ISP2454

Application note AN250502

Use of the ISP2454 Evaluation Board for LP, LX and LL versions



Introduction

Scope

This document gives details on hardware and software using and testing the Insight SiP Bluetooth Low Energy module ISP2454-LP-LX and LL versions.

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Document Revision History

Revision	Date	Ref	Change Description
R0	02/05/2025	cr pg	Initial release
R1	13/05/2026	cr pg	Updated using external memory. Additional matter examples using the memory (MX35R32).

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1. Recommended Documentation

The following documents are required to understand the complete setup and programming methods:

- The nRF54L15 datasheets
- The introduction to nRF Connect SDK
- Developing with nRF54L
- ISP2454-LX information

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2. Hardware content

2.1. Global Description

The Evaluation Board hardware includes:

- An Interface Board named ISP130603 with integrated J-Link OB JTAG/SWD Emulator
- One ISP2454 Test Board



2.2. About Insight SiP BT 6.0 Module

The ISP2454 module is based on nRF54L15 Nordic Semiconductor 2.4GHz wireless System on Chip (SoC) integrating a 2.4GHz transceiver, an ARM Cortex -M33 with TrustZone technology, RRAM and RAM memory adding digital peripherals.

It can support BLE, Mesh and a range of proprietary 2.4GHz protocols. Fully qualified stacks for nRF54L15 are freely for operating in Central role, Peripheral role, Scanning and Advertising.

The Cyber Resilience Act (CRA) is embodied in the EU regulation 2024/2847. ISP2454 rely on microprocessors that have been designed with Platform Security Architecture (PSA) certification in mind. It is certified to PSA level 3. This level of platform security reduces the risk of vulnerabilities occurring.

Ultra-low power consumption and advanced power management enable battery lifetimes up to several years on a coin cell battery. Even though its very small-size 8 x 8 x 1 mm, the module integrates, in addition to the wireless SoC, all required decoupling and load capacitors, DC-DC converter, 32 MHz crystal, 32.768 kHz crystal (option), 4MB flash memory (option), RF matching circuit and antenna.

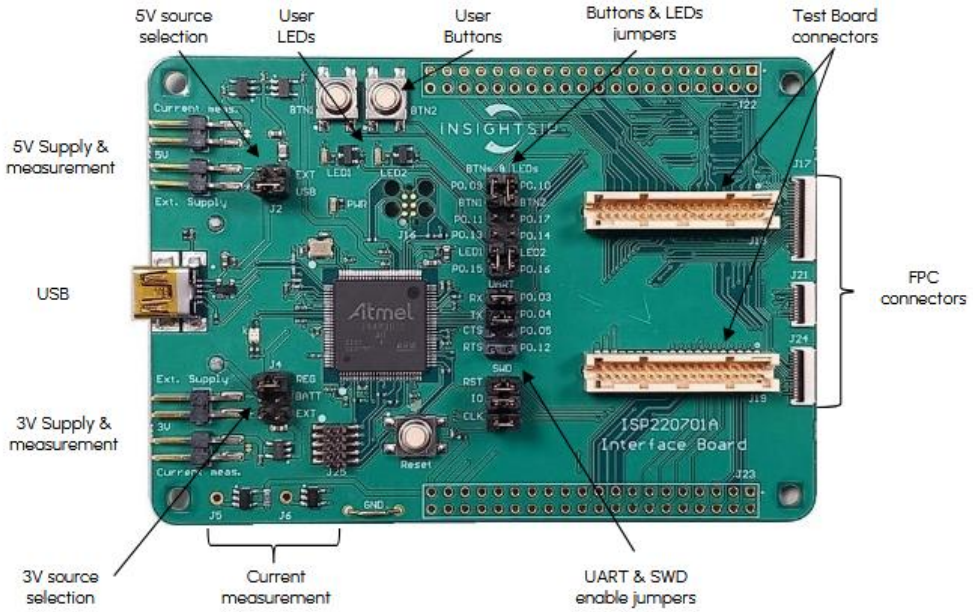
The ISP2454 is available in 3 different versions:

- **ISP2454-LL** provides only the 32 MHz crystal, without the 32.768 kHz crystal and without the 4MB flash memory, especially suited for application that does not require the best energy savings.
- **ISP2454-LX** provides the 2 crystals at 32 MHz and 32.768 kHz, but does not provide the 4MB flash memory.
- **ISP2454-LP** provides the 2 crystals at 32 MHz and 32.768 kHz and the 4MB flash memory, especially suited for application that requires larger memory size like Matter for instance.

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2.3. ISP130603G Interface Board

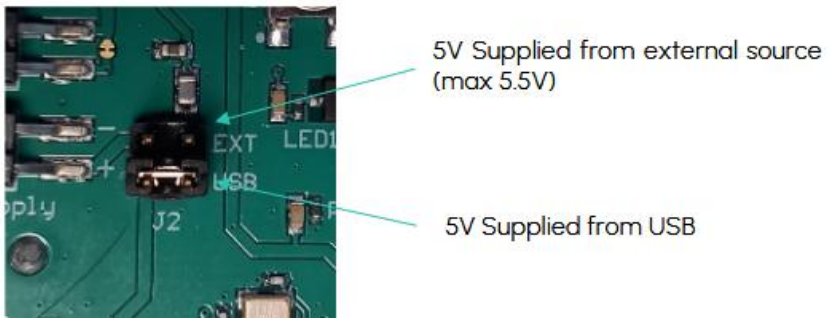
Board overview:



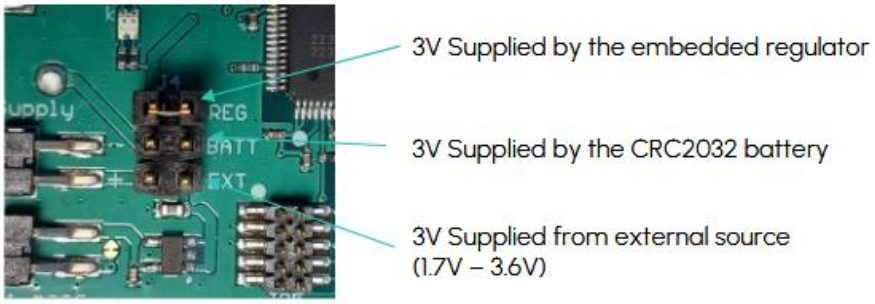


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- J2 jumpers select the 5V power supply source:

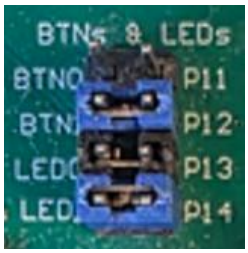


- J4 jumpers select the 3V power supply source:



- SWD & UART jumpers can connect or disconnect Debug and UART lines from the test board. It is recommended when powering up the board with a CR2032 battery or external 3V. With such supply sources the debugger will not be supplied

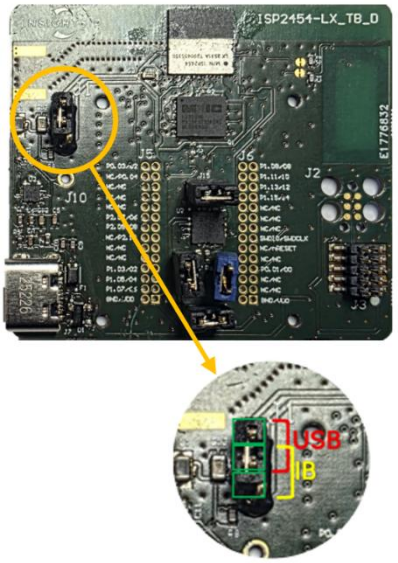
- BTNs & LEDs jumpers give the possibility to connect up 2 buttons & 2 LEDs to the test board:



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2.4. ISP2454-LX-TB Test Board

Board dimensions are 47 x 42 mm². It includes:



- ISP2454-LX BLE module
- 2x20 pins connectors at the bottom for Interface Board connection
- 2x5 pin header for programming and debug when connected to a Nordic Evaluation Board
- JTAG footprint for programming and debug when connected to a Segger J-Link
- 1x3 pin header (J1) with jumper position for alternative power options: **USB** or **IB** (Interface Board)
- 4x2 pins header for J13 (RX = P1_05), J14 (TX = P1_04), J15 (CTS = P1_07) and J16 (RTS = P1_06) GPIOs UART connections used if the test board is stand-alone powered with **USB**
- Printed NFC antenna

The Matter applications such as Light Bulb, Switch or Lock can only be used from the **ISP2454-LX-TB Revision D** that includes:

- External MX25R32 SPI NOR Flash memory (32 Mbit) used for data storage and firmware-related purposes

2.5. Hardware Setup

- Connect the USB cable from the Interface Board ISP130603 to your computer.
- Plug the BLE Test Board to the Interface Boad using the 2x20 connectors (Photo for illustrative purposes only).



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2.6. Pin mapping with the interface board

To use correctly the GPIO of the ISP2454 test board with the ISP130603 interface board, the following tab shows the matching between the GPIO pins of the interface board and the GPIO pins of the ISP2454 test board:

ISP130603 pins	ISP2454-TB pins
P02	P0.02
P03	P0.03
P04	P0.04
P05	P0.02
P06	P0.00
P07	P0.03
P08	P0.01
P09	-
P10	-
P11	P1.13
P12	P1.09
P13	P2.09
P14	P1.10
P15	
P16	P2.06
P17	P2.07
P18	P2.08
P19	
P20	P2.10
P21	(P2.00)
P22	(P2.01)
P23	(P2.02)
P24	(P2.03)
P25	(P2.04)
P26	(P2.05)
P27	-
P28	-
P29	-
P30	-
P31	-
P32	-
P33	-
P34	P1.02
P35	P1.03

ISP130603 pins	ISP2454-TB pins
P36	P1.04
P37	P1.05
P38	P1.06
P39	P1.07
P40	P1.08
P41	
P42	
P43	P1.11
P44	P1.12
P45	
P46	P1.14
P47	P1.15
P48	-
P49	-
P50	-
P51	-
P52	-
P53	-
P54	-
P55	-
T_SWCLK	SWDCLK
T_SWDIO	SWDIO
T_nRESET	nRESET
T_VBUS	-
T_D+	-
T_D-	-
P00	P0.00
P01	P0.01
P56	-
P57	-
P58	-
P59	-

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3. Software Content

3.1. Zephyr RTOS

The ISP2454 uses the nRF Connect SDK from Nordic Semiconductor running zephyr RTOS. Zephyr RTOS is a small, scalable, real-time operating system (RTOS) designed for resource-constrained embedded systems.

The main key features are described below:

- Preemptive real-time kernel with priority-based scheduling
- Multi-architecture support
- Integrated security features
- Built-in connectivity stacks
- Multithreading support with synchronization primitives
- Power management framework for ultra-low power applications
- Modern development tools: CMake, West, native SDK.
- Highly modular and configurable architecture with Device Tree and Kconfig files

For the last point, many things can be done in the two files:

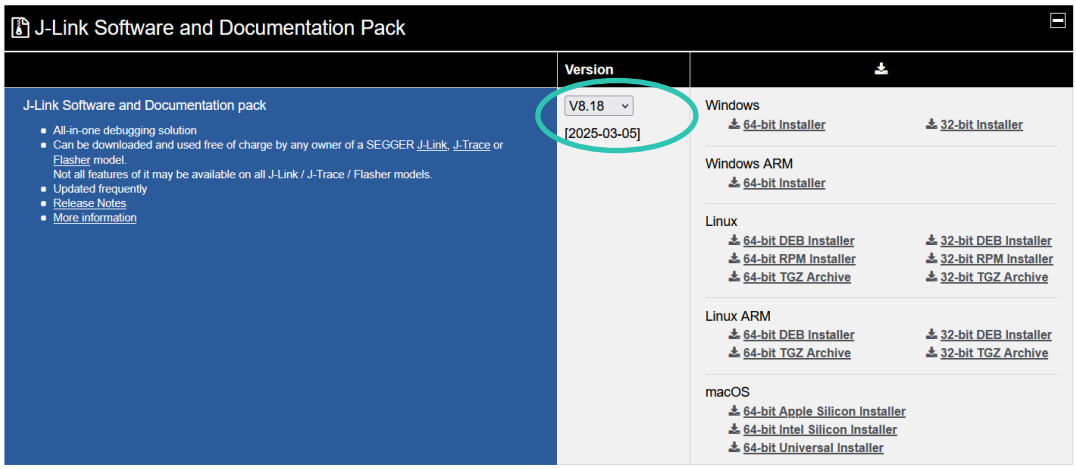
- The **prj.conf** file to enable or disable services (example: CONFIG_LOG_BACKEND_RTT=y allowing to enable the LOG on RTT)
- And the creation of an overlay file in the Device Tree for hardware configuration

3.2. PC Software Installation

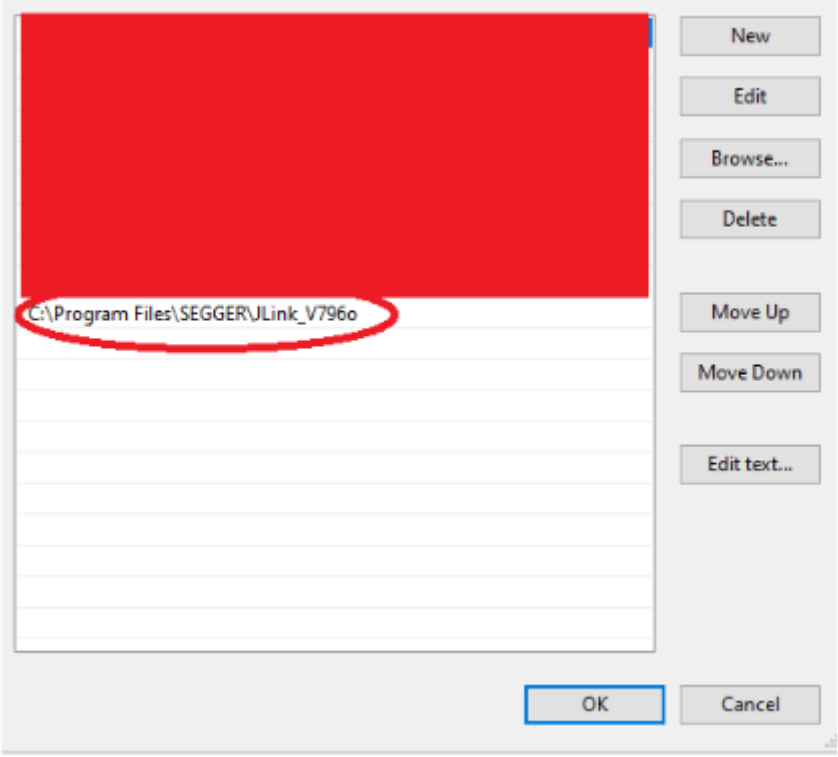
3.2.1. JLink installation

- Flashing & debugging the Insight SiP module is done using a J-Link probe
- Download and install the latest version of J-Link software at:
- https://www.segger.com/downloads/jlink

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- Once the J-Link software has been installed set a Path in the Environment variables to the location of JLink.exe for the latest version:



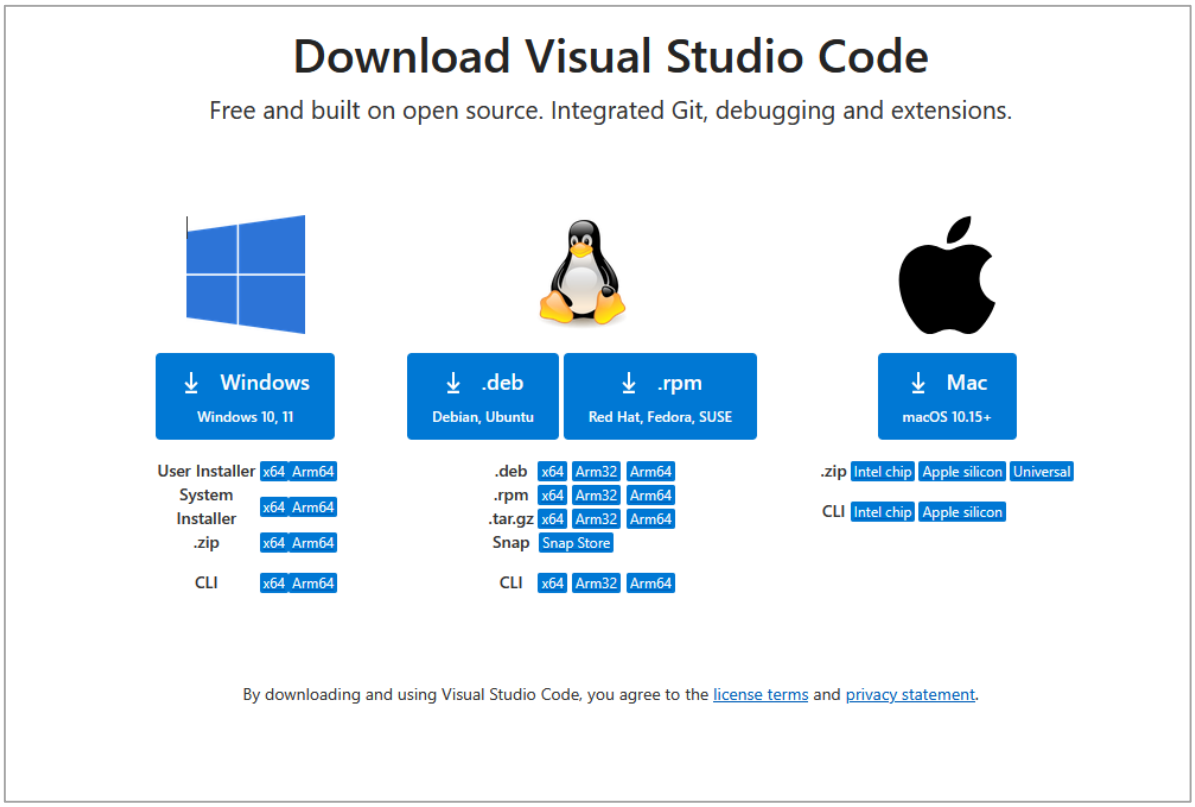
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3.2.2. nRF Util installation

- Install nRF Util from Nordic website: https://www.nordicsemi.com/Products/Development-tools/nRF-Util
- Copy the executable in C:/ncs
- As same that the previously step, add path to nRF Util to Windows Environment Variables
- Open Windows Power Shell
- Type the command "nrfutil install device"
- Type the command "nrfutil install toolchain-manager"

3.2.3. Visual Studio installation

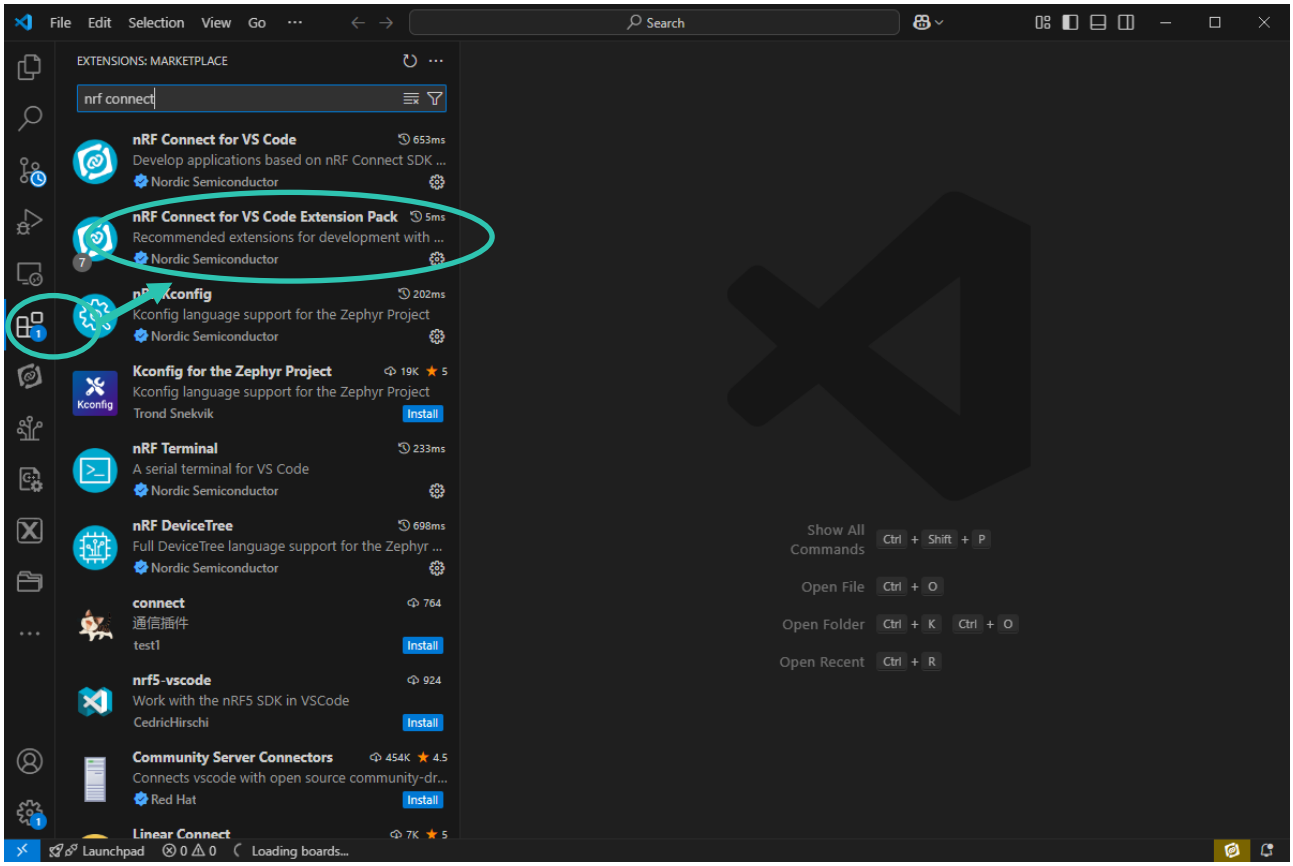
- Download the latest version for visual Studio Code at: https://code.visualstudio.com/download



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3.2.4. nRF Connect for VSCode installation

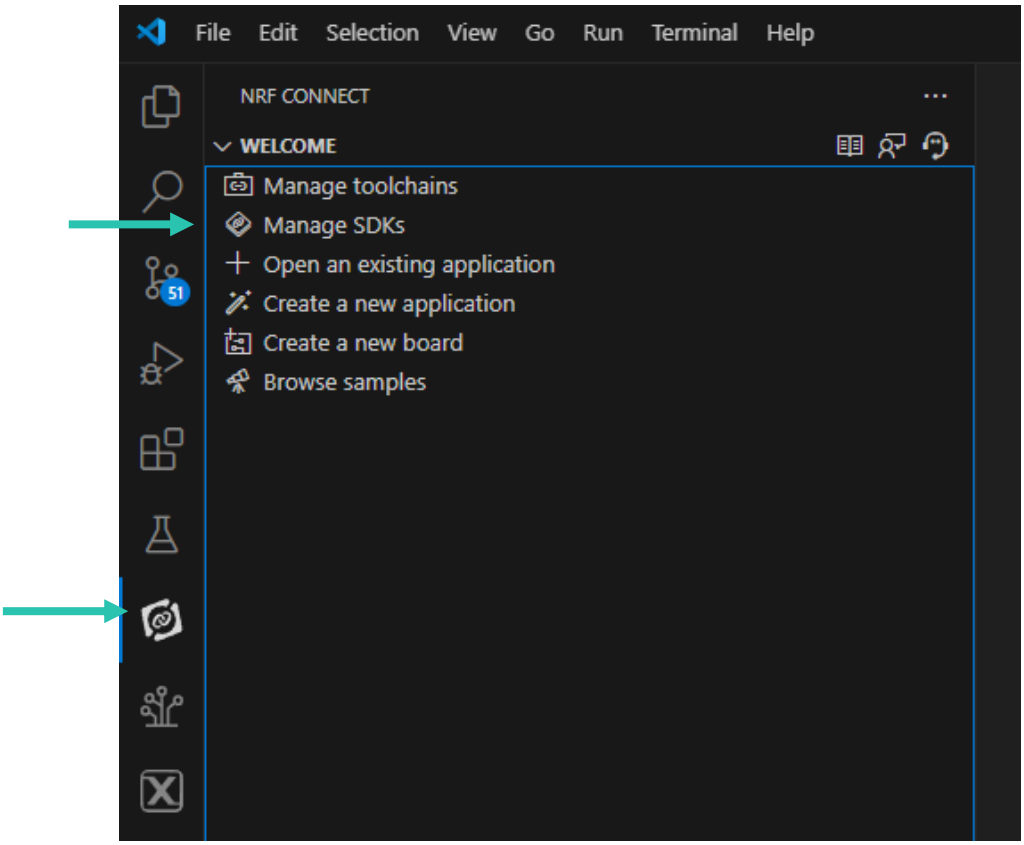
- Start VS Code, in extension menu search for nRF Connect and install the extension pack:



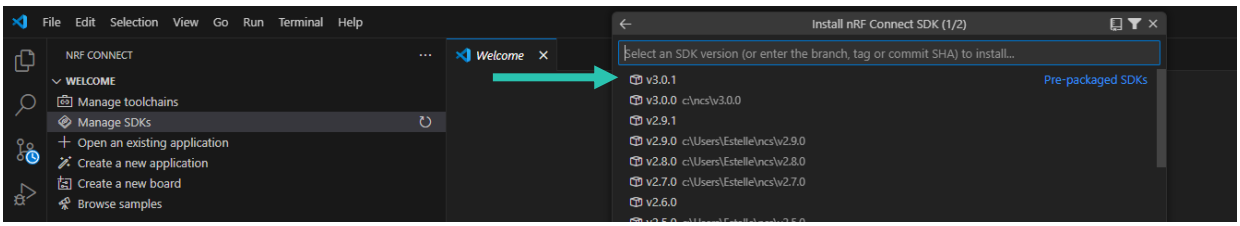
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3.2.5. Nordic SDK and toolchain Installation

- Open VS Code
- Click on the nRF Connect icon and in the nRF Connect area click on "Manage SDK":

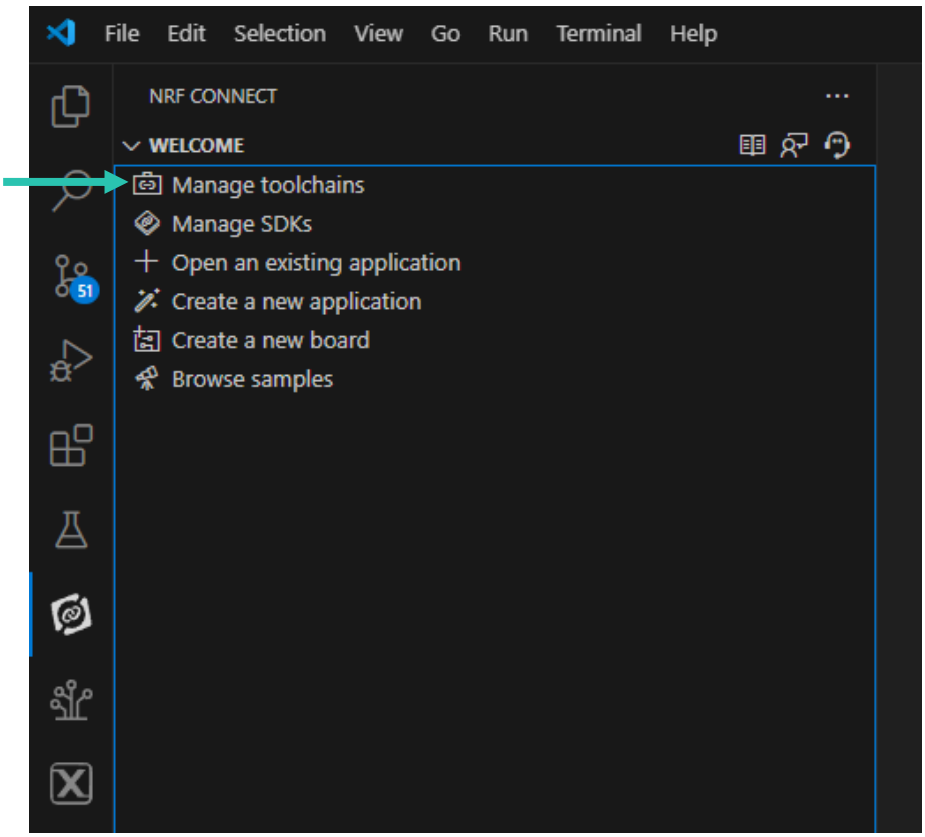


- In the top bar, click on "Install SDK" and select the latest SDK version:

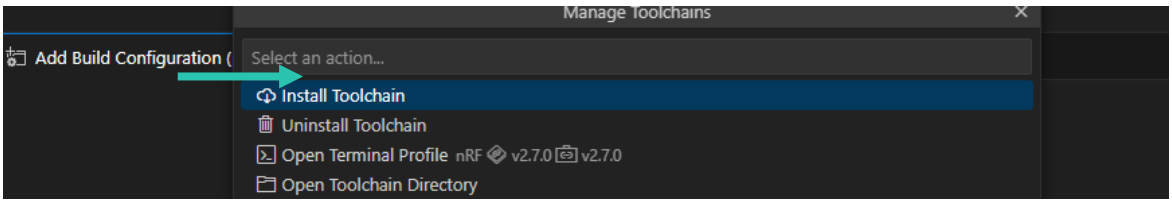


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- When SDK is installed, click on "Manage Toolchain":



- In the top bar, click on "Install Toolchain" and select the version that matching with the SDK version installed (for example 3.2.1 with a 3.2.1 SDK version)

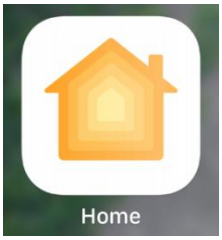


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3.3. Smartphone Software installation

Install the application "nRF Connect" available on App Store or on Google Play.

3.4. Smartphone Home app installation



The Home application is required to interact with the HomePod, which is used as a testing device to validate Matter applications running on the board.

The Home application can be downloaded from the App Store and is only available on iPhone and other Apple devices.

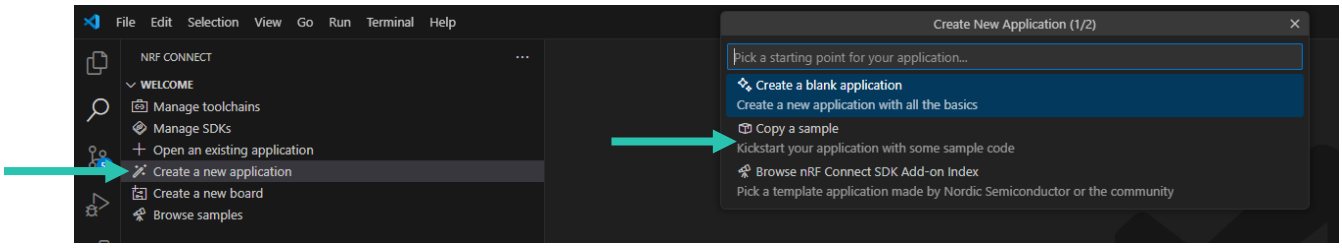
3.5. nRF Connect for Desktop

- Install the application "nRF Connect" for Desktop here: https://www.nordicsemi.com/Products/Development-tools/nRF-Connect-for-Desktop
- Download the "Direct Test Mode" application from "nRF Connect for Desktop"

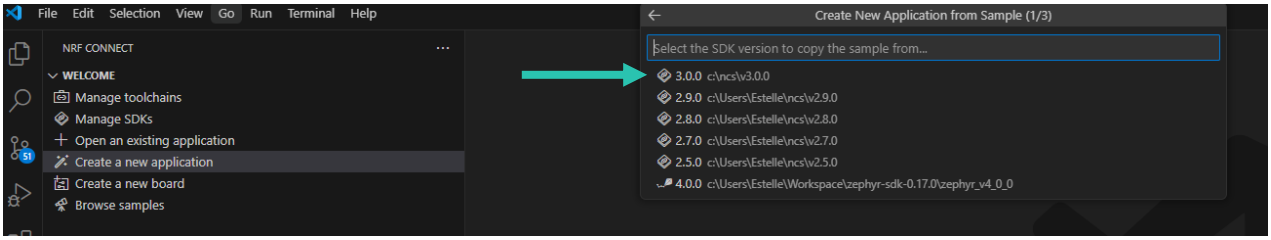
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4. HR Peripheral Example

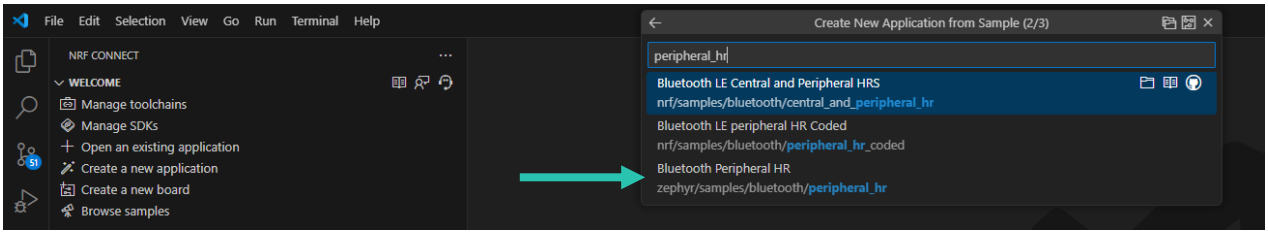
- Start VS Code
- In nRF Connect menu, ***create a new application*** and in search bar select ***Copy a sample***



- Select the nRF Connect SDK installed (v3.0.0 minimum):

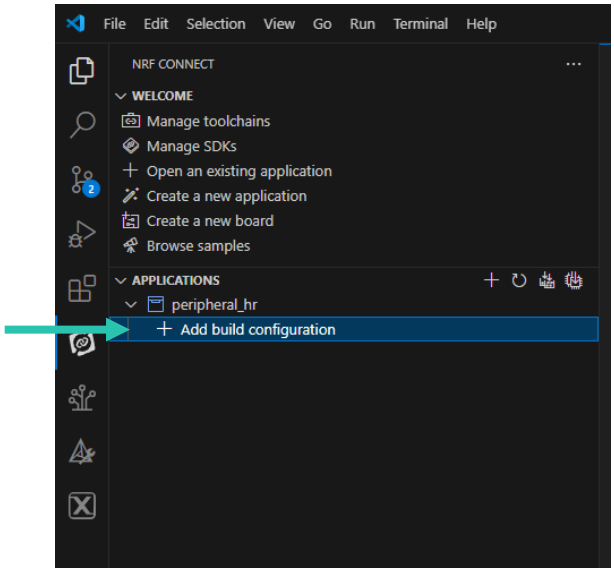


- Load the ***Bluetooth Peripheral HR*** example and press Enter:

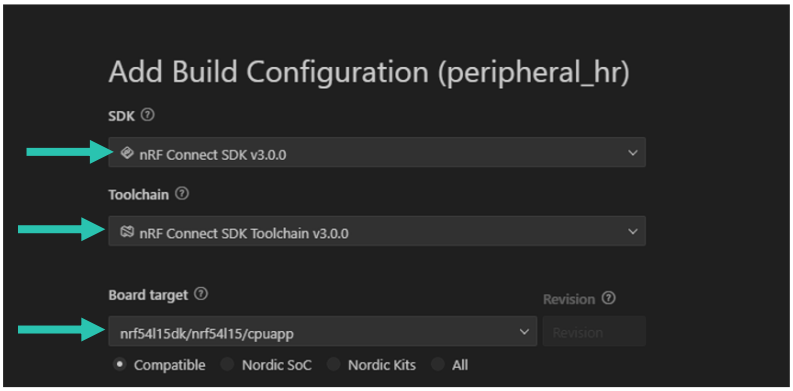


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- In APPLICATIONS section of the project, click on ***Add build configuration***:

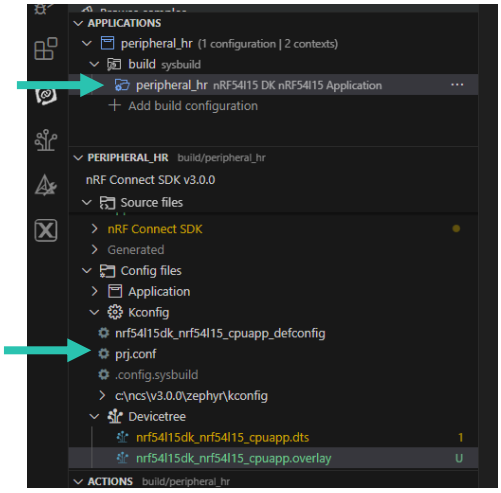


- A build configuration window opens on VS Code
- In this window, select the SDK and Toolchain version
- Choose the board target named "nrf54l15dk/nrf54l15/cpuapp"



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- Open the **prj.conf** file in the Kconfig area in your build project:

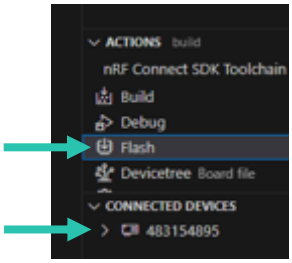


- If you are using the ISP2454-LL version using internal oscillator RC (without LFXO 32kHz), you have to modify the **prj.conf** file by adding the following configuration for the Clock:

peripheral_hr_26 > prj.conf

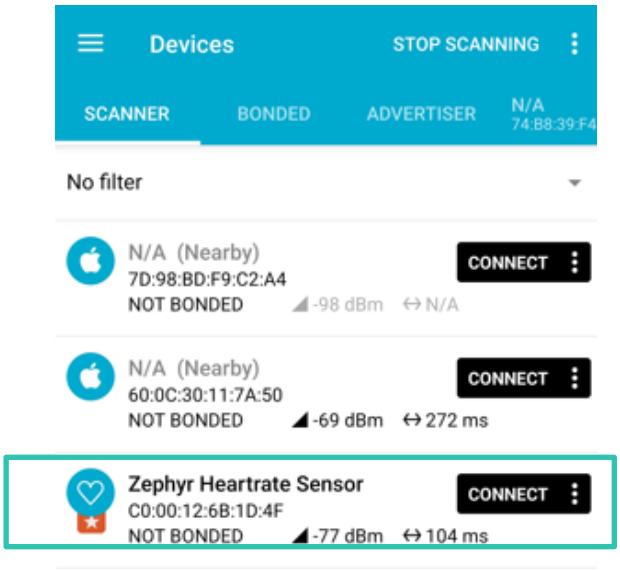
```
1   CONFIG_BT=y
2   CONFIG_LOG=y
3   CONFIG_BT_SMP=y
4   CONFIG_BT_PERIPHERAL=y
5   CONFIG_BT_DIS=y
6   CONFIG_BT_DIS_PNP=n
7   CONFIG_BT_BAS=y
8   CONFIG_BT_HRS=y
9   CONFIG_BT_DEVICE_NAME="Zephyr Heartrate Sensor"
10  CONFIG_BT_DEVICE_APPEARANCE=833
11
12  CONFIG_CLOCK_CONTROL_NRF=y
13  CONFIG_CLOCK_CONTROL_NRF_K32SRC_RC=y
14  CONFIG_CLOCK_CONTROL_NRF_K32SRC_SYNTH=y
15  CONFIG_CLOCK_CONTROL_NRF_K32SRC_RC_CALIBRATION=y
16  CONFIG_CLOCK_CONTROL_NRF_K32SRC_20PPM=n
```

- Click on Build
- In the ACTIONS section, after build successful, make sure the device is connected and flash it (proceed to a recover before flashing):



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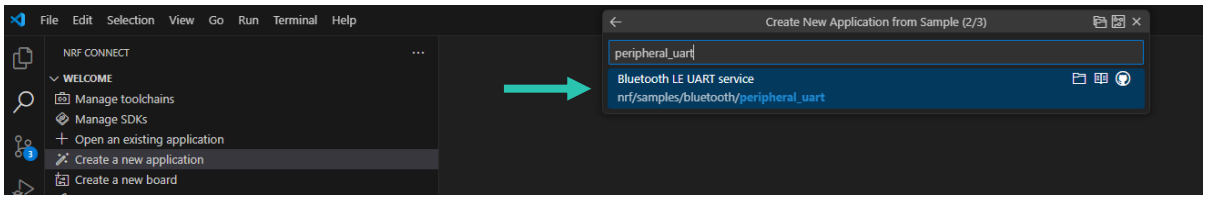
- Using "nRF Connect App" on your smartphone, scan for the devices and search the "Zephyr Heartrate Sensor":



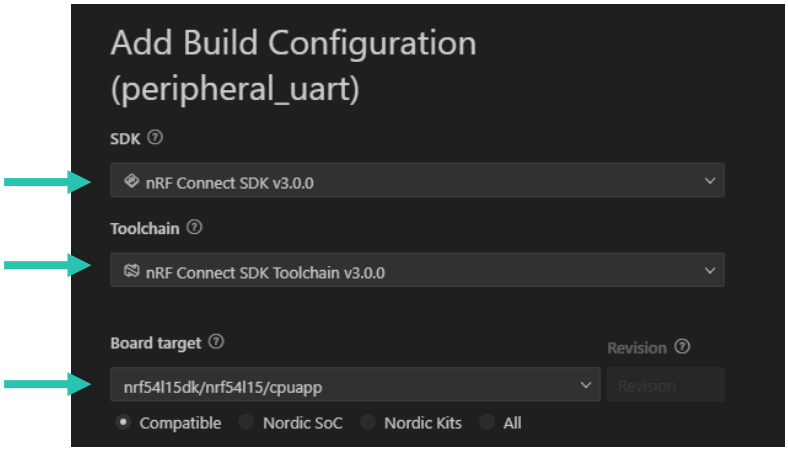
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5. Peripheral UART Example

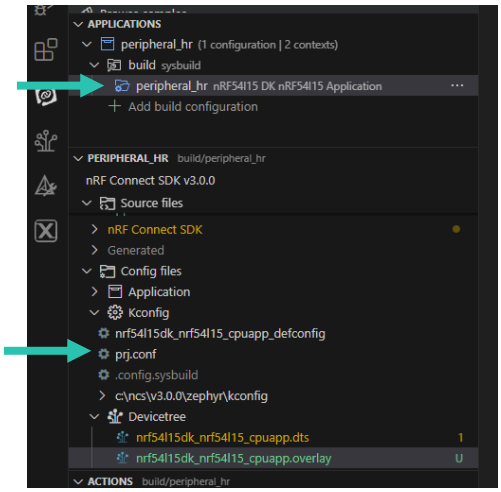
- As the same previously steps, create a new application by coping a sample
- Select the ***Bluetooth LE UART service*** application example



- As the same previously steps, add a build configuration with the last SDK, last toolchain and the board target named "nrf54l15dk/nrf54l15/cpuapp":

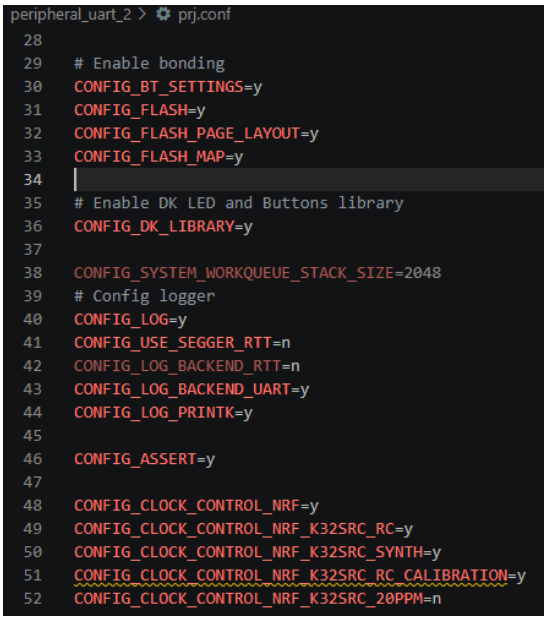


- Open the **prj.conf** file in the Kconfig area in your build project:

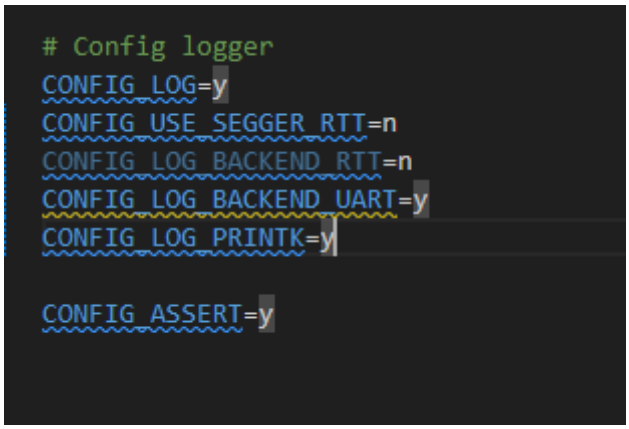


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- If you are using the ISP2454-LL version using internal oscillator RC (without LFXO 32kHz), you have to modify the **prj.conf** file by adding the following configuration for the Clock:



- To see the logs on the UART console, you need to enable the logs backend on UART and disabled the RTT* in the **prj.conf** file:

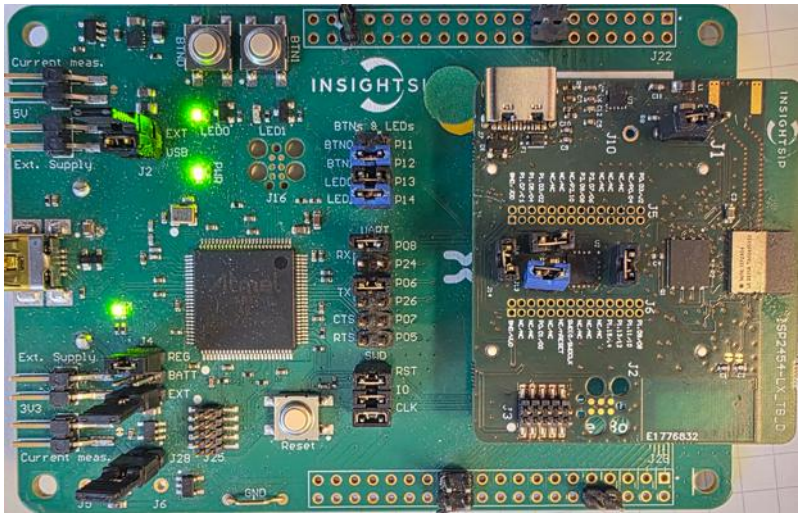


**RTT and UART can run in parallel on the nRF54l15 but there is a limitation of the software: the logger can generally use only one backend at a time for the same messages, except to write a custom solution.*

- Otherwise, if you want to see the logs over RTT, enable segger RTT and the log backend on RTT and disable the backend on UART
- Initially, the UART uses to log is the UART20 which uses the peripheral P1. TX is on the P1.04 GPIO pin and RX is on P1.05 GPIO pin

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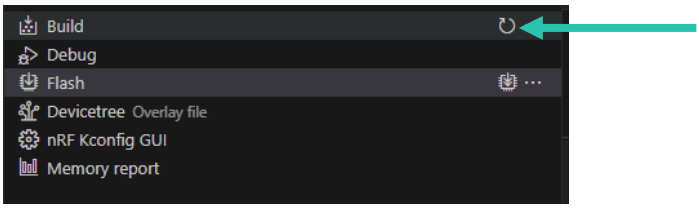
- If you want to use the initial UART, you need to connect the TX and RX pin of the interface boards to the correct GPIO pin.
  - Connect TX on pin P06 (*P1.04 GPIO*) on the interface board
  - Connect RX to pin P08 (*P1.05 GPIO*) on the interface board



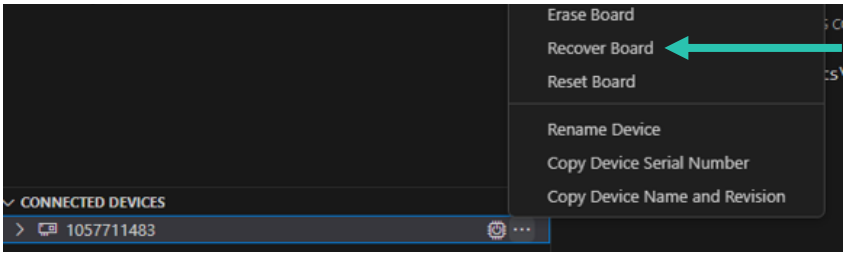


- If you want to modify the UART to log, you need to modify the overlay file to choose the nus-uart node and to map the pins that you want to use. Don't forget to connect the UART pins that match with the correct pins of the interface board (see the previous tab).

- Pristine build the project in the ACTION section:

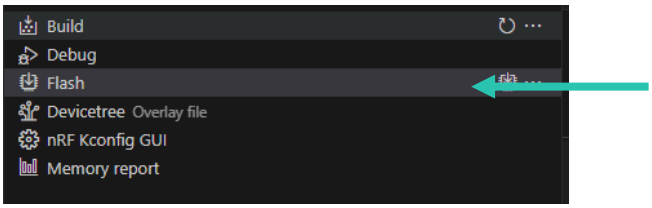


- Recover the board before flashing:

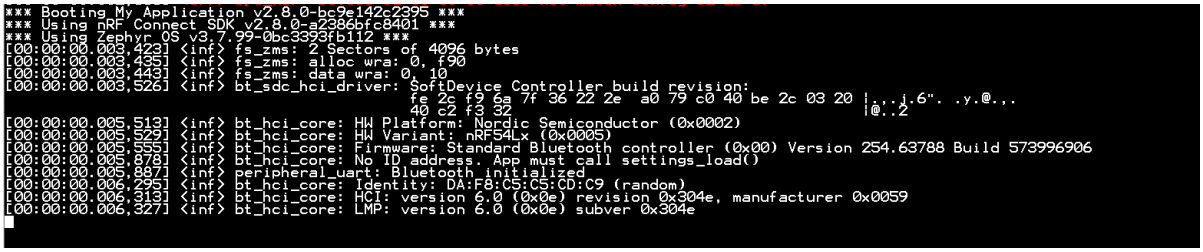


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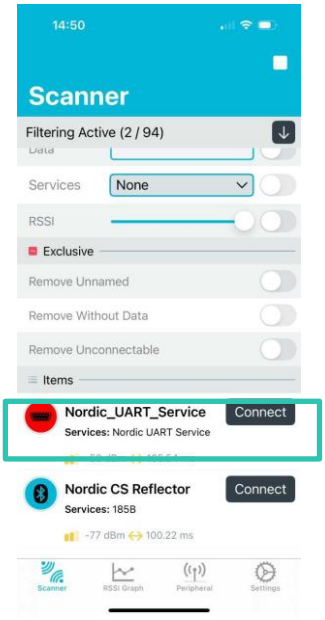
- Then flash:



- Open a terminal emulator
- Connect the port COM at 115200 bauds
- Reset the development kit with the "Reset" bouton
- See the following logs on your terminal



- Open the nRF Connect application on your smartphone
- Connect to the "Nordic_UART_Service":



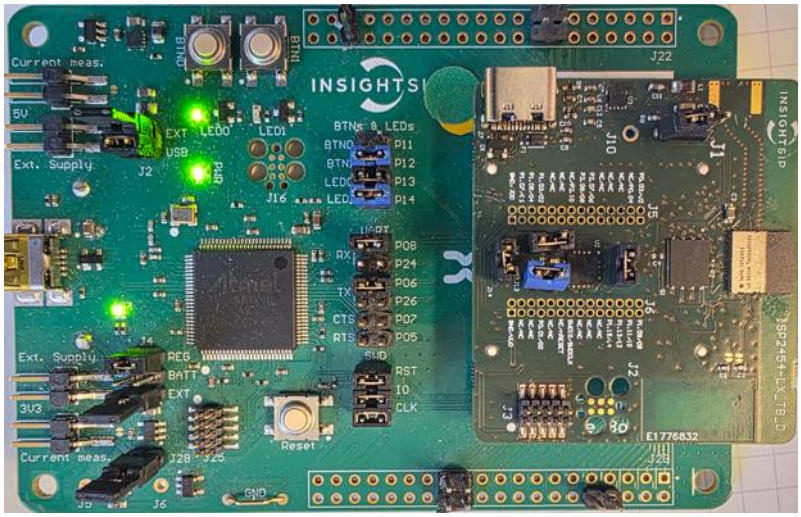
- See the log on emulator terminal that notifies that there is a device connected:



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6. Direct Test Mode Example

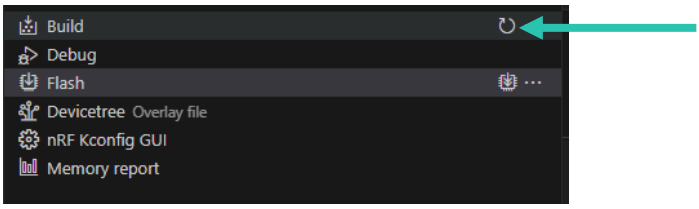
- As the same previously steps, create a new application by coping a sample
- Select the ***Direct Test Mode*** application example
- Initially, the UART uses for DTM is the UART20 which uses the peripheral P1. TX is on the P1.04 GPIO pin and RX is on P1.05 GPIO pin
- If you want to use the initial UART, you need to connect the TX and RX pin of the interface boards to the correct GPIO pin.
  - Connect TX on pin P06 (*P1.04 GPIO*) on the interface board
  - Connect RX to pin P08 (*P1.05 GPIO*) on the interface board





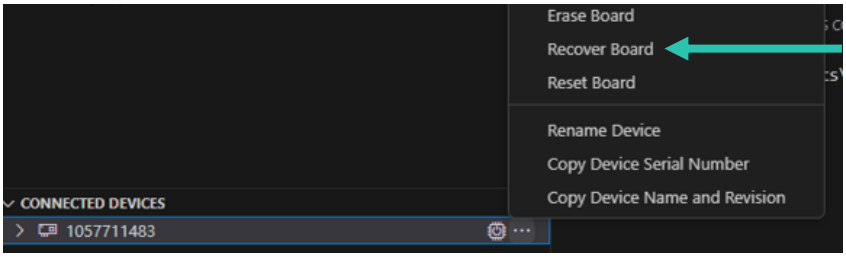
- If you want to modify the UART to use the dtm, you need to modify the overlay file to choose the dtm-uart node and to map the pins that you want to use. Don't forget to connect the UART pins that match with the correct pins of the interface board (see the previous tab).

- Pristine build the project in the ACTION section:

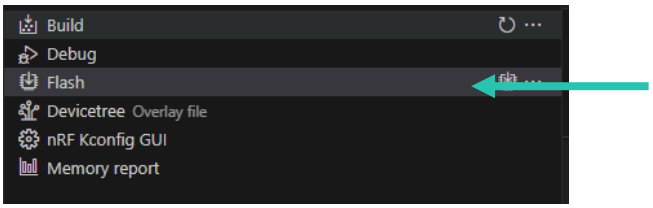


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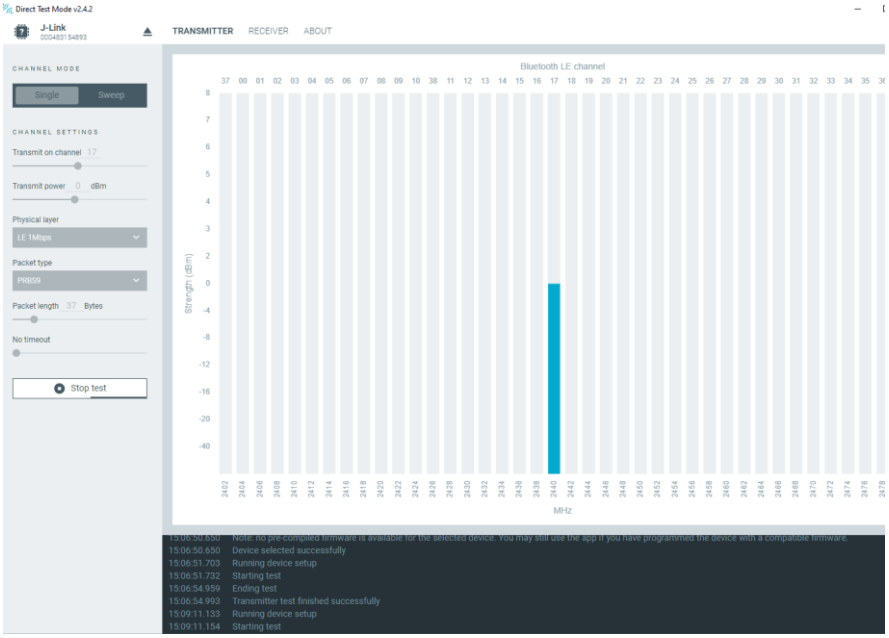
- Recover the board before flashing:



- Then flash:

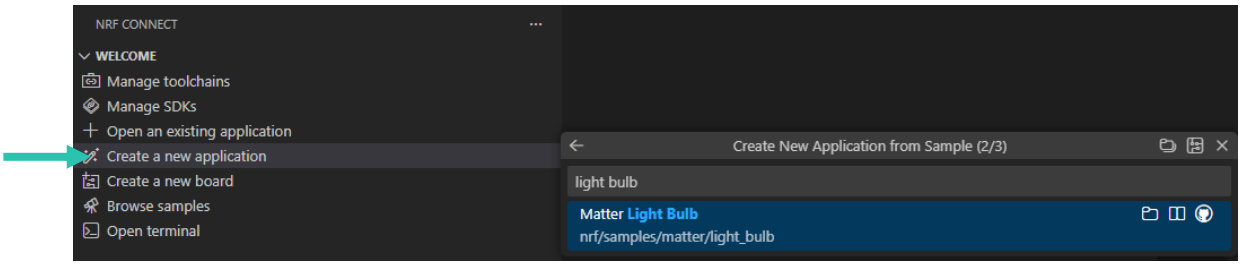


- Open the Direct Test Mode application in nRF Connect on your computer
- Connect to the JLink
- Then test the transmitter or receiver mode. For example, in transmitter mode on canal 17 with 0dBm power:

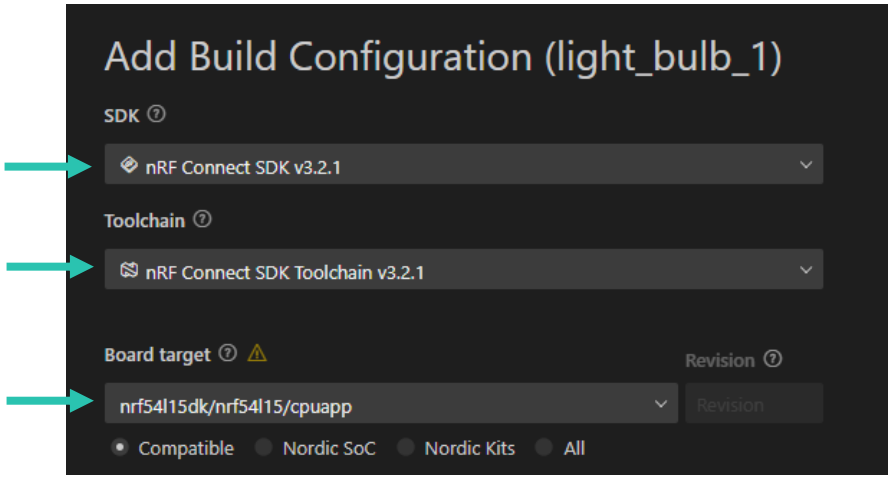


7. Light Bulb Matter example

- As in the previous examples, create a new application by copying a sample.
- Select the Matter Light Bulb application example.
- Note that this example requires the larger external memory available starting from Revision C of the test board



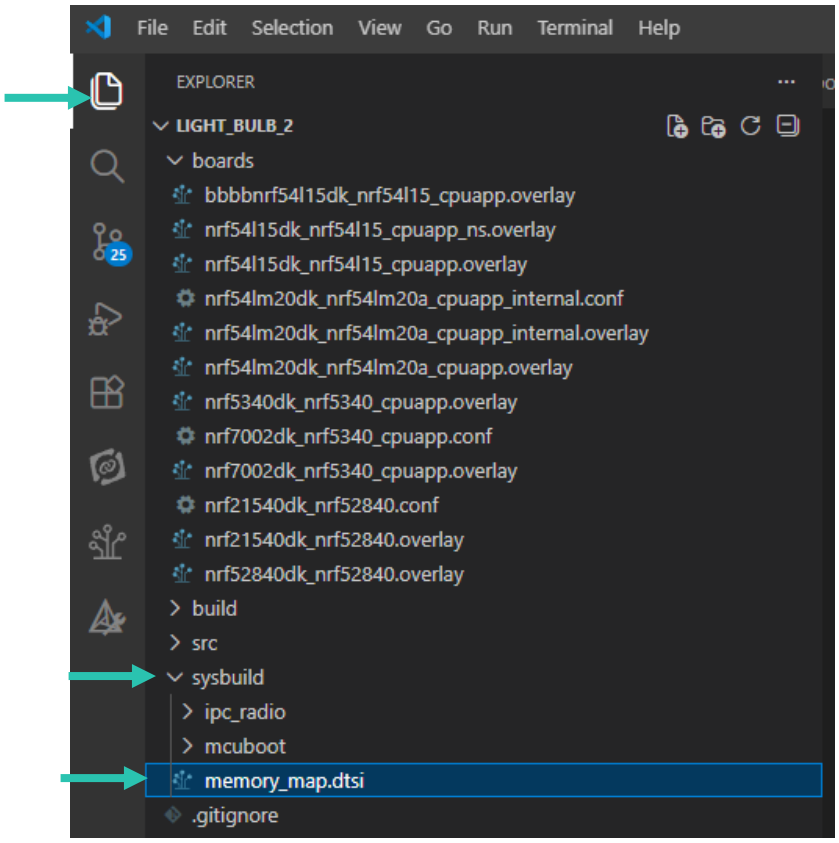
- As in the previous steps, add a build configuration using the latest SDK, the latest toolchain and the board target named "nrf54l15dk/nrf54l15/cpuapp":



- To make the application work, some default values must be modified, such as the TX/RX pins, buttons, LEDs, and the memory configuration. This configuration is done in four steps.

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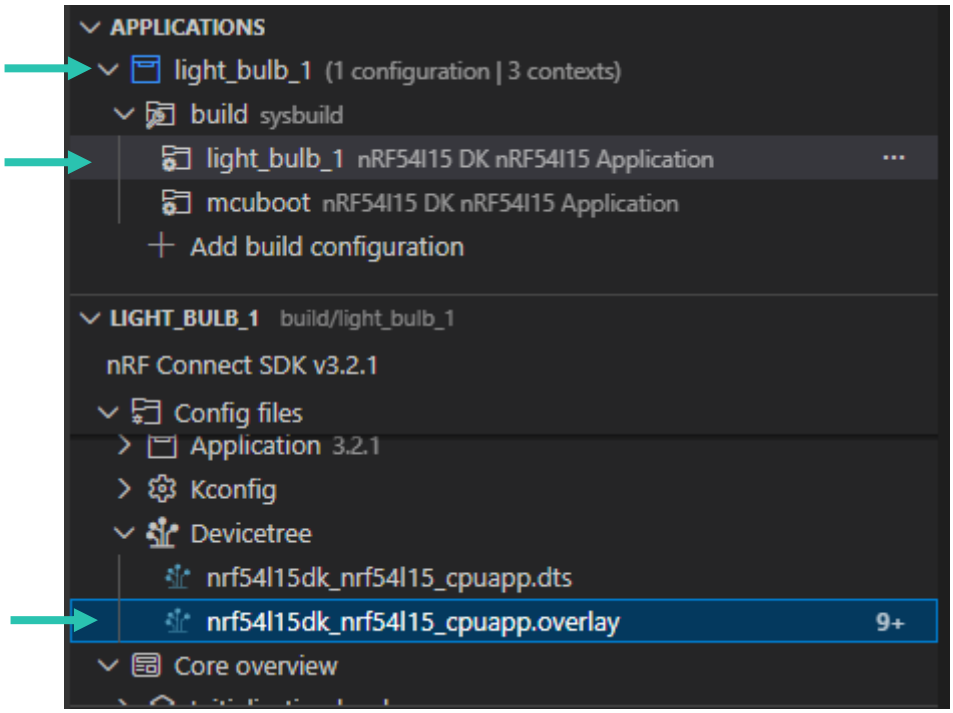
1. The first step consists of creating a new file in the following location: **.../sysbuild** that you can name **memory_map.dtsi**.



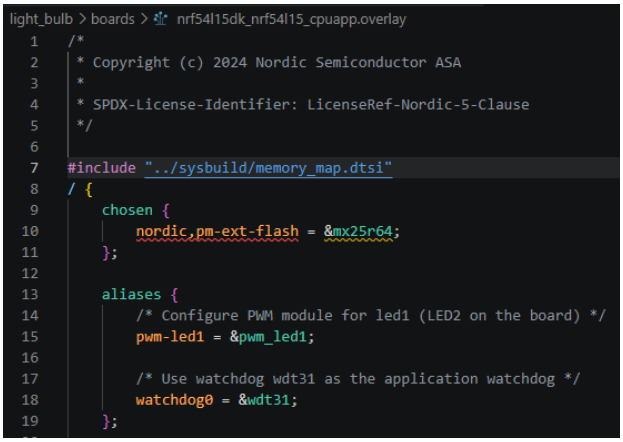
Once it is created, you can add the definition of the memory that you will be using. The required information can be found in the ZIP archive: **.../.../fichiers_overlay.zip**, available in the GitHub.

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2. Next, you will need to modify the overlay file nrf54l15dk_nrf54l15_cpuapp.overlay, which can be found in the Devicetree section inside the Config files:



First, include the file you just created by using its relative path.

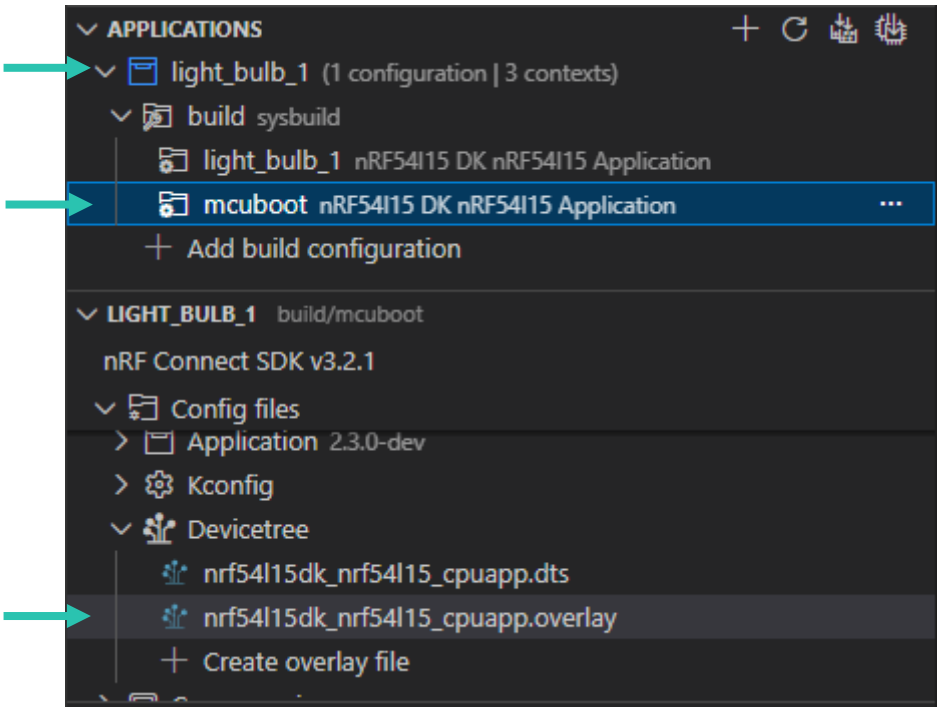


Changes related to the chosen memory, buttons, LEDs, and TX/RX pins are made directly in this file.

You then need to open this file in File Explorer and rename it (we do not want the application to use this version, so you can rename it as you prefer). Then, copy the file with the same original name provided in the ZIP archive and paste it into the same directory.

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To define the chosen external memory, modifications must also be made in another nrf54l15dk_nrf54l15_cpuapp.overlay file located this time in the mcuboot configuration area:



In this file, you must also include the file you created and choose the correct memory.

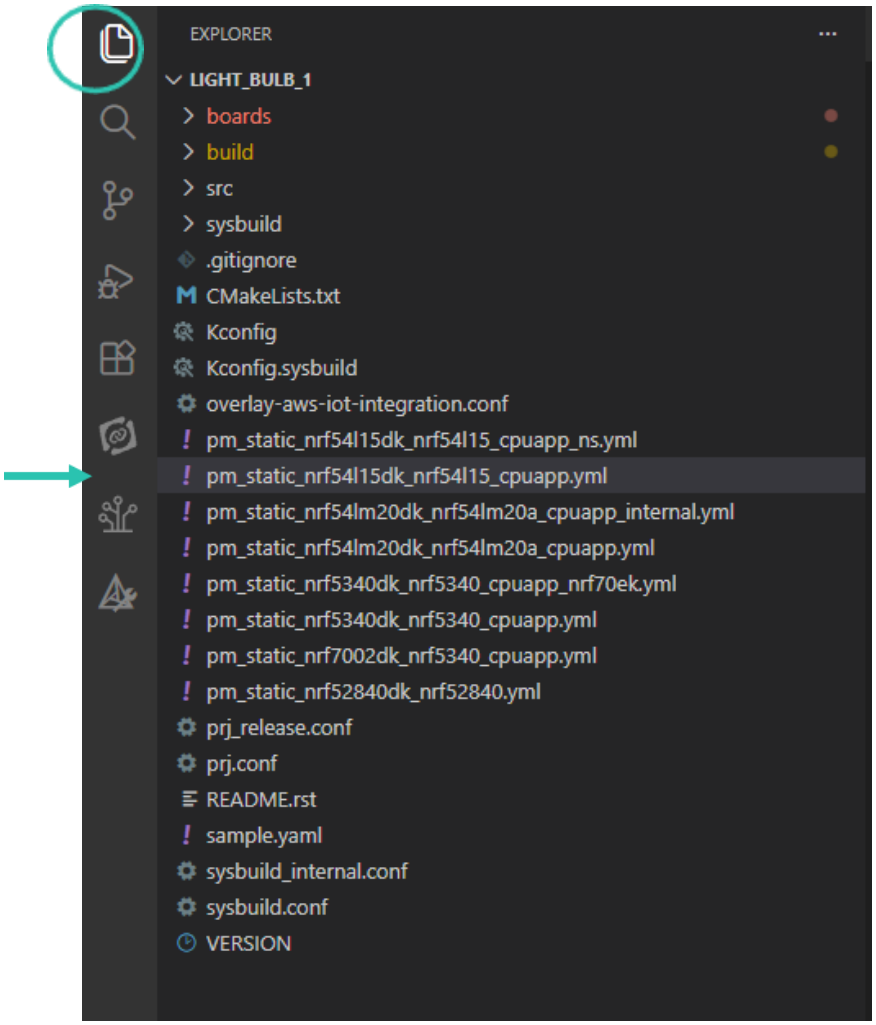
The modified file is also included in the ZIP archive under the name **nrf54l15dk_nrf54l15_cpuapp_mcuboot.overlay**.

You need to rename the default overlay file because we do not want to use it. During the build process, the example automatically includes any file with the specific name **nrf54l15dk_nrf54l15_cpuapp.overlay**.

Therefore, if the default file keeps this name, it will be used instead of ours. To ensure that our configuration is taken into account, rename the default file, then copy the file from the ZIP archive, paste it into the same directory, and rename it to **nrf54l15dk_nrf54l15_cpuapp.overlay**.

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3. The last modification concerns the memory allocation size for the external flash. This can be configured in the file pm_static_nrf54l15dk_nrf54l15_cpuapp.yml.



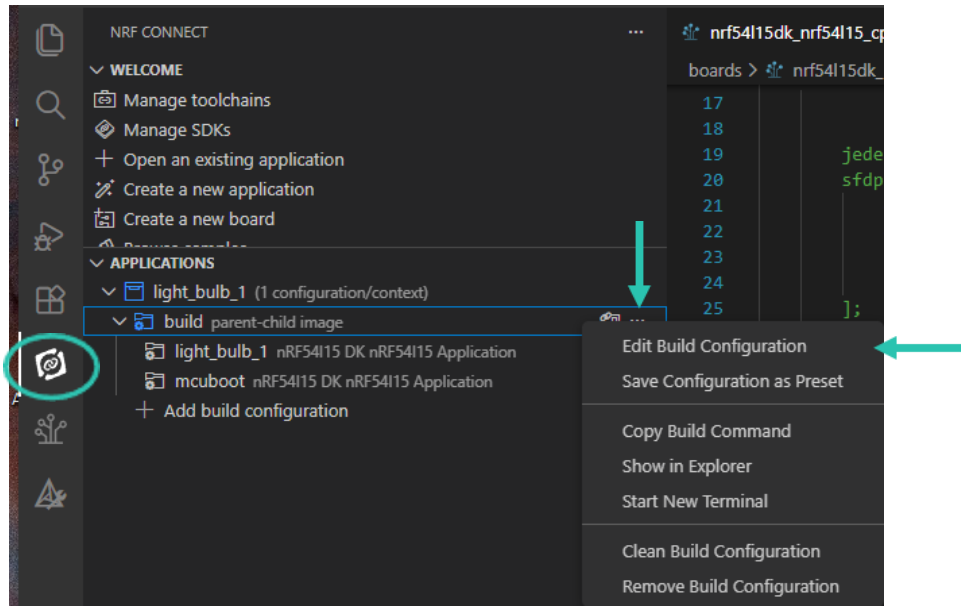
Only two parameters need to be updated: the « **external_flash** » size and the « **device** » name. The selected flash memory has a size of 4 MB, so the value must be adjusted accordingly (400000 - 165000 = 29B000).

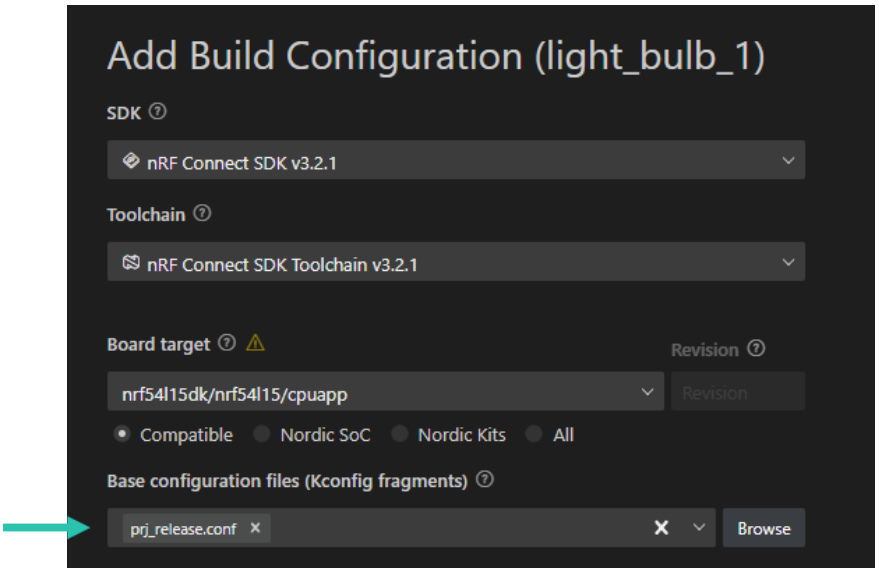
```
52 external_flash:
53   address: 0x165000
54   size: 0x29B000
55   device: MX25R32
56   region: external_flash
57
```

You can find this file in the ZIP archive as well.

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4. Finally, you need to edit the build configuration and choose « **prj_release.conf** » as the base configuration file.





You can either use **'prj.conf'**, which provides a debug version of the application with additional features such as logs to help verify application behavior, or **'prj_release.conf'**, which provides a release version enabling only the necessary functionalities to optimize performance.

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Example behavior summary

This example implements a Matter Light Bulb device using the development kit interface, including LEDs and buttons for status indication and user interaction.

LED 1 - Device status and connectivity

The first LED indicates the overall device state:

- Short flash (50 ms ON / 950 ms OFF): the device is not yet provisioned and is waiting for commissioning.
- Fast flashing (100 ms ON / 100 ms OFF): the device is unprovisioned and currently connected to a commissioning application over Bluetooth LE.
- Solid ON: the device is fully provisioned and connected to the Matter network.

LED 2 - Light bulb state

The second LED represents the light bulb status:

- Solid ON: the light bulb is ON.
- OFF: the light bulb is OFF.

Additionally, this LED blinks evenly (500 ms ON / 500 ms OFF) when an Identify command is received, for the duration specified in the command.

Button 1 - Device control

The behavior depends on how long the button is pressed:

- Press shorter than 3 seconds:

  - If the device is not provisioned, it starts Bluetooth LE advertising to allow commissioning and enables firmware update over BLE.

  - If already provisioned, it enables firmware update over BLE.
- Press longer than 3 seconds:

  Initiates a factory reset. The reset can be canceled if the button is released within three seconds after initiation.

Button 2 - Light control

Pressing the second button toggles the light bulb state between ON and OFF.

The same approach used for **the Light Bulb example** can also be applied to the **Matter Lock** and **Thermostat** examples, which function correctly under this method.

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