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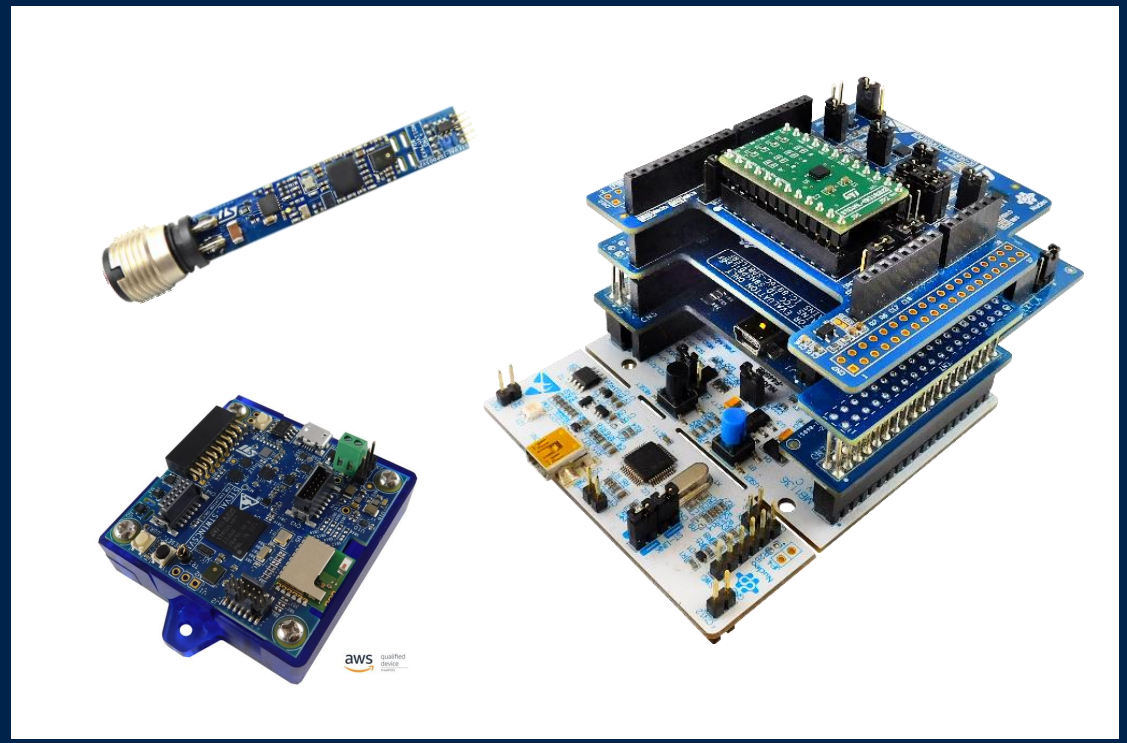


Quick Start Guide

STM32Cube function pack for multi sensors node with signal processing to enable predictive maintenance
(FP-IND-PREDMNT1)

Rev. 2.5 (July 12, 2021)

Agenda

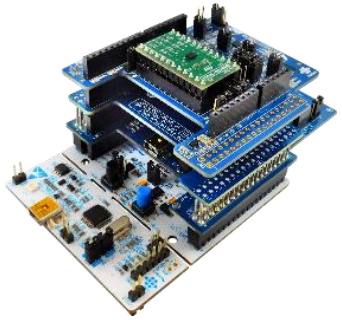
1. Hardware and Software overview
2. Setup & Demo Examples
3. Documents & Related Resources
4. STM32 Open Development Environment: Overview

1- Hardware and Software overview

Hardware Overview

Sample implementations are available for:

1. STM32 Nucleo with expansion boards
   - NUCLEO-F446RE + X-NUCLEO-CCA02M2 + X-NUCLEO-BNRG2A1 + X-NUCLEO-IKS01A3 + STEVAL-MKI182V2



2. STEVAL- BFA001V2B evaluation kit
   - STEVAL-IDP005V2 + STEVAL-UKI001V2 + 4-wire 2m cable

3. STEVAL-STWINKT1B evaluation kit with STEVAL-STWINWFV1 (Wi-Fi Expansion)
   - STWIN Core System + STLINK-V3MINI debugger + 480mAh Li-Po battery + Plastic box

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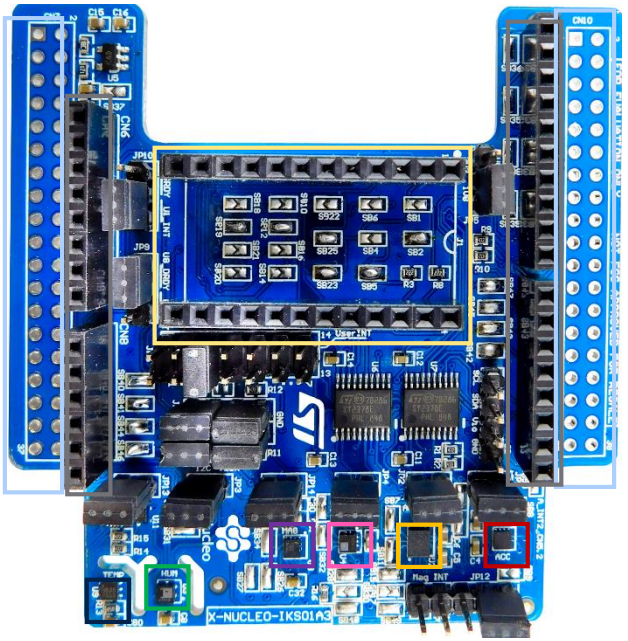
Motion MEMS and environmental sensors expansion board
STM32 Nucleo with Expansion boards - Hardware Overview (1/7)

X-NUCLEO-IKS01A3 Hardware Description

- 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 is designed around ST's latest sensors.

Key Product on board

- LSM6DSO MEMS 3D accelerometer (±2/±4/±8/±16 g) + 3D gyroscope (±125/±250/±500/±1000/±2000 dps)
- LIS2DW12 MEMS 3D accelerometer (±2/±4/±8/±16 g)
- LIS2MDL MEMS 3D magnetometer (±50 gauss)
- LPS22HH MEMS pressure sensor, 260-1260 hPa absolute digital output barometer
- HTS221: Capacitive digital relative humidity and temperature
- STTS751 Digital Temperature sensor
- DIL 24-pin Socket available for additional MEMS adapters and other sensors (UV index)



HTS221 LSM6DSO ST morpho connector**
LPS22HH LIS2DW12 Arduino UNO R3 connector
LIS2MDL STTS751 DIL 24-pin

*** Connector for the STM32 Nucleo Board*

Latest info available at www.st.com
X-NUCLEO-IKS01A3

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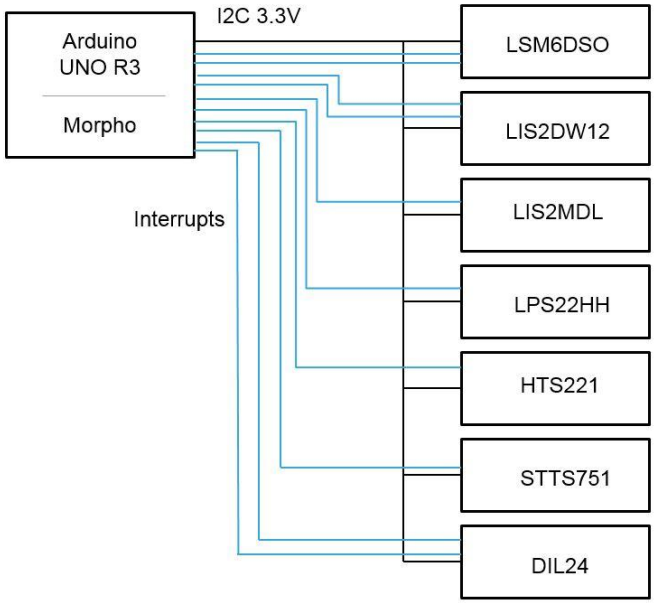
Motion MEMS and environmental sensors expansion board

STM32 Nucleo with Expansion boards - Hardware Overview (2/7)

X-NUCLEO-IKS01A3 Key Features

- The X-NUCLEO-IKS01A3 is a motion MEMS and environmental sensor evaluation board system.
- All sensor sensors are connected on a single I²C bus
- Sensor I²C address selection
- Each sensor has separate power supply lines allowing power consumption measurements
- Sensor disconnection (disconnects the I²C bus as well as the power supply)
- Interrupt and DRDY signals from sensors
- DIL24 socket (compatible with STEVAL-MKI***V* MEMS adapter boards)

** is used as a wildcard character for related part number*



Bluetooth Low Energy Expansion Board

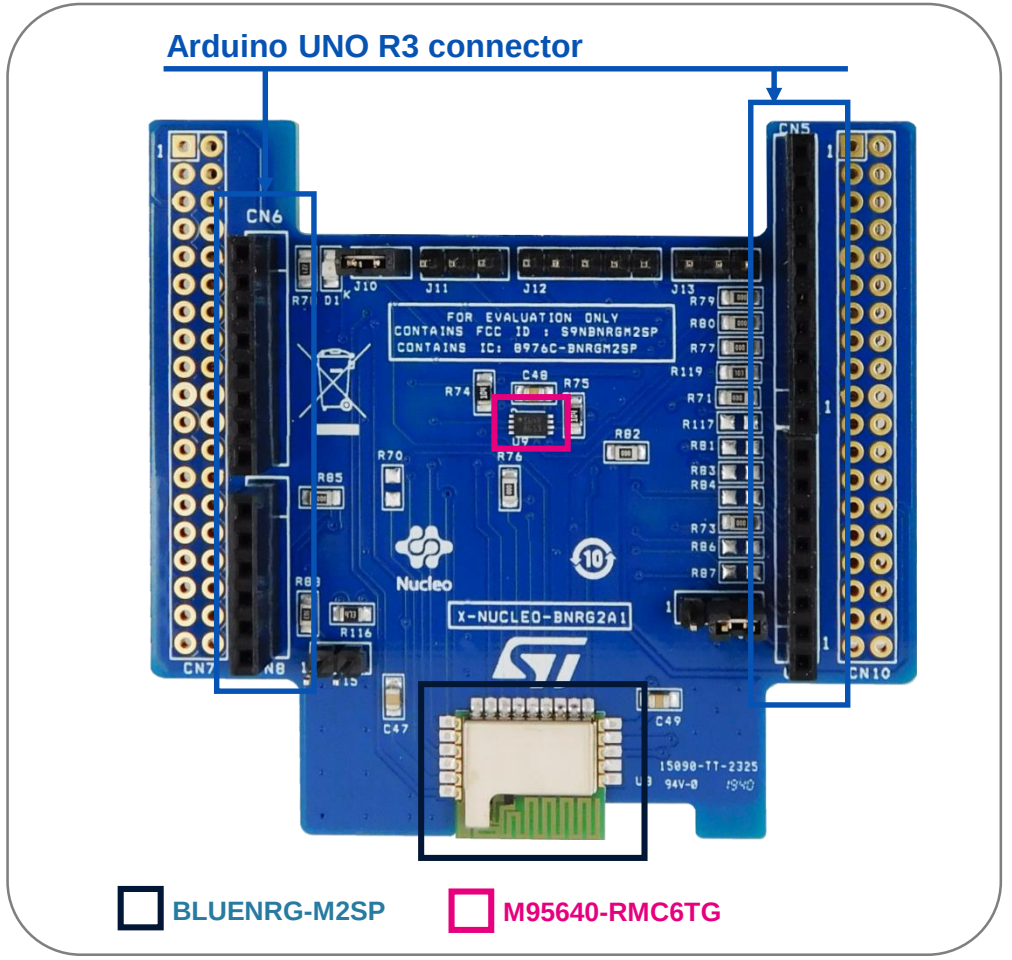
STM32 Nucleo with Expansion boards - Hardware Overview (3/7)

Hardware Description

- The X-NUCLEO-BNRG2A1 is a Bluetooth Low Energy (BLE) evaluation and development board system, designed around ST's BLUENRG-M2SP Bluetooth Low Energy module based on BlueNRG-2.
- The BlueNRG-2 processor hosted in the BLUENRG-M2SP module communicates with the STM32 microcontroller, hosted on the Nucleo development board, through an SPI link available on the Arduino UNO R3 connector.

Key Product on board

- BLUENRG-M2SP Bluetooth Low Energy, FCC and IC certified (FCC ID: S9NBNRGM2SP, IC: B976C-BNRGM2SP), module based on Bluetooth® Low Energy wireless network processor BlueNRG-2, BLE v5.0 compliant.
- BLUENRG-M2SP integrates a BALF-NRG-02D3 balun and a PCB antenna. It embeds 32 MHz crystal oscillator for the BlueNRG-2.
- M95640-RMC6TG 64-Kbit serial SPI bus EEPROM with high-speed clock interface



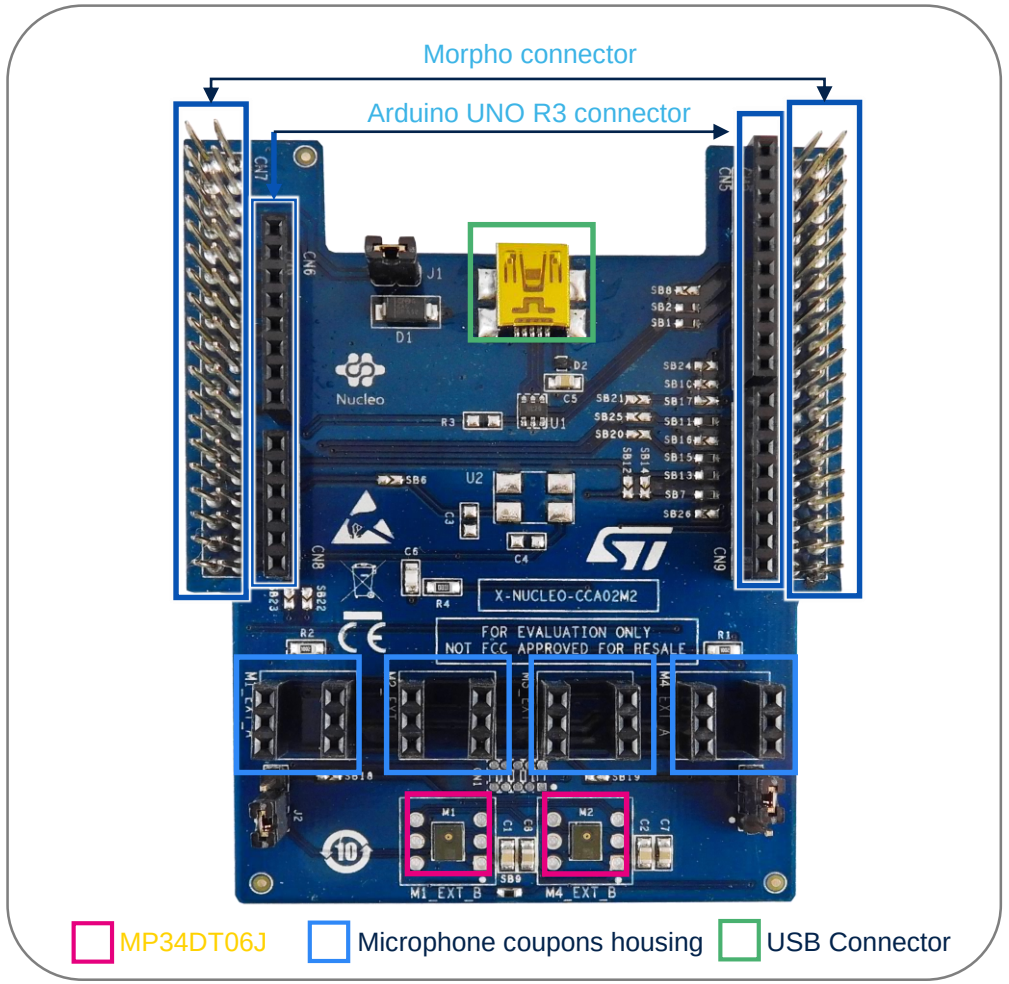
Latest info available at www.st.com
X-NUCLEO-BNRG2A1

MEMS Microphones expansion board (X-NUCLEO-CCA02M2)

STM32 Nucleo with Expansion boards - Hardware Overview (4/7)

Hardware Description

- The X-NUCLEO-CCA02M2 is an expansion board that has been designed around MP34DT06J digital MEMS microphone. It is compatible with the ST morpho connector layout and with digital microphone coupon boards such as STEVAL-MIC001V1, STEVAL-MIC002V1 and STEVAL-MIC003V1.
- The X-NUCLEO-CCA02M2 embeds two MP34DT06J microphones and allows synchronized acquisition and streaming of up to 4 microphones through I²S, SPI, DFSDM or SAI peripherals.



Key Product on board

- MP34DT06J ultra-compact, low-power, omnidirectional, digital MEMS microphone built with a capacitive sensing element and an IC interface.

Latest info available at www.st.com
X-NUCLEO-CCA02M2

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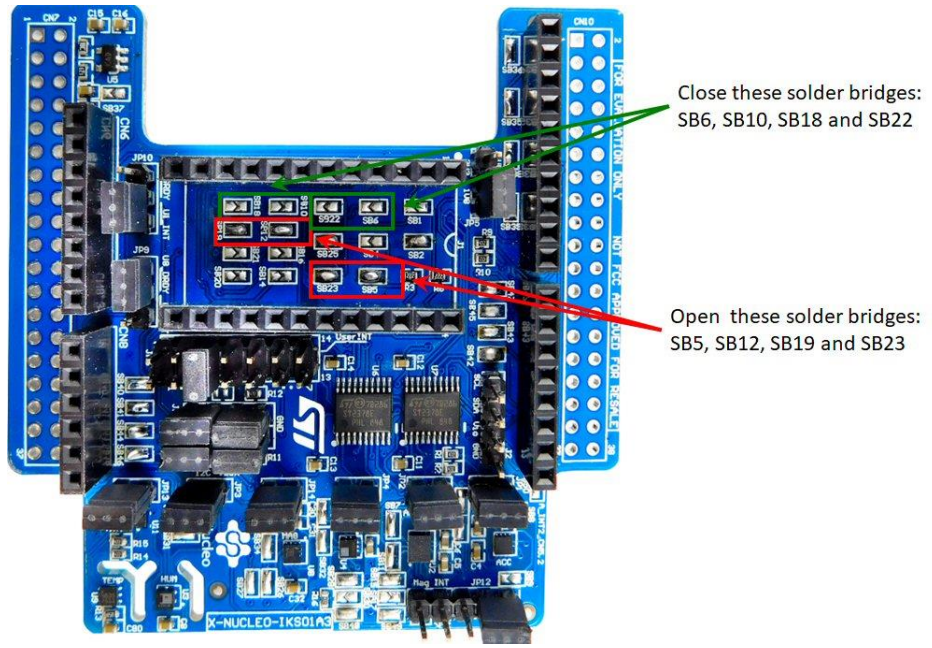
Important Hardware Additional Information

STM32 Nucleo with Expansion boards - Hardware Overview (5/7)



Modifications on the X-NUCLEO-IKS01A3 board for DIL24 + SPI connection

For only X-NUCLEO-IKS01A3 you can setect I2C or SPI connection mode for DIL24 socket by modification in the file iks01a3_conf.h ***USE_SPI_FOR_DIL24*** define as:

- 0 --> for enable I2C connection
- 1 --> for enable SPI connection

I2C connection is enabled as default.

These hardware patch to be performed on the X-NUCLEO-IKS01A3 to enable SPI support on DIL24 socket:

- Open solder bridges SB5, SB12, SB19 and SB23
- Close solder bridges SB6, SB10, SB18 and SB22

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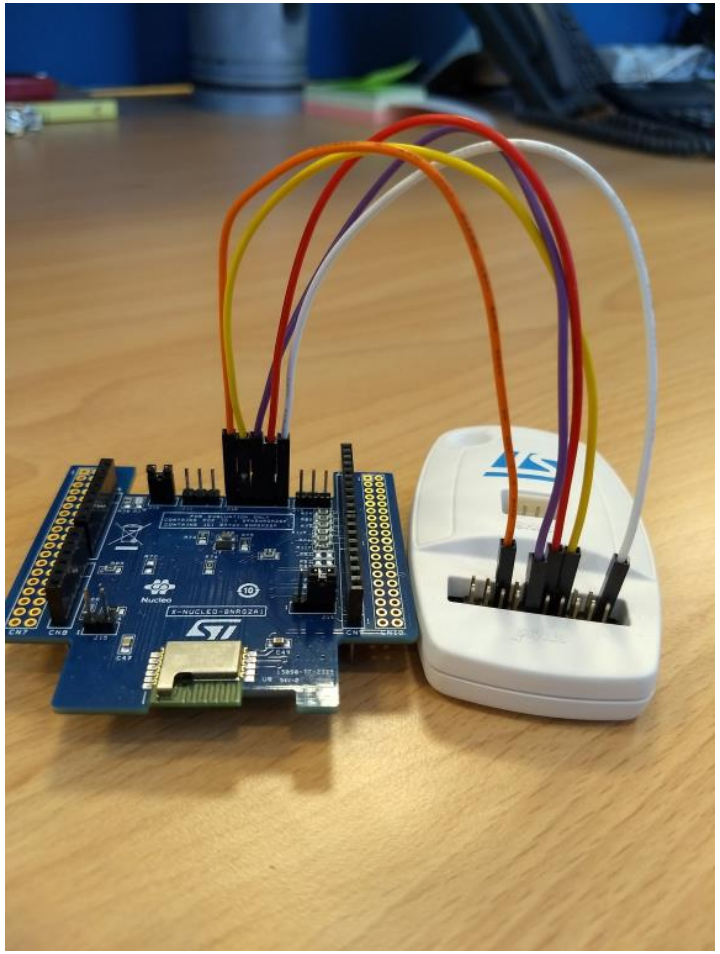
Important Hardware Additional Information

STM32 Nucleo with Expansion boards - Hardware Overview (6/7)



BlueNRG-2 library does not work with the stock firmware that is loaded in the BLE module of X-NUCLEO-BNRG2A1 expansion board.

For this reason:

- first of all, it is needed to solder on X-NUCLEO-BNRG2A1, if it is not soldered, a 0 Ohm resistor at R117.
- Then you can use a standard ST-Link V2-1 with 5 jumper wires female-female together with STSW-BNRGFLASHER software tool (currently available only for Windows PC) in order to update the firmware of the BLE module of X-NUCLEO-BNRG2A1.

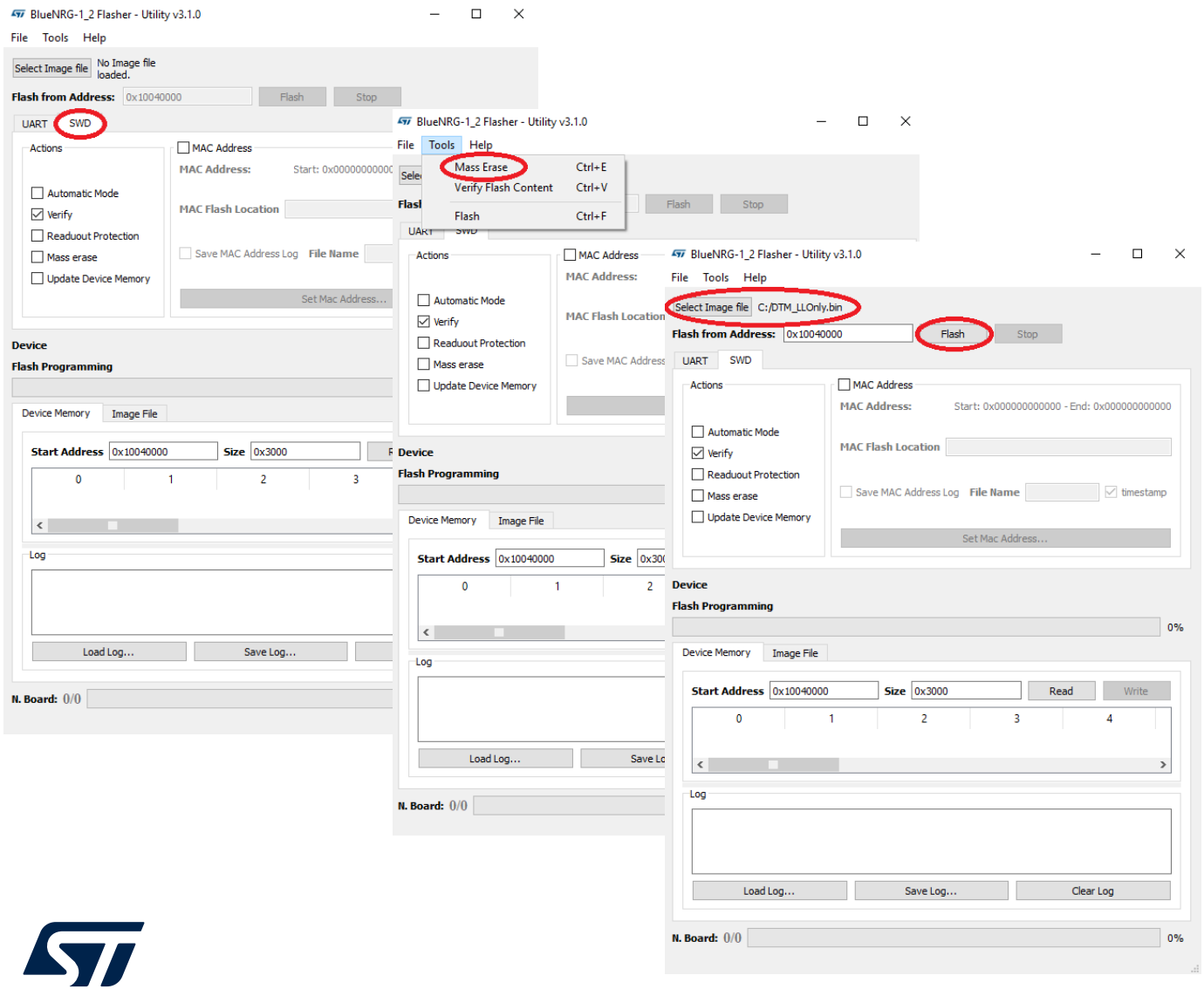
You need to connect the J12 pins of the X-NUCLEO-BNRG2A1 to the pins of the ST-Link V2-1 as shown in the picture and follow the steps show in the next slide.

In particular we have the following connections:

	J12	ST-Link V2-1
Pin	1	1
Pin	2	9
Pin	3	12
Pin	4	7
Pin	5	15

Important Hardware Additional Information

STM32 Nucleo with Expansion boards - Hardware Overview (7/7)



1. install the ST BlueNRG-1_2 Flasher Utility and open it, then select the SWD tab
2. Erase the flash memory of the BlueNRG-2 chip
3. Download the Link Layer Only firmware for the BLE module from the following link DTM_LLOnly.bin
4. Load the Link Layer Only firmware in the ST BlueNRG-1_2 Flasher Utility and then press the "Flash" button
5. If you need to restore the stock firmware of the BLE module of X-NUCLEO-BNRG2A1, you can repeat the procedure using this firmware image DTM_Full.bin
6. If you should find some issues during the update process, you can try to repeat the procedure closing the J15 jumper on the X-NUCLEO-BNRG2A1 expansion board.

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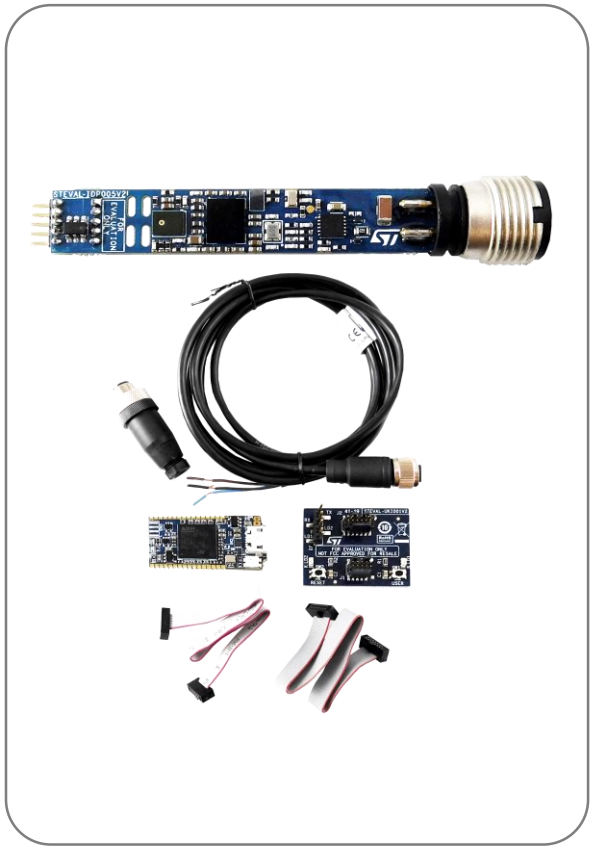
Multi-sensor predictive maintenance kit with IO-Link stack v.1.1 (STEVAL-BFA001V2B)

Hardware Overview

Industrial reference design kit Hardware Description

- The Predictive maintenance kit with sensors and IO-Link capability (STEVAL-BFA001V2B) is an industrial reference design kit designed for condition monitoring (CM) and predictive maintenance (PdM).
- The hardware development kit consists of an industrial sensor board (STEVAL-IDP005V2), communication adapter board (STEVAL-UKI001V2), ST-LINK-V3MINI programming and debugging interface, a 0.050” 10-pin flat cable, a 4-pole cable mount connector plug with male contacts and an M12 female connector with a 2 m cable.
- The package includes an industrial M12 cable for power or connection with a master port.
- The connection is managed using a standard multipolar cable with one wire used for IO-Link data, one for the L+ line (positive supply voltage pole) and one for the L- line (negative supply voltage pole).data acquisition campaigns



Key Product on board

- Sensor node (STEVAL-IDP005V2 - not available for separate sale)
  - 32-bit ARM® Cortex®-M4 core for signal processing and analysis (STM32F469AI)
  - Ultra-wide bandwidth (up to 6kHz), low-noise, 3-axis digital vibration sensor (IIS3DWB)
  - Absolute digital pressure sensor (LPS22HB)
  - Relative humidity and temperature sensors (HTS221)
  - Digital microphone sensors (MP34DT05-A)
  - IO-Link PHY device (L6362A)
  - EEPROM (M95M01-DF) for data storage
  - Step-down switching regulator and LDO regulator (L6984 and LDK220)
  - ESD protection (ESDALC6V1-1U2, SMBJ33CA)

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STEVAL-BFA001V2B

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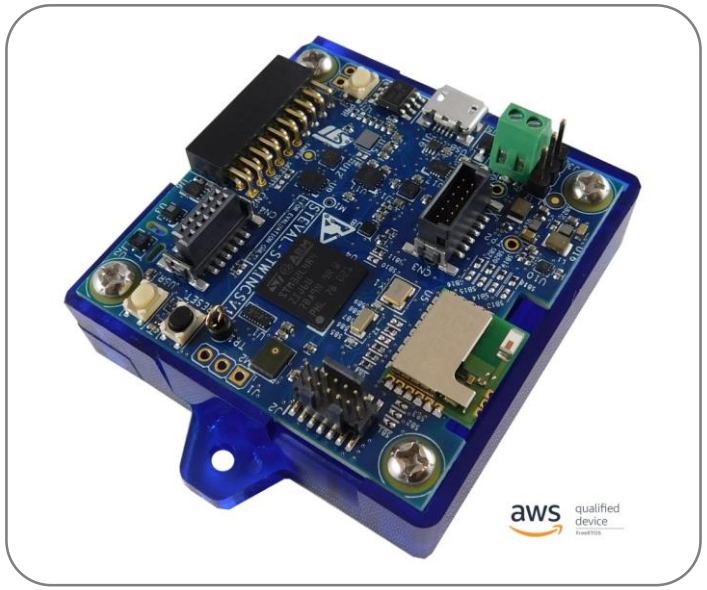
STWIN SensorTile Wireless Industrial Node development kit (STEVAL-STWINKT1B)
Hardware Overview

STWIN SensorTile Wireless Industrial Node development kit Hardware Description

- The STWIN SensorTile wireless industrial node (STEVAL-STWINKT1B) is a development kit and reference design that simplifies prototyping and testing of advanced industrial IoT applications such as condition monitoring and predictive maintenance.
- The kit supports BLE wireless connectivity through an on-board module, and Wi-Fi connectivity through a special plugin expansion board (STEVAL-STWINWFV1).

Key Product on board

- Multi-sensing wireless platform implementing vibration monitoring and ultrasound detection
- Built around STWIN core system board with processing, sensing, connectivity and expansion capabilities
- Micro SD Card slot for standalone data logging applications
- Wireless BLE4.2 (on-board) and Wi-Fi (with STEVAL-STWINWFV1 expansion board), and wired RS485 and USB OTG connectivity
- Option to implement Authentication and Brand protection secure solution with STSAFE-A110 (footprint)
- Wide range of industrial IoT sensors: ultra-wide bandwidth (up to 6 kHz), low-noise, 3-axis digital vibration sensor (IIS3DWB), 3D accelerometer + 3D Gyro iNEMO inertial measurement unit (ISM330DHCX) with machine learning core, ultra-low-power high performance MEMS motion sensor (IIS2DH), 3-axis magnetometer (IIS2MDC), digital absolute pressure sensor (LPS22HH), relative humidity and temperature sensor (HTS221) and low-voltage digital local temperature sensor (STTS751)
- Industrial grade digital MEMS microphone (IMP34DT05) and wideband analog MEMS microphone (MP23ABS1)
- Modular architecture, expandable via on-board connectors: STMOD+ and 40-pin flex general purpose expansions, 12-pin male plug for connectivity expansions and 12-pin female plug for sensing expansions
- Other kit components: Li-Po battery 480 mAh, STLINK-V3MINI debugger with programming cable and Plastic box



Latest info available at www.st.com
STEVAL-STWINKIT1B

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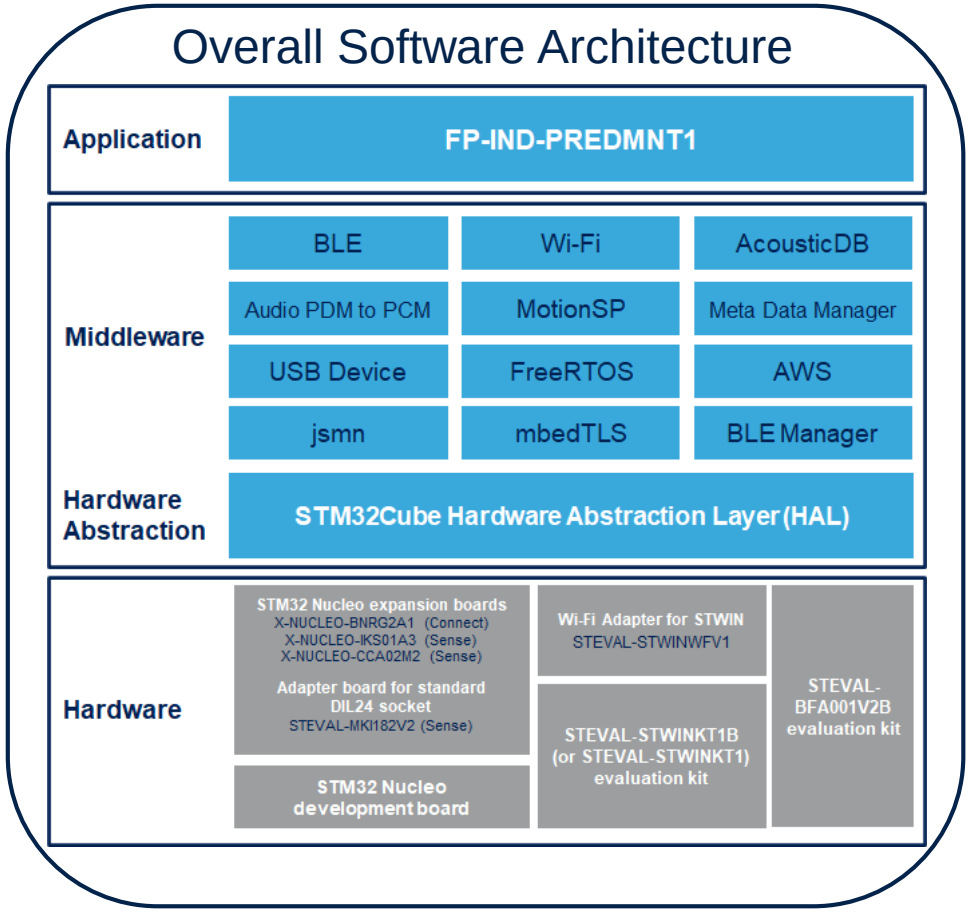
FP-IND-PREDMNT1 Software Description

- FP-IND-PREDMNT1 is an STM32Cube function pack including dedicated algorithms for advanced time and frequency domain signal processing and analysis of the 3D digital accelerometer with flat bandwidth up to 6 kHz. The package includes also pressure, relative humidity and temperature sensor monitoring and audio algorithms for acoustic emission (AE) up to 20 kHz, and ultrasound emission analysis up to 80 kHz.
- According to the designer's needs for connectivity and sensors, different options are available and selectable by changing parameter settings.
- With the NUCLEO-F446RE development board and the STEVAL-STWINKT1B kit with BLE connectivity, you can monitor and log the algorithm output and sensor data using the STBLESensor app.
- The STEVAL-IDP005V2 included in the STEVAL-BFA001V2B evaluation kit allows connecting a PC via USB to monitor and log the algorithm output, sensor data and equipment status.
- By using the STEVAL-STWINKT1B kit with Wi-Fi connectivity, you can connect the device to the dedicated DSH-PREDMNT web-based dashboard to monitor and log the algorithm output, sensor data and equipment status.
- The FP-IND-PREDMNT1, together with the suggested combination of STM32 and ST devices, can be used to develop specific industrial predictive maintenance applications for early detection of warning signs of potential failures.
- The software runs on the STM32 microcontroller and includes all the necessary drivers for the STM32 Nucleo development board and expansion boards, as well as for the STEVAL-BFA001V2 and STEVAL-STWINKTV1 evaluation kit.

Overall Software Architecture



Latest info available at www.st.com
FP-IND-PREDMNT1

FP-IND-PREDMNT1
Software Overview (2/2)

Key features

- Complete firmware to develop a sensor node for condition monitoring and predictive maintenance applications, featuring digital or analog microphone, environmental and motion sensors, and performing real-time monitoring of parameters and equipment status via:
  - user terminal by UART (available for the STEVAL-IDP005V2 evaluation board included in the STEVAL-BFA001V2B kit)
  - Wi-Fi connectivity (available for the STEVAL-STWINKT1B kit with the STEVAL-STWINWFV1 Wi-Fi adapter)
  - BLE connectivity (available for the NUCLEO-F446RE development board and the STEVAL-STWINKT1B kit)
- Signal processing (MotionSP) middleware for vibration analysis in time domain (speed RMS and acceleration peak) and frequency domain (FFT with programmable size, averaging, overlapping and windowing)
- PDM to PCM and sound pressure level (SPL) middleware for digital microphones (for NUCLEO-F446RE and STEVAL-BFA001V2B)
- Acoustic FFT Analysis for NUCLEO-F446RE and STEVAL-BFA001V2B
- Ultrasound FFT Analysis for STEVAL-STWINKT1B
- Configurable alarm and warning thresholds for key parameters
- Data logging capability through mobile app or PC serial terminal
- Compatible with STBLESensor application for Android/iOS, to perform sensor data reading, audio and motion algorithm feature demo, and firmware update over the air (FOTA) (feature available only when using NUCLEO-F446RE and STEVAL-STWINKT1B with BLE connectivity)
- Compatible with DSH-PREDMNT web-based predictive maintenance dashboard for monitoring sensor data and device status (feature available only when using the STEVAL-STWINKT1B with the STEVAL-STWINWFV1 Wi-Fi adapter)
- Sample implementation available for the STEVAL-BFA001V2B and STEVALSTWINKT1 kits
- Sample implementation available for X-NUCLEO-CCA02M2, X-NUCLEOIKS01A3, STEVAL-MKI182V2 (DIL24 based on ISM330DLC) and X-NUCLEO-BNRG2A1 connected to a NUCLEO-F446RE board
- Easy portability across different MCU families, thanks to STM32Cube
- Free, user-friendly license terms

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FP-IND-PREDMNT1

2- Setup & Demo Examples

Setup & Demo Examples

Software and Other prerequisites

- **STSW-LINK004 (Link)**
  - STM32 ST-LINK Utility is a full-featured software interface for programming STM32 microcontrollers
- **FP-IND-PREDMNT1**
  - Copy the .zip file content into a folder on your PC. The package will contain source code example (Keil, IAR, STM32CubeIDE) based only on **NUCLEO-F446RE** or **STEVAL-BFA001V2B** or **STEVAL-STWINKT1B**
- **ST BLE Sensor** Application for Android/iOS to download from Google Store / iTunes
- **ST DSH-PREDMNT** Account
- Common freely Serial line terminal (i.e. TeraTerm)

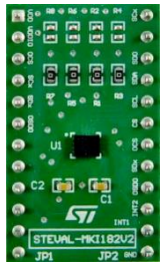
2.1- Setup Overview: STM32 Nucleo with Expansion boards

Setup Overview

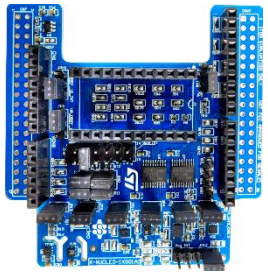
HW prerequisites with NUCLEO-F446RE

- 1x Bluetooth Low Energy Expansion Board (**X-NUCLEO-BNRG2A1**)
- 1x Motion MEMS and Environmental Sensor Expansion Board (**X-NUCLEO-IKS01A3**)
- 1x ISM330DLC adapter board for a standard DIL24 socket (**STEVAL-MKI182V2**)
- 1x Digital MEMS Microphone Expansion Board (**X-NUCLEO-CCA02M2**)
- 1x STM32 Nucleo Development Board (**NUCLEO-F446RE**)
- 1x Android™ or iOS™ device
- 1x PC with Windows 7 and above
- 1x USB type A to Mini-B USB cable

NUCLEO-F446RE

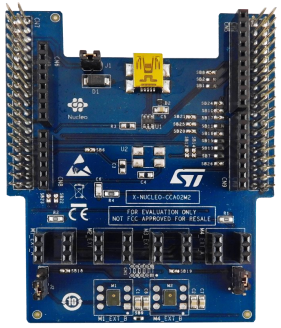


STEVAL-MKI182V2



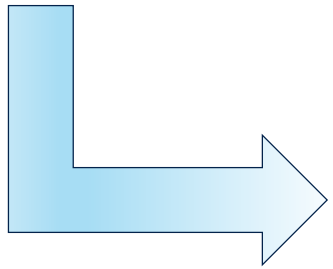
X-NUCLEO-IKS01A3

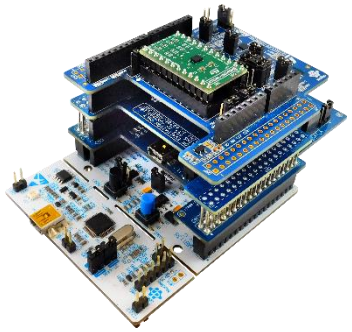
X-NUCLEO-BNRG2A1



X-NUCLEO-CCA02M2

Mini USB





It is necessary to connect the boards in the order shown in this picture

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Setup Overview

Start coding in just a few minutes (1/3)

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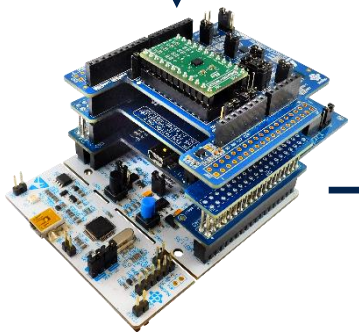
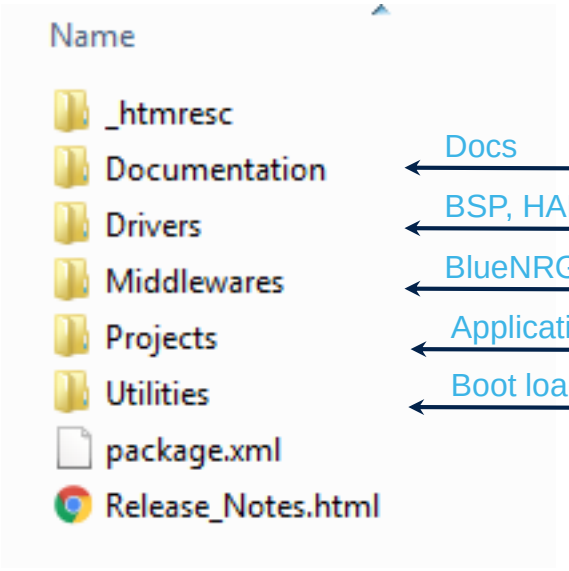
1 www.st.com/stm32ode



2 Select Function Pack: FP-IND-PREDMNT1

3 Download & unpack

FP-IND-PREDMNT1 package structure



4

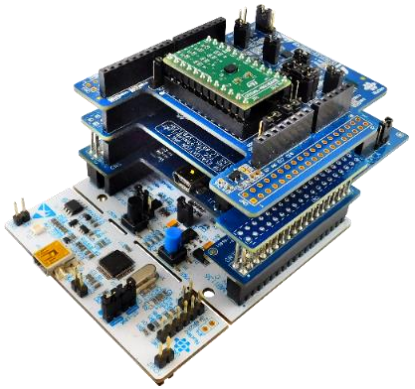
.\Projects\STM32F446RE-Nucleo\Demonstrations\Acoustic_Analysis
.\Projects\STM32F446RE-Nucleo\Demonstrations\Predictive_Maintenance

Android™/iOS™ smartphone and ST BLE Sensor application (V4.10.0 or higher) 6

Use the pre-compiled binaries for registering your device, or alternative re-compile the code adding your device certificate

STM32 CubeIDE · KEIL™ Tools by ARM · IAR SYSTEMS

5



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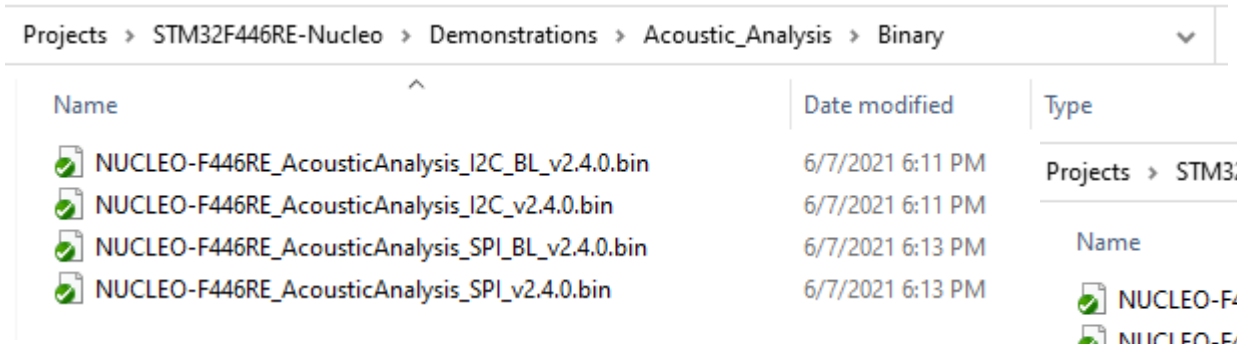
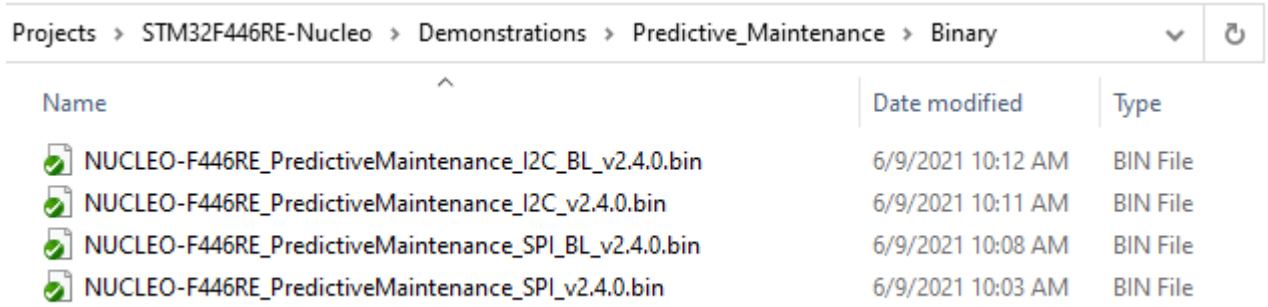
Setup Overview
Start coding in just a few minutes (2/3)

1. How to install the pre-compiled binary:

- For each demonstrations, there is inside the package one folder called “Binary”





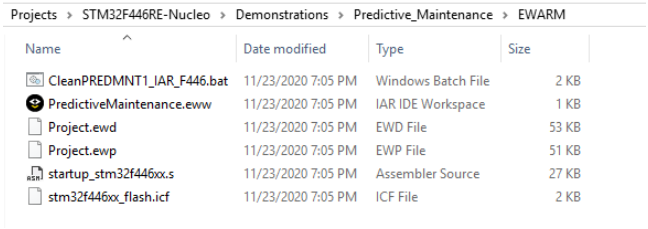
- It contains:
  - pre-compiled FP-IND-PREDMNT1 FW that could be flashed to a supported STM32 Nucleo Board using the ST-Link at the right position (0x08004000)
    - Important Note: this pre-compiled binary is compatible with the FOTA update procedure
  - pre-compiled FP-IND-PREDMNT1 + BootLoader FW that could be directly flashed to a supported STM32 Nucleo Board using the ST-Link or by doing “Drag & Drop” (the latter only for STM32 Nucleo boards)
    - Important Note: this pre-compiled binary is not compatible with the FOTA update procedure

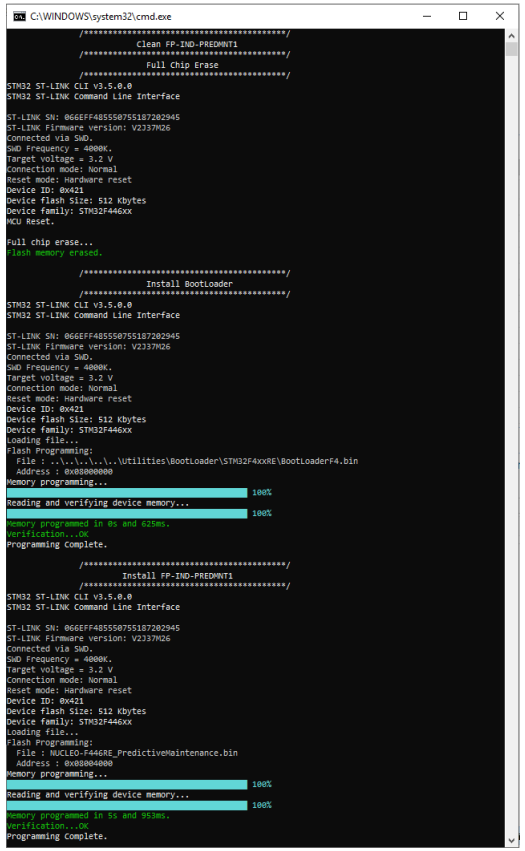
Setup Overview
Start coding in just a few minutes (3/3)

2. How Install the code after compiling the project:

- Compile the project with your preferred IDE
- On Windows: for each IDE and for each platform there is one batch script:
  - IAR toolchain Embedded Workbench V8.50.9:
    - CleanPREDMNT1_IAR_F446.bat
  - µVision toolchain - MDK-ARM Professional Version: 5.32.0:
    - CleanPREDMNT1_MDK-ARM_F446.bat
  - STM32CubeIDE Version 1.6.1:
    - CleanPREDMNT1_STM32CubeIDE_F446.bat
- For Linux/iOS: only for STM32CubeIDE and for each platform there is one OpenOCD:
    - CleanPREDMNT1_STM32CubeIDE_F446.sh

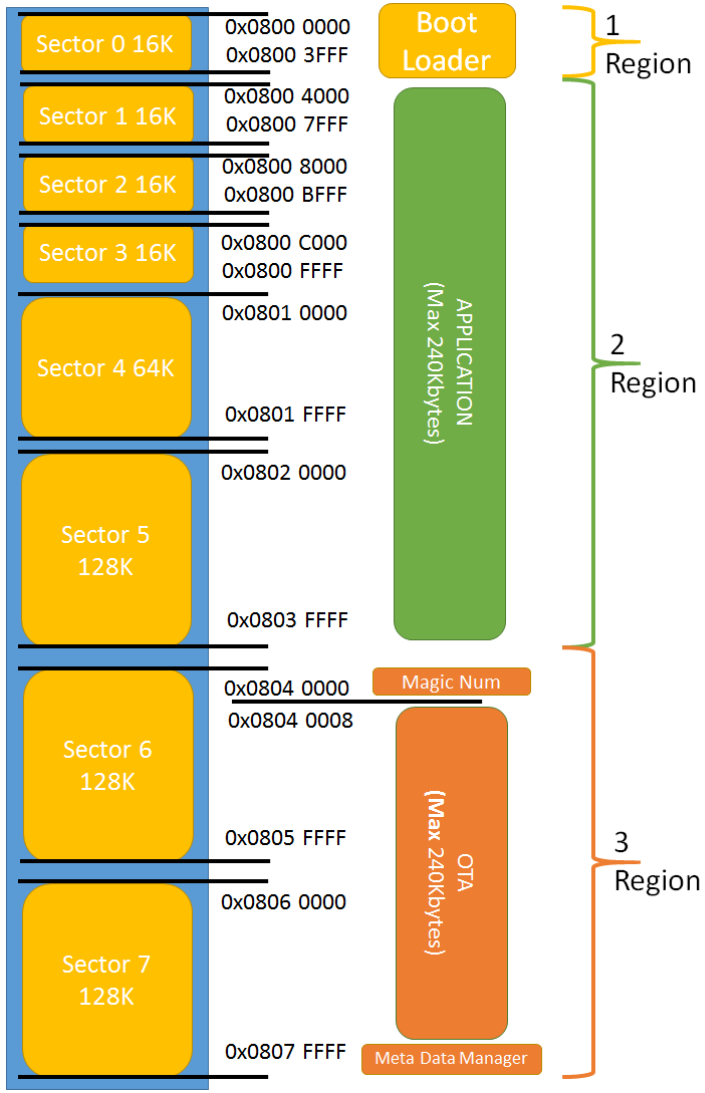
  It's necessary to edit this file for setting the right installation and Library path
- These scripts perform the following steps:
  - Full Flash Erase
  - Flash the right BootLoader at the right position (0x08000000)
  - Flash the PREDMNT1 firmware at the right position (0x08004000)
    - This is the firmware that was compiled with the IDE
    - This firmware is compatible with the FOTA update procedure
  - Save a complete Binary FW that includes both PREDMNT1 and the BootLoader
    - This binary can be directly flashed to a supported STM32 board using the ST-Link or by doing "Drag & Drop"
    - Important Note: this additional pre-compiled binary is not compatible with the FOTA update procedure





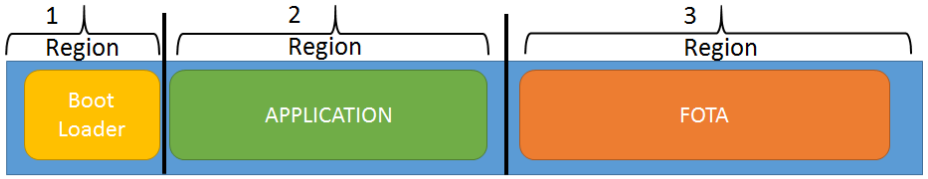
Setup Overview

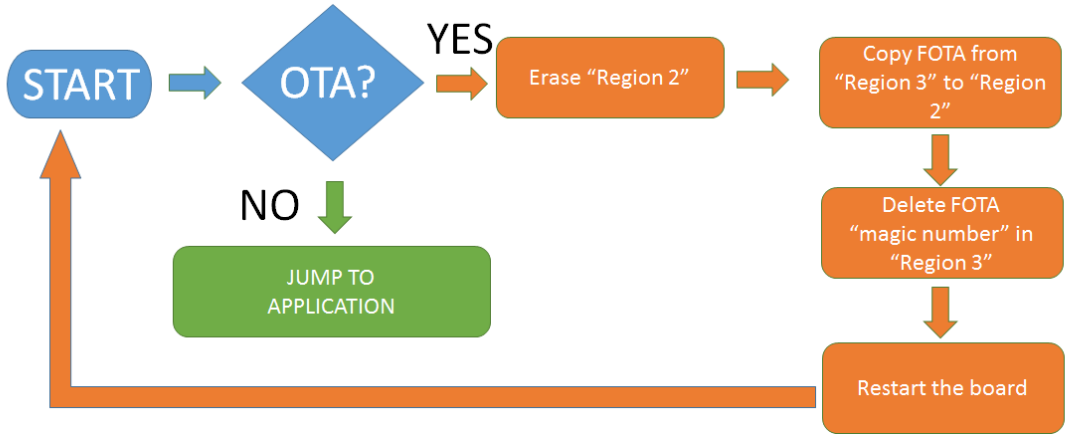
Flash Management and Boot Process



Flash Structure for STM32F446RE

FLASH Organization





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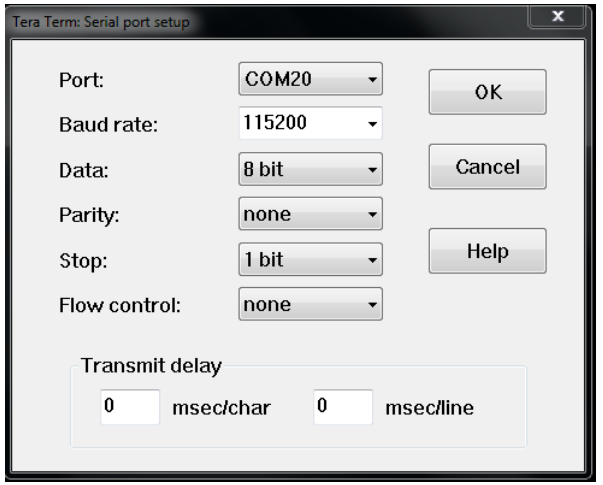
Setup Overview

Bluetooth low energy and sensors software

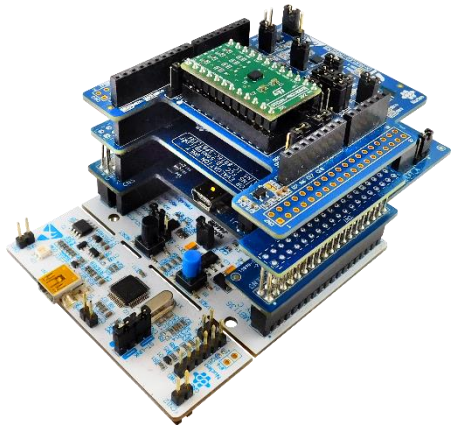
FP-IND-PREDMNT1 NUCLEO-F446RE - Serial line monitor (e.g.Tera Term)

- Pressing the **RESET** User button on STM32 Nucleo board. You could see the initialization phase

- When the boards are connected to an Android or iOS device, you can see what is transmitted via BLE



Configure the serial line monitor (speed, LF)



2.2- Setup Overview: STEVAL-BFA001V2B evaluation kit

Setup Overview

HW prerequisites for STEVAL-BFA001V1B(1/2)

- 1x **STEVAL-BFA001V2B** Kit:
  - One **STEVAL-IDP005V2** sensor node reference design (10 x 50 mm).
  - One adapter for ST-LINK programming and debugging tool - **STEVAL-UKI001V2**.
  - **STLINK-V3MINI** debugger/programmer for STM32 and **STDC14** flat cable.
  - One 0.050” 10-pin flat cable.
  - One 4-pole cable with M12 female connector.
  - One 4-pole mount M12 connector plug, with male contacts..
- 1x Generic power supply (range 18…32V)
- 1x PC with Windows 7 and above
- A USB micro-B connector.

STEVAL-BFA001V2B Kit

Micro USB

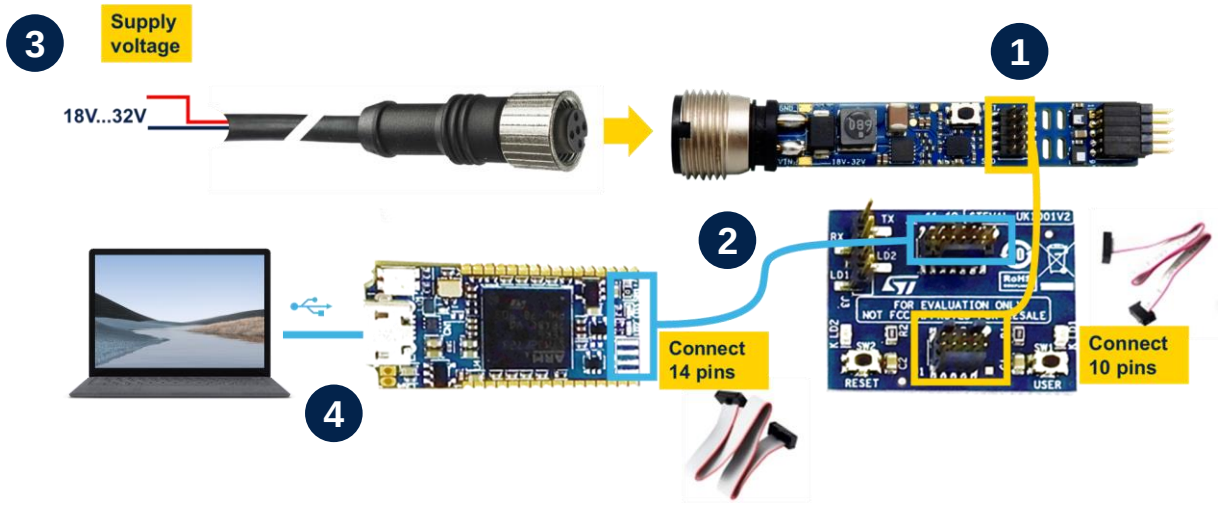
Generic power supply
(range 18…32V)

Setup Overview

HW prerequisites for STEVAL-BFA001V1B(2/2)

In order to program the board and run demo you need execute the following step:

1. Connect the STEVAL-UKI001V2 adapter to the STEVAL-IDP005V2 sensor node through the 10-pin flat cable.
2. Connect the STEVAL-UKI001V2 adapter to the STLINK-V3MINI programmer/debugger board through the STDC14 flat cable
3. Supply power (18V – 32V)
4. Connect the STLINK-V3MINI to the PC through the USB micro-B cable.



Setup Overview
Start coding in just a few minutes

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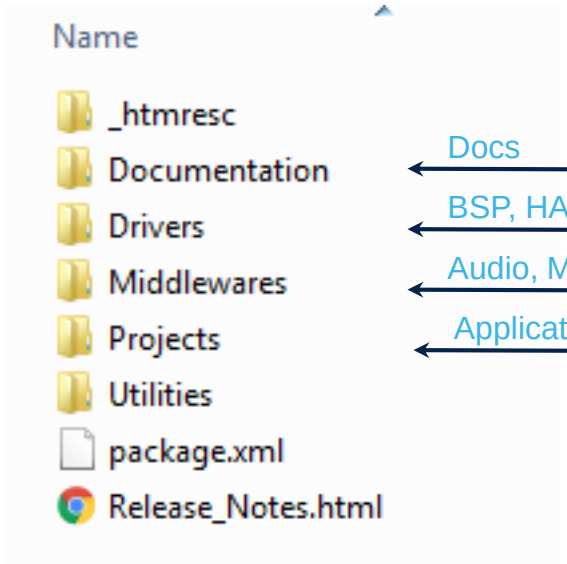
1 www.st.com/stm32ode

2 Select Function Pack: FP-IND-PREDMNT1

3 Download & unpack

FP-IND-PREDMNT1 package structure



4

.\Projects\ STM32F469AI-BFA001V2 \Applications\Acoustic_Analysis
.\Projects\ STM32F469AI-BFA001V2 \Applications\Environmental_Monitoring
.\Projects\ STM32F469AI-BFA001V2 \Applications\ Vibration_Analysis
.\Projects\ STM32F469AI-BFA001V2 \Demonstrations\Predictive_Maintenance_SRV

6

Standard User Terminal emulator
- **Teraterm**
- **Putty**
- **Realterm**
- **HyperTerminal**
- **Docklight**
- **Etc.**
- **Etc.**

Use the pre-compiled binaries for registering your device, or alternative re-compile the code adding your device certificate

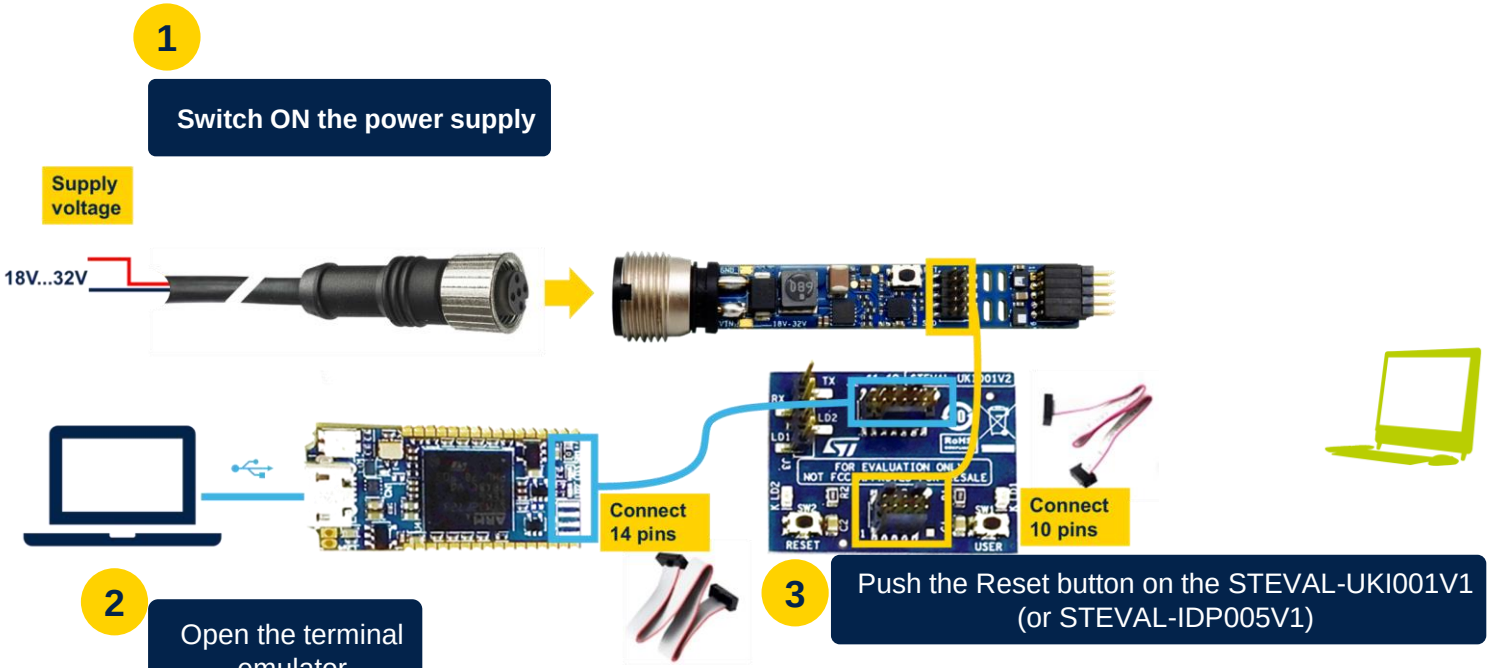
STM32 CubeIDE · KEIL Tools by ARM · IAR SYSTEMS

5

Setup Overview

Predictive Maintenance User Terminal Application (1/6)

STEVAL-BFA001V2B Startup & Hardware Info



Terminal emulator settings

- Name: COM Port name
- Baud Rate: 230400 (*)
- Data:8
- Parity: None
- Stop Bit: One
- Flow Control: None
- New Line:
  - Receive: AUTO
  - Transmit: LF

```
STMicroelectronics FP-IND-PREDMNT1
        Board - STEVAL-BFA001V2
        Application - Predictive Maintenance by SRV UART
        Version 2.3.0

STM32F4xx Libraries & IDE informations:
        (HAL 1.7.10_0)
        Compiled Nov 25 2020 17:52:25 (IAR)

MCU informations
        MCU Dev. ID      : 0x434
        MCU Rev. ID      : 0x1000
        MCU unique ID    : 0x393735303136510200043002A
        MCU Flash Size   : 2048 Kbytes
        MCU SYSCLK       : 180.00 MHz
        MCU HCLK         : 180.00 MHz
        MCU PCLK1        : 45.00 MHz
        MCU PCLK2        : 90.00 MHz

Starting project ...

 PREDICTIVE
 MAINTENANCE

Environmental Sensors Initialization
        Initialized Temperature and Humidity Sensor
        Initialized Temperature and Pressure Sensor
        Enabled Temperature      (Sensor1)
        Enabled Humidity         (Sensor1)
        Enabled Temperature      (Sensor2)
        Enabled Pressure         (Sensor2)

MotionSP Initialization
        Initialized Acceleration Sensor
        Enabled Acceleration Sensor
        Vibration parameters have been set as default values

        ******************************************************
        *          Vibration Analysis Parameters             *
        ******************************************************

        Accelerometer parameters are:
        - Acc. ODR       : 26667 Hz
        - FIFO BDR       : 26667 Hz
        - Acc. FS        : 4g
        - HW Filter      : HP ODR/800

        MotionSP parameters are:
        - FFT in size    : 4096
        - FFT OVL        : 75%
        - FFT window     : HANNING
        - Acq. time      : 2000 ms
        - RMS tau        : 50 ms
        - ID type        : SPEED
        - SubRanges      : 64

        Would you change the parameters? [y/n]
```

(*) Baud Rate: 921600 only for Acoustic_Analysis Application project

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Setup Overview
Predictive Maintenance User Terminal Application (2/6)

```
Would you change the parameters? [y/n]
y
Acc. FS? [2, 4, 8, 16][g]
16
HW Filter (HPF)? ODR divided by [4, 10, 20, 45, 100, 200, 400, 800]
800
FFT in size? [256, 512, 1024, 2048, 4096]
4096
FFT OVL? [5 - 85][%]
75
FFT window? [RECTANGULAR: 0, HANNING: 1, HAMMING: 2, FLAT TOP: 3]
3
Acq. time? [500 - 60000][ms]
5000
RMS tau? [25, 50, 100, 150, 250, 500, 1000, 1500, 2000][ms]
250
TD type? [SPEED: 0, ACCELERO: 1, SPEED & ACCELERO: 2]
2
SubRanges? [8, 16, 32, 64]
8
```

4 — Type ‘‘y’’ or ‘‘Y’’ to change

5 — For each parameter changing the line is overwritten. Type ‘‘Esc’’ to restart.

```
Accelerometer parameters are:
- Acc. ODR        : 26667 Hz
- FIFO BDR        : 26667 Hz
- Acc. FS         : 16g
- HW Filter       : HP ODR/800

MotionSP parameters are:
- FFT in size     : 2048
- FFT OVL         : 75%
- FFT window      : FLAT TOP
- Acq. time       : 5000 ms
- RMS tau         : 250 ms
- TD type         : SPEED & ACCELERO
- SubRanges       : 8

Would you change the parameters? [y/n]
n
```

Parameter summary
Press ‘‘n’’ or ‘‘N’’ to start monitoring

6

Restart the application

Parameters Configuration Details

Fs => accelerometer full scale in g
(2,4,8,16)
HW filter => Configurable inside the IIS3DWB sensor

Size => FFT size
(256, 512, 1024, 2048, 4096)
FFT OVL => OVERLAPPING in percentage
(5 ÷ 85) [%]

Windowing => Windowing method used for Spectral Analysis
0 (Rectangular)
1 (Hanning)
2 (Hamming)
3 (Flat Top)
Tacq => acquisition time in ms **(0.5 ÷ 60000)**
RMS Tau => timing constant for RMS in ms
(25,50,100,150,250,500,1000,1500,2000)
Tdtype => Time Domain Analysis selection
0 (Speed RMS)
1 (Acc RMS)
2 (Acc and Speed RMS)
Subrng => number of spectral subrange
(8, 16, 32, 64)

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Setup Overview

Predictive Maintenance User Terminal Application (3/6)

Time & Frequency Domain Analysis

```
The measured accelerometer ODR is 26758 Hz

Wait while acquisition ongoing for 5.00 s ...

|      *** Time Domain Data ***       |
| t [ms] |      Speed RMS [mm/s]      |
|        |   X    |   Y    |   Z    |
|  64530 |  0.000 |  0.000 |  0.000 |
|  64535 |  0.000 |  0.000 |  0.000 |
|  64541 |  0.000 |  0.000 |  0.000 |
|  64549 |  0.013 |  0.013 |  0.037 |
|  64557 |  0.013 |  0.014 |  0.032 |
|  64564 |  0.013 |  0.014 |  0.032 |
|  64572 |  0.013 |  0.020 |  0.027 |
|  64582 |  0.012 |  0.020 |  0.027 |
|  64589 |  0.012 |  0.020 |  0.027 |
|  64594 |  0.012 |  0.020 |  0.027 |
|  64599 |  0.011 |  0.019 |  0.033 |
|  64605 |  0.012 |  0.020 |  0.034 |
|  64610 |  0.012 |  0.019 |  0.033 |
|  64620 |  0.012 |  0.019 |  0.034 |
|  64627 |  0.012 |  0.018 |  0.035 |
|  64635 |  0.012 |  0.017 |  0.034 |
|  64640 |  0.012 |  0.017 |  0.034 |
|  64648 |  0.011 |  0.016 |  0.031 |
```

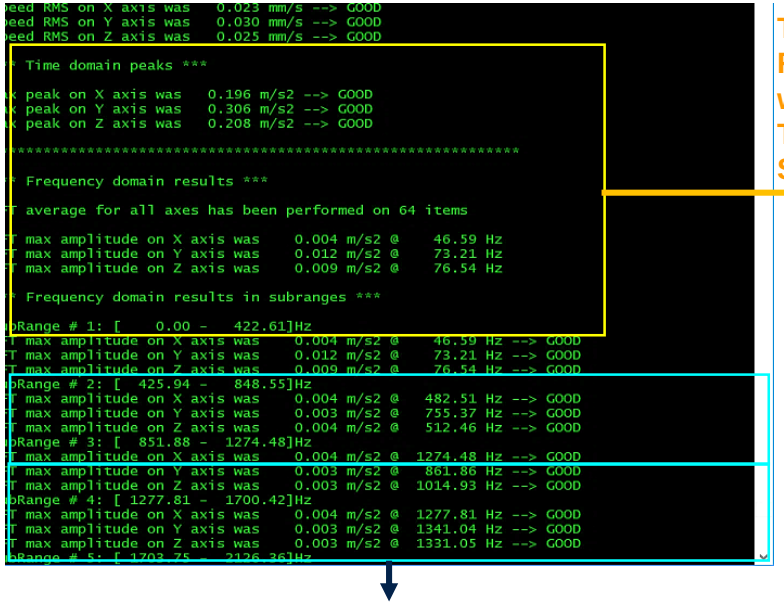
Analysis Start Time Domain (Speed RMS)

```
|    *** FFT Spectral Analysis ***    |
|bin Freq|     Amplitude [m/s2]       |
|  [Hz]  |   X    |   Y    |   Z     |
|    0.00|  0.000 |  0.000 |  0.001  |
|    3.33|  0.001 |  0.001 |  0.001  |
|    6.66|  0.001 |  0.001 |  0.002  |
|    9.98|  0.002 |  0.002 |  0.002  |
|   13.31|  0.002 |  0.002 |  0.003  |
|   16.64|  0.002 |  0.003 |  0.003  |
|   19.97|  0.003 |  0.003 |  0.003  |
|   23.29|  0.003 |  0.004 |  0.003  |
|   26.62|  0.003 |  0.004 |  0.003  |
|   29.95|  0.003 |  0.004 |  0.004  |
|   33.28|  0.003 |  0.004 |  0.004  |
|   36.60|  0.004 |  0.004 |  0.003  |
|   39.93|  0.004 |  0.003 |  0.004  |
|   43.26|  0.003 |  0.004 |  0.004  |
|   46.59|  0.003 |  0.004 |  0.004  |
|   49.91|  0.003 |  0.004 |  0.004  |
|   53.24|  0.003 |  0.004 |  0.004  |
|   56.57|  0.003 |  0.004 |  0.004  |
|   59.90|  0.003 |  0.003 |  0.004  |
|   63.23|  0.003 |  0.003 |  0.004  |
|   66.55|  0.003 |  0.003 |  0.004  |
|   69.88|  0.003 |  0.003 |  0.004  |
|   73.21|  0.003 |  0.003 |  0.004  |
|   76.54|  0.003 |  0.004 |  0.004  |
|   79.86|  0.003 |  0.004 |  0.004  |
|   83.19|  0.003 |  0.003 |  0.003  |
|   86.52|  0.003 |  0.003 |  0.003  |
|   89.85|  0.003 |  0.003 |  0.003  |
```

2° Analysis Frequency Domain Array (Acceleration)

Setup Overview
Predictive Maintenance User Terminal Application (4/6)

TDM & FDM final results with thresholds Status



TDM Results with Thresholds Status

FFT results: Absolute Max Amp @ Freq

FFT AVG numbers

FFT Subranges Results Max Amp @ Freq → Status

```
*** Frequency domain results in subranges ***

SubRange # 1: [    0.00 -   422.61]Hz
FFT max amplitude on X axis was    0.004 m/s2 @    46.59 Hz --> GOOD
FFT max amplitude on Y axis was    0.012 m/s2 @    73.21 Hz --> GOOD
FFT max amplitude on Z axis was    0.009 m/s2 @    76.54 Hz --> GOOD
SubRange # 2: [  425.94 -   848.55]Hz
FFT max amplitude on X axis was    0.004 m/s2 @   482.51 Hz --> GOOD
FFT max amplitude on Y axis was    0.003 m/s2 @   755.37 Hz --> GOOD
FFT max amplitude on Z axis was    0.004 m/s2 @   512.46 Hz --> GOOD
SubRange # 3: [  851.88 -  1274.48]Hz
FFT max amplitude on X axis was    0.004 m/s2 @  1274.48 Hz --> GOOD
FFT max amplitude on Y axis was    0.003 m/s2 @   861.86 Hz --> GOOD
FFT max amplitude on Z axis was    0.003 m/s2 @  1014.93 Hz --> GOOD
SubRange # 4: [ 1277.81 -  1700.42]Hz
FFT max amplitude on X axis was    0.004 m/s2 @  1277.81 Hz --> GOOD
FFT max amplitude on Y axis was    0.003 m/s2 @  1341.04 Hz --> GOOD
FFT max amplitude on Z axis was    0.003 m/s2 @  1331.05 Hz --> GOOD
SubRange # 5: [ 1703.75 -  2126.36]Hz
FFT max amplitude on X axis was    0.003 m/s2 @  2076.45 Hz --> GOOD
FFT max amplitude on Y axis was    0.002 m/s2 @  1893.43 Hz --> GOOD
FFT max amplitude on Z axis was    0.003 m/s2 @  1763.65 Hz --> GOOD
SubRange # 6: [ 2129.69 -  2552.30]Hz
FFT max amplitude on X axis was    0.003 m/s2 @  2236.17 Hz --> GOOD
FFT max amplitude on Y axis was    0.002 m/s2 @  2133.02 Hz --> GOOD
FFT max amplitude on Z axis was    0.002 m/s2 @  2139.67 Hz --> GOOD
SubRange # 7: [ 2555.63 -  2978.23]Hz
FFT max amplitude on X axis was    0.003 m/s2 @  2928.32 Hz --> GOOD
FFT max amplitude on Y axis was    0.002 m/s2 @  2598.88 Hz --> GOOD
FFT max amplitude on Z axis was    0.002 m/s2 @  2565.61 Hz --> GOOD
SubRange # 8: [ 2981.56 -  3404.17]Hz
FFT max amplitude on X axis was    0.003 m/s2 @  2981.56 Hz --> GOOD
FFT max amplitude on Y axis was    0.001 m/s2 @  3001.53 Hz --> GOOD
FFT max amplitude on Z axis was    0.001 m/s2 @  3004.86 Hz --> GOOD

######## TIME DOMAIN STATUS ###################

-------> GOOD <-------

######## FREQUENCY DOMAIN STATUS ###############

-------> GOOD <-------
```

Time And Frequency Domain All Thresholds Status

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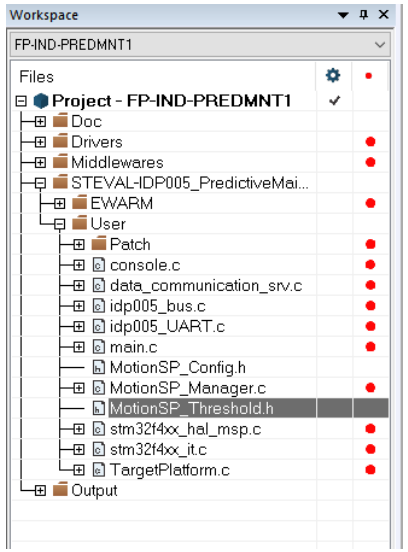
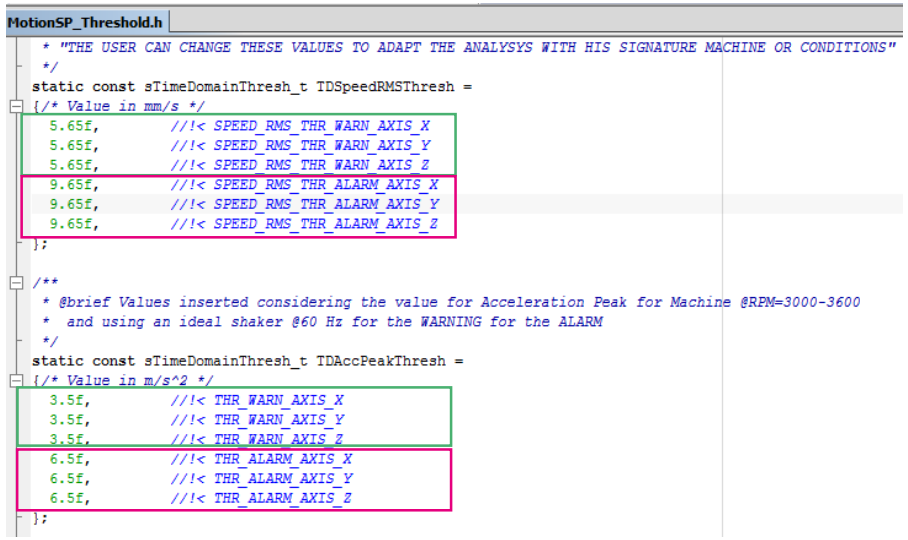
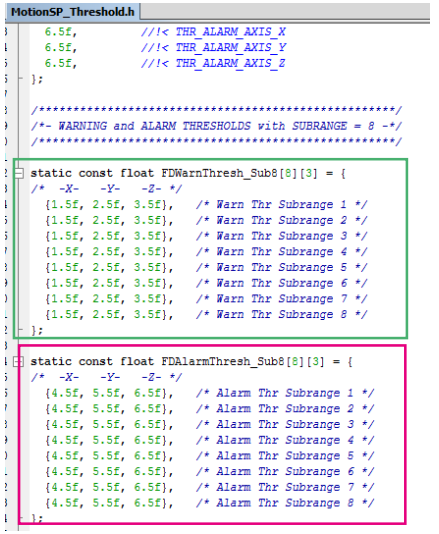
FW -Threshold settings

User can modify the alarm and warning thresholds for Speed RMS, Acc peak and spectral band.
It is possible in precompiling phase using the MotionSP_Threshold.h file.
Spectral band can be subdivided in 8, 16, 32 or 64 subrange.

Open the PredMaint_SVR project from ***\Projects\STEVAL-IDP005V1\Demonstrations\Predictive_Maintenance_SRV folder (*)***







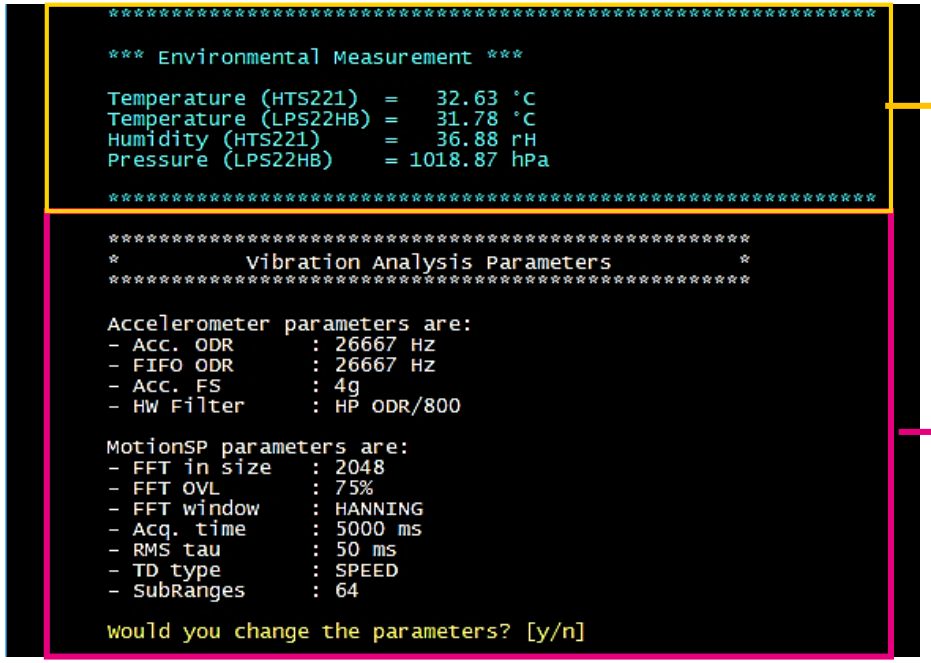
Threshold values for Warning

Threshold values for Alarm

(*) to change thresholds and recompile firmware it is necessary install one of the supported IDEs

Setup Overview
Predictive Maintenance User Terminal Application (6/6)

Environmental Measurements Parameters Overview and Restart



Environmental Measurements

Parameter Overview for the Next analysis

2.3- Setup Overview: STEVAL-STWINKT1B evaluation kit

Setup Overview

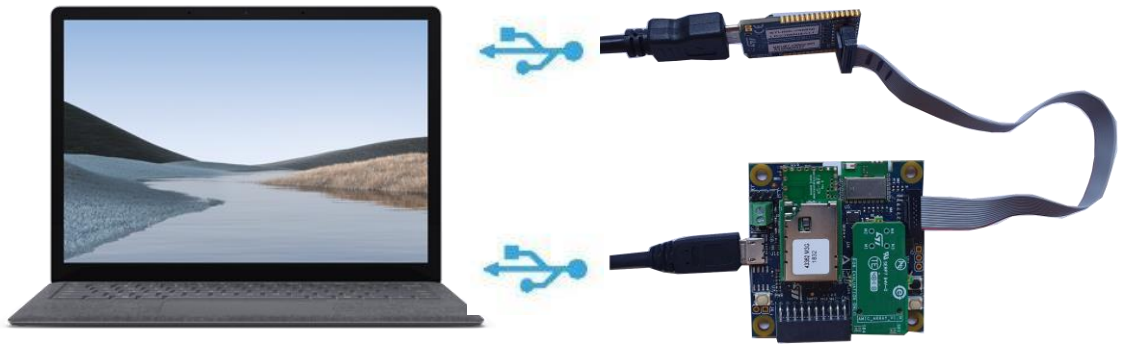
HW prerequisites for STEVAL-STWINKT1B (1/2)

- 1x STEVAL-STWINKT1B Kit:
  - STWIN Core System board
  - STLink-V3MINI debugger
  - Battery
  - Plastic Case
- 1x STEVAL-STWINWFV1:
  - STEVAL-STWINWFV1 Wi-Fi Expansion
- 1x PC with Windows 7 and above
- 1x USB type A to Micro USB cable for the STLink-V3MINI
- 1x USB type A to Micro USB cable for the STEVAL-STWINCSV1 Core System board
- Wi-Fi Router or access to a Wi-Fi network

STEVAL-STWINWFV1

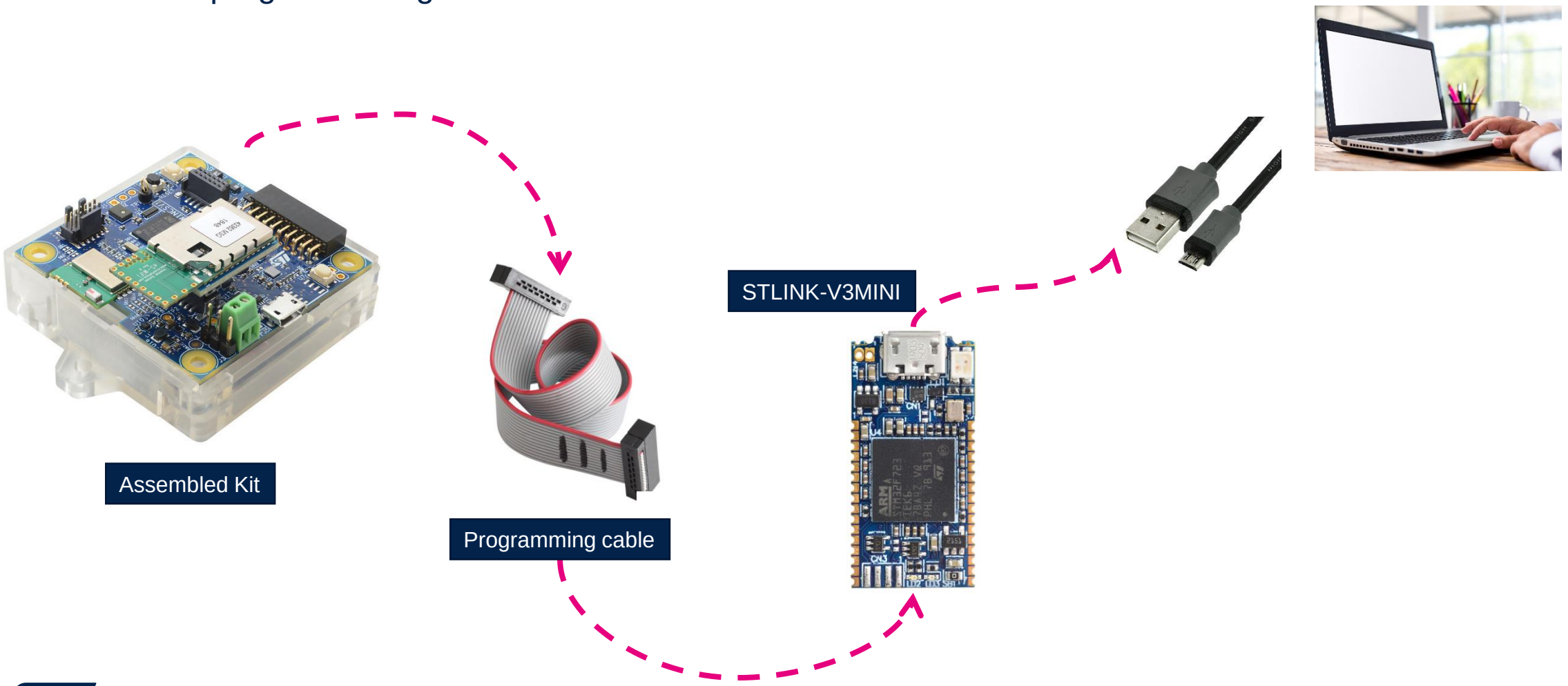
STEVAL-STWINKT1B

MicroUSB Cable



Setup Overview
HW prerequisites for STEVAL-STWINKT1B (2/2)

- How to re-program/debug the STWIN



Setup Overview

Start coding in just a few minutes for Bluetooth low energy (1/3)

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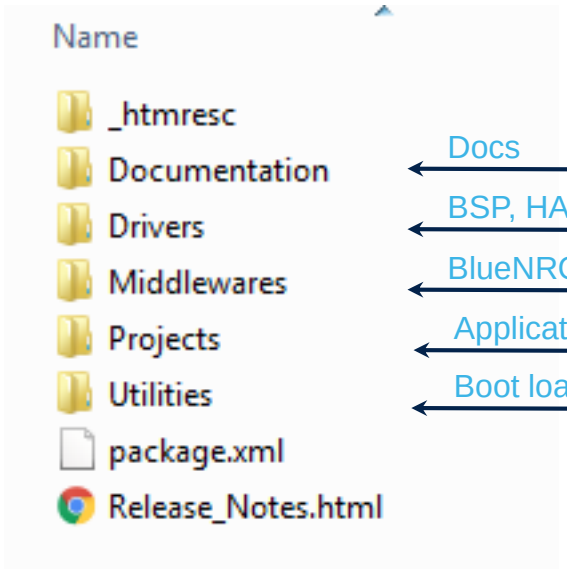
1 www.st.com/stm32ode

2

Select Function Pack:
FP-IND-PREDMNT1

3 Download & unpack

FP-IND-PREDMNT1 package structure



4

.\Projects\STM32L4R9ZI-STWIN\Demonstrations\Predictive_Maintenance_BLE

Android™/iOS™ smartphone and
ST BLE Sensor application
(V4.10.0 or higher)

6

Use the pre-compiled binaries for registering your device, or alternative re-compile the code adding your device certificate

STM32 CubeIDE · KEIL Tools by ARM · IAR SYSTEMS

5

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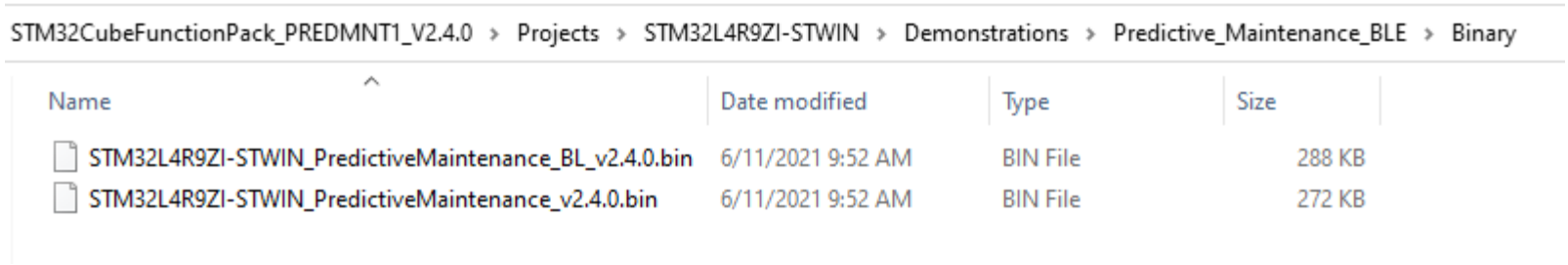
Setup Overview

Start coding in just a few minutes for Bluetooth low energy(2/3)

1. **How to install the pre-compiled binary:**
   - For each demonstrations, there is inside the package one folder called “Binary”



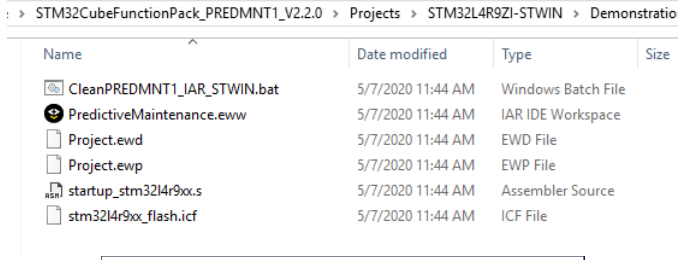
   - It contains:
     - pre-compiled FP-IND-PREDMNT1 FW that could be flashed to a supported STM32 Nucleo Board using the ST-Link at the right position (0x08004000)
       - Important Note: this pre-compiled binary is compatible with the FOTA update procedure
     - pre-compiled FP-IND-PREDMNT1 + BootLoader FW that could be directly flashed to a supported STM32 Nucleo Board using the ST-Link or by doing “Drag & Drop” (the latter only for STM32 Nucleo boards)
       - Important Note: this pre-compiled binary is not compatible with the FOTA update procedure

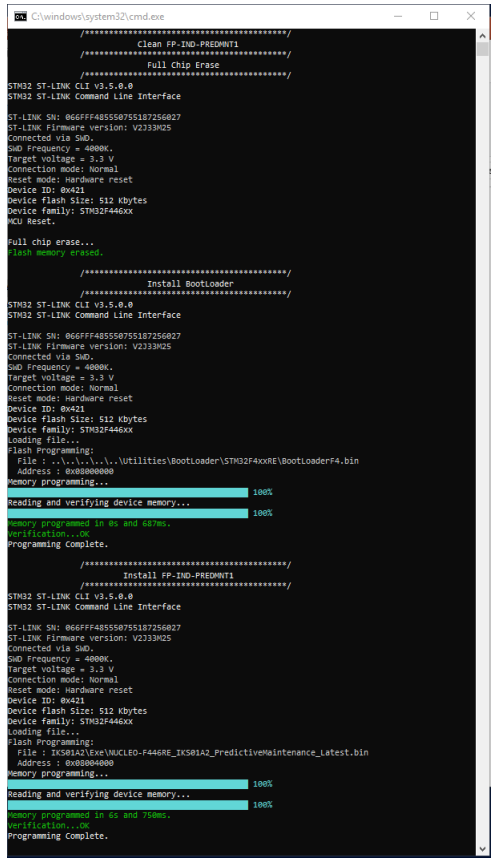
Setup Overview

Start coding in just a few minutes for Bluetooth low energy (3/3)

2. How Install the code after compiling the project:

- Compile the project with your preferred IDE
- On Windows: for each IDE and for each platform there is one batch script:
  - IAR toolchain Embedded Workbench V8.50.9:
    - CleanPREDMNT1_IAR_STWIN
  - µVision toolchain - MDK-ARM Professional Version: 5.32.0:
    - CleanPREDMNT1_MDK-ARM_STWIN
  - STM32CubeIDE Version 1.6.1:
    - CleanPREDMNT1_STM32CubeIDE_STWIN
- These scripts perform the following steps:
  - Full Flash Erase
  - Flash the right BootLoader at the right position (0x08000000)
  - Flash the PREDMNT1 firmware at the right position (0x08004000)
    - ➢ This is the firmware that was compiled with the IDE
    - ➢ This firmware is compatible with the FOTA update procedure
  - Save a complete Binary FW that includes both PREDMNT1 and the BootLoader
    - ➢ This binary can be directly flashed to a supported STM32 board using the ST-Link or by doing “Drag & Drop”
    - ➢ Important Note: this additional pre-compiled binary is not compatible with the FOTA update procedure





Setup Overview

Start coding in just a few minutes for Cloud Application

www.st.com/stm32ode-fp

1

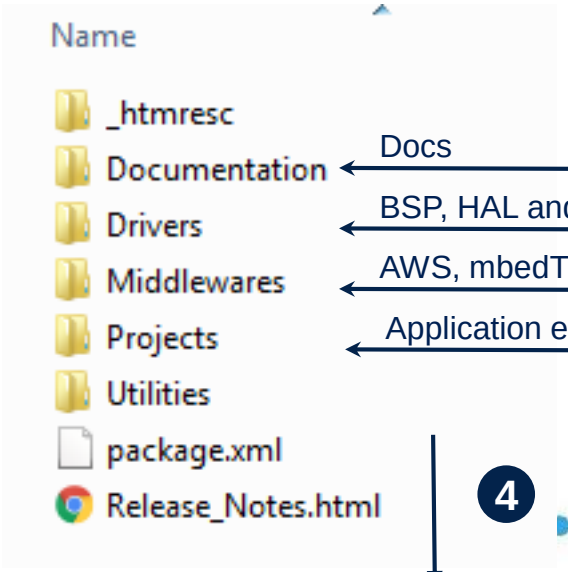
2

Select
FP-IND-PREDMNT1

3

Download & unpack

FP-IND-PREDMNT1 package structure



4

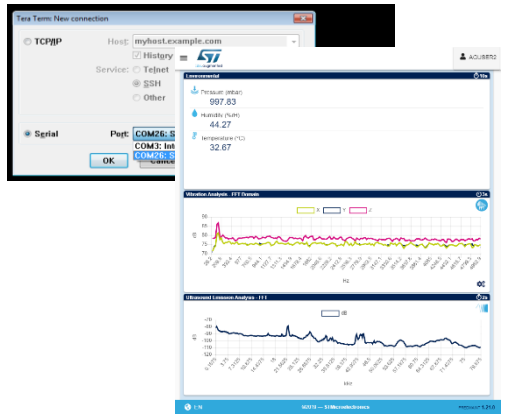
Compile/Flash and Run the project

STM32 CubeIDE IAR SYSTEMS KEIL Tools by ARM

5

6 Configure and Monitoring the application

- TeraTerm (v. 4.97 or higher)
- ST DSH-PREDMNT



.\Projects\STM32L4R9ZI-STWIN\Demonstrations\Predictive_Maintenance_WIFI\AWS\
OR
Load the pre-compiled binary using STM32 ST-LINK Utility

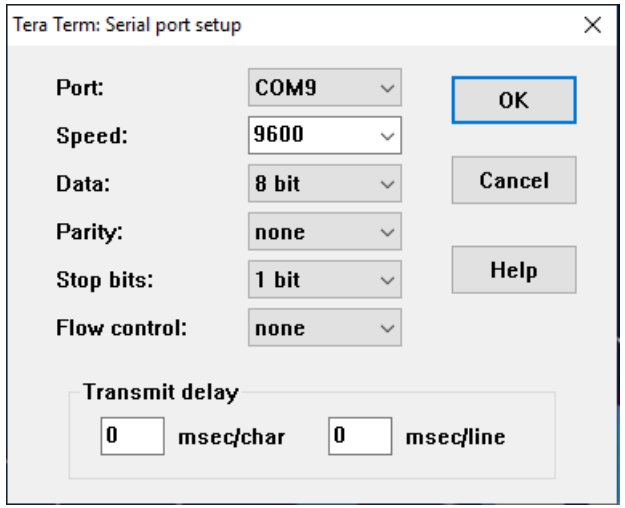
.\Projects\STM32L4R9ZI-STWIN\Demonstrations\Predictive_Maintenance_WIFI/AWS\Binary\STM32L4R9ZI-STWIN_PredictiveMaintenance_WIFI_v2.4.0.bin

Setup Overview

Predictive Maintenance with Bluetooth low energy

FP-IND-PREDMNT1 STEVAL-STWINKT1B with BLE connectivity - Serial line monitor (e.g.Tera Term)

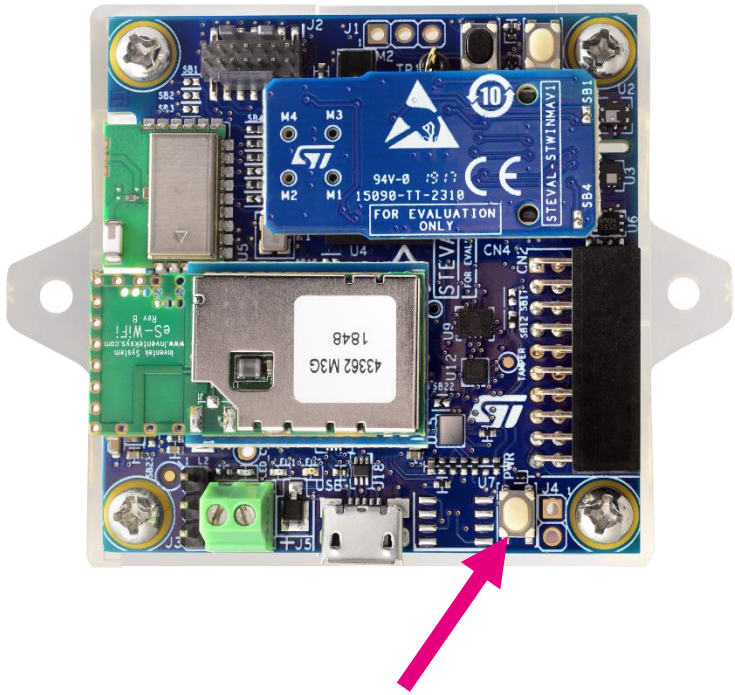
- Pressing the **RESET** User button on STEVAL-STWINCSV1 board. You could see the initialization phase
- When the boards are connected to an Android or iOS device, you can see what is transmitted via BLE



Configure the serial line monitor (speed, LF)

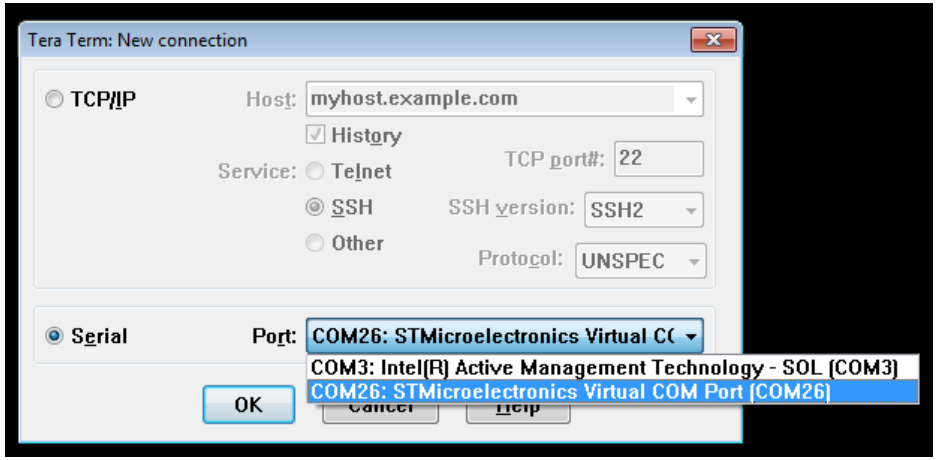
STWIN Power ON/OFF

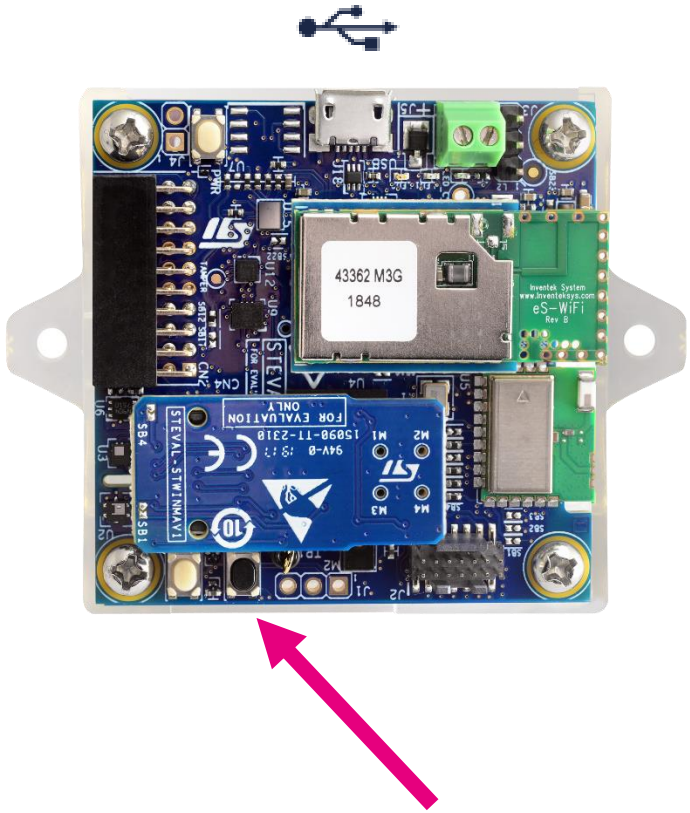
- Battery only (no USB cable):
  - Power ON
    - Long-press the PWR button until the red led turns off (~1 sec)
  - Power OFF
    - Press the PWR button
- Plugged mode (USB cable)
  - Power ON
    - When USB is plugged-in, the STWIN is always on. It doesn't matter if the battery is present or not
  - Power OFF
    - Unplug the cable and, if the battery is connected, press the PWR button.



Setup Overview
Predictive Maintenance Cloud Application (2/5)

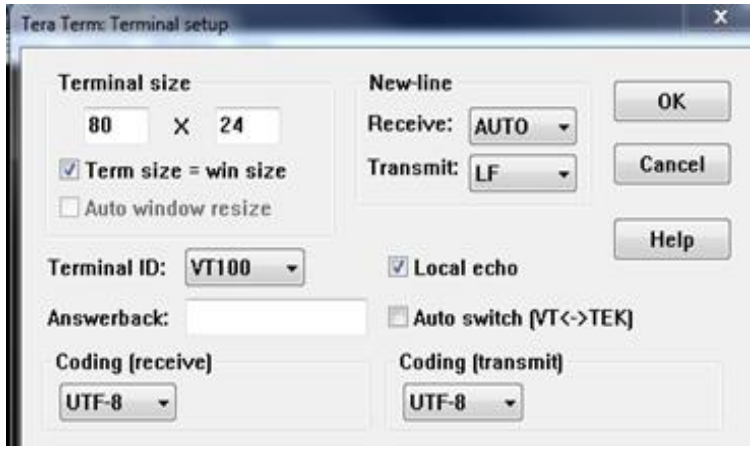
- Connect STWIN to the PC using a micro-USB cable
- Open TeraTerm (v. 4.97 or higher)
- File-> NewConnection
  - Select the right COM port





Reset Button

- Setup->Terminal
  - Set parameters as below



- Press RESET button of STWIN.

Setup Overview
Predictive Maintenance Cloud Application (3/5)

To change Wi-Fi network follow the instructions on the console:

- Press the STWIN USR button within 5 seconds

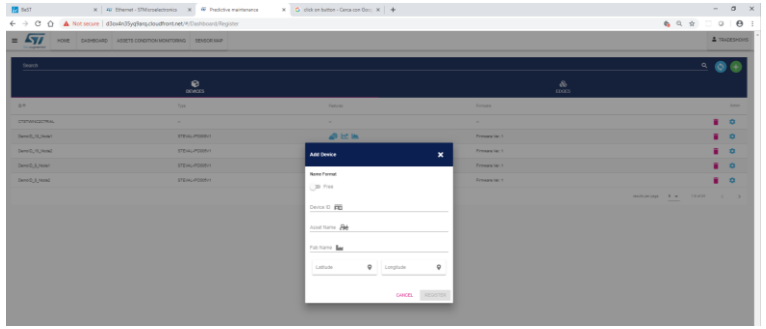
```
Push the User button (B3) within the next 5 seconds if you want to update the Wi
Fi network configuration.

Your WiFi parameters need to be entered to proceed.

Enter SSID:
```

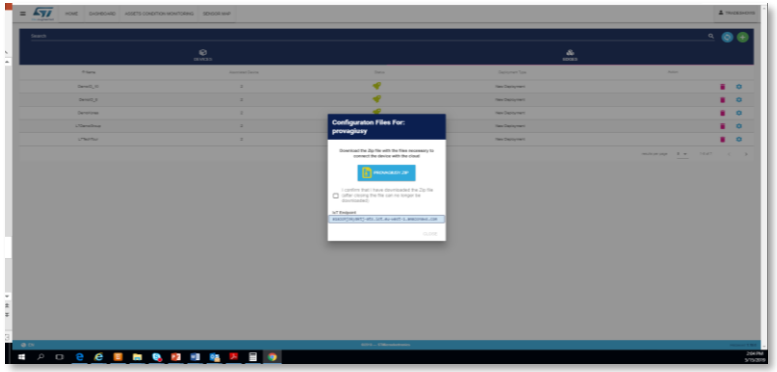
- Provide new Wi-Fi credentials:
  - SSID
  - Security mode
  - Password

```
Push the User button (B3) within the next 5 seconds if you want to update the Wi
Fi network configuration.

Your WiFi parameters need to be entered to proceed.

Enter SSID: IoT
You have entered IoT as the ssid.

Enter Security Mode (0 - Open, 1 - WEP, 2 - WPA, 3 - WPA2):3
You have entered 3 as the security mode.

Enter password: fjfjfjf
```

Setup Overview
Predictive Maintenance Cloud Application (4/5)

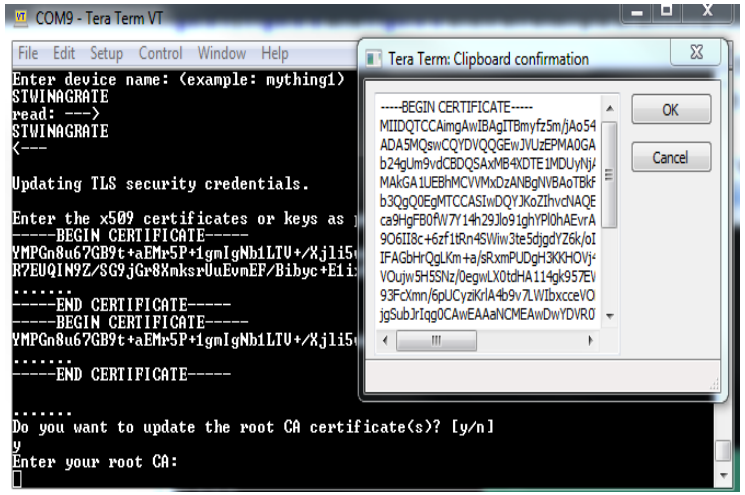
1 Register and provision the device by downloading the certificates





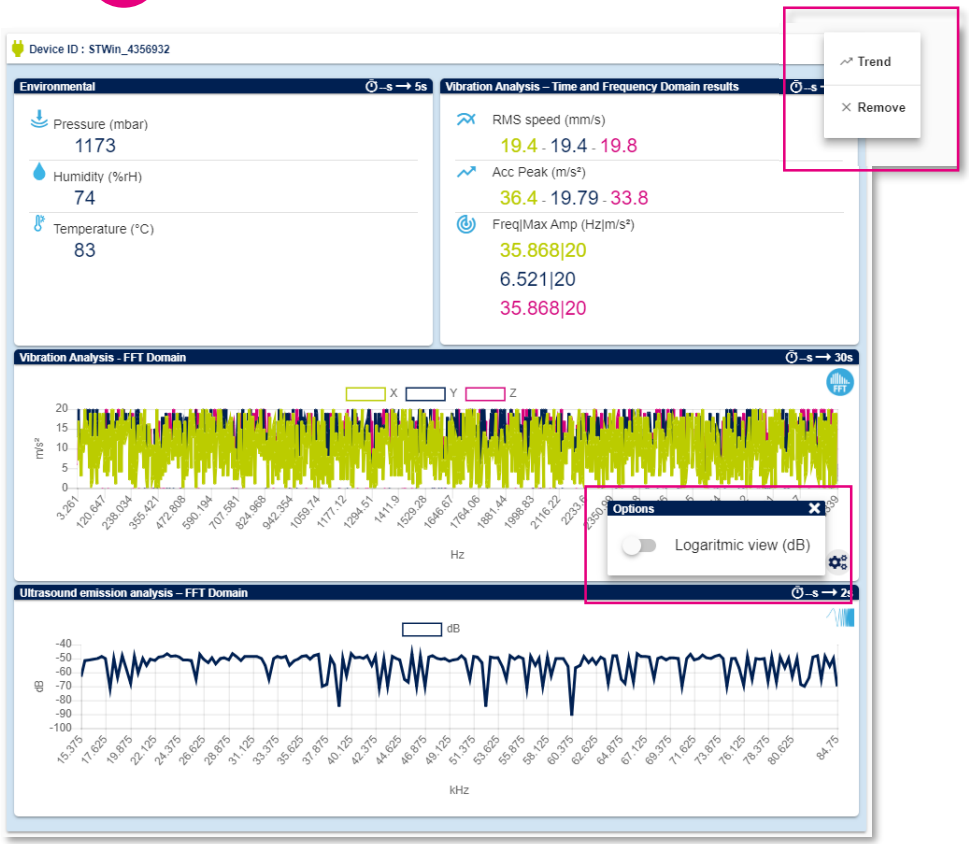
2 Configure AWS Credentials and load the certificates

- Press the USR button within 5 seconds
- Enter the AWS IoT Core endpoint
  - a1azohj3ky8ktj-ats.iot.eu-west-1.amazonaws.com (example for Predictive Maintenance Dashboard)
- Send via terminal the certificates obtained from the dashboard when the device was created:
  - Directly drag and drop the file or copy and paste the text

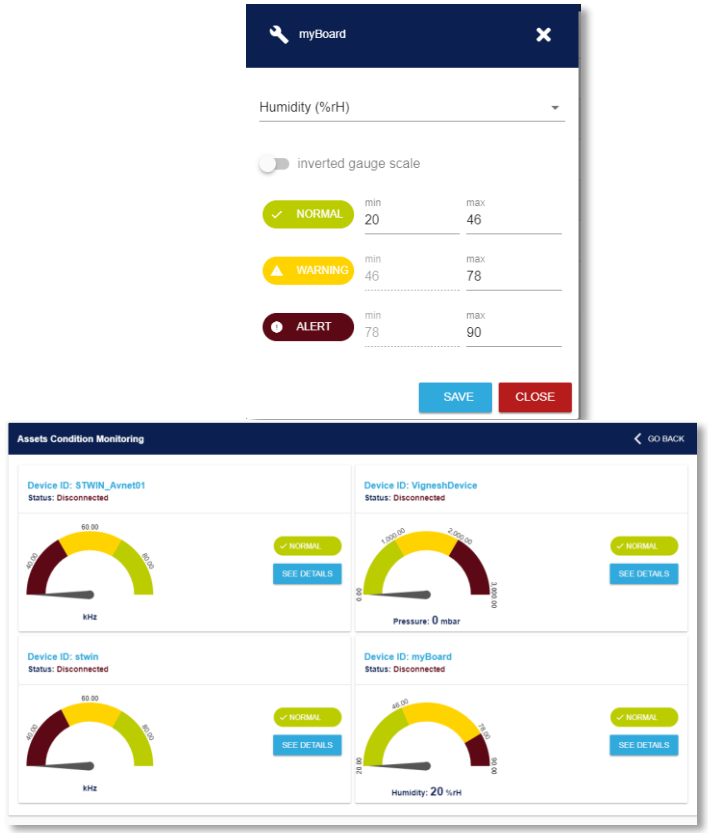


Setup Overview
Predictive Maintenance Cloud Application (5/5)

1 Add to the dashboard



2 Experiment thresholds



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2.4- Demo Examples
ST BLE Sensor Application Overview

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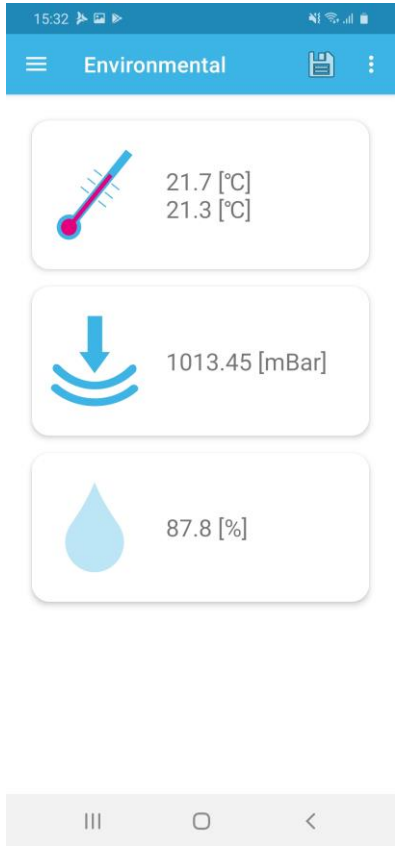
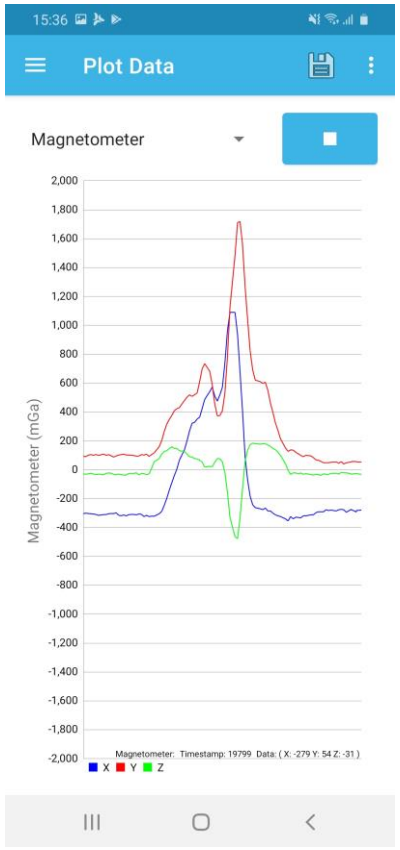
Demo Examples

ST BLE Sensor Application for Android/iOS (1/9)

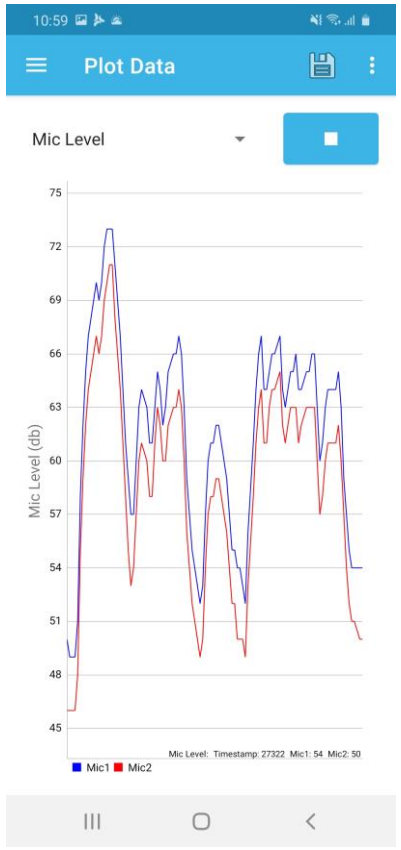
Hardware Features – Android Version



Environmental page

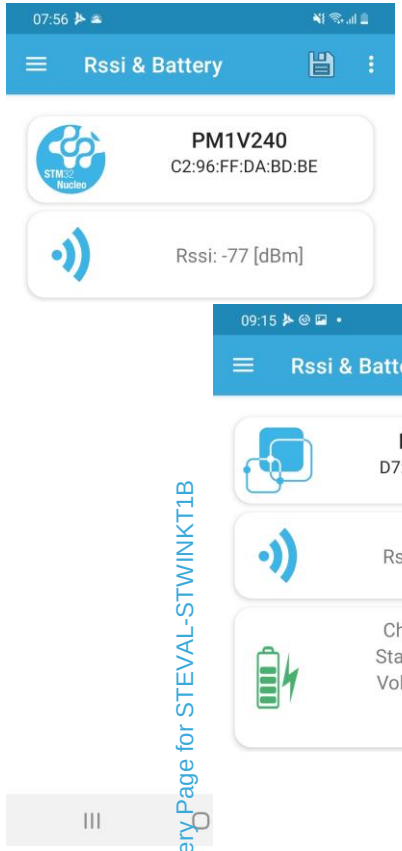


Magnetometer Plot

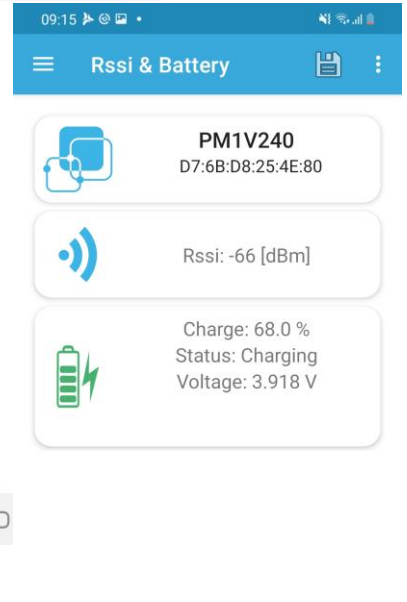


Microphones level plot

RSS & Battery Page for NUCLEO-F446RE



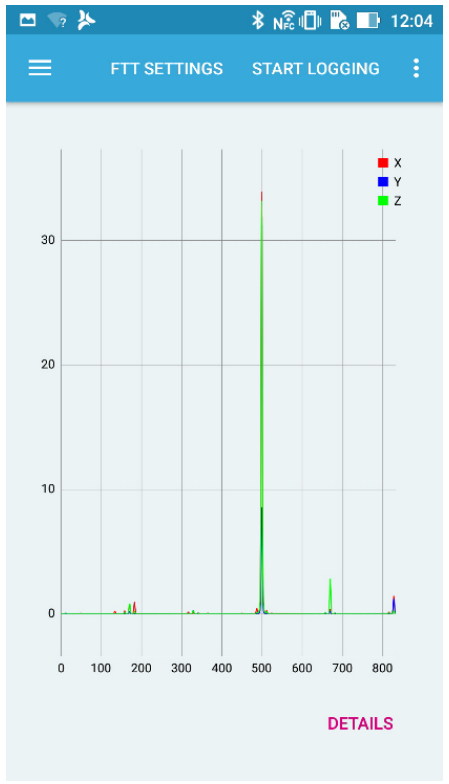
RSS & Battery Page for STEVAL-STWINKT1B



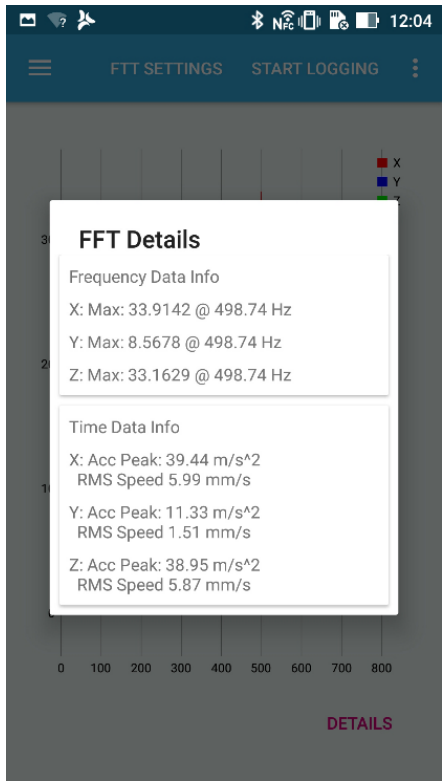
Demo Examples

ST BLE Sensor Application for Android/iOS (2/9)

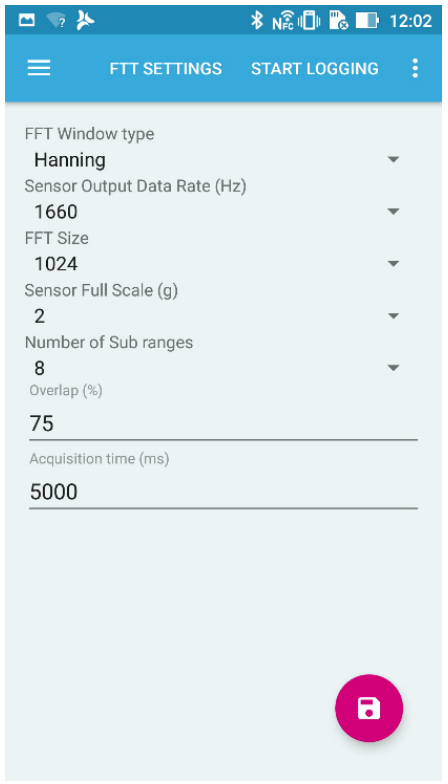
Motion Signal Processing – Android Version



ST BLE Sensor: FFT Amplitude

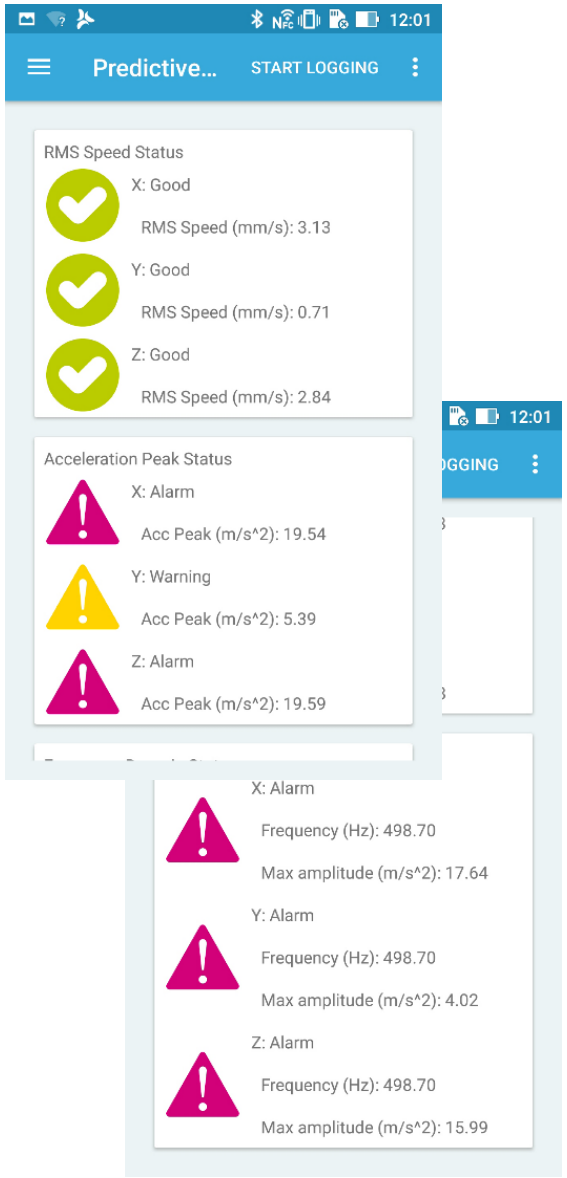


ST BLE Sensor: FFT Details



ST BLE Sensor: FFT Settings

ST BLE Sensor: Predictive Maintenance



FP-IND-PREDMNT1 NUCLEO-F446RE: Condition Monitoring & Predictive Maintenance Demonstrations
FP-IND-PREDMNT1 STEVAL-STWINKT1B: Predictive Maintenance BLE Demonstrations

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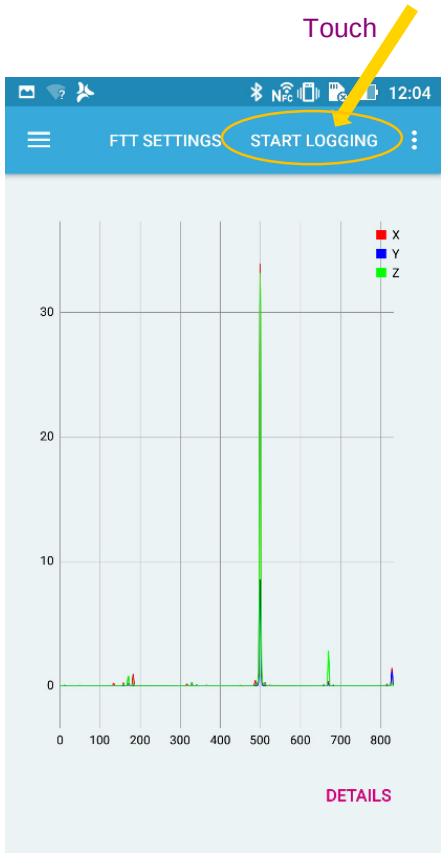
Demo Examples

ST BLE Sensor Application for Android/iOS (3/9)

Motion Signal Processing – Android Version



ST BLE Sensor: FFT Amplitude

After Stop Logging, you can compose a mail with the data log in attach.

Node: PM1V220 @373C30

Start: 2020-03-25 12:20:03
Components: 3
Sample: 512
Frequency Step: 0.407227

Frequency	AmplitudeX	AmplitudeY	AmplitudeZ
0	0.00039	0.000195	0.0004
0.407227	0.000145	0.000073	0.000067
0.814453	0.000255	0.000197	0.000209
1.22168	0.000316	0.000471	0.000357
1.628906	0.000362	0.000555	0.000543
2.036133	0.000604	0.000393	0.000791
2.443359	0.000449	0.000483	0.000567
2.850586	0.00046	0.000816	0.000748
3.257812	0.000633	0.000483	0.000976
3.665039	0.000649	0.000339	0.000767
4.072266	0.000459	0.000469	0.000978
4.479492	0.000693	0.000814	0.001144
4.886719	0.00068	0.000691	0.000891
5.293945	0.000542	0.000653	0.000959
5.701172	0.000656	0.000738	0.000966
6.108398	0.000759	0.000517	0.00117
6.515625	0.000734	0.000604	0.000907
6.922852	0.000546	0.000692	0.000637
7.330078	0.000419	0.000665	0.000898
7.737305	0.000571	0.000636	0.001215
8.144531	0.000617	0.000503	0.001173
8.551758	0.00053	0.000574	0.000593
8.958984	0.00037	0.000592	0.001126
9.366211	0.000329	0.000677	0.001264
9.773438	0.000566	0.000803	0.001172
10.180664	0.000379	0.000745	0.000803

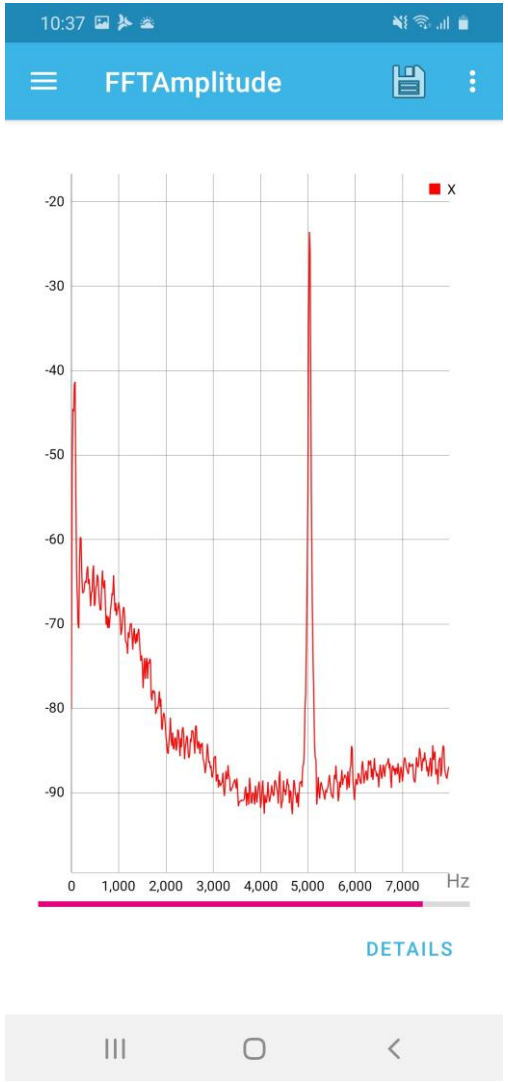
Demo Examples

ST BLE Sensor Application for Android/iOS (4/9)

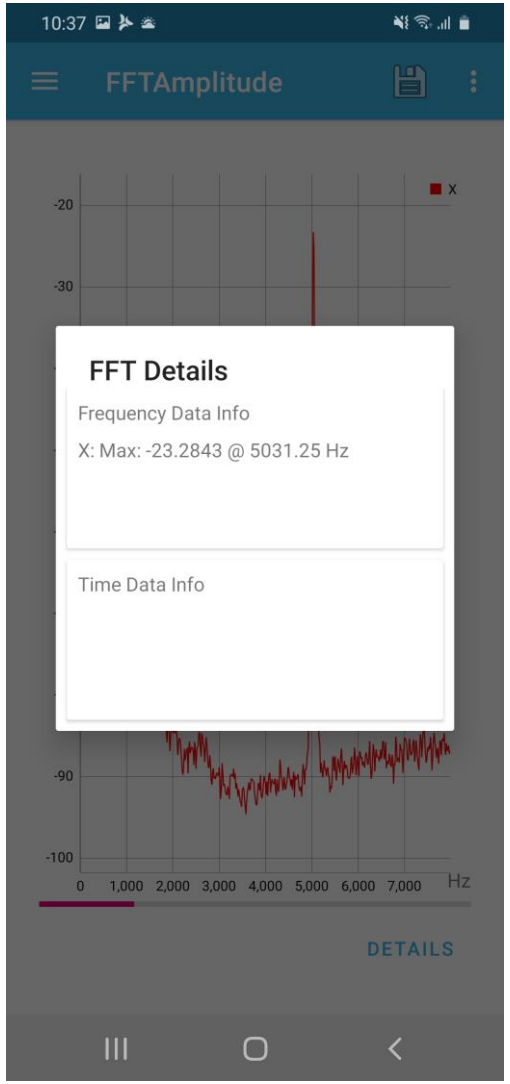
Motion Signal Processing – Android Version

Acoustic Analysis Demonstrations

ST BLE Sensor: FFT Amplitude



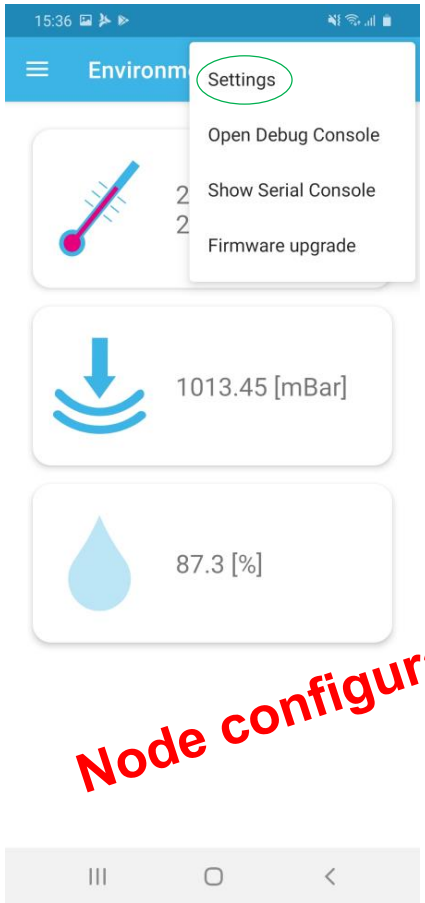
ST BLE Sensor: FFT Details



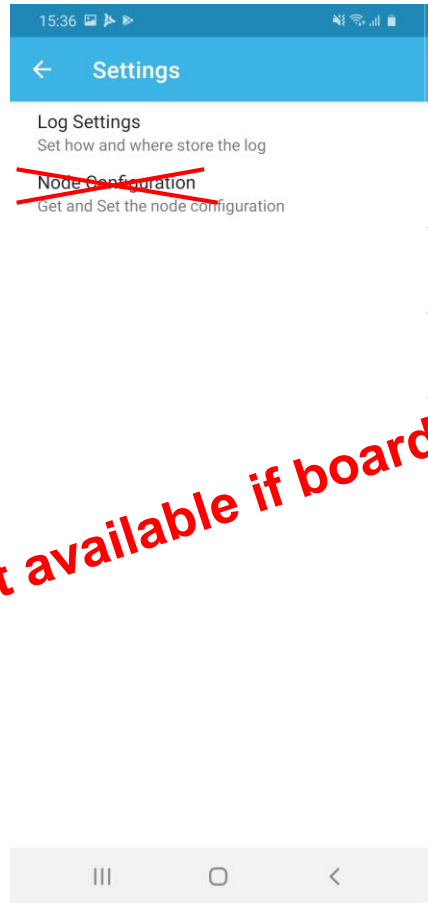
Demo Examples

ST BLE Sensor Application for Android/iOS (5/9)

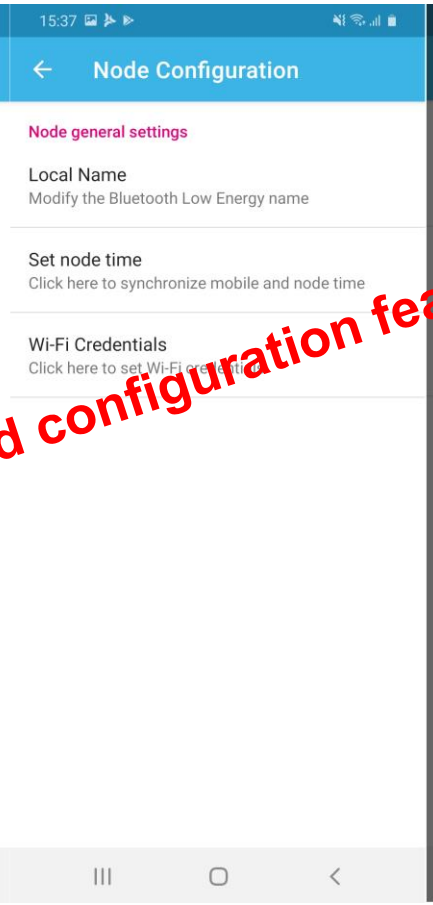
Settings – Android version



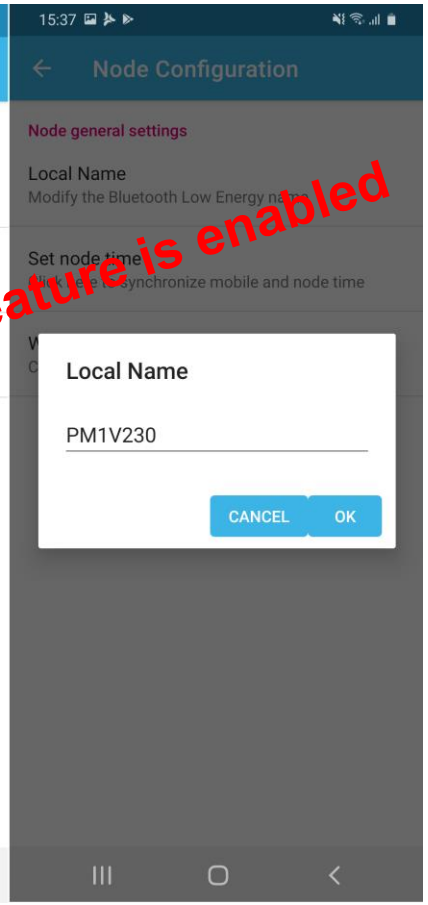
Menu Option



Settings



Node Configutation



Local Name

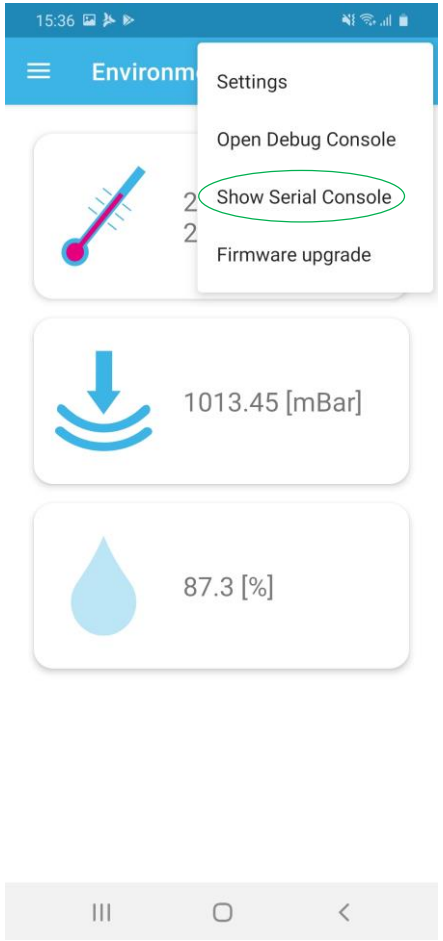
Node configuration is not available if board configuration feature is enabled

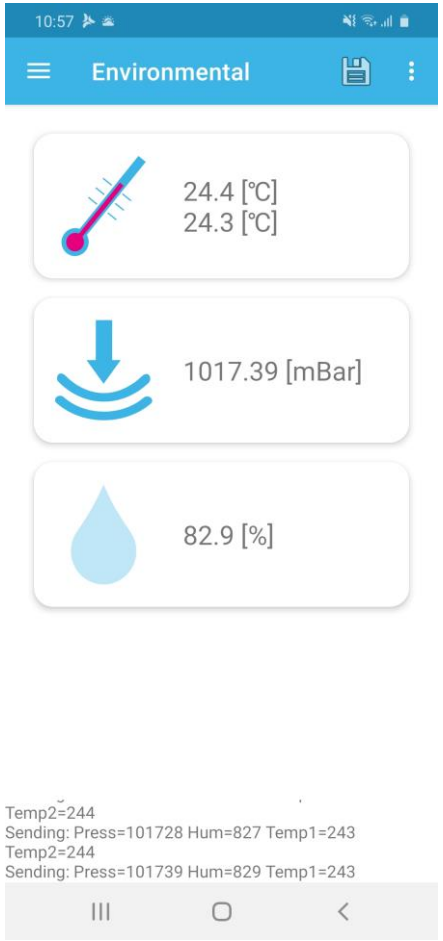
If Settings is chosen, it is possible to change the node name using the node configuration

Demo Examples

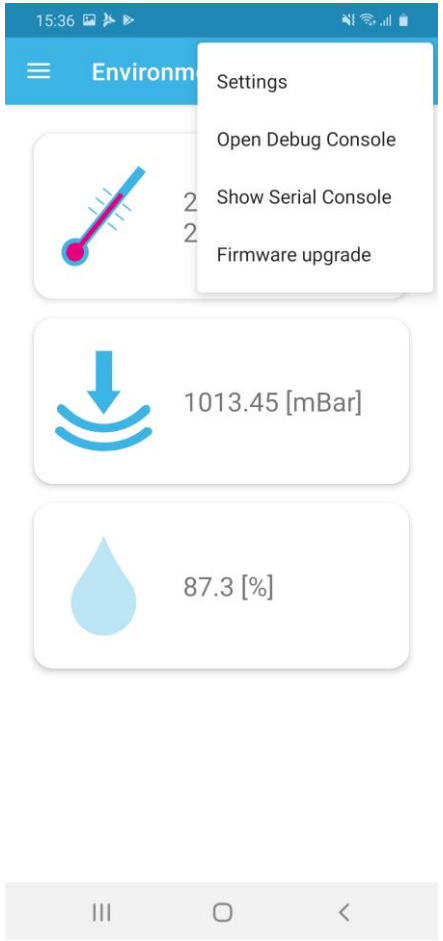
ST BLE Sensor Application for Android/iOS (6/9)

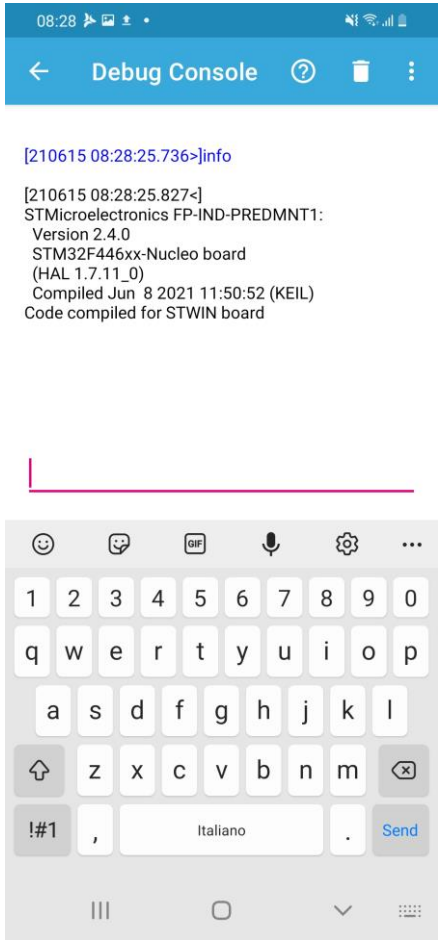
Serial & Debug Console – Android version





ST BLE Sensor: Menu Option & Serial Console (stdout/stderr)



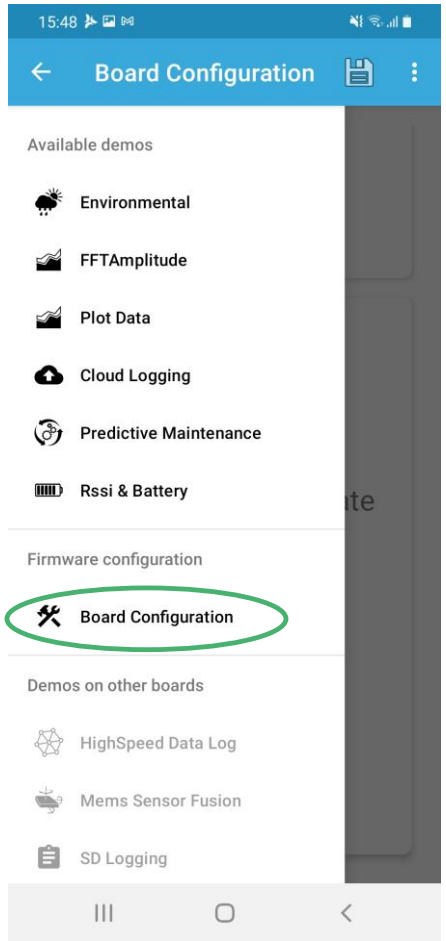


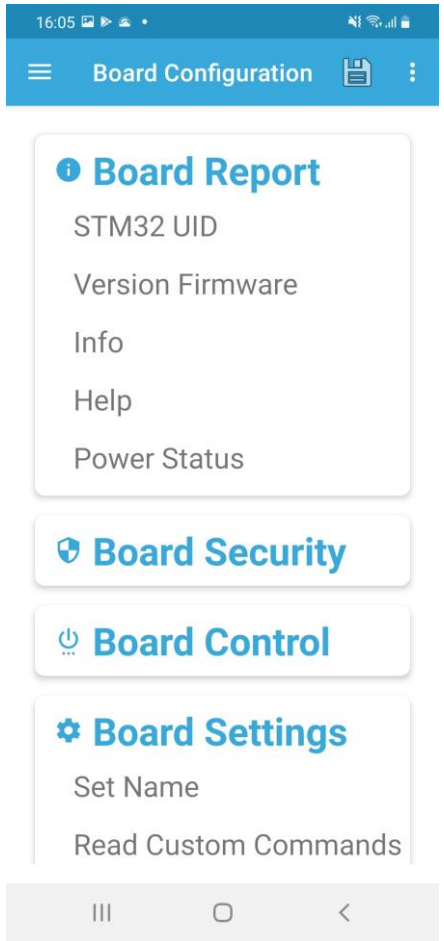
ST BLE Sensor: Menu Option & Debug Console (stdin/stdout/stderr)

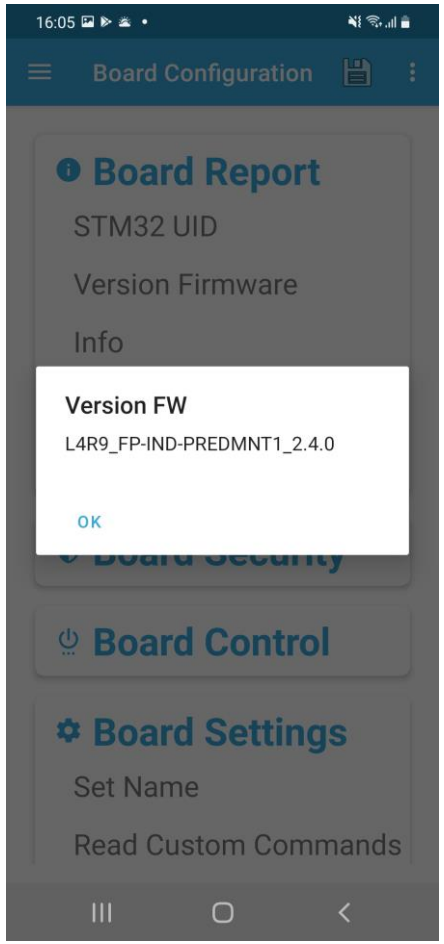
Demo Examples

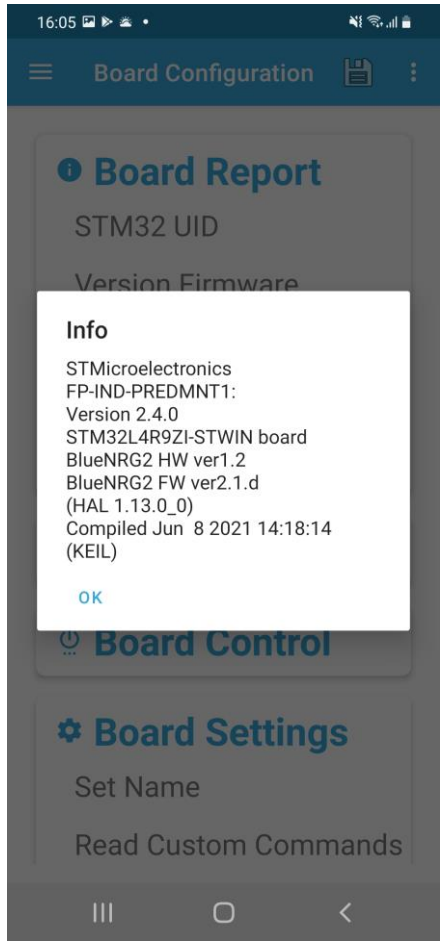
ST BLE Sensor Application for Android/iOS (7/9)

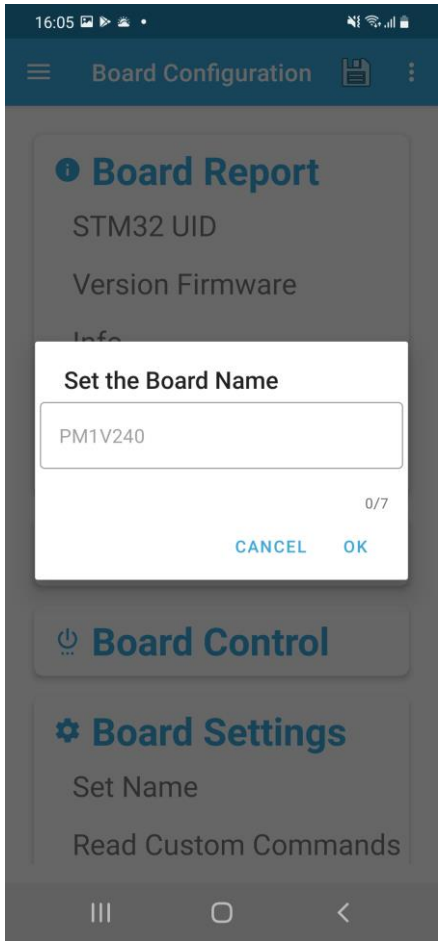
Board Configuration – Android version







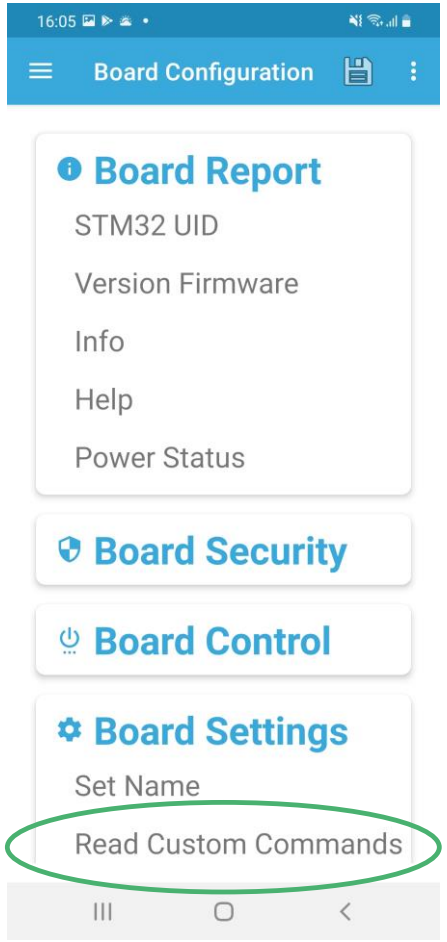


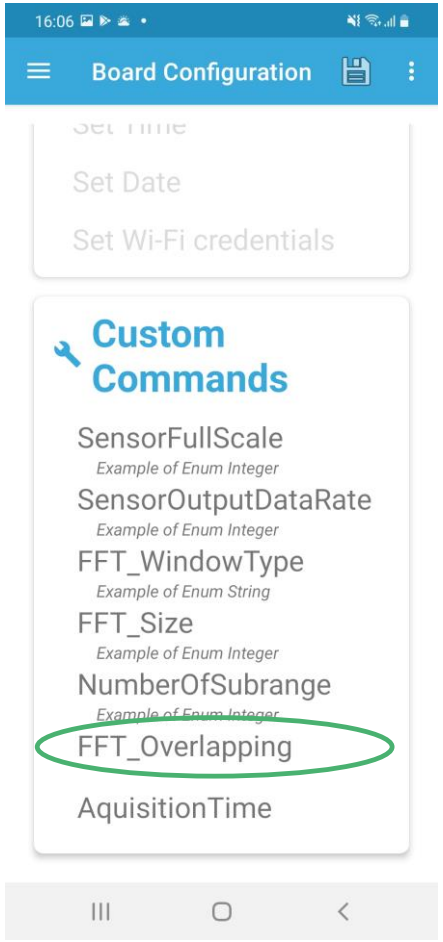


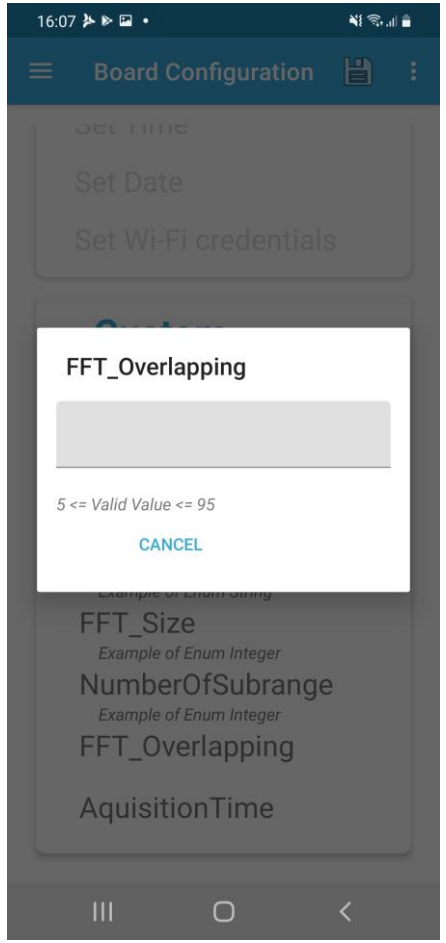
Demo Examples

ST BLE Sensor Application for Android/iOS (8/9)

Board Configuration – Android version



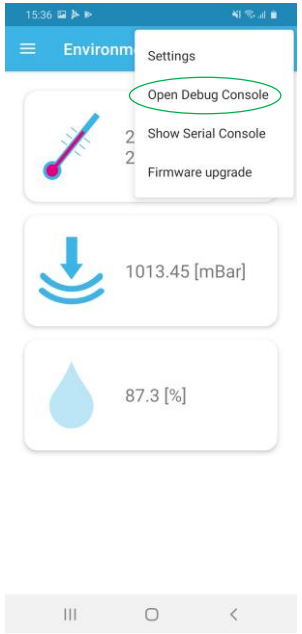




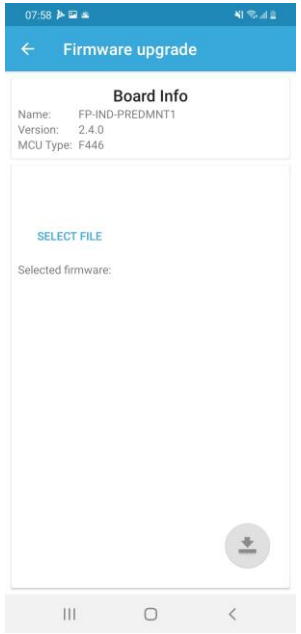
Demo Examples

ST BLE Sensor Application for Android/iOS (9/9)

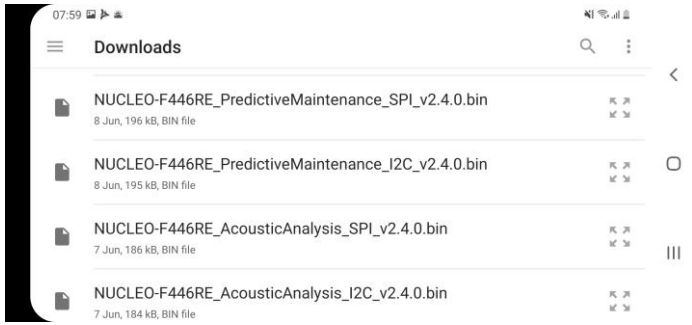
Firmware Upgrade – Android version



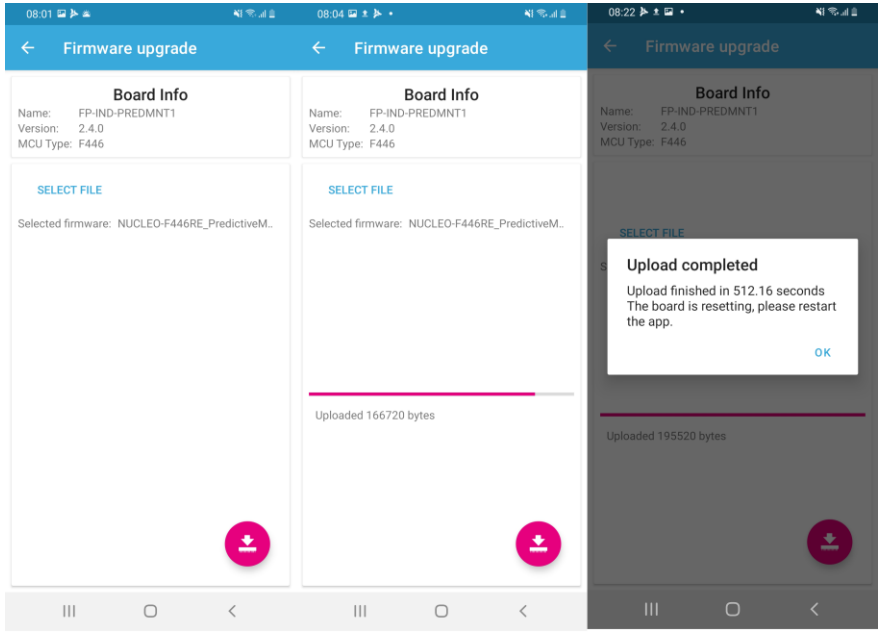
menu option



Firmware upgrade page



Firmware update file selection



Application page during FOTA and on completion

Terminal window information during FOTA

3- Documents & Related Resources

Documents & Related Resources (1/2)

All documents are available in the DESIGN tab of the related products webpage

FP-IND-PREDMNT1

- **DB3864:** STM32Cube function pack for multi sensors node with signal processing to enable predictive maintenance – **data brief**
- **UM2566:** Getting started with the STM32Cube function pack for multi sensors node with signal processing to enable predictive maintenance – **user manual**
- **Software setup file**

X-NUCLEO-CCA02M2

- **Gerber files, BOM, Schematics**
- **DB4016:** Digital MEMS microphone expansion board based on MP34DT06J for STM32 Nucleo – **data brief**
- **UM2631:** Getting started with the digital MEMS microphone expansion board based on MP34DT06J for STM32 Nucleo – **user manual**

X-NUCLEO-BNRG2A1

- **Gerber files, BOM, Schematic**
- **DB4086:** Bluetooth Low Energy expansion board based on the BLUENRG-M2SP module for STM32 Nucleo – **data brief**
- **UM2667:** Getting started with the X-NUCLEO-BNRG2A1 BLE expansion board based on BLUENRG-M2SP module for STM32 Nucleo – **user manual**

X-NUCLEO-IKS01A3

- **Gerber files, BOM, Schematic**
- **DS3851**: Motion MEMS and environmental sensor expansion board for STM32 Nucleo – **data brief**
- **UM2559**: Getting started with motion MEMS and environmental sensor expansion board for STM32 Nucleo – **user manual**

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Consult www.st.com for the complete list

Documents & Related Resources (2/2)

All documents are available in the DESIGN tab of the related products webpage

STEVAL-STWINKT1B

- **Gerber files, BOM, Schematic**
- **DB4345**:– **data brief**
- **UM2777:** How to use the STEVAL-STWINKT1B SensorTile Wireless Industrial Node for condition monitoring and predictive maintenance applications 3.0 – **user manual**

STEVAL-BFA001V2B

- **Gerber files, BOM, Schematic**
- **DB4059:** Multi-sensor predictive maintenance kit with IO-Link stack v.1.1 – **data brief**
- **UM2663**: Multi-sensor predictive maintenance kit with IO-Link device stack – **user manual**

White paper

- Capacitive MEMS accelerometer for condition monitoring

DSH-PREDMNT

- Cloud based web application for condition monitoring and predictive maintenance

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Consult www.st.com for the complete list

4- STM32 Open Development Environment: Overview

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STM32 ODE Ecosystem

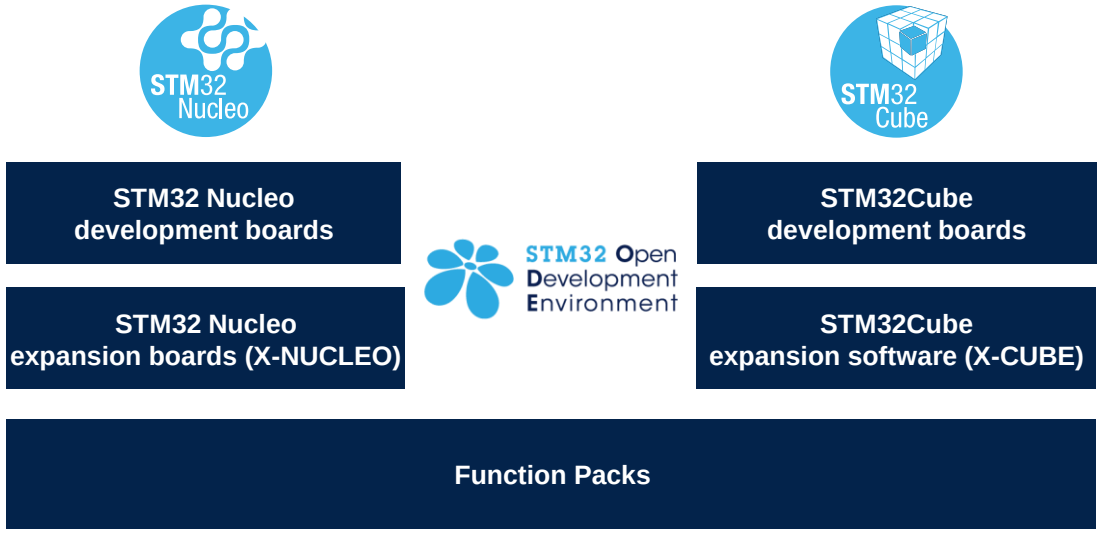
FAST, AFFORDABLE PROTOTYPING AND DEVELOPMENT

The STM32 Open Development Environment (ODE) is an **open**, **flexible**, **easy** and **affordable** way to develop innovative devices and applications based on the STM32 32-bit microcontroller family combined with other state-of-the-art ST components connected via expansion boards. It enables fast prototyping with leading-edge components that can quickly be transformed into final designs.

The STM32 ODE includes the following five elements:

- STM32 Nucleo development boards. A comprehensive range of affordable development boards for all STM32 microcontroller series, with unlimited unified expansion capability, and with integrated debugger/programmer
- STM32 Nucleo expansion boards. Boards with additional functionality to add sensing, control, connectivity, power, audio or other functions as needed. The expansion boards are plugged on top of the STM32 Nucleo development boards. More complex functionalities can be achieved by stacking additional expansion boards
- STM32Cube software. A set of free-of-charge tools and embedded software bricks to enable fast and easy development on the STM32, including a Hardware Abstraction Layer, middleware and the STM32CubeMX PC-based configurator and code generator
- STM32Cube expansion software. Expansion software provided free of charge for use with STM32 Nucleo expansion boards, and compatible with the STM32Cube software framework
- STM32 ODE Function Packs. Set of function examples for some of the most common application cases built by leveraging the modularity and interoperability of STM32 Nucleo development boards and expansions, with STM32Cube software and expansions.

The STM32 Open Development Environment is compatible with a number of IDEs including IAR EWARM, Keil MDK, mbed and GCC-based environments.



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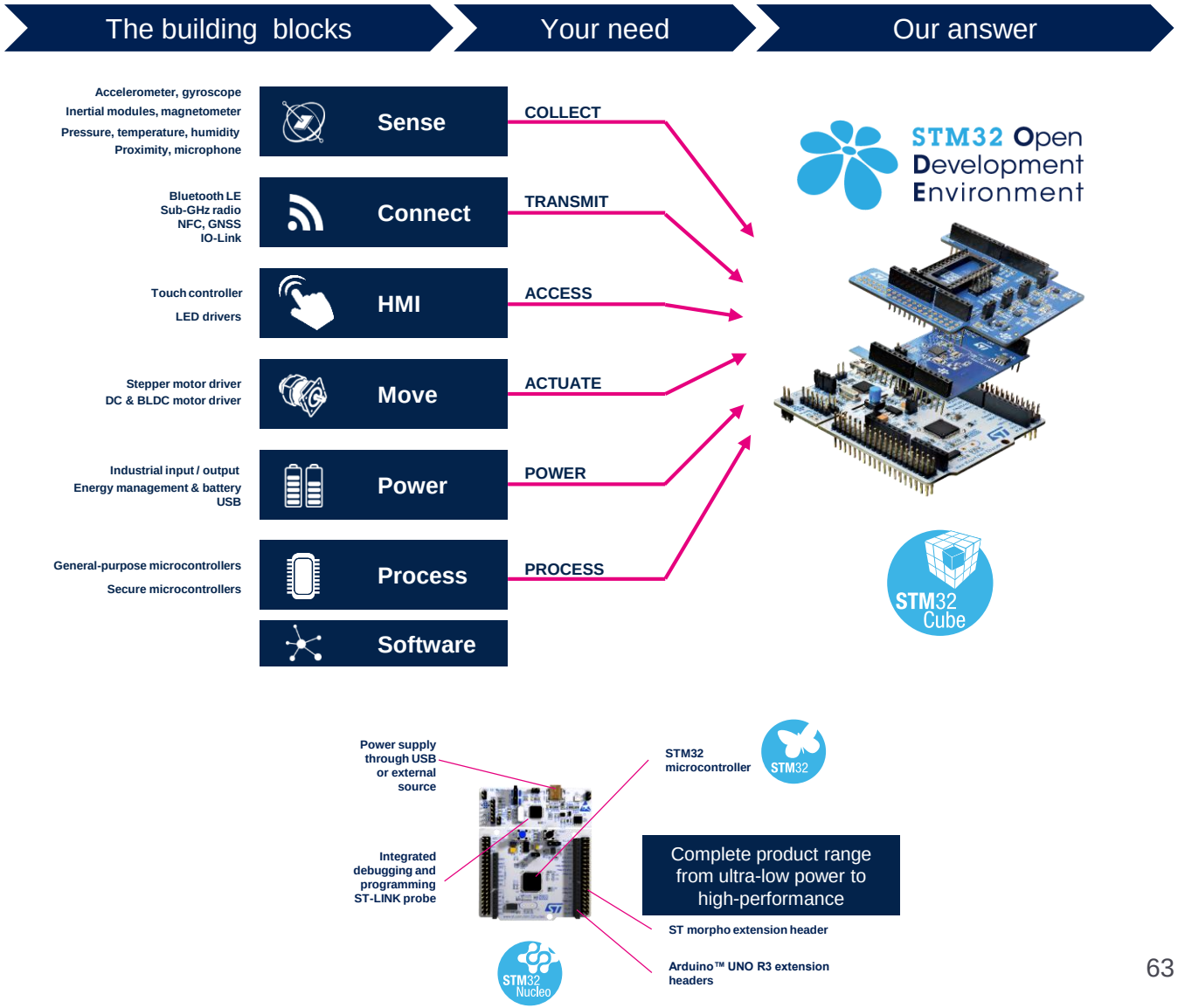
STM32 Open Development Environment: all that you need

The combination of a broad range of expandable boards based on leading-edge commercial products and modular software, from driver to application level, enables fast prototyping of ideas that can be smoothly transformed into final designs.

To start your design:

- Choose the appropriate STM32 Nucleo development board (MCU) and expansion (X-NUCLEO) boards (sensors, connectivity, audio, motor control etc.) for the functionality you need
- Select your development environment (IAR EWARM, Keil MDK, and GCC-based IDEs) and use the free STM32Cube tools and software.
- Download all the necessary software to run the functionality on the selected STM32 Nucleo expansion boards.
- Compile your design and upload it to the STM32 Nucleo development board.
- Then start developing and testing your application.

Software developed on the STM32 Open Development Environment prototyping hardware can be directly used in an advanced prototyping board or in and end product design using the same commercial ST components, or components from the same family as those found on the STM32 Nucleo boards.



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Thank you

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