UM2580

User manual

How to use the wireless multi sensor development kit with customizable app for IoT and wearable sensor applications

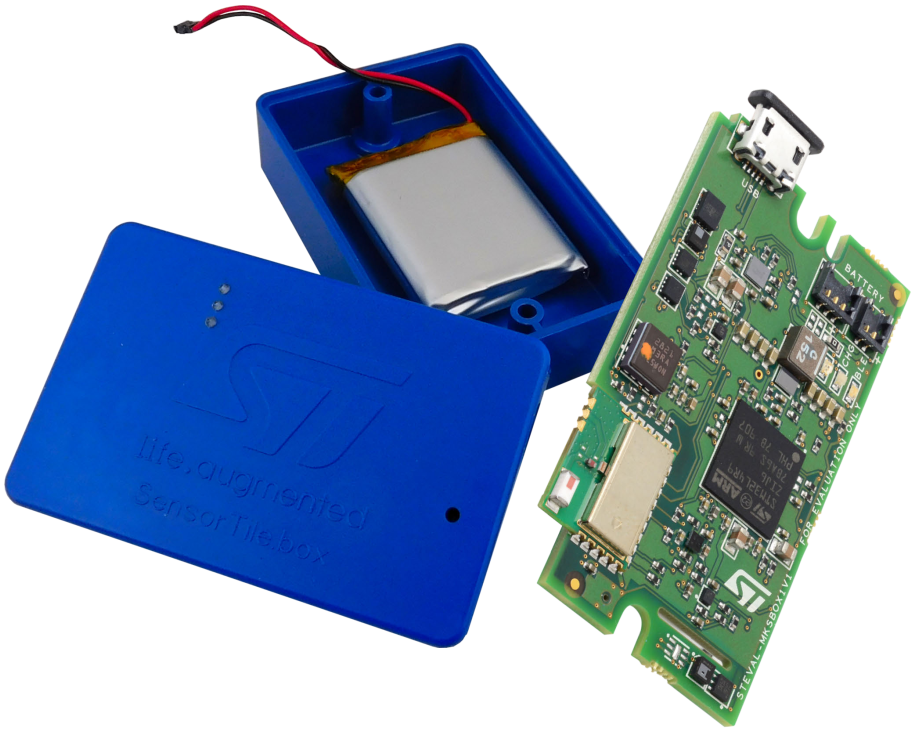
Introduction

The STEVAL-MKSBOX1V1 (SensorTile.box) is a ready-to-use box kit with wireless IoT sensor platform designed to help you build apps that use motion and environmental sensors, regardless of your level of expertise.

The hardware node is a board that fits into a small plastic shroud with a rechargeable battery. You can connect with your smartphone to the board via Bluetooth and immediately build your own apps through a special interface that offers beginner and expert level functionality. This multi-sensor kit therefore allows you to design wireless IoT and wearable sensor applications quickly and easily, without performing any programming.

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

Figure 1. STEVAL-MKSBOX1V1 (SensorTile.box) multi sensor development kit



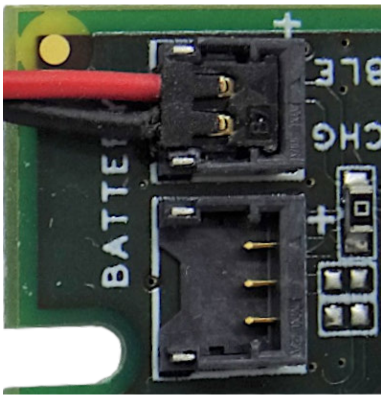
1 How to set up the hardware

Step 1. Remove the SensorTile.box contents from its package.
You should have the following items:
– An evaluation board in a plastic shroud
– A LiPo battery

Step 2. Unscrew the shroud cover.

Step 3. Slide the male battery connector vertically into the female connector on the board.
You will hear a light click when the connector is attached correctly.

Figure 2. **STEVAL-MKSBOX1V1 battery connection**



Step 4. Re-position the circuit with the battery below it and the close the shroud with one of the following types of lid:
– with flanges
– without flanges

Step 5. If necessary, charge the battery via a USB cable.
The red battery monitor LED indicates the battery charging status.

2 How to use ST BLE Sensor app with SensorTile.box

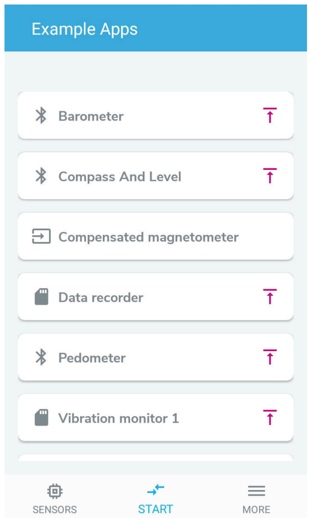
Before you begin, you need to download and install our ST BLE Sensor app on your smartphone. The app is available from the Google and Apple online stores.

Step 1. Launch the app on your smartphone.

Figure 3. ST BLE Sensor app main screen

Step 2. Select [**CREATE A NEW APP**].
The Example Apps screen that follows lists the preloaded apps that you can use immediately.

Figure 4. Example Apps screen



Step 3. Select one of the apps with the ⭱ icon from the list.
After you select the app, ST BLE Sensor will scan for available SensorTile.box devices in range.

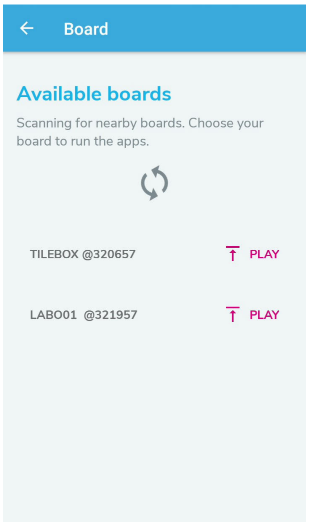


Figure 5. Board selection

Step 4. Select the appropriate SensorTile.box device from the Board screen.

A blue LED on the SensorTile.box device will flash slowly to confirm Bluetooth pairing.

A pop up message in ST BLE Sensor will prompt you to confirm loading the new app in replacement of any previously opened apps.

Step 5. Select the appropriate SensorTile.box device from the Device List.

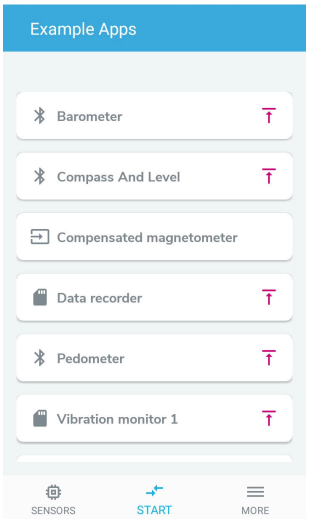
The app will commence monitoring or logging activity and return real time feedback data to the corresponding app screen in ST BLE Sensor.

3 Application descriptions

3.1 Entry level example apps

The ST BLE Sensor bundles the following ready-to-use app scenarios:
- Barometer
- Baby Crying
- Compass and Level
- Data Recorder
- Step counter (pedometer)
- Vehicle / goods tracking
- Vibration monitoring 1 and 2

Figure 6. Apps screen



App scenarios with the [Bluetooth icon] icon produce immediate outputs on your smartphone in real time.

App scenarios with the [SD card icon] icon store sample data on the internal micro SD card.

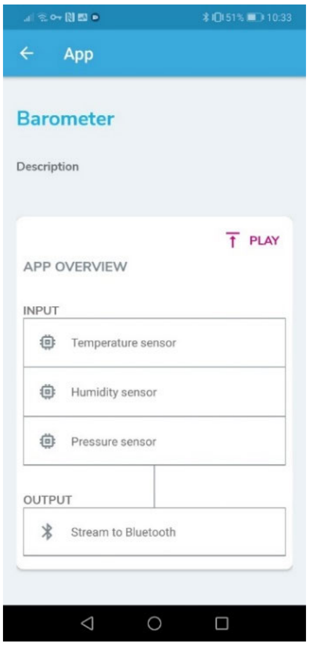
App scenarios with the [Expert mode icon] icon are reserved for Expert mode.

RELATED LINKS

2 How to use ST BLE Sensor app with SensorTile.box on page 3

3.1.1 Barometer app

Figure 7. Barometer App screen



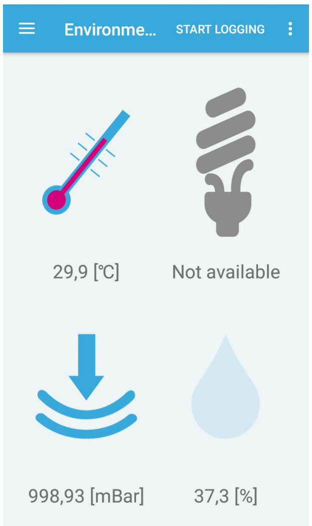
The Barometer app works with the following ST high accuracy environmental sensors and operating parameter settings:

- Temperature Sensor: STTS751
  - Output Data Rate (ODR): 1.0 Hz
- Pressure Sensor: LPS22HH
  - Power Mode: Low Noise
  - Output Data Rate (ODR): 1.0 Hz
  - Filter: ODR/2 Hz
- Humidity sensor: HTS221
  - Output Data Rate (ODR): 1.0 Hz

The output date rates for the environmental sensors are relatively low because these figures do not change rapidly in normal circumstances.

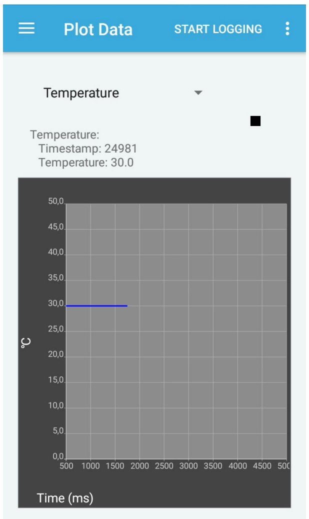
When you run the Barometer app and connect the SensorTile.box device, The ST BLE Sensor app shows a monitoring screen for the environmental sensors.

Figure 8. **Environmental screen**



You can access other output options from the ☰ menu icon in the top left of the screen.

Figure 9. **Plot Data screen**



3.1.2 Compass and Level app

The Compass and Level app works with the following ST high accuracy motion sensors and operating parameter settings:

- Acceleration sensor (high bandwidth): LSM6DSOX
  - Power Mode: Low power
  - Output Data Rate (ODR): 104 Hz
  - Filter: Low Pass 700 Hz
  - Full Scale: 2 g
- Gyroscope sensor: LSM6DSOX
  - Power Mode: Low Power
  - Output Data Rate (ODR): 104 Hz
  - Full Scale: 250 degrees per second (dps)
- Compensated magnetometer: LIS2MDL

- Power Mode: Low Power
- Output Data Rate (ODR): 100 Hz

The output date rates (around 100 Hz) for the motion sensors are suitable for capturing human movements. The Low Power Mode feature helps reduce power consumption.

3.1.3 Pedometer app

The Step counter app works with the following ST high accuracy motion sensor and operating parameter settings:

- Acceleration sensor (high bandwidth): LSM6DSOX
  - Power Mode: Low power
  - Output Data Rate (ODR): 104 Hz
  - Filter: Low Pass 700 Hz
  - Full Scale: 2 g

These parameters are appropriate for capturing human movement while filtering unwanted noise and not wasting battery energy to extend the potential working time.

3.1.4 Baby crying app

The baby crying app signals a detected baby crying event on your smartphone via Bluetooth. While the current version involves simple signal filtering, a future release will include an AI-based version.

Currently a band-pass filter from 1.75 kHz to 2.25 kHz is enabled through the Auto Regressive Moving Average (ARMA) function. Whenever a signal from the microphone is detected in the pass-band above a threshold that is set with the comparison function, the green user LED on the SensorTile.box board lights up and an alert is sent to the smartphone via Bluetooth.

The baby crying app works with the following ST high sensitivity audio sensor and operating parameter settings:

- Analog microphone: MP23ABS1
  - Sampling frequency: 8 kHz

The sampling frequency is appropriate for capturing human voice without distortions.

RELATED LINKS

A ARMA filter coefficient calculation on page 13

3.1.5 Vibration Monitoring

The Vibration Monitoring app demonstrates how engines, electric motors and the like are monitored to detect potential problems.

The example consists of the following components:

- **Vibration Monitoring 1**: is designed to acquire the vibration pattern of new or correctly functioning equipment. The vibration pattern is converted using the Fast Fourier Transform (FFT) function and is stored in the memory card on the SensorTile.box device.
- **Vibration Monitoring 2**: is designed to monitor the same equipment and compare the vibration patterns with the original sample captured by Vibration Monitoring 1.

If the difference between the vibration analysis in •Vibration Monitoring 1 and Vibration Monitoring 2 exceeds a set delta parameter (which can be modified according to equipment age and load conditions), the green user LED on the SensorTile.box device turns on.

The Vibration Monitoring apps work with the following ST high accuracy motion sensor and operating parameter settings:

- Acceleration sensor (high bandwidth): LSM6DSOX
  - Power Mode: High Performance
  - Output Data Rate (ODR): 6666 Hz
  - Filter: none
  - Full Scale: 2 g

3.1.6 Data Recorder and Vehicle (goods) tracking

Data recorder and vehicle (goods) tracking are very similar examples that can be used to monitor and record movements and/or environmental conditions that parcels or objects are subjected to during movement or shipping.

The data can be used to verify whether a parcel has suffered shocks or undesirable temperatures that could damage the goods, or if a vehicle has been driven according to appropriate speed and safety parameters.

Certain sensors are enabled according to what is being monitored, and data is stored in the internal memory card for later retrieval and analysis. Motion sensors are set to Low Power Mode with a data rate of around 50 to 100 Hz, while a data rate of 1 Hz is appropriate for environmental sensors.

3.1.7 Compensated magnetometer app

The Compensated magnetometer app can be used to build additional apps from the magnetometer output and a sensor fusion algorithm to compensate for disturbances from external magnetic fields.

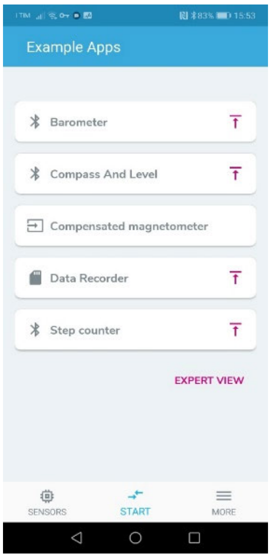
3.2 How to use Expert Mode functionality

The STE BLE Sensor app can help you develop your own app or customize an existing one, which you can then upload and run on the SensorTile.box device.

Step 1. Return to the main screen of the ST BLE Sensor app.

Step 2. Select [**CREATE A NEW APP**].

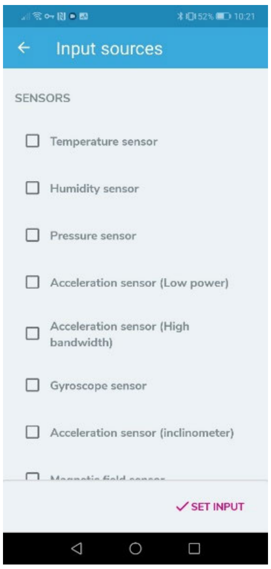
Figure 10. Example Apps screen



Step 3. Select [**EXPERT VIEW**].
A new screen appears with saved apps.

Step 4. Select [**+ NEW APP**].

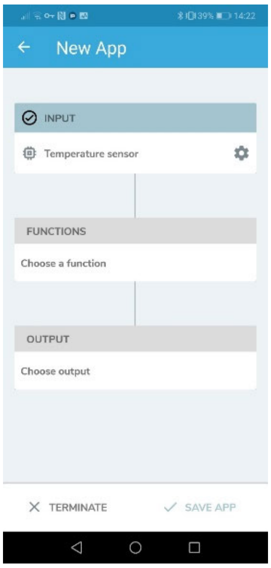
Figure 11. Input sources screen



Step 5. Select one or more of the desired sensor data inputs.
Unselected sensors are put in sleep mode.

Step 6. Select [**SET INPUT**] to confirm

Figure 12. Sensor data configuration screen

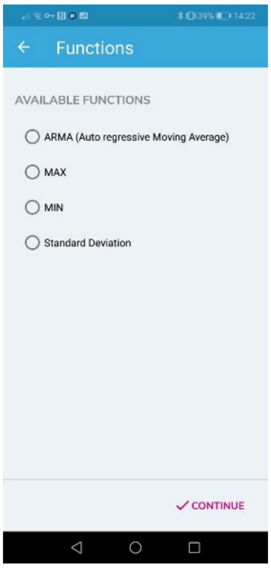


Step 7. Select the gear icon next to each sensor and set the parameters according to your application requirements

You can set parameters such as full scale, data rate (ODR), Power Mode, Filter, etc., according to device specifications provided in corresponding sensor datasheets.

Following sensor selection, the function screen lists the available functions for the enabled sensors. For the temperature sensor, for example, the available functions are shown below.

Figure 13. Custom app function screen



Step 8. Choose between one of the following output types:

- Via Bluetooth to your smartphone (to view certain data)
- To the memory card (micro SD)
- Via USB to a host master (i.e., a PC).
- To the user LED for logic data types (like the output of a threshold function or comparison).

The LED option is achieved by selecting [**Save as EXP**] in the output selection screen and enabling the associated output property.

There are two special output types:

– [**Save as INPUT**]: is a way to concatenate different functions and generate different branches which will be processed one after the other.
– [**Save as EXP**]: produces an app branch whose output is a digital “true” or “false”. This value can be used in other comparisons or logic functions.

An app saved as EXP or as INPUT appears in the input selection screen so it can be used more complex app generation.

Step 9. Save your app with an appropriate name and optional comment.

RELATED LINKS

A ARMA filter coefficient calculation on page 13

3.3 Pro Mode

SensorTile.box is fully compatible with the STM32 Open Development Environment (STM32 ODE) for developers to customize the SensorTile.box firmware. The board includes the ST-LINK V3 (with UART pins for debugging) compatibility.

Note: Your ST-LINK must have the level shifter to function at 1.8 V (the SensorTile.box power supply).

RELATED LINKS

Visit the ST website for all the resources you need regarding the STM32 Open Development Environment

A ARMA filter coefficient calculation

The built-in ARMA filter implemented by SensorTile.box firmware is a general IIR fifth-order polynomial filter described by the equation:

$$y(t) = \frac{ma(0)u(t) + ma(1)u(t-1) + ma(2)u(t-2) + ma(3)u(t-3) + ma(4)u(t-4) + ma(5)u(t-5)}{1 + ar(1)y(t-1) + ar(2)y(t-2) + ar(3)y(t-3) + ar(4)y(t-4) + ar(5)y(t-5)}$$

Where:

y(t) = output of the filter

u(t) = input signal

With this function, low-pass, high-pass, band-pass and band-reject filters can be implemented, and higher filter orders can be obtained by cascading two or more filters, one after the other.

The simplest way to calculate the ma(i) and ar(i) coefficients for the required filter shape is to use a math program like Octave. Octave has a “signal” extension package that can be loaded by typing the command `pkg load signal` at the Octave prompt. Once done, there are few filter calculation options, depending on the type of filter that is requested by the application: Butterworth, Bessel, Chebyshev and elliptic (Cauer) filters can be computed.

RELATED LINKS

3.1.4 Baby crying app on page 8

3.2 How to use Expert Mode functionality on page 10

Visit this web page for further insight regarding ARMA filters

GNU Octave home page

A.1 Filter calculation example

The following example illustrates how a second-order Butterworth band-pass filter can be implemented. We will assume that we want to filter our microphone signal with a band-pass filter in the 1 kHz – 3 kHz range.

Step 1. We set a microphone sampling rate of 16 kHz.

The maximum signal frequency (or Nyquist frequency) is therefore 16/2 = 8 kHz, according to Nyquist/Shannon theorem.

Step 2. Open the Octave command line prompt.

Step 3. Type the following command:`>>[MA, AR]=butter(2, [1/8, 3/8])`

This calls the butter function in Octave, where:

– 2 is the filter order

– 1/8 and 3/8 are the band limits relative to the Nyquist frequency

The program output is:

```
MA =
   0.09763   0.00000  -0.19526   0.00000   0.09763
AR =
   1.00000  -2.25233   2.27614  -1.23184   0.33333
```

Step 4. Set the above values for ma(0) to ma(4), and set ma(5) to zero in the ARMA property screen for the SensorTile.box app.

Step 5. Set the above values for ar(0) to ar(4), and set ar(5) to zero in the ARMA property screen for the SensorTile.box app.

Note that ar(0) is always equal to 1, so the ARMA property screen does not require it to be inserted.

RELATED LINKS

Similar functions can be used for the other type of filters; check Octave documentation for all the options

Revision history

Table 1. **Document revision history**

Date	Version	Changes
13-May-2019	1	Initial release.

Contents

List of figures