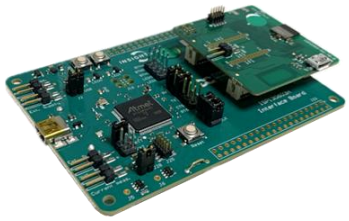
# ISP2053

## Application note AN220102

# Current Measurement with ISP2053-AX Evaluation Board



## Introduction

### Scope

This document gives information on how to use an Insight SiP Evaluation Board to measure the current consumption of the iSP2053-AX Bluetooth Low Energy module.

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## Document Revision History

| Revision | Date | Ref | Change Description |
|---|---|---|---|
| R0 | 17/02/2022 | jf | Initial release |
| R1 | 28/06/2022 | pd pg | Document layout update |
| R2 | 15/05.2025 | jf pg | Update test board generation |


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# 1. Recommended Documentation

The following Nordic Semiconductor document and Software Dev Kits are required.

### Nordic Semiconductor Documents

- nRF5340 Product Specification – make sure you have the most recent version.
- nRF5340 Development kit User Guide, hardware section should be partially ignored – Insight SiP development kit hardware replaces Nordic Semiconductor hardware.

To access documentation, information, go to:

- Official Nordic Semi website *http://www.nordicsemi.com*
- Documentation about nRF Connect SDK *https://developer.nordicsemi.com/nRF_Connect_SDK/doc/latest/nrf/index.html#*
- Ask any Nordic related question and get help *https://devzone.nordicsemi.com/questions*
- For any question, you can also open a case on the *http://www.nordicsemi.com*

### Insight SiP documents

- AN220102 App Note – this document.
- ISP2053 Module Data sheet – available on Insight SiP website.
- AN211001 Application note – Use of ISP2053-AX Module Evaluation Board


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# 2. Hardware Description

## 2.1. Evaluation Board Contents

This picture shows the Evaluation Board hardware content for the ISP2053-AX module:

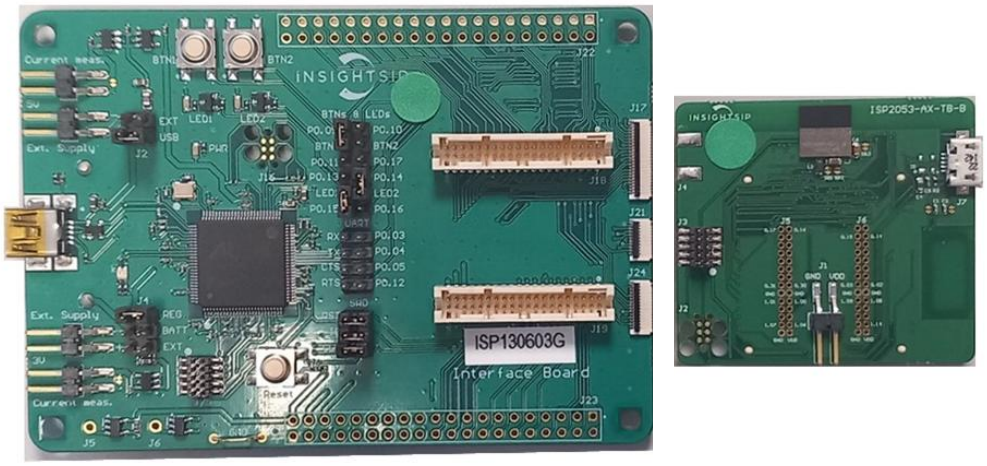
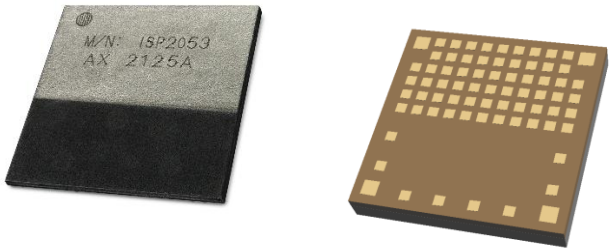



*Figure 1: Interface board (left) and test board (right)*

## 2.2. About Insight SiP ISP2053-AX Module

Based on nRF5340 Nordic Semiconductor wireless SoC with two Arm® Cortex®-M33 processors and advanced feature set, the ISP2053 module is ideally suited for LE Audio, professional lighting, advanced wearables, industrial, medical, and other complex IoT applications.






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Ultra-low power consumption and advanced power management enables battery lifetimes up to several years on a coin cell battery. Despite its exceedingly small size 8 x 8 x 1 mm, the module integrates decoupling capacitors, 32 MHz and 32.768 kHz crystals, load capacitors, DC-DC converters, RF matching circuit and antenna in addition to the wireless SoC. Combined with numerous Digital and Analog IOs, System Peripherals, high-speed SPI, QSPI, USB, up to 105 °C operating temperature, the ISP2053 is the most advanced fully certified 2.4 GHz low energy module available on the market.

The ISP2053 supports a large choice of wireless protocols:
- Bluetooth Low Energy Central, Peripheral, Observer and Broadcaster roles.
- Angle-of-arrival (AoA) and angle-of-departure (AoD) roles.
- LE Audio, high-throughput 2 Mbps, Advertising Extensions and Long Range.
- Mesh protocols like Bluetooth mesh, Thread and Zigbee that can be run concurrently with Bluetooth LE.
- NFC, ANT, 802.15.4 and 2.4 GHz proprietary protocols.

### 2.3. ISP2053-AX Test Board

Board dimensions are 47 x 42 mm². It includes:
- ISP2053-AX BLE module
- 2 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
- USB female connector
- Printed NFC antenna




*Figure 2: ISP2053-AX test board*

The Test Board electrical schematic is available from the website.


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## 2.4. ISP130603 Interface Board

### 2.4.1. Overview

ISP130603 is the application interface board that has dimensions of 100 x 80 mm². It provides the following features:

- Voltage adjustable Module Power Supply
- Segger J-Link Programming tool for all ISP modules
- Breakout headers that connect to the module GPIOs for simple prototyping of applications
- Current measurement amplifiers
- UART to PC COM Port adapter

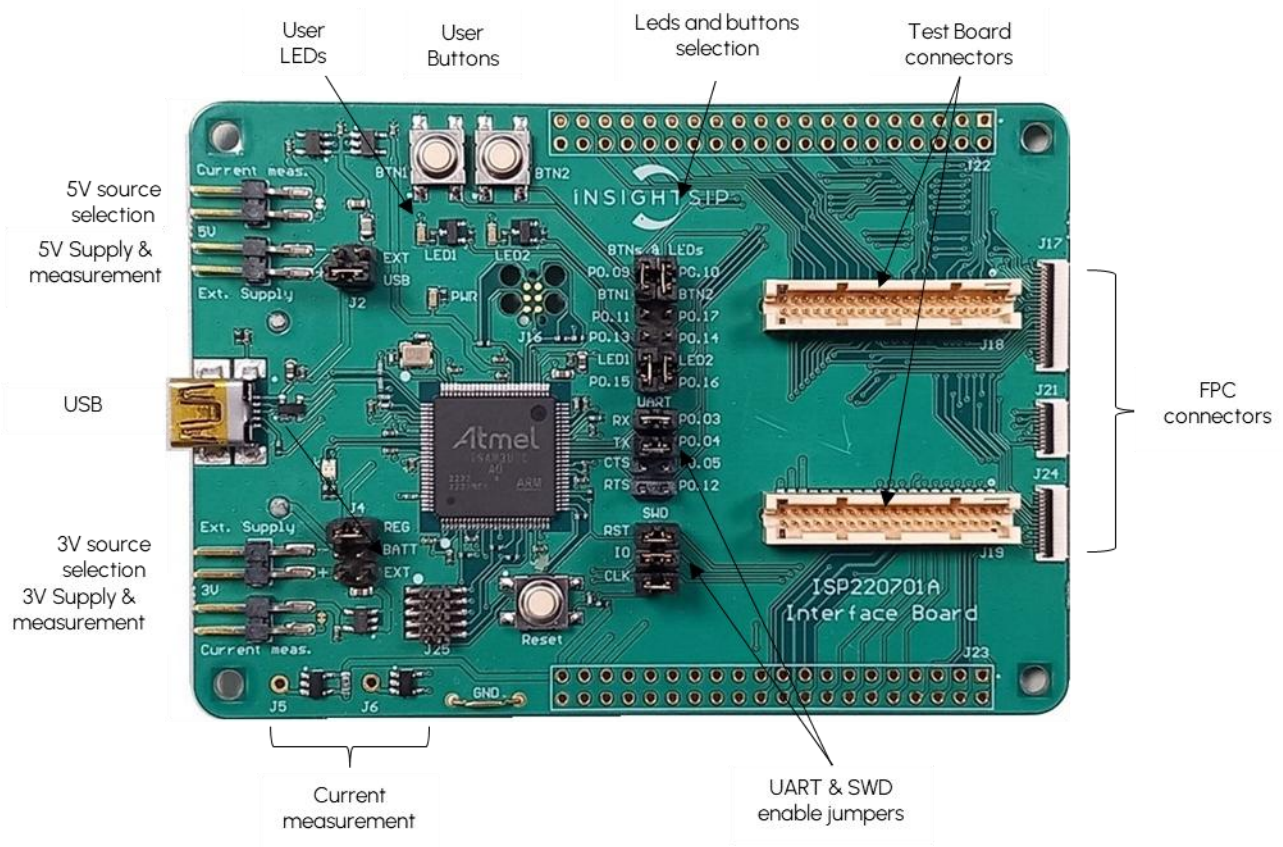



*Figure 3: Interface board overview*


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### 2.4.2. Electrical Schematic

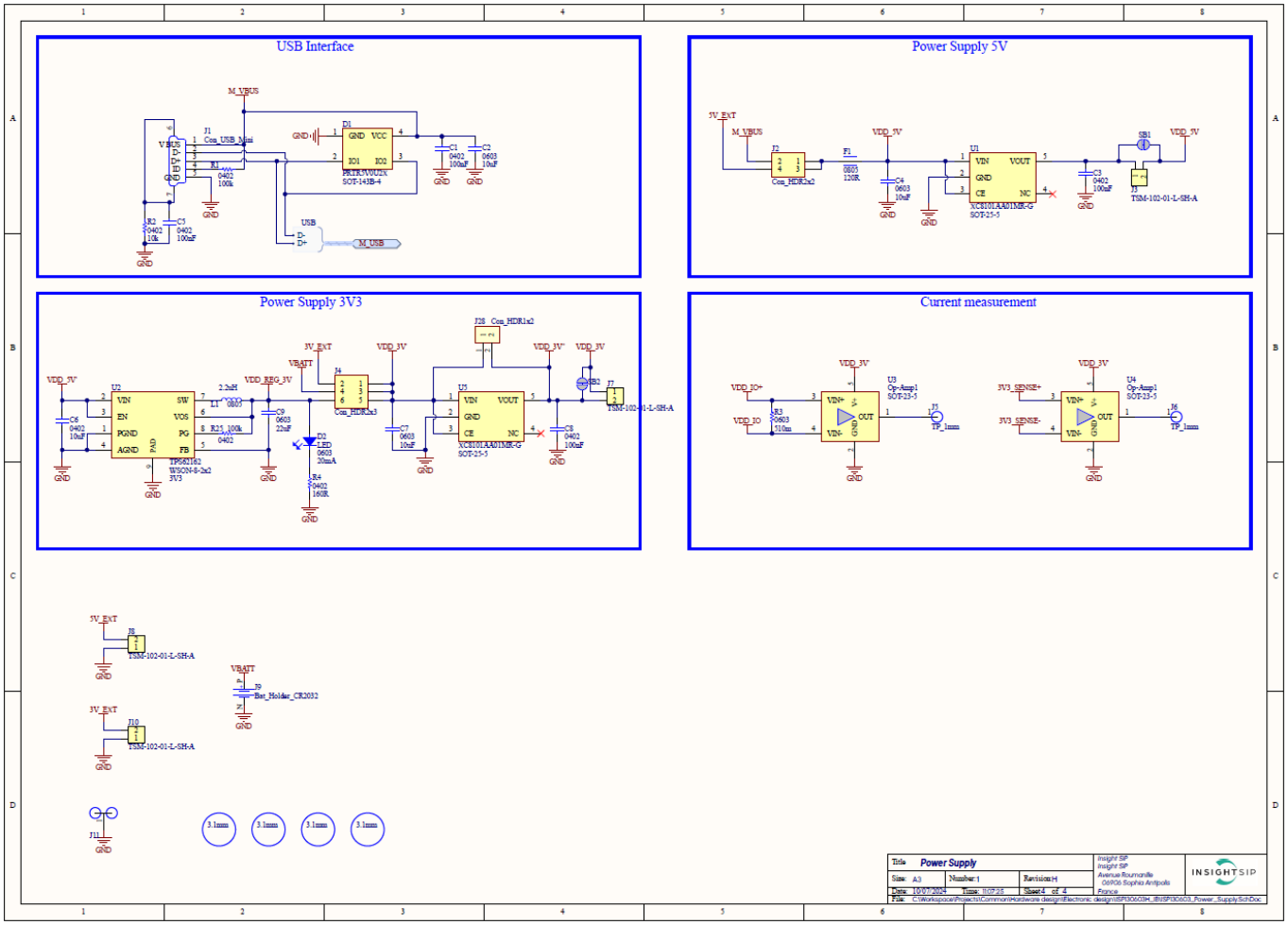



*Figure 4: Power supply*



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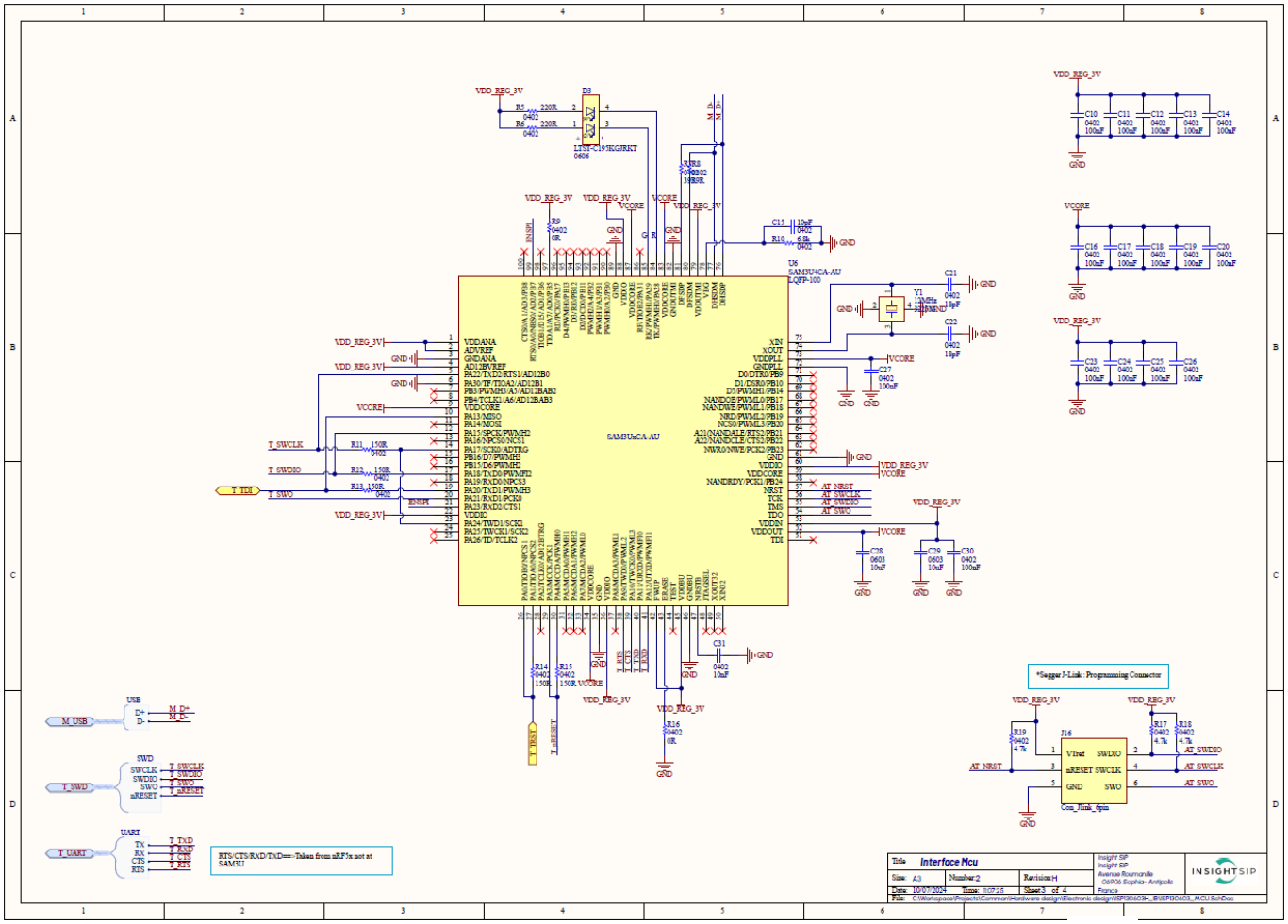



*Figure 5: Interface MCU*



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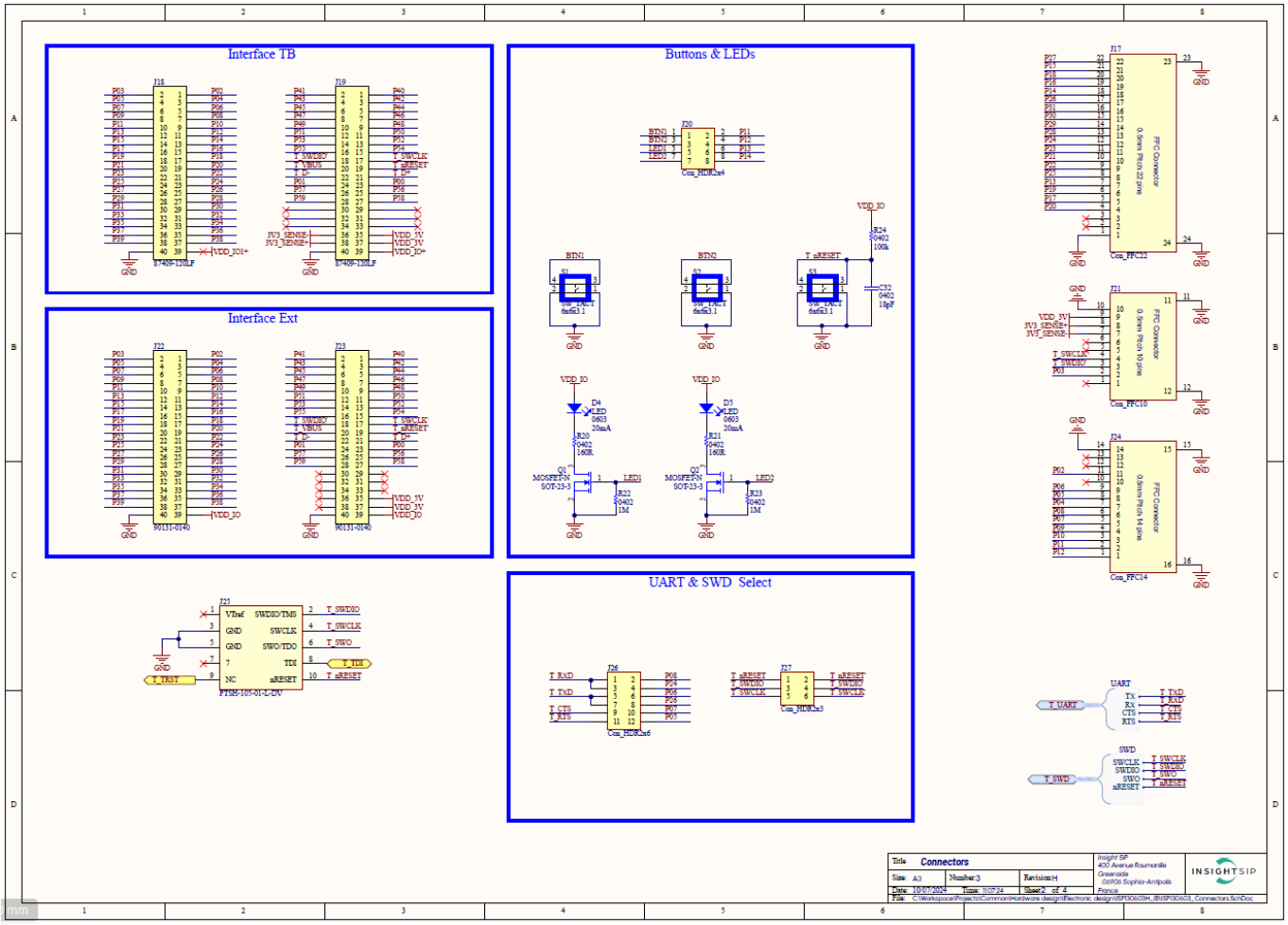



*Figure 6: Connectors*



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# 3. Current Measurement

This section describes the use of the interface board to make dynamic current measurements. To make such a current measurement on an ISP BLE module, you need the appropriate test board, an ISP130603 Interface Board, an oscilloscope, and a high impedance scope probe. The current measurement uses an INA195 OP Amplifier and resistors.

## 3.1. Measurement principle

Each current measurement uses an INA195 OP Amplifier and a resistor to convert current into voltage. The Interface Board and the Test Board have 0.51 Ohm resistors that are used to measure current. The voltage across these resistors is fed back to the Interface Board as inputs to the INA195 Op Amp. Since the gain of the INA195 Op amplifier is 100, this is equivalent to measuring current through a 51 Ohm resistor.

There are 2 test points used to measure current:
- J5 that gives the current flowing through user LEDs and/or additional loads added by the customer.
- J6 that gives the current flowing through the BLE Module.

## 3.2. Current Measurement Setup

1. Connect the USB cable from the Interface Board ISP130603 to your computer.
2. Plug the Test Board on the ISP130603 Interface Board.
3. Connect the oscilloscope to scope probe.

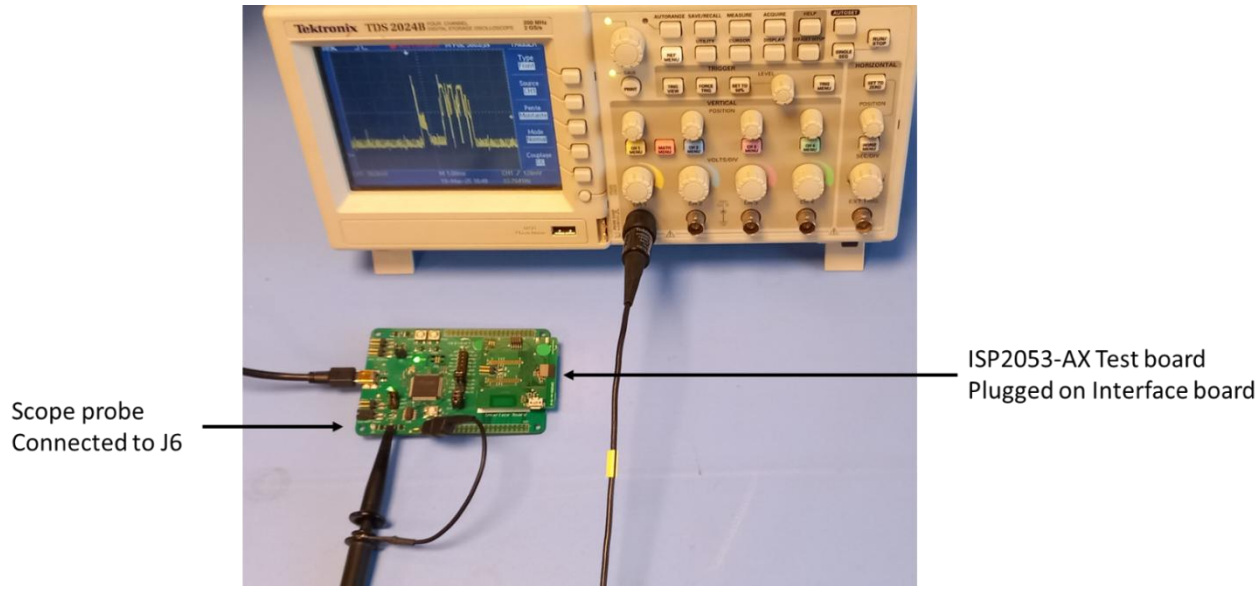


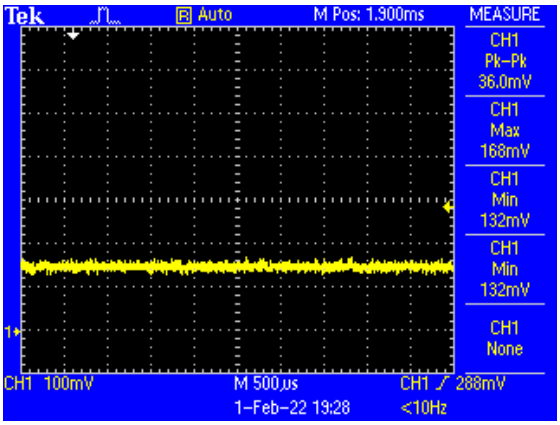

*Figure 7: Setup with scope probe*


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# 4. Example using Heart Rate sample

## 4.1. Measure the setup offset

The INA195 has a DC offset when measuring zero voltage. To remove the effect of this offset measure the voltage with only the interface board (Unplug the test board from the Interface board), this value will be subtracted to all measurement.




We measure an average voltage of 150mV. Note that this offset will vary from an interface board to another.

## 4.2. Measure total Current with DCDCs enabled

The BLE Heart Rate sample is used in this example. With this simple example it is easy to observe the current consumption of all stages of a BLE peripheral device (Sleep, Advertising, connected).
Refer to Application note "AN211001 Use of ISP2053 evaluation board" to get started with the software environment.

1. Using the Toolchain Manager start open a bash command prompt.

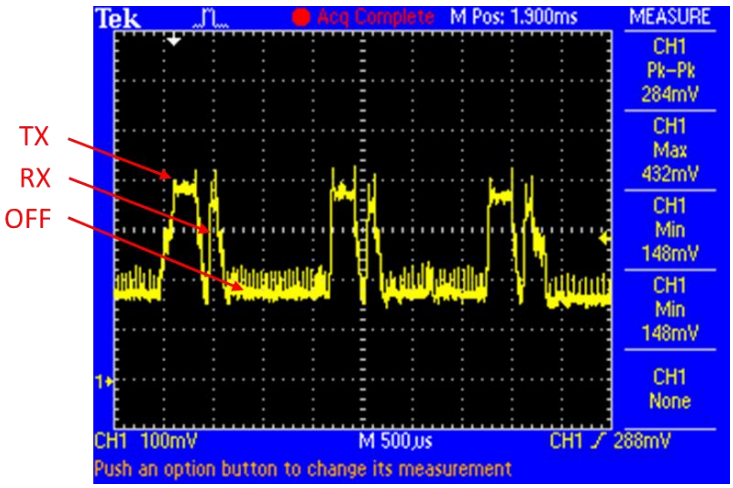
2. Go to the Heart rate sample directory and build the project. As the ISP2053 module integrates the nRF4340 SoC we can use nrf5340dk_nrf5340_cpuapp board. Therefore, we can build the project using the following commands:
   ```
   cd zephyr/samples/bluetooth/peripheral_hr
   west build -b nrf5340dk_nrf5340_cpuapp
   ```

3. By default, nRF Connect SDK projects enable logging via UART. This will cause an increased current consumption of few milliamps. Disable the feature by opening the config menu and unselect "Serial Drivers" located in "Device Drivers". We can enter the config menu with the following command:
   ```
   west build -t guiconfig
   ```


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4. Flash the module with:
   west flash

The scope probe is connected to J16 on ISP130603 Interface Board. We can observe an advertising event:




We have:

- Transmit current: $Itx = \frac{Vtx - Voffset}{51} = \frac{(0.384 - 0.15)}{51} = 0.0046\ A = 4.6\ mA$
- Receive current: $Irx = \frac{(Vrx - Voffset)}{51} = \frac{0.35 - 0.15}{51} = 0.0039\ A = 3.9\ mA$

Notice how the floor current is "noisy", this is due to the switching nature of the DCDCs. Depending on the voltage of your power supply, enabling DCDCs will reduce the current consumption.

### 4.3. Measure total Current with DCDCs disabled

To disable DCDCs open the config menu by typing the following command:
   west build -t guiconfig

In board option unselect:

- "Enable application CPU DCDC Converter"
- "Enable Network CPU DCDC Converter"

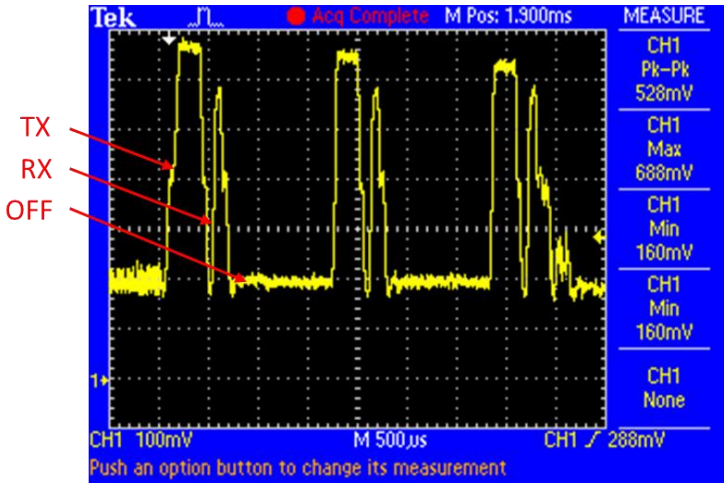

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Save and close the menu.

Build and flash the module with:

```
west flash
```

The measurement obtained is shown below:




We have:

- Transmit current: $Itx = \frac{Vtx - Voffset}{51} = \frac{(0.668 - 0.15)}{51} = 0.0101\ A = 10.1\ mA$
- Receive current: $Irx = \frac{(Vrx - Voffset)}{51} = \frac{0.572 - 0.15}{51} = 0.0083\ A = 8.3\ mA$


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