Quick Start Guide
STM32Cube function pack for creating a BLE star network connected via Wi-Fi to IBM Watson IoT cloud (FP-NET-BLESTAR1)
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FP-NET-BLESTAR1 STM32Cube function pack for creating a BLE star network connected via Wi-Fi to IBM Watson IoT cloud
Hardware and Software overview

Setup & Demo Examples
Documents & Related Resources

STM32 Open Development Environment: Overview
Hardware Description
• The X-NUCLEO-IDB05A1 is a Bluetooth Low Energy (BLE) evaluation and development board system, designed around ST’s SPBTLE-RF Bluetooth Low Energy module based on BlueNRG-MS.
• The BlueNRG-MS processor hosted in the SPBTLE-RF module communicates with the STM32 Nucleo developer board host microcontroller though an SPI link available on the Arduino UNO R3 connector.

Key Products on board

SPBTLE-RF

SPBTLE-RF integrates a BALF-NRG-01D3 balun and a chip antenna. It embeds 32 MHz and 32.768 kHz crystal oscillators for the BlueNRG-MS.

M95640-R
64-Kbit serial SPI bus EEPROM with high-speed clock interface
Hardware Description

- To avoid potential issues at high power level, it is highly recommended to use the X-NUCLEO-IDB05A1 with the writing, on the back of the BlueNRG-MS module, indicating the model and the FCCID (as shown in the red box).
Hardware Description

The X-NUCLEO-IDW01M1 is a Wi-Fi evaluation board based on the SPWF01SA module, which expands the STM32 Nucleo boards. The CE, IC and FCC certified SPWF01SA module has an embedded STM32 MCU, a low-power Wi-Fi b/g/n SoC with integrated power amplifier and power management and an SMD antenna. The SPWF01SA module communicates with the STM32 Nucleo developer board host microcontroller though an USART link available on the Arduino UNO R3 connector.

Main Features:
- X-NUCLEO-IDW01M1 hosts FCC, IC and CE certified SPWF01SA module (FCC ID: VRA-SG9011203, IC: 7420A-SG9011203 and ETSI compliant)
- SPWF01SA module major characteristics:
  - Compatible with STM32 Nucleo boards
  - Equipped both with ST morpho connector and Arduino UNO R3 connectors
  - Scalable solution; it can cascade multiple boards for larger systems
  - Free development firmware library and examples, compatible with STM32Cube
  - RoHS compliant

Key Products on board

**SPWF01SA**
ST SPWF01Sx module, 802.11 b/g/n compliant

Latest info available at www.st.com

X-NUCLEO-IDW01M1
STM32L4 Discovery Board for IoT node (B-L475E-IOT01A)

Hardware Description

The STM32L4 Discovery kit for the IoT node (B-L475E-IOT01A) allows users to develop applications with direct connection to cloud servers. The STM32L4 Discovery kit enables a wide diversity of applications by exploiting low-power multilink communication (BLE, Sub-GHz), multiway sensing (detection, environmental awareness) and ARM® Cortex®-M4 core-based STM32L4 Series features. Arduino™ Uno V3 and PMOD connectivity provide unlimited expansion capabilities with a large choice of specialized add-on boards.

Key Product on board

- Ultra-low-power STM32L4 Series MCUs based on ARM® Cortex®-M4 core with 1 Mbyte of Flash memory and 128 Kbytes of SRAM, in LQFP100 package
- Bluetooth® V4.1 module (SPBTLE-RF)
- Sub-GHz (868 or 915 MHz) low-power-programmable RF module (SPSGRF-868 or SPSGRF-915)
- Wi-Fi® module InvenTek ISM43362-M3G-L44 (802.11 b/g/n compliant)
- Dynamic NFC tag based on M24SR with its printed NFC antenna
- 2 digital omnidirectional microphones (MP34DT01)
- Capacitive digital sensor for relative humidity and temperature (HTS221)
- High-performance 3-axis magnetometer (LIS3MDL), 3D accelerometer and 3D gyroscope (LSM6DSL), 260-1260 hPa absolute digital output barometer (LPS22HB), Time-of-Flight and gesture-detection sensor (VL53L0X)
- USB OTG FS with Micro-AB connector
- Expansion connectors: Arduino™ Uno V3, PMOD
- Flexible power-supply options: ST LINK USB VBUS or external sources
- On-board ST-LINK/V2-1 debugger/programmer with USB re-configuration capability: mass storage, virtual COM port and debug port

Latest info available at www.st.com B-L475E-IOT01A
FP-NET-BLESTAR1 Software Description

FP-NET-BLESTAR1 is an STM32 Cube function pack which lets you connect your IoT node in a BLE sensor network to the Internet via a Wi-Fi network. Sensor data from a device in the BLE star network can be transparently sent to the IBM Watson IoT cloud platform and visualized on a client connected to the cloud.

The software, together with the suggested combination of STM32 and ST devices, can be used, for example, to develop smart home or remote monitoring applications. The included sample application configures either a STM32 Nucleo board (equipped with the Wi-Fi and BLE expansion boards) or a STM32L4 Discovery Board (equipped with the BLE expansion board) as a BLE master connected to several peripherals, or nodes, in a star network topology.

The software runs on the STM32 microcontroller and includes drivers to exploit the functionality of the X-NUCLEO-IDB05A1 Bluetooth low energy expansion board based on the SPBTLE-RF module, and the X-NUCLEO-IDW01M1 Wi-Fi expansion board based on the SPWF01SA module. The driver for the WiFi ISM43362-M3G-L44 (from Inventek Systems), mounted on the B-L475E-IOT01A Discovery Kit, is also provided.

Key features

- Complete firmware to build applications based on BLE and Wi-Fi connectivity, allowing either a STM32 Nucleo board or a STM32L4 Discovery Board to connect with both BLE-enabled smartphones/tablets and cloud-based services
- Integrated MQTT protocol middleware for easy access to Watson IoT cloud services provided by IBM
- Sample application for NUCLEO-F401RE (with X-NUCLEO-IDB05A1 and X-NUCLEO-IDW01M1 expansion boards) and B-L475E-IOT01A (with X-NUCLEO-IDB05A1 expansion board), which behave simultaneously as BLE master and slave,
- Compatible with BLE sensors nodes implemented using the FP-SNS-ALLMEMS1, FP-SNS-FLIGHT1 and FP-SNS-MOTENV1 function packs
- Compatible with the SensNet application for Android™/iOS™ devices to control the BLE star network and to display the data sent by the slave nodes
- Easy portability across different MCU families, thanks to STM32Cube
- Free, user-friendly license terms

Overall Software Architecture

<table>
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<th>BLESTAR1</th>
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<td>STM32Cube Hardware Abstraction Layer (HAL)</td>
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<td>STM32 Nucleo expansion boards X-NUCLEO-IDB05A1 (Connect) X-NUCLEO-IDW01M1 (Connect)</td>
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Latest info available at www.st.com

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HW prerequisites for the Central Node 1/3

• 1x Bluetooth Low Energy expansion board (X-NUCLEO-IDB05A1)

  Note: To avoid potential issues at high power level, it is highly recommended to use the X-NUCLEO-IDB05A1 with the writing, on the back of the BlueNRG-MS module, indicating the model and the FCCID (as shown in the red box)

• 1x Wi-Fi expansion board (X-NUCLEO-IDW01M1)

  Notes:
  • Jumper on position JP3 (middle and bottom) is required
  • Jumper on position JP4 (middle and left) is required
  • To achieve best results while debugging, it is highly recommended to remove the R21 resistor

• 1x STM32 Nucleo development board (NUCLEO-F401RE)

• 1x PC with Windows 7, 8 or 10

• 1x USB type A to Mini-B USB cable
Configuration for the central node alternative to one in the previous slide

- 1x Bluetooth Low Energy expansion board (**X-NUCLEO-IDB05A1**)
  
  **Note 1**: To avoid potential issues at high power level, it is highly recommended to use the X-NUCLEO-IDB05A1 with the writing, on the back of the BlueNRG-MS module, indicating the model and the FCCID (as shown in the red box)

  **Note 2**: Since the X-NUCLEO-IDB05A1 is not fully Arduino compatible, a small HW patch is needed. This patch consists in removing zero resistor R4 and instead soldering zero resistor R6. Alternatively pins D13 and D3 must be bridged.

- 1x STM32L4 Discovery Board for IoT node (**B-L475E-IOT01A**)

- 1x PC with Windows 7, 8 or 10

- 1x USB type A to micro USB cable
## Setup & Demo Examples

### HW prerequisites for the Central Node 3/3

| Additional requirements |
|--------------------------|-----------------|-----------------|
| **PC**                   | **Router**      | **Tablet/Smartphone (**)** |
| Tera Term terminal (*) running on PC | Router with internet connection | Android/iOS device with STSensNet app installed |

(*) or equivalent terminal  
(**) Android™ ≥ v4.3 or iOS™ ≥ 8.0

### Summary of the possible Central Node hw configurations

<table>
<thead>
<tr>
<th>Using the Nucleo-F401RE</th>
<th>Using the B-L475E-IOT01A</th>
</tr>
</thead>
</table>

**Note:**  
Plug the boards with X-NUCLEO-DB05A1 on top to optimize the performance of the SPBTLE-RF module

**Note:** remove zero resistor R4 and instead solder zero resistor R6 on the X-NUCLEO-IDB05A1. Alternatively, bridge pins D13 and D3.
The following Function Packs, available on www.st.com, can be used as nodes to be connected to the Central Node:

- FP-SNS-ALLMEMS1 V3.2.0 or higher
- FP-SNS-FLIGHT1 V3.1.0 or higher
- FP-SNS-MOTENV1 V3.1.0 or higher

The reference versions of these packages are reported in the Release_Notes and readme files of the FP-NET-BLESTAR1 package.

The binary files of these packages are also included in folder Utilities\Node_Firmware.
Setup & Demo Examples

HW prerequisites for the ALLMEMS1 Peripheral Nodes (2/4)

- Bluetooth Low Energy expansion board (X-NUCLEO-IDB05A1)
  
  **NOTE:** To avoid potential issues at high power level, it is highly recommended to use the X-NUCLEO-IDB05A1 with the writing, on the back of the BlueNRG-MS module, indicating the model and the FCCID (as shown in the red box).

- MEMS and Environmental Sensors expansion board (X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2)

- MEMS Microphone expansion board (X-NUCLEO-CCA02M1)

- STM32 Nucleo development board (NUCLEO-F401RE or NUCLEO-L476RG)

- USB type A to Mini-B USB cable

**Note:** Plug the boards using this sequence to optimize the performance of the SPBTLE-RF module within X-NUCLEO-IDB05A1
Setup & Demo Examples

HW prerequisites for the FLIGHT1 Peripheral Nodes (3/4)

- Bluetooth Low Energy expansion board (X-NUCLEO-IDB05A1)
  
  **NOTE:** To avoid potential issues at high power level, it is highly recommended to use the X-NUCLEO-IDB05A1 with the writing, on the back of the BlueNRG-MS module, indicating the model and the FCCID (as shown in the red box).

- MEMS and Environmental Sensors expansion board (X-NUCLEO-IKS01A1)

- Proximity and Ambient Light sensor expansion board (X-NUCLEO-6180XA1 or X-NUCLEO-53L0A1)

- STM32 Nucleo development board (NUCLEO-F401RE or NUCLEO-L476RG)

- USB type A to Mini-B USB cable

**Note:** Plug the boards using this sequence to optimize the performance of the SPBTLE-RF module within X-NUCLEO-IDB05A1
Setup & Demo Examples

HW prerequisites for the MOTENV1 Peripheral Nodes (4/4)

• Bluetooth Low Energy expansion board (X-NUCLEO-IDB05A1)
  
  NOTE: To avoid potential issues at high power level, it is highly recommended to use the X-NUCLEO-IDB05A1 with the writing, on the back of the BlueNRG-MS module, indicating the model and the FCCID (as shown in the red box).

• MEMS and Environmental Sensors expansion board (X-NUCLEO-IKS01A1 + STEVAL-MKI160V1 (optional) or X-NUCLEO-IKS01A2)

• STM32 Nucleo development board (NUCLEO-F401RE, NUCLEO-L053R8 or NUCLEO-L476RG)

• USB type A to Mini-B USB cable

Note: Plug the boards using this sequence to optimize the performance of the SPBTLE-RF module within X-NUCLEO-IDB05A1
Setup & Demo Examples
SW prerequisites

- **STSW-LINK009**
  - ST-LINK/V2-1 USB driver

- **STSW-LINK007**
  - ST-LINK/V2-1 firmware upgrade

- **Flash Updater Tool**
  - Tool to upgrade the BlueNRG firmware on the X-NUCLEO-IDB05A1 expansion boards to the latest version 7.2c (tool and instructions on how to upgrade the BlueNRG firmware can be found in package X-CUBE-BLE1 in folder Utilities\PC_Software\FlashUpdaterTool).

- **FP-NET-BLESTAR1**
  - Copy the .zip file content into a folder on your PC. The package will contain source code example (Keil, IAR, System Workbench) based on NUCLEO-F401RE and B-L475E-IOT01A

- **ST SensNet Application for** [Android/iOS]
FP-NET-BLESTAR1

Start coding in few minutes (1/2)

- Flash all peripheral nodes with the firmware included in Utilities\Node_Firmware
  - Flash *F401RE*.bin on Nucleo-F401RE
  - Flash *L053R8*.bin on Nucleo-L053R8
  - Flash *L476RG*.bin on Nucleo-L476RG
- Flash the Central node with the firmware in Projects<Board_Name>\Applications\BLESTAR1\Binary\ (for browsing/editing/building the application code see next slide)
- Download and install the STSensNet app available both on the Google Store and on the Apple Store on the Android/iOS BLE Client

**Note**: To flash the firmware on a STM32 Nucleo board, connect it to the PC and copy and paste the *.bin file on the virtual file system of the board.
FP-NET-BLESTAR1
Start coding in few minutes (2/2)

1. Go to www.st.com/stm32ode-fp

2. Select FP-NET-BLESTAR1

3. Download & unpack FP-NET-BLESTAR1

FP-NET-BLESTAR1 package structure

- _htmresc
- Documentation
- Drivers
- Middlewares
- Projects
- Utilities
- readme.txt
- Release_Notes.html

Docs
BSP, HAL and Drivers
BlueNRG, Wi-Fi
Application example
Peripheral Nodes FW

4. Download and install STM32 Nucleo ST-LINK/V2-1 USB driver

5. Open project example BLESTAR1

6. Modify and build the application
Network Architecture

- **Cloud Connected Client**
- **Wi-Fi connection**
- **BLE connection**

**IBM Watson IoT Cloud Platform**

- **Wi-Fi Access Point**
- **BLE Peripheral Node #1**
- **BLE Peripheral Node #2**
- **BLE Peripheral Node #3**
- **BLE Peripheral Node #4**
- **BLE Peripheral Node #5**
- **BLE Peripheral Node #6**
- **BLE Central Node & BLE Slave (for the Android/iOS BLE Client)**

**Android/iOS BLE Client**
Configure the serial line monitor (speed, data, parity, LF, ...).

![Tera Term Serial port setup window]

- **Port**: COM22
- **Baud rate**: 115200
- **Data**: 8 bit
- **Parity**: none
- **Stop**: 1 bit
- **Flow control**: none

**Transmit delay**:
- 0 msec/char
- 0 msec/line

**USB type A to Mini-B USB cable**
Using serial line monitor – e.g. Tera Term (2/3)

Turn on all BLE peripheral nodes, connect the BLE Central node and open the serial terminal to manage operations on the Central. Then follow next steps.

Pressing the **RESET** button on STM32 Nucleo, the Wi-Fi configuration phase starts. By keeping pressed the **USER** button for 5 seconds, the user can set the SSID, password and encryption mode. Otherwise the default values saved on flash will be used.

After configuration is complete, the Wi-Fi initialization starts: the network is scanned, the STM32 Nucleo connects first to the AP and then to the IBM Watson IoT Cloud platform. On the serial console the URL of the IBM Cloud web page is shown (see the yellow box).
Using serial line monitor – e.g. Tera Term (3/3)

Once all Wi-Fi steps are completed, the BLE discovery process starts and the following steps are executed.

1. The Central node scans the network. If a BLE peripheral node (running the firmware in Utilities\Node_Firmware) is found, the Central node establishes a connection with it.

2. Once a peripheral node is connected, the Central node starts the discovery phase of the peripheral node BLE Services and Characteristics.

3. Once the peripheral node BLE Services and Characteristics are discovered, the Central node starts receiving sensor data from the peripheral node.

4. Once all data are received, the steps 1-3 above are repeated until all the peripheral nodes are connected.
Data received by the Central node from peripheral nodes are sent to the IBM Watson IoT Cloud Platform and can be remotely controlled by means of a cloud connected client at the URL shown during the Wi-Fi initialization phase on the serial console.
After starting to receive data from a peripheral node, the STM32 development board, acting simultaneously as BLE Master and Slave, is able to accept connection from a BLE client (an Android/iOS device).

After downloading and installing the STSensNet app available both on the Google Store and on the Apple Store, the Android/iOS device can be used to locally monitor and control the BLE network.

- Enable/Disable the peripheral nodes scanning
- Node ID

Temperature value in °C
Pressure value in mBar
Ambient Light in Lux
Humidity value in %
Proximity value in mm
LED status
Wake Up event with timestamp
Environment Noise level in dB

USB type A to Mini-B USB cable
All documents are available in the DESIGN tab of the related products webpage

**FP-NET-BLESTAR1:**
- **DB2917:** Bluetooth Low Energy and Wi-Fi software expansion for STM32Cube – **data brief**
- **UM2061:** Getting started with the FP-NET-BLESTAR1 Bluetooth Low Energy and Wi-Fi software expansion for STM32Cube – **User Manual**
- Software setup file

**X-NUCLEO-IDB05A1:**
- Gerber files, BOM, Schematic
- **DB2592:** Bluetooth Low Energy expansion board based on SPBTLE-RF module for STM32 Nucleo – **data brief**
- **UM1912:** Getting started with X-NUCLEO-IDB05A1 Bluetooth low energy expansion board based on SPBTLE-RF module for STM32 Nucleo – **User Manual**

**X-NUCLEO-IDW01M1:**
- Gerber files, BOM, and schematics
- **DB2726:** Wi-Fi expansion board based on SWPF01SA module for STM32 Nucleo – **Data brief**
- **UM1975:** Getting started with X-NUCLEO-IDW01M1 Wi-Fi expansion board based on SPWF01SA module for STM32 Nucleo – **User Manual**
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STM32 Open Development Environment: Overview
The STM32 Open Development Environment (ODE) consists of a set of stackable boards and a modular open SW environment designed around the STM32 microcontroller family.

STM32Cube development software

STM32 Nucleo development boards

STM32 Nucleo expansion boards (X-NUCLEO)

STM32Cube expansion software (X-CUBE)

Function Packs (FP)

www.st.com/stm32ode
STM32 Nucleo Development Boards (NUCLEO)

- A comprehensive range of affordable development boards for all the STM32 microcontroller series, with unlimited unified expansion capabilities and integrated debugger/programmer functionality.

Power supply through USB or external source

Integrated debugging and programming ST-LINK probe

STM32 microcontroller

Complete product range from ultra-low power to high-performance

ST morpho extension header

Arduino™ UNO R3 extension headers

www.st.com/stm32nucleo
• Boards with additional functionality that can be plugged directly on top of the STM32 Nucleo development board directly or stacked on another expansion board.

Motion MEMS sensors
Environmental sensors
DIL24 support for new devices

Example of STM32 expansion board (X-NUCLEO-IKS01A1)

www.st.com/x-nucleo
STM32 Open Development Environment
Software components

- **STM32Cube software (CUBE)** - A set of free tools and embedded software bricks to enable fast and easy development on the STM32, including a Hardware Abstraction Layer and middleware bricks.

- **STM32Cube expansion software (X-CUBE)** - Expansion software provided free for use with the STM32 Nucleo expansion board and fully compatible with the STM32Cube software framework. It provides abstracted access to expansion board functionality through high-level APIs and sample applications.

- **Compatibility with multiple Development Environments** - The STM32 Open Development Environment is compatible with a number of IDEs including IAR EWARM, Keil MDK, and GCC-based environments. Users can choose from three IDEs from leading vendors, which are free of charge and deployed in close cooperation with ST. These include Eclipse-based IDEs such as Ac6 System Workbench for STM32 and the MDK-ARM environment.

**Tools & IDEs**
- IAR EWARM, Keil MDK-ARM, GCC-based IDEs (e.g. Ac6 System Workbench for STM32)

**Applications**
- Sample applications (e.g. based on ST OpenSoftwareX)

**Middleware**
- STM32Cube middleware
- Upper level middleware (e.g. ST OpenSoftwareX)

**Hardware Abstraction**
- STM32Cube Hardware Abstraction Layer (HAL)

**Hardware**
- STM32 Nucleo expansion boards (X-NUCLEO)
- STM32 Nucleo developer boards

Open License Models: STM32Cube software and sample applications are covered by a mix of fully open source BSD license and ST licenses with very permissive terms.

www.st.com/stm32cube
www.st.com/x-cube
STM32 Open Development Environment
Building block approach

The building blocks

- Sense
  - Accelerometer, gyroscope
  - Inertial modules, magnetometer
  - Pressure, temperature, humidity
  - Proximity, microphone
- Connect
  - Bluetooth LE, Sub-GHz radio
  - NFC, Wi-Fi, GNSS
- Translate
  - Audio amplifier
  - Touch controller
  - Operation Amplifier
- Move / Actuate
  - Stepper motor driver
  - DC & BLDC motor driver
  - Industrial input / output
- Power
  - Energy management & battery
- Process
  - General-purpose microcontrollers
  - Secure microcontrollers
- Software

Your need

- COLLECT
- TRANSMIT
- ACCESS
- CREATE
- POWER
- PROCESS

Our answer

www.st.com/stm32ode