EU036 Multisensorboard

Software User's Guide

Contents

1. Overview

In this document some demos, based on the Multisensorboard, will be shown.

The purpose is to demonstrate several ways to distribute the sensors' data through wired and wireless protocols:

1. Demo1: data sent to ASi5 board.
2. Demo2A: data sent to the cloud, using the ethernet connection available on the EK-RA6M3 board.
3. Demo2B: data shown on a display and transmitted via BLE using a SK-S7G2 board.
4. Demo3: data transmitted via BLE using a RL78 BLE PMOD.
5. Demo4: data sent to the cloud, using a WiFi connection with an EK-RA6M3 board and a WINC1500 PMOD module.

For the Multisensorboard the RA FSP platform is used, while the other boards also make use of the Synergy SSP and the RL78 BLE Framework.

For more detailed information, refer also to the Hardware User's Guide [1] and the Quick Start Guide [2].

1.1 Prerequisites

This guide assumes you have some experience with the Renesas e^2 studio ISDE together with the Flexible Software Package (FSP) and the Synergy Software Package (SSP). Before you perform the procedure in this application note, follow the procedures in the FSP and SSP User Manuals to build and run the **Blinky** projects. Doing so enables you to become familiar with the e^2 studio and the software packages, to ensure that the debug connection to your board functions properly. In addition, this application note assumes you have some knowledge on BLE and its communication protocols.

1.2 Tools and software versions required

- e^2 studio ISDE v7.8.0 or greater
- Flexible Software Package (FSP) 1.0.0 using the GCC ARM Embedded Toolchain 9.2.1.20191025
- RA WiFi WINC1500 pack version 1.0.0
- Synergy Software Package (SSP) 1.7.5 using the GCC ARM Embedded Toolchain 7.2.1.20170904
- Segger J-Link USB driver
- IDTSense (Android App and iOS, see section 5.2)
- (optional – needs NDA) ZMOD4410 Indoor Air Quality eCO2 Firmware ver. 20200205
- (optional – needs NDA) ZMOD4510 Outdoor Air Quality Firmware ver. 20191014

1.3 Boards and modules required

- Y-MULTISENSORBOARD1
- SK-S7G2 (https://www.renesas.com/us/en/products/synergy/hardware/kits/sk-s7g2.html)
- EK-RA6M3 (https://www.renesas.com/kr/en/products/software-tools/boards-and-kits/eval-kits/ek-ra6m3.html)
- WINC1500 PMOD (http://www.reloc.it/products/pmod-wi-fi-atwinc1500/)
- RL78 BLE PMOD (https://www.renesas.com/kr/en/products/software-tools/boards-and-kits/eval-kits/rl78-g1d-ble-module-expansion-board.html)

2. Integration of the external ZMOD libraries

The ZMOD4410 and ZMOD4510 air quality sensors are distributed together with a closed source library that provides the interface API for getting the measures from the sensors.

These libraries require to sign an NDA (Non-Disclosure Agreement) with Renesas so they are not included into the projects. Contact the **Sales Support** (https://idt.na4.teamsupport.com/createticket) on the ZMOD product page for more information:

- https://www.idt.com/us/en/products/sensor-products/gas-sensors/zmod4410-indoor-air-quality-sensor-platform

- https://www.idt.com/us/en/products/sensor-products/gas-sensors/zmod4510-outdoor-air-quality-sensor-platform

In this section the integration of ZMOD libraries is explained. <u>The projects are distributed with these sensors disabled as default</u>.

2.1 ZMOD4410

In Figure 1 all the files required for the ZMOD4410 drivers are listed. The zmod4410 folder is located, in each project of the Multisensorboard, at this address:

   `<project_name>\src\drivers\zmod4410`
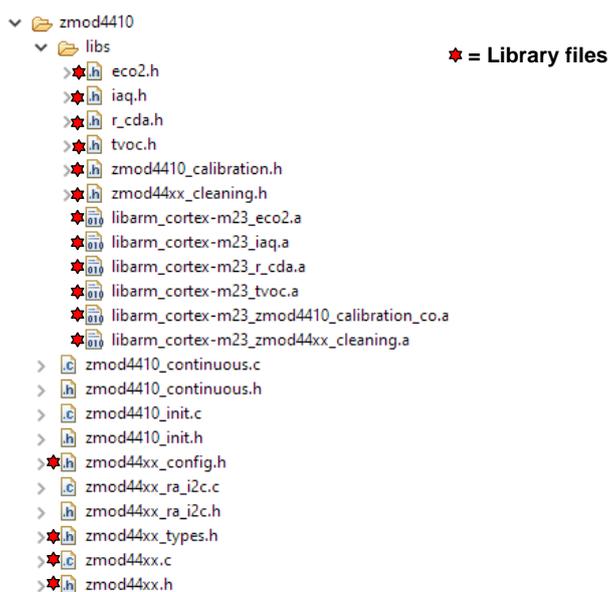
Figure 1: ZMOD4410's driver folder with the Library files under NDA indicated.

The files indicated with a red star are part of the library under NDA and must be copied from the downloaded archive "`IDT_ZMOD4410-Air-Quality-eCO2-Firmware_SWR_20200205.zip`". In details:

1. "eco2.h" from the folder
   "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\eco2_arm"

2. "iaq.h" from the folder
   "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\iaq_arm"

3. "r_cda.h" from the folder
   "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\r_cda_arm"

4. "tvoc.h" from the folder
   "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\tvoc_arm"

5. "zmod4410_calibration.h" from the folder
    "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\zmod4410_calibration_co_arm"

6. "zmod44xx_cleaning.h" from the folder
    "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\zmod44xx_cleaning_arm"

7. "libarm_cortex-m23_eco2.a"[1] from the folder
    "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\eco2_arm\lib"

8. "libarm_cortex-m23_iaq.a"[1] from the folder
    "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\iaq_arm\lib"

9. "libarm_cortex-m23_r_cda.a"[1] from the folder
    "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\r_cda_arm\lib"

10. "libarm_cortex-m23_tvoc.a"[1] from the folder
    "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\tvoc_arm\lib"

11. "libarm_cortex-m23_ zmod4410_calibration_co.a"[1] from the folder
    "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\zmod4410_calibration_co_arm\lib"

12. "libarm_cortex-m23_ zmod44xx_cleaning.a"[1] from the folder
    "ZMOD4410-standard-firmware\gas-algorithm-libraries\ARM\zmod44xx_cleaning_arm\lib"

13. "zmod_44xx_config.h" from the folder
    "ZMOD4410-standard-firmware\zmod44xx-api-example_1.5.0\src"

14. "zmod_44xx_types.h" from the folder
    "ZMOD4410-standard-firmware\zmod44xx-api-example_1.5.0\src"

15. "zmod_44xx.c" from the folder
    "ZMOD4410-standard-firmware\zmod44xx-api-example_1.5.0\src"

16. "zmod_44xx.h" from the folder
    "ZMOD4410-standard-firmware\zmod44xx-api-example_1.5.0\src"

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[1] Rename the library extension from ".lib" to ".a"

Once copied all the files, the libraries must be included in the project as shown in Figure 2.
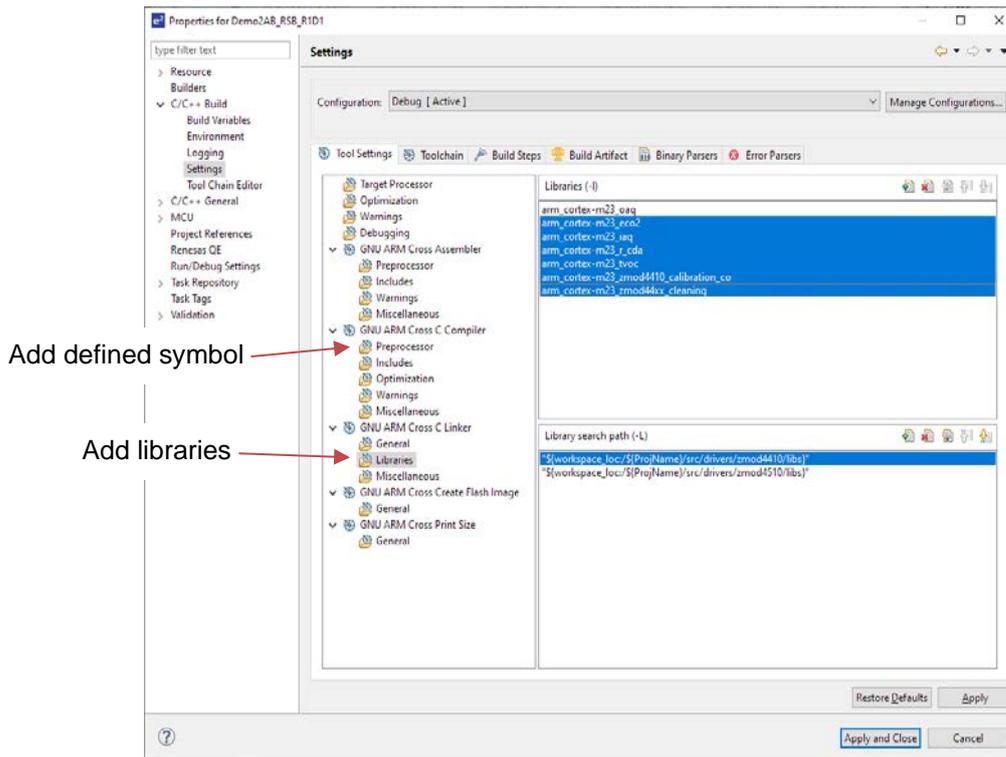
Figure 2: ZMOD4410 compiled libraries added to the project (the highlighted only).

Lastly, the ZMOD4410 driver must be enabled defining a new symbol "ENABLE_ZMOD4410" in the "GNU ARM Cross C Compiler/Preprocessor" project settings, as indicated in Figure 2.

2.2 ZMOD4510

Similarly, to the ZMOD4410, in Figure 3 all the files required for the ZMOD4510 drivers are listed. The zmod4510 folder is located, in each project of the Multisensorboard, at this address:

<project_name>\src\drivers\zmod4510
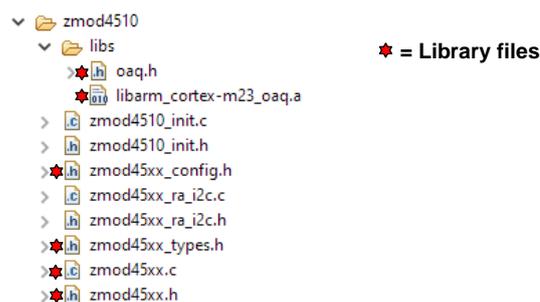
Figure 3: ZMOD4510's driver folder with the Library files under NDA indicated.

The files indicated with a red star are part of the library under NDA and must be copied from the downloaded archive "IDT_ZMOD4510-OAQ-Firmware_SWR_20191014.zip". In details:

1. "oaq.h" from the folder
   "ZMOD4510-oaq-firmware\oaq-libraries_4.0.0\ARM\oaq_arm"

2. "libarm_cortex-m23_oaq.a"[2] from the folder
   "ZMOD4510-oaq-firmware\oaq-libraries_4.0.0\ARM\oaq_arm\lib"

3. "zmod_45xx_config.h" from the folder
   "ZMOD4510-oaq-firmware\ZMOD45xx_example_2.0.0\src"

4. "zmod_45xx_types.h" from the folder
   "ZMOD4510-oaq-firmware\ZMOD45xx_example_2.0.0\src"

5. "zmod_45xx.c" from the folder
   "ZMOD4510-oaq-firmware\ZMOD45xx_example_2.0.0\src"

6. "zmod_45xx.h" from the folder
   "ZMOD4510-oaq-firmware\ZMOD45xx_example_2.0.0\src"

Once copied all the files, the libraries must be included in the project as shown in Figure 4 and, lastly, the ZMOD4510 driver must be enabled defining a new symbol "ENABLE_ZMOD4510" in the "GNU ARM Cross C Compiler/Preprocessor" project settings, as indicated in Figure 4.
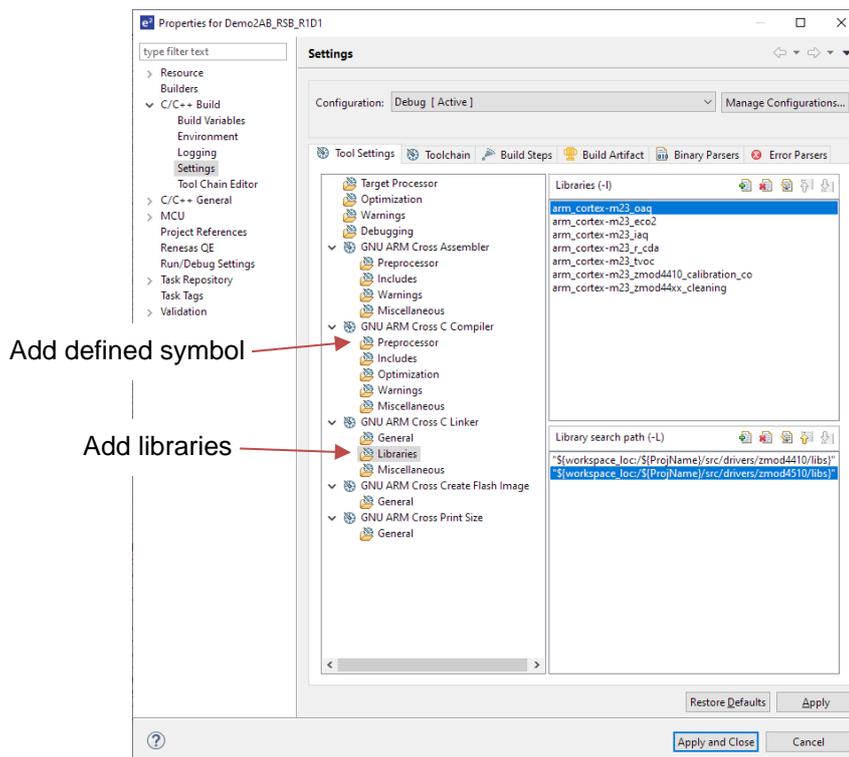
Figure 4: ZMOD4510 compiled libraries added to the project (the highlighted only).

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[2] Rename the library extension from ".lib" to ".a"

3.   Demo1 – Multisensorboard + Y-ASI4U-V5-DB (ASi-5 Slave)

VERY IMPORTANT: Remove jumpers J27 and J9 before connecting the two boards.

The goal of this demo is to use the Multisensorboard in combination with the Y-ASI4U-V5-DB in order to easily evaluate the new industrial fieldbus protocol: **Actuator Sensor Interface 5 (ASi-5).**

Both **Simple and Complex Slave** configurations are supported by the Multisensorboard and are described in the following document:

   -    Y-ASI4U-V5-DB_software_application_note.pdf

This document also describes how to build a minimalist ASi-5 Master/Slave network in order to transfer the sensor's data from the Multisensorboard to the ASi-5 Master.

Connect the Y-ASI4U-V5-DB with the Multisensorboard using the custom parallel provided cable. Additionally, make sure to connect the longest wire of the cable to pin 4 of the connector J39.

Figure 5: Demo1 connections.

The project to load on the boards is "***Demo1_RSB_ASI5***". The Y-ASI4U-V5-DB software configuration is described in the Y-ASI4U-V5-DB_software_application_note.pdf.

4. Demo2A – Multisensorboard + EK-RA6M3 for Cloud by ethernet

NOTE: The default jumper configuration [1] is used for this demo.

Aim of this demo is to send some sensors data to the IO Adafruit cloud using the ethernet connection available on the EK-RA6M3 board.
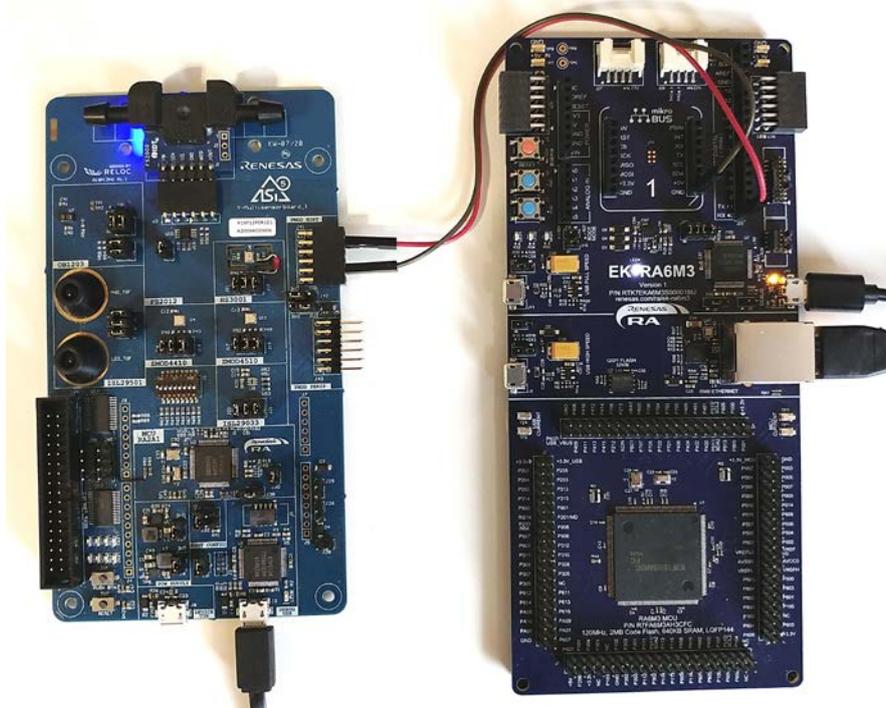
Figure 6: Demo2A connections.

Because of the IO Adafruit Free account limitation, only 4 values (temperature, humidity, ambient light and proximity) are sent each 10 seconds. Moreover, it is possible to control LED1 on the EK-RA6M3 board for testing the subscription channel from the cloud. The result is shown in Figure 7.
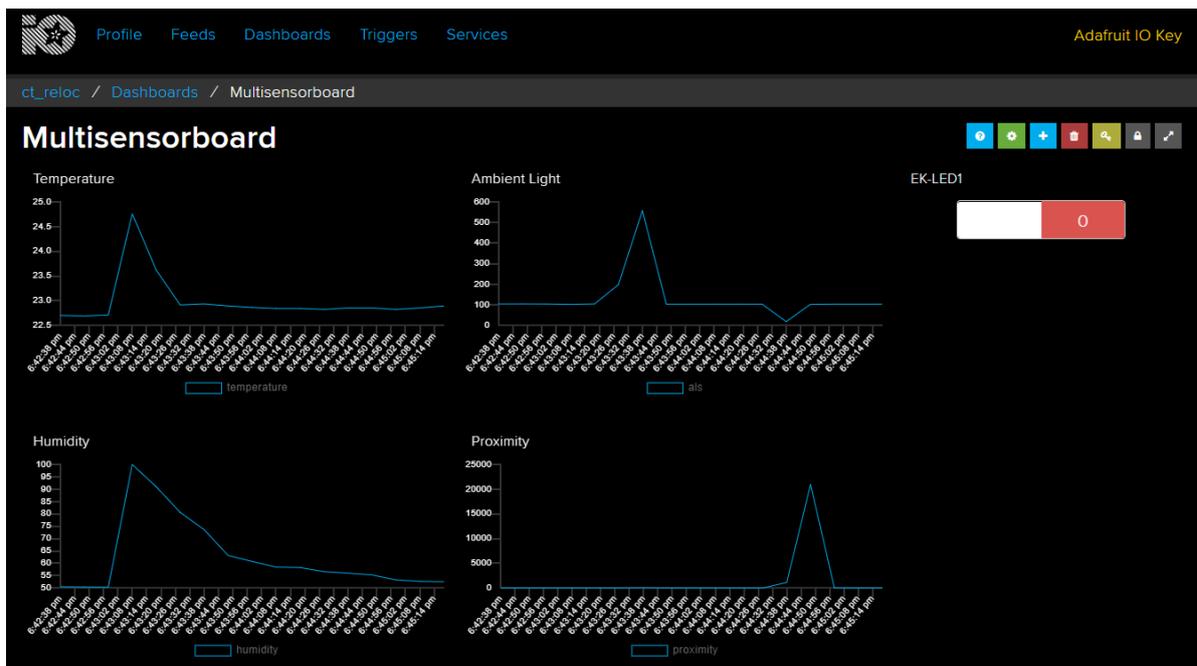
Figure 7: Demo2A Dashboard on the IO Adafruit cloud.

The different sensors measurements are collected from the Multisensorboard and sent through a UART bus to the EK-RA6M3. Those values are written in an internal database on the RA6M3 that keeps an image of the latest data.
Asynchronously, the measures are sent to a MQTT server (**IO Adafruit** in this example) that allows to display and register the trend.

On the ethernet port a DHCP client is enabled so no network configurations are required.
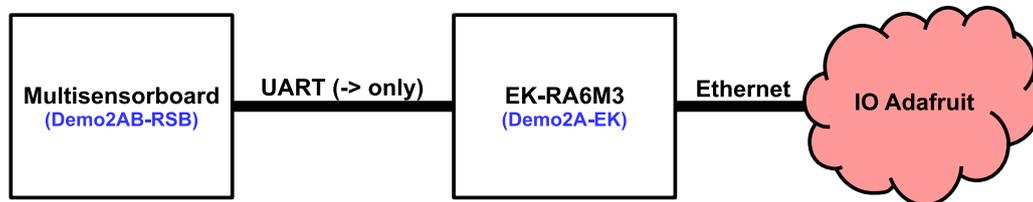
Figure 8: Demo2A high-level block diagram.

The two projects to load on the boards are:

1. "***Demo2AB_RSB_R1D1***" on the Multisensorboard.

2. "***Demo2A_EKRA6M3_ETH_IOADA***" on the EK-RA6M3. This project must be modified in order to add the IO Adafruit account information. In the next sections the complete procedure will be explained.

4.1 IO Adafruit account creation and configuration

1. Open the IO Adafruit webpage https://io.adafruit.com/ and sign up a new account.

2. Create Feeds (Figure 9): Click on the Feeds menu, create 5 new Feeds and name it as:

    a. als

    b. humidity

    c. proximity

    d. temperature

    e. EK-LED1

3. Create a Dashboard (Figure 10): Click on the Dashboard menu and create a new dashboard.

4. Configure the Dashboard:

    a. Create 4 Line Graphs linked to the first 4 feeds created above (Figure 11, Figure 12 and Figure 14).

    b. Create a Toggle Button linked to the EK-LED1 feed and configure it as shown in Figure 14.

    c. It is possible to rearrange the objects on the dashboard (Figure 13).
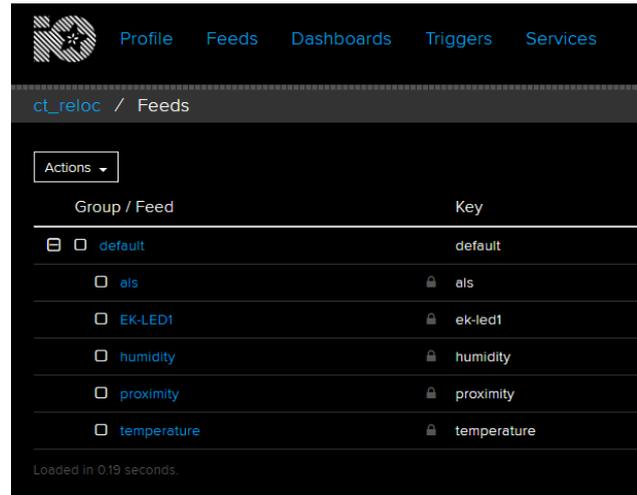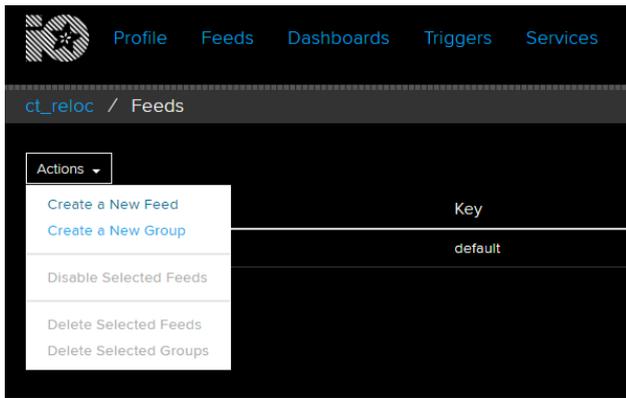
Figure 9: Create feeds.
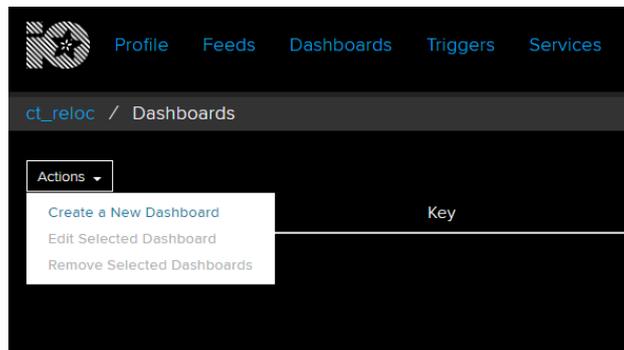
Figure 10: Create a new Dashboard.
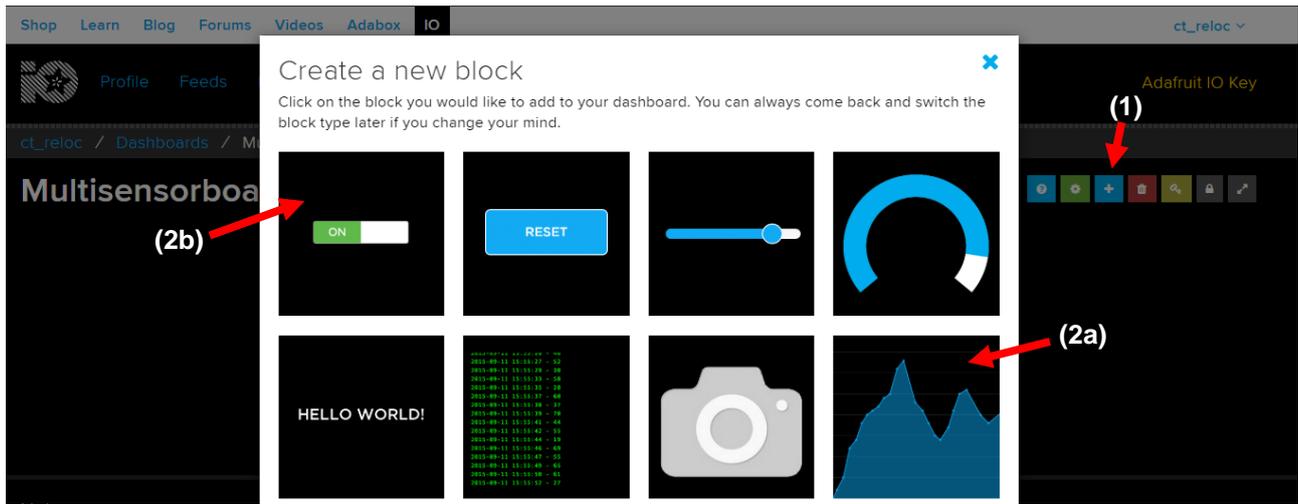
Figure 11: Create a new Line Chart in the Dashboard.
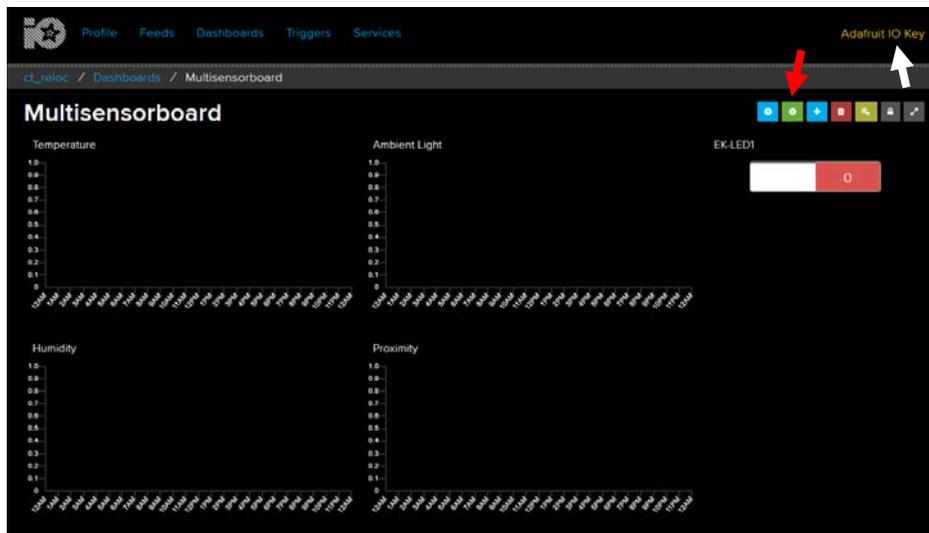
Figure 13: Complete Dashboard view.
The red arrow indicates the configuration button used to reorganize the blocks.
The white arrow indicates the key menu location.
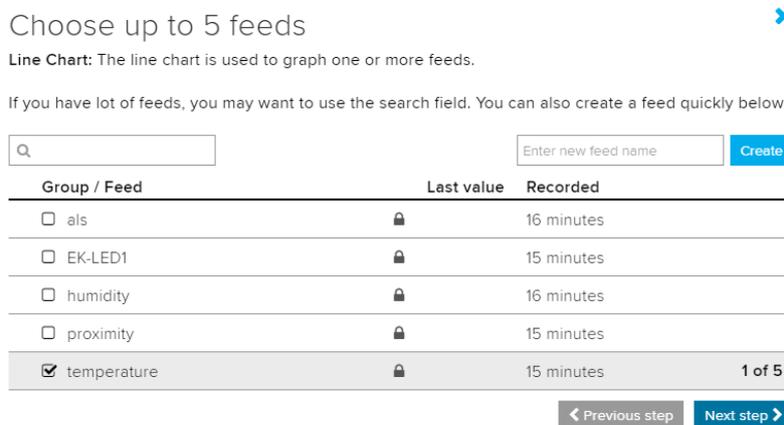
Figure 12: Select the Feed to display on the Line Chart.
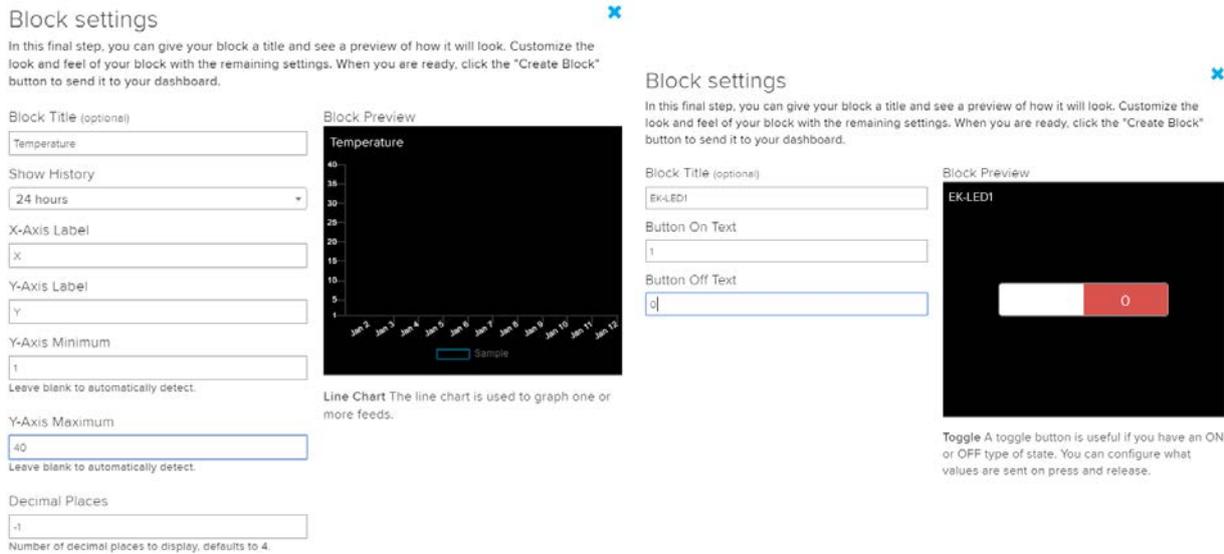
Figure 14: Line Chart and Toggle Button settings.

4.2   Cloud connection configuration

Only two values must be configured for the IO Adafruit connection:

1. The username.
2. The Adafruit IO Key.

It is possible to find them clicking on the Adafruit IO Key button indicated by the white arrow in Figure 13.

This information must be copied in the file "new_thread0_entry.c". See Figure 15.

Figure 15: IO Adafruit connection configuration.

4.3   Boards connection

The UART bus only requires a single connection (in addition to GND) between the two boards.

On the EK-RA6M3 board, the RX point is on pin 1 of J23 on the Arduino connector.

On the Multisensorboard, the TX pin is available in different locations, the user can choose the most convenient one:

- Pin 7 of J6 on the Arduino connector
- Pin 2 of J41 on the PMOD Host port
- Pin 3 of J43 on the PMOD Peripheral port

5.   Demo2B – Multisensorboard + SK-S7G2 TFT and RL78 BLE

VERY IMPORTANT: Carefully read the section 5.1 before connecting the two boards.

In this demo, all the sensors' measurements are displayed on the SK-S7G2 LCD display. Moreover, the ZMOD4410 TVOC and eCO2 are sent over BLE Advertising data. With the IDTSense app it is possible to read and plot the values, refer to section 5.2 for more information.
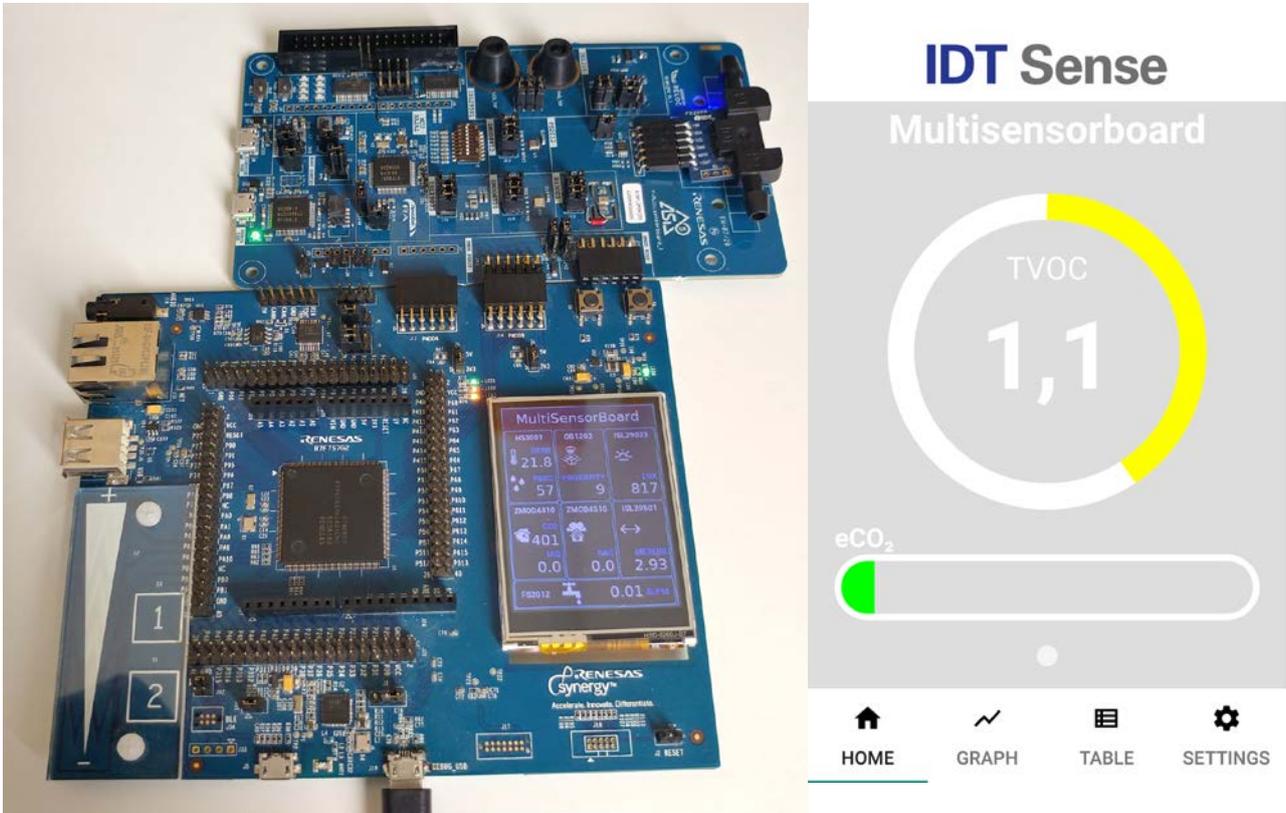
Figure 16: Complete Demo2B running and IDT Sense app.

The different sensors measurements are collected from the Multisensorboard and sent via the UART bus to the SK-S7G2 using the PMOD ports. Those measurements are written in an internal database that keeps an image of the latest data.
Asynchronously, the data is periodically refreshed on the display of the SK and sent using the BLE advertising payload.
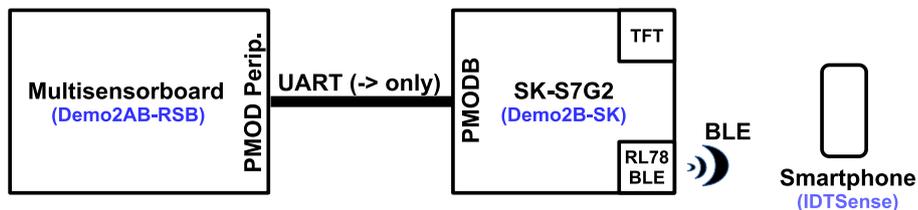
Figure 17: Demo2B high-level block diagram.

The two projects to load on the boards are:

1. "***Demo2AB_RSB_R1D1***" on the Multisensorboard.

2. "***Demo2B_SKS7G2***" on the SK-S7G2.

5.1 Boards connection and jumper configuration

The two boards must be connected using the PMOD Peripheral port on the Multisensorboard and the PMODB on the SK-S7G2.

Using the PMOD port allows to power the Multisensorboard directly from the SK. Before connecting the boards, make sure that:

1. Verify that the J15 jumper on the SK-S7G2 is positioned on the 3V3 selection.

2. Move the J44 jumper on the Multisensorboard on the pins 2-3 in order to select the 3V3 voltage.

3. Open J9 on the Multisensorboard disabling the internal 3.3 V buck.

If this configuration is not respected the boards can be permanently damaged.
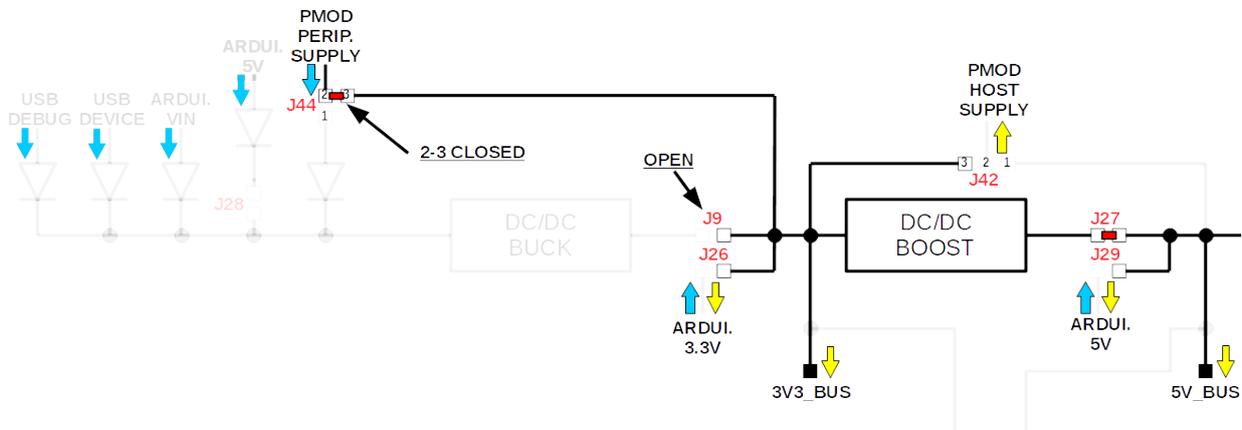
Figure 18: Power supply chain configuration for the Demo2B.
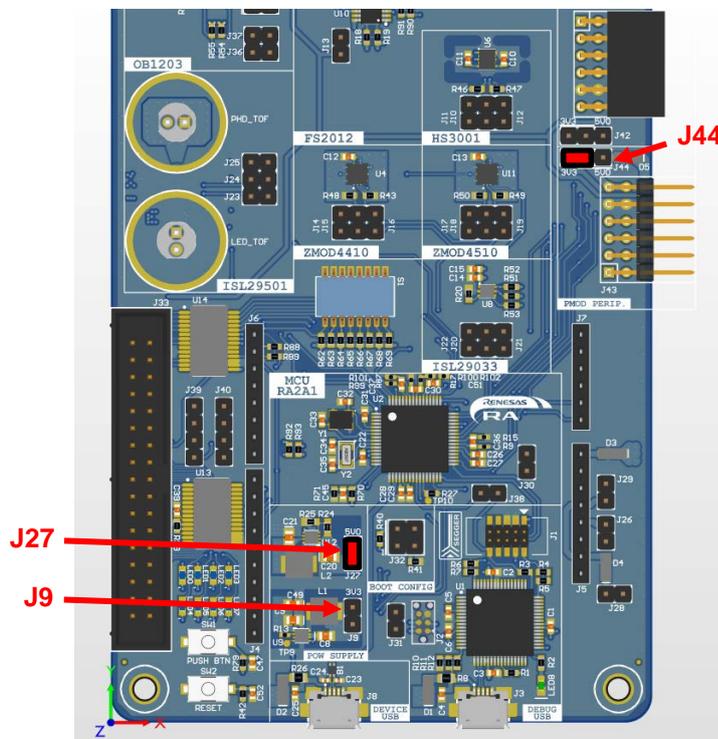
Figure 19: Position of the power supply jumper for the Demo2B.

5.2 IDTSense App for smartphones

This application is available for Android and for iOS:

- iOS: https://apps.apple.com/us/app/idtsense/id1388222456

- Android: https://play.google.com/store/apps/details?id=com.idt.europe.idtsense

Once the IDTSense App is opened, the Multisensorboard should appear on the screen (Figure 20 on the left).
Select it and tap on the "Start" button positioned in the lower right corner of the screen. The TVOC and the eCO2 values, coming from the ZMOD4410, will be visualized and updated in real time (Figure 20 on the right).
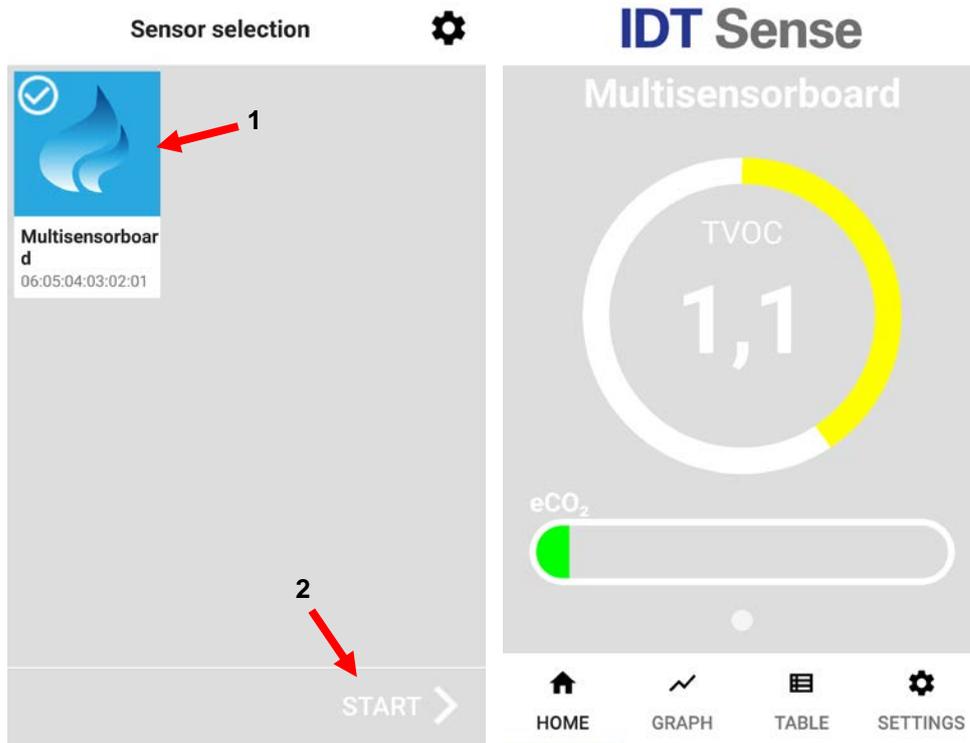
Figure 20: IDTSense App connection to the Multisensorboard.

6.   Demo 3 – Multisensorboard + RL78 BLE PMOD

NOTE: The default jumper configuration [1] is used for this demo.

Demo3 makes the same BLE advertising of ZMOD4410 data of the Demo2B. The difference is that a RL78 BLE PMOD is directly connected to the PMOD Host port of the Multisensorboard.

PIN1-PIN3
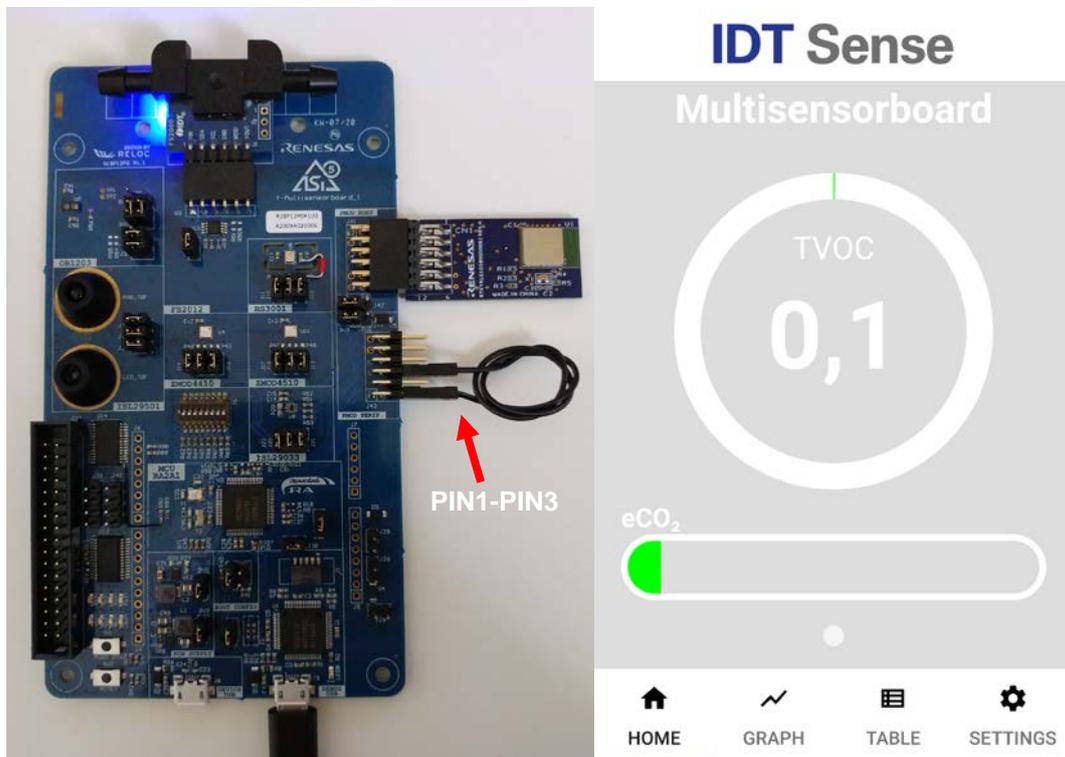
Figure 21: Demo3 connections and IDTSense app. In the picture on the left is shown the "UART 2-wire with branch connection".

Only the ZMOD4410 sensor is initialized and used, its measurements are written in an internal database that keeps an image of the most updated values read.
Asynchronously, the data is periodically sent using the BLE advertising payload.
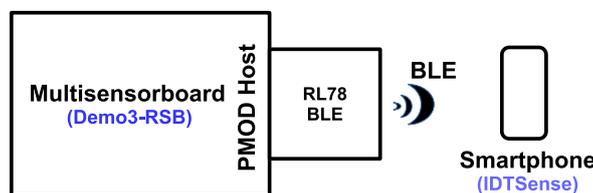
Figure 22: Demo3 high-level block diagram.

The projects to load on the board is:

1.   "***Demo3_RSB_R1D1***" on the Multisensorboard.

6.1   RL78 BLE PMOD connection

The RL78 BLE PMOD is connected to the PMOD Host port of the Multisensorboard; the latter is configured for providing a 3.3 V power supply (J42 closed on pins 2-3, as default configuration).

The RA2A1 and the RL78 are connected with a "UART 2-wire with branch connection", as described in [13].

The "branch" connection between the TX pin of the RA2A1 and the WAKEUP pin of the RL78 is made with an external wire: taking advantage of the PMOD Peripheral port of the Multisensorboard (that expose the same pins of the PMOD Host) a wire shorts the pins 1 and 3 as shown in Figure 21.
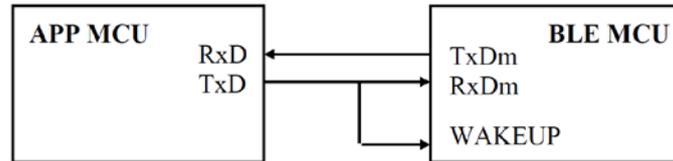
Figure 23: RL78 PMOD BLE Module "UART 2-wire with branch connection".

7.   Demo 4 – Multisensorboard + EK-RA6M3 + WINC1500 PMOD for Cloud by WiFi

NOTE: The default jumper configuration [1] is used for this demo.

This demo is very similar to Demo2A: some sensor data is sent to the IO Adafruit cloud, to only difference is that a WiFi connection is used instead of the ethernet cable.
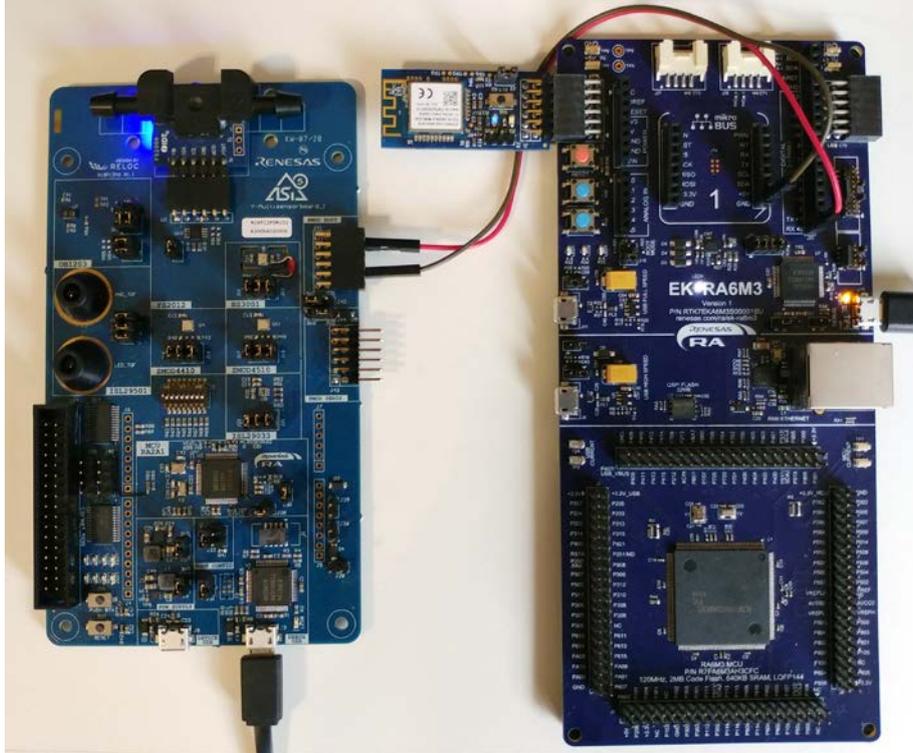
Figure 24: Demo 4 connections.

The WiFi module is a WINC1500 PMOD connected to the PMOD1 port of the EK-RA6M3.
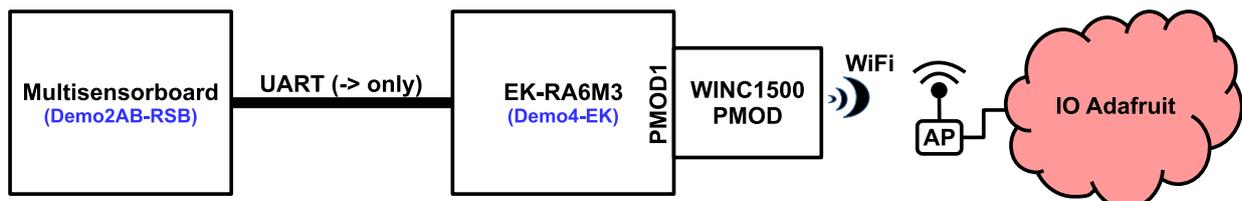
Figure 25: Demo4 high-level block diagram.

The two projects to load on the boards are:

1. "***Demo2AB_RSB_R1D1***" on the Multisensorboard.

2. "***Demo4_EKRA6M3_WIFI_IOADA***" on the EK-RA6M3. This project must be modified in order to add the IO Adafruit account information and the WiFi configuration.
   For the details about the cloud connection please refer to the section 3 of this document.

Moreover, the WINC1500 WiFi driver must be installed in the e2studio IDE: copy the file "`Renesas.RA_wifi_winc1500.1.0.0.pack`" into the folder:

> `<e2studio_install_dir>\internal\projectgen\ra\packs`

7.1 WiFi configuration

The only information required are the Access Point SSID, the password and the security type.

This information must be written in this file:

```
src\config_files\aws_clientcredential.h
```

at lines 58, 64 and 74 (Figure 26).

Figure 26: WiFi configuration.

On the WiFi port a DHCP client in enabled so no other network information is necessary.

References

[1] Renesas Electronics, "Multisensorboard – Hardware User's Guide".

[2] Renesas Electronics, "Multisensorboard – Quick Start Guide".

[3] Renesas Electronics, "Y-ASI4U-V5-DB – Software Application Note".

[4] Renesas Electronics, "Renesas RA2A1 Group - User's Manual: Hardware" Oct. 2019 - R01UH0888EJ0100: Link.

[5] Renesas Electronics, "FS2012 Series Datasheet - High Performance Flow Sensor Module", Aug. 24, 2018: Link.

[6] Renesas Electronics (IDT), "HS300x Datasheet - High Performance Relative Humidity and Temperature Sensor", Aug. 6, 2018: Link.

[7] Renesas Electronics, "ISL29033 Datasheet - Ultra-Low Lux, Low Power, Integrated Digital Ambient Light Sensor with Interrupt Function", Rev 5.00 Sep. 28, 2016: Link.

[8] Renesas Electronics, "ISL29501 Datasheet - Time of Flight (ToF) Signal Processing IC", May. 5, 2017: Link.

[9] Renesas Electronics, "ISL29501 AN1724 – Firmware Routines", Rev 1.00 Mar. 31, 2017: Link.

[10] Renesas Electronics (IDT), "OB1203 Preliminary Datasheet - Digital RGB / Ambient Light, Proximity and Photoplethysmography Sensor", Mar. 6, 2019: Link.

[11] Renesas Electronics (IDT), "ZMOD4410 Datasheet - Gas Sensor Module for TVOC and Indoor Air Quality", Jul. 30, 2019: Link.

[12] Renesas Electronics (IDT), "ZMOD4510 Datasheet - Gas Sensor Module for Outdoor Air Quality", Sep. 9, 2019: Link.

[13] Renesas Electronics, "Bluetooth® Low Energy Protocol Stack – User's Manual", Mar 2018 - R01UW0095EJ0122: Link.

Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
0.01	21 Mar 2020		Initial version.
0.02	25 Mar 2020		Renesas feedback corrections.
0.03	31 Mar 2020		ASi-5 project feedback
0.04	02 Apr 2020		
0.05	07 Apr 2020		Projects and documents updated to FSP 1.0.0
0.06	09 Apr 2020		Added notes on jumper setting for all demos. Added WiFi module driver installation note.
01.00	03 Sept, 2020		Added Document #R30AN0363ED0100

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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