Getting started with the X-CUBE-BLEMGR Bluetooth® Low Energy manager software expansion for STM32Cube

Introduction

The X-CUBE-BLEMGR is an expansion software package for STM32Cube for the Bluetooth® LE manager and runs on the STM32.

This expansion software includes the STM32_BLE_Manager library, which provides APIs to manage the Bluetooth® LE service according to the BlueNRG-MS, BlueNRG-1, BlueNRG-2, BlueNRG-LP, STM32WB07_06 and STM32WB05N middleware APIs.

The software is also available on GitHub, where the users can signal bugs and propose new ideas through [Issues] and [Pull Requests] tabs.

1 X-CUBE-BLEMGR software expansion for STM32Cube

1.1 Overview

- Sample implementation of a Bluetooth® Low Energy connection to the STBLESensor mobile application
- STM32_BLE_Manager library to manage the Bluetooth® Low Energy service according to the Bluetooth® Low Energy middleware APIs
- Sample applications that the developer can use to start experimenting with the code
- References to free Android and iOS apps that can be used with the sample applications
- Sample implementations available for:
  - X-NUCLEO-BNRG2A1 connected to a NUCLEO-L476RG or NUCLEO-U575ZI-Q board
  - X-NUCLEO-WB05KN1 connected to a NUCLEO-U575ZI-Q board
  - STEVAL-MKBOXPRO evaluation boards
- Compatible with STM32CubeMX, can be downloaded from and installed directly into STM32CubeMX
- Easy portability across different MCU families, thanks to STM32Cube
- Free, user-friendly license terms

The sample application creates the following Bluetooth® Low Energy services:

1. the first service exposes the following characteristics:
   a. random values for temperature, pressure, and humidity (randomly evaluated with a dedicated function)
   b. random values for the quaternions (randomly evaluated with a dedicated function)
2. the second is the Console service that includes two characteristics:
   a. stdin/stdout with a bidirectional communication between the client and the server
   b. stderr for a mono-directional channel from the STM32 Nucleo development board to an Android/iOS device
3. the last service is used to switch the LED on/off and for configuration purpose

1.2 Architecture

The proposed software is based on the STM32CubeHAL. The package extends STM32Cube by providing a board support package (BSP) for the BlueNRG-2, STM32WB07,STM32WB05N and BlueNRG-LP network processor and middleware components for the communication with other Bluetooth® LE devices.

The implementation uses low-power consumption strategies suitable for this field of application, compliant with the Bluetooth® Low Energy specifications (for BlueNRG-2 onto X-NUCLEO-BNRG2A1 board, STM32WB05KN onto X-NUCLEO-WB05KN1 board, BlueNRG-LP onto STEVAL-MKBOXPRO Rev A and Rev B board and STM32WB07KC onto STEVAL-MKBOXPRO Rev C board) for STM32 development boards.

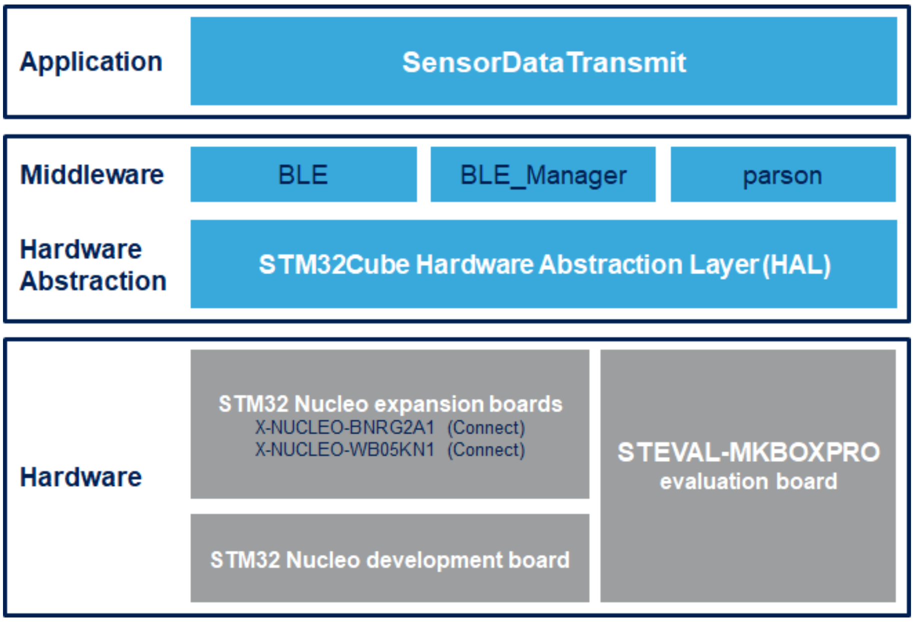
The provided drivers abstract low-level hardware details, so middleware components and applications can run in a hardware-independent manner.

The package includes a sample application to transmit the values randomly evaluated (temperature, humidity, pressure, quaternions) to a Bluetooth® Low Energy-enabled device such as an Android™ or iOS™-based smartphone.

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

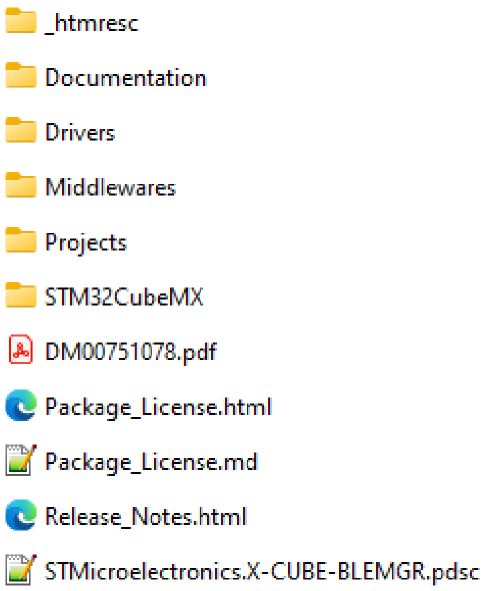
- **STM32Cube HAL layer**: consists of simple, generic, and multi-instance APIs (application programming interfaces) which interact with the upper layer applications, libraries, and stacks. These generic and extension APIs are based on a common framework so that overlying layers like middleware can function without requiring specific microcontroller unit (MCU) hardware information. This structure improves library code reusability and guarantees easy portability across other devices.
- **Board support package (BSP) layer**: provides software support for the STM32 Nucleo board peripherals, excluding the MCU. These specific APIs provide a programming interface for certain board-specific peripherals like LEDs, user buttons, etc., and can also be used to fetch individual board version information. It also provides support for initializing, configuring, and reading data.

Figure 1. X-CUBE-BLEMGR software architecture


Application
SensorDataTransmit
Middleware
BLE
BLE_Manager
parson
Hardware Abstraction
STM32Cube Hardware Abstraction Layer (HAL)
Hardware
STM32 Nucleo expansion boards
X-NUCLEO-BNRG2A1 (Connect)
X-NUCLEO-WB05KN1 (Connect)
STEVAL-MKBOXPRO evaluation board
STM32 Nucleo development board

1.3 Folder structure

Figure 2. X-CUBE-BLEMGR package folder structure



_htmresc
Documentation
Drivers
Middlewares
Projects
STM32CubeMX
DM00751078.pdf
Package_License.html
Package_License.md
Release_Notes.html
STMicroelectronics.X-CUBE-BLEMGR.pdsc

The following folders are included in the software package:

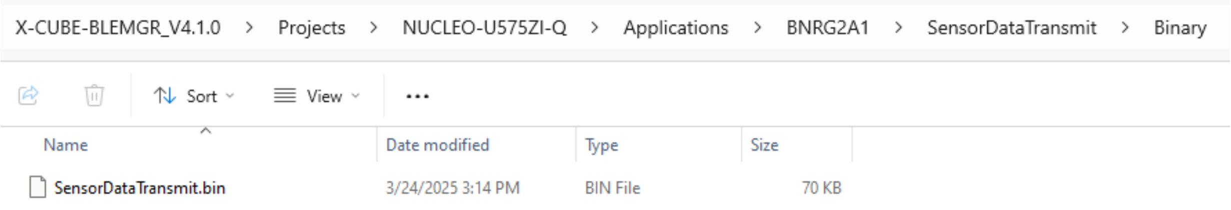
- Documentation: contains a compiled HTML file generated from the source code, detailing the software components and APIs.
- Drivers: contains the HAL drivers, the board-specific drivers for each supported board or hardware platform, including the on-board components and the CMSIS vendor-independent hardware abstraction layer for the Cortex-M processor series.
- Middlewares: contains libraries and protocols for BlueNRG-2, STM32WB07KC, STM32WB05KN and BlueNRG-LP Bluetooth® Low Energy and STM32_BLE_Manager Bluetooth® Low Energy manager.

- Projects: contains a sample application that the developer can use to start experimenting with the code to help the users manage the Bluetooth® Low Energy connectivity, for example with a mobile application such as STBLESensor, and provided for the NUCLEO-L476RG, NUCLEO-U575ZI-Q and STEVAL-MKBOXPRO and through the IAR Embedded Workbench for ARM, RealView Microcontroller Development Kit (MDK-ARM), and STM32CubeIDE development environments.

1.4 The installation process

The package binary directory contains an image (in .bin format) for the supported platform. This image can be directly flashed into a supported STM32 Nucleo development board with the STM32CubeProgrammer or via drag and drop.

Figure 3. X-CUBE-BLEMGR binary folder


X-CUBE-BLEMGR_V4.1.0 > Projects > NUCLEO-U575ZI-Q > Applications > BNRG2A1 > SensorDataTransmit > Binary

Name	Date modified	Type	Size
SensorDataTransmit.bin	3/24/2025 3:14 PM	BIN File	70 KB

1.5 APIs

Detailed technical information about the APIs available to the user can be found in a compiled HTML file located inside the “Documentation” folder of the software package where all the functions and parameters are fully described.

1.6 Sample application description

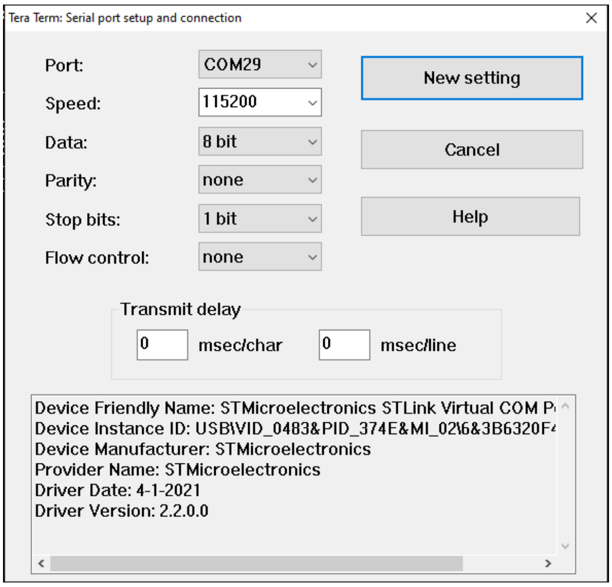
A sample application is provided in the projects folder for the:

- X-NUCLEO-BNRG2A1 expansion board connected to the NUCLEO-L476RG or NUCLEO-U575ZI-Q development board
- X-NUCLEO-WB05KN1 expansion board connected to the NUCLEO-U575ZI-Q development board
- STEVAL-MKBOXPRO Rev A, Rev B and Rev C evaluation boards

Ready to build projects are available for multiple IDEs.

You can set up a terminal window for the appropriate UART communication port to control the initialization phase.

Figure 4. Terminal settings


Tera Term: Serial port setup and connection

Port: COM29
Speed: 115200
Data: 8 bit
Parity: none
Stop bits: 1 bit
Flow control: none

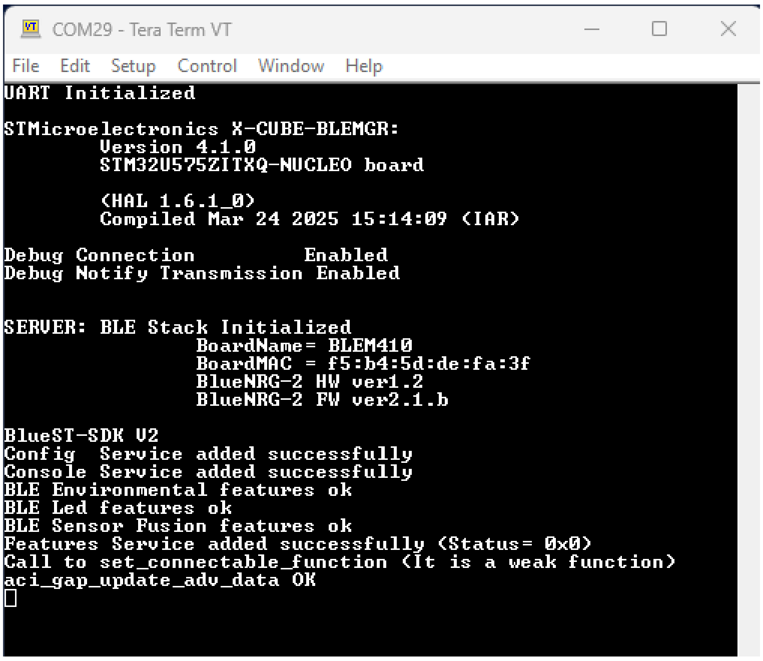
Transmit delay
0 msec/char 0 msec/line

```
Device Friendly Name: STMicroelectronics STLink Virtual COM P
Device Instance ID: USB\VID_0483&PID_374E&MI_02\6&3B6320F
Device Manufacturer: STMicroelectronics
Provider Name: STMicroelectronics
Driver Date: 4-1-2021
Driver Version: 2.2.0.0
```

When you first press the reset button on the NUCLEO-L476RG or NUCLEO-U575ZI-Q or STEVAL-MKBOXPRO development board, the application:

- starts initializing the UART
- determines which BlueNRG expansion board is connected to the STM32 Nucleo board
- recognizes the hardware and firmware version information
- shows a random Bluetooth® Low Energy MAC address
- initializes the Bluetooth® Low Energy feature service (temperature, humidity, pressure, LED, and SensorFusion characteristics)
- initializes the Bluetooth® Low Energy console service adding the stdin/stdout and stderr characteristics
- initializes the Bluetooth® Low Energy configuration service

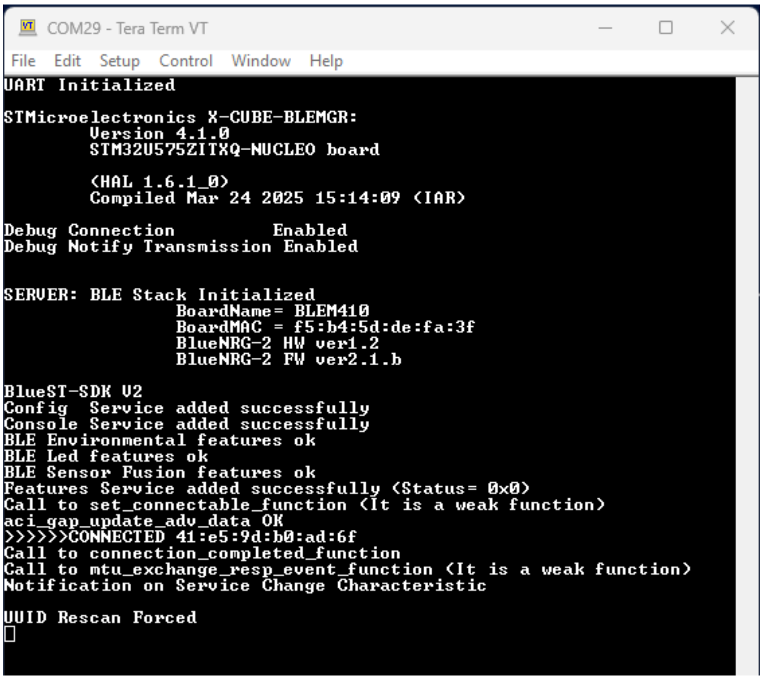
Figure 5. UART output initialization



```
UART Initialized

STMicroelectronics X-CUBE-BLEMGR:
        Version 4.1.0
        STM32U575ZITXQ-NUCLEO board

        (HAL 1.6.1_0)
        Compiled Mar 24 2025 15:14:09 (IAR)

Debug Connection         Enabled
Debug Notify Transmission Enabled


SERVER: BLE Stack Initialized
                BoardName= BLEM410
                BoardMAC = f5:b4:5d:de:fa:3f
                BlueNRG-2 HW ver1.2
                BlueNRG-2 FW ver2.1.b

BlueST-SDK V2
Config  Service added successfully
Console Service added successfully
BLE Environmental features ok
BLE Led features ok
BLE Sensor Fusion features ok
Features Service added successfully (Status= 0x0)
Call to set_connectable_function (It is a weak function)
aci_gap_update_adv_data OK
```

When an Android/iOS device is connected to the NUCLEO-L476RG or NUCLEO-U575ZI-Q or STEVAL-MKBOXPRO board, it is possible to control the data transmitted by the board.

Figure 6. UARTÂ output connected



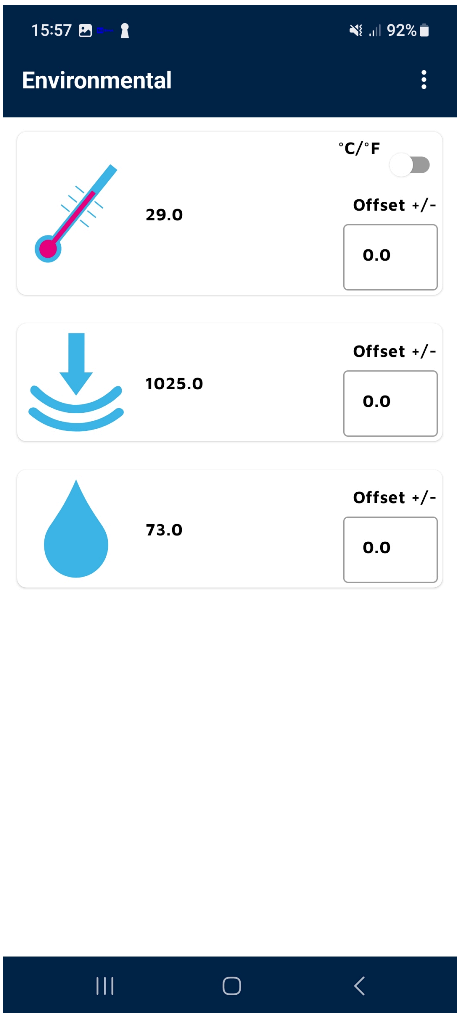
```
UART Initialized

STMicroelectronics X-CUBE-BLEMGR:
        Version 4.1.0
        STM32U575ZITXQ-NUCLEO board

        (HAL 1.6.1_0)
        Compiled Mar 24 2025 15:14:09 (IAR)

Debug Connection         Enabled
Debug Notify Transmission Enabled


SERVER: BLE Stack Initialized
                BoardName= BLEM410
                BoardMAC = f5:b4:5d:de:fa:3f
                BlueNRG-2 HW ver1.2
                BlueNRG-2 FW ver2.1.b

BlueST-SDK V2
Config  Service added successfully
Console Service added successfully
BLE Environmental features ok
BLE Led features ok
BLE Sensor Fusion features ok
Features Service added successfully (Status= 0x0)
Call to set_connectable_function (It is a weak function)
aci_gap_update_adv_data OK
>>>>>>CONNECTED 41:e5:9d:b0:ad:6f
Call to connection_completed_function
Call to mtu_exchange_resp_event_function (It is a weak function)
Notification on Service Change Characteristic

UUID Rescan Forced
```

1.7 Android and iOS STBLESensor client application

The X-CUBE-BLEMGR software for STM32Cube is compatible with the STBLESensor Android (version 5.0.0 or higher) or iOS (version 5.0.0 or higher) application available at Google Play or iOS stores. We use the Android application in this example.

After the connection, STBLESensor shows the main page below. It displays the random values of temperature, pressure, and humidity.

Figure 7. Environmental data



15:57

92%

Environmental

°C/°F

29.0

Offset +/-

0.0

1025.0

Offset +/-

0.0

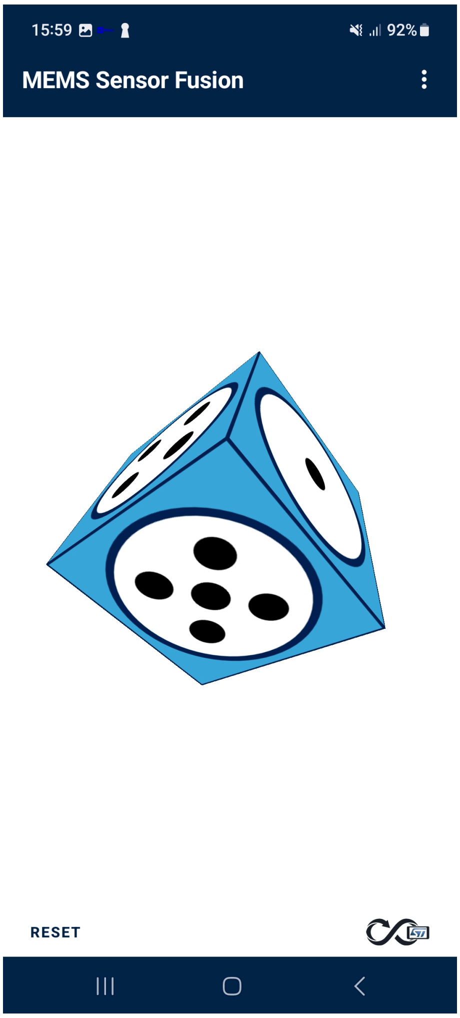
73.0

Offset +/-

0.0

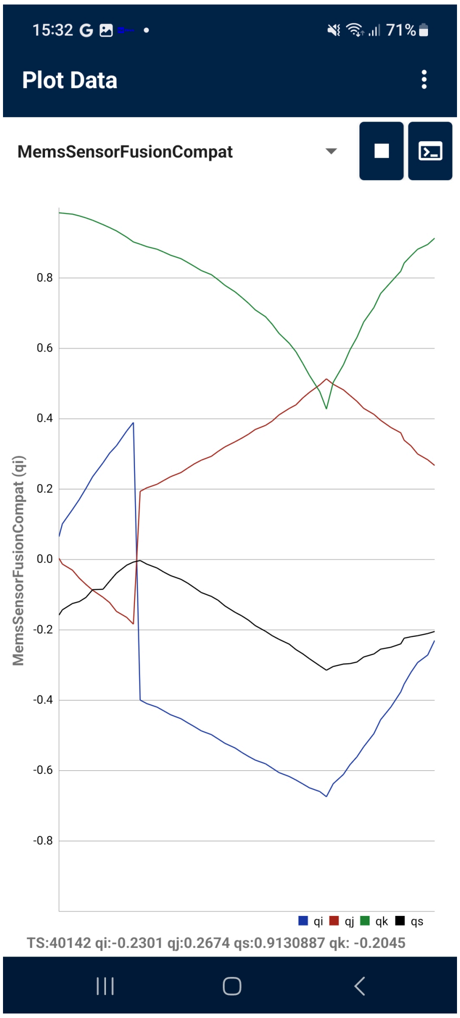
The following page shows a cube that rotates starting from the random quaternions values.

Figure 8. MEMS data



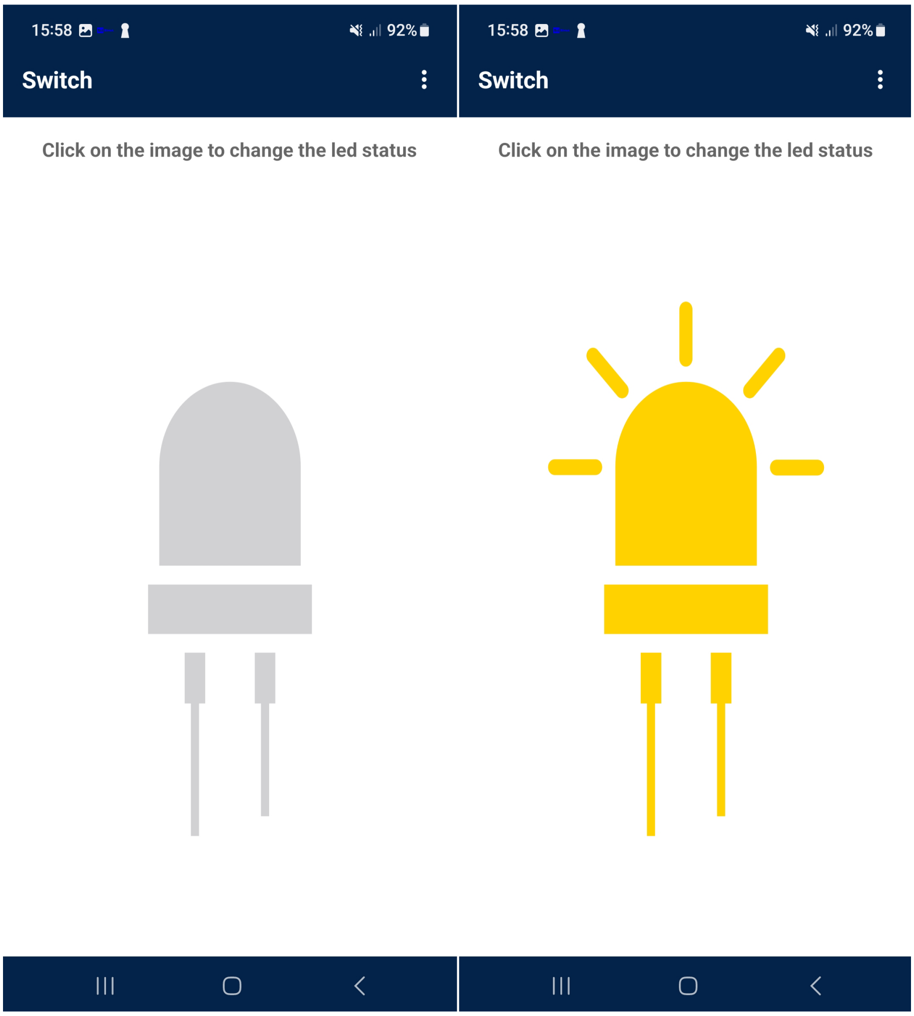
On the next page, you can plot any random value evaluated.

Figure 9. Plot data



TS:40142 qi:-0.2301 qj:0.2674 qs:0.9130887 qk: -0.2045

The following page shows the LED on/off control.



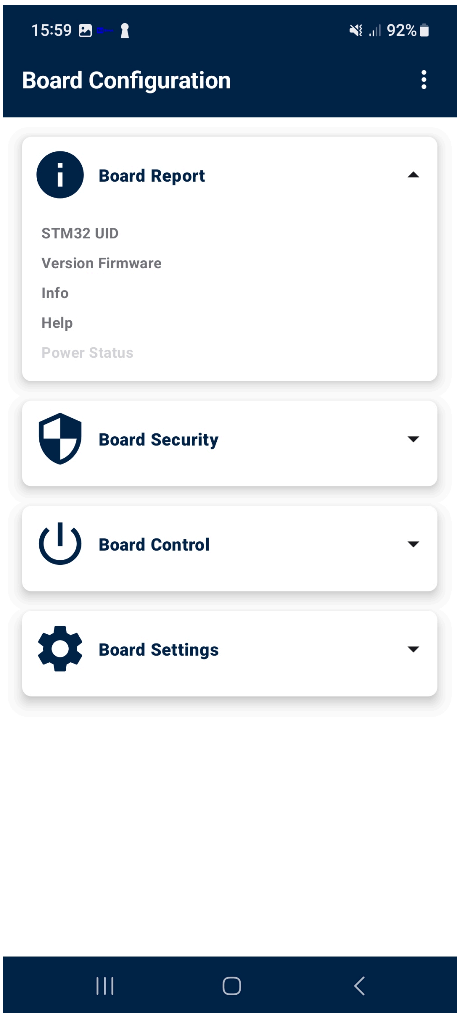
Click on the image to change the led status

Click on the image to change the led status

Figure 10. LED control

Through the board configuration page, you can see a few firmware details.

Figure 11. Board report (1 of 2)



15:59

92%

Board Configuration

Board Report

STM32 UID

Version Firmware

Info

Help

Power Status

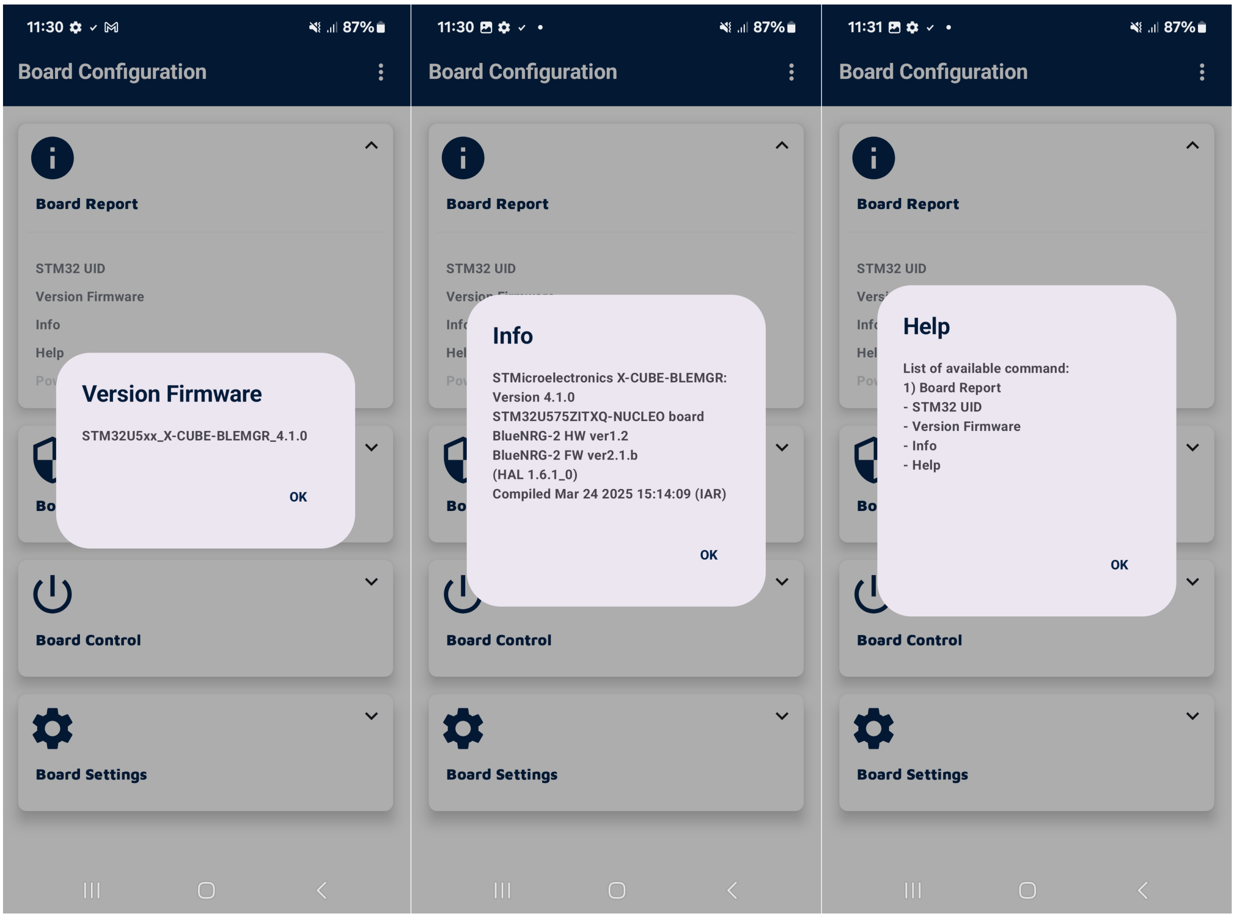
Board Security

Board Control

Board Settings

Note: *NOTE: Not available for X-NUCLEO-WB05KN1 due to memory constraint of the STM32WB05KN Bluetooth module.*

Figure 12. Board report (2 of 2)



Version Firmware

STM32U5xx_X-CUBE-BLEMGR_4.1.0

OK

Info

STMicroelectronics X-CUBE-BLEMGR:
Version 4.1.0
STM32U575ZITXQ-NUCLEO board
BlueNRG-2 HW ver1.2
BlueNRG-2 FW ver2.1.b
(HAL 1.6.1_0)
Compiled Mar 24 2025 15:14:09 (IAR)

OK

Help

List of available command:
1) Board Report
- STM32 UID
- Version Firmware
- Info
- Help

OK

Note: Not available for X-NUCLEO-WB05KN1 due to memory constraint of the STM32WB05KN Bluetooth module.

2 System setup guide

2.1 Hardware description

2.1.1 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.

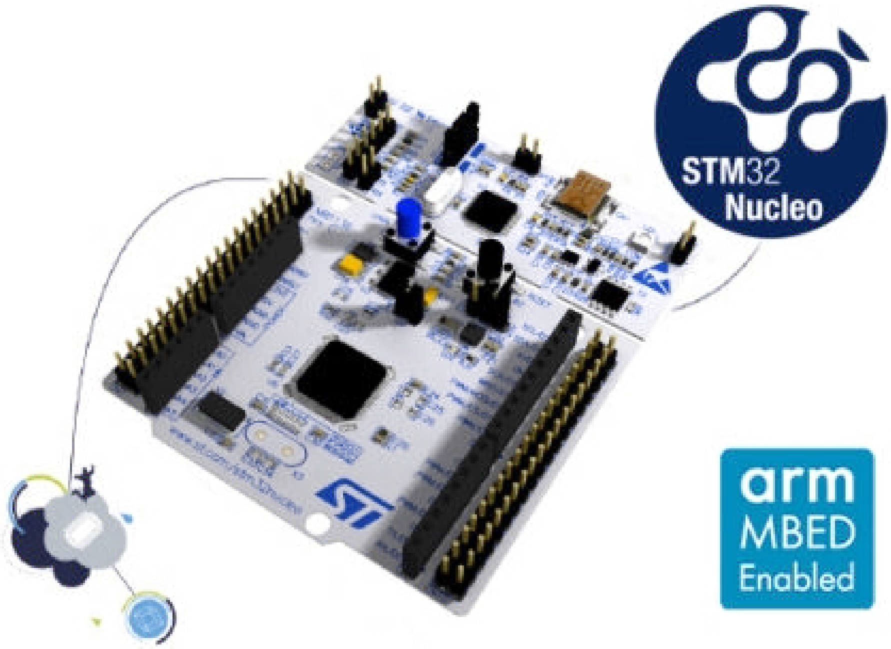
The Arduino connectivity support and ST morpho connectors make it easy to expand the functionality of the STM32 Nucleo open development platform with a wide range of specialized expansion boards to choose from.

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 13. **STM32 Nucleo board**



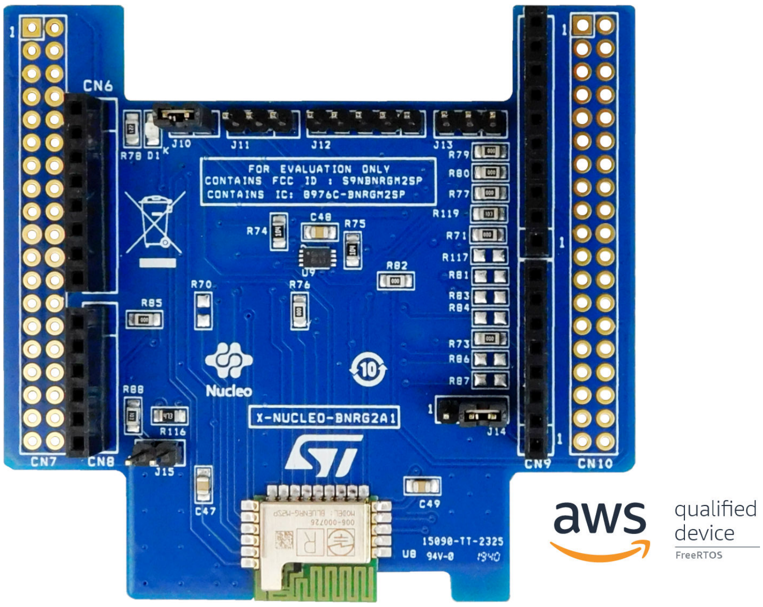
2.1.2 X-NUCLEO-BNRG2A1 expansion board

The X-NUCLEO-BNRG2A1 expansion board provides Bluetooth® Low Energy connectivity for developer applications and can be plugged onto an STM32 Nucleo development board (for example, NUCLEO-L476RG with an ultra-low power STM32 microcontroller) through its Arduino UNO R3 connectors.

The expansion board features the Bluetooth® v5.2 compliant and FCC certified BlueNRG-M2SP application processor module based on the ST BlueNRG-2 System-on-Chip. This SoC manages the complete Bluetooth® Low Energy stack and protocols on its Cortex-M0 core and programmable flash memory, which can accommodate custom applications developed using the SDK. The BlueNRG-M2SP module supports master and slave modes, increased transfer rates with data length extension (DLE), and AES-128 security encryption.

The X-NUCLEO-BNRG2A1 interfaces with the STM32 Nucleo microcontroller via SPI connections and GPIO pins, some of which can be configured through the hardware.

Figure 14. X-NUCLEO-BNRG2A1 BLE expansion board



2.1.3 X-NUCLEO-WB05KN1 expansion board

The X-NUCLEO-WB05KN1 expansion board provides Bluetooth® Low Energy connectivity for developer applications and can be plugged into an STM32 Nucleo development board (for example NUCLEO-U575ZI-Q) through its ARDUINO® Uno V3 connectors.

The expansion board features the Bluetooth® v5.4 compliant and FCC-certified STM32WB05KN. This SoC manages the complete Bluetooth® Low Energy stack and protocols on its Arm® Cortex®-M0+ core and programmable flash memory.

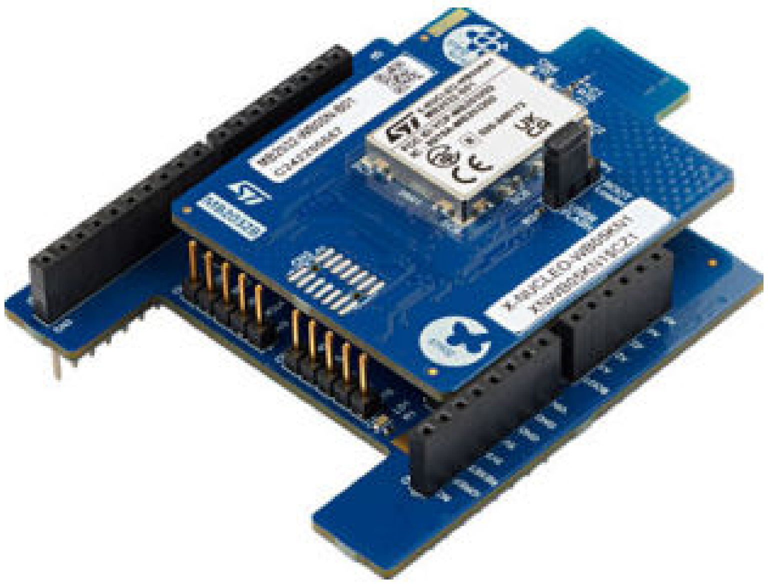
The STM32WB05KN supports central and peripheral modes and increased transfer rates with data length extension (DLE).

The X-NUCLEO-WB05KN1 interfaces with the STM32 Nucleo microcontroller via UART (default) with and without hardware flow control. Full duplex SPI with an interrupt line is also available. The firmware loaded on the module defines the host interface and, to modify it, simply changes the firmware without modifying the hardware.

Table 1. Board description for X-NUCLEO-WB05KN1

Order code	Board references	Description
X-NUCLEO-WB05KN1	MB2160	ARDUINO® interface board
	MB2032	MCU RF mini board

Figure 15. **X-NUCLEO-WB05KN1 Bluetooth LE expansion board**



*X-NUCLEO-WB05KN1 global view.
Picture is not contractual.*

Information about the X-NUCLEO-WB05KN1 expansion board is available at http://www.st.com/x-nucleo.

2.1.4 STEVAL-MKBOXPRO evaluation kit

The STEVAL-MKBOXPRO (SensorTile.box PRO) is the new ready-to-use programmable wireless box kit for developing any IoT application based on remote data gathering and evaluation, exploit the full kit potential by leveraging both motion and environmental data sensing, along with a digital microphone, and enhance the connectivity and smartness of whatever environment you find yourself into.

You can entirely enjoy the SensorTile.box PRO experience regardless of your level of expertise, the box kit could be exploited according to three different modalities:

Entry mode: run a wide range of already embedded IoT applications on your box.

You can download the free STBLESensor App on your smartphone and immediately begin commanding the board with any of the following applications that have been specifically designed to work with the board sensors:

1) Motion: Compass, Free-fall detection, Level, Pedometer, Sensor-fusion - Quaternion

2) Environmental: Barometer

3) Log: Data recorder

4) AI and MLC: Baby crying detector, Human activity recognition

5) User interface: Qtouch

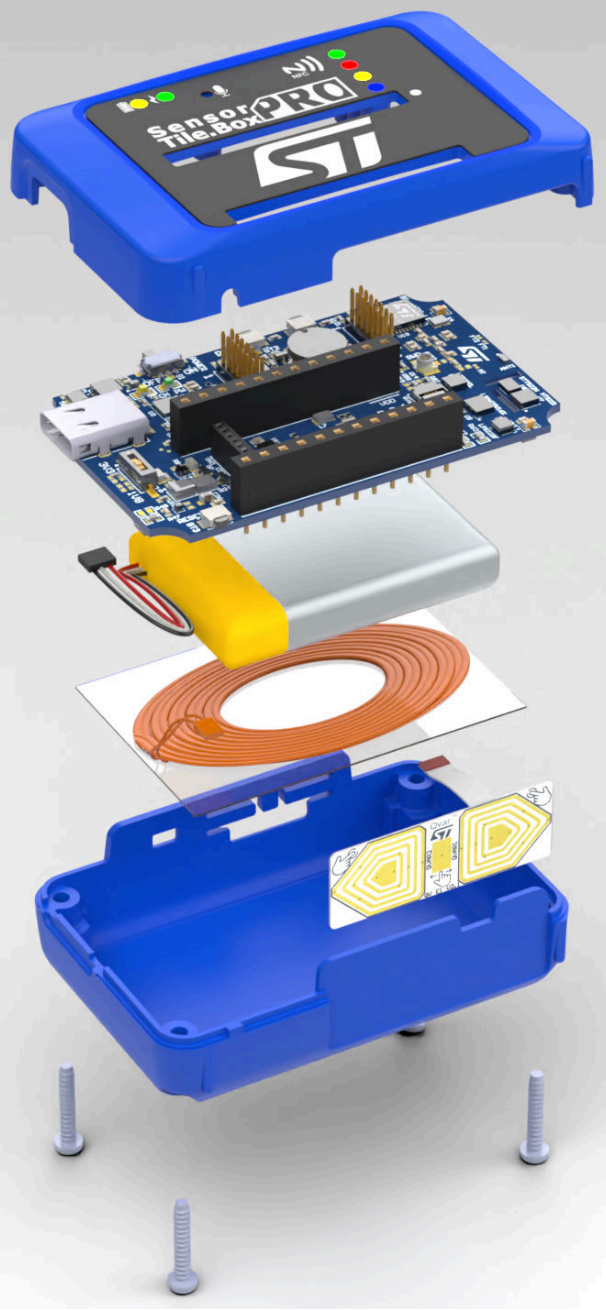
6) Connectivity: NFC Tag

Expert mode: build custom applications through the STBLESensor App by selecting specific input data and operating parameters from corresponding available in-box sensors, functions to assess/compute those data, and output types that you need, while leveraging on the available powerful algorithms.

Pro mode: develop quickly your own tailored IoT application taking advantage of STM32 open development environment (ODE) and ST function pack libraries, including sensing AI function pack with neural network libraries, without the need to perform any coding activity.

The SensorTile.box PRO board fits into a small plastic box with a long-life 480mAh rechargeable battery, for the first time leveraging also on a wireless charger and a programmable NFC tag. The board can be easily connected via Bluetooth to the ST BLE Sensor app on your smartphone, from which the box kit can be enjoyed in Entry and Expert mode. In Pro mode, professional users can exploit the firmware programming and debugging interface in the STM32 ODE for developing their firmware from scratch.

Figure 16. STEVAL-MKBOXPRO evaluation kit



2.2 Hardware setup

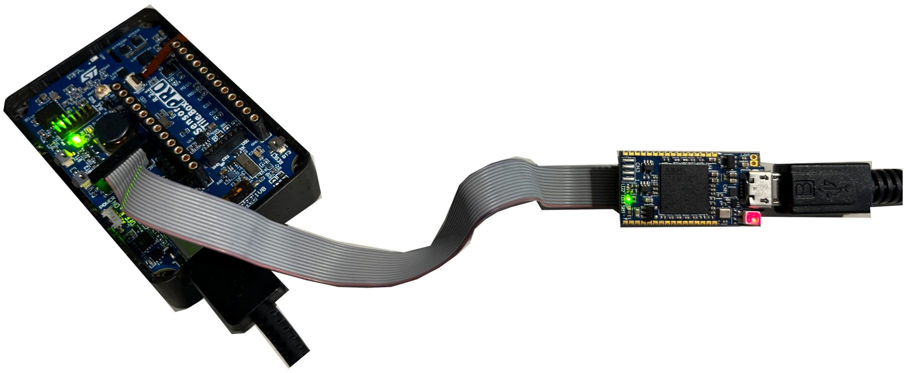
The following hardware components are needed:

1. One STM32 Nucleo development platform (order code: NUCLEO-L476RG or NUCLEO-U575ZI-Q)
2. One Bluetooth® Low Energy expansion board (order code: X-NUCLEO-BNRG2A1 or X-NUCLEO-WB05KN1)
3. Cable to connect the STM32 Nucleo to the PC

The following hardware components are needed for STEVAL-MKBOXPRO:

- One SensorTile.box-Pro evaluation kit (order code: STEVAL-MKBOXPRO)
- One STLINK-V3SET (or STLINK-V3SET) debugger/programmer
- One USB type A to Micro-B USB cable to connect the STLINK-V3SET to the PC or one USB type A to USB type C cable to connect the STLINK-V3MINIE to the PC
- One type-C USB cable to connect the STEVAL-MKBOXPRO to the PC

Figure 17. **STWIN.box+STLinkV3_Mini setup**



2.3 Software setup

The following software components are required to set up a suitable development environment for creating applications for the STM32 Nucleo equipped with the sensors and the BlueNRG expansion board:

- X-CUBE-BLEMGR: the Bluetooth® Low Energy manager software for STM32Cube. The X-CUBE-BLEMGR firmware and related documentation is available on www.st.com.
- Development tool-chain and Compiler: the STM32Cube expansion software supports the three following environments:
  - IAR Embedded Workbench for Arm (IAR-EWARM) toolchain + ST-LINK
  - RealView Microcontroller Development Kit (MDK-ARM-STM32) toolchain + ST-LINK
  - STM32CubeIDE + ST-LINK

After choosing one of the integrated development environments supported by the STM32Cube expansion software, follow the system requirements and setup information provided by the selected IDE provider.

2.4 System setup

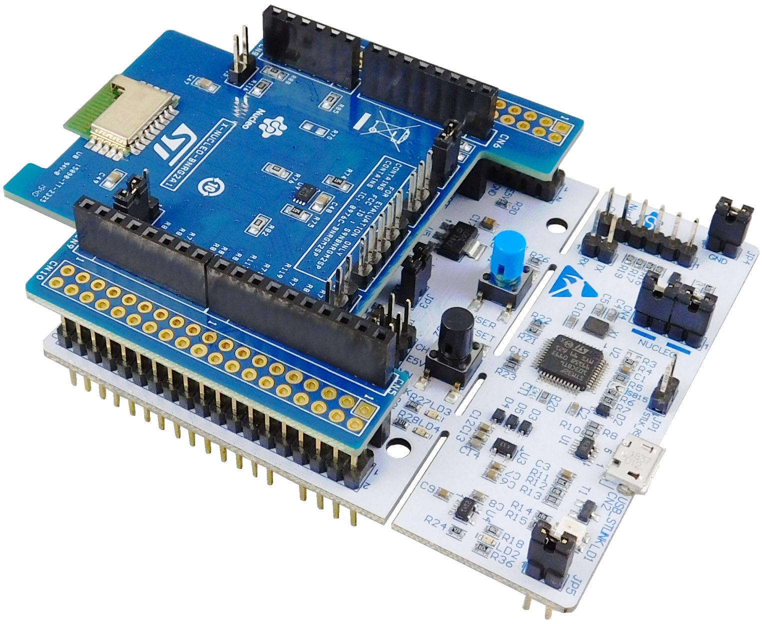
2.4.1 STM32 Nucleo and sensor expansion board setup

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

The developer can download the relevant version of the ST-LINK/V2-1 USB driver from STSW-LINK009.

The X-NUCLEO-BNRG2A1 BlueNRG Bluetooth® Low Energy expansion board can be easily connected to the STM32 Nucleo through the Arduino UNO R3 extension connector as shown in the figure below.

Figure 18. **X-NUCLEO-BNRG2A1 and NUCLEO-L476RG**



2.4.2 X-NUCLEO-BNRG2A1 setup

The procedure described below is required to make the BlueNRG-2 library correctly work with the firmware embedded in the X-NUCLEO-BNRG2A1 Bluetooth® Low Energy module.

Step 1. Solder a 0 Ohm resistor to R117 on the X-NUCLEO-BNRG2A1 expansion board.

Step 2. Update the X-NUCLEO-BNRG2A1 Bluetooth® Low Energy module through the ST-LINK/V2-1 and the STSW-BNRGFLASHER flasher utility.

Step 3. Connect the X-NUCLEO-BNRG2A1 J12 pins to the ST-LINK/V2-1 pins through the 5-wire cable included as shown in the picture below and detailed in Table 2.

Figure 19. Connection between X-NUCLEO-BNRG2A1 expansion board and ST-LINK/V2-1

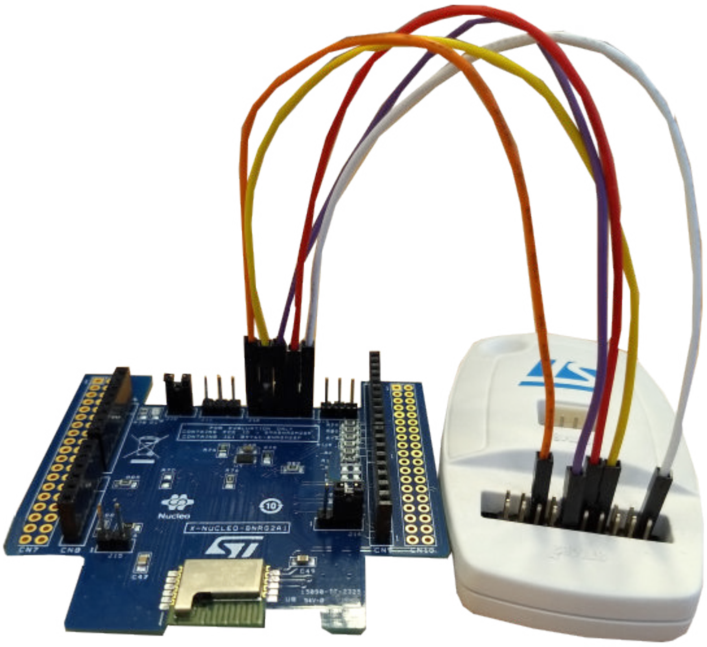


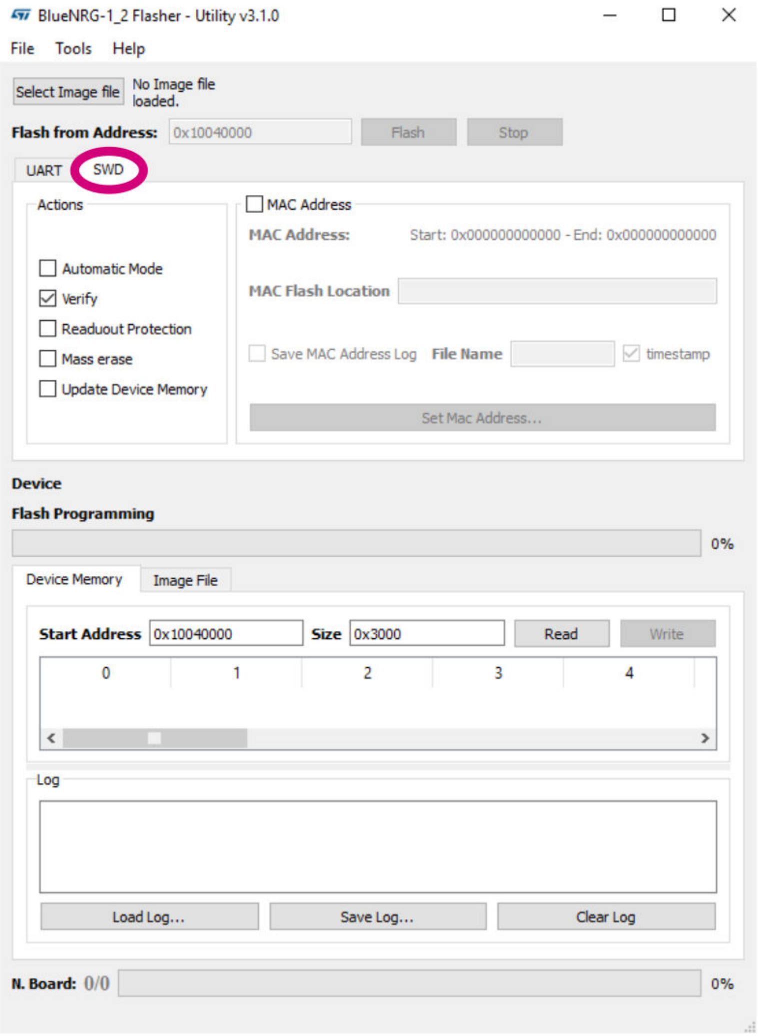
Table 2. X-NUCLEO-BNRG2A1 and ST-LINK/V2-1 pin connections

X-NUCLEO-BNRG2A1 J12 pin no.	ST-LINK/V2-1 pin no.
1	1
2	9
3	12
4	7
5	15

Step 4. Install the STSW-BNRGFLASHER and open it.

Step 5. Select the SWD tab.

Figure 20. **STSW-BNRGFLASHER - SWD tab**



No Image file loaded.

Flash from Address: 0x10040000

□ Automatic Mode
☑ Verify
□ Readuout Protection
□ Mass erase
□ Update Device Memory

□ MAC Address

MAC Address: Start: 0x000000000000 - End: 0x000000000000

MAC Flash Location

□ Save MAC Address Log **File Name** ☑ timestamp

0%

Start Address 0x10040000 **Size** 0x3000

N. Board: 0/0 0%

Step 6. Erase the BlueNRG-2 flash memory.

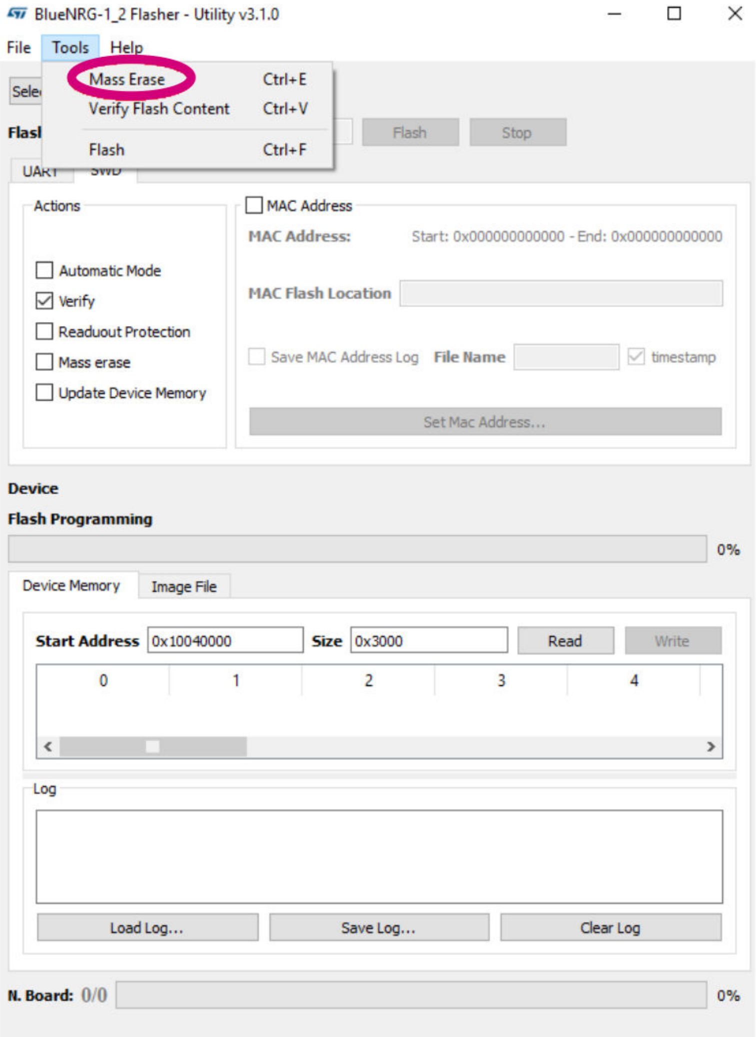
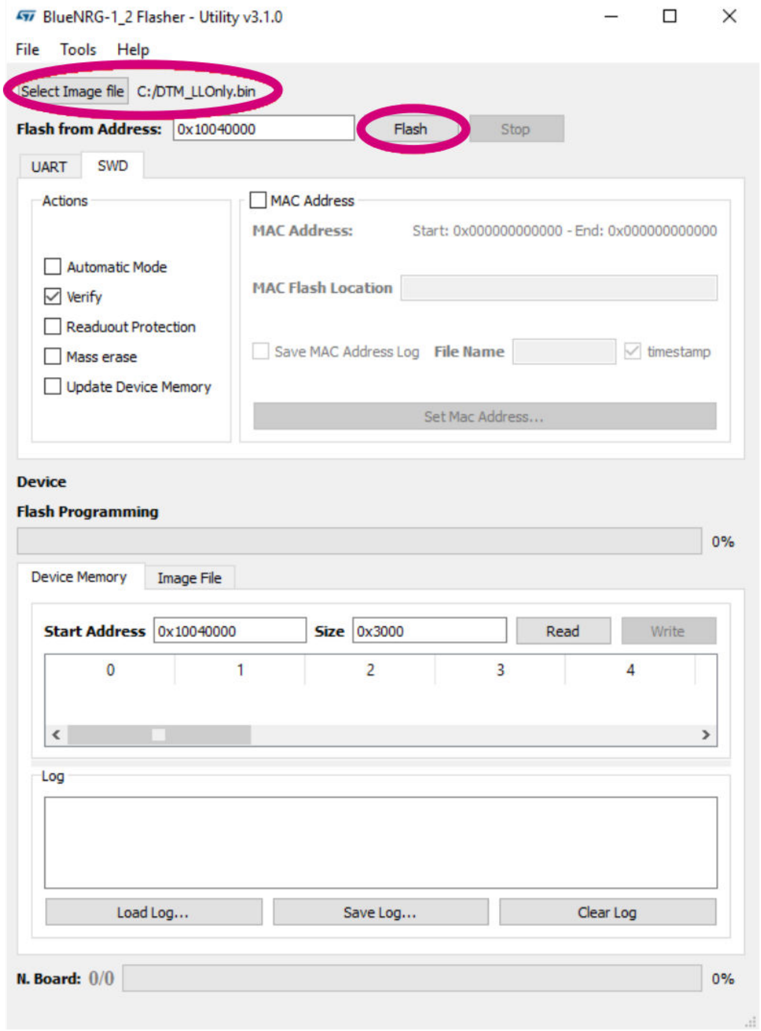


Figure 21. **STSW-BNRGFLASHER - mass erase**

Step 7. Download the Link Layer Only firmware for the Bluetooth® Low Energy module.

Step 8. Load the Link Layer Only firmware into the STSW-BNRGFLASHER and press the [**Flash**] button.



Select Image file C:/DTM_LLOnly.bin

Flash from Address: 0x10040000

□ Automatic Mode
☑ Verify
□ Readuout Protection
□ Mass erase
□ Update Device Memory

□ MAC Address
MAC Address: Start: 0x000000000000 - End: 0x000000000000
MAC Flash Location
□ Save MAC Address Log File Name ☑ timestamp

Flash Programming 0%

Start Address 0x10040000 Size 0x3000

0	1	2	3	4

N. Board: 0/0 0%

Figure 22. **STSW-BNRGFLASHER - Flash button**

Step 9. To restore the X-NUCLEO-BNRG2A1 Bluetooth® Low Energy module embedded firmware, repeat the procedure using the following firmware image: DTM_Full.bin.

In case of issues during the update process, close the X-NUCLEO-BNRG2A1 J15 jumper before repeating the procedure.

2.4.3 X-NUCLEO-WB05KN1 setup

The firmware of X-NUCLEO-WB05KN1 to be upgraded with latest BLE_Transparent_Mode_STM32WB05_location_essential binary images present in X-CUBE-WB05N_V2.0.0/ Utilities/BLE_Transparent_Mode_STM32WB05_location_essential folder.

Thanks to refer to UM3406/section 3.3 for steps to upgrade the X-NUCLEO-WB05KN1 firmware.

Depending on the use case the user can select between UART/SPI image:

- For SPI - select BLE_TransparentMode_SPI_with_Updater.hex image present in \Utilities\BLE_Transparent_Mode_STM32WB05_location_essential\SPI folder
- For UART - select BLE_TransparentMode_UART_with_Updater.hex image present in \Utilities\BLE_Transparent_Mode_STM32WB05_location_essential\UART folder

Revision history

Table 3. **Document revision history**

Date	Revision	Changes
04-Jul-2022	1	Initial release.
06-Jun-2023	2	Updated Overview. Added compatibility to STM32CubeMX.
07-Nov-2023	3	Updated *Section 1.4 The installation process, Section 1.6 Sample application description* and *Section 1.7 Android and iOS STBLESensor client application*.
13-Nov-2024	4	Updated Section 1.1: Overview, Section 1.2: Architecture, Section 1.3: Folder structure, Section 1.4: The installation process, Section 1.6: Sample application description and Section 2.2: Hardware setup. Added Section 2.1.2: X-NUCLEO-BNRG2A1 expansion board.
18-Jun-2025	5	Updated Section Introduction, Section 1.1: Overview, Section 1.3: Folder structure, Section 1.4: The installation process, Section 1.7: Android and iOS STBLESensor client application, Section 2.2: Hardware setup, .Added Section 2.1.3: X-NUCLEO-WB05KN1 expansion board and Section 2.4.3: X-NUCLEO-WB05KN1 setup.

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