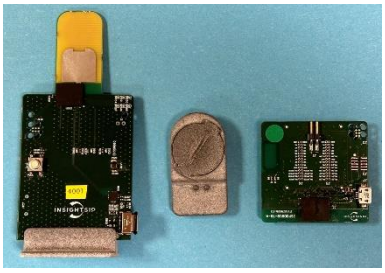
ISP3080
Application note AN240101

Use of ISP3080-UX Development Kit



Introduction

Scope

This document gives details on hardware and software for using and testing Insight SiP Bluetooth Low Energy and Ultra-Wideband module ISP3080.-UX.

Contents

Document Revision History

Revision	Date	Ref	Change Description
R0	9/1/2024	Jf cb	Initial release

1. Recommended Documentation

The following Nordic Semiconductor documents are required to understand the complete setup and programming methods.

Nordic Semiconductor Documents

- nRF52833 Development kit User Guide, hardware section should be partially ignored – Insight SiP development kit hardware replaces Nordic Semiconductor hardware.
- nRF52833 Product Specification– make sure you have the latest document version updated.

To access documentation, information, go to:

- Official Nordic Semi website *http://www.nordicsemi.com*
- The Nordic Semiconductor Infocenter is a "comprehensive library" containing technical documentation for current and legacy solutions and technologies *http://infocenter.nordicsemi.com/index.jsp*
- Find documentation about nRF Connect SDK here *https://developer.nordicsemi.com/nRF_Connect_SDK/doc/latest/nrf/index.html*
- Find documentation about nRF SDK here: *https://infocenter.nordicsemi.com/topic/struct_sdk/struct/sdk_nrf5_latest.html*
- Ask any Nordic related question and get help *https://devzone.nordicsemi.com/questions*
- For any question, you can also open a case here *https://devzone.nordicsemi.com/support/add*

Qorvo Documents

- QM33110W Data sheet
- QM33110W User Manual

To access documentation, information, go to: https://www.qorvo.com/products/p/QM33110W#documents

Insight SiP documents

The following documents are available on Insight SIP website or/and on request:

- ANxxxxxx App Note – this document.
- ISP3080-UX data sheet.
- ISP3080-UX-TB schematic.
- ISP3080-UX-TG and ISP3080-UX-AN schematics
- ISP130603 Interface Board schematic.

2. Hardware kit content

2.1. Global description

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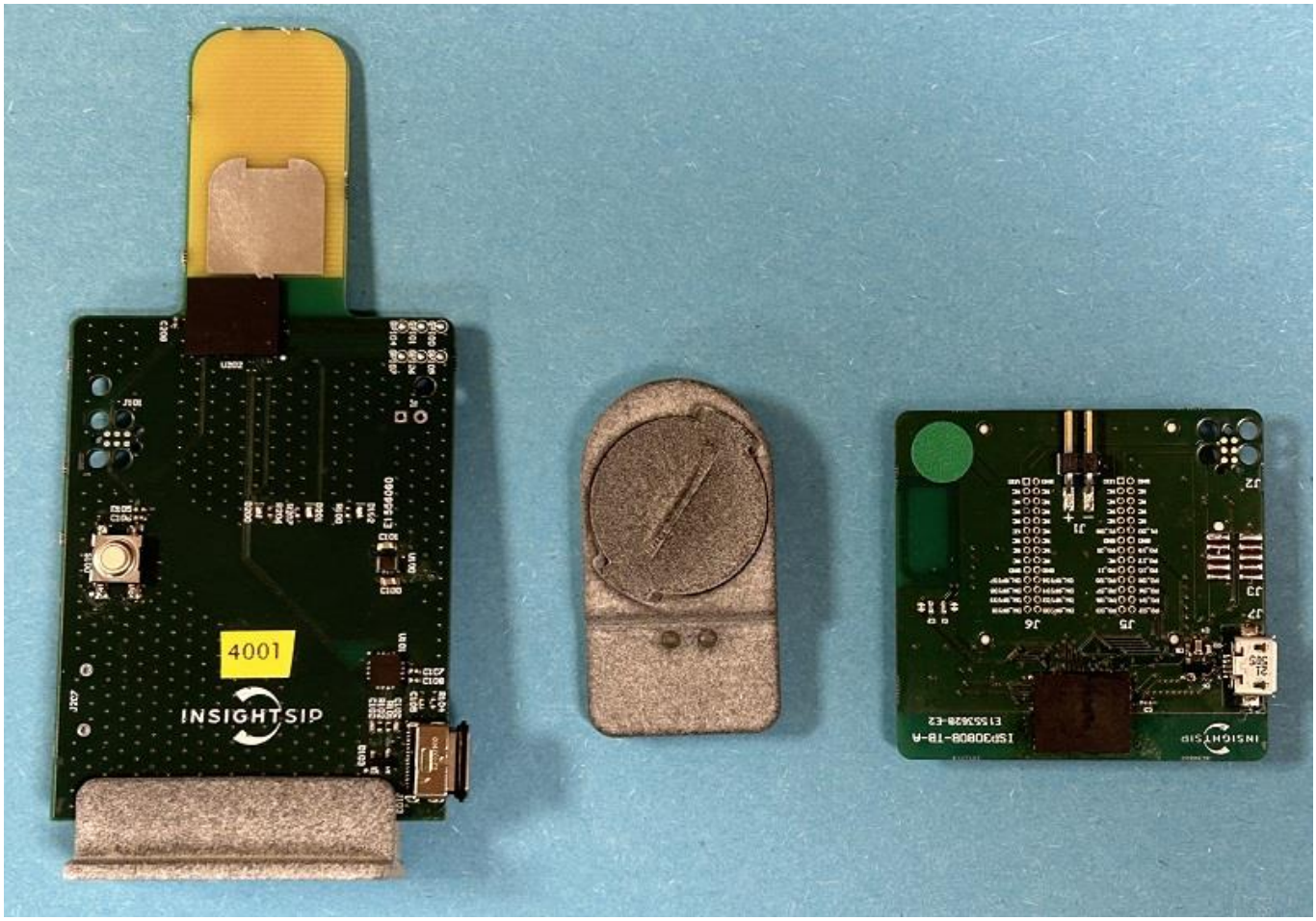
The picture below shows the Evaluation Kit hardware content for the ISP3080-UX module.

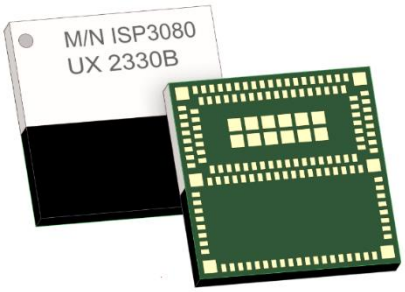


Anchor Tag Test Board

The kit also includes an interface board ISP130603G-UWB that is shown in section 2.4.

2.2. ISP3080-UX module

The ISP3080-UX module is based on Qorvo QM33110 single-chip UWB transceiver and nRF52833 Nordic Semiconductor 2.4GHz wireless System on Chip (SoC).

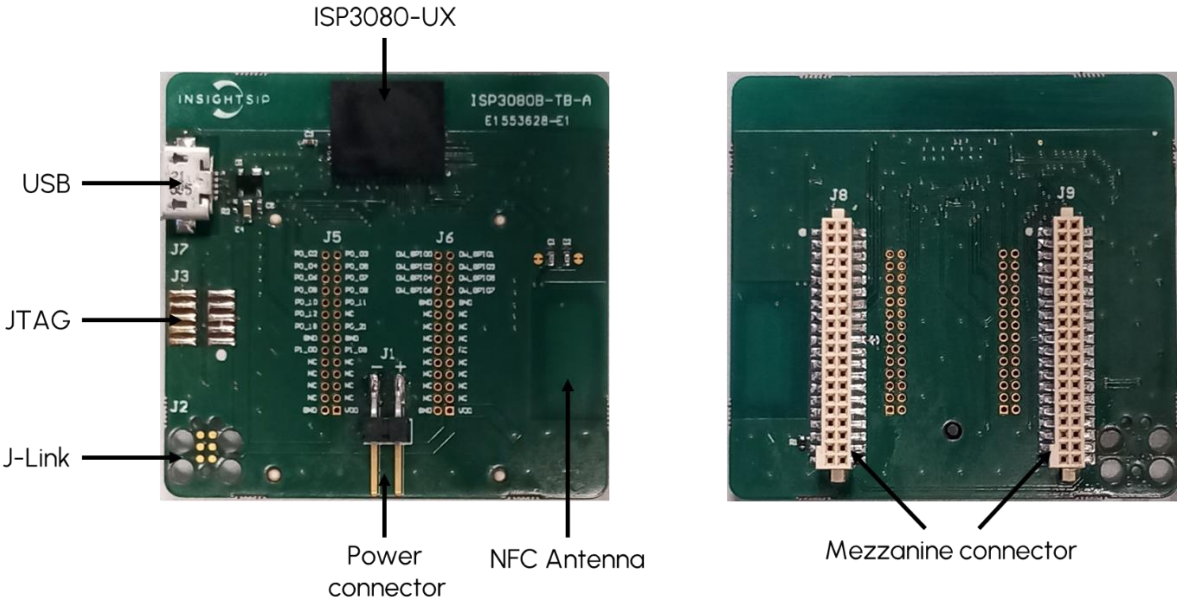


It integrates a 32-bit ARM Cortex™ M4 CPU,512 kB flash memory, 64 kB RAM as well as analog and digital peripherals. Despite the small size of 12 x 12 x 1.0 mm, the module integrates decoupling capacitors, 38.4 MHz crystal for UWB, 32 MHz and 32.768kHz crystals for BLE, DC-DC converters, RF matching circuits and two antennas in addition to the wireless SoCs. Low power consumption and advanced power management enables battery lifetimes up to several months on a coin cell battery.

For more details, see the ISP3080-UX datasheet.

2.3. ISP3080-UX-TB test board

The ISP3080-UX-TB test board consists of a module mounted on a PCB for prototyping and testing purposes. It has dimensions of 47 x 45 mm².



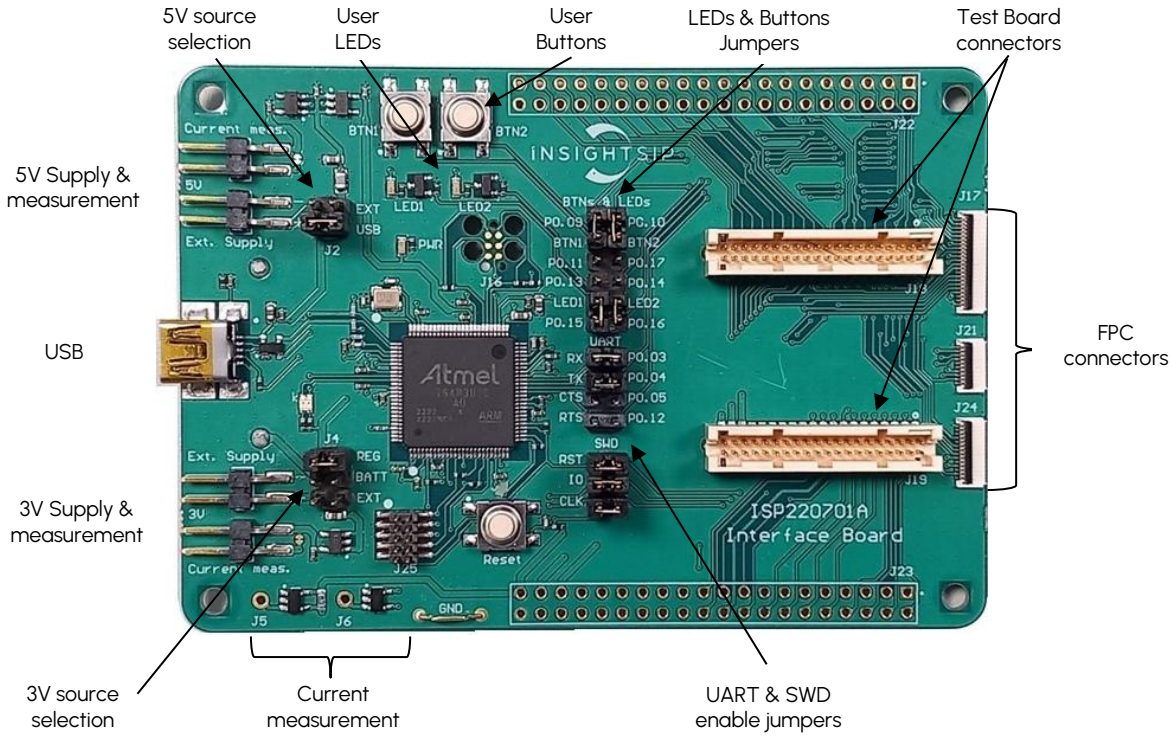
It encloses:

- ISP3080-UX module.
- 2 mezzanine connectors at the bottom side of the board (for connection to an interface board)..
- 2 x footprints for optional 2x14 pin/1.27mm pitch connector for access to the module pins.
- JTAG footprint for programming using 6 pin Segger Jlink Adapter. https://www.segger.com/products/debug-probes/j-link/accessories/adapters/6-pin-needle-adapter/
- 2x5 pin header for programming using Segger Jlink interface contained in Nordic Evaluation Board.
- 2-pin header for power supply when using 6 pin JTAG or Nordic JTAG programming options.
- USB connector connected to the module's USB interface.
- NFC Antenna on PCB.

2.4. ISP130603 interface board

The ISP130603 board is an interface board that has dimensions of 100x70mm². It can interface with test boards and is responsible for providing:

- Power supply.
- Programming and debugging capabilities.
- Access to all Ios



2.5. ISP3080-UX-AN

The ISP3080-UX-AN consists of a PCB integrating an ISP3080-UX module and a USB C socket for connection to a PC port com. It enables the communication with a TAG through UWB standards. The board dimensions are 105x50mm².
It can also be referred as "Anchor".

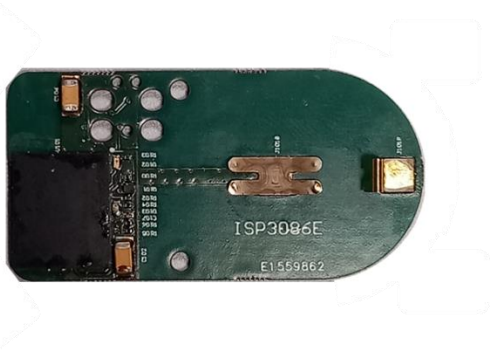
ISP3080-UX-AN

It encloses:

- ISP3080-UX module.
- 3 mini-LEDs (PWR ON and UWB TX/RX LEDs).
- USB-C connector.
- JTAG footprint for programming using 6 pin Segger Jlink Adapter. https://www.segger.com/products/debug-probes/j-link/accessories/adapters/6-pin-needle-adapter/
- FTDI USB-to-Serial adapter.
- UWB Antenna on PCB.
- 3V Regulator.

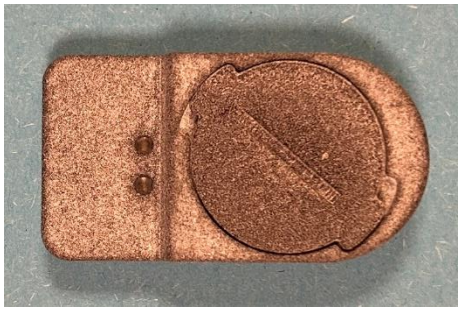
2.6. ISP3080-UX-TG (ISP3086)

The ISP3080-UX-TG consists of a small 44x22mm² PCB integrating an ISP3080-UX module powered by a coin cell.
It can also be referred as "Tag".



ISP3080-UX-TG

The tag is supplied in a plastic case that houses the battery:



ISP3080-UX-TG in casing

To start the tag a CR2032 battery should be placed in the battery compartment, plus side visible:

ISP3080-UX-TG showing battery

All the necessary components are shown below. The battery is not supplied in the kit.

ISP3080-UX-TG in casing CR2032 Battery Tag case battery cover

It encloses:

- ISP3080-UX module.
- 2 x user programmable mini-LEDs.
- Battery holder.
- JTAG footprint for programming using 6 pin Segger Jlink Adapter. https://www.segger.com/products/debug-probes/j-link/accessories/adapters/6-pin-needle-adapter/
- Plastic case and battery cover

3. Getting started with the kit

3.1. Software Developpement kit (SDK) content

Insight SiP provides an SDK for the ISP3080-UX available here:
https://github.com/insightsip

This SDK is a nRF52833 port of the Release 6.0C of the Qorvo/Decawave API software. For reference this software can be found on the DWM3000EVB page:
For more information see https://www.qorvo.com/products/p/DWM3000EVB#documents.

This SDK needs the Segger Embedded Studio (SES) IDE to build the projects. We recommend using SES version 5.42a as newer version might be incompatible with the nRF SDK. SES can be freely downloaded at https://www.segger.com/downloads/embedded-studio.

The ISP3080-UX SDK directory tree is shown below:

```
ISP3080-SDK
    ├─ TWR_Demo                    // Insight SiP's TWR demo
    │    └────application          // application SES project
    │    └────secure_bootloader    // bootloader SES project
    │    └────vault                // bootloader private key
    └─ DW3XXX_API_rev9p3
         └─ API
              ├─ Shared            // Qorvo's UWB chip driver
              ├─ Src               // Qorvo's code examples
              └─Build_Platforms
                   └─ nRF52833-DK  // SES project for Qorvo's examples
                        └─ sdk     // Adapted nRF SDK v17.0.2
```

3.2. Setup

To start working with the ISP3080-UX module, plug the test board (ISP3080-UX-TB) on the interface board (ISP130603) using the two mezzanine connectors.

Make sure that:

- J2 jumper is on ***USB*** position.
- J4 jumper is on ***REG*** position.
- All 3 ***SWD*** jumpers (***RST***, ***IO*** and ***CLK***) are present.

Plug the USB connector to your computer.

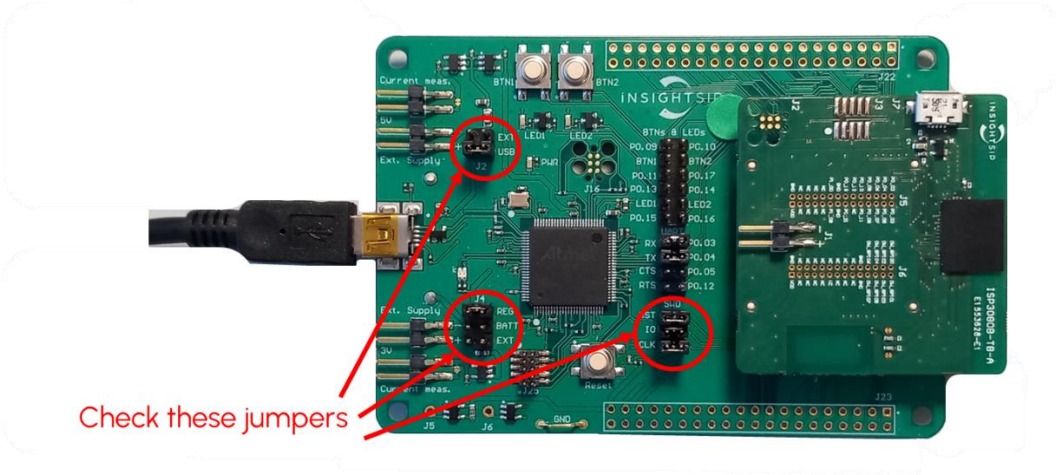


Figure 1: Setup on Interface Board

On the computer open ***Device Manager*** and check that the following devices appear in the list:

- ***J-Link driver*** in ***Universal Serial Bus Controllers.***
- ***J-Link CDC UART Port*** in ***Ports.***

If they do not appear install that J-Link drivers on the computer. They can be downloaded here: https://www.segger.com/downloads/jlink

3.3. Qorvo's basic examples

To use any of the Qorvo examples, open the dw3000_api.emProject file using SES. The file is located in "ISP3080-SDK"\DW3XXX_API_rev9p3\API\Build_Platforms\nRF52833-DK.

Edit the example_selection.h and uncomment the example to build. The file is located in "ISP3080-UWB"\Software\ISP3080-SDK\DW3XXX_API_rev9p3\API\Src

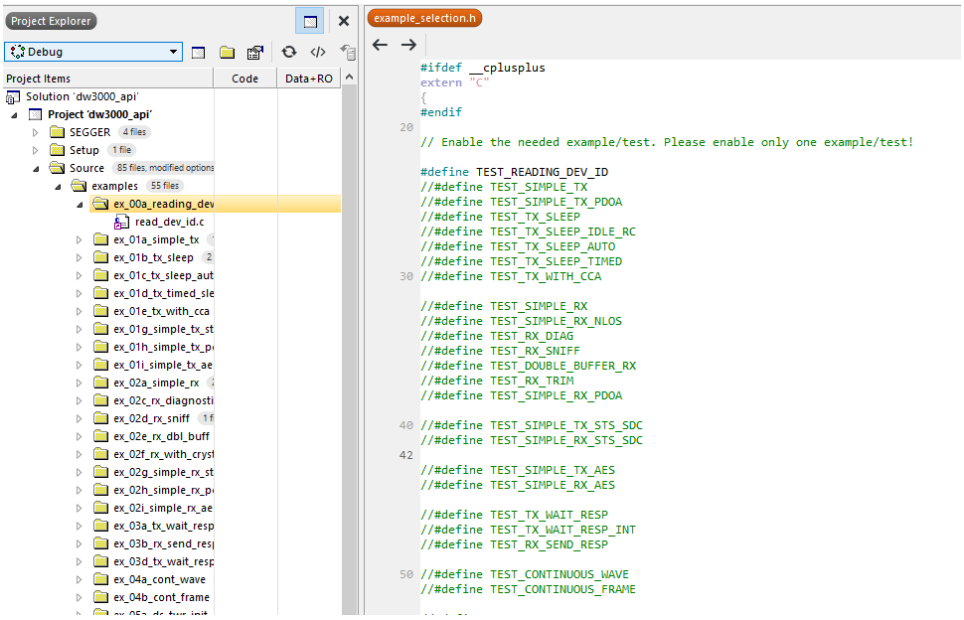


Figure 2: Example_selection.h

Make sure to uncomment only one line.

Click "Build and Run" to build the selected project and load it to the module.

3.4. TWR_Demo

3.4.1. description

The Two-way ranging (TWR) demonstrator folder is divided into three subfolders:

- Application folder.
- Secure bootloader: Used for Device Firmware Update (DFU) operations.
- Vault: Contains keys for bootloader .

The content of the application folder is:

Figure 3: TWR_Demo repertory content

It contains:

- **ble_services**: files containing all the custom BLE services used by the TWR_Demo.
- **config**: contains the sdk_config.h file.
- **drivers**: files containing all the "sensor" drivers.
- **module**: files containing high level features.
- **ses**: Contains the SES project.

Open the TWR_Demo/application/ses/TWR_Demo.emProject using SES to access the sub-projects:

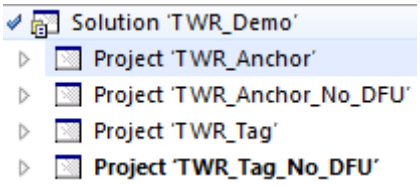


Figure 4: TWR_Demo project explorer

There are four different sub-projects available. Switch between sub-project is possible by simply right-clicking on the project and selecting "Set as active project" as shown below:

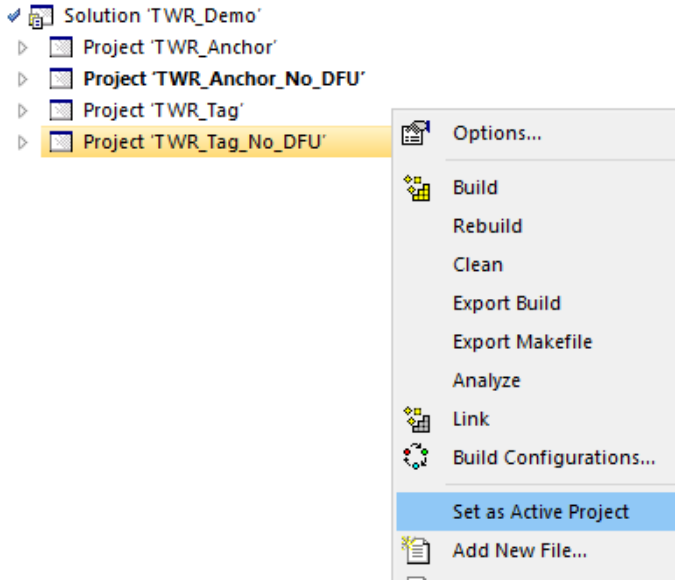


Figure 5: Project selection in SES

3.4.2. Using the "no DFU" version

To get started open the TWR_Demo/application/ses/TWR_Demo.emProject file using SES.
The SES project is divided into four sub-projects, the ones that is used in this chapter are:

- **TWR_Tag_No_DFU**: It is used to generate firmware that can be loaded on the tag. This version of the firmware is very power optimized which enable the use of coin cell battery as power source.
- **TWR_Anchor_No_DFU**: It is used to generate firmware that can be loaded on the anchor. This version of the firmware will enable UWB Reception most of the time thus is power hungry.

Select one of them.

Click "Build and Run" to build the selected project and directly load it to the module.

Note: It is recommended to erase.all the flash first before loading a new file.

3.4.3. Using the "DFU" version

In the DFU version the application is loaded from a smartphone/tablet to the module via BLE transfer. In this case a bootloader is flashed on the module instead of the application. The application can then be downloaded later to module using the adequate tool on the smartphone/tablet.

Step 1; Build the DFU package of the application.

To get started open the TWR_Demo/application/ses/TWR_Demo.emProject file using SES.
The SES project is divided into four sub-projects, the ones that is used in this chapter are:

- **TWR_Tag**: It is used to generate firmware that can be loaded on the tag. This version of the firmware is very power optimized which enable the use of coin cell battery as power source.
- **TWR_Anchor**: It is used to generate firmware that can be loaded on the anchor. This version of the firmware will enable UWB Reception most of the time thus is power hungry.

Select one of them.

Click "Build TWR_XXX" or press F7. In this case don't load it to the module.

Instead, we need to build a DFU package using nrfutil. Download it here:

https://www.nordicsemi.com/Products/Development-tools/nrf-util

Install the necessary tools using the command:

.\nrfutil install nrf5sdk-tools.

Build the DFU package using the command (it assumes that nrfutil.exe is located in the vault folder, if not adapt paths as necessary):

.\nrfutil.exe pkg generate --application ..\application\ses\Output\Release\Exe\TWR_Tag.hex --application-version-string "1.0.0" --hw-version 52 --sd-req 0x102 --key-file .\priv.pem TWR_Tag.zip

Or:

.\nrfutil.exe pkg generate --application ..\application\ses\Output\Release\Exe\TWR_Anchor.hex --application-version-string "1.0.0" --hw-version 52 --sd-req 0x102 --key-file .\priv.pem TWR_Anchor.zip

The generated package (TWR_Tag.zip) must now be copied to the smartphone/tablet.

Step 2; Build and load the the bootloader.

Open the TWR_Demo/secure_bootloader/ses/TWR_Demo.emProject file using SES and select the needed sub-project.

Note: The sub-project here is not important. It just add LEDs blink for the Tag version.

The bootloader uses the "micro_ecc" cryptography. The library is not present in this SDK.

To install it follow the steps:

- Download it at https://github.com/kmackay/micro-ecc.

- Extract it in "ISP3080-SDK"\DW3XXX_API_rev9p3\API\Build_Platforms\nRF52833-DK\sdk\external\micro-ecc.
- Run build_all.bat located in micro-ecc folder.

Now the secure_bootloader project can be built. Click "Build and Run" to build the selected project and directly load it to the module.

The module (Tag or Anchor) will start in DFU mode.

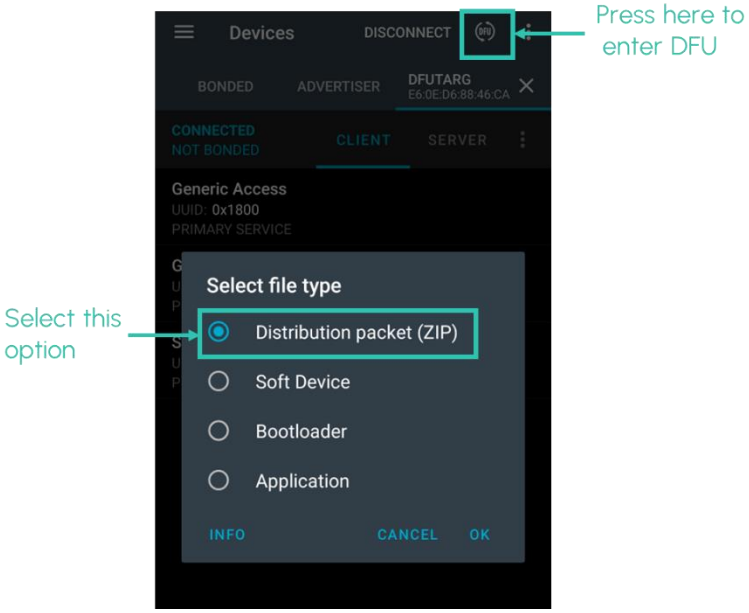
Step 3: Transfer over BLE

Install ***nRF Connect*** (https://play.google.com/store/apps/details?id=no.nordicsemi.android.mcp) on a smpartphone/tablet and open it.

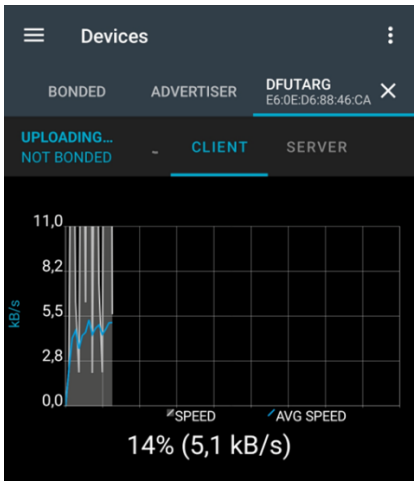
When no valid application is present on the module will advertise with the name "DfuTarg". Connect to it.

Figure 6: DFU advertisement

Press DFU icon at the top of the screen and select "Distribution packet (ZIP)".



Choose the previously built DFU package and transfer will automatically start.



The module will reset and start the updated application.

4. Two-Way Ranging (TWR) Demonstrator

4.1. Description

This paragraph shows you how to set up the Insight SiP's Range application between the Anchor and the Tag. The range is calculated using UWB and results are sent via the Bluetooth link to a smartphone/tablet.

In this demo, the Anchor and the Tag operate as a pair. The Tag the one initiating the ranging exchange and the Anchor is listening for the tag messages and responding to it. At the end of the ranging exchange the Tag board can then calculate the time of flight thus the range between the Tag and the Anchor.

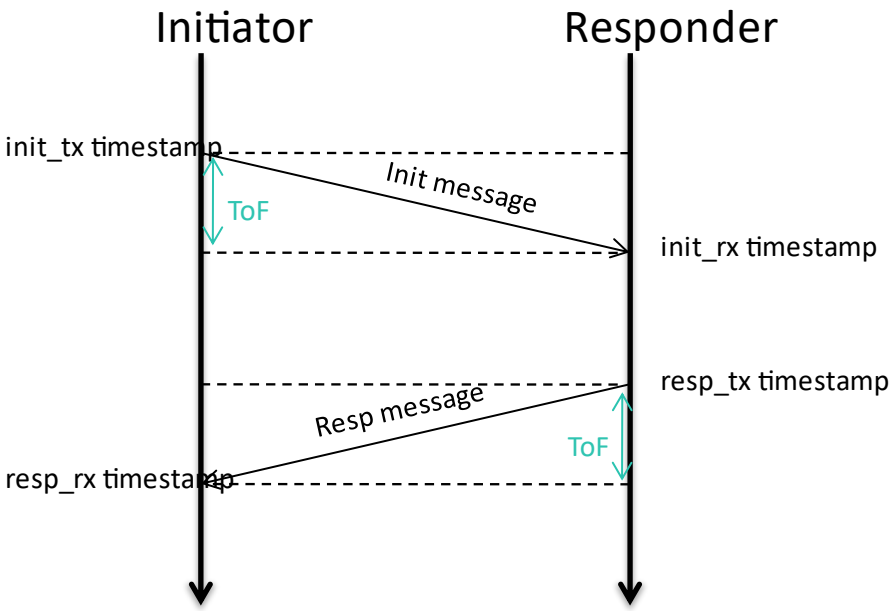


Figure 7: Two-Way Ranging

The initiator can calculate the time of flight (ToF) using the formula:

$$ToF = \frac{(resp_{rx} - init_{tx} - resp_{tx} + init_{rx})}{2}$$

Where:

- Resp_rx is the timestamp of the "resp" message reception.
- Init_tx is the timestamp of the "init" message transmission.
- Resp_tx is the timestamp of the "resp" message transmission.
- Init_rx is the timestamp of the "init" message reception.

The range is then:

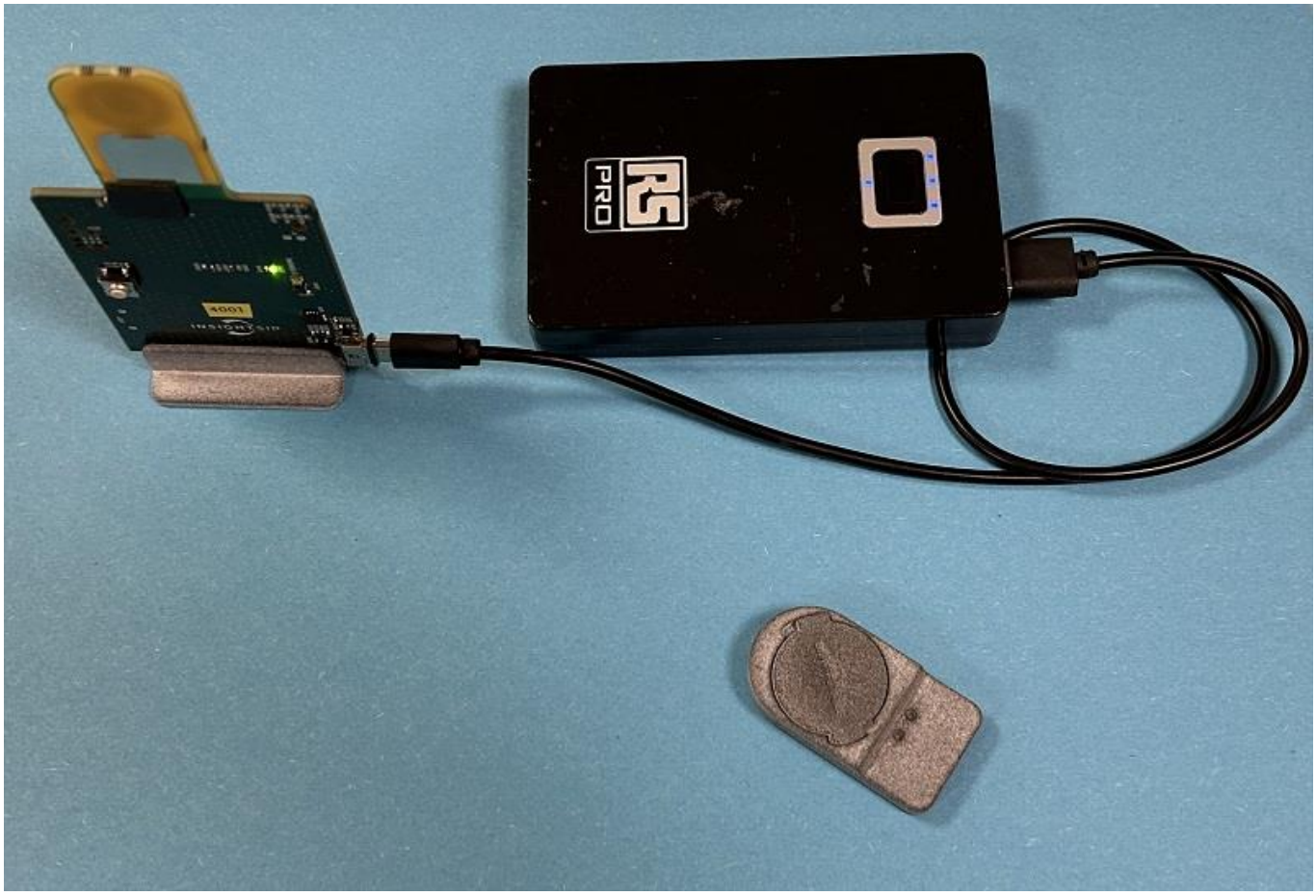
$$Range = ToF * SpeedOfLight$$

The demonstration requires the use of an Android device. The Android application is available on Google Play (https://play.google.com/store/apps/details?id=com.insightsip.demouwb)

On Google Play, search "uwb ranging app" and download the App. The android App is a demonstration App that is provided "as is" to demonstrate the module capabilities.

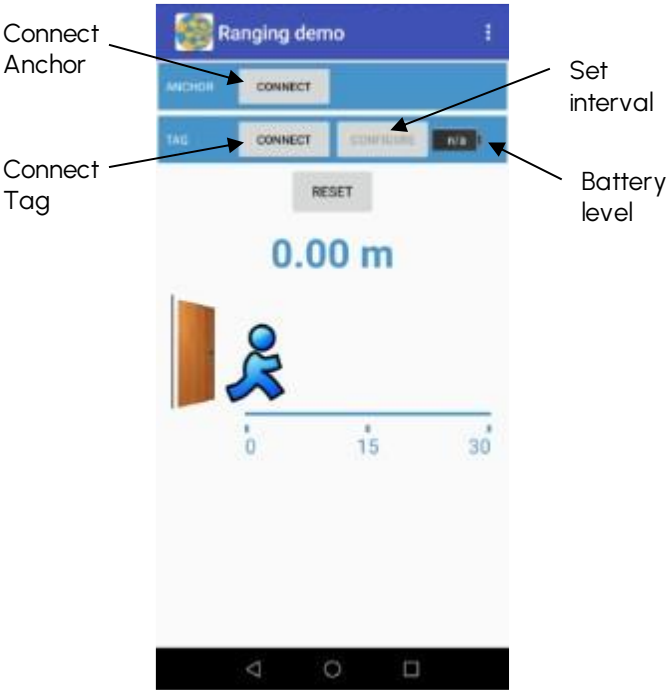
Both Tag and Anchor boards come pre-flashed with the TWR_Demo firmware.

4.2. Running the demo

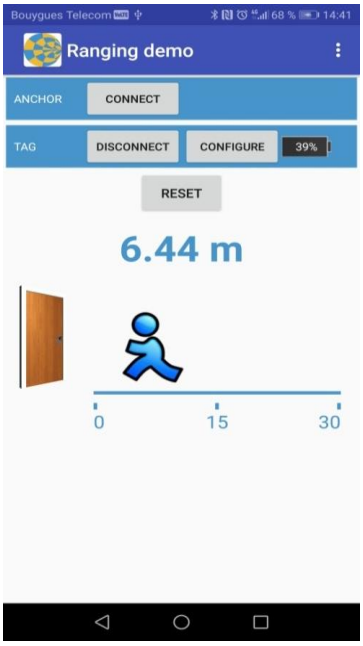


ISP3080-UX Ranging Demo Setup

1. Power up both boards.
   - Insert a CRC2032 coin cell battery in the Tag.
   - Plug the Anchor into a USB power supply.
2. The demo immediately starts TWR operations. Check activity using LEDs.
   - On Tag, the green LED blinks for each successful TWR operation and the red LED blinks if the TWR operation fails or timeouts.
   - On Anchor there 3 green LEDs.. One for power supply, one for UWB RX activity and one for TX activity.
3. Start "Ranging Demo" application on your Android, you can establish a BLE connection with the Tag, the Anchor or both by clicking the "connect" buttons.



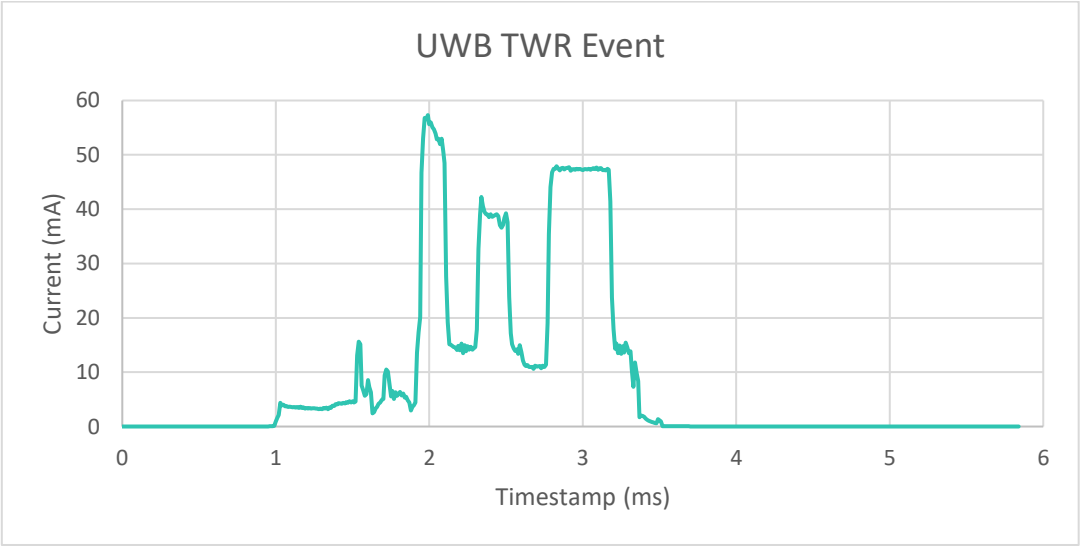
4. When BLE connection is established, the range between the Anchor and the Tag should be displayed on the App.



4.3. Tag current consumption

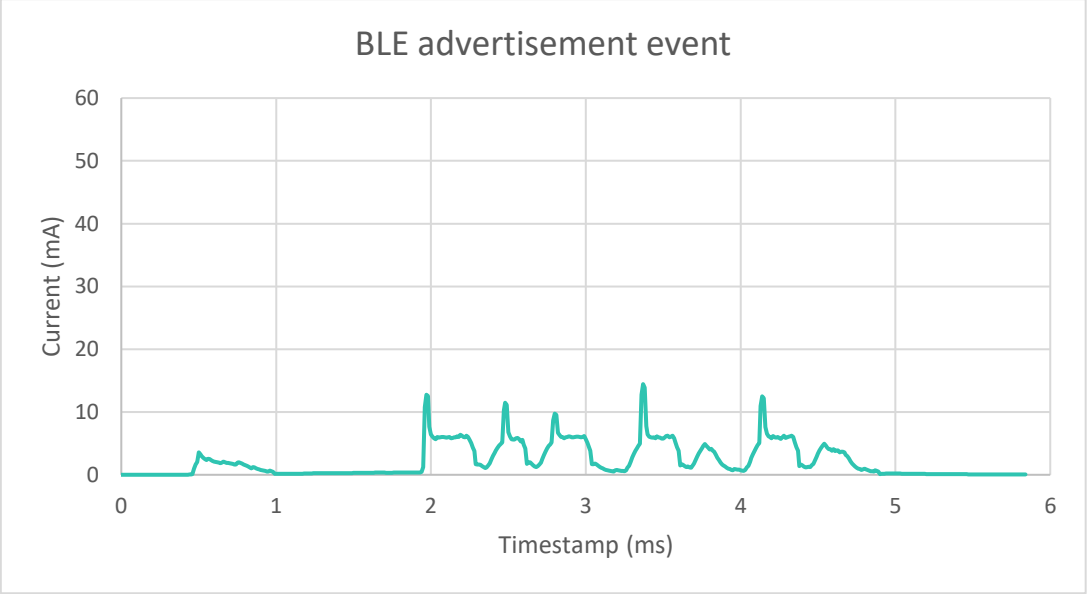
Since the Tag is powered by a CR2032 coin cell current should be minimized as much as possible to ensure good lifetime.

This is the current curve of a TWR event:



The charge used by this event is around 50uC

This is the current curve of a BLE advertisement event:



The charge used by this event is around 13uC

Assuming 3 TWR events per seconds, 3 BLE Advertisements per seconds and a sleep current of ~5uA, the average current consumption of the TAG is 194uA. With a CR2023 (210mAh) the lifetime is 1082 hours or 45 days.

Note: To protect the CR2032 from the current peaks during TWR event the Tag implements a loading circuit that store charges in a high value capacitor. There previous measurements were done by bypassing this circuit.