Getting started with the STM32Cube function pack for IoT tracker node with Sigfox connectivity, Bluetooth connectivity and sensors

Introduction

FP-ATR-SIGFOX1 is an STM32Cube function pack which lets you read data from environmental and GNSS sensors and send collected data via Sigfox connectivity.

Message sending is triggered via user button, timer event, threshold crossing events on environmental values or movement detection by the on-board accelerometer.

Thresholds can be set using the ST Asset Tracking app and transmitted to the firmware by Bluetooth connectivity.

The package implements low power profiles and related transitions to ensure long battery autonomy.

This software, together with the suggested combination of STM32 and ST devices, is intended particularly to develop asset tracking applications. In addition to GNSS geolocation, low-energy device geolocation is provided by the Sigfox infrastructure.

The software runs on the STM32 microcontroller and includes drivers for the S2-LP ultra-low power RF transceiver, the Bluetooth Low Energy module, the motion, environmental and GNSS sensors.

RELATED LINKS

Visit the STM32Cube ecosystem web page on www.st.com for further information

1 Acronyms and abbreviations

Table 1. List of acronyms

Acronym	Description
API	Application programming interface
BSP	Board support package
CMSIS	Cortex® microcontroller software interface standard
GNSS	Global navigation satellite system
GPS	Global positioning system
HAL	Hardware abstraction layer
I²C	Inter-integrated circuit
IoT	Internet of Things
MEMS	Micro electro-mechanical systems
RCZ	Radio control zone
RF	Radio frequency
SPI	Serial peripheral interface
USB	Universal serial bus

2 FP-ATR-SIGFOX1 software expansion for STM32Cube

2.1 Overview

The FP-ATR-SIGFOX1 software package expands STM32Cube functionality.

The key features of the package are:

- Complete firmware to connect an IoT node to a Sigfox network, sending environmental sensor and GNSS positioning data
- Drivers for the S2-LP high performance ultra-low power RF transceiver
- Wake-up, tilt and orientation detection by the on-board accelerometer
- Middleware library supporting Sigfox connectivity from the X-CUBE-SFXS2LP1 software package and Bluetooth connectivity from the X-CUBE-BLE1 software package
- GNSS geolocation and low-energy device geolocation service provided by the Sigfox infrastructure
- Compatible with ST Asset Tracking client application supporting firmware setting via Bluetooth connectivity
- Sample implementation available for X-NUCLEO-S2868A1 or X-NUCLEO-S2868A2 and X-NUCLEO-S2915A1, X-NUCLEO-IDB05A1 or X-NUCLEO-IDB05A2, X-NUCLEO-IKS01A2 or X-NUCLEO-IKS01A3 and X-NUCLEO-GNSS1A1 expansion boards connected to NUCLEO-L073RZ and NUCLEO-L476RG development boards
- Easy portability across different MCU families, thanks to STM32Cube
- Free, user-friendly license terms

This software enables gathering environmental sensor data to transmit via Sigfox network connection. Received data can be displayed on the Sigfox backend and received by e-mail. Low energy device geolocation is provided by the Sigfox infrastructure.

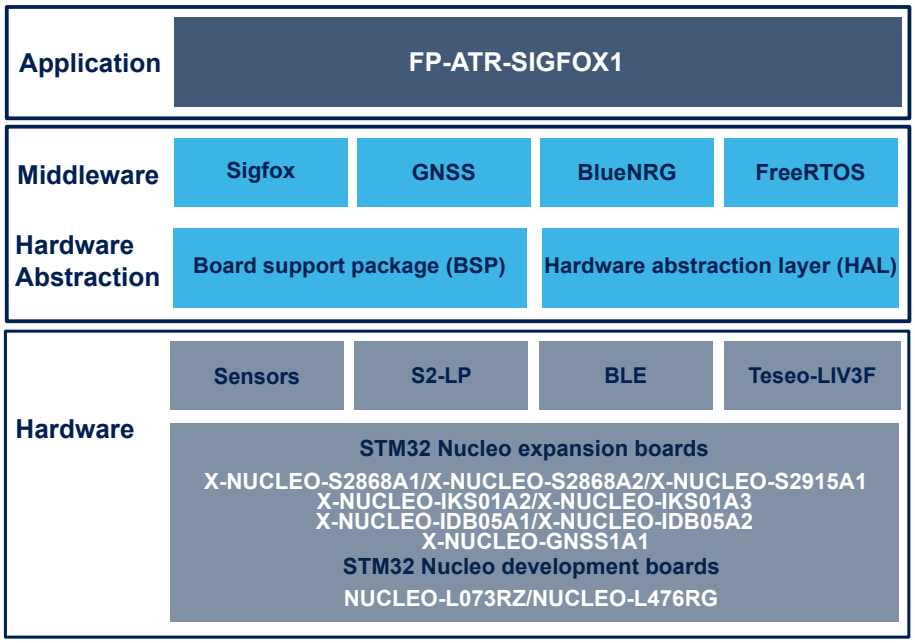
2.2 Architecture

The software is based on the STM32CubeHAL, the hardware abstraction layer for the STM32 microcontroller. The package extends STM32Cube by providing a Board Support Package (BSP) for the sensors and S2-LP expansion boards and some middleware components for Sigfox and Bluetooth communication.

The software layers used by the application software to access and use the expansion boards are:

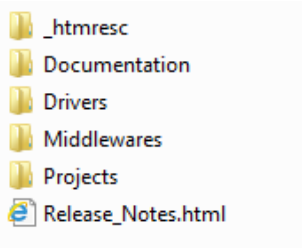
- the **STM32Cube HAL layer**, which provides a simple, generic, multi-instance set of application programming interfaces (APIs) to interact with the upper application, library and stack layers. It has generic and extension APIs and is directly built around a generic architecture and allows successive layers like the middleware layer to implement functions without requiring specific hardware configurations for a given microcontroller unit (MCU). This structure improves library code reusability and guarantees an easy portability on other devices.
- the **board support package** (BSP) layer supports all the peripherals on the STM32 Nucleo except the MCU. This limited set of APIs provides a programming interface for certain board-specific peripherals like the LED, the user button, etc. This interface also helps in identifying the specific board version.

Figure 1. **FP-ATR-SIGFOX1 software architecture**



2.3 Folder structure

Figure 2. **FP-ATR-SIGFOX1 package folder structure**



The following folders are included in the software package:

- **Documentation**: contains a compiled HTML file generated from the source code which details the software components and APIs.
- **Drivers**: contains the HAL drivers and the board-specific drivers for each supported board or hardware platform, including the on-board components and the CMSIS vendor-independent hardware abstraction layer for ARM Cortex-M processor series.
- **Middlewares**: contains libraries and protocols related to the communication of application data with a Sigfox network.
- **Projects**: contains a sample application used to perform the Sigfox asset tracker sample application. This application is provided for the NUCLEO-L073RZ and NUCLEO-L476RG platforms with three development environments: IAR Embedded Workbench for ARM, RealView Microcontroller Development Kit (MDK-ARM), and Integrated Development Environment for STM32 (STM32CubeIDE).

2.4 APIs

Detailed technical information with full user API function and parameter description are in a compiled HTML file in the “Documentation” folder.

2.5 Sample application description

An example application for asset tracking using the STM32 Nucleo and the X-NUCLEO-S2868A1, X-NUCLEO-S2868A2 or X-NUCLEO-S2915A1, X-NUCLEO-IDB05A1 or X-NUCLEO-IDB05A2, X-NUCLEO-GNSS1A1 and X-NUCLEO-IKS01A2 or X-NUCLEO-IKS01A3 expansion boards is provided in the “Projects” directory. Ready to be built projects are available for multiple IDEs.

Pre-compiled binary executables are available for NUCLEO-L073RZ and NUCLEO-L476RG platforms for any Sigfox Radio Control Zone, with and without Bluetooth support, through the Monarch service library.

The user interface is provided via serial port, which needs to be configured with baud rate 115200, 8N1 parameters.

The application collects environmental sensor data (humidity, temperature and pressure) and GNSS position data and sends them in two Sigfox frames over the Sigfox network.

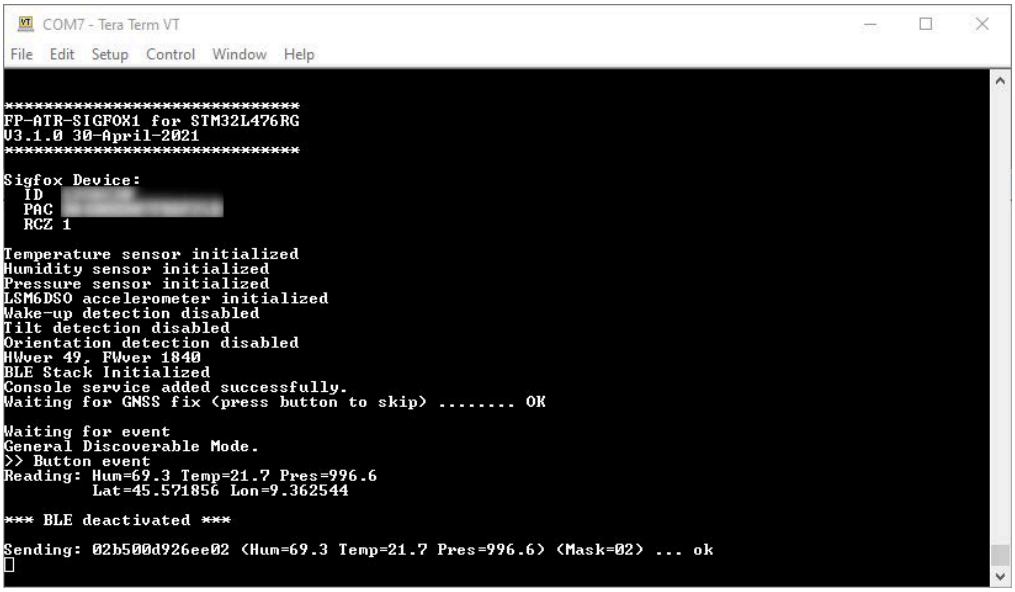
The message sending is triggered by any of the following events:

- User button pressure
- Timer expiration
- Threshold crossing events on environmental values
- Motion detection by the on-board accelerometer sensor (wake-up, tilt and orientation detection are possible)

Thresholds can be set using the dedicated ST Asset Tracker mobile app and transmitted to the firmware by Bluetooth Low Energy connection. It is also possible to set sensor polling interval and message sending interval.

Note: Thresholds can only be used when a Bluetooth board is present; otherwise only wake-up detection is enabled by default.

Figure 3. FP-ATR-SIGFOX1: example of serial interface

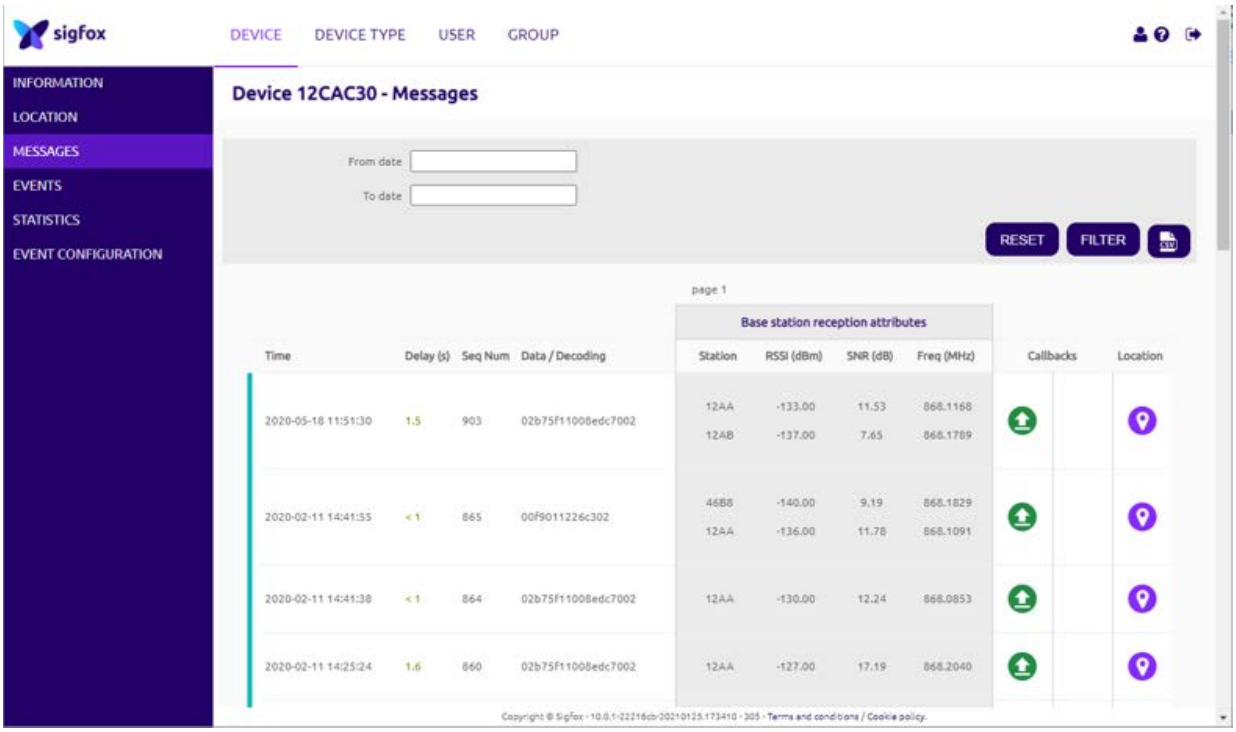


After the message is sent, the application switches to low-power state and remains in this state until the next message request is sent.

To transmit messages, Sigfox network coverage is needed. Alternatively, a Sigfox network emulator kit can be used.

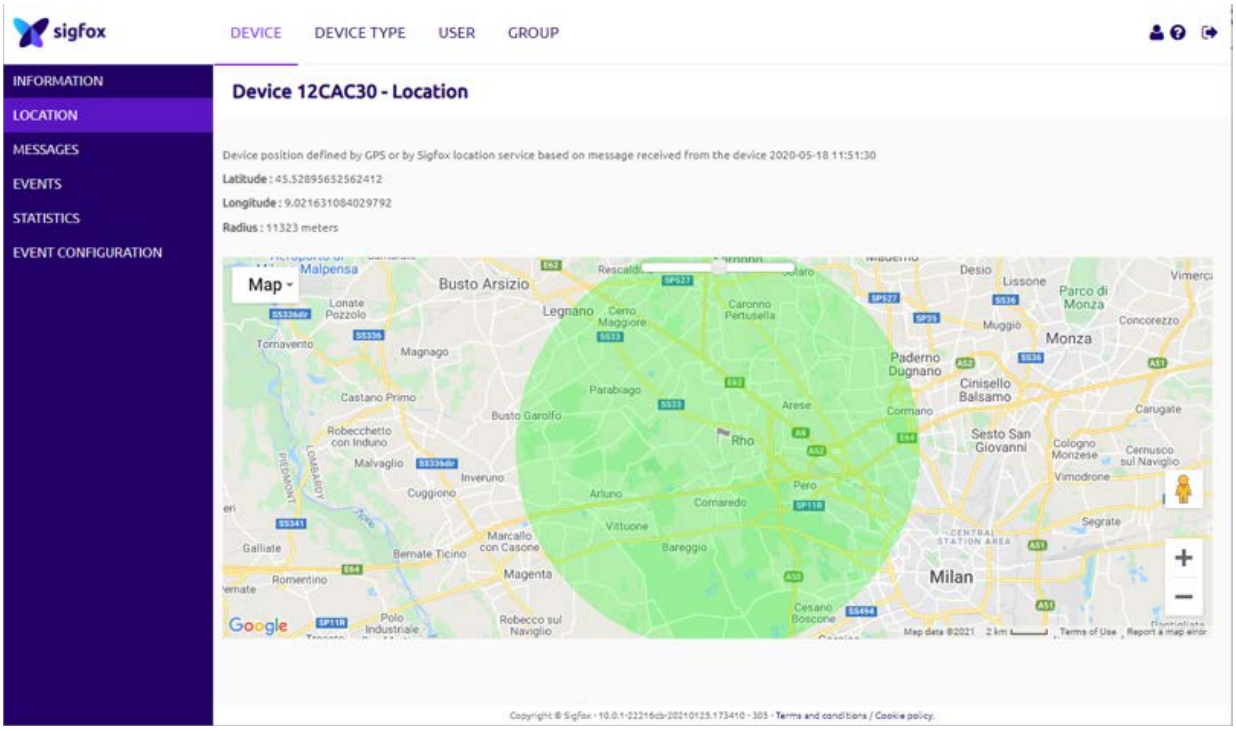
To see the received data, connect to Sigfox backend (Section Appendix A 4) and select the message list for your device.

Figure 4. **FP-ATR-SIGFOX1: example of message list received in Sigfox backend**



It is possible to display the map directly on the Sigfox backend by selecting the device message list and then clicking on [**LOCATION**] for each message.

Figure 5. **Example of map in Sigfox backend**



2.6 Configuration and registration

Step 1. Register the Sigfox device as described in [4.].

Step 2. Follow the two steps: ST side registration and Sigfox side registration.

Step 3. Watch the tutorials on YouTube for more details:

- For ST side registration https://www.youtube.com/watch?v=JD6UE7ekRxE
- For Sigfox side registration https://www.youtube.com/watch?v=fTipdrGij7I

Step 4. Create a free account at http://backend.sigfox.com.

2.7 Sample client application

The FP-ATR-SIGFOX1 software for STM32Cube is compatible with the ST Asset Tracking Android/iOS application available at the respective Google Play/iOS store.

The client application starts with the main page where several supported devices are listed: FP-ATR-SIGFOX1 must be selected.

In the second page, a list of available nodes is shown for Bluetooth connection. You must select the BlueSFX one.

After that, a third page with a list of possible settings is shown. All the settings will be uploaded to the board via Bluetooth connection by clicking on the [**Save**] button indicated by a disk icon. After that, you can close the Bluetooth connection.

The first two settings are the values of `Sensor Sample Interval` in minutes and `Cloud Sync Interval` in minutes.

The first value represents the time interval for sampling the values of environmental sensors (the minimum value is 1 minute). The second value represents the time interval of the transmission of two Sigfox messages.

Note: To reduce power consumption, the Bluetooth connection is disabled on the board after the first Sigfox message sending by timer event. After that, no further configuration is possible, unless you reset the board by pressing the reset button.

Figure 6. ST Asset Tracking application: main page

Figure 7. **ST Asset Tracking application: node selection**

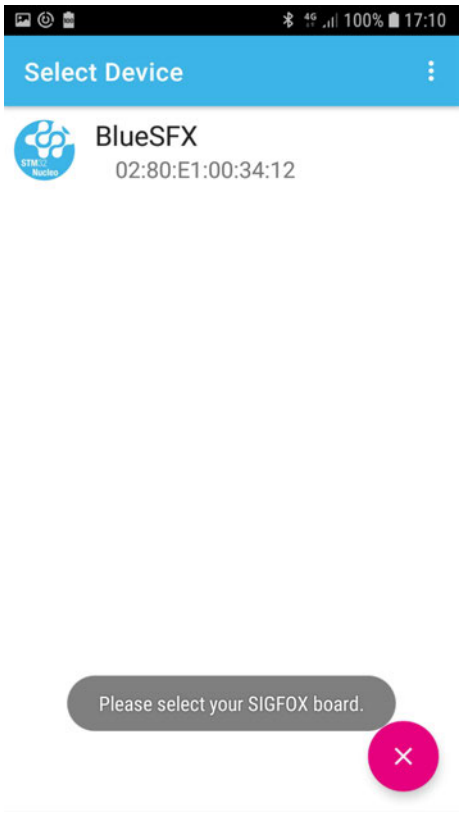
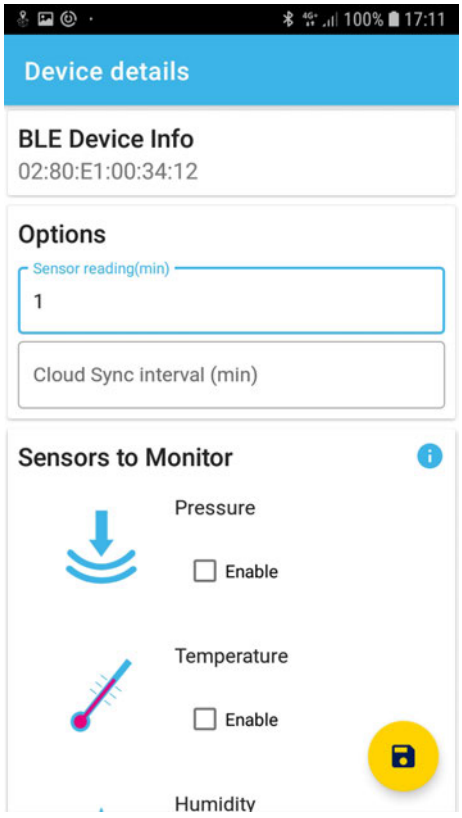


Figure 8. **ST Asset Tracking application: adding thresholds**



The first three kinds of thresholds are dedicated to the environmental sensor values.

For each physical characteristic (i.e. temperature, pressure and humidity), it is possible to specify a maximum and minimum value.

In this way, an event is generated when the sensor value at that sampling time is greater or smaller than the threshold values. The values are expressed in Celsius degrees (min. -20.0, max. +100.0) for temperature, in mmHg (min. 500, max. 1260) for pressure and in percentage (min. 0.0, max. 100.0) for humidity.

The subsequent three kinds of thresholds are dedicated to accelerometer events.

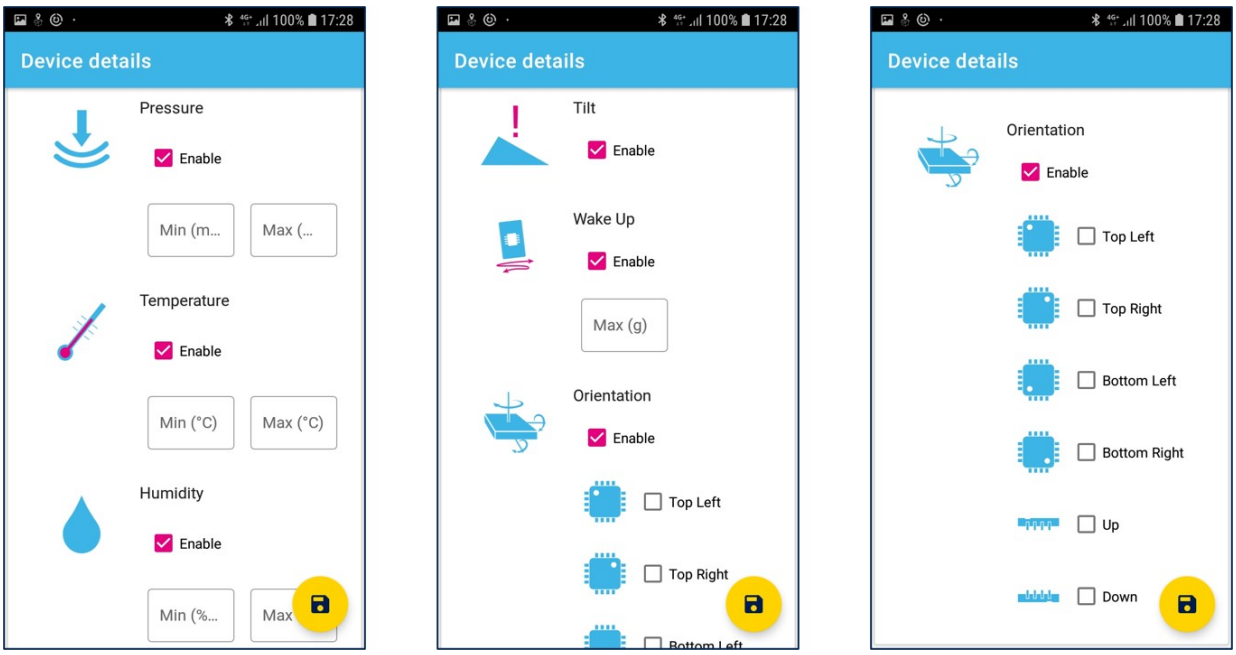
For wake-up detection, it is possible to set a threshold value between 1 and 16 g (gravitational acceleration): the event is triggered when the board undergoes an acceleration that is greater than the indicated value.

For tilt detection, there is no threshold value: the event is triggered when the board is tilted.

For orientation detection, it is possible to set the board orientation direction among 6 possibilities (top-left, bottom-left, top-right, bottom-right, up and down): the event is triggered when the board is oriented towards the selected semi-axis.

While the environmental events are synchronized with the sampling time interval, the accelerometer events are asynchronous as they are generated when you move the board.

Figure 9. ST Asset Tracking application: all threshold windows



Whenever an event is generated, the sending of a 7-bytes or 9-bytes Sigfox message is triggered, containing either the values of environmental sensors (2 bytes for temperature, 2 bytes for pressure and 2 bytes for humidity) or the values of GNSS positioning (4 bytes for latitude and 4 bytes for longitude), plus a single last byte whose bits indicate which kind of event triggered the sending as follows:

Table 2. Sigfox message last byte details

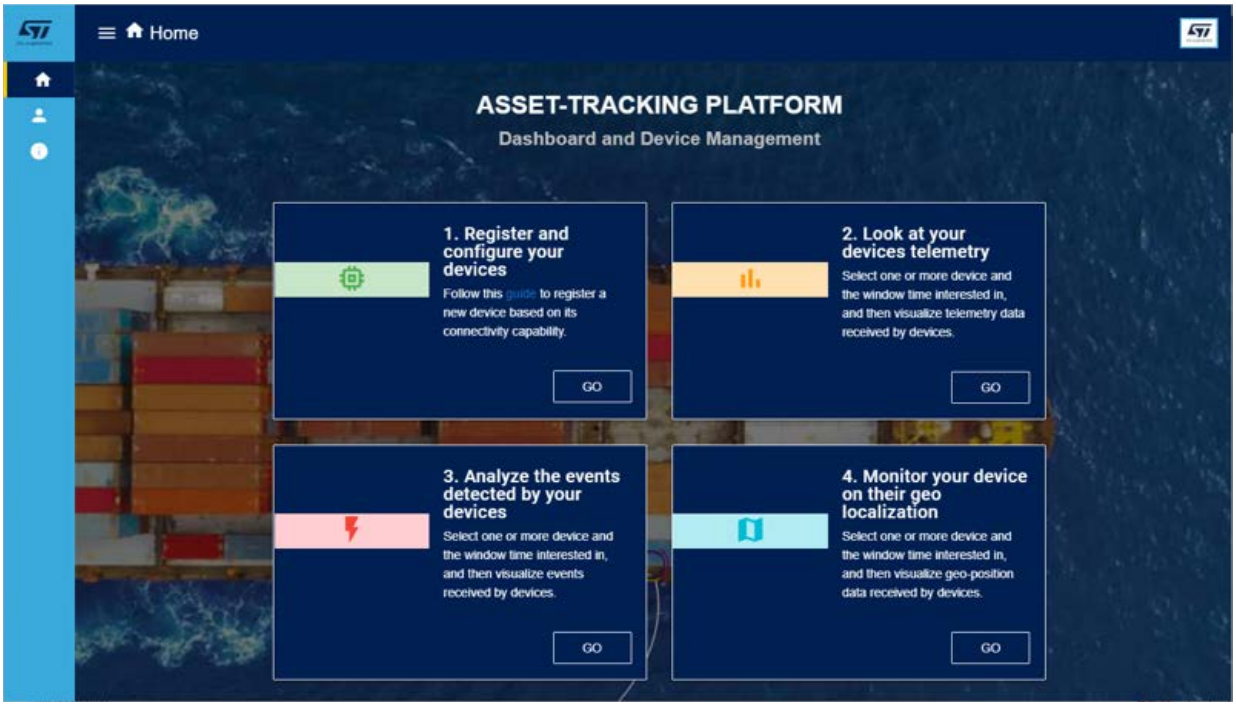
Bit set	Triggering event
0	Timer expiration
1	User button press
2	Orientation detection
3	Tilt detection
4	Wake-up detection
5	Humidity sensor value
6	Pressure sensor value
7	Temperature sensor value

2.8 Asset tracking dashboard

A web dashboard to display device properties is available at the address: https://dsh-assetracking.st.com/.

After signing in, follow the procedure to register your device and display device data with sensor values, charts and maps with device location.

Figure 10. Web dahsboard



3 System setup guide

3.1 Hardware description

3.1.1 STM32 Nucleo

STM32 Nucleo development boards provide an affordable and flexible way for users to test solutions and build prototypes with any STM32 microcontroller line.

The Arduino™ connectivity support and ST morpho connectors make it easy to expand the functionality of the STM32 Nucleo open development platform with a wide range of specialized expansion boards to choose from.

The STM32 Nucleo board does not require separate probes as it integrates the ST-LINK/V2-1 debugger/ programmer.

The STM32 Nucleo board comes with the comprehensive STM32 software HAL library together with various packaged software examples for different IDEs (IAR EWARM, Keil MDK-ARM, STM32CubeIDE, mbed and GCC/ LLVM).

All STM32 Nucleo users have free access to the mbed online resources (compiler, C/C++ SDK and developer community) at www.mbed.org to easily build complete applications.

Figure 11. STM32 Nucleo board

Information regarding the STM32 Nucleo board is available at www.st.com/stm32nucleo

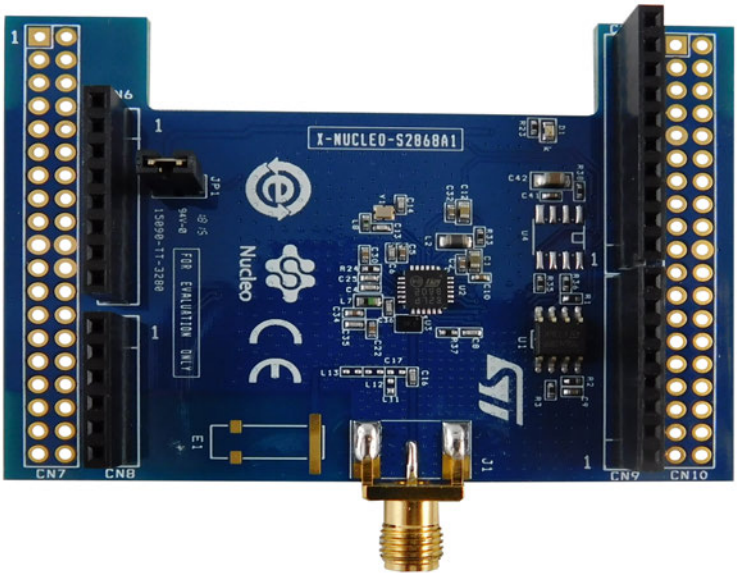
3.1.2 X-NUCLEO-S2868A1 expansion board

The X-NUCLEO-S2868A1 expansion board is based on the S2-LP radio and operates in the 868 MHz ISM frequency band.

The expansion board is compatible with ST morpho and Arduino UNO R3 connectors.

The X-NUCLEO-S2868A1 interfaces with the STM32 Nucleo microcontroller via SPI connections and GPIO pins. You can change some of the GPIOs by mounting or removing the resistors.

Figure 12. **X-NUCLEO-S2868A1 expansion board**



3.1.3 X-NUCLEO-S2868A2 and X-NUCLEO-S2915A1 expansion boards

The X-NUCLEO-S2868A2 expansion board is based on the S2-LP radio and operates in the 868 MHz ISM frequency band.

The X-NUCLEO-S2915A1 expansion board is based on the S2-LP radio and operates in the 915 MHz ISM frequency band.

The expansion boards are compatible with ST morpho and Arduino UNO R3 connectors, and interface with the STM32 Nucleo microcontroller via SPI connections and GPIO pins.

You can change some of the GPIOs by mounting or removing the resistors.

Figure 13. **X-NUCLEO-S2868A2 expansion board**

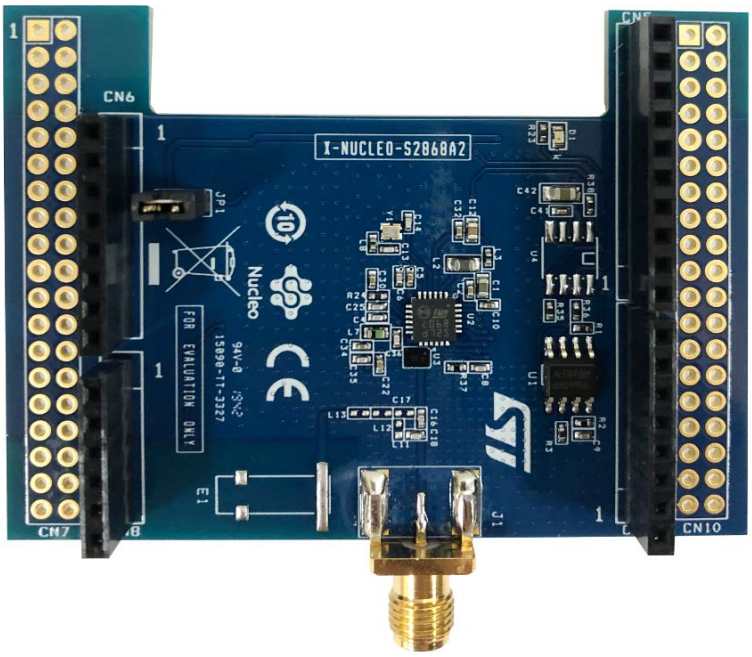
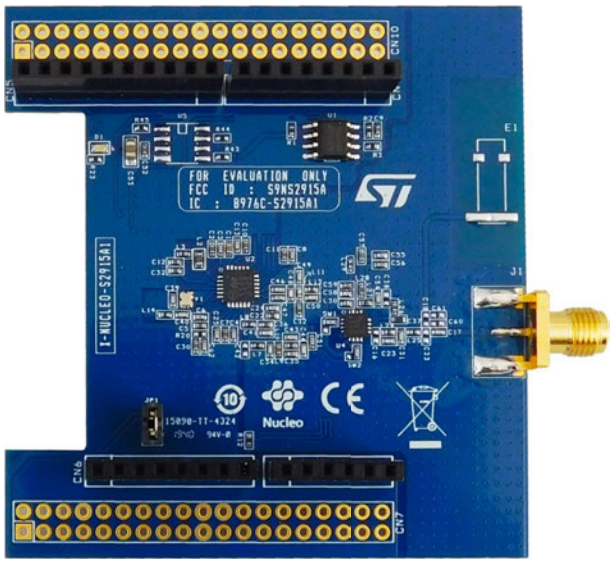


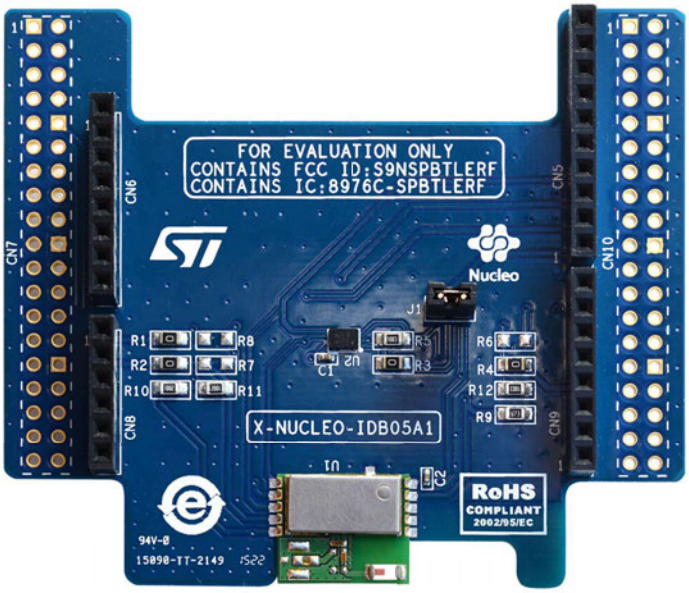
Figure 14. **X-NUCLEO-S2915A1 expansion board**



3.1.4 X-NUCLEO-IDB05A1 expansion board

The X-NUCLEO-IDB05A1 is a Bluetooth low energy evaluation board based on the SPBTLE-RF BlueNRG-MS RF module to allow expansion of the STM32 Nucleo boards. The SPBTLE-RF module is FCC (FCC ID: S9NSPBTLERF) and IC certified (IC: 8976C-SPBTLERF). The BlueNRG-MS is a very low power Bluetooth low energy (BLE) single-mode network processor, compliant with Bluetooth specification v4.2. X-NUCLEO-IDB05A1 is compatible with the ST morpho and Arduino™ UNO R3 connector layout. This expansion board can be plugged into the Arduino UNO R3 connectors of any STM32 Nucleo board.

Figure 15. **X-NUCLEO-IDB05A1 expansion board**



3.1.5 X-NUCLEO-IDB05A2 expansion board

The X-NUCLEO-IDB05A2 Bluetooth low energy expansion board is based on the BlueNRG-M0 BLE network processor module.

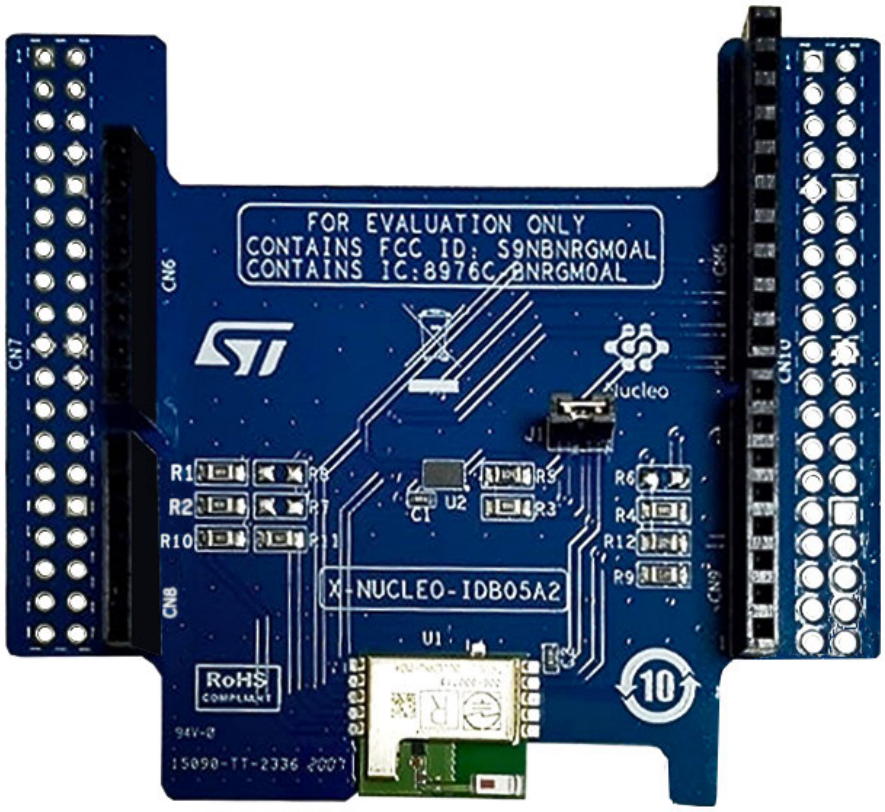
The BlueNRG-M0 is Bluetooth v4.2 compliant, FCC and IC certified (FCC ID: S9NBNRGM0AL; IC: 8976C-BNRGM0AL). It supports simultaneous master/slave roles and can behave as a Bluetooth low energy sensor and hub device at the same time.

The BlueNRG-M0 provides a complete RF platform in a tiny form factor, with integrated radio, antenna, high frequency and LPO oscillators.

The X-NUCLEO-IDB05A2 is compatible with the ST morpho (not mounted) and Arduino UNO R3 connector layout.

The X-NUCLEO-IDB05A2 interfaces with the STM32 microcontroller via the SPI pin and allows changing the default SPI clock, SPI chip select and SPI IRQ by replacing a resistor on the expansion board.

Figure 16. X-NUCLEO-IDB05A2 expansion board



3.1.6 X-NUCLEO-GNSS1A1 expansion board

The X-NUCLEO-GNSS1A1 expansion board is based on the Teseo-LIV3F tiny GNSS module.

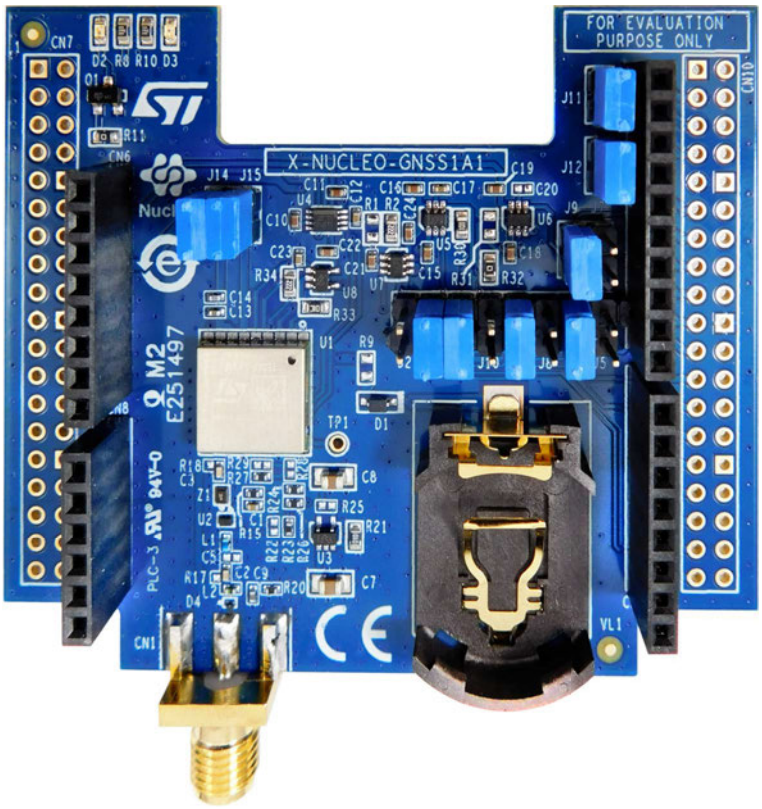
It represents an affordable, easy-to-use, global navigation satellite system (GNSS) module, embedding a TeseoIII single die standalone positioning receiver IC, usable in different configurations in your STM32 Nucleo project.

The Teseo-LIV3F is a compact (9.7x10.1 mm) module that provides superior accuracy thanks to the on-board 26 MHz temperature compensated crystal oscillator (TCXO) and a reduced time-to-first fix (TTFF) with its dedicated 32 KHz real-time clock (RTC) oscillator.

The Teseo-LIV3F module runs the GNSS firmware (X-CUBE-GNSS1) to perform all GNSS operations including acquisition, tracking, navigation and data output without external memory support.

The X-NUCLEO-GNSS1A1 expansion board is compatible with the Arduino™ UNO R3 connector and the ST morpho connector, so it can be plugged to the STM32 Nucleo development board and stacked with additional STM32 Nucleo expansion boards.

Figure 17. **X-NUCLEO-GNSS1A1 expansion board**



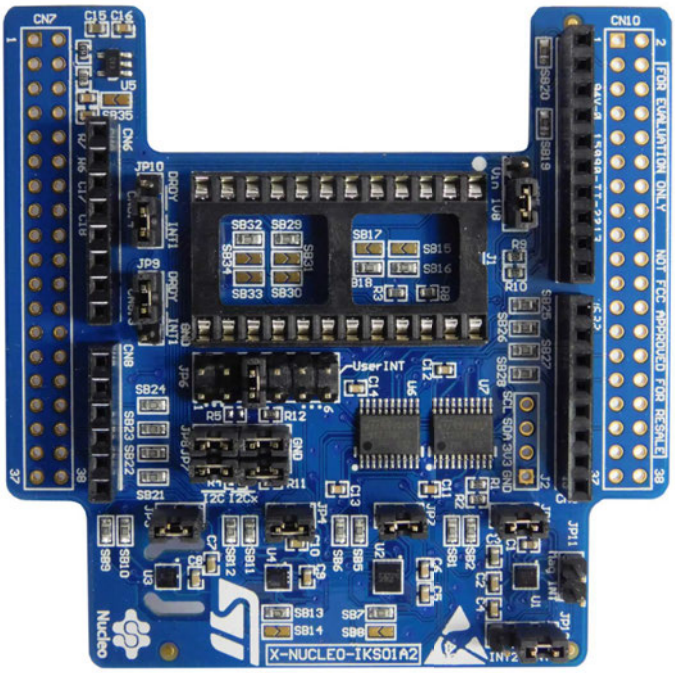
3.1.7 X-NUCLEO-IKS01A2 expansion board

The X-NUCLEO-IKS01A2 is a motion MEMS and environmental sensor expansion board for STM32 Nucleo.

It is compatible with the Arduino UNO R3 connector layout, and is designed around the LSM6DSL 3D accelerometer and 3D gyroscope, the LSM303AGR 3D accelerometer and 3D magnetometer, the HTS221 humidity and temperature sensor and the LPS22HB pressure sensor.

The X-NUCLEO-IKS01A2 interfaces with the STM32 microcontroller via the I²C pin, and it is possible to change the default I²C port.

Figure 18. **X-NUCLEO-IKS01A2 MEMS and environmental sensor expansion board**



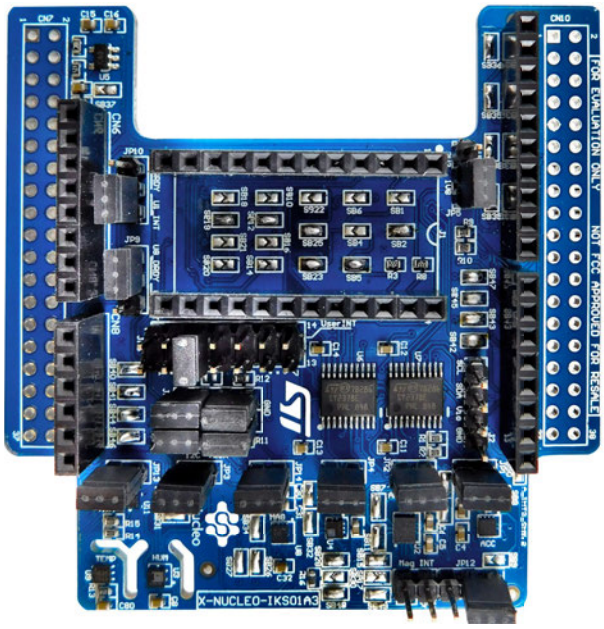
3.1.8 X-NUCLEO-IKS01A3 expansion board

The X-NUCLEO-IKS01A3 is a motion MEMS and environmental sensor evaluation board system.

It is compatible with the Arduino UNO R3 connector layout and features the LSM6DSO 3-axis accelerometer + 3-axis gyroscope, the LIS2MDL 3-axis magnetometer, the LIS2DW12 3-axis accelerometer, the HTS221 humidity and temperature sensor, the LPS22HH pressure sensor, and the STTS751 temperature sensor.

The X-NUCLEO-IKS01A3 interfaces with the STM32 microcontroller via the I²C pin, and it is possible to change the default I²C port.

Figure 19. **X-NUCLEO-IKS01A3 MEMS and environmental sensor expansion board**



3.2 Hardware setup

The following hardware components are needed:

1. One STM32 Nucleo development board (order code: NUCLEO-L073RZ or NUCLEO-L476RG).
2. One Sub-1 GHz 868 or 915 MHz RF expansion board (order code: X-NUCLEO-S2868A1, X-NUCLEO-S2868A2 or X-NUCLEO-S2915A1).
3. One (optional) Bluetooth Low Energy expansion board (order code: X-NUCLEO-IDB05A1 or X-NUCLEO-IDB05A2)
4. One GNSS sensor expansion board (order code: X-NUCLEO-GNSS1A1)
5. One motion MEMS and environmental sensor expansion board (order code: X-NUCLEO-IKS01A2 or X-NUCLEO-IKS01A3).
6. One USB type A to Mini USB Type B cable to connect the STM32 Nucleo board to the PC.

3.3 Software setup

The following software components are required for the setup of a suitable development environment to create applications for the STM32 Nucleo board with the sensor expansion board:

- FP-ATR-SIGFOX1: an STM32Cube function pack dedicated to asset tracking applications development. The firmware and related documentation are available on www.st.com.
- Development tool-chain and Compiler. The STM32Cube expansion software supports the three following environments to select from:
  - IAR Embedded Workbench for ARM® (IAR-EWARM) toolchain + ST-LINK
  - RealView Microcontroller Development Kit (MDK-ARM-STM32) toolchain + ST-LINK
  - Integrated Development Environment for STM32 (STM32CubeIDE)

3.4 System setup

The STM32 Nucleo board integrates the ST-LINK/V2-1 debugger/programmer.

The developer can download the ST-LINK/V2-1 USB driver by looking at the STSW-LINK009 software on www.st.com.

The X-NUCLEO-S2868A1, X-NUCLEO-S2868A2 or X-NUCLEO-S2915A1, the X-NUCLEO-IDB05A1 or X-NUCLEO-IDB05A2 and the X-NUCLEO-IKS01A2 or X-NUCLEO-IKS01A3 expansion boards can be easily connected to the STM32 Nucleo through the Arduino UNO R3 extension connector.

The boards interfaces with the external STM32 microcontroller on STM32 Nucleo using serial peripheral interface (SPI) for the X-NUCLEO-S2868A1, X-NUCLEO-S2868A2 or X-NUCLEO-S2915A1 and X-NUCLEO-IDB05A1 or X-NUCLEO-IDB05A2, serial interface for X-NUCLEO-GNSS1A1 and inter-integrated circuit (I²C) transport layer for the X-NUCLEO-IKS01A2 or X-NUCLEO-IKS01A3.

Note: When the Bluetooth board is present, the following hardware modifications are needed on the boards:

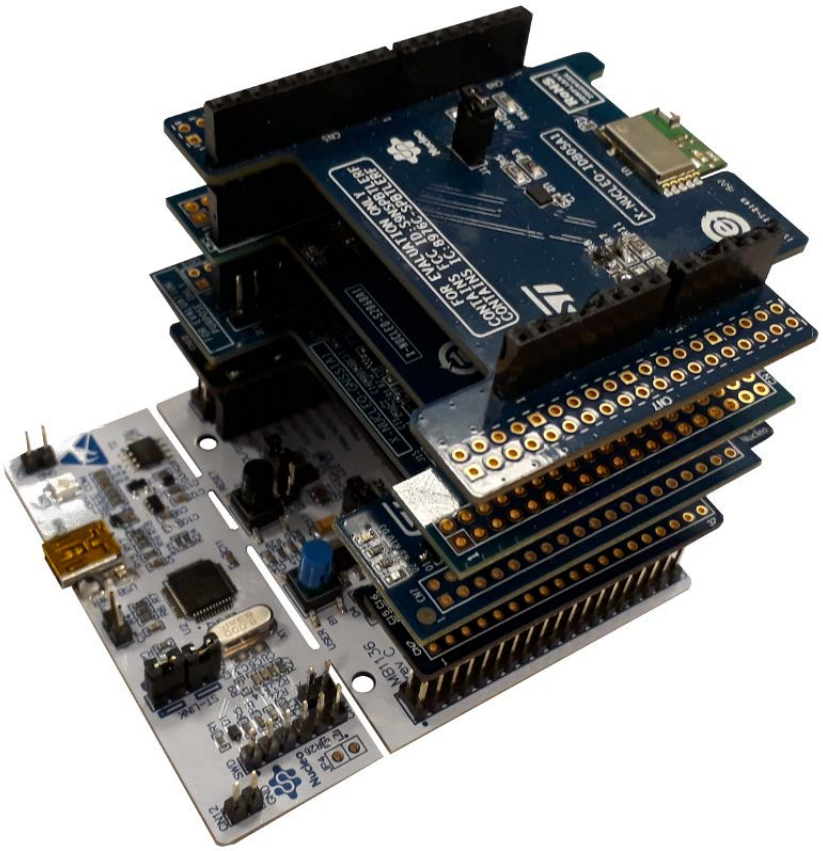
- *On the X-NUCLEO-S2868A1 and X-NUCLEO-S2868A2, unmount R10 and mount R19*
- *On the X-NUCLEO-IKS01A2, open SB25*
- *On the X-NUCLEO-IKS01A3, open SB47 and SB39*
- *On the X-NUCLEO-IDB05A1 and X-NUCLEO-IDB05A2, unmount R2 and mount R7*

For the X-NUCLEO-GNSS1A1 expansion board:

- *open jumpers: J3, J5, J6, J7, J8, J11, J12, J13*
- *close jumpers: J2, J4, J9, J10, J14, J15*

Important: With the X-NUCLEO-S2915A1 expansion board, only the configurations without Bluetooth work properly.

Figure 20. STM32 Nucleo, X-NUCLEO-S2868A1, X-NUCLEO-GNSS1A1, X-NUCLEO-IDB05A1 and X-NUCLEO-IKS01A2 stack



Appendix A References

1. UM2405: "Getting started with the X-NUCLEO-S2868A1 Sub-1 GHz 868 MHz RF expansion board based on S2-LP radio for STM32 Nucleo"
2. UM2638: "Getting started with the X-NUCLEO-S2868A2 Sub-1 GHz 868 MHz RF expansion board based on S2-LP radio for STM32 Nucleo"
3. UM2641: "Getting started with the X-NUCLEO-S2915A1 Sub-1 GHz 915 MHz RF expansion board based on S2-LP radio for STM32 Nucleo"
4. UM2169: "Getting started with the Sigfox S2-LP kit"
5. UM2121: "Getting started with the X-NUCLEO-IKS01A2 motion MEMS and environmental sensor expansion board for STM32 Nucleo"
6. UM2559: "Getting started with the X-NUCLEO-IKS01A3 motion MEMS and environmental sensor expansion board for STM32 Nucleo"
7. UM1912: "Getting started with X-NUCLEO-IDB05A1 BLE expansion board based on the SPBTLE-RF module for STM32 Nucleo"
8. UM2327: "Getting started with the X-NUCLEO-GNSS1A1 expansion board based on Teseo-LIV3F tiny GNSS module for STM32 Nucleo"
9. UM2700: "Getting started with X-NUCLEO-IDB05A2 BLE expansion board based on the BlueNRG-M0 module for STM32 Nucleo"
10. https://backend.sigfox.com

All the user manuals are freely available on www.st.com.

Revision history

Table 3. **Document revision history**

Date	Version	Changes
05-Nov-2018	1	Initial release.
22-May-2019	2	Updated Introduction, Section 3.1 Overview, Figure 2. FP-ATR-SIGFOX1 software architecture, Section 3.5 Sample application description, Section 4.2 Hardware setup and Section 4.4 System setup. Added Section 3.7 Sample client application and Section 4.1.3 X-NUCLEO-IDB05A1 expansion board.
18-Jul-2019	3	Updated Figure 1. FP-ATR-SIGFOX1 software architecture, Section 2.5 Sample application description, Section 3.2 Hardware setup and Section 3.4 System setup. Added Section 3.1.5 X-NUCLEO-IKS01A3 expansion board.
19-Feb-2020	4	Updated Introduction, Section 1 Acronyms and abbreviations, Section 2.1 Overview, Figure 1. FP-ATR-SIGFOX1 software architecture, Figure 3. FP-ATR-SIGFOX1: example of serial interface, Figure 11. ST Asset Tracking application: example of threshold definition, Section 3.2 Hardware setup, Section 3.4 System setup and Section Appendix A References. Added Section 3.1.3 X-NUCLEO-S2868A2 and X-NUCLEO-S2915A1 expansion boards and Section 3.1.5 X-NUCLEO-GNSS1A1 expansion board. Added NUCLEO-L073RZ development board, X-NUCLEO-S2868A2 and X-NUCLEO-S2915A1 expansion board compatibility information.
16-Feb-2021	5	Updated Section 2.5 Sample application description and Section 2.7 Sample client application. Added Section 2.8 Asset tracking dashboard.
12-May-2021	6	Updated Section 2.1 Overview, Section 2.2 Architecture, Section 2.5 Sample application description, Section 3.2 Hardware setup, Section 3.4 System setup and Section Appendix A References. Added Section 3.1.5 X-NUCLEO-IDB05A2 expansion board.

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