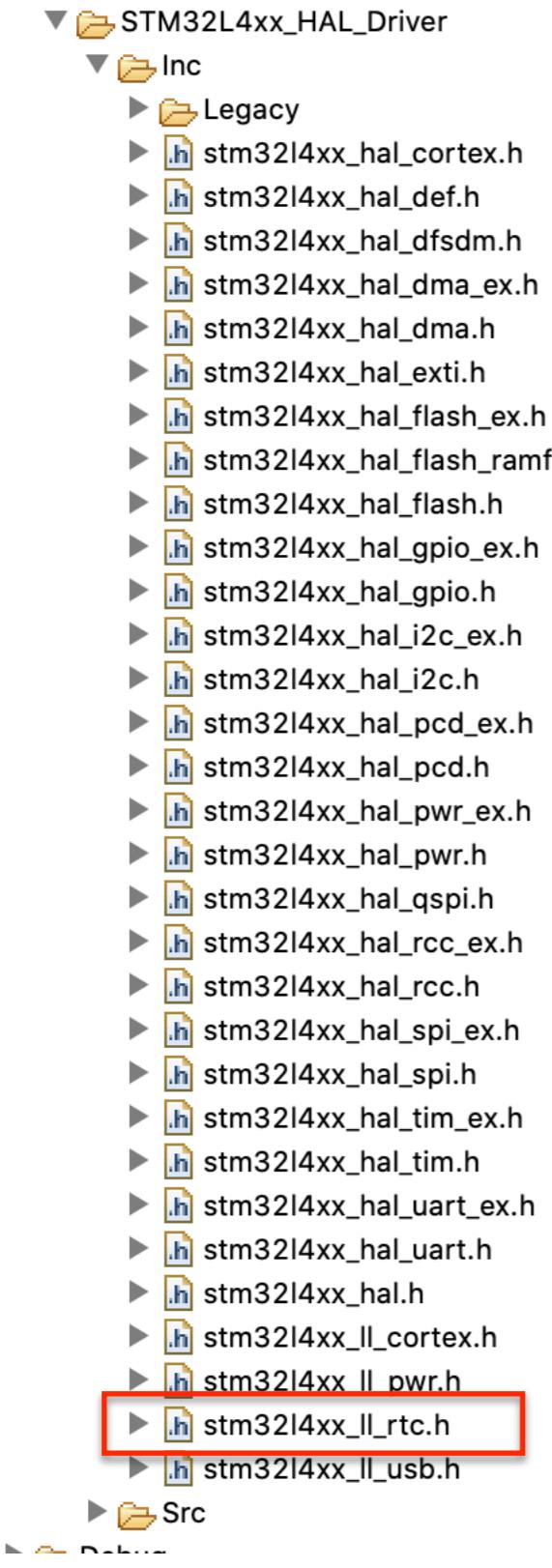


The screenshot shows a CDT Build Console window titled "CDT Build Console [HelloBLE]". The console output is as follows:

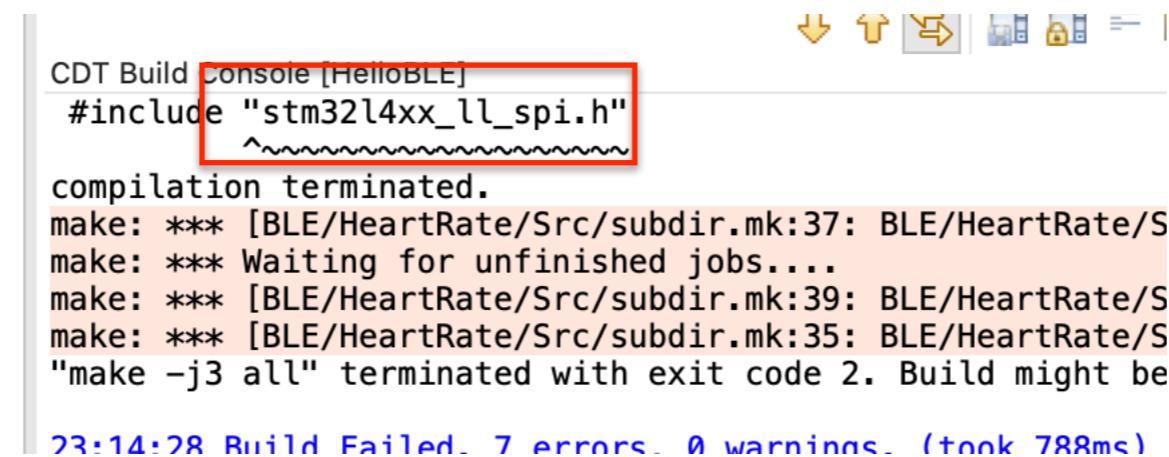
```
make: *** [BLE/HeartRate/Src/subdir.mk:35: BLE/HeartRate/Src/hr.o] Error
In file included from ../BLE/HeartRate/Src/hrs_app.c:23:0:
/Users/nncentire/SIM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h
#include "stm32l4xx_ll_rtc.h"
^~~~~~
compilation terminated.
make: *** [BLE/HeartRate/Src/subdir.mk:37: BLE/HeartRate/Src/hrs_app.o] E
"make -j3 all" terminated with exit code 2. Build might be incomplete.
```

A red box highlights the line "#include "stm32l4xx_ll_rtc.h"" to indicate the source of the error.

Copy File



Attempt to build

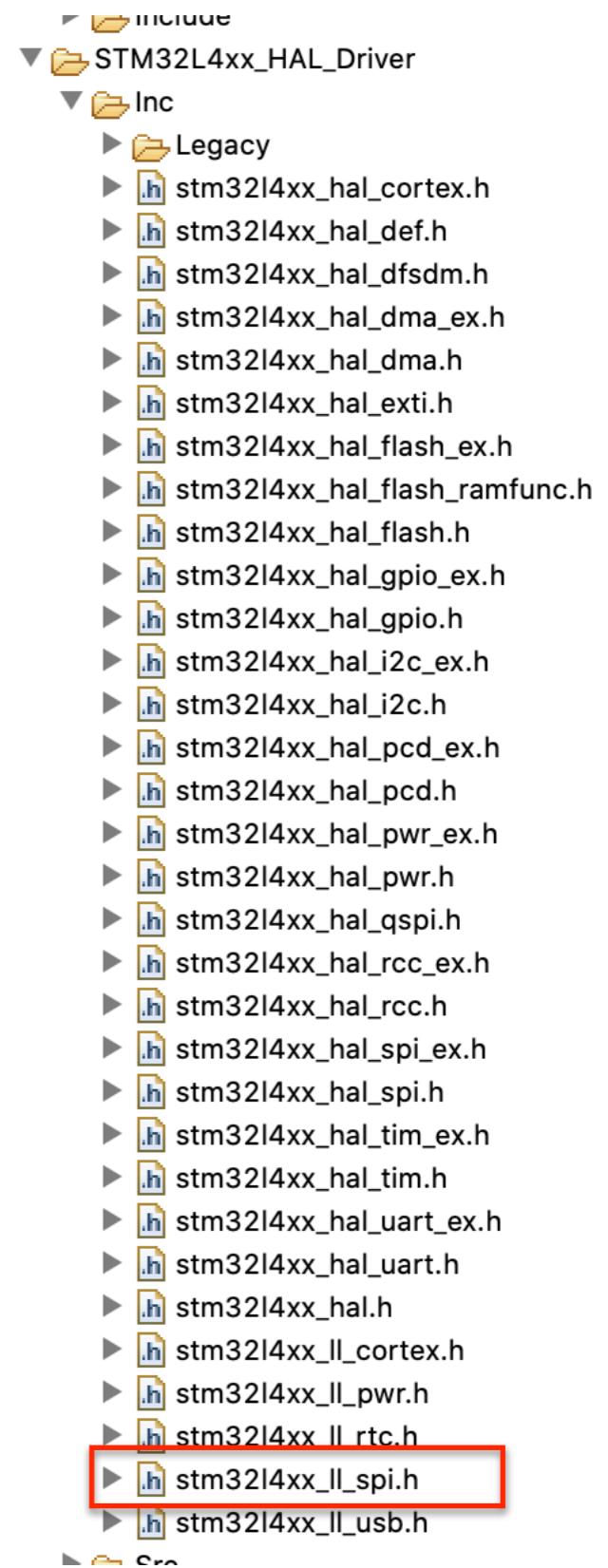
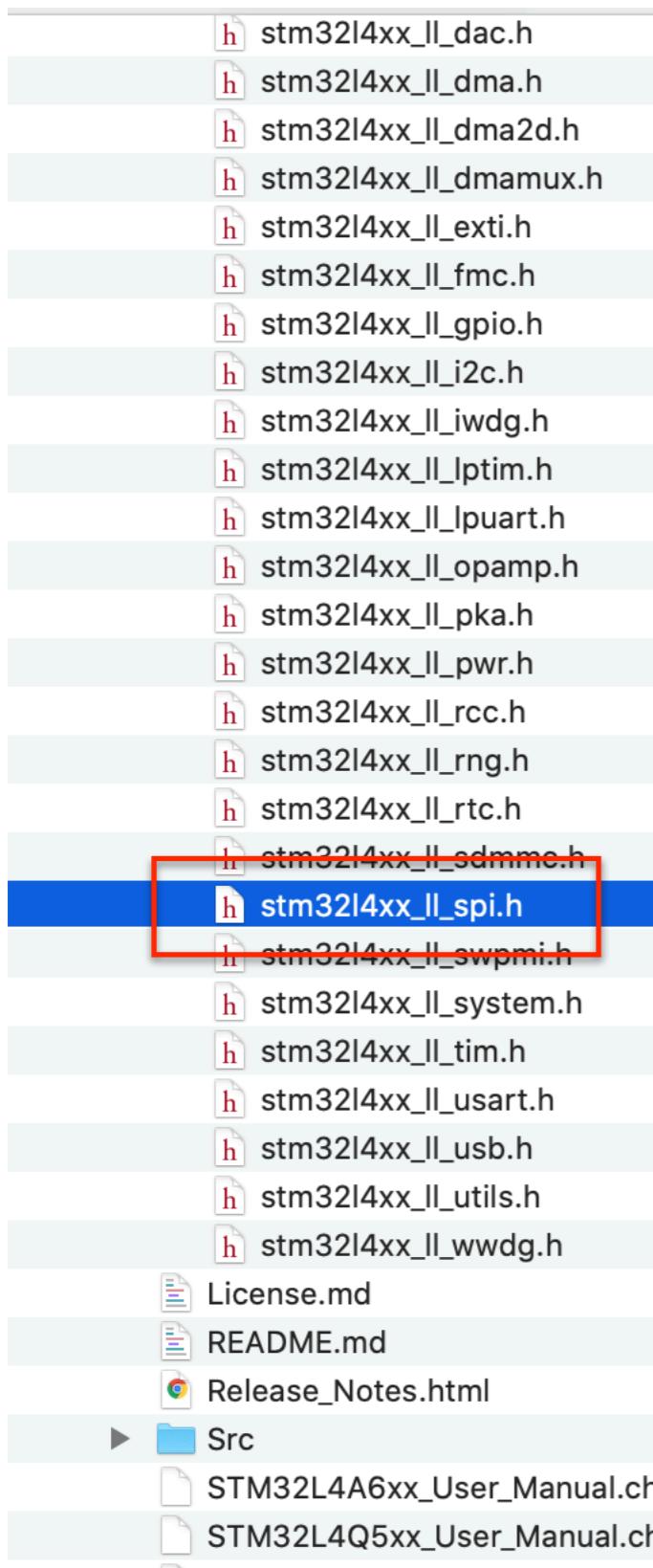


The screenshot shows a CDT Build Console window titled "Console [HelloBLE]". The console output is as follows:

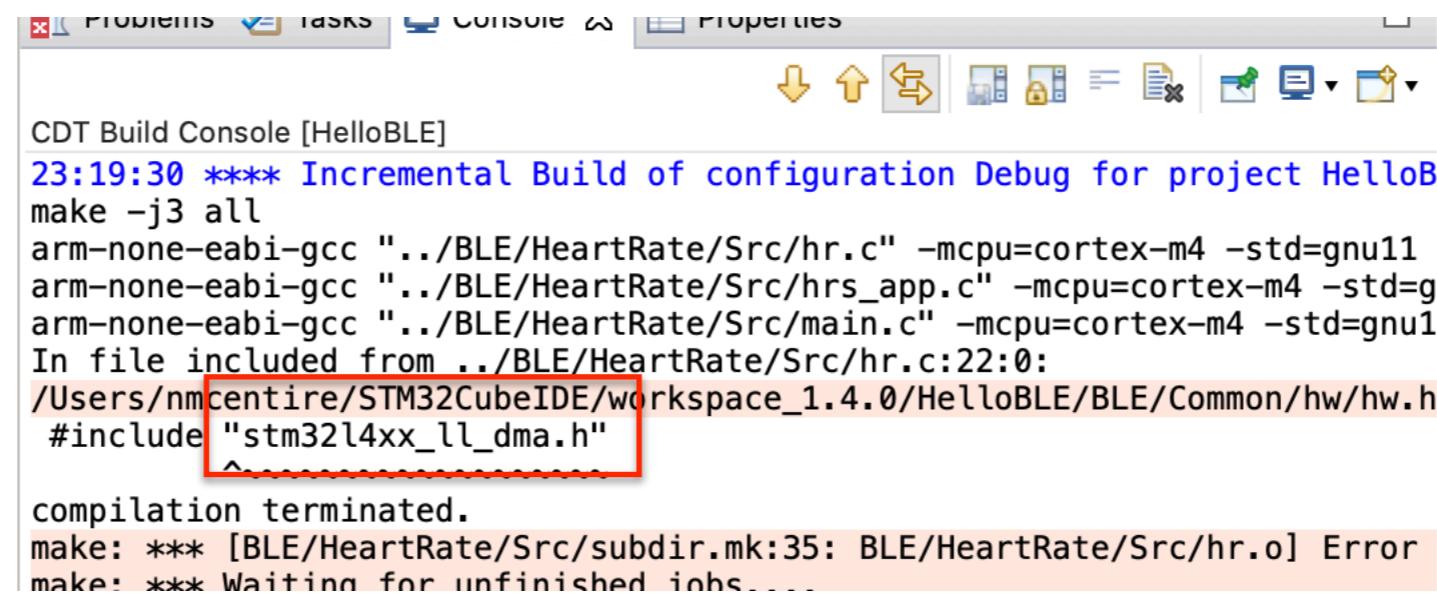
```
CDT Build Console [HelloBLE]
#include "stm32l4xx_ll_spi.h"
^~~~~~
compilation terminated.
make: *** [BLE/HeartRate/Src/subdir.mk:37: BLE/HeartRate/S
make: *** Waiting for unfinished jobs....
make: *** [BLE/HeartRate/Src/subdir.mk:39: BLE/HeartRate/S
make: *** [BLE/HeartRate/Src/subdir.mk:35: BLE/HeartRate/S
"make -j3 all" terminated with exit code 2. Build might be
23:14:28 Build Failed. 7 errors, 0 warnings. (took 788ms)
```

The line `#include "stm32l4xx_ll_spi.h"` is highlighted with a red rectangle and a red arrow pointing to the character 'h'. The status bar at the bottom of the window displays the message `23:14:28 Build Failed. 7 errors, 0 warnings. (took 788ms)`.

Copy File



Attempt to build



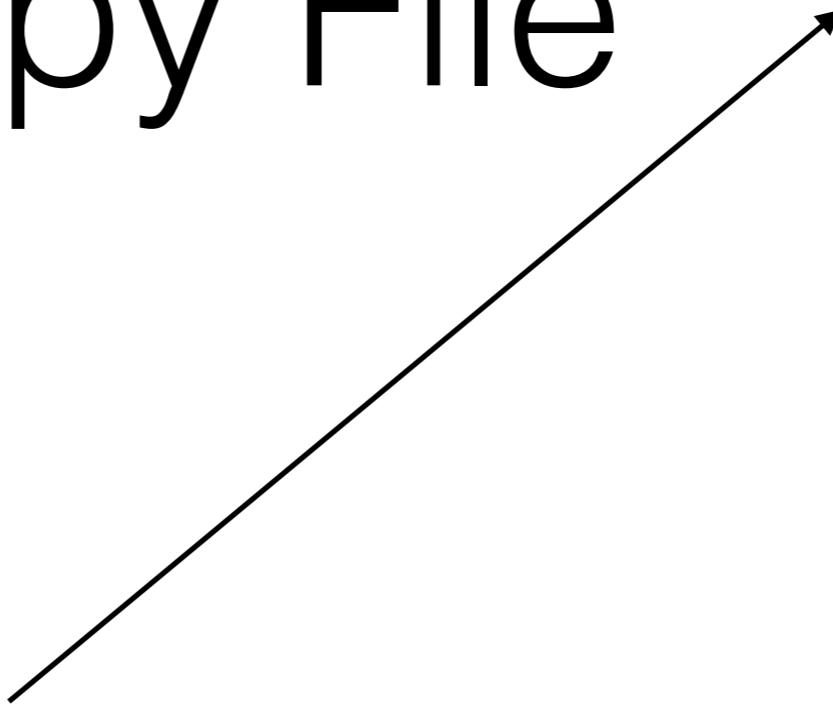
The screenshot shows a CDT Build Console window titled "CDT Build Console [HelloBLE]". The console output is as follows:

```
23:19:30 *** Incremental Build of configuration Debug for project HelloB
make -j3 all
arm-none-eabi-gcc "../BLE/HeartRate/Src/hr.c" -mcpu=cortex-m4 -std=gnu11
arm-none-eabi-gcc "../BLE/HeartRate/Src/hrs_app.c" -mcpu=cortex-m4 -std=g
arm-none-eabi-gcc "../BLE/HeartRate/Src/main.c" -mcpu=cortex-m4 -std=gnu1
In file included from ../BLE/HeartRate/Src/hr.c:22:0:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h
#include "stm32l4xx_ll_dma.h"
^
compilation terminated.
make: *** [BLE/HeartRate/Src/subdir.mk:35: BLE/HeartRate/Src/hr.o] Error
make: *** Waiting for unfinished jobs...
```

A red box highlights the line "#include "stm32l4xx_ll_dma.h"" in the error message.

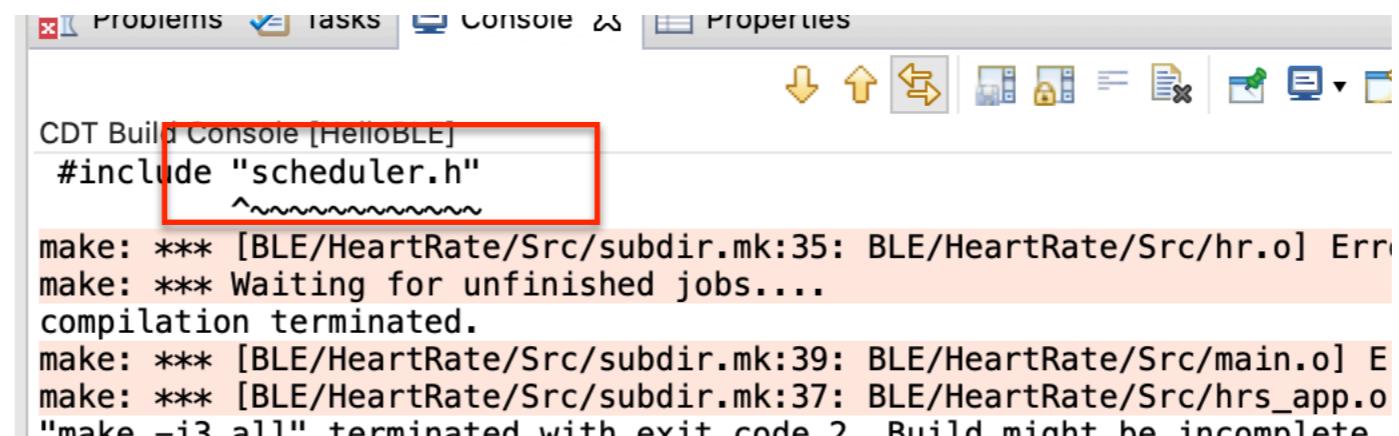
Copy File

Name
h stm32l4xx_ll_dac.h
h stm32l4xx_ll_dma.h
h stm32l4xx_ll_dma2d.h
h stm32l4xx_ll_dmamux.h
h stm32l4xx_ll_exti.h
h stm32l4xx_ll_fmc.h
h stm32l4xx_ll_gpio.h
h stm32l4xx_ll_i2c.h
h stm32l4xx_ll_iwdg.h
h stm32l4xx_ll_lptim.h
h stm32l4xx_ll_lpuart.h
h stm32l4xx_ll_opamp.h
h stm32l4xx_ll_pkah.h
h stm32l4xx_ll_pwr.h



STM32L4xx_HAL_Driver
Inc
Legacy
h stm32l4xx_hal_cortex.h
h stm32l4xx_hal_def.h
h stm32l4xx_hal_dfsdm.h
h stm32l4xx_hal_dma_ex.h
h stm32l4xx_hal_dma.h
h stm32l4xx_hal_exti.h
h stm32l4xx_hal_flash_ex.h
h stm32l4xx_hal_flash_ramfunc.h
h stm32l4xx_hal_flash.h
h stm32l4xx_hal_gpio_ex.h
h stm32l4xx_hal_gpio.h
h stm32l4xx_hal_i2c_ex.h
h stm32l4xx_hal_i2c.h
h stm32l4xx_hal_pcd_ex.h
h stm32l4xx_hal_pcd.h
h stm32l4xx_hal_pwr_ex.h
h stm32l4xx_hal_pwr.h
h stm32l4xx_hal_qspi.h
h stm32l4xx_hal_rcc_ex.h
h stm32l4xx_hal_rcc.h
h stm32l4xx_hal_spi_ex.h
h stm32l4xx_hal_spi.h
h stm32l4xx_hal_tim_ex.h
h stm32l4xx_hal_tim.h
h stm32l4xx_hal_uart_ex.h
h stm32l4xx_hal_uart.h
h stm32l4xx_hal.h
h stm32l4xx_ll_cortex.h
h stm32l4xx_ll_dma.h
h stm32l4xx_ll_pwr.h
h stm32l4xx_ll_rtc.h
h stm32l4xx_ll_spi.h
h stm32l4xx_ll_usb.h
Src

Attempt to build

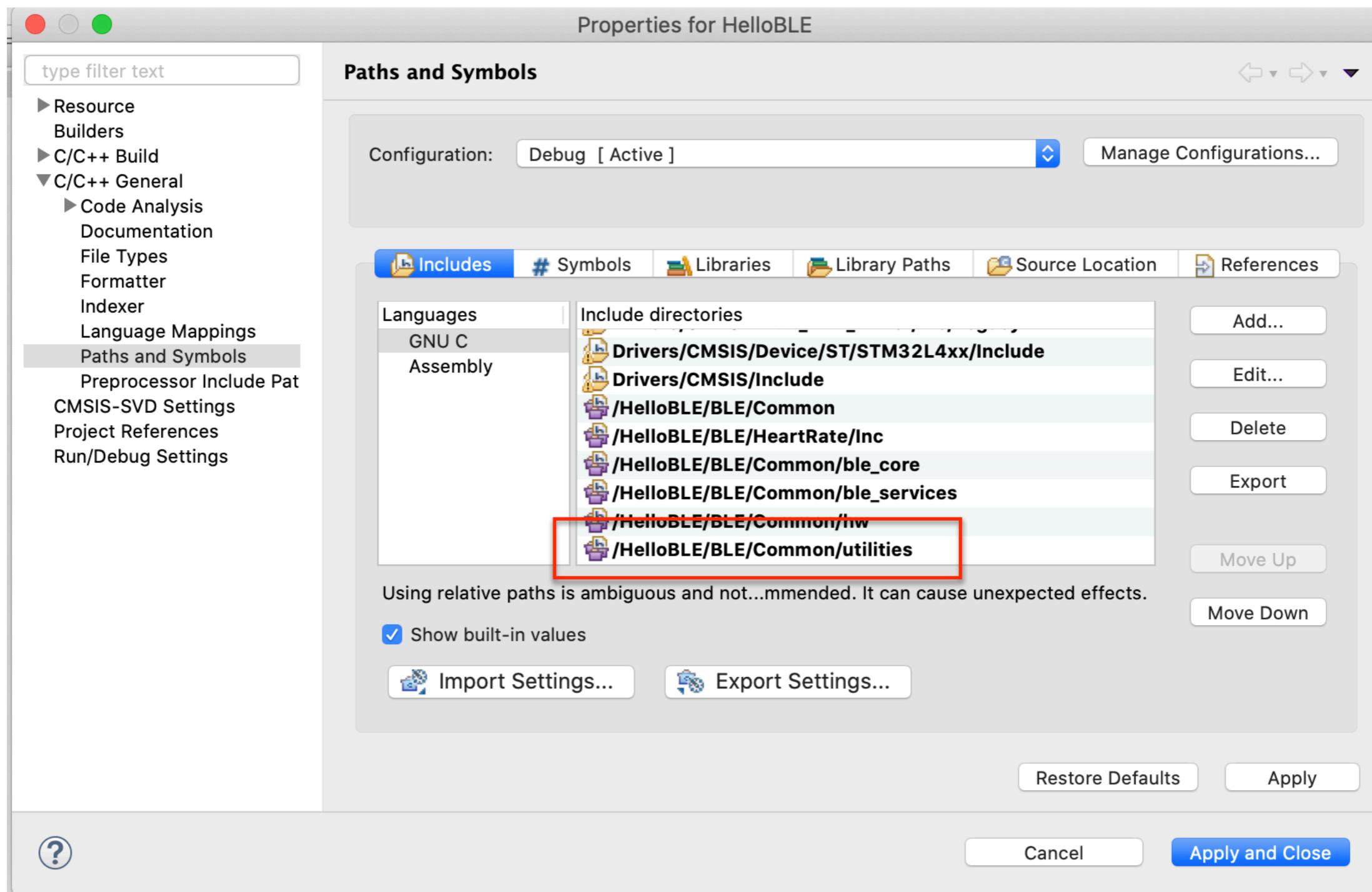


The screenshot shows a CDT Build Console window with the title "CDT Build Console [HelloBLE]". The console output is as follows:

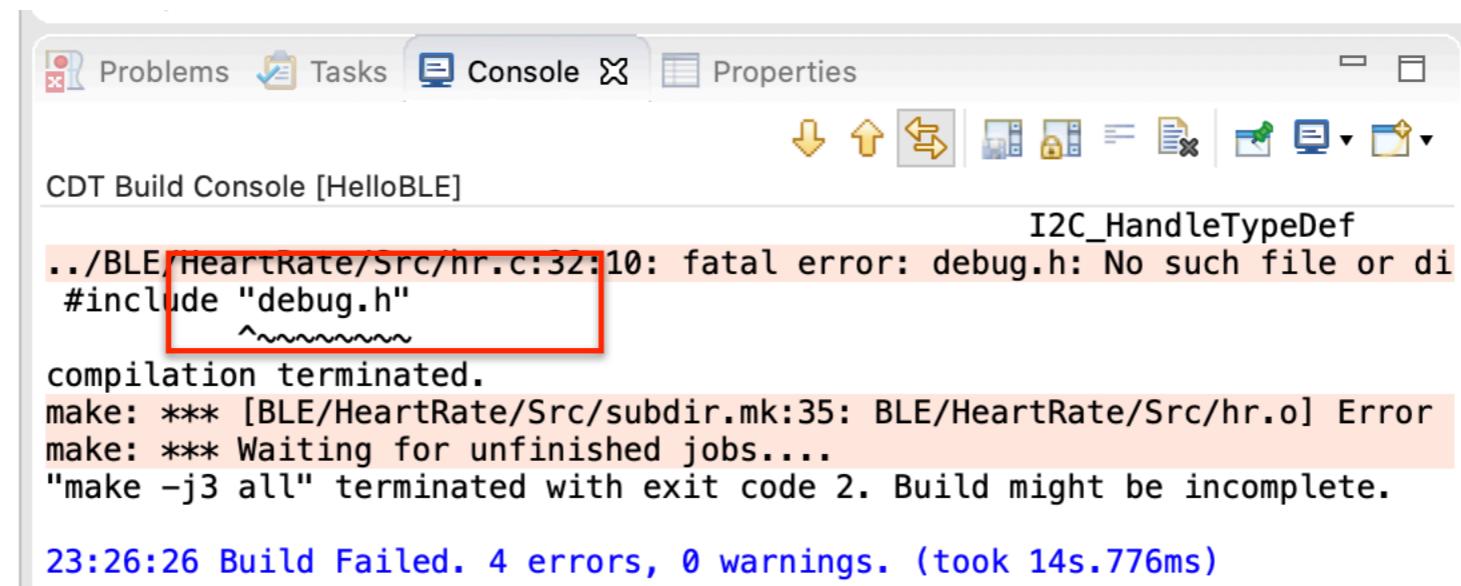
```
CDT Build Console [HelloBLE]
#include "scheduler.h"
^~~~~~
make: *** [BLE/HeartRate/Src/subdir.mk:35: BLE/HeartRate/Src/hr.o] Error 1
make: *** Waiting for unfinished jobs....
compilation terminated.
make: *** [BLE/HeartRate/Src/subdir.mk:39: BLE/HeartRate/Src/main.o] Error 1
make: *** [BLE/HeartRate/Src/subdir.mk:37: BLE/HeartRate/Src/hrs_app.o] Error 1
"make -i3 all" terminated with exit code 2. Build might be incomplete.
```

The line `#include "scheduler.h"` is highlighted with a red box, and the caret (`^`) is positioned under the first character of the word `scheduler`. The error message indicates that the build failed at step 35 due to an error in `hr.o`, and it was waiting for unfinished jobs before terminating the compilation.

Add Path



Attempt to build



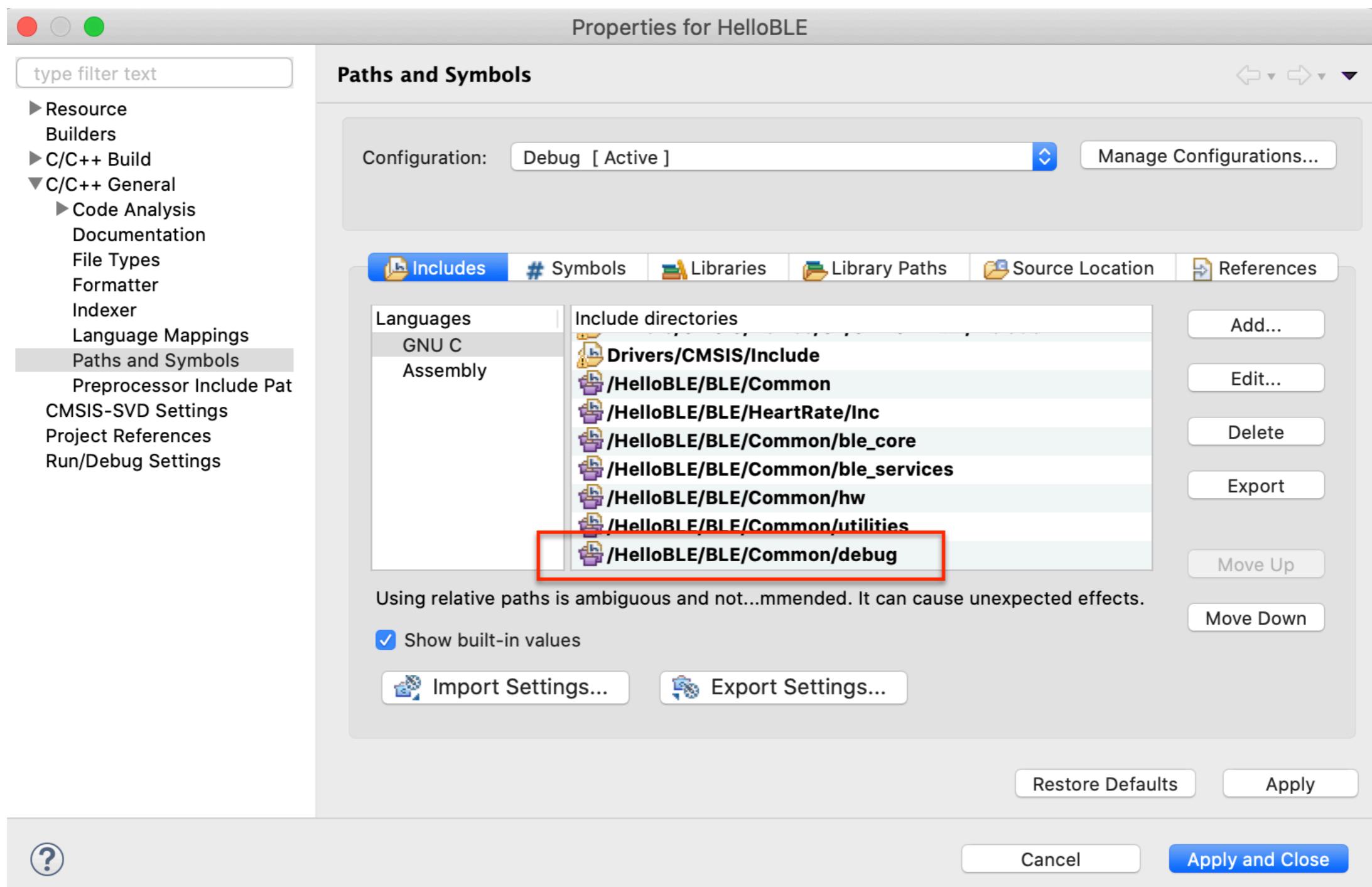
The screenshot shows a CDT Build Console window titled "CDT Build Console [HelloBLE]". The console output is as follows:

```
I2C_HandleTypeDef
./BLE/HeartRate/Src/hr.c:32:10: fatal error: debug.h: No such file or di
#include "debug.h"
^~~~~~
compilation terminated.
make: *** [BLE/HeartRate/Src/subdir.mk:35: BLE/HeartRate/Src/hr.o] Error
make: *** Waiting for unfinished jobs....
"make -j3 all" terminated with exit code 2. Build might be incomplete.

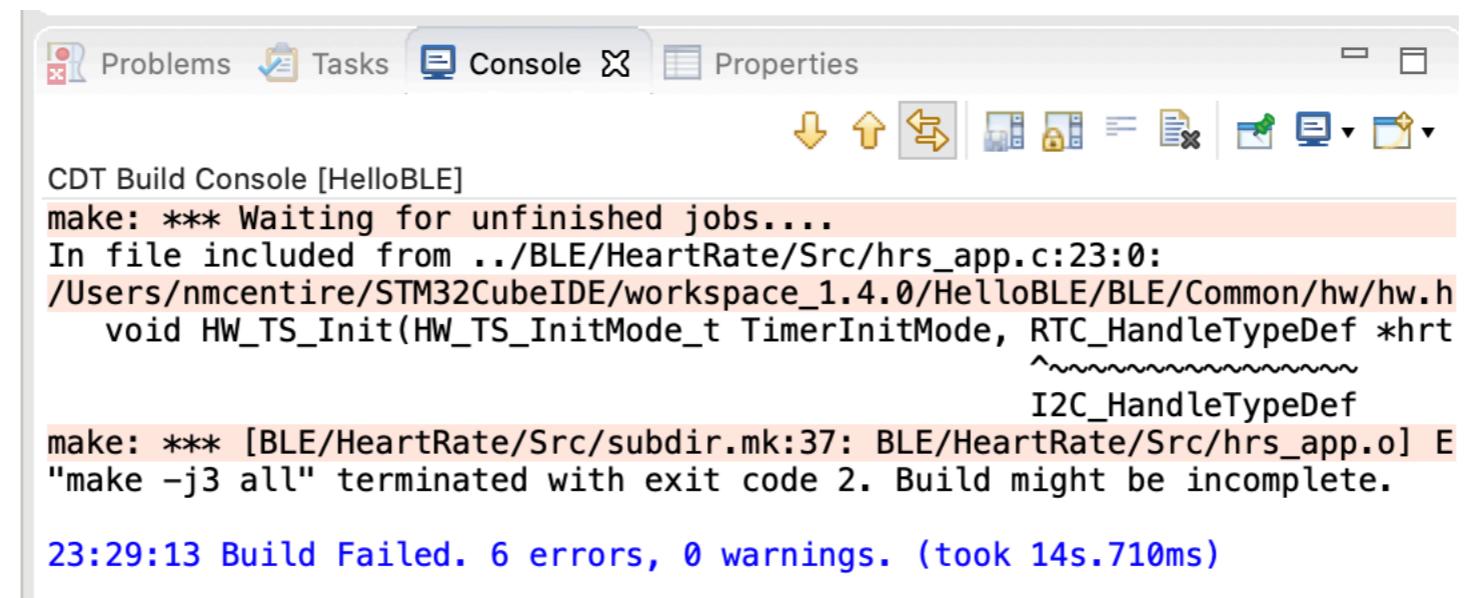
23:26:26 Build Failed. 4 errors, 0 warnings. (took 14s.776ms)
```

A red box highlights the line of code that caused the error: `#include "debug.h"`. The caret in the code indicates the position of the error.

Add Path



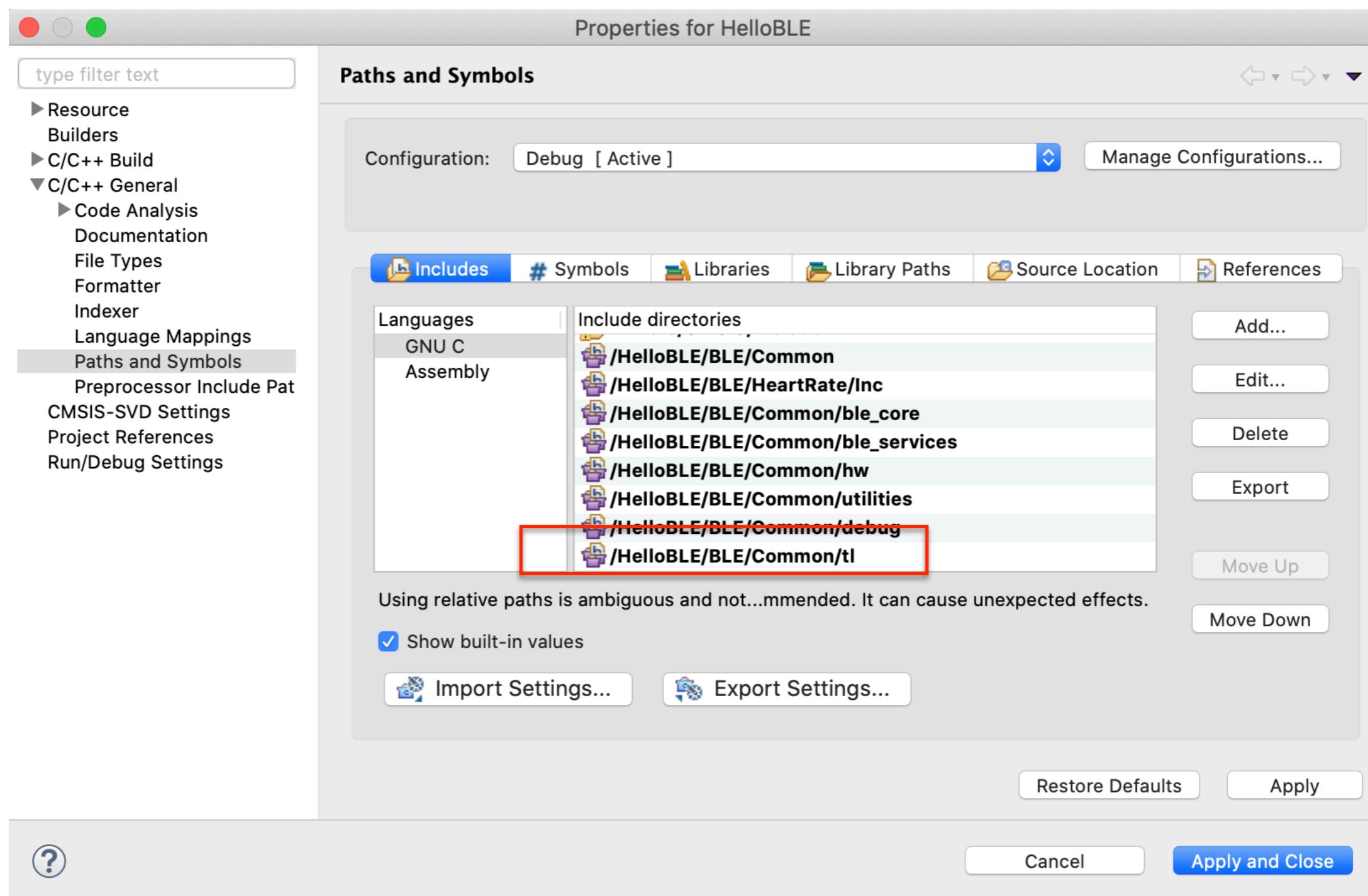
Attempt to build



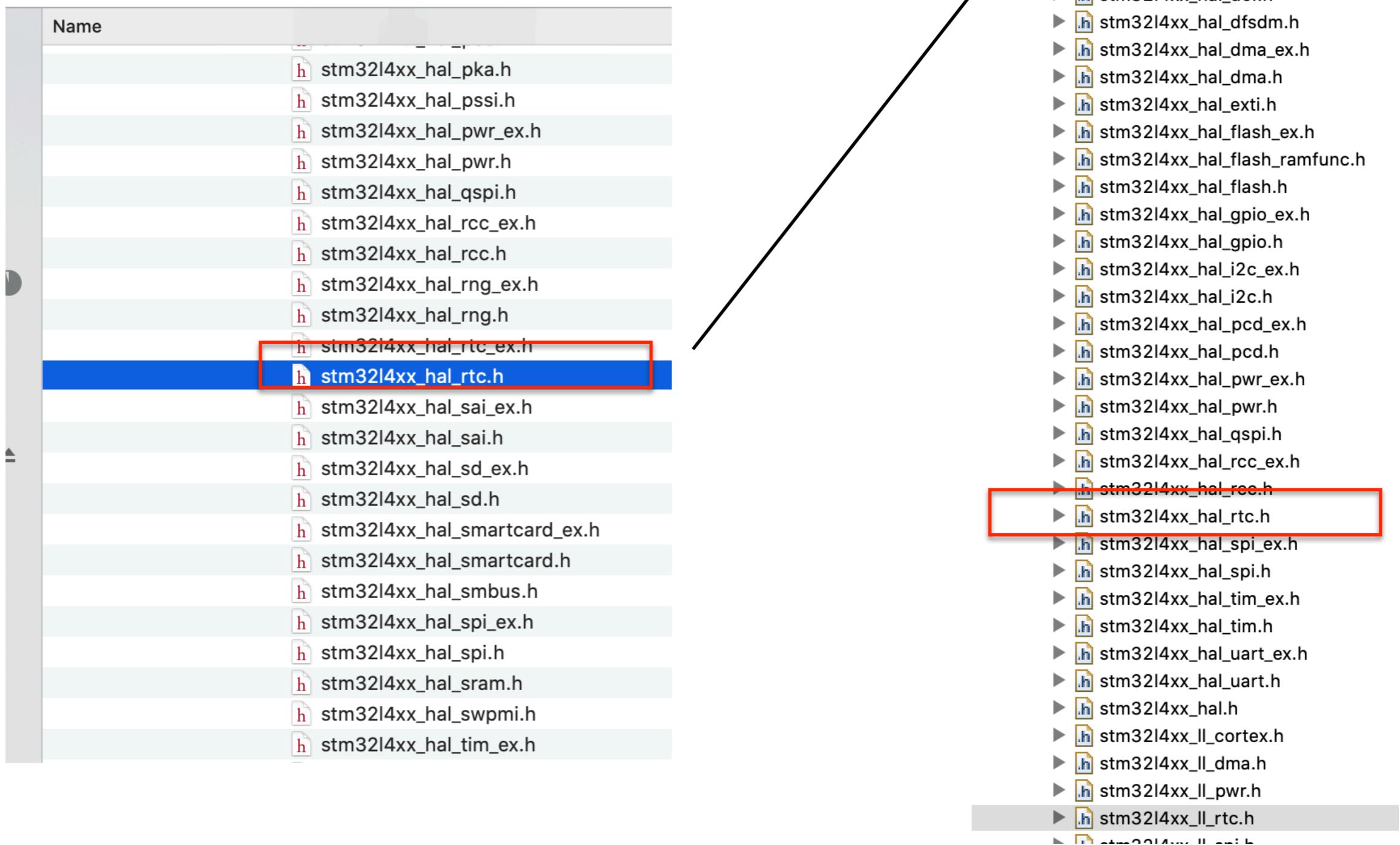
The screenshot shows a CDT Build Console window titled "CDT Build Console [HelloBLE]". The console output is as follows:

```
make: *** Waiting for unfinished jobs....  
In file included from ../BLE/HeartRate/Src/hrs_app.c:23:0:  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h  
    void HW_TS_Init(HW_TS_InitMode_t TimerInitMode, RTC_HandleTypeDef *hrt  
                      ^~~~~~  
                      I2C_HandleTypeDef  
make: *** [BLE/HeartRate/Src/subdir.mk:37: BLE/HeartRate/Src/hrs_app.o] Error 2  
"make -j3 all" terminated with exit code 2. Build might be incomplete.  
  
23:29:13 Build Failed. 6 errors, 0 warnings. (took 14s.710ms)
```

Add Path



Copy File

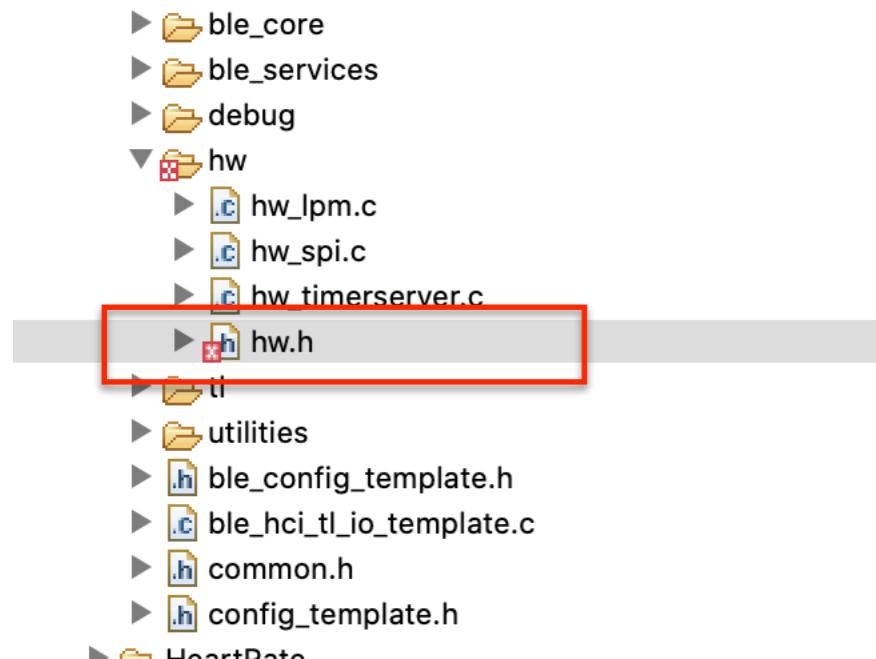


Attempt Build

```
CDT Build Console [HelloBLE]
23:39:07 **** Incremental Build of configuration Debug for project HelloBLE ****
make -j3 all
arm-none-eabi-gcc "../BLE/HeartRate/Src/hr.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../Core/
arm-none-eabi-gcc "../BLE/HeartRate/Src/hrs_app.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../
arm-none-eabi-gcc "../BLE/HeartRate/Src/main.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx -c -I../Cor
In file included from ../BLE/HeartRate/Src/hrs_app.c:23:0:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h:97:51: error: unknown type name 'RTC_HandleTypeDef'; di
  void HW_TS_Init(HW_TS_InitMode_t TimerInitMode, RTC_HandleTypeDef *hrtc);
                           ^~~~~~
                           I2C_HandleTypeDef
In file included from ../BLE/HeartRate/Src/main.c:22:0:
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/hw/hw.h:97:51: error: unknown type name 'RTC_HandleTypeDef'; di
  void HW_TS_Init(HW_TS_InitMode_t TimerInitMode, RTC_HandleTypeDef *hrtc);
                           ^~~~~~
                           I2C_HandleTypeDef
../BLE/HeartRate/Src/main.c:47:8: error: unknown type name 'RTC_HandleTypeDef'
  static DTC_HandleTypeDef hrtc;  /* DTC handler declaration */

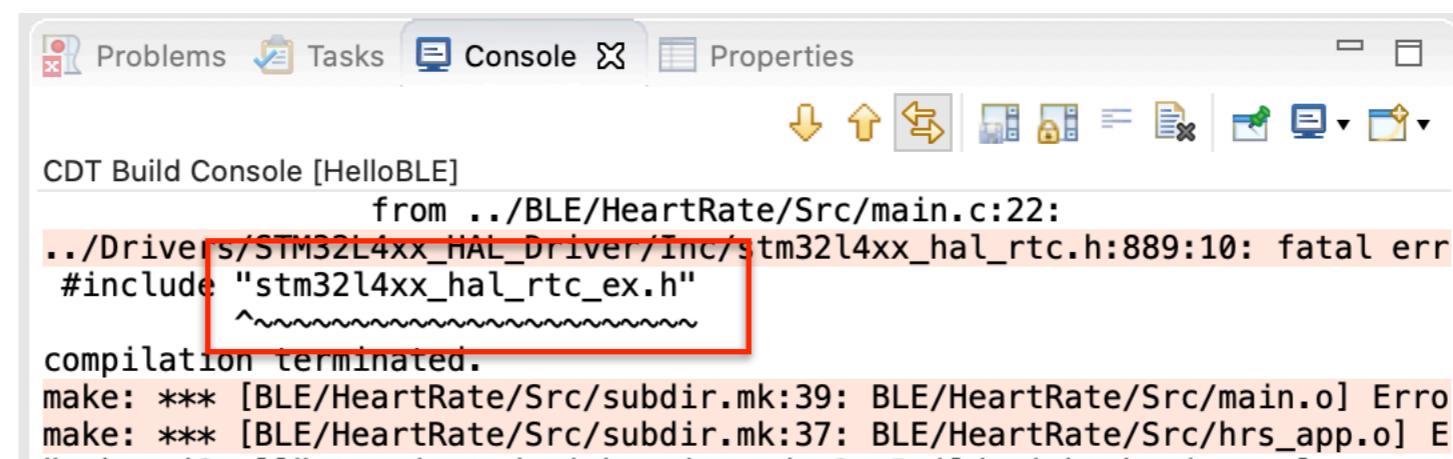
```

Edit Header file to add HAL RTC



```
23 //-----  
24 #ifdef __cplusplus  
25 extern "C" {  
26 #endif  
27  
28 /* Includes -----  
29 #include "stm32l4xx.h"  
30 #include "stm32l4xx_ll_pwr.h"  
31 #include "stm32l4xx_ll_cortex.h"  
32 #include "stm32l4xx_ll_rtc.h"  
33 #include "stm32l4xx_ll_spi.h"  
34 #include "stm32l4xx_ll_dma.h"  
35  
36 #include "stm32l4xx_hal_rtc.h" //For RTC_HandleTypeDef|  
37  
38  
39
```

Attempt Build

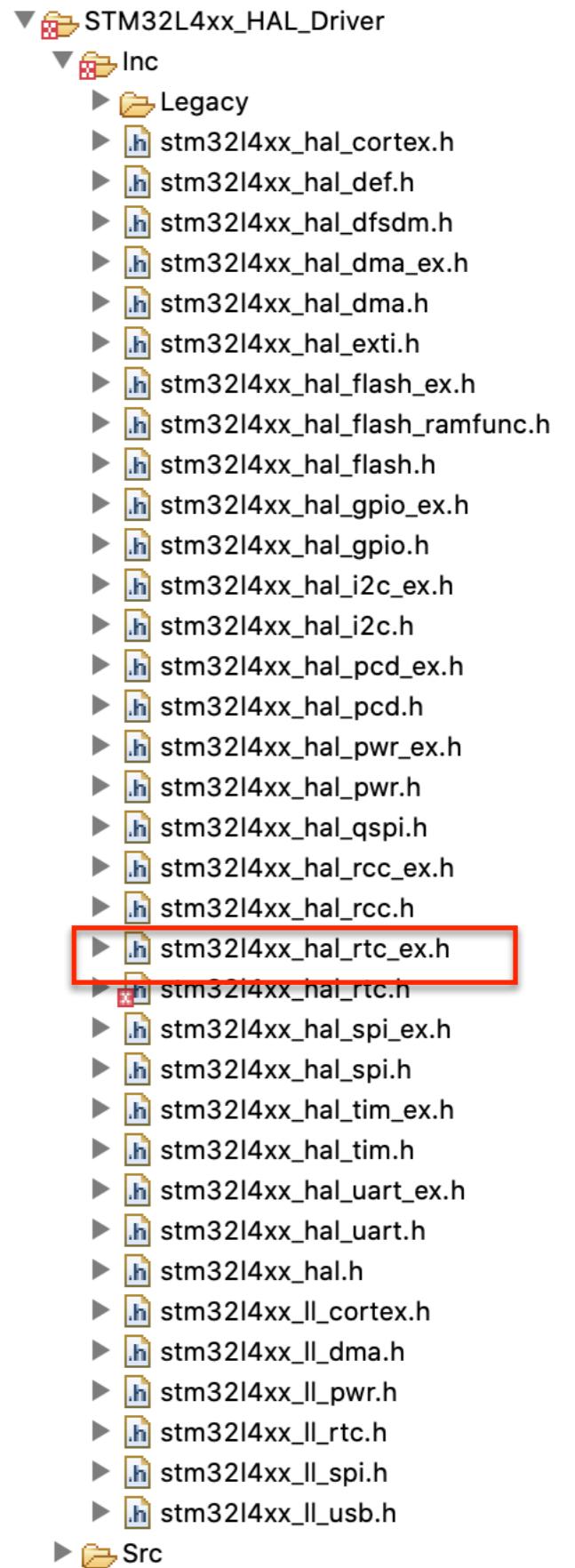
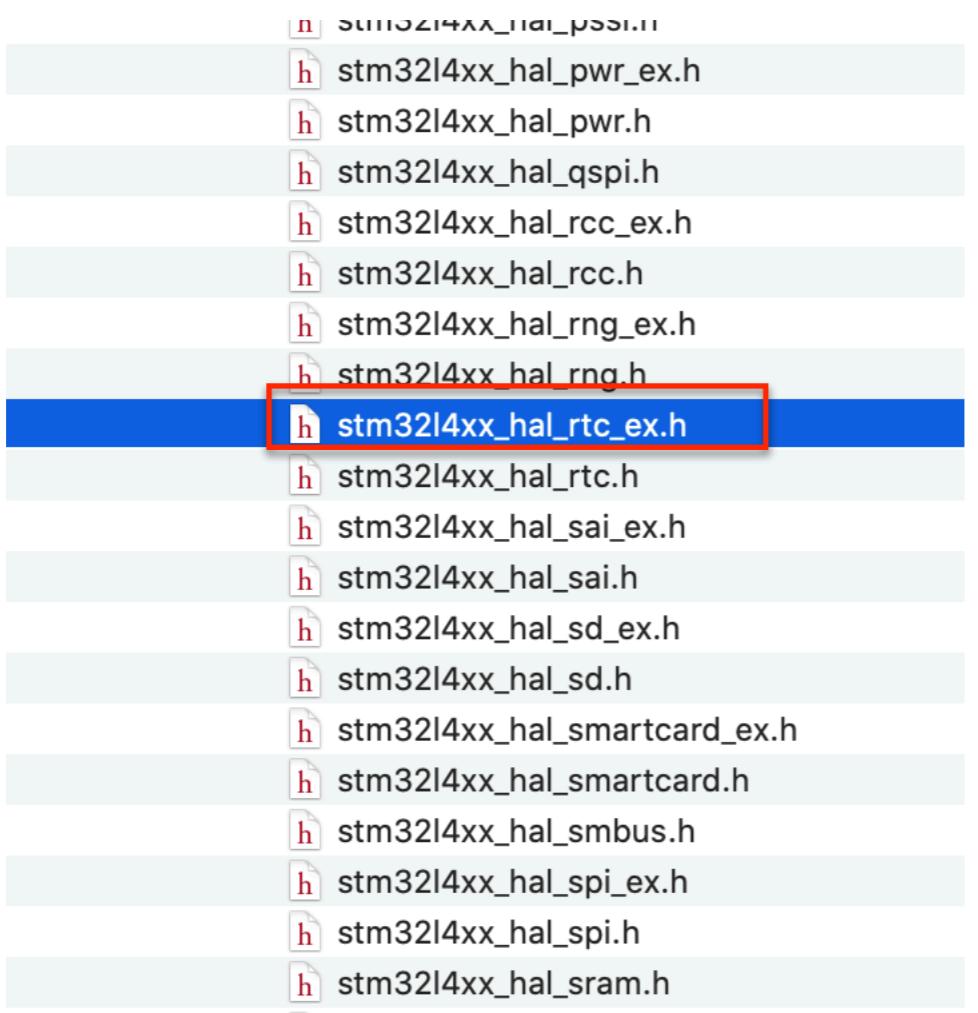


The screenshot shows a CDT Build Console window titled "CDT Build Console [HelloBLE]". The console output is as follows:

```
from ../BLE/HeartRate/Src/main.c:22:  
./Drivers/STM32L4xx_HAL_Driver/Inc/stm32l4xx_hal_rtc.h:889:10: fatal err  
#include "stm32l4xx_hal_rtc_ex.h"  
^~~~~~  
compilation terminated.  
make: *** [BLE/HeartRate/Src/subdir.mk:39: BLE/HeartRate/Src/main.o] Errro  
make: *** [BLE/HeartRate/Src/subdir.mk:37: BLE/HeartRate/Src/hrs_app.o] E
```

A red box highlights the line "#include "stm32l4xx_hal_rtc_ex.h"" and its preceding whitespace, indicating the error location.

Copy File



Attempt Build

```
from ..BLE/Common/ble_services/svc_ctl.c:28:  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/ble_core/bluenrg_gap_aci.h:103:12: note:  
tBleStatus aci_gap_init(uint8_t role,  
^~~~~~  
../BLE/Common/ble_services/svc_ctl.c:152:5: error: too many arguments to function 'aci_gap_init'  
    aci_gap_init(role,  
^~~~~~  
In file included from /Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/ble_core/ble_lib.h:  
      from ..BLE/Common/ble_services/svc_ctl.c:28:  
/Users/nmcentire/STM32CubeIDE/workspace_1.4.0>HelloBLE/BLE/Common/ble_core/bluenrg_gap_aci.h:103:12: note:  
tBleStatus aci_gap_init(uint8_t role,  
^~~~~~  
make: *** [BLE/Common/ble_services/subdir.mk:33: BLE/Common/ble_services/svc_ctl.o] Error 1  
make: *** Waiting for unfinished jobs....  
"make -j3 all" terminated with exit code 2. Build might be incomplete.  
  
05:20:45 Build Failed. 3 errors, 6 warnings. (took 8s.686ms)
```

Notice Function Prototype is inside #ifdef

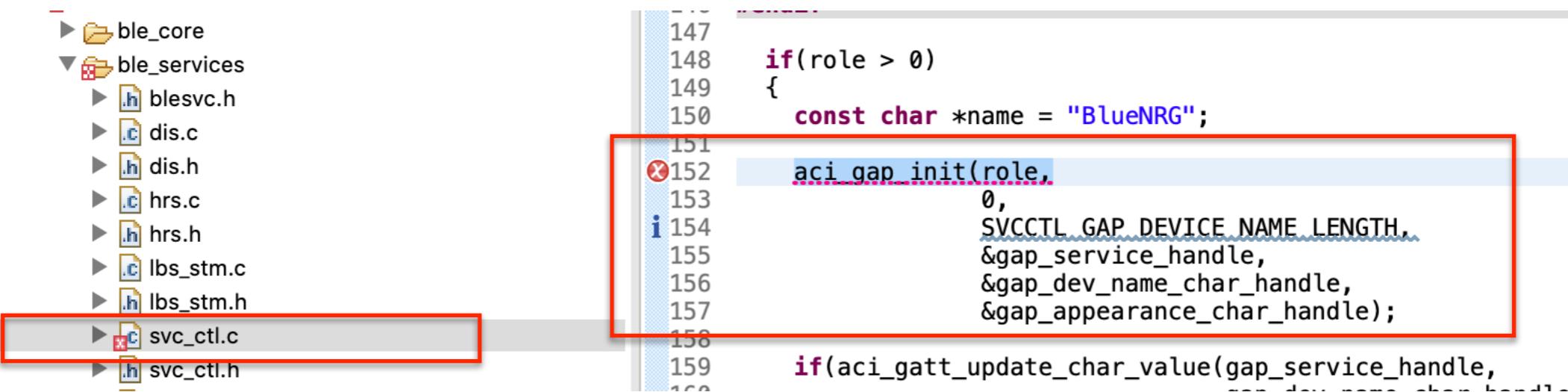
```
30
31 #if BLUENRG_MS
32 // @cond BLUENRG_MS
33 /**
34 * @brief Initialize the GAP layer.
35 * @note Register the GAP service with the GATT.
36 * All the standard GAP characteristics will also be added:
37 * @li Device Name
38 * @li Appearance
39 * @li Peripheral Preferred Connection Parameters (peripheral role only)
40 * @code
41
42 * @param role Bitmap of allowed roles: see @ref gap_roles "GAP roles".
43 * @param privacy_enabled Enable (1) or disable (0) privacy.
44 * @param device_name_char_len Length of the device name characteristic
45 * @param[out] service_handle Handle of the GAP service.
46 * @param[out] dev_name_char_handle Device Name Characteristic handle
47 * @param[out] appearance_char_handle Appearance Characteristic handle
48 * @retval tBleStatus Value indicating success or error code.
49 */
50 tBleStatus aci_gap_init(uint8_t role, uint8_t privacy_enabled,
51                         uint8_t device_name_char_len,
52                         uint16_t* service_handle,
53                         uint16_t* dev_name_char_handle,
54                         uint16_t* appearance_char_handle);
55
56 /**
57 * @param role One of the allowed roles: @ref GAP_PERIPHERAL_ROLE
58 * @param[out] service_handle Handle of the GAP service.
59 * @param[out] dev_name_char_handle Device Name Characteristic handle
60 * @param[out] appearance_char_handle Appearance Characteristic handle
61 * @retval tBleStatus Value indicating success or error code.
62 */
63
64 tBleStatus aci_gap_init(uint8_t role, uint8_t privacy_enabled,
65                         uint8_t device_name_char_len,
66                         uint16_t* service_handle,
67                         uint16_t* dev_name_char_handle,
68                         uint16_t* appearance_char_handle);
69
70 // @endcond
71 #else
72
73 // BLE
74 // Common
75 // ble_core
76 // ble_lib.h
77 // ble_status.h
78 // bluenrg_aci_const.h
79 // bluenrg_gap_aci.c
80 // bluenrg_gap_aci.h
81 // bluenrg_gap.h
82 // bluenrg_gatt_aci.c
83 // bluenrg_gatt_aci.h
84 // bluenrg_gatt_server.h
85 // bluenrg_hal_aci.c
86 // bluenrg_hal_aci.h
```

5-Params

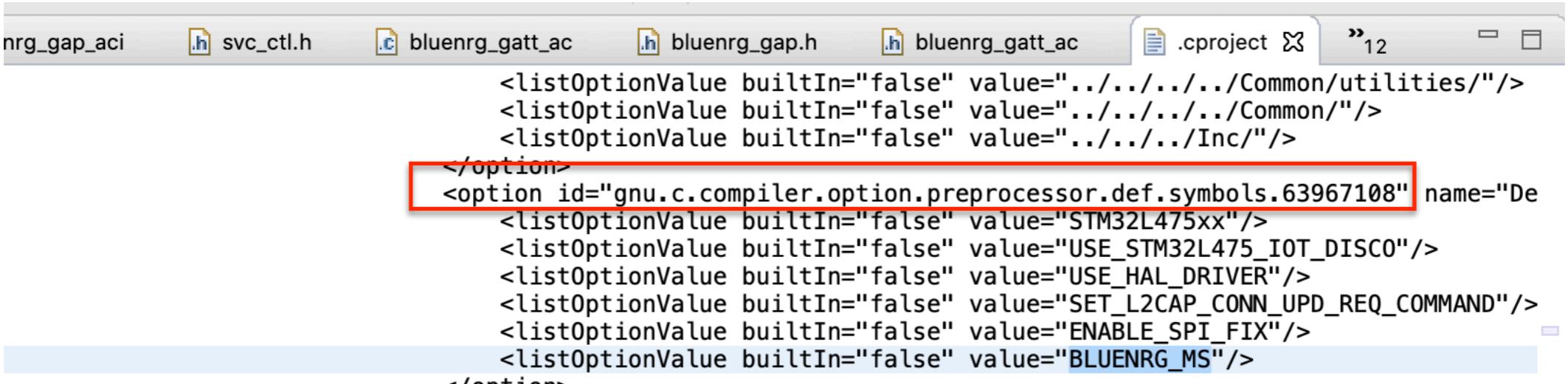
```
93 *
94 * PRINTF("aci_gatt_update_char_value failed.\n");
95 *
96 * @endcode
97 * @param role One of the allowed roles: @ref GAP_PERIPHERAL_ROLE
98 * @param[out] service_handle Handle of the GAP service.
99 * @param[out] dev_name_char_handle Device Name Characteristic handle
100 * @param[out] appearance_char_handle Appearance Characteristic handle
101 * @retval tBleStatus Value indicating success or error code.
102 */
103 BleStatus aci_gap_init(uint8_t role,
104                         uint16_t* service_handle,
105                         uint16_t* dev_name_char_handle,
106                         uint16_t* appearance_char_handle);
107 // @endcond
108 endif
```

4-Params

5-Param Version Used By Code

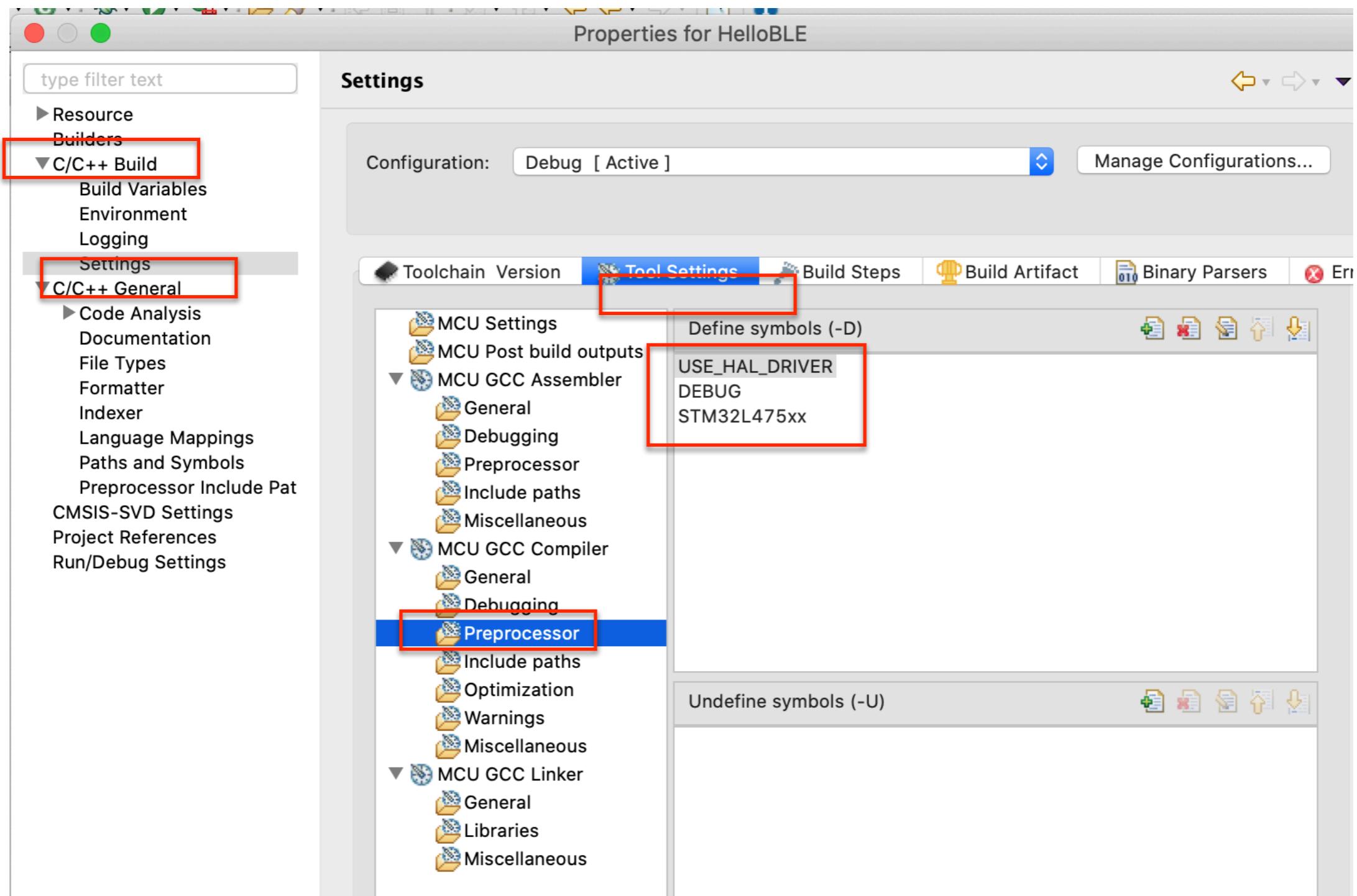


Value of BLUENRG_MS set to false

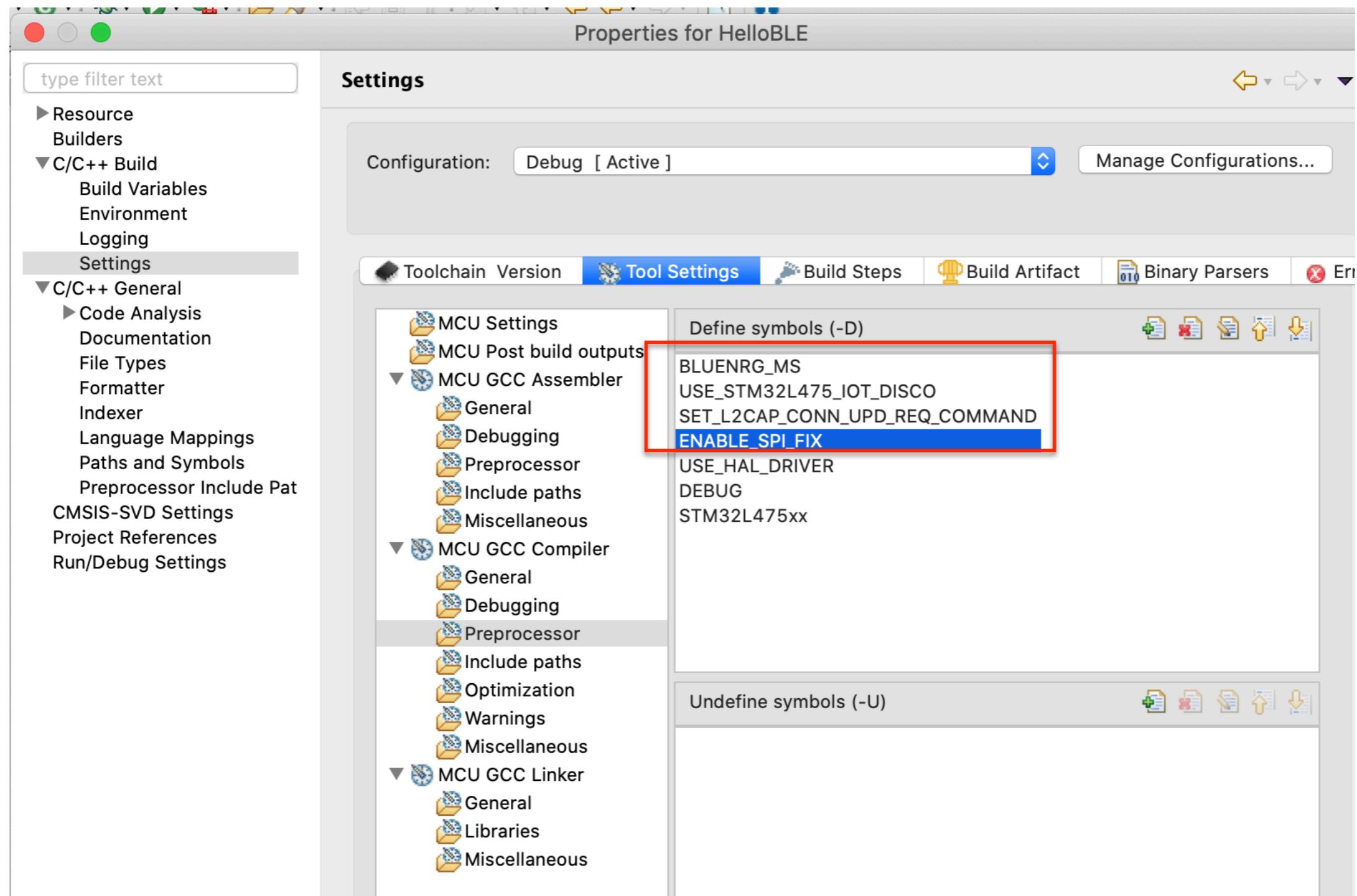


```
nrg_gap_aci    svc_ctl.h    bluenrg_gatt_ac    bluenrg_gap.h    bluenrg_gatt_ac    .cproject »12
<listOptionValue builtIn="false" value="../../../../Common/utilities//"/>
<listOptionValue builtIn="false" value="../../../../Common//"/>
<listOptionValue builtIn="false" value="../../../../Inc//"/>
</option>
<option id="gnu.c.compiler.option.preprocessor.def.symbols.63967108" name="De
    <listOptionValue builtIn="false" value="STM32L475xx"/>
    <listOptionValue builtIn="false" value="USE_STM32L475_IOT_DISCO"/>
    <listOptionValue builtIn="false" value="USE_HAL_DRIVER"/>
    <listOptionValue builtIn="false" value="SET_L2CAP_CONN_UPD_REQ_COMMAND"/>
    <listOptionValue builtIn="false" value="ENABLE_SPI_FIX"/>
    <listOptionValue builtIn="false" value="BLUENRG_MS"/>
</option>
<option id="fr.ac6.managedbuild.gnu.c.compiler.option.misc_other.1245544107" name="
```

Original Values

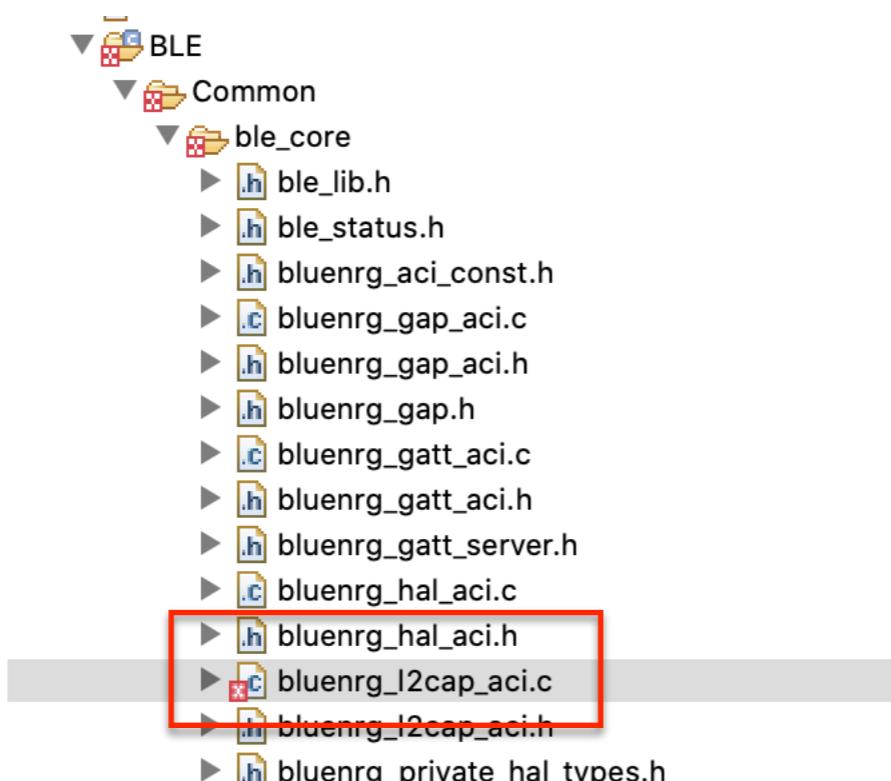


Add Values



Attempt Build

```
./BLE/Common/ble_core/bluenrg_l2cap_aci.c:16:10: fatal error: hal_types.h: No such file or directory
#include "hal_types.h"
^~~~~~
compilation terminated.
make: *** [BLE/Common/ble_core/subdir.mk:39: BLE/Common/ble_core/bluenrg_l2cap_aci.o] Error 1
make: *** Waiting for unfinished jobs....
"make -j3 all" terminated with exit code 2. Build might be incomplete.
```



```
3 * Author          : AMS - HEA&RF BL
4 * Version         : V1.0.0
5 * Date            : 4 Multiple markers at this column, mapped to line 1
6 * Description     : File with HCI c
7 ****
8 * THE PRESENT FIRMWARE WHICH IS FOR GL
9 * WITH CODING INFORMATION REGARDING TH
10 * AS A RESULT, STMICROELECTRONICS SHAL
11 * INDIRECT OR CONSEQUENTIAL DAMAGES WI
12 * CONTENT OF SUCH FIRMWARE AND/OR THE
13 * INFORMATION CONTAINED HEREIN IN CONN
14 ****
15
16 #include "hal_types.h" // Line 16, highlighted with a red box
17 #include "osal.h"
18 #include "ble_status.h"
19 #include "hal.h" // Line 19, highlighted with a red box
20 #include "osal.h"
21 #include "hci_const.h"
22 #include "bluenrg_aci_const.h"
23 #include "bluenrg_hal_aci.h"
```

Comment Out Header Files

```
▶ .h stm32l4xx_hal_pca.h
▶ .h stm32l4xx_hal_pwr_ex.h
▶ .h stm32l4xx_hal_pwr.h
▶ .h stm32l4xx_hal_qspi.h
▶ .h stm32l4xx_hal_rcc_ex.h
▶ .h stm32l4xx_hal_rcc.h
▶ .h stm32l4xx_hal_rtc_ex.h
▶ .h stm32l4xx_hal_rtc.h
▶ .h stm32l4xx_hal_spi_ex.h
▶ .h stm32l4xx_hal_spi.h
▶ .h stm32l4xx_hal_tim_ex.h
▶ .h stm32l4xx_hal_tim.h
▶ .h stm32l4xx_hal_uart_ex.h
▶ .h stm32l4xx_hal_uart.h
▶ .h stm32l4xx_hal.h
▶ .h stm32l4xx_ll_cortex.h
▶ .h stm32l4xx_ll_dma.h
```

```
3 * Author : AMS - HEA&RF BL
4 * Version : V1.0.0
5 * Date : 4-Oct-2013
6 * Description : File with HCI c
7 ****
8 * THE PRESENT FIRMWARE WHICH IS FOR GL
9 * WITH CODING INFORMATION REGARDING TH
10 * AS A RESULT, STMICROELECTRONICS SHAL
11 * INDIRECT OR CONSEQUENTIAL DAMAGES WI
12 * CONTENT OF SUCH FIRMWARE AND/OR THE
13 * INFORMATION CONTAINED HEREIN IN CONN
14 ****
15
16 // #include "hal_types.h"
17 #include "osal.h"
18 #include "ble_status.h"
19 // #include "hal.h"
20 #include "osal.h"
21 #include "hci_const.h"
22 #include "bluenrg_aci_const.h"
23 #include "bluenrg_hal_aci.h"
```

Attempt to build

```
make -j3 all
arm-none-eabi-gcc "../BLE/Common/ble_core/bluenrg_l2cap_aci.c" -mcpu=cortex-m4 -std=gnu11
arm-none-eabi-gcc "../BLE/Common/ble_core/hci_le.c" -mcpu=cortex-m4 -std=gnu11 -q3 -DBLUEI
arm-none-eabi-gcc "../BLE/Common/ble_hci_tl_io_template.c" -mcpu=cortex-m4 -std=gnu11 -g3
../BLE/Common/ble_hci_tl_io_template.c:25:1: error: unknown type name 'int32_t'
int32_t hci_send_req(struct hci_request *r, uint8_t async)
^~~~~~
../BLE/Common/ble_core/hci_le.c:19:10: fatal error: hal_types.h: No such file or director
#include "hal_types.h"
^~~~~~
compilation terminated.
../BLE/Common/ble_hci_tl_io_template.c:25:45: error: unknown type name 'uint8_t'
int32_t hci_send_req(struct hci_request *r, uint8_t async)
^~~~~~

make: *** [BLE/Common/subdir.mk:18: BLE/Common/ble_hci_tl_io_template.o] Error 1
make: *** Waiting for unfinished jobs....
make: *** [BLE/Common/ble_core/subdir.mk:41: BLE/Common/ble_core/hci_le.o] Error 1
../BLE/Common/ble_core/bluenrg_l2cap_aci.c: In function 'aci_l2cap_connection_parameter_u
../BLE/Common/ble_core/bluenrg_l2cap_aci.c:37:20: warning: implicit declaration of functi
    cp.conn_handle = htobs(conn_handle);
        ^~~~~~
```

Summary

- BLE compared to Wi-Fi
- BLE Concepts
- BLE Data Sheet
- Schematics - BLE on STM32L Discovery Kit for IoT
- Hands-On Project - BLE