Getting started with SensorTile.box PRO multi-sensors and wireless connectivity development kit for any intelligent IoT node

Introduction

The STEVAL-MKBOXPRO (SensorTile.box PRO) is the new ready-to-use programmable wireless box kit for developing any IoT application based on remote data gathering and evaluation. It exploits the full kit potential by leveraging both motion and environmental data sensing, along with a digital microphone, and enhances connectivity and smartness in all environments.

The hardware node is a board that fits into the palm of your hand (40x63 mm) with a long-life 3.7 V 480 mAh rechargeable battery. The user can connect to the board via Bluetooth® by using the ST BLE Sensor Classic app (available both on Google Play and the Apple Store) on their smartphone and immediately build their own apps through a special interface. Apps can be developed quickly regardless of the level of expertise:

• **Entry mode**: play around with the default apps and see what STMicroelectronics sensors can achieve
• **Expert mode**: create your own app in a simple graphic environment
• **Pro mode**: develop code in an intuitive way using the STM32 open development environment (ODE) and STMicroelectronics function pack libraries

The kit board includes an ultra-low power programmable Bluetooth® Low Energy wireless SoC solution BlueNRG-LP 355AC, that is compliant with Bluetooth(R) Low Energy v5.2. This transmitter module is FCC (FCC ID: S9N-MKBOXPRO) certified and IC (IC: 8976C-MKBOXPRO; PMN: STEVAL-MKBOXPRO; HVIN: STEVAL-MKBOXPRO; FVIN: STSW-MKBOXPRO-BL) certified. The board also includes a wireless charger and a programmable NFC tag.

In addition, a DIL24 socket for easy MEMS adapter connection and a microSD™ card for storing data are available.

Figure 1. STEVAL-MKBOXPRO (SensorTile.box PRO) multi-sensor and wireless connectivity development kit
1 Getting started

1.1 Precaution for use

**Warning:** Charge the device with a DC 5 V–500 mA USB charger at a temperature from 10 °C to 35 °C. The kit must be used within the working temperature range. It must never be exposed to excessive heat such as direct sunlight, fire, or heating equipment.

**Danger:** Use only USB chargers equipped with short-circuit protections to prevent fire hazard.

**Danger:** Use only wireless chargers with foreign object detection (FOD) to prevent high temperatures.

**Danger:** Use only the LiPo battery provided with the kit (HiMax 752535). Replacing the battery with an incorrect type can void any safeguards. LiPo batteries can be damaged and even explode if they are short-circuited, overcharged, or through improper usage, such as mechanical crushes, hot oven, or battery cutting.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>10°C to 35°C</td>
</tr>
<tr>
<td>Charging temperature</td>
<td>10°C to 35°C</td>
</tr>
<tr>
<td>Humidity</td>
<td>Up to 80%</td>
</tr>
<tr>
<td>Operating altitude</td>
<td>Up to 2000 m</td>
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</table>

1.2 Features

- Ultra-low-power with FPU Arm-Cortex-M33 with a TrustZone® microcontroller (STM32U585AI)
- High precision sensors to gather high-quality data:
  - Low-voltage local digital temperature sensor (STTS22H)
  - 6-axis inertial measurement unit (LSM6DSV16X)
  - 3-axis low-power accelerometer (LIS2DU12)
  - 3-axis magnetometer (LIS2MDL)
  - Pressure sensor (LPS22DF)
  - Digital microphone/audio sensor (MP23DB01HP)
- User interface:
  - Hardware power switch
  - Green and orange system LED to display the power supply state
  - Four programmable status LEDs (green, red, orange, blue)
  - Two programmable push-buttons
  - Audio buzzer
  - Reset button
  - Qvar with electrodes for user interface experience
  - Interface for J-Link/SWD debug-probe
  - Interface for extension board
  - Socket for DIL24 sensor adapters
Connectivity:
- microSD™ card slot
- Bluetooth® Low Energy 5.2 (BlueNRG 355AC)
- NFC tag (ST25DV04K)

Power and charging options:
- USB Type-C® charging and connecting
- 5 W wireless charging
- 480 mAh battery

1.3 RF specifications
- RF output power for Bluetooth® Low Energy: 0 dBm
  - Bluetooth® Low Energy frequency range: 2402 - 2480 MHz
  - Bluetooth(r) Low Energy Channel spacing: 2 MHz
  - NFC frequency: 13.56 MHz
  - SMD ferrite coil inductor antenna for passive NFC

1.4 Kit components
The STEVAL-MKBOXPRO development kit includes:
- the SensorTile.Box Pro (main board)
- a plastic case with M2.5 screws
- a 480 mAh 3.7 V LiPo battery
- Qvar electrodes
- wireless charger receiver circuit
- programmable NFC tag
- microSD™ card
- STEVAL-MKIGIBV4 STLINK adapter with programming cable.

Figure 2. STEVAL-MKBOXPRO components
1.5 Layout of the STEVAL-MKBOXPRO

Figure 3. Layout of the core system board components - top
Figure 4. Layout of the core system board components - bottom
1.6 Core system board

Figure 5. STEVAL-MKBOXPRO block diagram

**Sense, Process and Connect**

- **Motion Sensors**
  - 6-axis inertial measurement unit (LSM6DSYV10X)
  - 3-axis low-power accelerometer (LIS2DU12)
  - 3-axis magnetometer (LIS2MDL)

- **Environmental Sensors**
  - Low-voltage local digital temperature sensor (STTS22H)
  - Pressure/barometer sensor (LP622DF)
  - Digital microphone / audio sensor (MP23DB01HP)
  - NFC tag on board (ST25DV04K)

**Connectivity**

- MICRO SD card slot
- BLE 5.2 (blueNRG 355 AC)

**Power options and User Interface**

- **Power Options**
  - USB-C charging port
  - 5 W wireless charging
  - 480mAh long life battery

- **User Interface**
  - 4 Programmable LEDs
  - 2 Programmable buttons + Reset button
  - Programmable Audio Buzzer
  - 2 Qvar sensor electrodes
Figure 6. STEVAL-MKBOXPRO evaluation kit - top view

Figure 7. STEVAL-MKBOXPRO evaluation kit - bottom view
1.7 Functional blocks

1.7.1 Sensing

The core system board offers a wide range of sensors specifically designed to support personal electronics applications and to satisfy the demanding requirements of the consumer market.

Figure 8. STEVAL-MKBOXPRO - overview of the sensing components

The motion and environmental sensors communicate with the STM32U585AI microcontroller via SPI and/or I²C in order to accommodate the data rates. The signal from the digital microphone is directly managed by the audio digital filter (ADF) interface of the MCU.

Figure 9. STEVAL-MKBOXPRO - sensors on the top side
1.7.1.1 LPS22DF

The LPS22DF low-power high-precision ambient pressure sensor. It features from 260 hPa to 1260 hPa absolute pressure range, absolute pressure accuracy of 0.5 hPa, relative accuracy of 0.015 hPa, current consumption down to 1.7 μA at 1 Hz, and an output data rate from 1 Hz to 200 Hz. It also features an embedded FIFO and interrupt generation logic. The embedded temperature sensor is in the range of -40 °C to +85 °C, with an absolute accuracy of 1.5 °C.

<table>
<thead>
<tr>
<th>I/O</th>
<th>Configuration</th>
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<tbody>
<tr>
<td>PB6</td>
<td>I2C1_SCL</td>
</tr>
<tr>
<td>PB7</td>
<td>I2C1_SDA</td>
</tr>
</tbody>
</table>
1.7.1.2 **STTS22H**

The STTS22H is an ultra-low-power, high-accuracy, digital temperature sensor. It offers a high performance over the entire operating temperature range.

The STTS22H is coupled with an ASIC featuring A/D converter, signal processing logic, and an I²C/SMBus 3.0 interface.

The sensor is housed in a small 2 x 2 x 0.50 mm 6-lead UDFN package, with the exposed pad down, for a better temperature match with the surrounding environment.

The STTS22H is factory-calibrated and requires no additional calibration.

The STTS22H units are 100% tested on a production setup that is NIST traceable and verified with equipment calibrated in accordance with the IATF 16949:2016 standard.

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<tr>
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<td>I²C1_SDA</td>
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<tr>
<td>PB15</td>
<td>TEMP_INT</td>
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</table>

1.7.1.3 **LSM6DSV16X**

The LSM6DSV16X accelerometer and the gyroscope with triple processing chain; 2, 4, 8, 16 g accelerometer full-scale, 16 g for the secondary channel; 125, 250, 500, 1000, 2000, 4000 dps gyroscope full-scale. The output data rate is from 1.875 Hz to 7.68 kHz.

It features an enhanced machine learning core (MLC) and finite state machine (FSM). The FSM core can also reconfigure the sensor.

<table>
<thead>
<tr>
<th>I/O</th>
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<td>PI2</td>
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<td>SPI2_CLK</td>
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<td>PI5</td>
<td>SPI_sen_CS_G</td>
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<td>PB7</td>
<td>I²C1_SDA</td>
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<tr>
<td>PA4</td>
<td>IMU_INT1</td>
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<tr>
<td>PD11</td>
<td>IMU_INT2</td>
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1.7.1.4 **LIS2DU12**

The LIS2DU12 is a linear 3-axis accelerometer with advanced digital functions. The MEMS and ASIC have been expressly designed to build an outstanding ultra-low-power architecture, in which the anti-aliasing filter operates with some of the lowest current consumption on the market.

The LIS2DU12 has user-selectable full-scales of ±2g/±4g/±8g/±16g, and is capable of measuring accelerations with output data rates from 1.6 Hz to 800 Hz. The LIS2DU12 has an integrated 128-level FIFO buffer, allowing to store a wide range of data, reducing system power consumption.

The embedded self-test capability allows the user to check that the sensor works in the final application. The LIS2DU12 has a dedicated internal engine to process motion and acceleration detection including free-fall, wake-up, single/double-tap recognition, activity/inactivity, and 6D/4D orientation.

The LIS2DU12 is available in a small 2.0 x 2.0 mm plastic land grid array package (LGA) only 0.74 mm thin, which places it among the smallest solutions available on the market. It is guaranteed to operate over an extended temperature range from -40 °C to + 85 °C.
Table 5. LIS2DU12 I/O configuration

<table>
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<tr>
<td>PF15</td>
<td>ACC_INT2</td>
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1.7.1.5 LIS2MDL

The LIS2MDL is a high-accuracy, ultra-low-power, 3-axis digital magnetometer. It features a magnetic field dynamic range up to ±50 gausses.

The LIS2MDL includes an I²C serial bus interface, which supports standard, fast mode, fast mode plus, high-speed (100 kHz, 400 kHz, 1 MHz, and 3.4 MHz), and an SPI serial standard interface.

The device can be configured to generate an interrupt signal for magnetic field detection.

The LIS2MDL is available in a plastic land grid array package (LGA) and is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

Table 6. LIS2MDL I/O configuration

<table>
<thead>
<tr>
<th>I/O</th>
<th>Configuration</th>
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<tbody>
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<td>I2C1_SDA</td>
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<tr>
<td>PE6</td>
<td>MAG_DRDY</td>
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1.7.1.6 MP23DB01HP

The MP23DB01HP is an ultra-compact, low-power, omnidirectional, digital MEMS microphone, built with a capacitive sensing element and an IC interface with optional stereo configuration.

The sensing element, capable of detecting acoustic waves, is manufactured using a specialized silicon micromachining process dedicated to producing audio sensors. The IC interface is manufactured using a CMOS process that allows designing a dedicated circuit able to provide a digital signal externally in PDM format.

The MP23DB01HP offers multiple performance modes (power-down, low-power, and performance mode) enabled by different clock frequency ranges. The device has a very high AOP in performance mode, sensitivity range of ±1 dB and high SNR for all operative modes. The MP23DB01HP is available in a bottom-port, SMD-compliant, EMI-shielded package and is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

Table 7. MP23DB01HP I/O configuration

<table>
<thead>
<tr>
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<th>Configuration</th>
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<td>MIC_ADF_CK</td>
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<td>PE10</td>
<td>MIC_ADF_SD</td>
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<tr>
<td>GND</td>
<td>L/R</td>
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</table>
1.7.2 Processing and connectivity

The SensorTile.box PRO core system board features USB, wireless connectivity options, and the ultra-low-power STM32U585AI microcontroller.

The microcontroller belongs to the STM32U5 series of ultra-low-power MCUs based on the high-performance Arm Cortex®-M33 with TrustZone®, which operates at up to 160 MHz and embeds 786 Kbytes of SRAM and 2 MB of dual bank flash memory.

Figure 11. Main connectivity components and the STM32U585AI processing unit

Figure 12. MCU and connectivity components (top view)
Figure 13. MCU and connectivity components (bottom view)

- U1: STM32U585AI ultra-low-power Arm Cortex®-M33 with FPU and TrustZone® at 160 MHz
- U19: BlueNRG-LP Bluetooth® Low Energy v5.2 wireless technology SoC
- U17: NFC tag
- L3: NFC coil
- J4: microSD™ card socket

1.7.2.1 STM32U585AI

The STM32U585xx device belongs to an ultra-low-power microcontroller family (STM32U5 series) based on the high-performance Arm Cortex®-M33 32-bit RISC core. They operate at a frequency of up to 160 MHz.

The Arm Cortex®-M33 core features a single-precision FPU (floating-point unit), which supports all the Arm single-precision data-processing instructions and all the data types. It also implements a full set of digital signal processing (DSP) instructions and a memory protection unit (MPU) that enhances the application security.

The device embeds high-speed memories (2 Mbytes of flash memory and 786 Kbytes of SRAM), a flexible external memory controller (FSMC) for static memories (for devices with packages of 90 pins and more), two OCTOSPI flash memory interfaces (at least one quad-SPI available on all packages), an extensive range of enhanced I/Os and peripherals connected to three APB buses, three AHB buses, and a 32-bit multi-AHB bus matrix.

The device offers security foundation compliant with the trusted-based security architecture (TBSA) requirements from Arm. It embeds the necessary features to implement a secure boot, secure data storage, and secure firmware update.

The device also incorporates a secure firmware installation feature that allows the customer to secure the provisioning of the code during its production.

A flexible lifecycle is managed thanks to multiple levels of readout protection and debug unlock with password. Firmware hardware isolation is supported thanks to securable peripherals, memories and I/Os, and privilege configuration of peripherals and memories.
The device features several protection mechanisms for embedded flash memory and SRAM: readout protection, write protection, secure, and hide protection areas. They also embed several peripherals reinforcing security: a fast AES coprocessor, a secure AES coprocessor with DPA resistance, and a hardware unique key that can be shared by hardware with fast AES, a public key accelerator (PKA) with DPA resistance, an on-the-fly decryption engine for OCTOSPI external memories, a HASH hardware accelerator, and a true random number generator.

The device also features active tamper detection and protection against transient and environmental perturbation attacks, thanks to several internal monitors generating secret data erase in case of attack. This helps to fit the PCI requirements for point of sales applications.

The device offers one fast 14-bit ADC (2.5 Msps), one 12-bit ADC (2.5 Msps), two comparators, two operational amplifiers, two DAC channels, an internal voltage reference buffer, a low-power RTC, four 32-bit general-purpose timers, two 16-bit PWM timers dedicated to motor control, three 16-bit general-purpose timers, two 16-bit basic timers, and four 16-bit low-power timers. The device supports a multifunction digital filter (MDF) with six filters dedicated to the connection of external sigma-delta modulators. Another low-power digital filter dedicated to audio signals is embedded (ADF), with one filter supporting sound-activity detection.

The device embeds a Chrom-ART Accelerator dedicated to graphic applications, and mathematical accelerators (a trigonometric functions accelerator plus a filter mathematical accelerator). In addition, up to 24 capacitive sensing channels are available.

The device also features standard and advanced communication interfaces such as: four I2Cs, three SPIs, three USARTs, two UARTs, one low-power UART, two SAIs, one digital camera interface (DCMI), two SDMMCs, one FDCAN, one USB OTG full-speed, one USB Type-C®/USB Power Delivery controller, and one generic synchronous 8-/16-bit PSSI (parallel data input/output slave interface). The device operates in the -40 °C to +85 °C (+105 °C junction) and -40 °C to +125 °C (+130 °C junction) temperature ranges from a 1.71 V to 3.6 V power supply.

A comprehensive set of power-saving modes allows the design of low-power applications. Many peripherals (including communication, analog, timers, and audio peripherals) can be functional and autonomous down to stop mode with direct memory access, thanks to low-power background autonomous mode (LPBAM).

Some independent power supplies are supported, like an analog independent supply input for ADC, DACs, OPAMPs and comparators, a 3.3 V dedicated supply input for USB and up to 14 I/Os, that can be supplied independently down to 1.08 V. A VBAT input is available for connecting a backup battery in order to preserve the RTC functionality and to back up 32-bit registers and 2-Kbyte SRAM. The devices offer eight packages from 48 to 169 pins.
**BlueNRG-LP**

The BlueNRG-LP is an ultra-low-power programmable Bluetooth® Low Energy wireless SoC solution. It embeds STMicroelectronics’ state-of-art 2.4 GHz RF radio IPs combining unparalleled performance with extremely long battery lifetime. It is compliant with Bluetooth® Low Energy SIG core specification version 5.2, addressing point-to-point connectivity and Bluetooth™ mesh networking, and allows large-scale device networks to be established in a reliable way. The BlueNRG-LP is also suitable for 2.4 GHz proprietary radio wireless communication to address ultra-low latency applications. The BlueNRG-LP embeds a Cortex®-M0+ microcontroller that can operate up to 64 MHz and also the BlueNRG core coprocessor (DMA based) for Bluetooth® Low Energy timing critical operations. The main Bluetooth® Low Energy 5.2 specification supported features are: 2 Mbps data rate, long range (coded PHY), advertising extensions, channel selection algorithm #2, GATT caching, hardware support for simultaneous connection, master/slave and multiple roles simultaneously, and extended packet length support. In addition, the BlueNRG-LP provides enhanced security hardware support by dedicated hardware functions: True random number generator (RNG), encryption AES maximum 128-bit security coprocessor, public key accelerator (PKA), CRC calculation unit, 64-bit unique ID, and flash memory read and write protection. The BlueNRG-LP operates as a single device in the application for managing the both the application code and the Bluetooth® Low Energy stack. The BlueNRG-LP embeds high-speed and flexible memory types: Flash memory of 256 Kbytes, RAM memory of 64 Kbytes, one-time-programmable (OTP) memory area of 1 Kbyte, ROM memory of 7 Kbytes. Direct data transfer between memory and peripherals, and from memory-to-memory, is supported by eight DMA channels with a full flexible channel mapping by the DMAMUX peripheral. The BlueNRG-LP embeds a 12-bit ADC, allowing measurements of up to eight external sources and up to three internal sources, including battery monitoring and a temperature sensor. The BlueNRG-LP has a low-power RTC and one advanced 16-bit timer. The BlueNRG-LP features standard and advanced communication interfaces: 1x SPI, 2x SPI/I2S, 1x LPUART, 1x USART supporting ISO 7816 (smartcard mode), IrDA and Modbus mode, 2x I²C supporting SMBus/PMBus, 1x channel PDM. The BlueNRG-LP operates in the temperature range of -40 to +105 °C from a 1.7 V to 3.6 V power supply. A comprehensive set of power-saving modes enables the design of low-power applications. The BlueNRG-LP integrates a high efficiency SMPS step-down converter and an integrated PDR circuitry with a fixed threshold that generates a device reset when the VDD drops under 1.65 V. The BlueNRG-LP comes in different package versions supporting up to: 32 I/Os for the QFN48 package, 20 I/Os for the QFN32 package, 30 I/Os for the WCSP49 package.

**NFC tag**

The ST25DV04K is an NFC RFID tag offering 4 Kbit of electrically erasable programmable memory (EEPROM). This device has two interfaces: the first one is an I²C serial link that can be operated from a DC power supply, the second one is an RF link activated when the device acts as a contactless memory powered by the received carrier electromagnetic wave.

In I²C mode, the user memory contains up to 512, 2048, or 8192 bytes, which can be split into four flexible and protectable areas.

In RF mode, following ISO/IEC 15693 or NFC Forum Type 5 recommendations, the user memory contains up to 128, 512, or 2048 blocks of 4 bytes, which can be split into four flexible and protectable areas.

The ST25DV04K device offers a fast transfer mode between the RF and contact worlds, thanks to a 256-byte volatile buffer (also called Mailbox). In addition, the GPO pin provides data about incoming events, like RF field detection, RF activity in progress, or mailbox message availability. An energy harvesting feature is also available when external conditions make it possible.

The active area of the NFC coil is between the buttons and DIL24 socket, where the NFC label is on the top of the case.

**MicroSD™ card**

On the bottom side of the SensorTile.box PRO core system board is a microSD™ card socket that is accessible even when the board is mounted in the plastic case.

A four-bit wide SDIO port allows accessing the card for the maximum performance.
1.7.3 Power options

The SensorTile.box PRO core system board includes a range of power management features that enable very low power consumption in final applications. The main supply is through a lithium-ion polymer battery (3.7 V, 480 mAh) and the integrated battery charger (STBC08) with Vin [4.25; 6.5V].

Figure 14. Power management of the SensorTile.box PRO core system board

- USB-C charging port
- 5 W wireless charging
- 480mAh long life battery

Figure 15. Power components - top view
Power management IC
- J_USB_C1: USB3.1 type C
- U20: 5 W wireless charging
- BATTERY: 480 mAh long life battery 3v7
- COIL: connector for wireless charger coil
- VDD SEL: switch for choosing power voltage domain.

1.7.3.1 USB Type-C®
The on-board USB Type-C® connector can be used for both power supply and data transfer (USB device only). You can find several examples of USB class implementation in the STM32 software packages.

1.7.3.2 Wireless charging
The SensorTile Box Pro integrates a wireless power receiver suitable for portable applications and capable of managing up to 5 W of output power. The chip has been designed to support Qi 1.2.4 specifications for inductive communication protocol and base power profile (BPP). It shows excellent efficiency performance thanks to the integrated low-loss synchronous rectifier and the low drop-out linear regulator: both elements are dynamically managed by the digital core, to minimize the overall power dissipation over a wide range of output load conditions. Through the I²C interface, the user can access and modify different configuration parameters, tailoring the operation of the device to the needs of custom applications.
The active area of the wireless charger coil is on the bottom of the case, when the board is in the box.

1.7.3.3 Battery
Connect the long-life 3.7 V 480 mA LiPo battery included in the kit to the dedicated battery connector (BATT) in order to provide the battery supply voltage (VBAT).
1.7.3.4 **Power supply**

Different sources can supply the SensorTile.box PRO core system board:

- **V_USB**: through USB Type-C® connector (sink only, 5 V)
- **Wireless charger connector** (annotation “COIL” on the board)

The STBC08 battery charger automatically charges the battery from the available main source, with the right battery profile.

The equipment is intended to work properly with an operating temperature of 35 °C.

Moreover, two LEDs are used to display the battery state:

- **LED D8**, green LED turns on when an external power supply source is present (wireless charger or USB)
  - It does not mean that the board is turned on
- **LED D9**, orange LED turns on when the battery is being charged
  - It turns off when the battery is fully charged or disconnected

There is also a POWER switch to turn on and off the board, and a RESET button connected to the STM32 reset pin (BT3).

1.7.3.5 **Switch for choosing board power voltage domain**

As the label points out, the domain can be switched between 1.8 and 3.3 V.

Both STM32 and BlueNRG-LP automatically follow the selected domain.

1.7.3.6 **Power-on and power-off procedure**

The POWER switch can be used to turn on and off the SensorTile.boxPRO board. Whether it is turned on or off, both the USB and the wireless charger can be used to charge the battery.
1.8 User interface options

The SensorTile.box PRO core system board includes several user interfaces for the user interaction:

- Hardware power switch
- Green and orange system LED to display the battery state
- 4 programmable status LEDs (green, red, orange, blue)
- Programmable push-buttons
- Audio buzzer
- Qvar electrodes for user interface experience
- Interface for J-Link/SWD debug-probe
- Interface for extension board
- Socket for DIL24 sensor adapters

Figure 17. SensorTile.box PRO user interface
User interface:
- D5, D6, D7, D10: four programmable LEDs
- BT1, BT2: two programmable buttons, and a RESET button
- SPK1: audio buzzer
- Qvar sensor electrodes connected to the board through a flex connector JP1
- J1: Socket DIL24
- JP4: extension board connector

1.8.1 Programmable LEDs
The SensorTile.box PRO core system board includes four programmable LEDs for user interaction:
- LED D5: green
- LED D6: red
- LED D7: orange
- LED D10: blue
They are all connected to the STM32.

1.8.2 Programmable buttons
The SensorTile.box PRO core system board includes two user buttons: BT1 and BT2. They are connected to the STM32.

1.8.3 Buzzer
The SensorTile.box PRO core system board includes a piezoelectric sounder, which is connected to the STM32. It can be used to produce frequencies for audio applications.
1.8.4 Qvar
The SensorTile.box PRO core system board includes an embedded Qvar (electric charge variation detection) channel which can be enabled for sensing left/right and right/left swipe, and different tap configurations. Qvar electrodes are accessible outside the case, as shown in the image below.
For further details about Qvar, please refer to AN5755 "Qvar sensing".

Figure 19. SensorTile.box PRO Qvar electrodes

1.8.5 Socket DIL24
The SensorTile.box PRO core system board includes a socket DIL24 for easy MEMS adapter connection. For further details about DIL24 adapters, please refer to the product selector at the following path: https://www.st.com/en/evaluation-tools/mems-motion-sensor-eval-boards.html#products, where STEVAL-MKI adapter boards are considered.

Figure 20. SensorTile.box PRO DIL24 socket

1.8.6 Interface for extension board
It features SPI or I²C communication interface along 2 GPIOs.
Power supply can be 1.8 V or 3 V.
2 How to program the board

2.1 Restore to factory settings
To restore the factory settings, the user must download the STSW-MKBOXPRO-FS binary package. Open this package on your PC and follow the instructions.

Note: If you would restore the DTM of Bluetooth® Low Energy using the STLINK programmer following the instruction in Section 2.3 How to program the SensorTile.box PRO with an external debugger, only connecting the programmer cable to the Bluetooth® Low Energy connector (BLE_SWD or JP3).

2.2 How to program the SensorTile.box PRO in “DFU mode” (via USB)
This is the easiest mode if the user wants to download a binary into the board via USB, without the need of any debugging capabilities.

The advantage is that no additional debugger is needed, just a USB Type-C® cable and STM32CubeProgrammer software installed on the PC.

To enter the “Firmware upgrade” mode, follow the procedure below:

Step 1. Turn off the board through power switch S1
Step 2. Connect USB Type-C® cable to the board
Step 3. To enter DFU mode, turn on the board through power switch S1, while pressing button BT2 and then release the button
Step 4. You can upgrade the firmware by following the steps below:
   Step 4a. Open STM32CubeProgrammer software
   Step 4b. Select [USB] on the top-right corner
   Step 4c. Click on [Connect]
   Step 4d. Go to the [Erasing and Programming] tab
   Step 4e. Search for the new .bin or .hex binary file to be flashed into the board
   Step 4f. Click on [Start Programming]

2.3 How to program the SensorTile.box PRO with an external debugger
The SensorTile.boxPro programming connector JP2 is natively compatible with the STLINK-V3 debugger family (STLINK-V3SET or STLINK-V3MINIE).

Note: STLINK-V3 programmers are not included in the kit.

To offer more alternatives, an adapter to STLINK V2-1 (STM32 Nucleo development board) or standard JTAG connector is included in the kit (STEVAL-MKIGIBV4 STLINK adapter with programming cable).

When using an STM32 Nucleo development board as an external debugger, the user needs to disconnect the on-board STM32 by removing the two jumpers on CN2 on the Nucleo board.

Once the hardware connections are in place, the user can flash memory with the provided projects with their preferred IDE (STM32CubeIDE, EWARM, or Keil®).
2.4 Troubleshooting

If the board is seen in the Connect to a device screen as in the screen below (only board name and ID: MAC address) it means that the board has no database entry.

![Figure 21. Example of a board shown with no database entry](image)

In this case, the user should follow the following procedure to be able to perform a Fast FOTA update to the latest version of the default firmware (STSW-MKBOXPRO - entry/expert mode).

**Step 1.** From the home screen, click on Create a new application and select the sensrotile.box-PRO. From this screen, select the MORE tab in the bottom right corner of the screen and choose the Custom Fw Db Entry.

![Figure 22. MORE tab in ST BLE Sensor Classic app](image)
Step 2. A screen is opened with a custom Database entry for the sensortile.box-PRO. Here, the user should open the options window by tapping the three dots in the upper right corner, and tap on the download icon (circled in red).

Figure 23. Browser screen example where to download the json file
Step 3. Go back to the home screen of the ST BLE Sensor Classic app and return to the Connect a new device screen. Here, tap on the three dots in the bottom right corner, and select “Add Custom Fw Db Entry”.

![Add Custom Fw Db Entry screen](image)

Figure 24. Add Custom Fw Db Entry screen

Step 4. The file manager of the phone will open, here you can search in the downloads folder of your browser for the file just downloaded, named DefaultFw_0_9_0.json and select it. The board should now be seen as in the figure below, with a custom model loaded. Now you can connect to it.

![Example of board shown with custom database entry](image)

Figure 25. Example of board shown with custom database entry

Step 5. Open the menu in the upper left corner and go to the Board Configuration screen and select Firmware Download, in the Board Control Section.
Step 6. By clicking on the list of compatible firmware (circled in red) the STSW-MKBOXPRO entry/expert mode will be available to choose. Tap on it and then tap on install STSW-MKBOXPRO entry/expert mode.

Figure 26. Firmware Download screen

The Fast FOTA procedure will update the board and the new official Database entry will be updated automatically (no need for this procedure on the next updates).
Development applications

The ST BLE Sensor Classic app on your smartphone (both on the Android Play Store and iOS App Store) allows you to immediately connect to the box kit (the required PIN for pairing the default firmware with the app is 123456).

The user can appreciate the full SensorTile.box PRO experience regardless of their level of expertise; the box kit could be exploited according to three different modalities:

- **Entry mode**: wide range of default IoT and wearable applications
- **Expert mode**: build custom applications leveraging the available algorithms
- **Pro mode**: develop code in an intuitive way using STM32 open development environment (ODE) and STMicroelectronics function pack libraries.

3.1 Entry mode

The ST BLE Sensor Classic bundles a wide range of default IoT and wearable applications:

1. Turn on your SensorTile.box PRO by sliding the Power button to 'ON'
2. Open the ST BLE Sensor Classic app (with Bluetooth® enabled)
   - At the first power-on, navigate the app to "Connect one device", and once paired and connected, start the firmware upgrade with the FOTA function by clicking on the prompt
     - The FOTA function is used whenever a new version of the board firmware is released
3. The user can try the default application by connecting, or click on "Create a new Application" in the app home screen. The user can experiment with all the possibilities, using pre-defined applications or developing their own with a simple interface in "expert mode".

This is a list of the entry mode applications:

- **Motion**
  - Compass
  - Free-Fall Detection
  - Level
  - Pedometer
  - Sensor fusion - quaternion
- **Environmental**
  - Barometer
- **Log**
  - Data recorder
- **AI and MLC**
  - Human activity recognition
  - Baby Crying Detector
  - In-Vehicle Baby Alarm
- **User interface**
  - Qtouch
- **Connectivity**
  - NFC tag
3.2 Expert mode

In expert mode the user can build custom applications through the **ST BLE Sensor Classic** app by selecting specific input data and operating parameters. From the corresponding available in-box sensors, functions to assess/compute those data, and output types that the user needs, while leveraging the available powerful algorithms.

There are 3 main steps to create a new application:

1. **INPUT** - choose one of the sensors available on the board as an input
   - Multiple sensors can be selected at the same time, if they are compatible
   - After selecting the sensor, the options can be modified, like ODR and acquisition time, clicking on the gear symbol on the right

2. **FUNCTION** - choose a corresponding function to use on data (optional)
   - Keep in mind that some functions must have more than one input sensor, and some functions may not be available for some sensors
   - Functions also have options that can be modified with the gear symbol on the right

3. **OUTPUT** - choose an output for displaying the results
   - File to microSD™ card is for saving data on the sd-card
   - Stream to USB is for sending data through USB
   - Stream to Bluetooth® is for sending the results on the phone app
   - Save as input is for having this result as an input to a new application (available only for some demo flows)

For further details, please refer to the dedicated documents available at [www.st.com](http://www.st.com).

3.3 Pro mode

Pro mode: quickly develop tailored IoT applications taking advantage of the STM32 open development environment (ODE) and STMicroelectronics function pack libraries, including:

- **FP-SNS-BLEMESH1**
- **FP-ATR-BLE1** (running in STM32U5)
- **FP-SNS-DATALOG2**

For further details, please refer to the webpage [FP-SNS-STBOX1](http://www.st.com).
Figure 28. Sensortilebox_pro_main
Figure 29. Sensortilebox_pro_Power
Figure 30. Sensortilebox_pro_MCU
Figure 31. Sensortilebox_pro_sensors
Figure 32. Sensortilebox_pro_BLE

NOTE: ANT2 is physically unconnected, in fact C85 and C91 are not mounted (DNM means Do Not Mount) and their absence isolate the ANT2 connector by the circuitry.
Figure 33. Sensortilebox_pro_Peripherals

SD CARD

NFC
## 5 Bill of materials

### Table 8. BOM

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## Board versions

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1. This code identifies the STEVAL-MKBOXPRO evaluation board first version. It is printed on the board PCB.
7 Regulatory compliance information

Formal Notice Required by the U.S. Federal Communications Commission

Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.

US Agent contact located in the United States:
Name: Francesco Doddo; address: STMicroelectronics Inc, 200 Summit Drive, Suite 405, Burlington MA, 01803, U.S.A.; e-mail: francesco.doddo@st.com

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the manufacturer could void the user’s authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
• Reorient or relocate the receiving antenna.
• Increase the separation between the equipment and receiver.
• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
• Consult the dealer or an experienced radio/TV technician for help.

Radio Frequency (RF) Exposure Information for USA

This product complies with FCC radiation exposure limits set forth for an uncontrolled environment. The antenna should be installed and operated with minimum distance of ≥ 20 cm between the radiator and your body.

Formal Product Notice Required by Industry Canada

Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.

Responsible party’s contact located in Canada: name: John Langner; address: STMicroelectronics, Inc., 350 Burnhamthorpe Road West, Suite 303 L5B 3J1, Mississauga, ON, Canada; e-mail: john.langner@st.com

Innovation, Science and Economic Development Canada Compliance

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada’s licence exempt RSS(s). Operation is subject to the following two conditions:
(1) This device may not cause interference.
(2) This device must accept any interference, including interference that may cause undesired operation of the device.

This radio transmitter has been approved by Innovation, Science and Economic Development Canada with the maximum permissible gain indicated.

This device complies with Health Canada’s Safety Code. The installer of this device should ensure that RF radiation is not emitted in excess of the Health Canada’s requirement.

This class B device complies with Canadian Interference-Causing Equipment Standard ICES-003: CAN ICES-003(B) / NMB-003(B)

Conformité à Innovation, Sciences et Développement Économique Canada

L’émetteur/recepteur exempt de licence contenu dans le present appareil est conforme aux CNR d’Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence.

L’exploitation est autorisée aux deux conditions suivantes: (1) L’appareil ne doit pas produire de brouillage; (2) L’appareil doit accepter tout brouillage radioelectrique subi, meme si le brouillage est susceptible d’en compromettre le fonctionnement.

Le présent émetteur radio a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec un gain admissible maximal.
Cet appareil est conforme avec Santé Canada Code de sécurité 6. Le programme d'installation de cet appareil doit s'assurer que les rayonnements RF n'est pas émis au-delà de l'exigence de Santé Canada.

Cet appareil numérique de classe B est conforme à la Norme sur le matériel brouilleur NMB-003 du Canada: CAN ICES-003(B) / NMB-003(B)

Radio Frequency (RF) Exposure Information for Canada
This product complies with Innovation, Science and Economic Development Canada (ISED) radiation exposure limits set forth for an uncontrolled environment. The antenna should be installed and operated with minimum distance of ≥ 20 cm between the radiator and your body.

Cet appareil est conforme aux limites d'exposition aux rayonnements de l'Innovation, Sciences et Développement économique Canada (ISDE) pour un environnement non contrôlé. L'antenne doit être installé de façon à garder une distance minimale de ≥ 20 centimètres entre la source de rayonnements et votre corps.

Notice for the European Union
The kit STEVAL-MKBOXPRO is in conformity with the essential requirements of the Directive 2014/53/EU (RED) and of the Directive 2015/863/EU (RoHS). Applied harmonized standards are listed in the EU Declaration of Conformity.

Notice for United Kingdom
The kit STEVAL-MKBOXPRO is in compliance with the UK Radio Equipment Regulations 2017 (UK SI 2017 No. 1206 and amendments) and with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (UK SI 2012 No. 3032 and amendments). Applied standards are listed in the UK Declaration of Conformity.
## Revision history

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<td>Updated Section 1.7.3.2 Wireless charging, Section 3.1 Entry mode and Section 7 Regulatory compliance information.</td>
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<td>Updated Section 1.3 RF specifications, Figure 32. Sensortilebox_pro_BLE and Figure 32. Sensortilebox_pro_BLE. Added Section 2.4 Troubleshooting.</td>
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