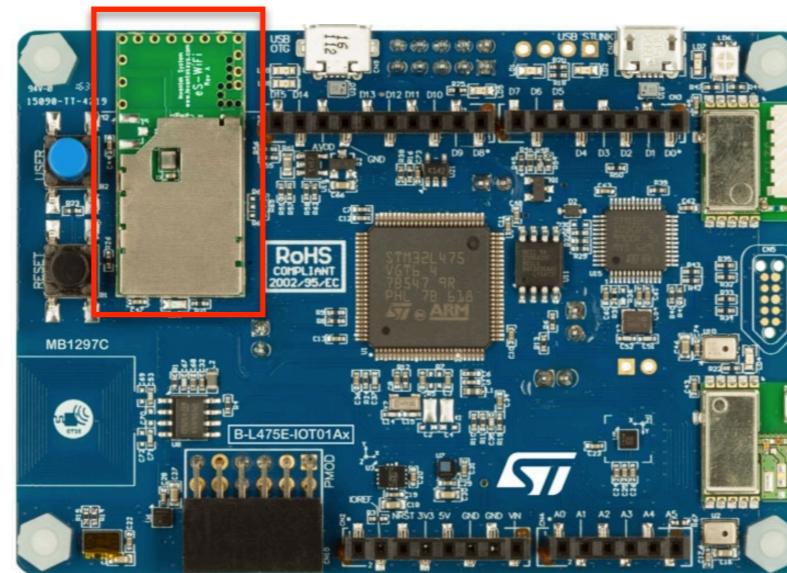


Embedded Systems

Hardware Interfacing

Wi-fi

Norman McEntire



Contents

- Transition Point in Course
- Wifi Concepts
- Wifi Data Sheet
- Schematics - Wifi on STM32L Discovery Kit for IoT
- Hands-On Project - Wifi HTTP Server

References

- <https://en.wikipedia.org/wiki/Wi-Fi>
- https://en.wikipedia.org/wiki/Wi-Fi_Alliance
- https://en.wikipedia.org/wiki/IEEE_802.11
- <https://www.inventeksys.com/ism4336-m3g-l44-e-embedded-serial-to-wifi-module/>
- 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>

Transition Point In Course

- Previous Lessons (non wireless)
 - L1: GPIO, L2: ADC, L3: UART
 - L4: I2C, L5: SPI, L6: USB
- Transition to wireless network interfacing
 - L7: Wi-fi
 - L8: Bluetooth
 - L9: Sub GHz (e.g. 915 Mhz ISM)

Wi-fi



Wifi Concepts

- Wifi is a family of wireless protocols - See next slide
- Based on IEEE 802.11 - See next slide
- 2.4 Ghz and 5 Ghz
- Work through Wireless Access Points (APs)
 - SSID - Service Set ID
 - PSK - Pre Shared Key
- All Wi-Fi devices have a MAC address
 - Media Access Control Address
- Wifi is higher power than other RF (e.g. Bluetooth) but longer range

802.11 Protocols

4 Protocol

- 4.1 [802.11-1997 \(802.11 legacy\)](#)
- 4.2 [802.11a \(OFDM waveform\)](#)
- 4.3 [802.11b](#)
- 4.4 [802.11g](#)
- 4.5 [802.11-2007](#)
- 4.6 [802.11n](#)
- 4.7 [802.11-2012](#)
- 4.8 [802.11ac](#)
- 4.9 [802.11ad](#)
- 4.10 [802.11af](#)
- 4.11 [802.11-2016](#)
- 4.12 [802.11ah](#)
- 4.13 [802.11ai](#)
- 4.14 [802.11aj](#)
- 4.15 [802.11aq](#)
- 4.16 [802.11ax](#)
- 4.17 [802.11ay](#)
- 4.18 [802.11ba](#)
- 4.19 [802.11be](#)

Wifi Generations

Wi-Fi Generations

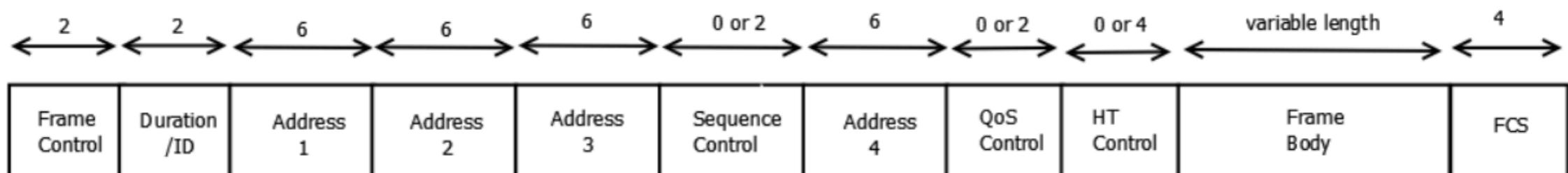
Generation/IEEE Standard	Maximum Linkrate	Adopted	Frequency
Wi-Fi 6E (802.11ax)	600 to 9608 Mbit/s	2019	6 GHz
Wi-Fi 6 (802.11ax)	600 to 9608 Mbit/s	2019	2.4/5 GHz
Wi-Fi 5 (802.11ac)	433 to 6933 Mbit/s	2014	5 GHz
Wi-Fi 4 (802.11n)	72 to 600 Mbit/s	2008	2.4/5 GHz
802.11g	6 to 54 Mbit/s	2003	2.4 GHz
802.11a	6 to 54 Mbit/s	1999	5 GHz
802.11b	1 to 11 Mbit/s	1999	2.4 GHz
802.11	1 to 2 Mbit/s	1997	2.4 GHz
(Wi-Fi 1, Wi-Fi 2, Wi-Fi 3, Wi-Fi 3E are unbranded ^[41] but have unofficial assignments ^[42])			

Wi-Fi 802.11 Frame

Communication stack [edit]

Main articles: [IEEE 802](#) and [IEEE 802.11](#)

Wi-Fi is part of the IEEE 802 protocol family. The data is organized into [802.11 frames](#) that are very similar to [Ethernet frames](#) at the data link layer, but with extra address fields. MAC addresses are used as [network addresses](#) for routing over the LAN.^[66]



Wi-Fi Modes

Infrastructure [edit]

In infrastructure mode, which is the most common mode used, all communications go through a base station. For communications within the network, this introduces an extra use of the airwaves but has the advantage that any two stations that can communicate with the base station can also communicate through the base station, which enormously simplifies the protocols.

Ad hoc and Wi-Fi direct [edit]

Wi-Fi also allows communications directly from one computer to another without an access point intermediary. This is called *ad hoc* Wi-Fi transmission. Different types of ad hoc networks exist. In the simplest case network nodes must talk directly to each other. In more complex protocols nodes may forward packets, and nodes keep track of how to reach other nodes, even if they move around.

Similarly, the Wi-Fi Alliance promotes the specification Wi-Fi Direct for file transfers and media sharing through a new discovery- and security-methodology.^[1]

Wi-Fi Channels and Interference

A standard speed Wi-Fi signal occupies five channels in the 2.4 GHz band. Interference can be caused by overlapping channels. Any two channel numbers that differ by five or more, such as 2 and 7, do not overlap (no [adjacent-channel interference](#)). The oft-repeated adage that channels 1, 6, and 11 are the *only* non-overlapping channels is, therefore, not accurate. Channels 1, 6, and 11 are the *only group of three* non-overlapping channels in North America. However, whether the overlap is significant depends on physical spacing. Channels that are four apart interfere a negligible amount-much less than reusing channels (which causes [co-channel interference](#))-if transmitters are at least a few metres apart.^[87] In Europe and Japan where channel 13 is available, using Channels 1, 5, 9, and 13 for [802.11g](#) and [802.11n](#) is recommended.

Wi-Fi Example

<https://www.adafruit.com/product/1030>



USB WiFi (802.11b/g/n) Module with Antenna for Raspberry Pi

PRODUCT ID: 1030

Make your Internet of Things device cable-free by adding super WiFi. Take advantage of the Raspberry Pi and Beagle Bone's USB port to add a low cost, but high-reliability wireless link. We tried half a dozen modules to find ones that work well with the Pi and Bone without the need of...

Wi-Fi Example

<https://www.adafruit.com/product/2022>



OUT OF STOCK

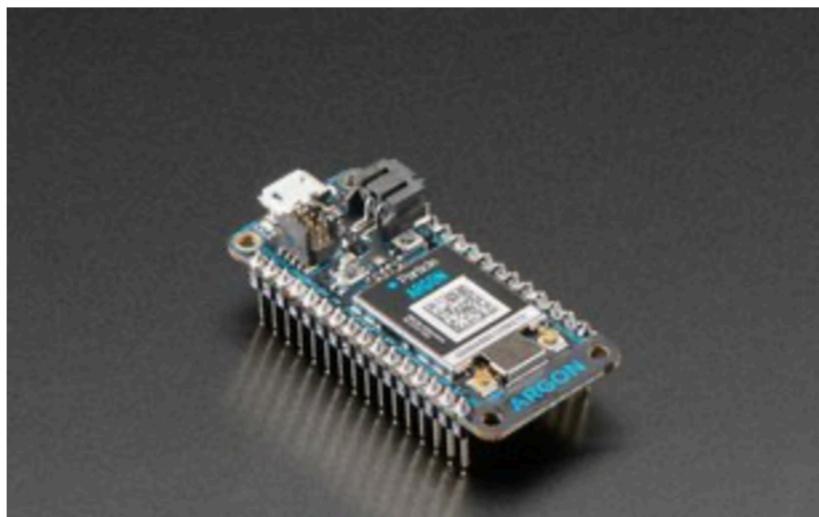
[ACKme WiConnect WiFi Module - Mackerel Evaluation Board](#)

PRODUCT ID: 2022

The same team that built Roving Networks is now at ACKme, where they're designing the future of WiFi connectivity. Their first release is the ACKme WiConnect, a super-smart WiFi module that has a lot of built-in capability such as SSL, AP mode, auto-connection, etc. The AMW004-E03...

Wi-Fi Example

<https://www.adafruit.com/product/3997>



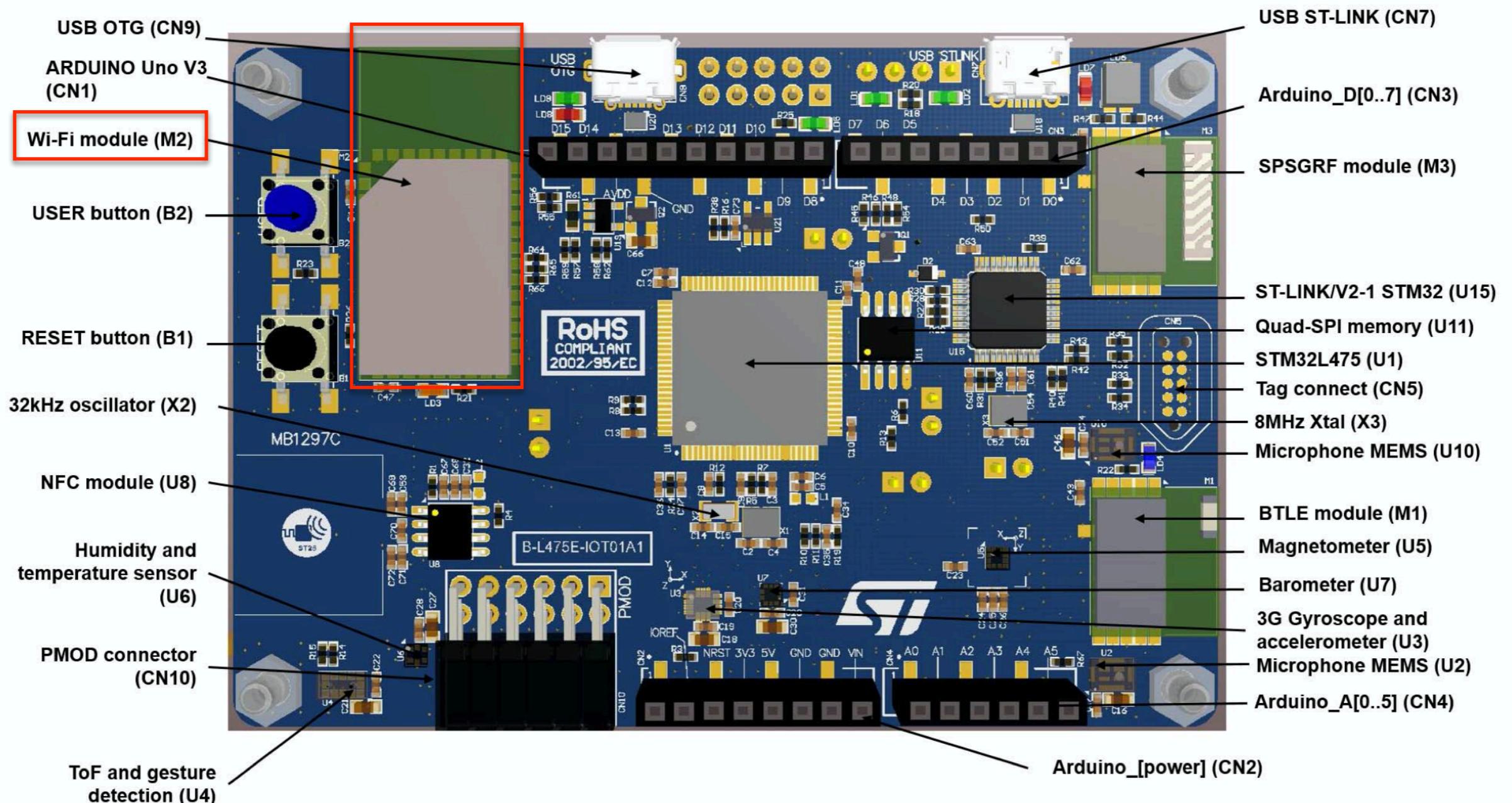
Particle Argon - nRF52840 with Mesh and WiFi

PRODUCT ID: 3997

Woohoo, it's time for a Particle Mesh party! And the Particle Argon is bringing it with a mix of Mesh networking and WiFi, your two most favorite 2.4GHz wireless protocols. The Argon is a powerful WiFi enabled development kit that can act as either a standalone WiFi...

Wifi Example

Discovery Kit



Data Sheet

ISM43362-M3G-L44-E/U Serial-to-WiFi Module



<https://www.inventeksys.com/ism4336-m3g-l44-e-embedded-serial-to-wifi-module/>

ISM43362-M3G-L44-E/U Serial-to-WiFi Module



The ISM43362-M3G-L44-E/U is an embedded 2.4 GHz Wi-Fi module. The Wi-Fi module hardware consists of a Cypress CYW43362, an integrated antenna or optional external antenna, and a STM32F205 host processor that has a SPI or UART interface capability.

The Wi-Fi module requires no operating system and has an integrated TCP/IP stack that only requires a simple AT command set to establish connectivity for your wireless product. The module has a very small 14.5mm x 30mm surface mount footprint and has full FCC, IC, Japan and CE module certification.

<https://www.inventeksys.com/ism4336-m3g-l44-e-embedded-serial-to-wifi-module/>

ISM43362-M3G-L44-E/U Serial-to-WiFi Module



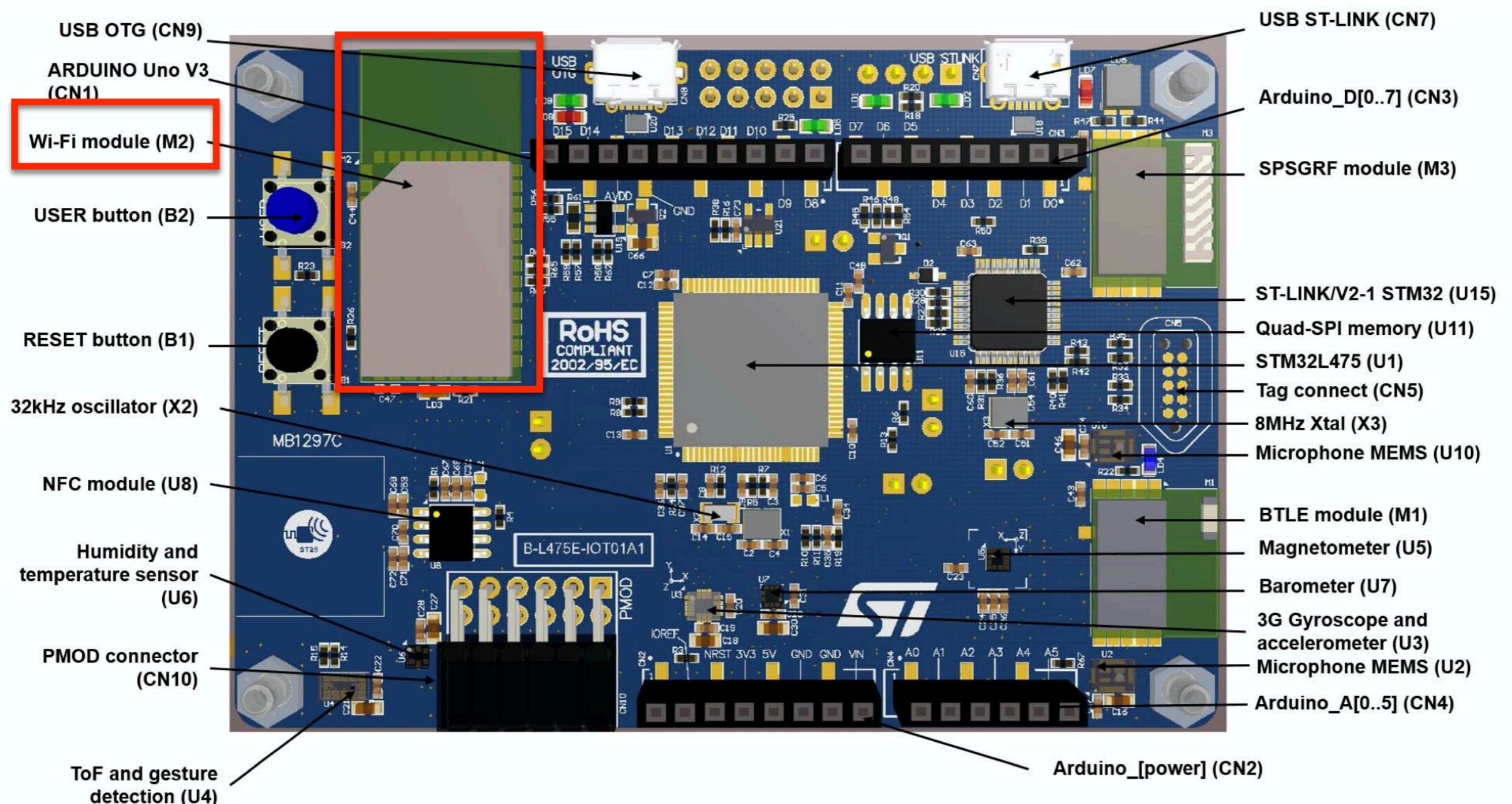
A summary of the key module features:

- ⌚ 802.11 b/g/n Compatible based on Broadcom MAC/Baseband/Radio device.
- ⌚ Fully contained TCP/IP stack thus minimizing host CPU requirements
- ⌚ Configurable through Inventek IWIN AT commands or Cypress WICED SDK
- ⌚ Host interface: UART, SPI up to 25 MHz
- ⌚ Network features ICMP (Ping), ARP, DHCP, TCP, UDP
- ⌚ Low power operation (3.3V supply) with built-in low power modes.
- ⌚ Secure Wi-Fi authentication WEP-128, WPA-PSK (TKIP), WPA2-PSK

User Manual

STM32L Discovery Kit IoT Node

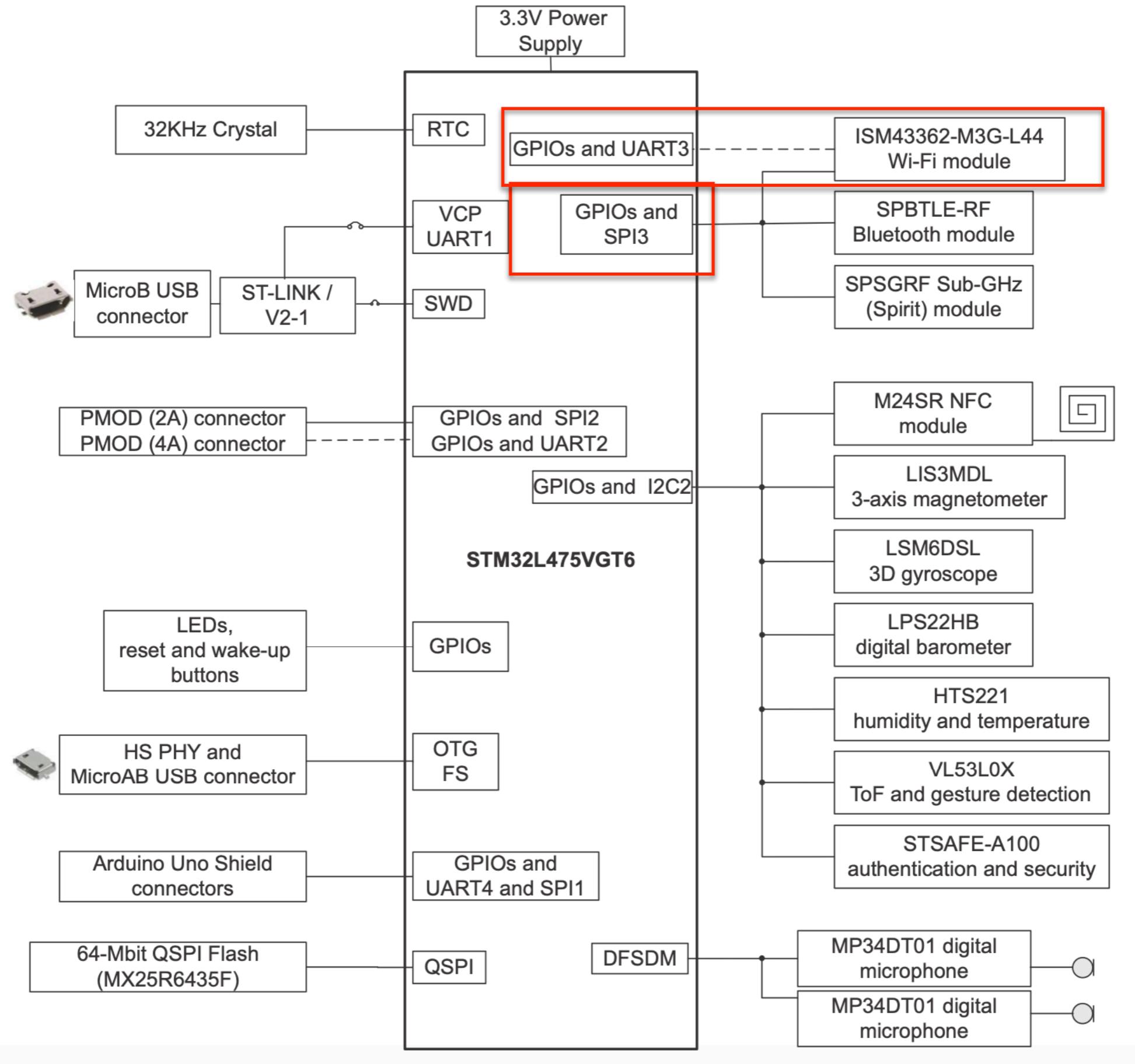
Use of Wi-Fi



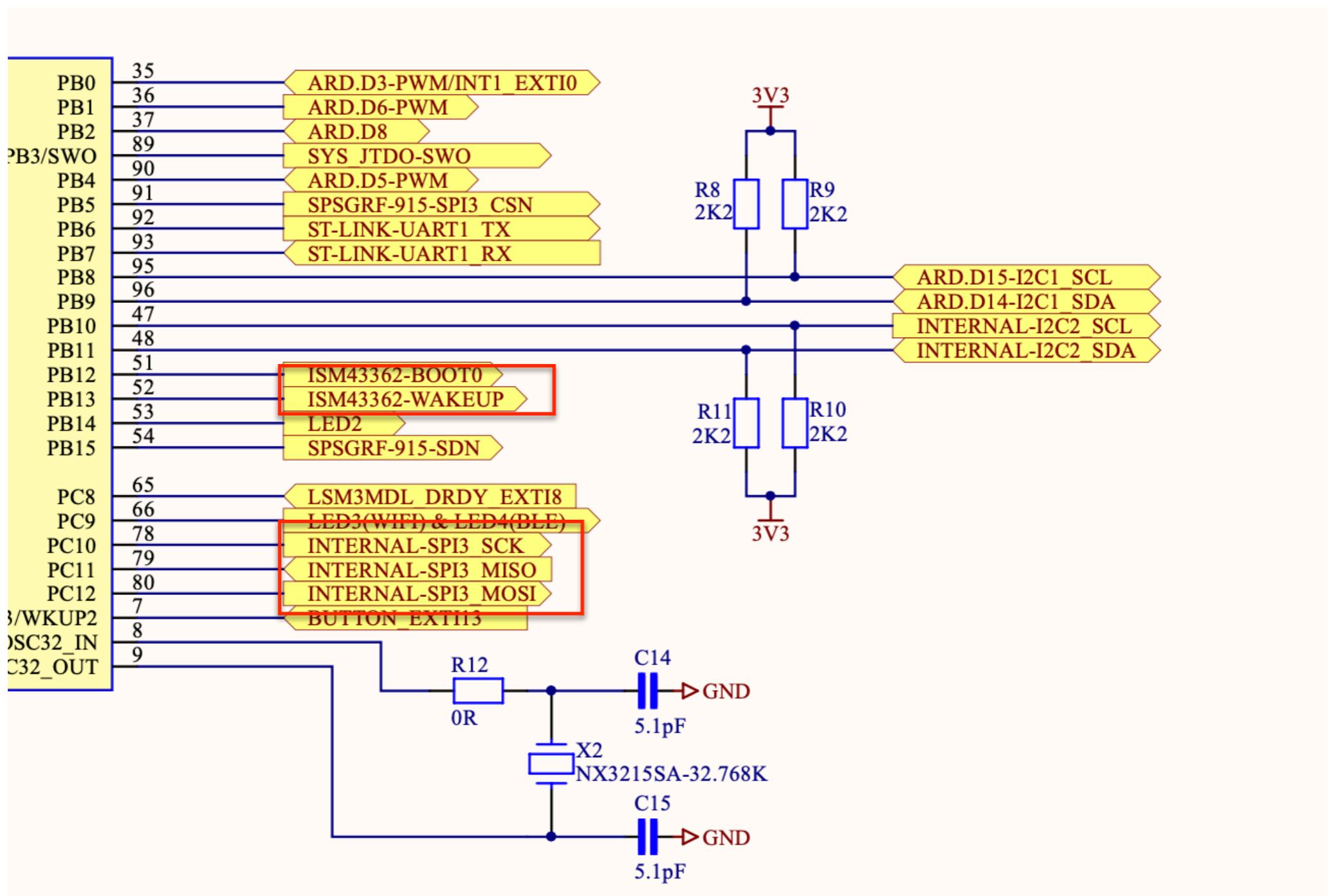
Schematics

STM324L Discovery Kit

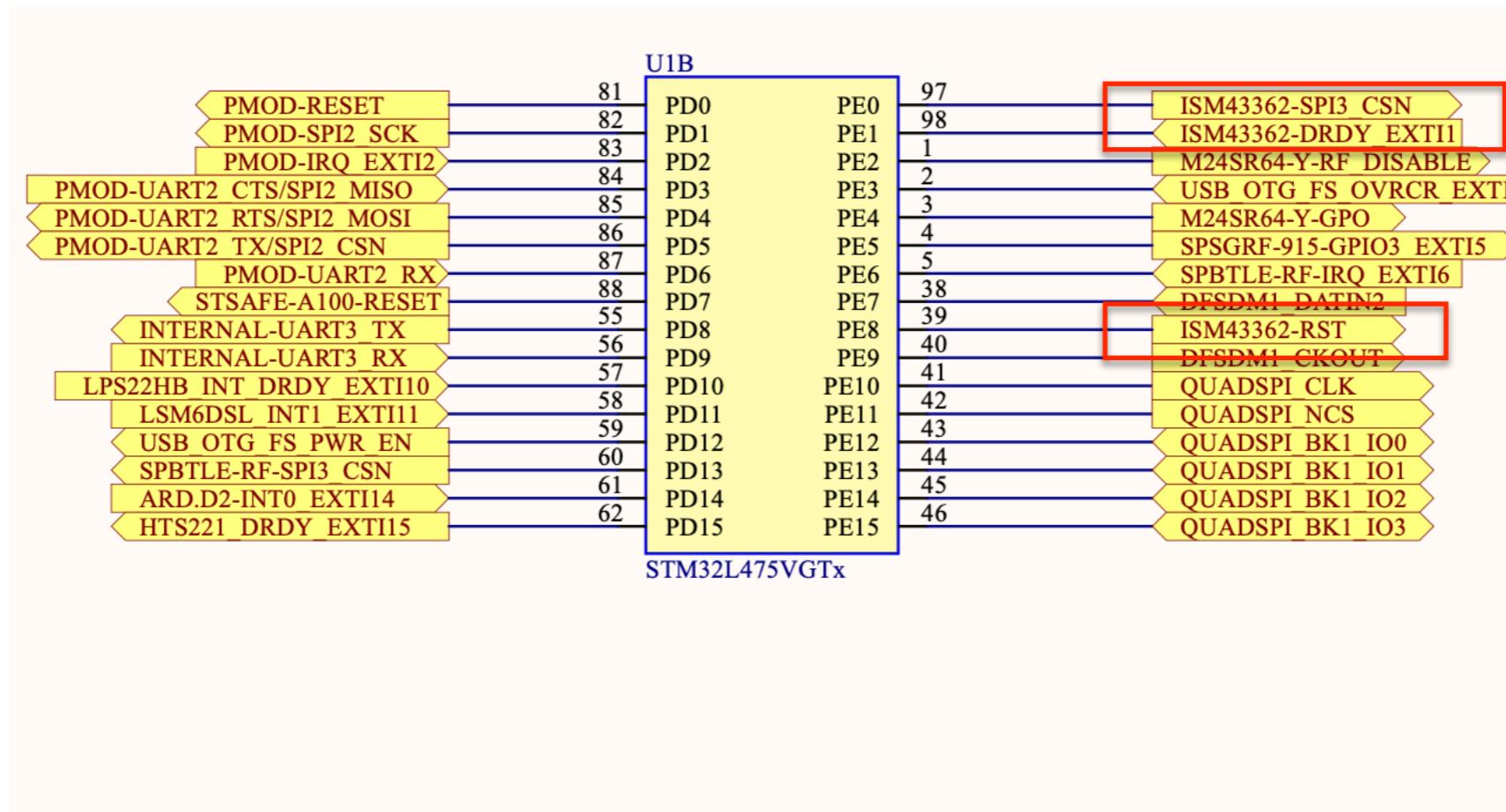
IoT Node



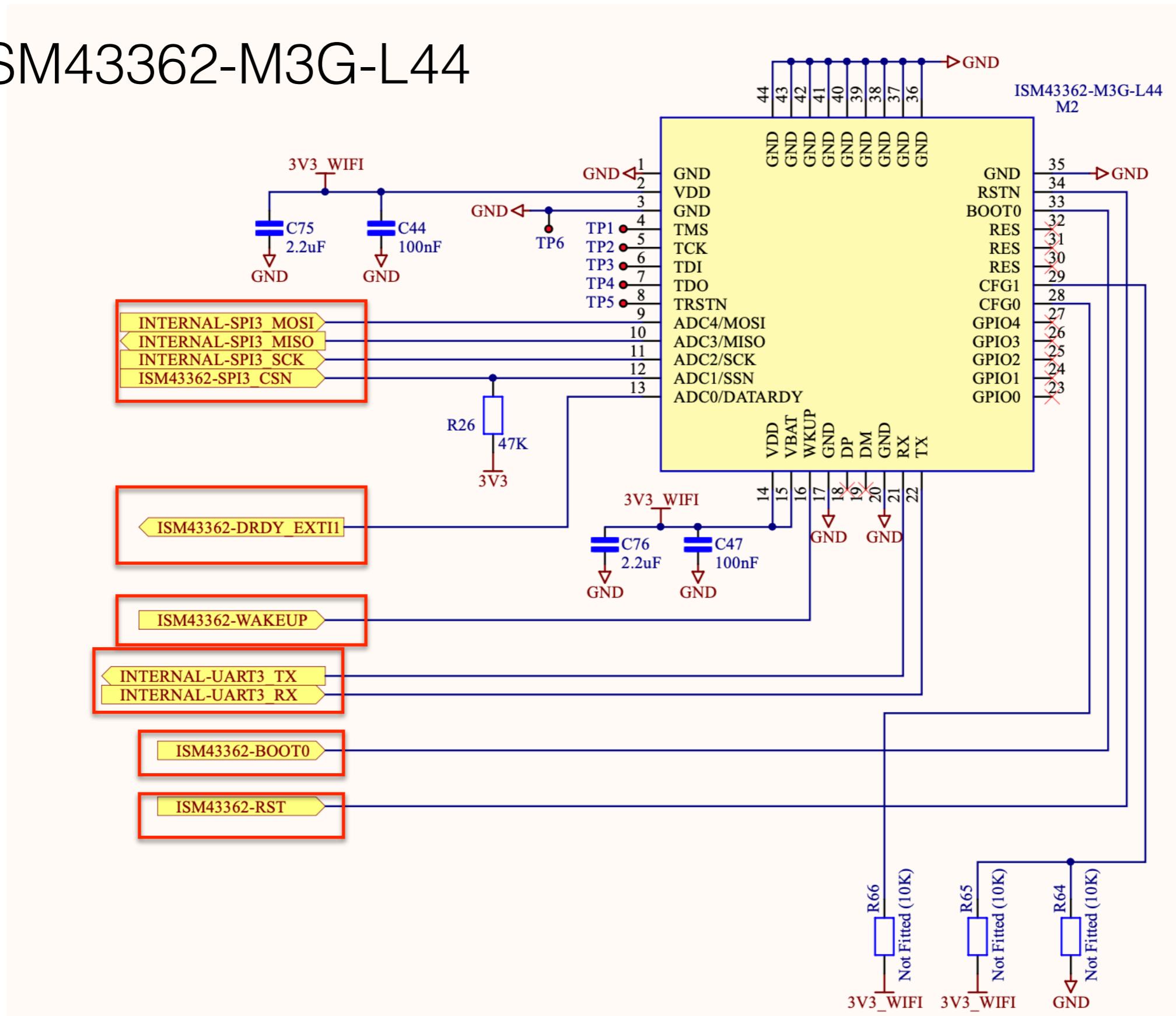
STM32L475



STM32L475



ISM43362-M3G-L44



Wi-Fi Hands-On Project

Wi-Fi Hands-On Project

Overview

- The goal of this project is to give you hands-on experience with adding Wi-Fi 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

Wi-Fi HTTP Server README

Part 1

@par Application Description

This application shows how to make **HTTP requests** using the Es-WiFi module based on STM32Cube HAL.

In this example, you will use Es_WiFi module and a web Browser to create a simple Web server.

After opening a browser and navigating to es-WiFi **shield's IP address**, the B_L475E-IOT01ax board will be able to answer a HTTP request with es-WIFI shield.

An HTTP client sends a request message to an HTTP server.

This application may be used with a Smartphone (more detailed setup instructions are described in section "Hardware and Software environment").

If the **USART** is used to output a message on **hyperterminal** (`#define TERMINAL_USE in main.c`), log messages will be displayed on **Hyperterminal** to inform user about es_wifi module status

The communication is done with a web browser application in a SmartPhone.

This HTTP server contains a html page:

- + LED control: allows to control the Green Led LED2 located in the B_L475E-IOT01ax board
- + ADC conversion: it shows the temperature sensor converted value

Wi-Fi HTTP Server README

Part 2

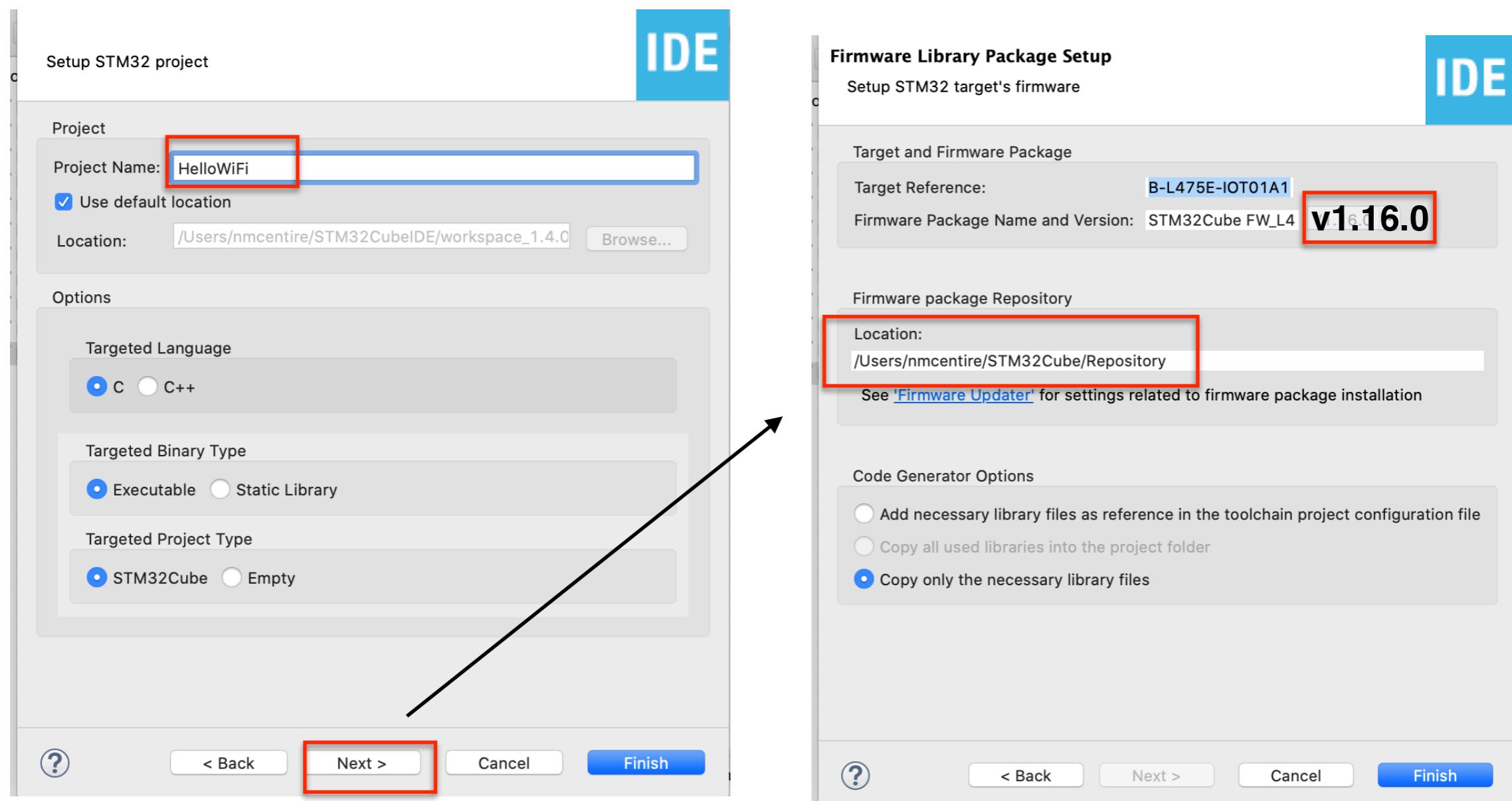
T ADC CONVERSION. IT SHOWS THE TEMPERATURE SENSOR CONVERTED VALUE

@par Directory contents

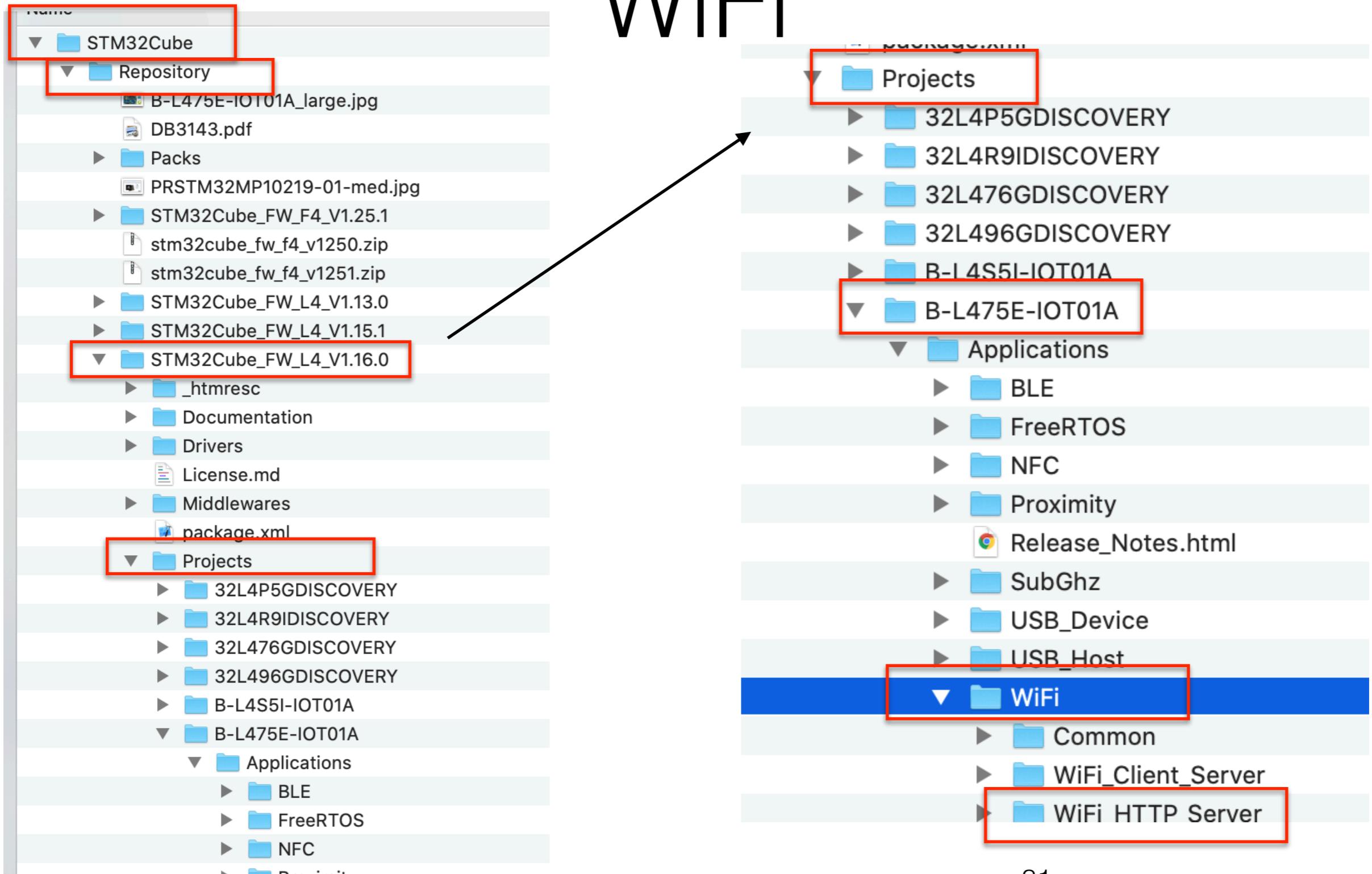
- WiFi/WiFi_HTTP_Server/Inc/main.h
- WiFi/WiFi_HTTP_Server/Inc/stm32l4xx_hal_conf.h
- WiFi/WiFi_HTTP_Server/Inc/stm32l4xx_it.h
- WiFi/WiFi_HTTP_Server/Src/main.c
- WiFi/WiFi_HTTP_Server/Src/system_stm32l4xx.c
- WiFi/WiFi_HTTP_Server/Src/stm32l4xx_it.c
- WiFi/Common/Src/es_wifi.c
- WiFi/Common/Src/es_wifi_io.c
- WiFi/Common/Src/wifi.c
- WiFi/Common/Inc/es_wifi.h
- WiFi/Common/Inc/es_wifi_io.h
- WiFi/Common/Inc/wifi.h

- header for main.c module
- HAL configuration file
- STM32 interrupt handlers header file
- Main Program
- STM32L4xx system clock configuration file
- STM32 interrupt handlers
- Implementation of the ES_WIFI_XXX() API.
- Implementation of the ES_WIFI_IO_XXX() API.
- Implementation of the WIFI_XXX() API.
- Header for the functions and defines used by the es_wifi.c
- Header for the functions and defines used by the es_wifi_io.c
- Header for the functions and defines used by the wifi.c

Create New Project (And Find Location of Repository)



Projects/B-L475E-IOT01A/ WiFi

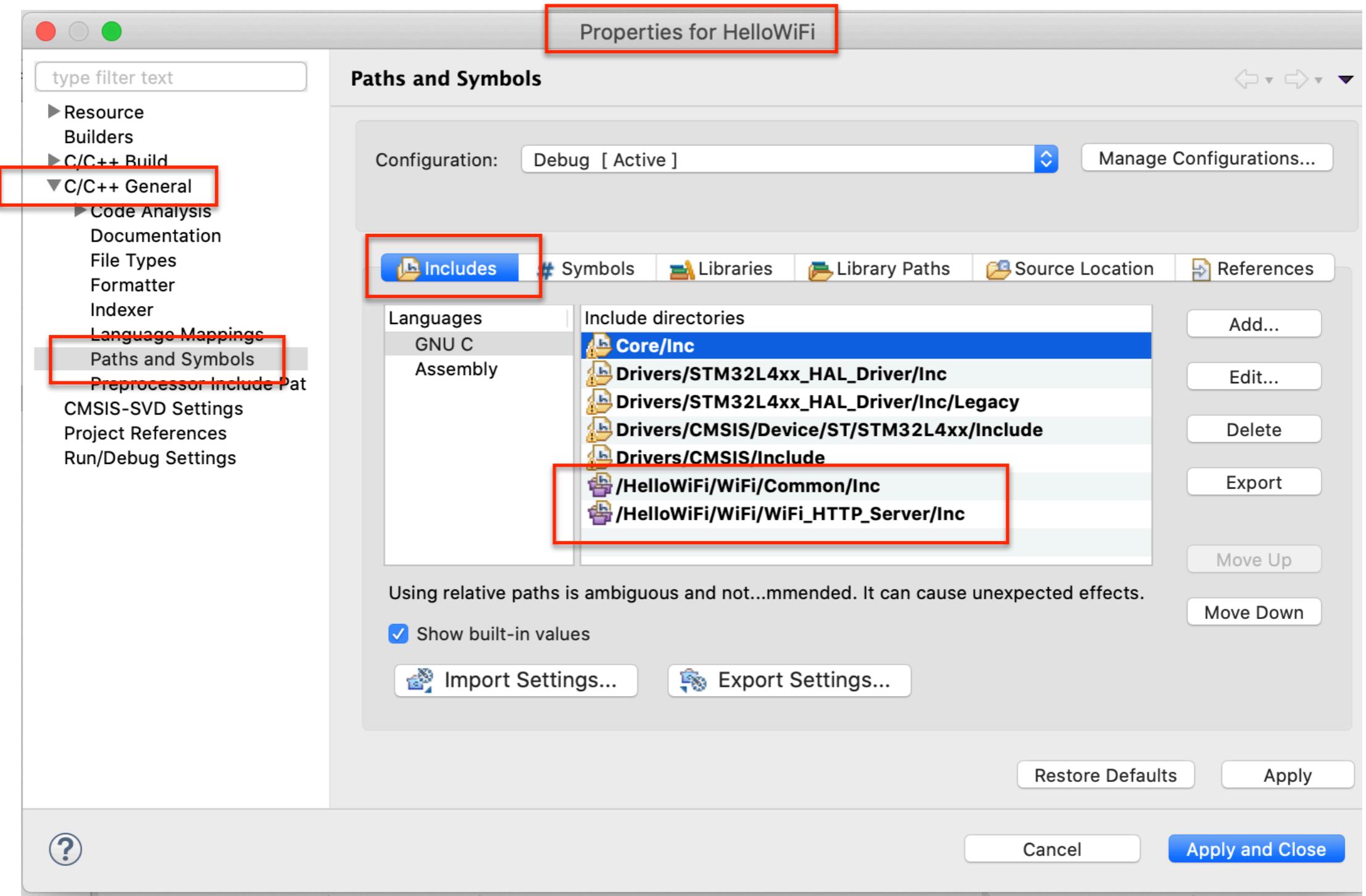


WiFi Folder

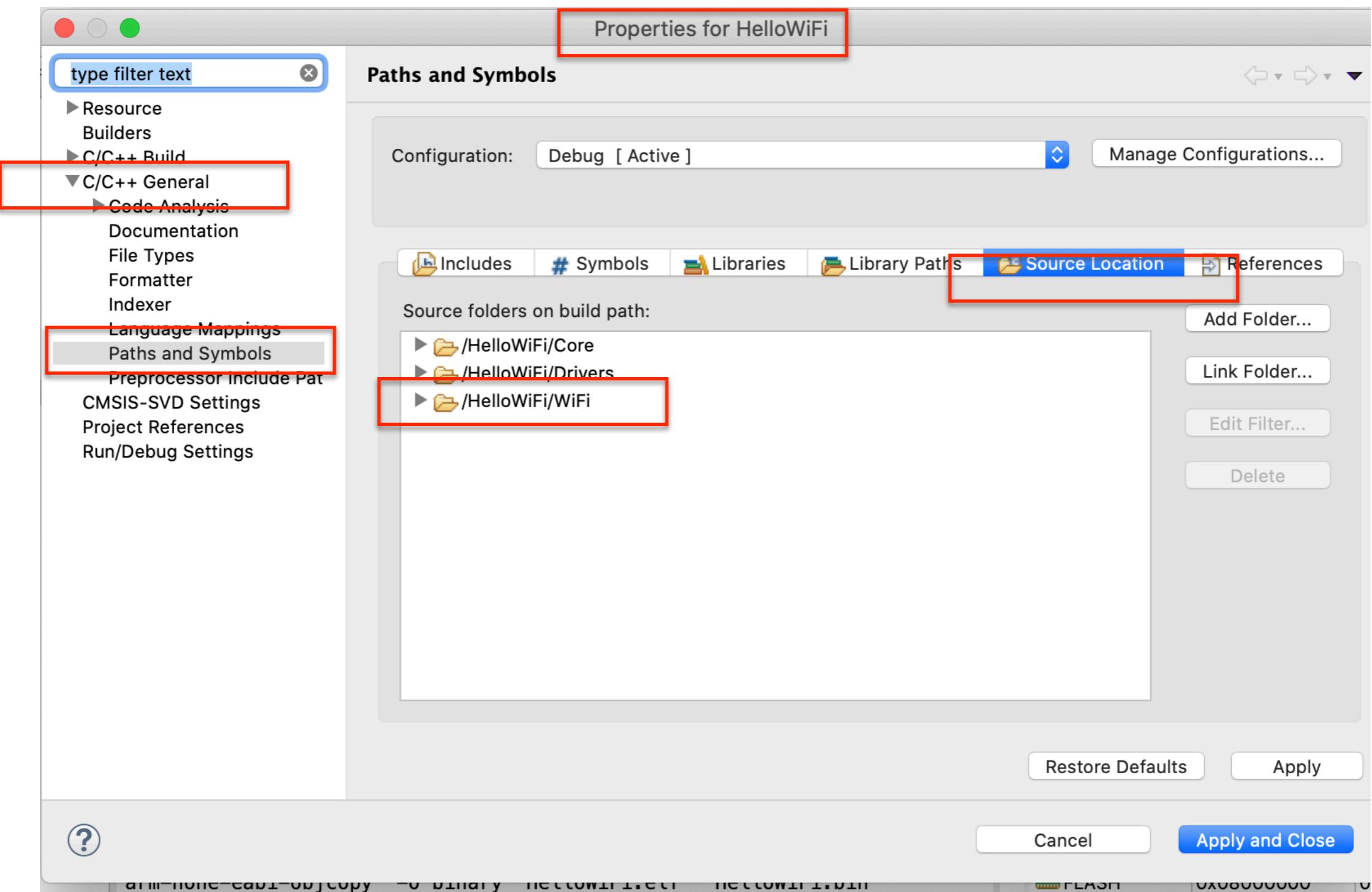
Drag/Drop (COPY FILES)



Add Include Paths To Project Properties



Add Source Paths To Project Properties



Summary

- Transition Point in Course
- Wifi Concepts
- Wifi Data Sheet
- Schematics - Wifi on STM32L Discovery Kit for IoT
- Hands-On Project - Wifi HTTP Server