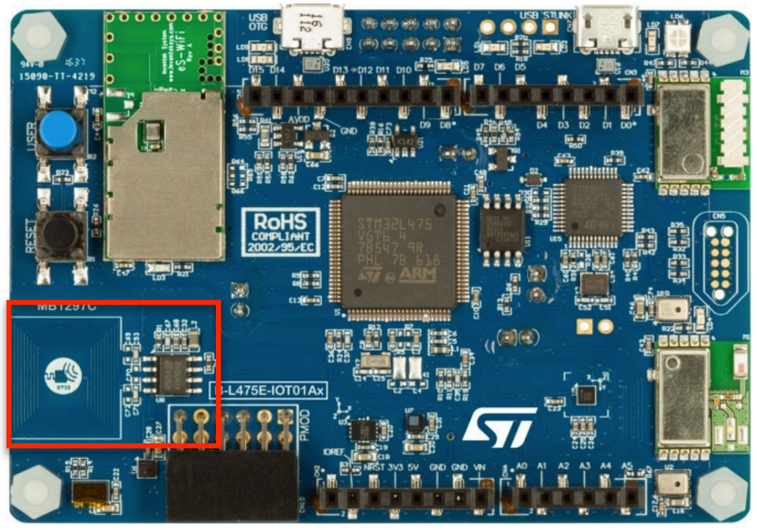
Embedded Systems Hardware Interfacing

NFC

N-Mark Logo for NFC-enabled devices

Norman McEntire



Contents

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

References

- https://en.wikipedia.org/wiki/Near-field_communication
- https://nfc-forum.org
- https://www.st.com/en/nfc/m24sr64-y.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

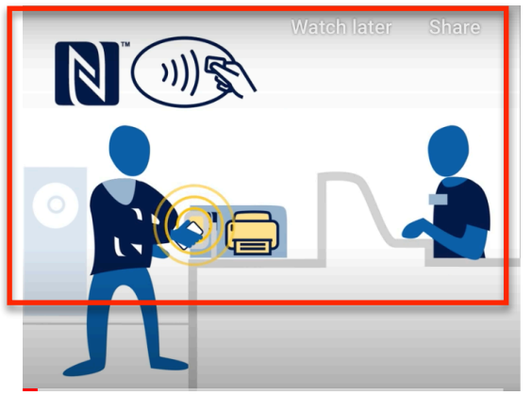
NFC Forum

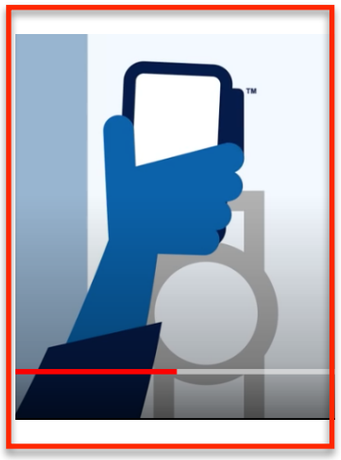
- Non Profit Industry Association
  - Goal is to advance the use of NFC
- Founded by
  - NXP Semiconductors
  - Sony
  - Nokia
- As of Jan 2020: 120 Member Companies
- Standardized on Four Distinct Tag Types - Different Attributes of each

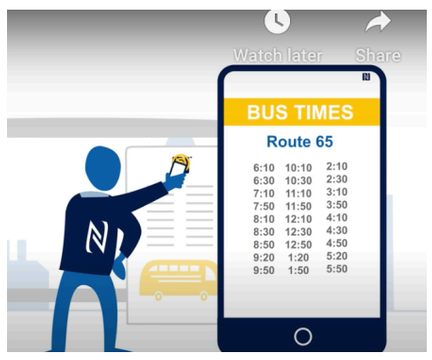
NFC Tag Types Grouped By The Following Attributes

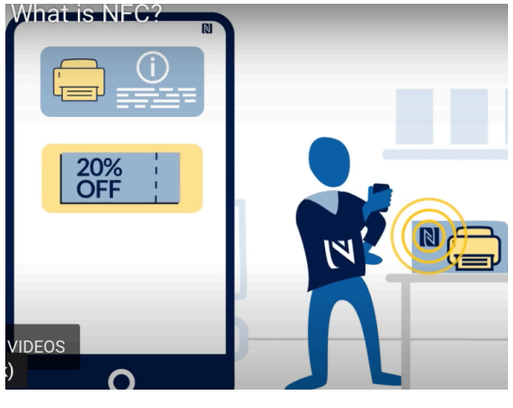
- Tag Type Organized by
  - Communication Speeds
  - Memory Size
  - Security
  - Data Retention
  - Write Endurance

NFC Video on NFC-Forum.org









NFC Use In Embedded
NFC to Bootstrap to Bluetooth or Wifi

- NFC provides low-speed connection to bootstrap to higher-speed connection
- Examples
  - Uses NFC to enable Bluetooth pairing for file transfer (Android Beam)
  - NFC to pair Headsets, Speakers, to Bluetooth

NFC Use In Embedded
NFC For Identify and Access Tokens

- NFC can act as Identity or Access Token
  - NFC encryption support make it more stable than less private RFID systems

NFC Compared to Bluetooth Compared to Wi-Fi: Range

- Range
- **NCF - 10 cm**
- BLE - 50 M
- Wi-Fi - 100 M+

NFC Compared to Bluetooth Compared to Wi-Fi: Frequency

- Frequency
- **NCF - 13.56 MHz ISM** (Industrial, Scientific, Medical)
- BLE - 2.4 GHz ISM
- Wi-Fi - 2.4 GHz and 5Ghz ISM

NFC Compared to Bluetooth Compared to Wi-Fi: Bit Rate

- Bit Rate
- **NCF - 106 kbps, 212 kpbs, 424 kbps**
- BLE - 1 Mbps
- Wi-Fi - 10 Mbps+

NFC Concepts - Part 1

- NFC - Near Field Communications
- Short-range wireless - 10cm or less
- 13.56MHz ISO/IEC 18000-3 Air Interface
- 106 kpbs, 212 kbps, 424 kbps

NFC Concepts - Part 2

- NFC Requires Two Roles
    - **Initiator**
        - Generates the RF field to power passive target
    - **Target**
        - Typically unpowered simple device (e.g. tag)
        - Exception: Target can be powered for peer-to-peer communication with Initiator
- NOTE: Some ICs provide dual mode - both initiator and target at same time

NFC Concepts - Part 3

- NFC Tags are:
  - Typically Read Only
    - Sometimes writable
  - Typically encoded with NFC Forum specs
    - Custom encoded possible too

NFC Modes

- Three NFC Modes
  - **NFC Card Emulation**
    - NFC devices (e.g. Android, iPhone) perform as smart cards for payments or tickets
  - **NFC Read/Writer**
    - Read/Write info to inexpensive NFC tags
      - NFC Tags are passive devices
        - Power to tag received via radio waves - NFC Reader/Write provides power and communication
  - **NFC Peer-to-Peer**
    - Two NFC devices communicate

NFC ISO/IEC 18092 Data Rates

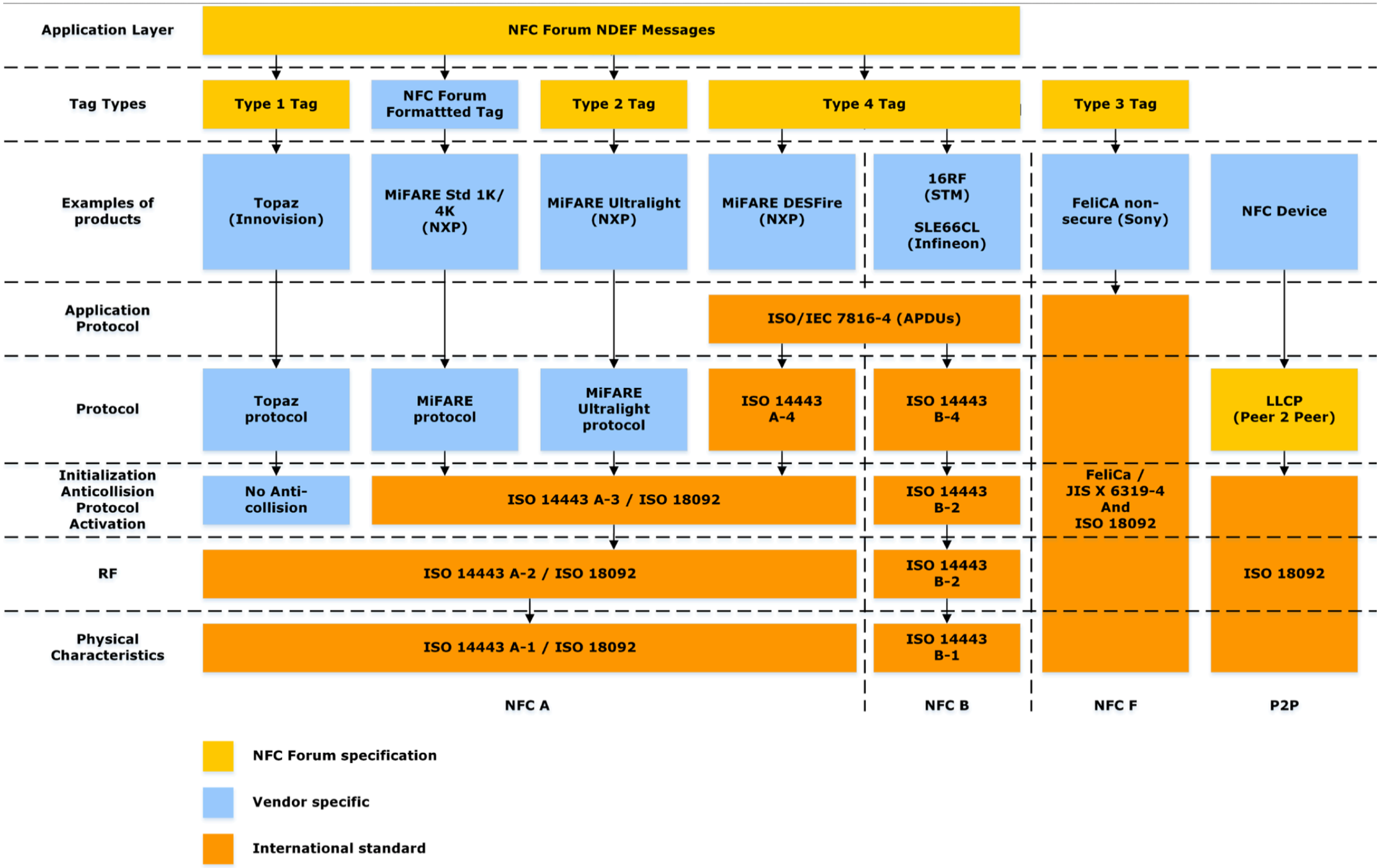
Speed (kbit/s)	Active device	Passive device
424	Man, 10% ASK	Man, 10% ASK
212	Man, 10% ASK	Man, 10% ASK
106	Modified Miller, 100% ASK	Man, 10% ASK

ASK = Amplitude Shift Keying

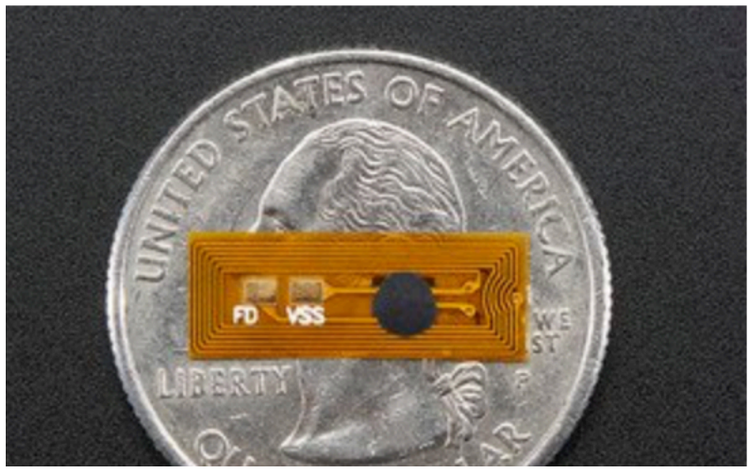
Man = Manchester Encoding

MM = Modified Miller Encoding

NFC Protocol Stack



NFC Example
https://www.adafruit.com/product/2800



Micro NFC/RFID Transponder - NTAG203

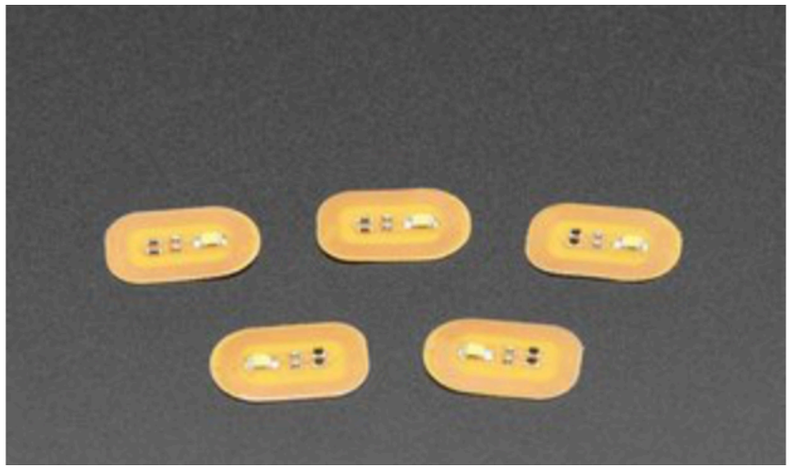
13.56MHz

PRODUCT ID: 2800

This tiny micro NFC/RFID tag is super small, and contains an NTAG203 chip plus antenna. It's super tiny, flexible and a great way to DIY an RFID or NFC device if you're interested in designing your own ring, wearable or whatever other tiny device with near field communication incorporated....

This tiny micro NFC/RFID tag is super small, and contains an NTAG203 chip plus antenna. It's super tiny, flexible and a great way to DIY an RFID or NFC device if you're interested in designing your own ring, wearable or whatever other tiny device with near field communication incorporated. Contains 144 bytes of read-write accessible memory.

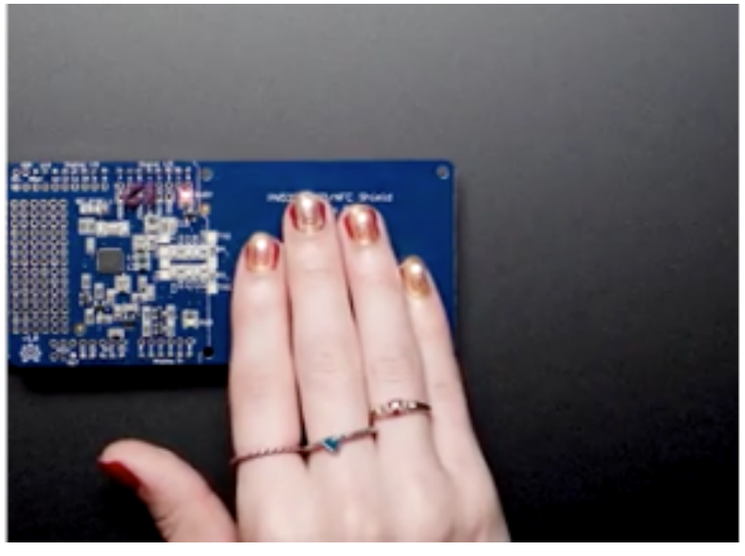
NFC Example
https://www.adafruit.com/product/3781



RFID/NFC Nail Stickers - 5 Pack with White LEDs

PRODUCT ID: 3781

You're at New York's hottest cyberpunk club is Near Field Commune(ication), and it's got everything, Adabot & the Circuit Playground, Collin's wondrous, mind-blowing, heart-stirring Pulse Room, and more! And you are dressed to the cyber-nine's, with wearable LEDs,...



NFC Example

https://www.adafruit.com/product/3781

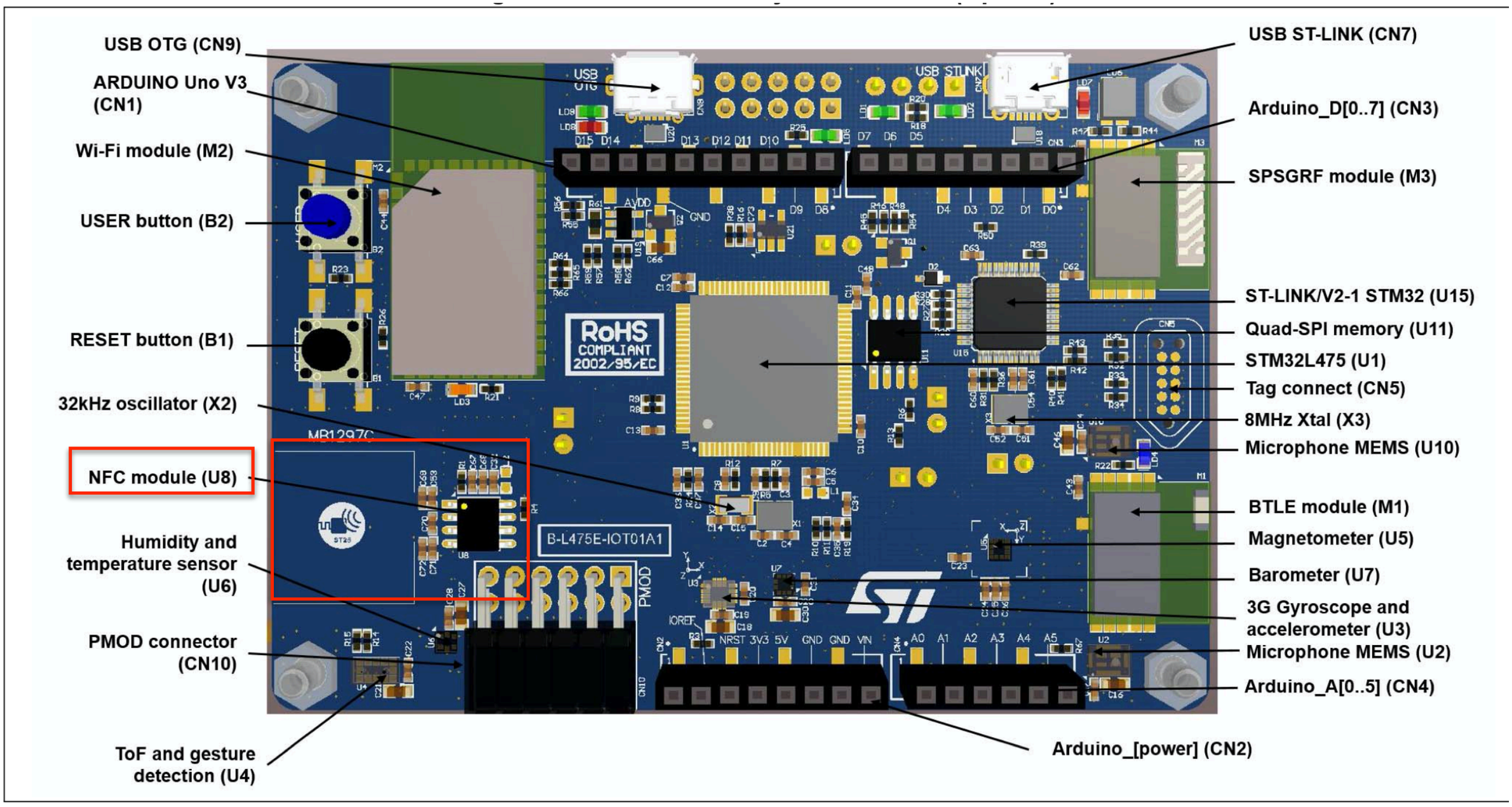
42 IN STOCK

RFID / NFC Smart Ring - Size 7 - NTAG213

PRODUCT ID: 2801

What did Lord Sauron, when forging the One Ring in the fires of Mount Doom forget to include in his all powerful ring? What did he forget to leave out of the ring impervious even to dragon fire, designed to rule over all free peoples of Middle Earth in perpetuity - a...

Bluetooth Example Discovery Kit



Data Sheet

Dynamic NFC/RFID tag IC with 64-Kbit EEPROM, NFC Forum Type 4 Tag and I²C interface

life.augmented

M24SR64-Y

Dynamic NFC/RFID tag IC with 64-Kbit EEPROM,
NFC Forum Type 4 Tag and I²C interface

I²C interface

- Two-wire I²C serial interface supports 1 MHz protocol
- Single supply voltage: 2.7 V to 5.5 V

Contactless interface

- NFC Forum Type 4 Tag
- ISO/IEC 14443 Type A
- 106 Kbps data rate
- Internal tuning capacitance: 25 pF

NDEF

NFC
Data
Exchange
Format

life.augmented

M24SR64-Y

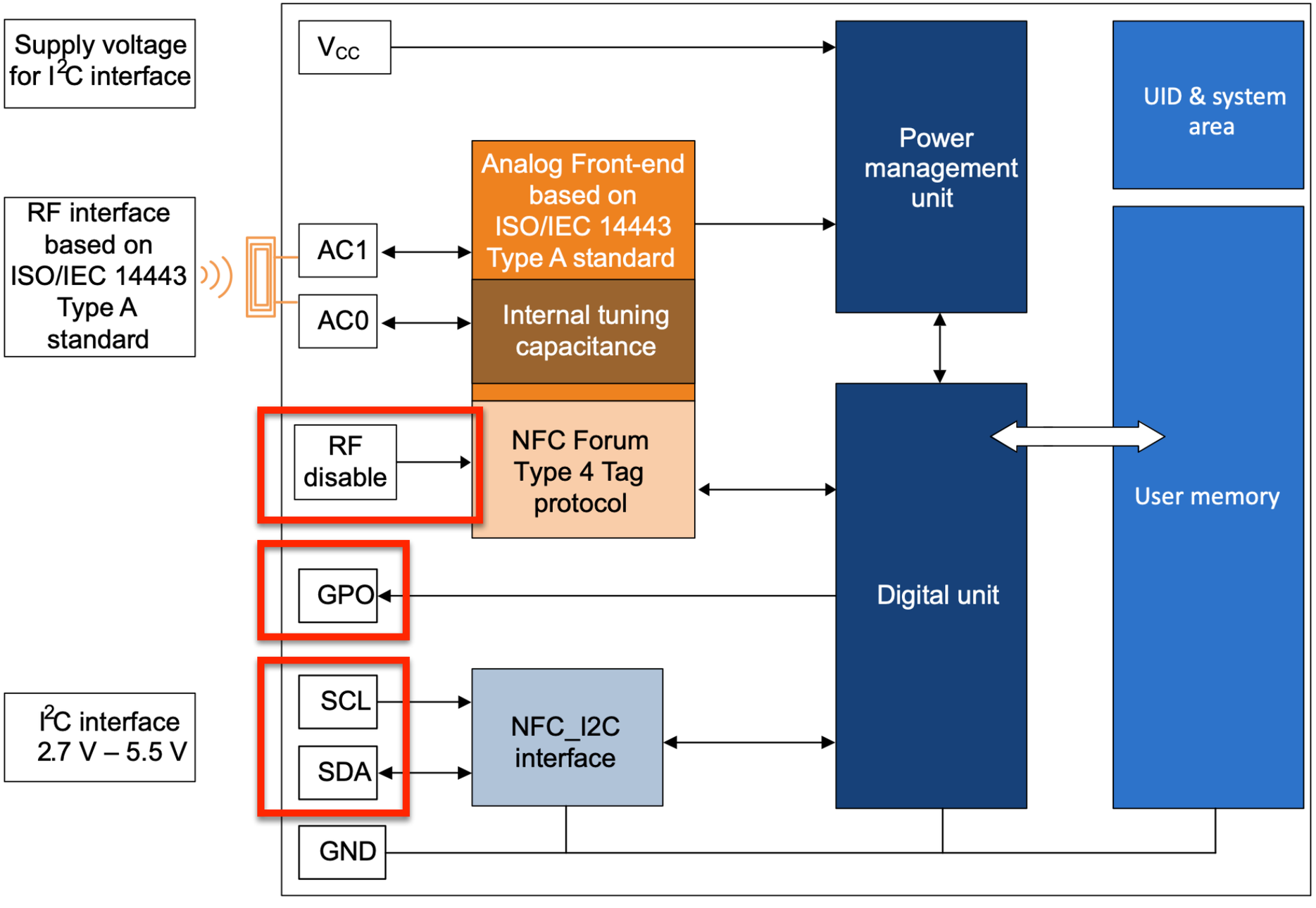
Dynamic NFC/RFID tag IC with 64-Kbit EEPROM,
NFC Forum Type 4 Tag and I²C interface

Memory

- 8-Kbyte (64-kbit) EEPROM
- Support of NDEF data structure
- Data retention: 200 years
- Endurance: 1 million erase-write cycles
- Read up to 246 bytes in a single command
- Write up to 246 bytes in a single command
- 7 bytes unique identifier (UID)
- 128 bits passwords protection

NDEF
NFC
Data
Exchange
Format

Block Diagram - View



Signal Names

Table 1. Signal names

Signal name	Function	Direction
SDA	Serial data	I/O
SCL	Serial clock	Input
AC0, AC1	Antenna coils	-
V_{CC}	Supply voltage	-
VSS	Ground	-
GPO	Interrupt output (1)	Open drain output
RF disable	Disable the RF communication (2)	Input

1. An external pull-up > 4.7 kΩ is required.
2. An external pull-down is required when the voltage on V_{cc} is above its POR level.

Functional Modes

Functional modes

The M24SR64-Y has two functional modes available. The difference between the modes lies in the power supply source (see *Table 2*).

Table 2. Functional modes

Modes	Supply source	Comments
I^2C mode	V_{CC}	The I^2C interface is available
Tag mode	RF field only	The I^2C interface is disconnected
Dual interface mode	RF field or V_{CC}	Both I^2C and RF interfaces are available

User Manual

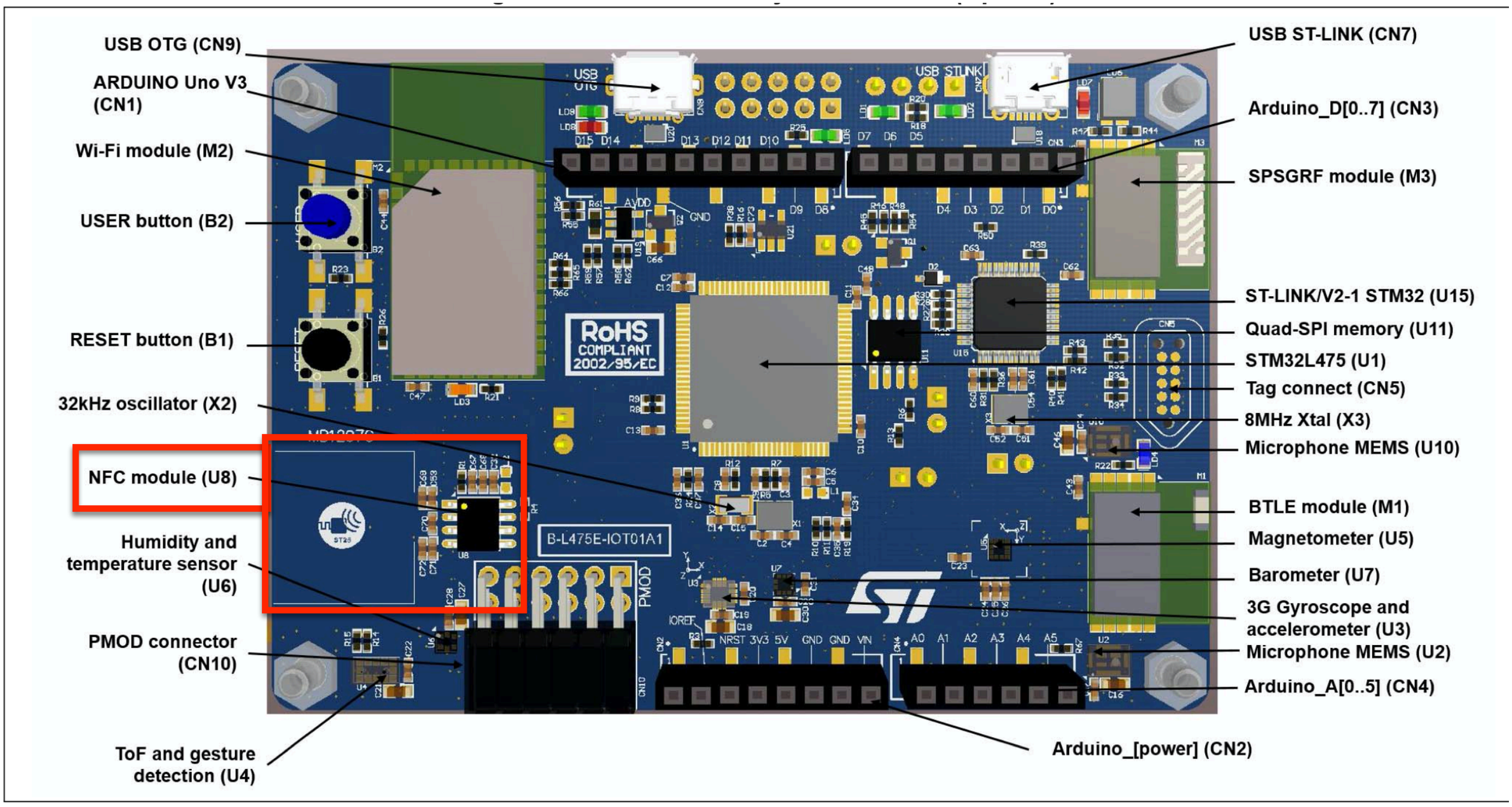
STM32L Discovery Kit IoT Node

life.augmented

UM2153
User manual

Discovery kit for IoT node, multi-channel communication with STM32L4

Use of NFC



User Manual
NFC - Part 1

7.11.4 Dynamic NFC Tag based on M24SR with its printed NFC antenna

M24SR64-Y belongs to the ST25 family which includes all STMicroelectronics NFC/RFID Tag and reader products. The M24SR64-Y device is a dynamic NFC/RFID Tag IC with a dual interface. It embeds an EEPROM memory. It can be operated from an I^2C interface or by a 13.56 MHz RFID reader or by an NFC phone. The I^2C interface uses a two-wire serial interface, consisting of a bidirectional data line and a clock line. It behaves as a slave in the I^2C protocol.

The RF protocol is compatible with ISO/IEC 14443 Type A and NFC Forum Type 4 Tag

User Manual
NFC - Part 2

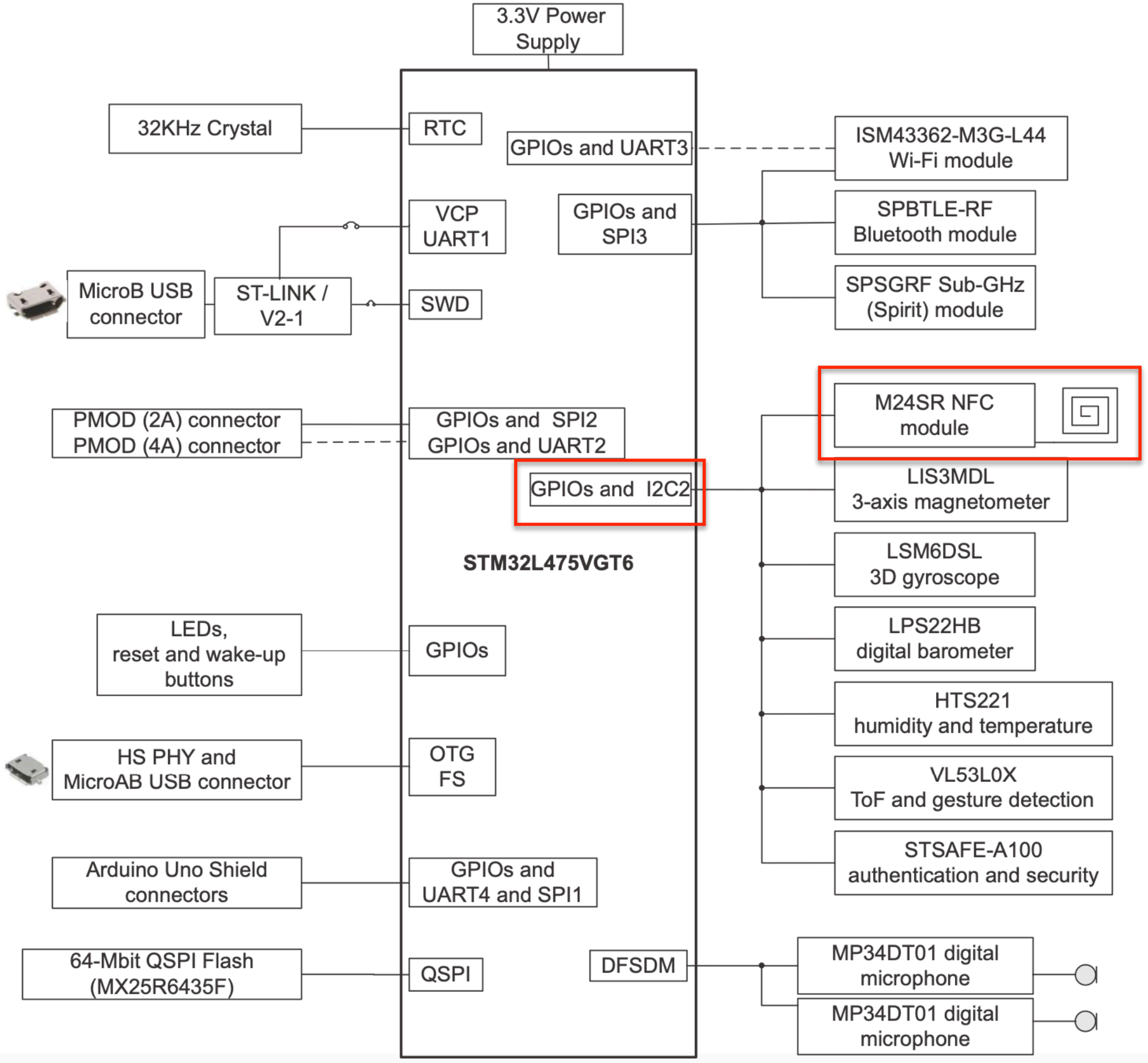
The main features of the M24SR64-Y are:

- I^2C interface (I2C2 of STM32L475VGT6). The two-wire I^2C serial interface supports 1 MHz protocol.
- Contactless interface:
  - NFC Forum Type 4 Tag
  - ISO/IEC 14443 Type A
  - 106 Kbps data rate
  - Internal tuning capacitance: 25 pF
- Memory:
  - 8-Kbyte (64-kbit) EEPROM
  - Support of NDEF data structure
  - Data retention: 200 years
  - Write cycle endurance:
    1 million Write cycles at 25 °C
    600 K Write cycles at 85 °C
    500 K Write cycles at 105 °C
- Read up to 246 Bytes in a single command
- Write up to 246 Bytes in a single command
- 7-Byte unique identifier (UID)
- 128-bit password protection

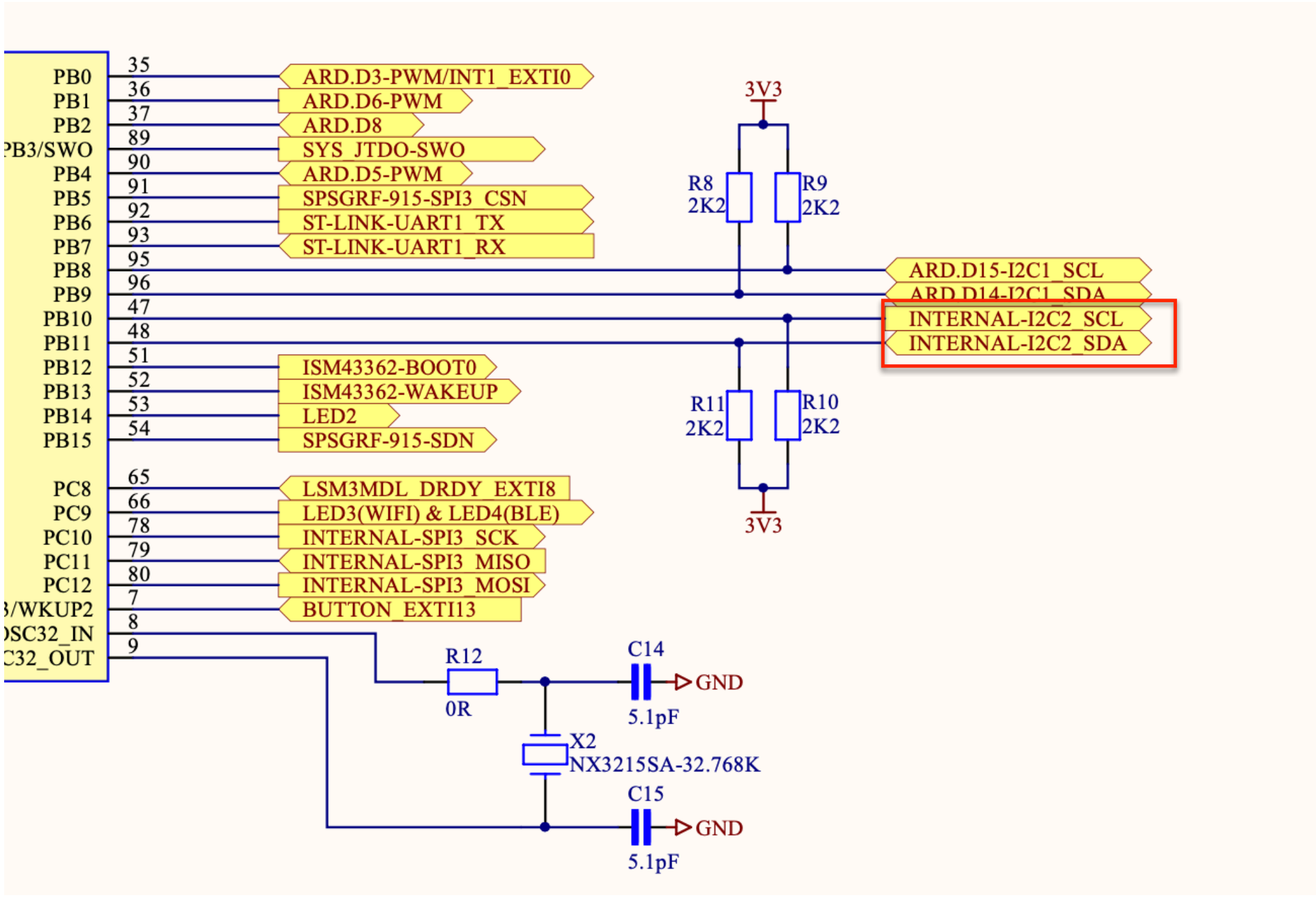
NDEF
NFC
Data
Exchange
Format

Schematics

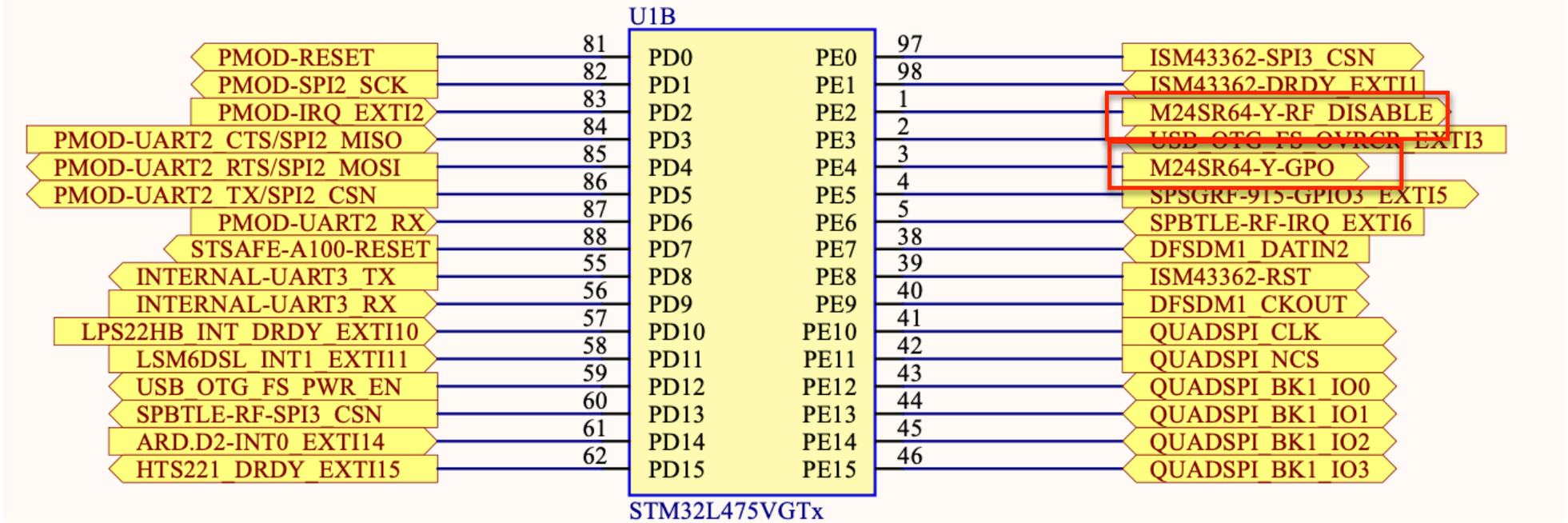
STM324L Discovery Kit IoT Node



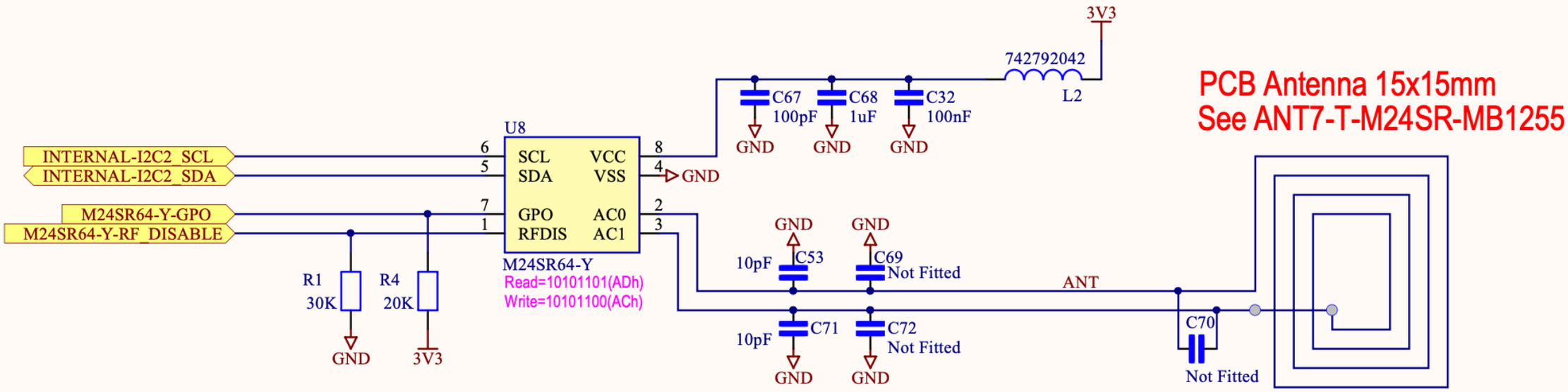
STM32L475



STM32L475



M24SR64-Y



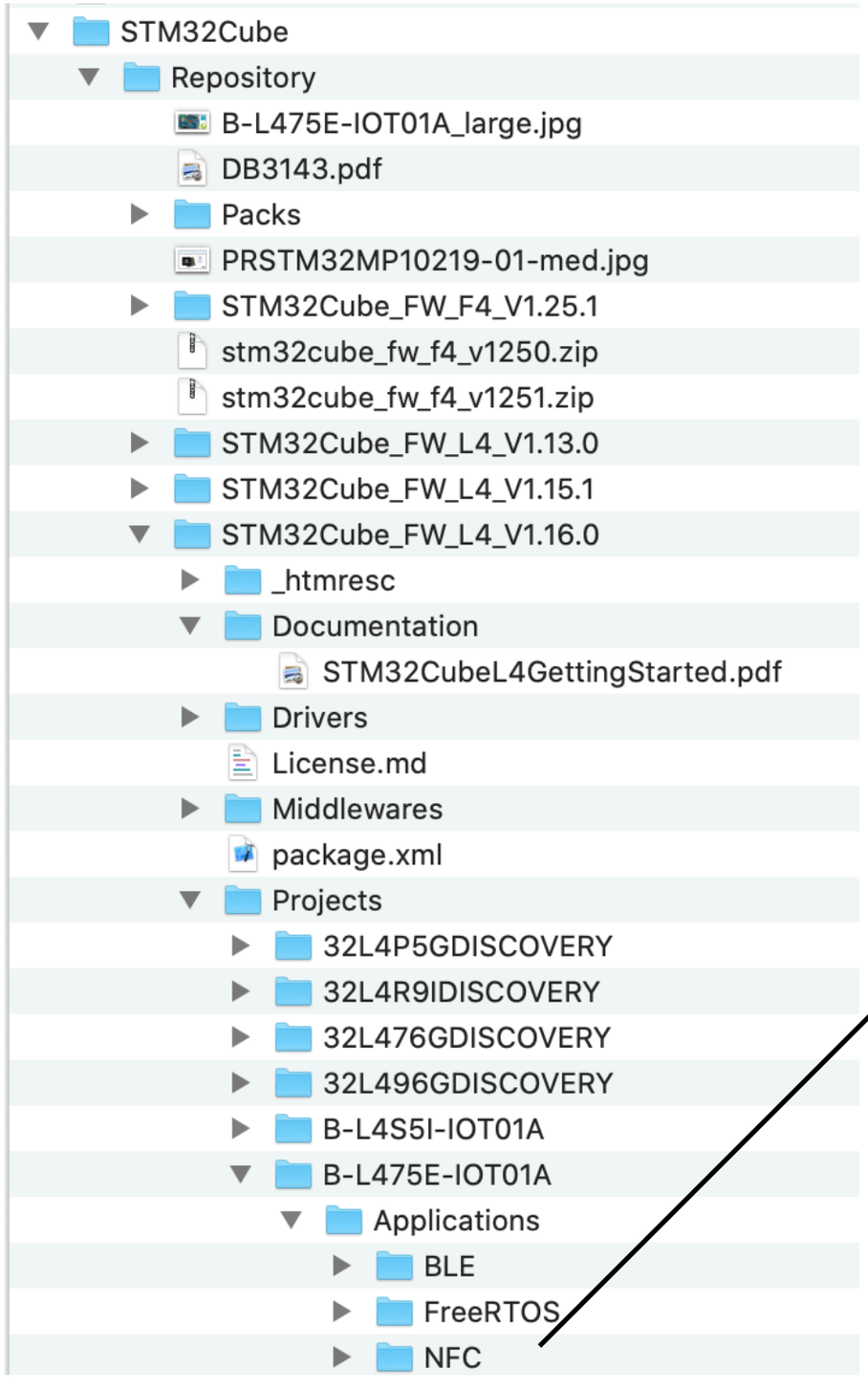
NFC

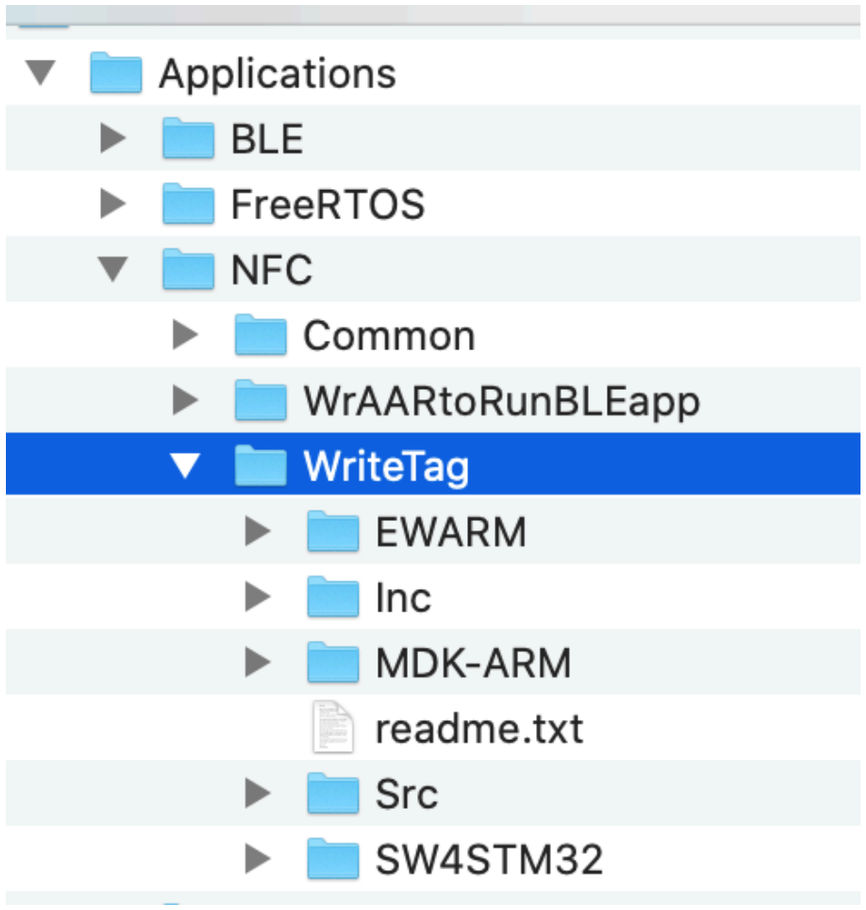
Hands-On Project

NFC Hands-On Project Overview

- The goal of this project is to give you hands-on experience with adding NFC to your embedded design
  - 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





WriteTag README

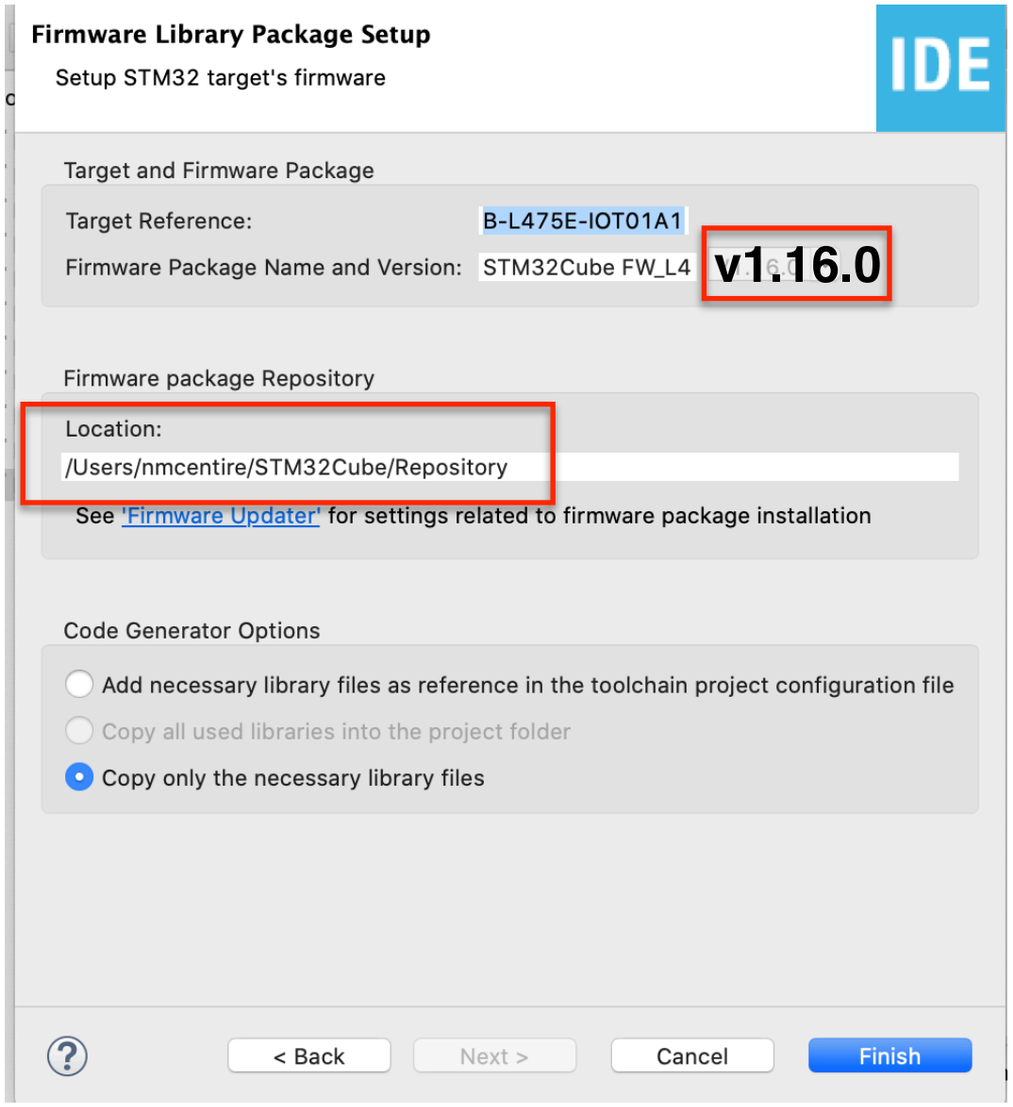
```
This application aims at showing how to write NDEF messages to an M24SR type 4 NFC tag
so that the associated application is launched on the smartphone when it comes near the NFC antenna.

First the NFC component is initialised, the LED2 goes ON to indicate Initialization is terminated.
Then when the smartphone approches the NFC antenna and action will be taken by the smartphone
depending on the NDEF message written on the tag.
This example writes a different message each time the USER BUTTON is pressed:
 - URI:    the "www.st.com" website is opened by the browser
 - SMS:    an SMS is prepeaed on the smartphone and ready to be sent to +33612345678
 - EMAIL:  an email is prepeaed on the smartphone and ready to be sent to customer.service@st.com
 - VCARD:  a vCard content from image file is shown on the smartphone display
 - VCARD2: a vCard content from VcardStruct is shown on the smartphone display
 - AAR:    the STM BLE application is opened on the smartphone (downloaded the first time)
```

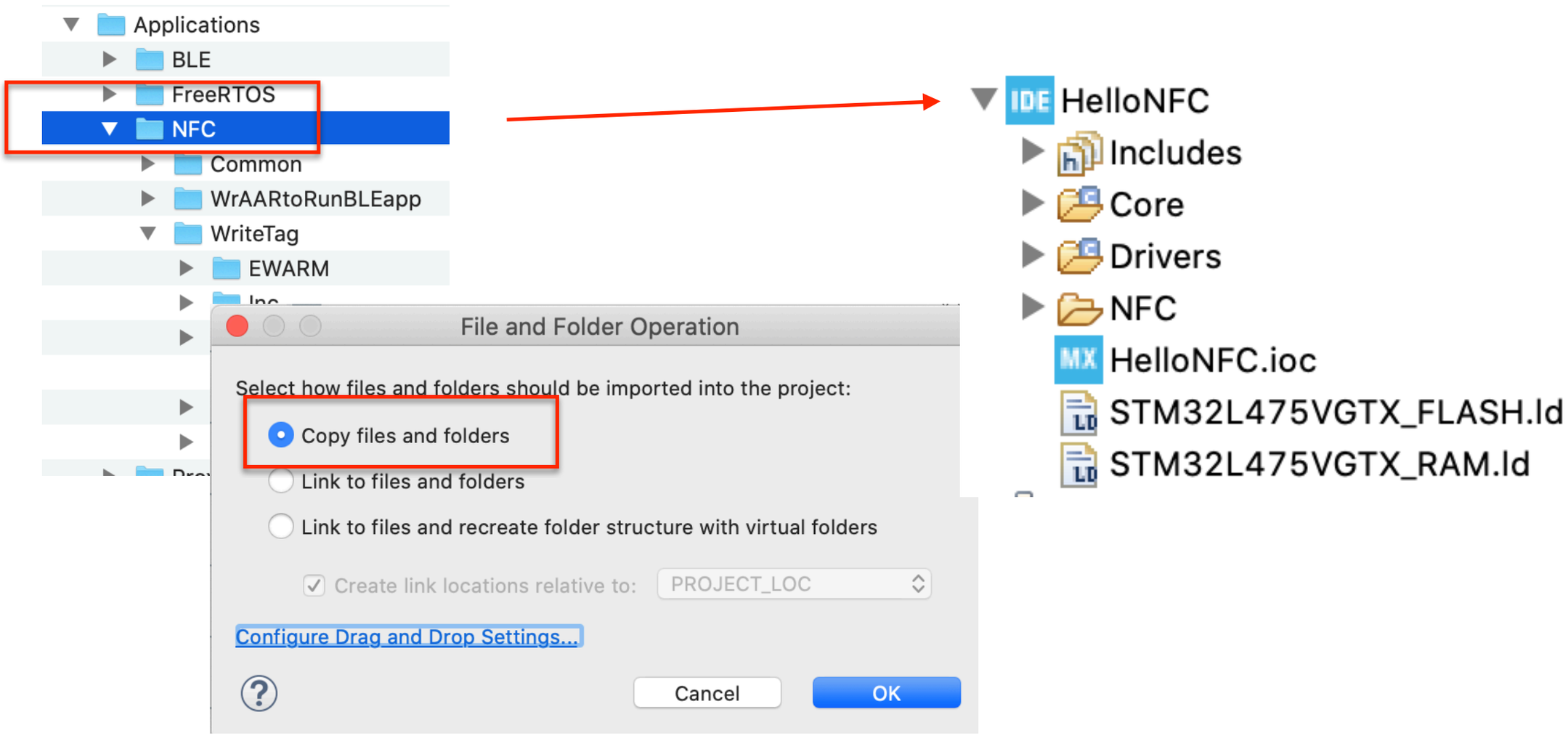
WriteTag README Part 2

```
- NFC/WriteTag/Src/main.c                  Main program file with several NDEF examples.
- NFC/WriteTag/Src/system_stm32l4xx.c      STM32L4xx system clock configuration file.
- NFC/WriteTag/Src/stm32l4xx_it.c          STM32 interrupt handlers (M24SR_GPO and user button).
- NFC/WriteTag/Inc/stm32l4xx_hal_conf.h    HAL configuration file.
- NFC/WriteTag/Inc/stm32l4xx_it.h          STM32 interrupt handlers header file.
- NFC/WriteTag/Inc/VcardCSL1.h             Vcard image format (data array).
- NFC/Common/                              These files are Common also to other applic/examples then WriteTag.
- NFC/Common/NDEF_TagType4_lib/            This directory contains a set of source files that write NDEF messages
                                           on M24SR (tag type 4) to be exchanged with smartphone devices.
- NFC/Common/M24SR/m24sr_wrapper.c         It simplifies the use of the M24SR driver by sequencing some commands.
- NFC/Common/M24SR/m24sr_wrapper.h         API to M24SR wrapper, called by the middleware NDEF Libs.
```

Create New Project (And Find Location of Repository)

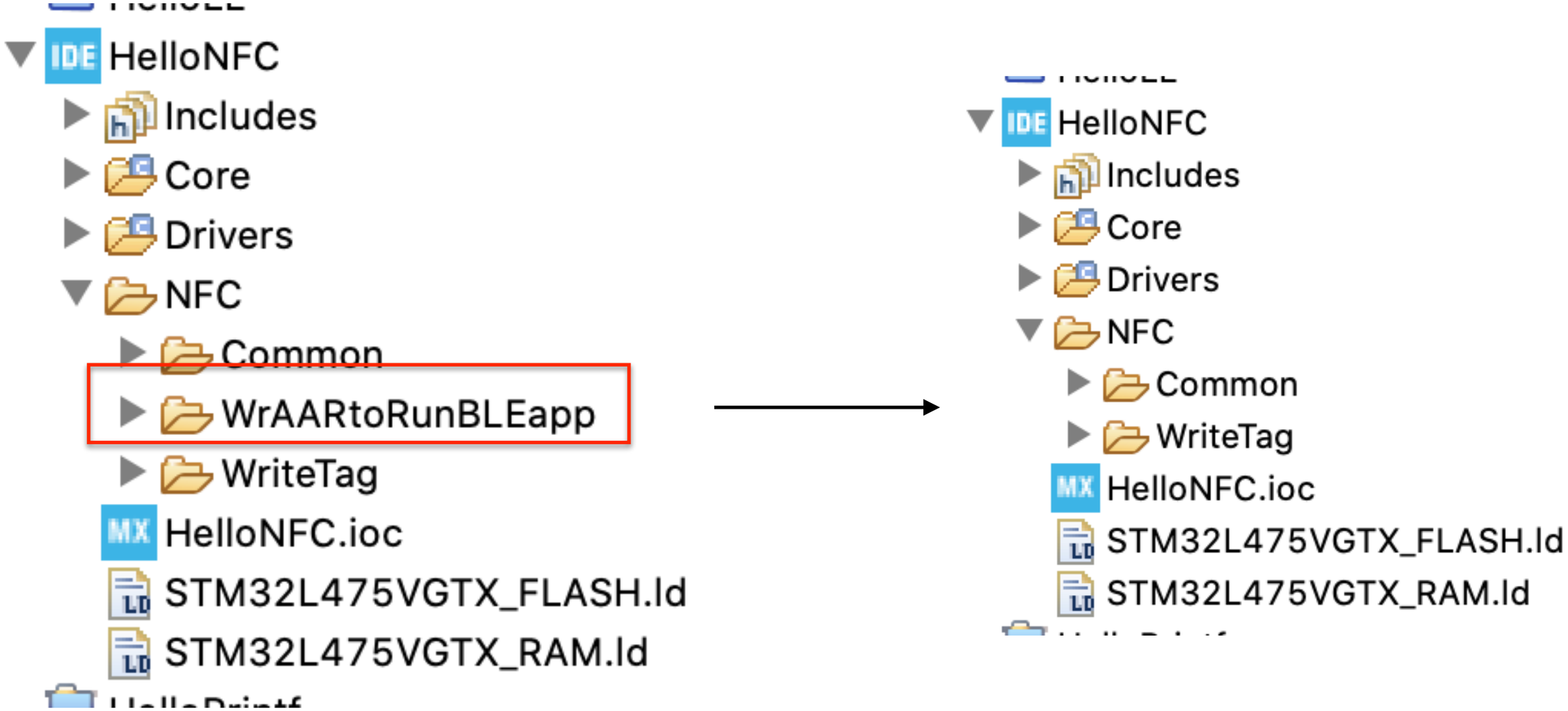


NFC Folder Drag/Drop (COPY FILES)

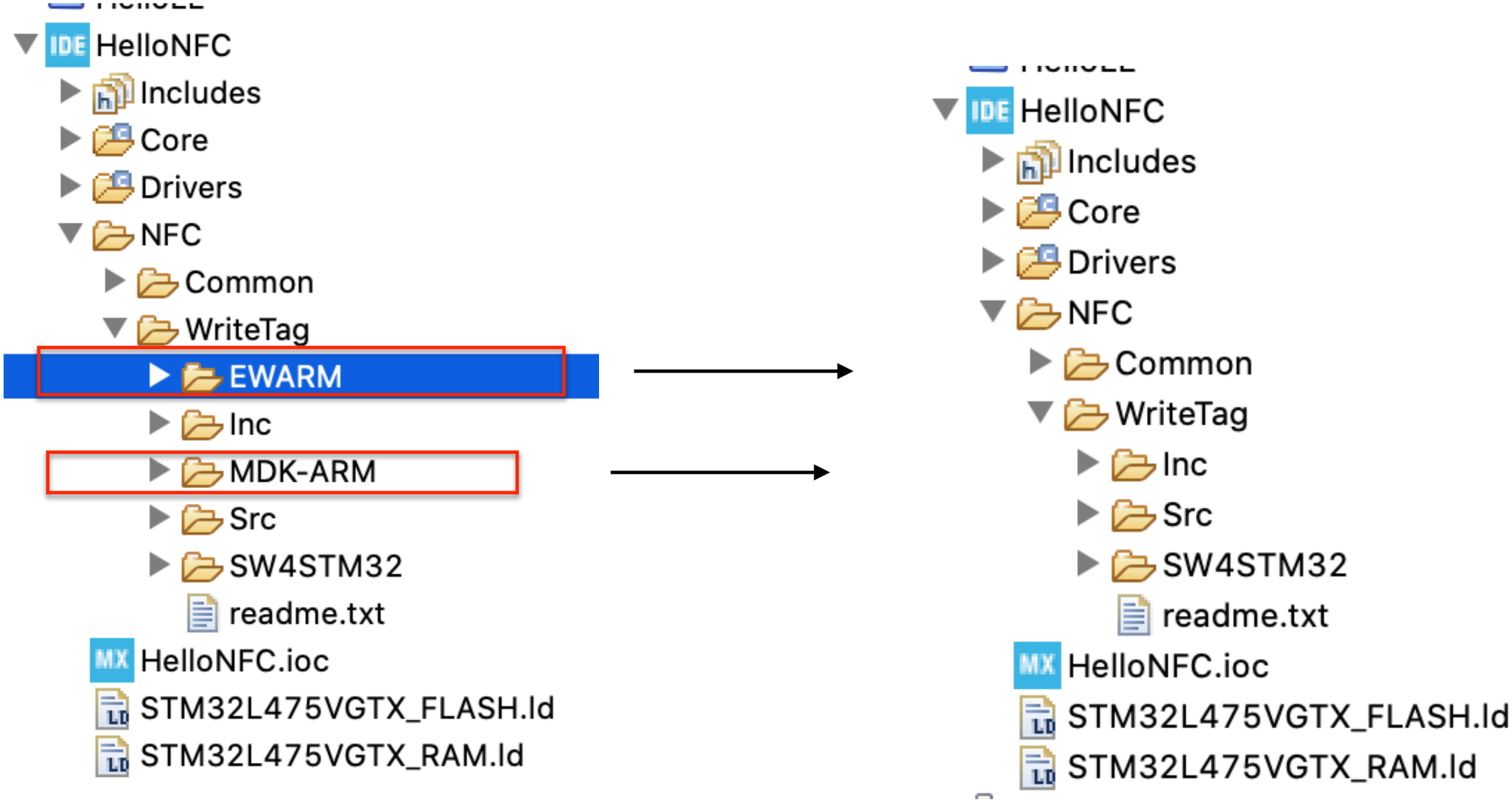


NOTE: Notice NFC Folder at top level with Core and Drivers

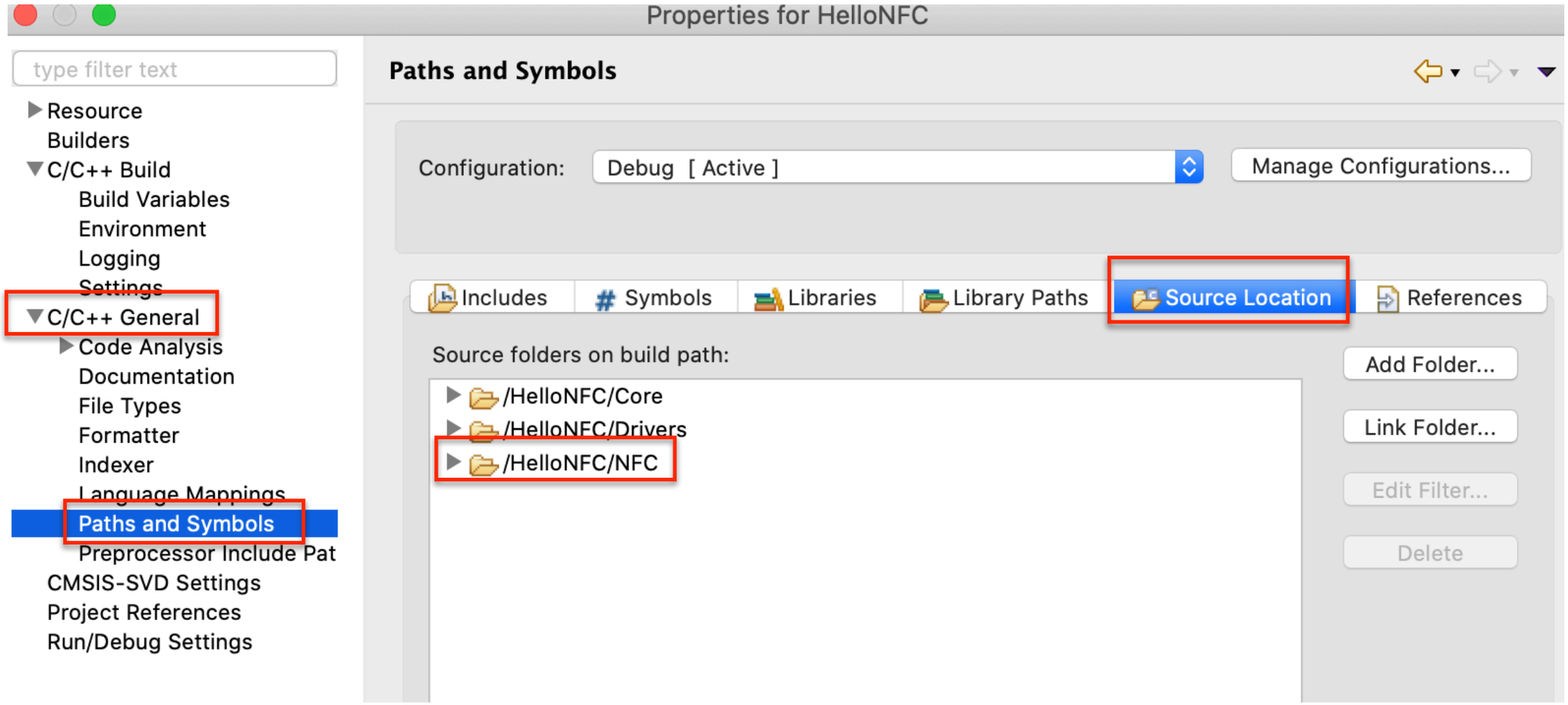
Delete WrAARtoRunBLEapp Folder



Delete **EWARM** Folder and **MDK-ARM** Folder



Add NFC to Source Path



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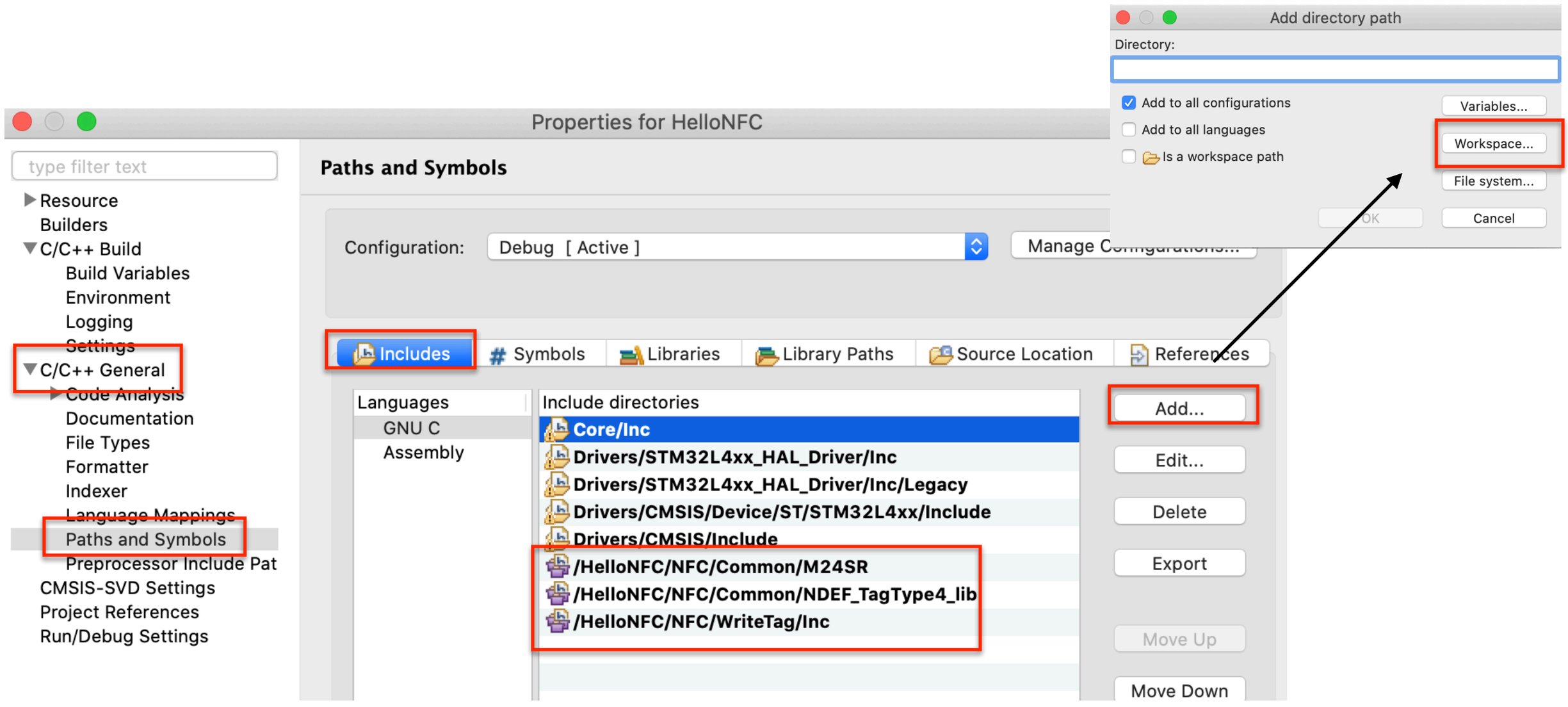
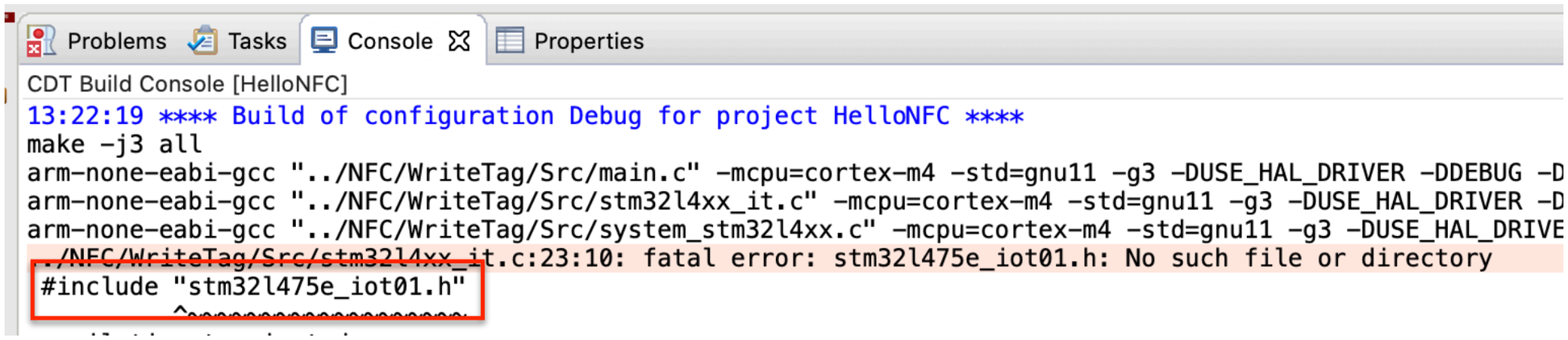


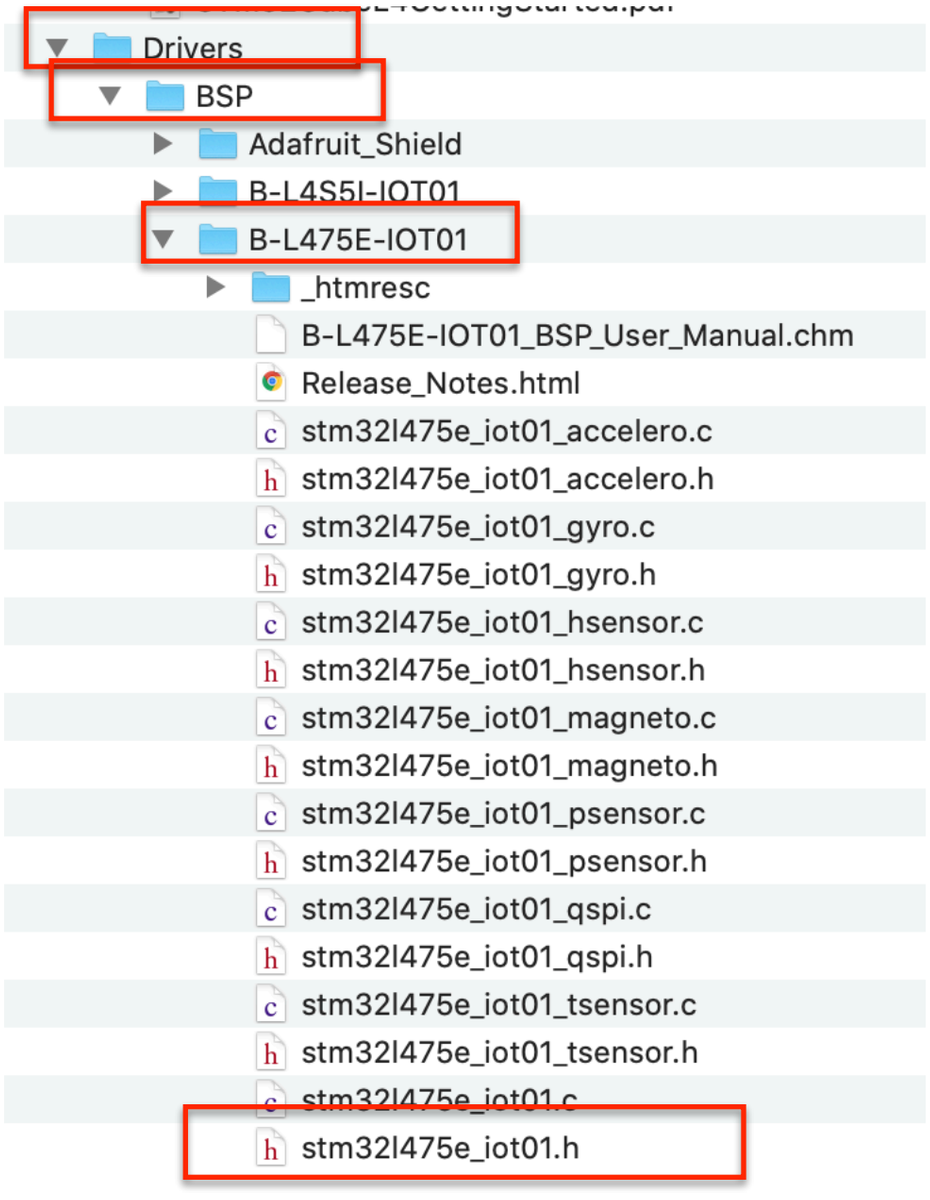
Attempt to Build
Missing Header File
stm32l475e_iot01.h



NOTE

This header file from BSP
(Board Support Package)

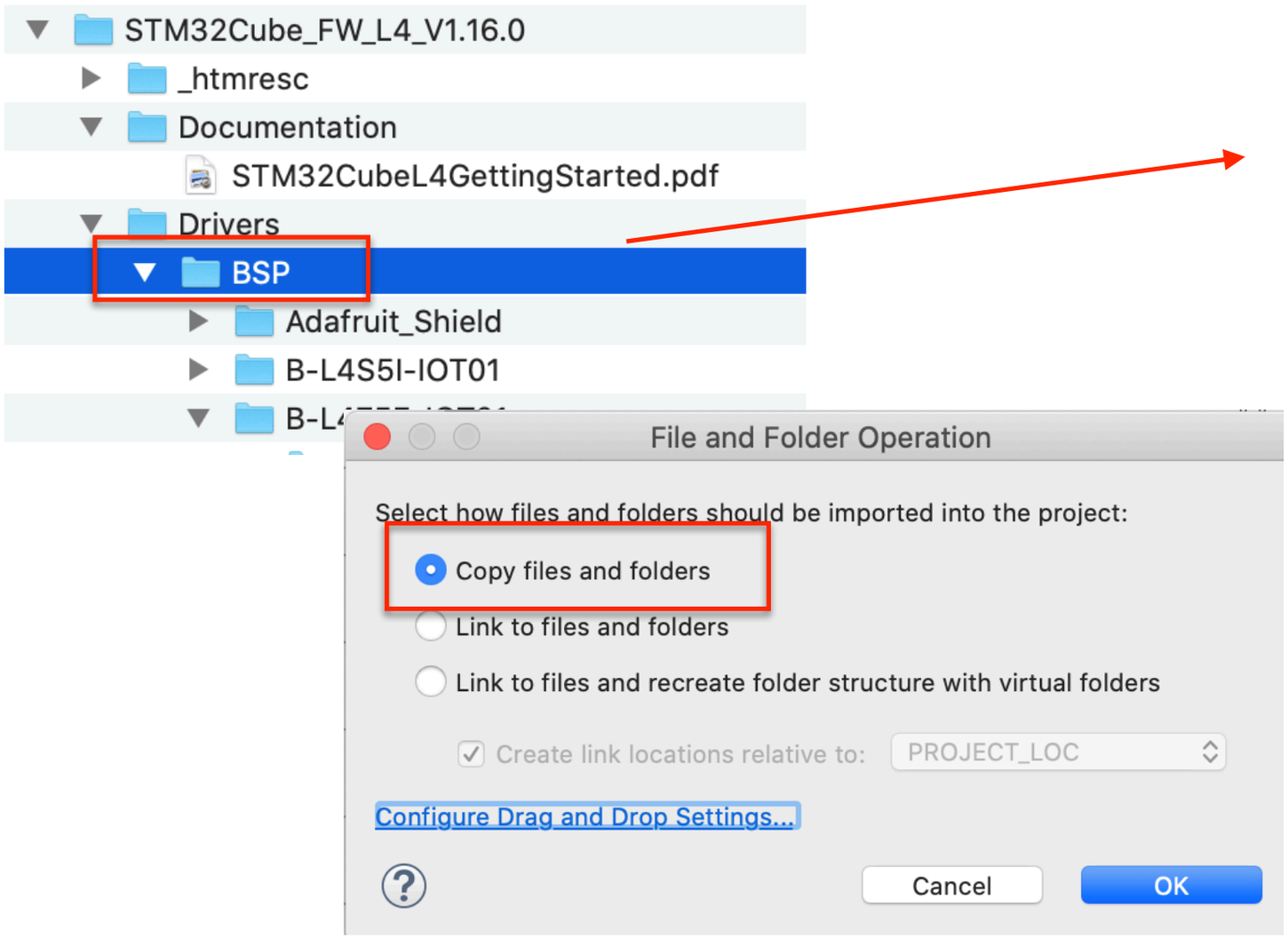
Where to find needed BSP header files

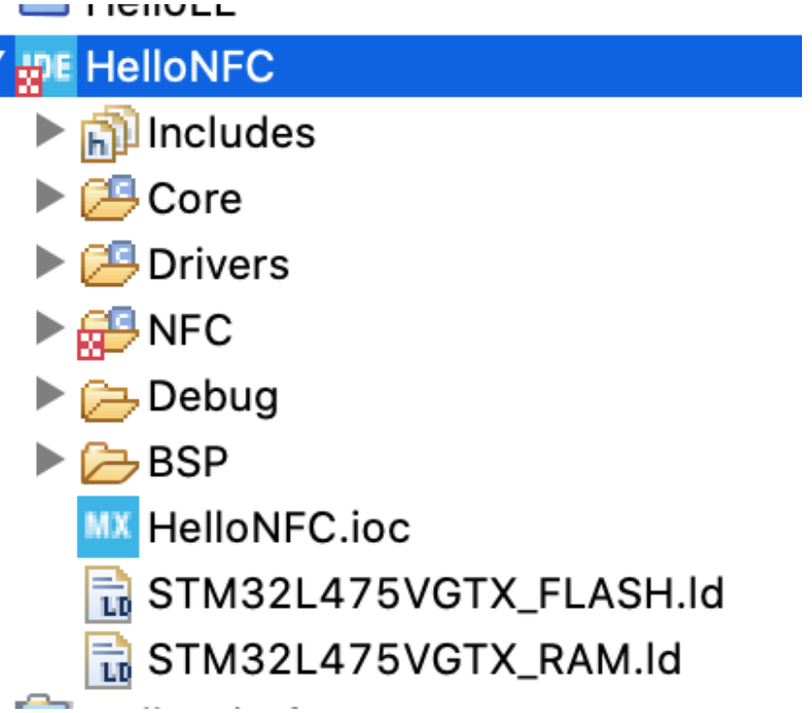


BSP

Board Support Package

BSP Folder Drag/Drop (COPY FILES)





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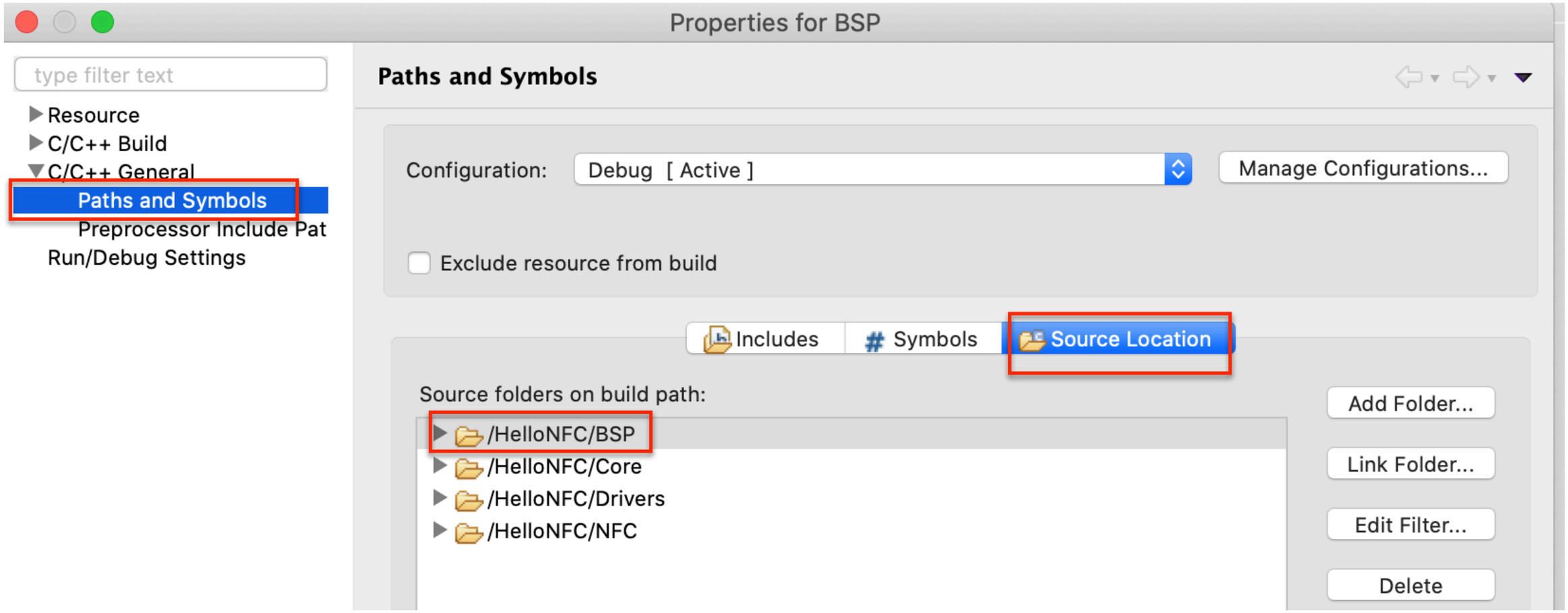

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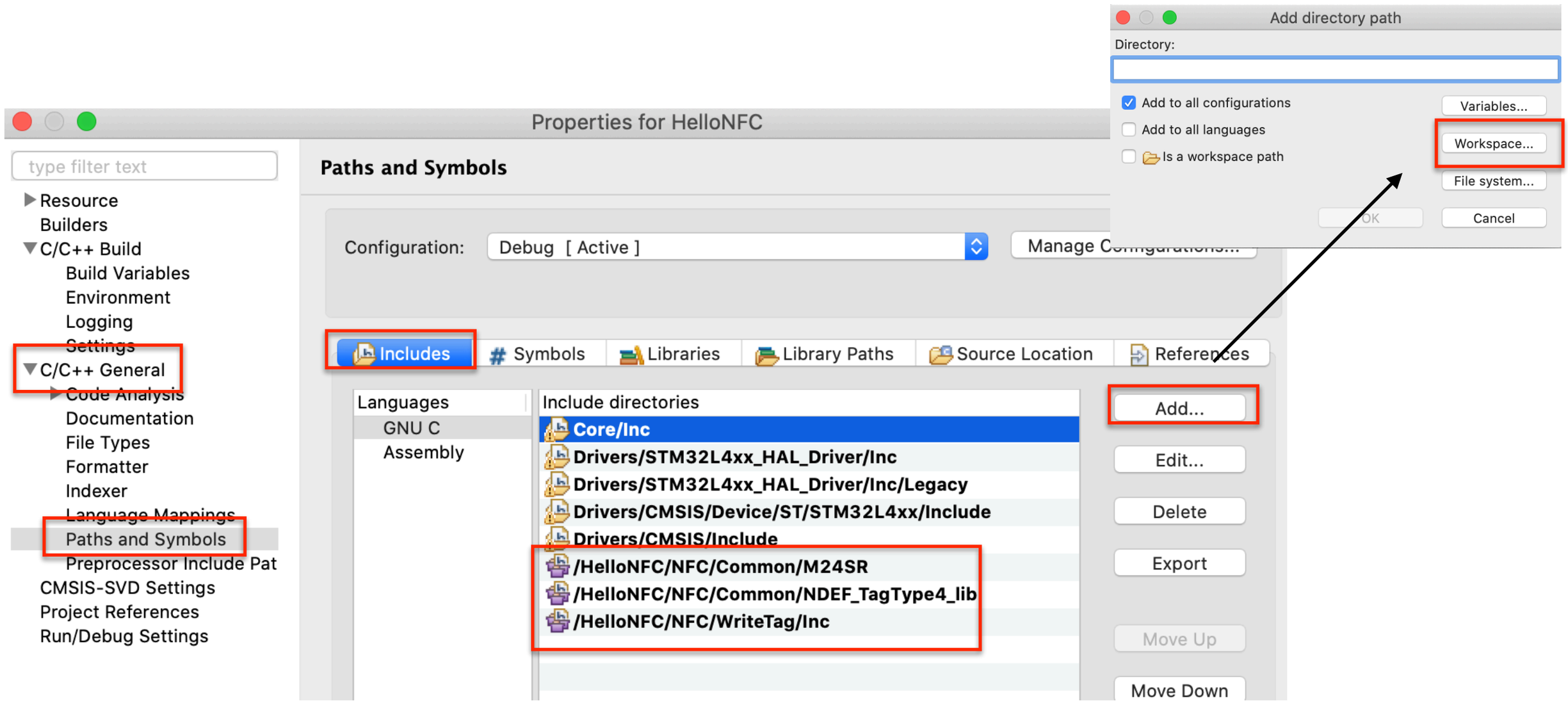
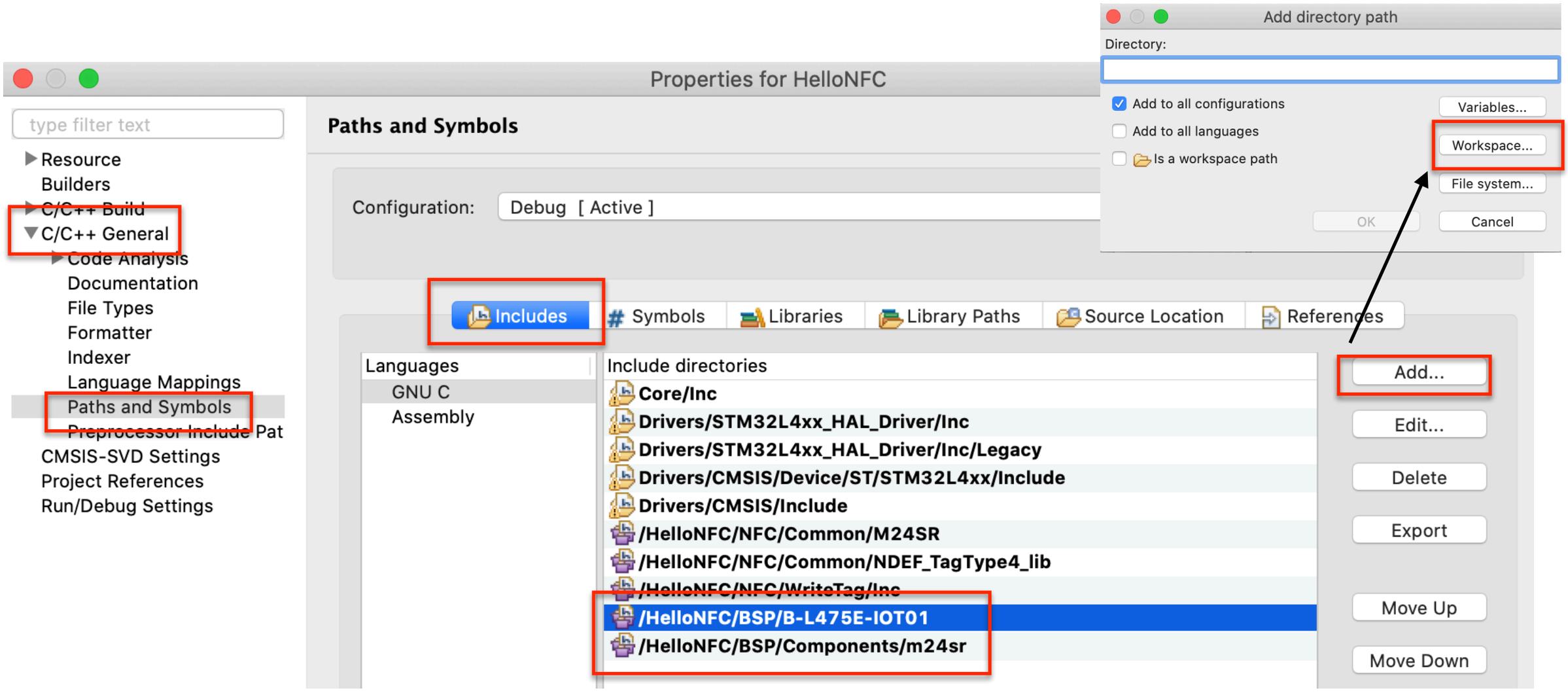
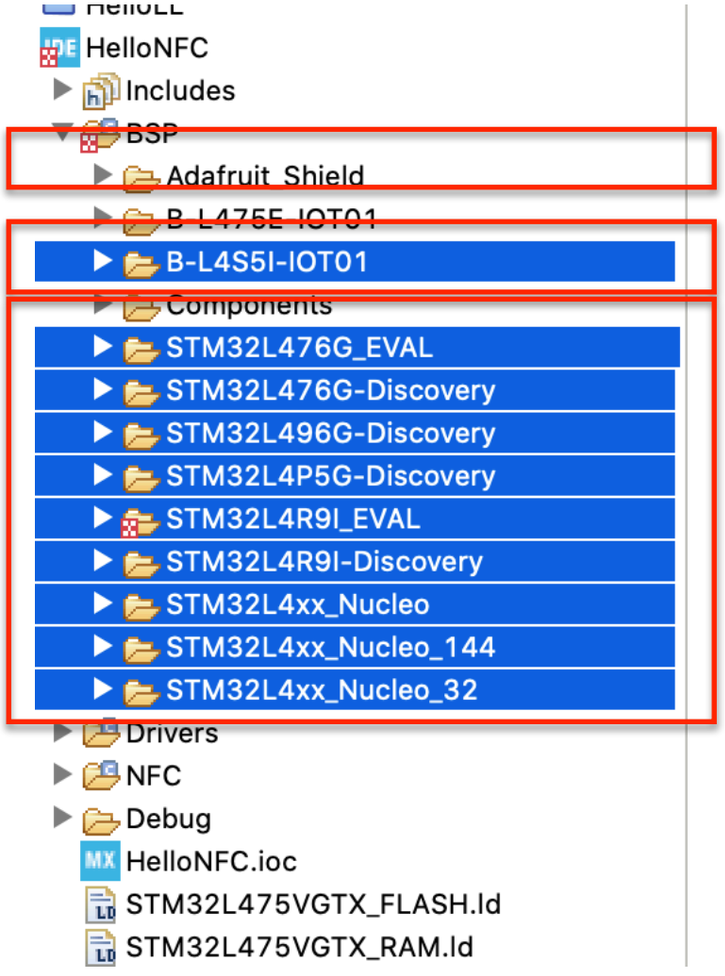


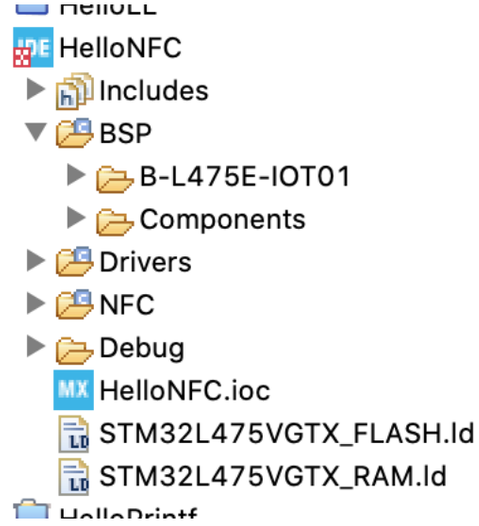
Add Include Paths To Project Properties



Delete Unused Board Directories

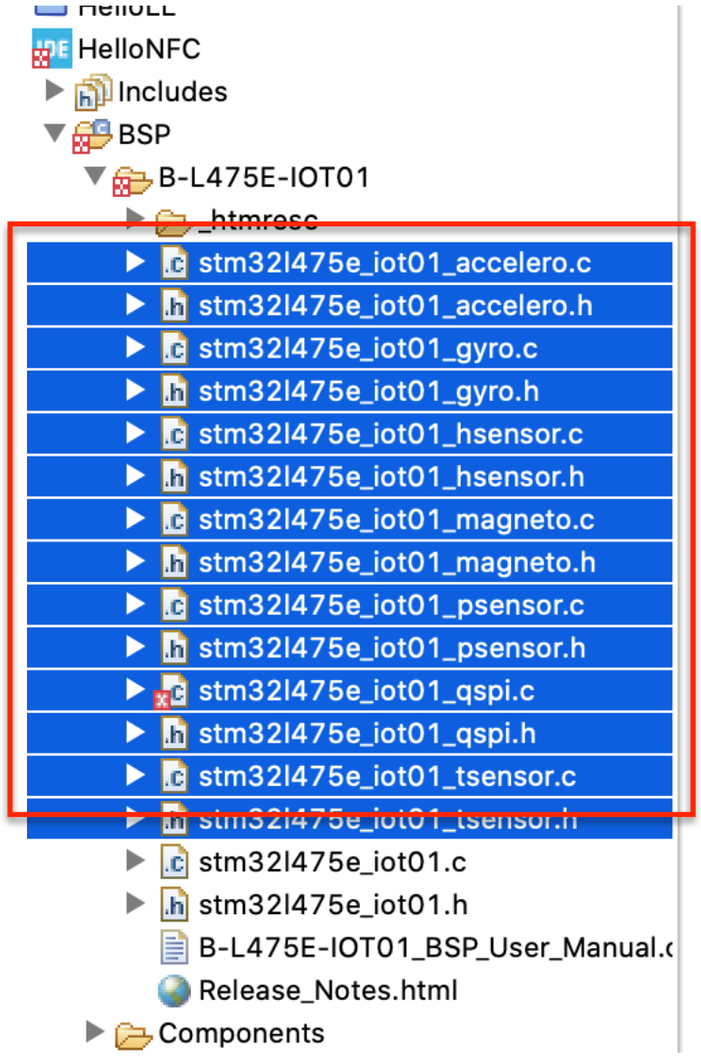


Delete Unused Board Directories

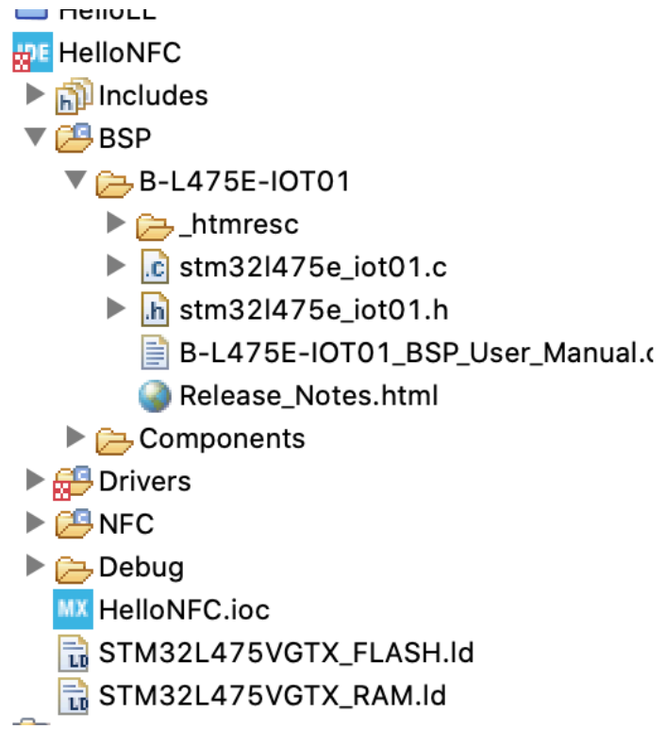


Results

Delete Unused Component Directories

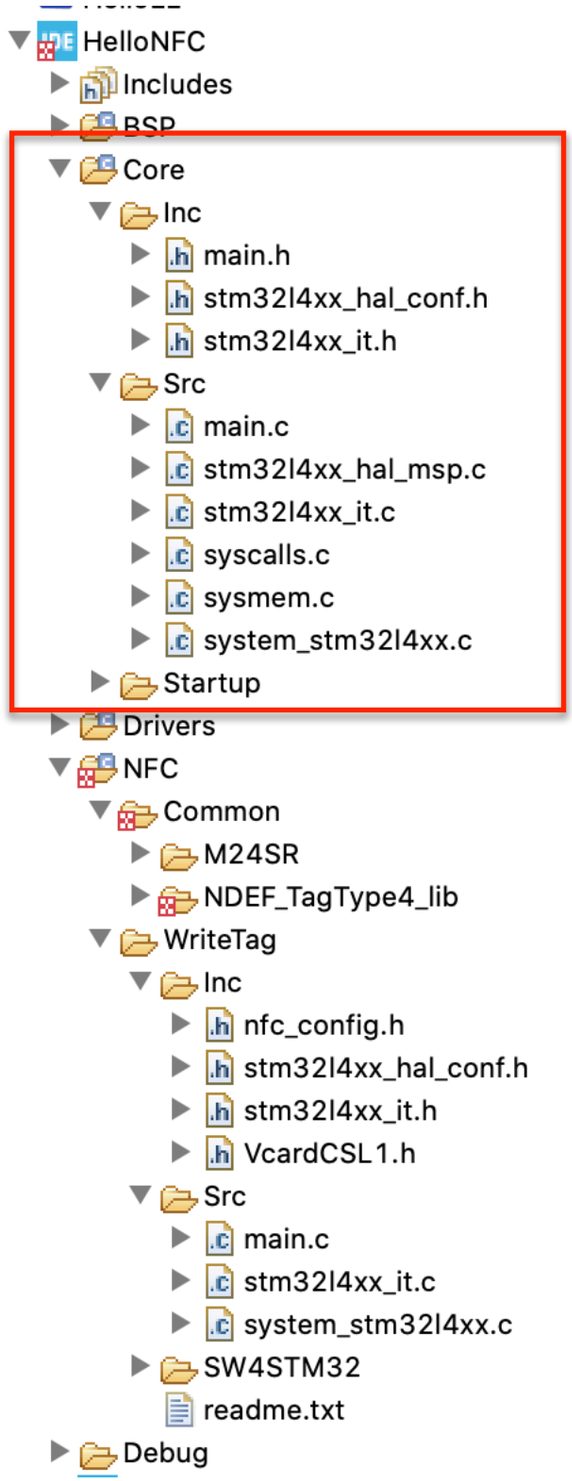


Delete Unused Board Directories



Results

Remove Core Files (NFC has same files)



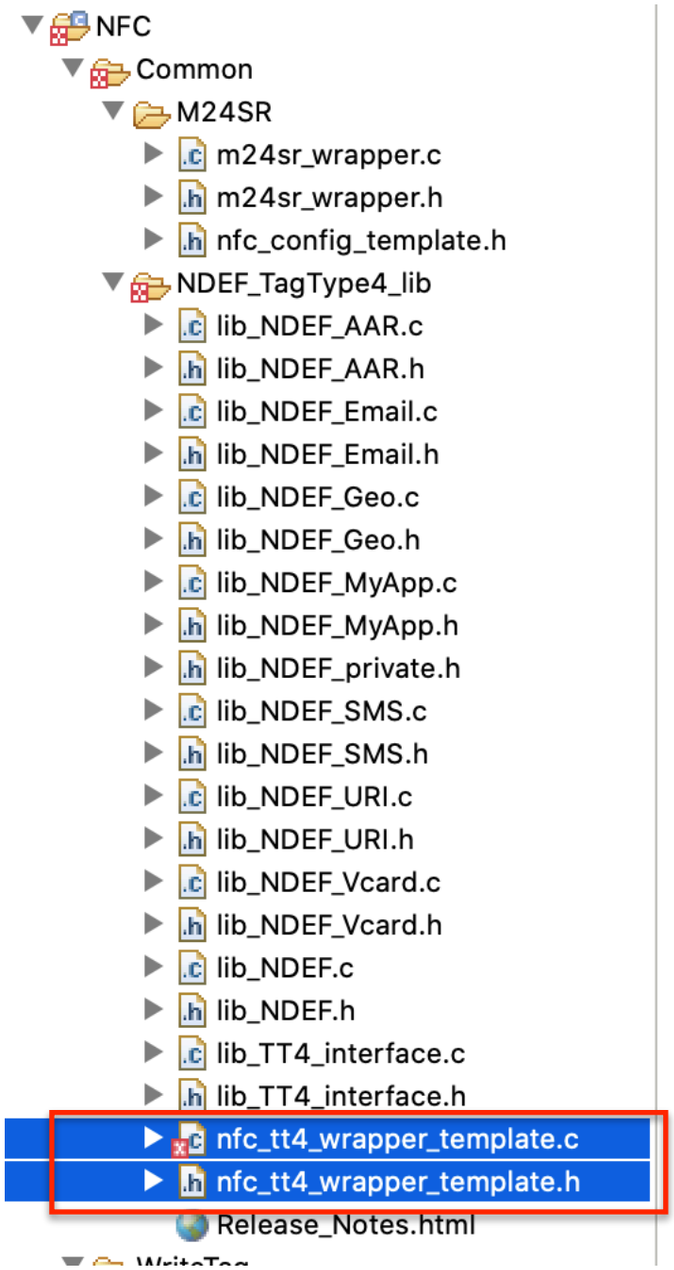
Remove Core Directory

Attempt to Build Missing Header File component.h

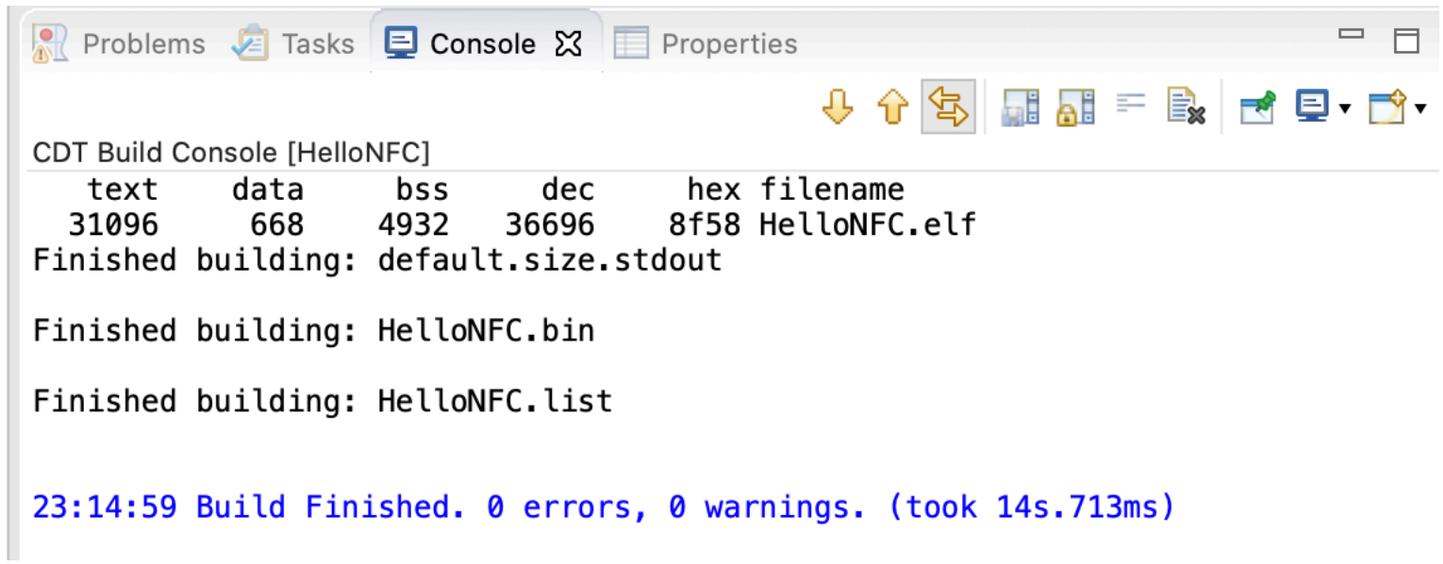
```
arm-none-eabi-gcc "../NFC/Common/M24SR/m24sr_wrapper.c" -mcpu=cortex-m4 -std=gnu11 -g3 -DUSE_HAL_DRIVER -DDEBUG -DSTM32L475xx
In file included from ../NFC/Common/NDEF_TagType4_lib/nfc_tt4_wrapper_template.c:22:0:
../NFC/Common/NDEF_TagType4_lib/nfc_tt4_wrapper_template.h:31:10: fatal error: component.h: No such file or directory
 #include "component.h"
          ^~~~~~~~~~~~~
compilation terminated.
make: *** [NFC/Common/NDEF_TagType4_lib/subdir.mk:63: NFC/Common/NDEF_TagType4_lib/nfc_tt4_wrapper_template.o] Error 1
make: *** Waiting for unfinished jobs....
"make -j3 all" terminated with exit code 2. Build might be incomplete.

22:59:53 Build Failed  3 errors  0 warnings  (took 5s.463ms)
```

Remove Files template files



Successful Build



As You Run

- When you startup you will see LED2 blinking
- Every time you press the Blue Button rate will change
- If you are using iPhone, you just install an app to see your NFC
  - Example: I installed “GoToTags”
- As you place phone near NFC you will see the results! Cool!

Summary

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