Quick Start Guide

STM32Cube function pack for ultra-low power IoT node with Artificial Intelligence (AI) application based on audio and motion sensing (FP-AI-SENSING1)
Quick Start Guide Contents

- **FP-AI-SENSING1**: STM32Cube function pack for ultra-low power IoT node with Artificial Intelligence (AI) application based on audio and motion sensing
  Hardware and Software overview

- **Setup & Demo Examples**
  Documents & Related Resources

- **STM32 Open Development Environment**: Overview
Sample implementations are available for:

1. **STM32 Nucleo with expansion boards**
   - NUCLEO-L476RG + X-NUCLEO-CCA02M1 + X-NUCLEO-IDB05A1 + X-NUCLEO-IKS01A2

2. **STEVAL-STLKT01V1 evaluation boards**
   - STEVAL-STLCS01V1 + STEVAL-STLCR01V1 + STEVAL-STLCX01V1

3. **STM32L4 Discovery Board for IoT node (B-L475E-IOT01A)**

4. **STEVAL-MKSBOX1V1 evaluation board**
X-NUCLEO-IKS01A2 Hardware Description

• The X-NUCLEO-IKS01A2 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

**LSM6DSL**
MEMS 3D accelerometer (±2/±4/±8/±16 g) + 3D gyroscope (±125/±245/±500/±1000/±2000 dps)

**LSM303AGR**
MEMS 3D magnetometer (±50 gauss) + MEMS 3D accelerometer (±2/±4/±8/±16 g)

**LPS22HB**
MEMS pressure sensor, 260-1260 hPa absolute digital output barometer

**HTS221**
Capacitive digital relative humidity and temperature
DIL 24-pin

Socket available for additional MEMS adapters and other sensors (UV index)

Latest info available at www.st.com X-NUCLEO-IKS01A2

** Connector for the STM32 Nucleo Board
X-NUCLEO-IDB05A1 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

Latest info available at www.st.com
X-NUCLEO-IDB05A1
X-NUCLEO-CCA02M1 Hardware Description

- The X-NUCLEO-CCA02M1 is a board based on digital MEMS microphones. It has two MP34DT01-M microphones soldered on board and it offers the possibility to plug additional microphones using MP34DT01 based coupon evaluation boards (STEVAL-MKI129V* or STEVAL-MKI155V*).

- The X-NUCLEO-CCA02M1 enables the acquisition and streaming of up 4 microphones using both I²S and SPI bus available on ST morpho connector.

Key Products on board

**MP34DT01-M:** 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-CCA02M1

* is used as a wildcard character for related part number
Before connecting the expansion board to the NUCLEO-L476RG board it is needed to change default solder bridges on the expansion boards:

- **On the X-NUCLEO-IKS01A2**
  - Open SB25

- **On the X-NUCLEO-CCA02M1**
  - Open SB7/SB15/SB17
  - Close SB12/SB16
STEVAL-STLKT01V1 Hardware Description

- STEVAL-STLKT01V1 is the development kit for the SensorTile board (STLCS01V1), a highly Integrated Development Platform with a broad range of functionalities aiming to improve system design cycle and accelerate delivery of results.

- Two host boards are also provided as part of the kit, both featuring SWD programming interface.
  - Cradle expansion has a plugin connection for SensorTile Core System and an Arduino interface.
  - The Cradle is a small host featuring battery charger and SD card interface that supports on-the-field testing and data acquisition campaigns.
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-enumeration capability: mass storage, virtual COM port and debug port

Latest info available at www.st.com B-L475E-IOT01A
Multi sensor kit with portable sensor box and smart sensor app

Hardware Description

The STEVAL-MKSBOX1V1 (SensorTile.box) is a ready-to-use box kit with wireless IoT and wearable sensor platform to help you use and develop apps based on remote motion and environmental sensor data, regardless of your level of expertise.

The SensorTile.box board fits into a small plastic shroud with a long-life rechargeable battery, and the ST BLE Sensor app on your smartphone connects via Bluetooth to the board and allows you to immediately begin using the wide range of default IoT and wearable sensor applications.

SensorTile.box includes a firmware programming and debugging interface that allows professional developers to engage in more complex firmware code development using the STM32 Open Development Environment (STM32 ODE), which includes a sensing AI function pack with neural network libraries.

Key Product on board

- Ultra-low-power STM32L4 Series MCUs based on ARM® Cortex®-M4 MCU 120 MHz with 2048 kbytes Flash (STM32L4R9ZI)
- Accurate temperature: STTS22H
- Low power precise 6x IMU: LSM6DSOX
- Stand-alone XLS: LIS3DHH, LIS2DW12
- Magnetometer: LIS2MDL
- Altimeter / pressure sensor: LPS22HH
- Wide-band microphone: MP23ABS1
- Humidity sensor: HTS221

Latest info available at www.st.com
STEVAL-MKSBOX1V1
Software Description

FP-AI-SENSING1 is an STM32Cube function pack featuring examples that let you connect your IoT node to a smartphone via BLE and use a suitable Android™ or iOS™ application, like the ST BLE Sensor app, to configure the device.

The package enables advanced applications such as human activity recognition or audio scene classification, on the basis of outputs generated by neural networks (NN). The NN are implemented by libraries generated by the X-CUBE-AI extension for STM32CubeMX tool. The package comes with an AI utility for data logging and annotation on SD card. The user is able to record the data from the sensors and to define what are the classes or the events he wants to record. With the recorded annotated data, the user will be able to train his own Neural Network on his PC/GPU/Cloud, get the model, use X-CUBE-AI extension for STM32CubeMX tool for conversion, and then run it on the STM32 platform.

Key features

- Complete firmware to develop an IoT node with BLE connectivity, digital microphone, environmental and motion sensors, and perform real-time monitoring of sensors and audio data
- Middleware libraries generated thanks to STM32CubeMx extension called X-CUBE-AI, featuring example implementation of neural networks for real-time human activity recognition (HAR) and acoustic scene classification (ASC) applications
- AI utility for data logging and annotation on SD card
- Ultra-low power implementation based on the use on an RTOS
- Compatible with ST BLE Sensor application for Android/iOS, to perform sensor data reading, audio and motion algorithm feature demo, and firmware update over the air (FOTA)
- Easy portability across different MCU families, thanks to STM32Cube.
- Free, user-friendly license terms.

Overall Software Architecture

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Hardware

- STM32 Nucleo expansion boards:
  - X-NUCLEO-IDB05A1 (Connect)
  - X-NUCLEO-IKS01A2 (Sense)
  - X-NUCLEO-CCA02M1 (Sense)
- Evaluation boards:
  - STEVAL-STLKT01V1
  - STEVAL-MKSBOX1V1
- B-L475E-IOT01A discovery Kit IoT Node

Latest info available at www.st.com
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Hardware and Software overview

Setup & Demo Examples
Documents & Related Resources

STM32 Open Development Environment: Overview
Setup & Demo Examples

HW prerequisites

- 1x STM32 Nucleo Bluetooth Low Energy expansion board (X-NUCLEO-IDB05A1)
- 1x STM32 Nucleo Motion MEMS and environmental sensor expansion Board (X-NUCLEO-IKS01A2)
- 1x STM32 Nucleo Digital MEMS microphone expansion board (X-NUCLEO-CCA02M1)
- 1x STM32 Nucleo Development Board (NUCLEO-L476RG)
- 1x Android™ or iOS™ device
- 1x PC with Windows 7 and above
- 1x USB type A to Mini-B USB cable

It is necessary to connect the boards in the order shown in this picture.
Setup & Demo Examples

HW prerequisites and setup with SensorTile (1/2)

- 1x SensorTile Kit (STEVAL-STLKT01V1):
  - SensorTile Core System: STLCS01V1
  - SensorTile Cradle eXpansion: STLCX01V1
  - SensorTile Cradle: STLCR01V1
  - Battery
  - Programming cable

- 1x Android™ or iOS™ device

- 1x PC with Windows 7 and above

- 1x STM32-Nucleo or ST-Link programmer

- 1x USB type A to Mini-B USB cable for the ST-Link

- 1x USB type A to Micro-B USB cable for SensorTile Cradles
In order to program the board you need to connect an external ST-Link to the SWD connector on the cradles, a 5pin flat cable is provided within the SensorTile Kit package.

The easiest way is to get an STM32-Nucleo board which includes an ST-Link V2.1 programmer.

Be sure that CN2 Jumpers are OFF and connect your STM32 Nucleo board to the SensorTile Cradle through the provided cable paying attention to the polarity of the connectors. Pin 1 can be identified by a little circle on the PCB silkscreen (STM32 Nucleo board and SensorTile Cradle Expansion) or by the square shape of the soldering pad of the connector (SensorTile Cradle).

Cradle SWD connection

Cradle eXpansion SWD connection
Setup & Application Examples
HW prerequisites for B-L475E-IOT01A

- 1x B-L475E-IOT01A development board
- Laptop/PC with Windows 7, 8 or 10
- 1 x microUSB cable
Setup & Application Examples
HW prerequisites for STEVAL-MKSBOX1V1

- 1x STEVAL-MKSBOX1V1 evaluation board
- Laptop/PC with Windows 7, 8 or 10
- 1 x microUSB cable
- 1x USB type A to Mini-B USB cable
- ST-Link/V2 in-circuit debugger/programmer for STM8 and STM32
• **STSW-LINK009**
  - ST-LINK/V2-1 USB driver

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

• **FP-AI-SENSING1**
  - Copy the .zip file content into a folder on your PC. The package will contain source code example (Keil, IAR, System Workbench) based only on **NUCLEO-L476RG**, **STEVAL-STLKT01V1**, **B-L475E-IOT01A** or **STEVAL-MKSBOX1V1**

• **ST BLE Sensor** Application for **Android/iOS** to download from Google Store / iTunes
FP-AI-SENSING1

Setup Overview


2. Select FP-AI-SENSING1

3. Download & unpack

4. FP-AI-SENSING1 package structure

5. Compile/Flash and Run the project

6. Android™/iOS™ smartphone and ST ST BLE Sensor application

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IMPORTANT:
Read the chapter “The Boot Process” on User Manual for understanding how to install the Boot Loader on the board
1. How to install the pre-compiled binary:

- Inside the package there is one folder called “Binary” that contains:

  - pre-compiled FP-AI-SENSING1 (*.bin) FW that can be flashed to a supported NUCLEO-L476RG, SensorTile, SensorTile.box board or B-L475E-IOT01A 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-AI-SENSING1+BootLoader (*.BL.bin) FW that could be directly flashed to a supported NUCLEO-L476RG, SensorTile, SensorTile.Box board or B-L475E-IOT01A using the ST-Link or by doing “Drag & Drop” (the latter only for STM32 Nucleo and B-L475E-IOT01A)
    - Important Note: this pre-compiled binary is not compatible with the FOTA update procedure

Without Boot loader, can be used for FOTA

With Boot loader, cannot be used for FOTA
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: CleanSENSING1.bat
  - System Workbench for STM32: CleanSENSING1.bat
  - µVision toolchain - MDK-ARM Professional: CleanSENSING1.bat
- For Linux/iOS: only for Openstm32 IDE and for each platform there is one OpenOCD:
  - CleanSENSING1.sh

It’s necessary to edit this file for setting the right installation and Library path

- These scripts perform the following steps:
  1. Full Flash Erase
  2. Flash the right BootLoader at the right position (0x08000000)
  3. Flash the SENSING1 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
  4. Save a complete Binary FW that includes both SENSING1 and the BootLoader
     - This binary can be directly flashed to a supported STM32 Nucleo, SensorTile and B-L475E-IOT01A board board using the ST-Link or by doing “Drag & Drop” (the latter only for STM32 Nucleo and B-L475E-IOT01A boards)
     - Important Note: this additional pre-compiled binary is not compatible with the FOTA update procedure
Flash Management and Boot Process

Flash Structure

**Region 3 start for SensorTile.box is 0x08100000** (vs. 0x08080000 for all other boards)
FP-AI-SENSING for NUCLEO-L476RG or B-L475E-IOT01A

- When pressing the **RESET** User button on STM32 board, you can 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)
ST BLE Sensor Application for Android/iOS (1/5)

Initial Steps

Starting Page

Discovery Page

Clear Device Cache

Device Connected
ST BLE Sensor Application for **Android/iOS (2/5)**

Data Monitoring

Environmental page

Accelerometer plot

Microphones level plot

DS3/DSM/DSL Menu Events

RSS & Battery Page

Hardware Features – Android Version

DS3/DSM/DSL Event

Multiple events page

Pedometer

Wake Up

Orientation
ST BLE Sensor Application for Android/iOS (3/5)
HAR and ASC Features

HAR-GMP/HAR_IGN Activity Recognition

HAR_IGN_SWDM Activity Recognition

Audio Scene Classification
• Data logging feature is available in order to enable users to create their data sets for training their NN models
• Pre-processing python scripts for model re-training are also provided in the package
ST BLE Sensor Application for Android/iOS (5/5)

Firmware Upgrade – Android version

ST BLE Sensor: Firmware update file selection

ST BLE Sensor: Firmware upgrade page

ST BLE Sensor: application page during FOTA and on completion

Terminal window information after FOTA
All documents are available in the DESIGN tab of the related products webpage

FP-AI-SENSING1

- **DB3785**: STM32Cube function pack for ultra-low power IoT node with artificial intelligence (AI) application based on audio and motion sensing – **data brief**
- **UM2524**: Getting started with the STM32Cube function pack for ultra-low power IoT node for Artificial Intelligence (AI) application based on audio and motion sensing – **user manual**
- Software setup file

X-NUCLEO-CCA02M1

- Gerber files, BOM, Schematics
- **DB2593**: Digital MEMS microphones expansion board based on MP34DT01-M for STM32 Nucleo – **data brief**
- **UM1900**: Getting started with the digital MEMS microphones expansion board based on MP34DT01-M for STM32 Nucleo – **user manual**

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**
- **AN4642**: Overview of the BLE Profiles application for X-CUBE-BLE1, expansion for STM32Cube – **application note**

Consult www.st.com for the complete list
Documents & Related Resources (2/3)

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

X-NUCLEO-IKS01A2
- Gerber files, BOM, Schematic
- DB3009: Motion MEMS and environmental sensor expansion board for STM32 Nucleo – data brief
- UM2121: Getting started with the X-NUCLEO-IKS01A2 motion MEMS and environmental sensor expansion board for STM32 Nucleo – user manual

STEVAL-STLKT01V1
- Gerber files, BOM, Schematic
- DB2956: SensorTile development kit – data brief
- UM2101: Getting started with the STEVAL-STLKT01V1 SensorTile integrated development platform – user manual

B-L475E-IOT01A:
- Gerber files, BOM, Schematic
- DB3009: Motion MEMS and environmental sensor expansion board for STM32 Nucleo – product specification
- UM2121: Getting started with motion MEMS and environmental sensor expansion board for STM32 Nucleo – user manual

Consult www.st.com for the complete list
All documents are available in the DESIGN tab of the related products webpage

STEVAL-MKSBOX1V1

- Gerber files, BOM, Schematic
- **DB3903**: SensorTile.box wireless multi sensor development kit with user friendly app for IoT and wearable sensor applications – data brief
- **UM2580**: How to use the wireless multi sensor development kit with customizable app for IoT and wearable sensor applications – 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 expansion boards (X-NUCLEO)
- STM32 Nucleo development boards
- STM32Cube expansion software (X-CUBE)

Function Packs (FP)

www.st.com/stm32ode
• A comprehensive range of affordable development boards for all the STM32 microcontroller series, with unlimited unified expansion capabilities and integrated debugger/programmer functionality.
STM32 Nucleo Expansion Boards (X-NUCLEO)

• 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)
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)
- STM32Cube expansion middleware

**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