
Getting started with the software package for Bluetooth low energy and sensors in BLUEMICROSYSTEM2

Introduction

The BLUEMICROSYSTEM2 expansion software package for STM32Cube lets you read and display real-time environmental sensor data, digital microphone levels, battery level (STEVAL-STLKT01V1 only), voice communication over Bluetooth low energy and acoustic source localization information with a dedicated BlueMS App for Android/iOS.

The package implements application level functions based on the BLE protocol and enables communication with Android and iOS devices. Developers can use it to prototype applications with Android or iOS services and transmit real-time sensor data.

The software includes the drivers for the embedded STM32 Nucleo expansion board and STEVAL-STLKT01V1 development kit devices, and comes with a sample solution to kick-start development.

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1 BLUEMICROSYSTEM2 software description

1.1 Overview

The key features of the BLUEMICROSYSTEM2 package are:

- For STM32 Nucleo expansion boards, complete middleware to build applications using:
 - environmental (HTS221, LPS25HB), motion (LIS3MDL, LSM6DS0 and LSM6DS3 mounted on DIL24) and microphone (2 x MP34DT01-M) sensor
 - environmental (HTS221, LPS22HB), motion (LSM303AGR, LSM6DSL) and microphone (2 x MP34DT01-M) sensor.
- For STEVAL-STLKT01V1 development kit, complete middleware to build applications using pressure sensor (LPS22HB), motion sensors (LSM303AGR and LSM6DSM), microphone sensor (MP34DT04) and Gas Gauge IC level (STC3115) sensors.
- BLE for sending information to one client.
- Real-time motion sensor data fusion and real-time recognition algorithms (activity, carry-position and gesture for accelerometer-only), under the Open.MEMS license.
- Real-time sound source localization and voice communication over Bluetooth low energy, under the Open.Audio license.
- View information sent via BLE in the app BlueMS (v2.0.0 or higher).
- Over-the-air firmware update (X-NUCLEO-IDB05A1 only) and option to request and enable Open.MEMS and Open.Audio licenses through BlueMS (v 3.0.0 or higher).
- Gas Gauge on STEVAL-STLKT01V1 with BlueMS (ver. 3.2.0 or higher).
- Based on STM32Cube framework.
- Free, user-friendly license terms.
- Separate sample implementations for X-NUCLEO-CCA02M1, X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2 and X-NUCLEO-IDB04A1 or X-NUCLEO-IDB05A1 expansion boards connected to a NUCLEO-F401RE or NUCLEO-L476RG development board, and for the STEVAL-STLKT01V1 development kit.

This software creates the following Bluetooth services:

1. The first service exposes all the hardware and software characteristics:
 - HW characteristics related to MEMS sensor devices:
 - Temperature
 - Pressure
 - Humidity
 - 3D gyroscope, 3D magnetometer, 3D accelerometer
 - Microphones dB noise level.
 - Gas Gauge: remaining battery charge, voltage and status (charging/discharging/low battery) only for STEVAL-STLKT01V1
 - SW characteristics:
 - quaternions generated by the osxMotionFX library in short precision
 - magnetic North direction (e-Compass)
 - recognized activity using the osxMotionAR algorithm
 - recognized carry position using the osxMotionCP algorithm
 - recognized gesture using the osxMotionGR algorithm
 - audio source localization using the osxAcousticSL algorithm
 - voice over Bluetooth low energy using the OSXBLUEVOICE algorithm
2. The second service exposes the Console service with:
 - stdin/stdout for bi-directional communication between client and server

- stderr for a mono-directional channel from the STM32 Nucleo board to an Android/iOS device
- 3. The last service is for transmitting/resetting the calibration status and enabling the following expansion hardware features when LSM6DS3 is mounted on an X-NUCLEO-IKS01A1 expansion board with DIL24 for STM32 Nucleo F4 and L4, or for LSM6DSL on an X-NUCLEO-IKS01A2 expansion board for STM32 Nucleo L4 only, or for LSM6DSM motion sensor for STEVAL-STLKT01V1:
 - Pedometer
 - Free fall detection
 - Single tap detection
 - Double tap detection
 - Wake up detection
 - Tilt detection
 - 3D orientation

This software gathers:

- the temperature, humidity, pressure, audio and motion sensor drivers for the HTS221, LPS25H, 2 x MP34DT01-M, LSM6DS0 (or LSM6DS3) and LIS3MDL devices for STM32 Nucleo expansion boards
- the temperature, humidity, pressure, audio and motion sensor drivers for the HTS221, LPS22H, 2xMP34DT01-M, LSM6DSL and LSM303AGR devices for STM32 Nucleo expansion boards
- the temperature, pressure, audio, motion sensor and Gas Gauge IC drivers for the LPS22HB, MP34DT04, LSM6DSM, LSM303AGR and STC3115 devices for STEVAL-STLKT01V1 running on STM32.

This package is compatible with the BlueMS Android/iOS (Ver. 2.2.0 or higher) application available at respective Play/iTunes stores, which can be used for displaying information sent via the Bluetooth low energy protocol. BlueMS Version 3.0.0 and above is required for over-the-air firmware updates (for X-NUCLEO-IDB05A1 Bluetooth low energy expansion board only) and requesting and enabling the Open.MEMS and OpenAudio licenses. BlueMS Version 3.2.0 and above is required for the Gas Gauge level information for STEVAL-STLKT01V1 feature.

1.2 Architecture

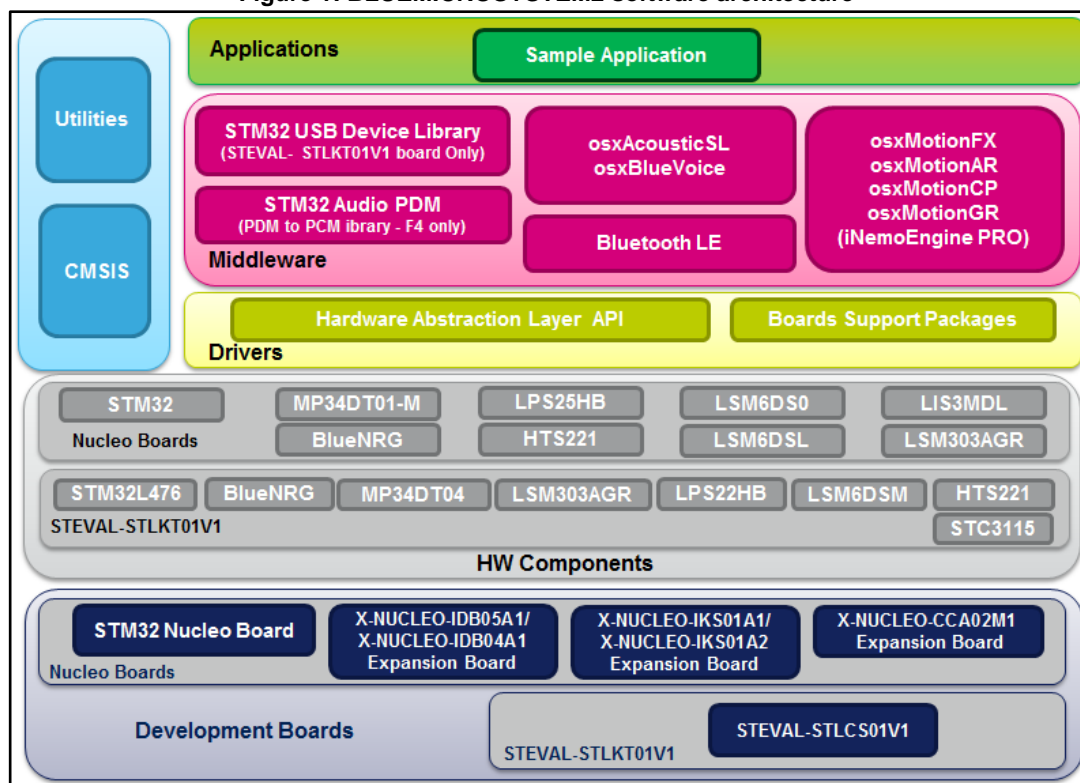
The software is based on the STM32CubeHAL hardware abstraction layer for the STM32 microcontroller.

The package provides a board support package (BSP) for the sensor expansion board and middleware components for serial communication with a PC.

To access and use the sensor expansion board, the application software uses:

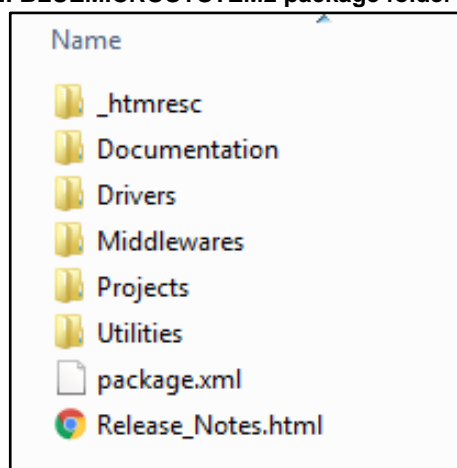
- **STM32Cube HAL layer:** provides a simple, multi-instance set of generic and extension APIs (application programming interfaces) to interact with the upper layer application, libraries and stacks. Its generic architecture allows layers built on top of it (e.g., middleware) to function without requiring the hardware specifics of the host microcontroller unit (MCU). This structure improves library code re-usability and guarantees easy portability across other devices.
- **Board support package (BSP) layer:** supports the peripherals on the STM32 Nucleo board (except the MCU) with a limited set of APIs which form a programming interface for certain board-specific peripherals like the LED, user button, etc., and helps determine the specific board version. For the sensor expansion board, it provides the programming interface for various inertial and environmental sensors and support for initializing and reading sensor data.

Figure 1: BLUEMICROSYSTEM2 software architecture



1.3 Folder structure

Figure 2: BLUEMICROSYSTEM2 package folder structure



The following folders are included in the software package:

- **Documentation:** contains a compiled HTML file generated from the source code, which details the software components and APIs.
- **Drivers:** contains the HAL drivers, the board-specific drivers for each supported board or hardware platform, including the on-board components, and the CMSIS vendor-independent hardware abstraction layer for the Cortex-M processor series.
- **Middlewares:** contains libraries and protocols for BlueNRG Bluetooth low energy, USB Device Library, the Meta Data Manager, osxMotionFX (iNEMOEngine PRO) sensors fusion library, osxMotionAR (iNEMOEngine PRO) activity-recognition library,

osxMotionCP (iNEMOEngine PRO) carry-position recognition library, osxMotionGR (iNEMOEngine PRO) gesture recognition library, osxAcousticSL sound source localization library and OSXBLUEVOICE real-time voice communication over Bluetooth low energy library.

- **Projects:** contains a sample application used for transmitting the output of the sensor data and of the osxMotionFX sensor fusion and e-Compass, osxMotionAR activity-recognition, osxMotionCP carry-position, osxMotionGR gesture recognition, osxAcousticSL sound source localization and OSXBLUEVOICE over Bluetooth low energy libraries by using the Bluetooth low energy protocol provided for the NUCLEO-F401RE/NUCLEO-L476RG and STEVAL-STLKT01V1 platforms through the IAR Embedded Workbench for ARM, RealView Microcontroller Development Kit (MDK-ARM) and System Workbench for STM32 development environments.
- **Utilities:** contains the boot loader binary ready to be flashed for STM32F401RE and STM32L476RG

1.4 Flash management

Apart from storing its code, BLUEMICROSYSTEM2 uses the Flash memory for:

1. saving the Open.MEMS and Open.Audio licenses activated for the board inside the Meta Data Manager
2. allowing the Firmware-Over-The-Air update

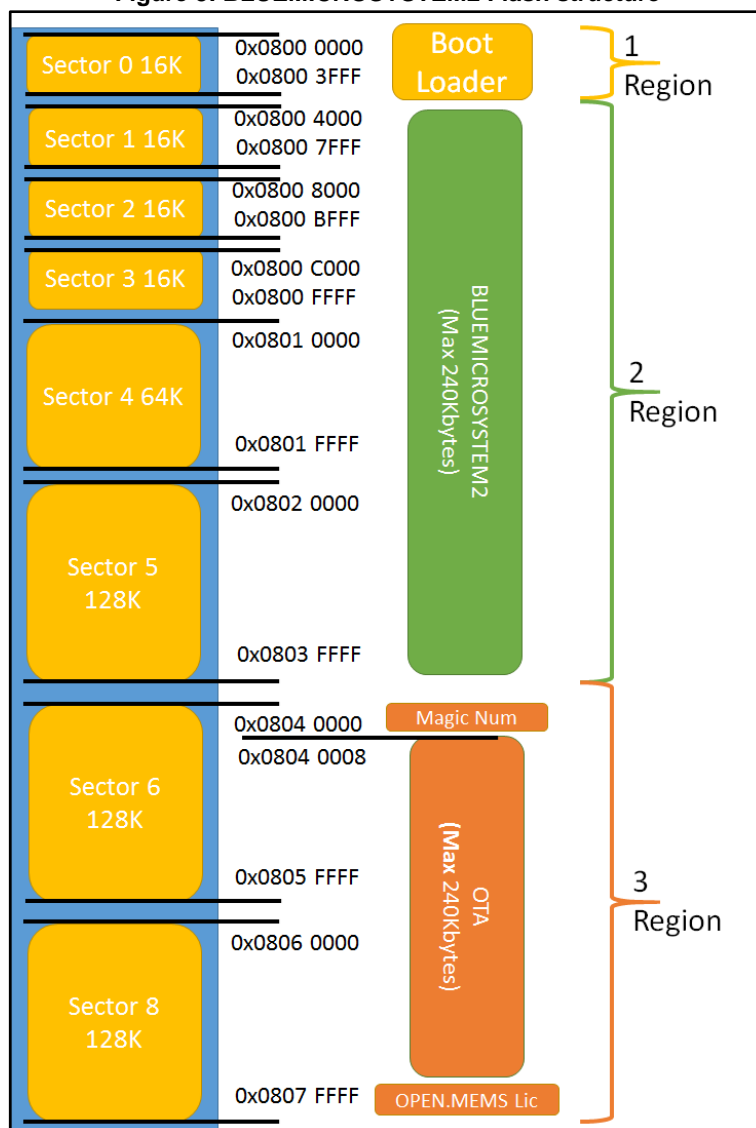
To enable these features the Flash is divided into these different regions (see [Figure 3: "BLUEMICROSYSTEM2 Flash structure"](#)):

1. the first region contains a custom boot loader
2. the second region contains the BLUEMICROSYSTEM2 firmware
3. The third region is used for storing the FOTA before the update and for saving the Open.MEMS and Open.Audio licenses inside the Meta Data Manager

Even if the STM32F401RE (512 KB) and the STM32L476RG (1024 KB) cache sizes and arrangements differ, the same FLASH arrangement applies to both devices. The Meta Data Manager is placed at the end of the FLASH (0x08007000 for STM32F401RE and 0x080FF000 for STM32L476RG). For more information, refer to:

- (RM0368) Reference manual STM32F401xB/C and STM32F401xD/E advanced ARM®-based 32-bit MCUs
- (RM0351) Reference manual STM32L4x6 advanced ARM®-based 32-bit MCUs

Figure 3: BLUEMICROSYSTEM2 Flash structure



1.5 The boot process

The BLUEMICROSYSTEM2 cannot not be flashed at the beginning of the Flash (address 0x08000000), and is therefore compiled to run from the beginning of the second Flash region, at 0x08004000.

To enable this behavior, we set the vector table offset in Src/system_stm32f4xx.c (for STM32F401) and Src/system_stm32l4xx.c (for STM32L476) thus: `#define VECT_TAB_OFFSET 0x4000`.

We also changed the linker script. For example, the Linker script for BLUEMICROSYSTEM2 running on STM32F401RE and compiled using IAR Embedded Workbench for ARM is:

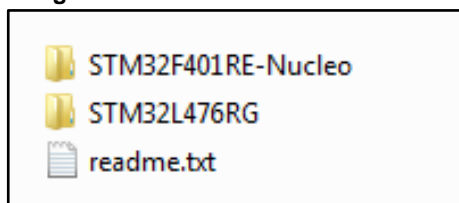
```
define symbol __ICFEDIT_intvec_start__ = 0x08004000;
/*-Memory Regions-*/
define symbol ICFEDIT_region_ROM_start = 0x08004000;
define symbol ICFEDIT_region_ROM_end = 0x0803FFFF;
define symbol ICFEDIT_region_RAM_start = 0x20000000;
```

```
define symbol ICFEDIT region RAM end = 0x20017FFF;
/*-Sizes-*/
define symbol ICFEDIT_size_cstack = 0x8000;
define symbol ICFEDIT_size_heap = 0x800;
```

Using the above linker script, the maximum usable code size is fixed at 240 KB.

You must flash the appropriate bootloader binary for STM32F401RE or STM32L476RG, found in the Utilities\BootLoader folder, to the first FLASH region (address 0x08000000).

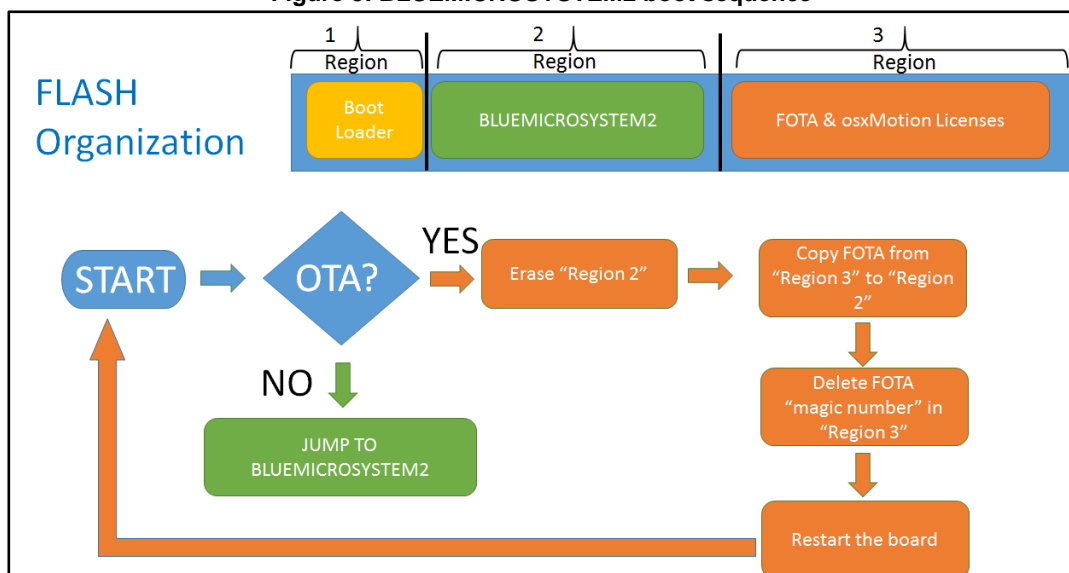
Figure 4: BootLoader folder content



On any board reset:

- If there is a FOTA in the third Flash region, the boot loader overwrites the second Flash region (with BLUEMICROSYSTEM2 firmware) and replaces its content with the FOTA and restarts the board.
- If there is no FOTA, the boot loader jumps to the BLUEMICROSYSTEM2 firmware.

Figure 5: BLUEMICROSYSTEM2 boot sequence



1.6 Firmware update

The package Binary directory contains an image (in .bin and .hex format) that includes for each supported platform (NUCLEO-F401RE, NUCLEO-L476RG, STEVAL-STLKT01V1):

- pre-compiled BLUEMICROSYSTEM2 firmware that may be flashed via ST-LINK to the correct memory location (0x08004000) on a supported STM32 Nucleo or SensorTile board
this pre-compiled binary is compatible with the FOTA update procedure
- pre-compiled BLUEMICROSYSTEM2+BootLoader firmware that may be directly flashed to a supported STM32 Nucleo or SensorTile Board via ST-LINK or a drag and drop (STM32 Nucleo boards only) operation
this pre-compiled binary is not compatible with the FOTA update procedure

Figure 6: Binary Folder Content

Projects > Multi > Applications > BlueMicrosystem2 > Binary >			ti > Applications > BlueMicrosystem2 > Binary > STM32F401RE-Nucleo		
Name	Date modified	Type	Name	Date modified	Type
STM32F401RE-Nucleo	12/13/2016 4:16 PM	File folder	BlueMS2_IKS01A1_NucleoF4.bin	12/1/2016 12:48 PM	BIN File
STM32L476RG-Nucleo	10/14/2016 11:50 AM	File folder	BlueMS2_IKS01A1_NucleoF4.hex	12/2/2016 8:36 AM	HEX File
STM32L476RG-SensorTile	10/14/2016 11:50 AM	File folder	BlueMS2_IKS01A1_NucleoF4_BL.bin	12/1/2016 3:58 PM	BIN File
			BlueMS2_IKS01A1_NucleoF4_BL.hex	12/2/2016 8:36 AM	HEX File
			BlueMS2_IKS01A2_NucleoF4.bin	12/1/2016 12:49 PM	BIN File
			BlueMS2_IKS01A2_NucleoF4.hex	12/2/2016 8:34 AM	HEX File
			BlueMS2_IKS01A2_NucleoF4_BL.bin	12/1/2016 3:47 PM	BIN File
			BlueMS2_IKS01A2_NucleoF4_BL.hex	12/2/2016 8:34 AM	HEX File

If you need to flash modified BLUEMICROSYSTEM2 firmware, simply flash the compiled code to the correct memory address (0x08004000).

A batch script is provided to simplify this operation by saving the firmware and the BootLoader to the right location; it is available for each platform (NUCLEO-F401RE, NUCLEO-L476RG, STEVAL-STLKT01V1) and for each IDE (IAR/RealView/System Workbench):

- IAR toolchain Embedded Workbench V7.70.2:
 - For Nucleo F4: CleanBlueMS2_IAR_IKS01A1_F4.bat or CleanBlueMS2_IAR_IKS01A2_F4.bat
 - For Nucleo L4: CleanBlueMS2_IAR_IKS01A1_L4.bat or CleanBlueMS2_IAR_IKS01A2_L4.bat
 - For STEVAL-STLKT01V1: CleanBlueMS2_IAR_ST.bat
- System Workbench for STM32 Version 1.11.0.201610101338:
 - For Nucleo F4: CleanBlueMS2_SW4STM32_IKS01A1_F4.bat or CleanBlueMS2_SW4STM32_IKS01A2_F4.bat
 - For Nucleo L4: CleanBlueMS2_SW4STM32_IKS01A1_L4.bat or CleanBlueMS2_SW4STM32_IKS01A2_L4.bat
 - For STEVAL-STLKT01V1: CleanBlueMS2_SW4STM32_ST.bat
- µVision toolchain - MDK-ARM Professional Version: 5.21.1:
 - For Nucleo F4: CleanBlueMS2_MDK_ARM_IKS01A1_F4.bat or CleanBlueMS2_MDK_ARM_IKS01A2_F4.bat
 - For Nucleo L4: CleanBlueMS2_MDK_ARM_IKS01A1_L4.bat or CleanBlueMS2_MDK_ARM_IKS01A2_L4.bat
 - For STEVAL-STLKT01V1: CleanBlueMS2_MDK_ARM_ST.bat

Figure 7: Content of a project folder

Applications > BlueMicrosystem2 > EWARM > STM32F401RE-Nucleo			Search
Name	Date modified	Type	
BlueMS2_NF4.eww	10/14/2016 11:50 ...	IAR IDE Workspa	
CleanBlueMS2_IAR_IKS01A1_F4.bat	11/11/2016 1:27 PM	Windows Batch	
CleanBlueMS2_IAR_IKS01A2_F4.bat	11/11/2016 1:28 PM	Windows Batch	
Project.ewd	11/7/2016 4:39 PM	EWD File	
Project.ewp	12/9/2016 3:49 PM	EWP File	
startup_stm32f401xe.s	10/14/2016 11:50 ...	Assembler Sourc	
stm32f401xe_flash.icf	11/15/2016 12:15 ...	ICF File	

This script:

- performs a full Flash erase to start clean

- flashes the BootLoader to 0x08000000
- flashes the BLUEMICROSYSTEM2 firmware to 0x08004000

Figure 8: BootLoader and BLUEMICROSYSTEM2 installation

```

C:\Windows\system32\cmd.exe

/*****
Clean BlueMicrosystem2
*****/
/*****
Full Chip Erase
*****/
STM32 ST-LINK CLI v2.3.0
STM32 ST-LINK Command Line Interface

ST-LINK SN : 0671FF54552867067015725
ST-LINK Firmware version : U2J24M11
Connected via SWD.
SWD Frequency = 4000K.
Target voltage = 3.3 V.
Connection mode : Normal.
Device ID:0x433
Device flash Size : 512 Kbytes
Device family :STM32F401xE
Full chip erase...
Flash memory erased.

/*****
Install BootLoader
*****/
STM32 ST-LINK CLI v2.3.0
STM32 ST-LINK Command Line Interface

ST-LINK SN : 0671FF54552867067015725
ST-LINK Firmware version : U2J24M11
Connected via SWD.
SWD Frequency = 4000K.
Target voltage = 3.3 V.
Connection mode : Normal.
Device ID:0x433
Device flash Size : 512 Kbytes
Device family :STM32F401xE
Loading file...
Flash Programming:
File : ..\..\..\Utilities\BootLoader\STM32F401RE-Nucleo\BootLoaderF4.
bin
Address : 0x08000000
Memory programming... 100%
Reading and verifying device memory... 100%
Memory programmed in 1s and 34ms.
Verification...OK
Programming Complete.

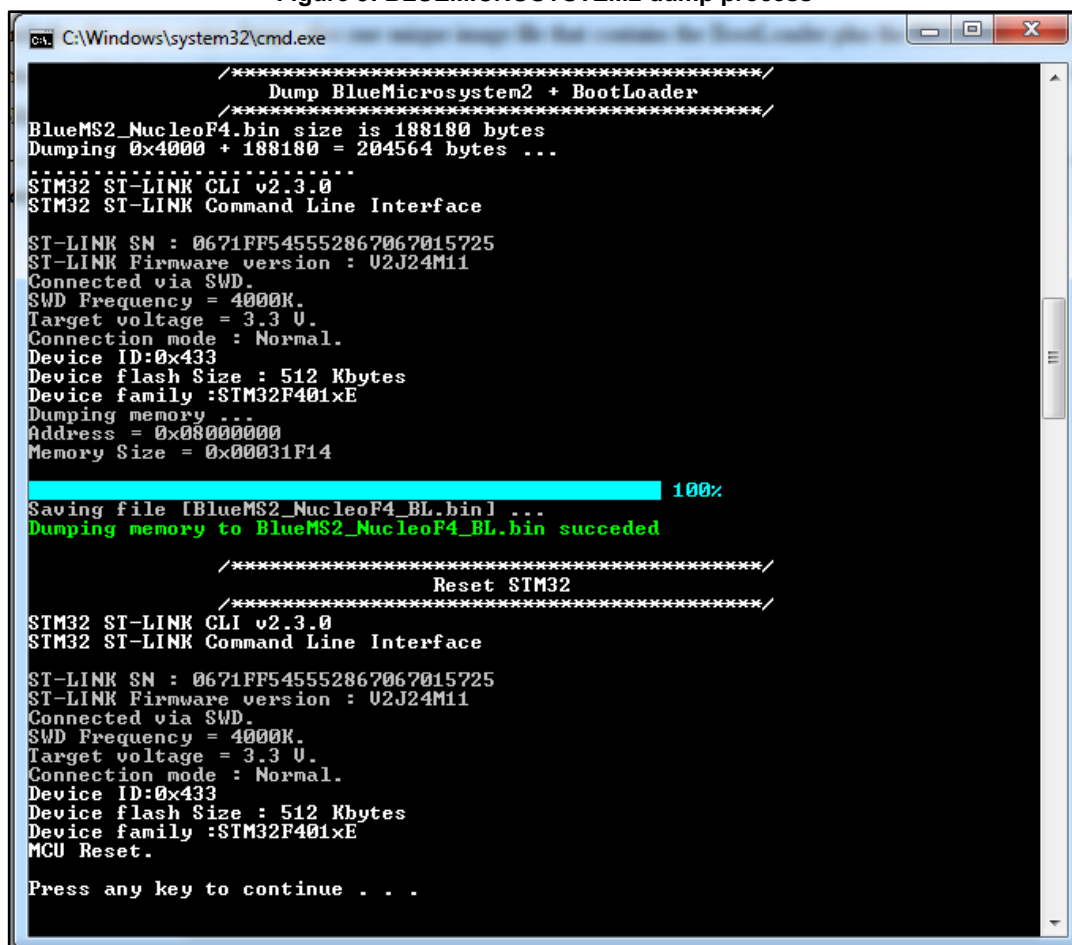
/*****
Install BlueMicrosystem2
*****/
STM32 ST-LINK CLI v2.3.0
STM32 ST-LINK Command Line Interface

ST-LINK SN : 0671FF54552867067015725
ST-LINK Firmware version : U2J24M11
Connected via SWD.
SWD Frequency = 4000K.
Target voltage = 3.3 V.
Connection mode : Normal.
Device ID:0x433
Device flash Size : 512 Kbytes
Device family :STM32F401xE
Loading file...
Flash Programming:
File : BlueMS2_NucleoF4.bin
Address : 0x08004000
Memory programming... 100%
Reading and verifying device memory... 100%
Memory programmed in 12s and 963ms.
Verification...OK
Programming Complete.

```

The same script also dumps a unique image file that contains the BootLoader and the BLUEMICROSYSTEM2 firmware. This image file can be directly flashed to the beginning of the memory like the image provided in the Binary folder.

Figure 9: BLUEMICROSYSTEM2 dump process



```

C:\Windows\system32\cmd.exe

/*****
Dump BlueMicrosystem2 + BootLoader
*****/
BlueMS2_NucleoF4.bin size is 188180 bytes
Dumping 0x4000 + 188180 = 204564 bytes ...

*****
STM32 ST-LINK CLI v2.3.0
STM32 ST-LINK Command Line Interface

ST-LINK SN : 0671FF545552867067015725
ST-LINK Firmware version : U2J24M11
Connected via SWD.
SWD Frequency = 4000K.
Target voltage = 3.3 V.
Connection mode : Normal.
Device ID:0x433
Device flash Size : 512 Kbytes
Device family :STM32F401xE
Dumping memory ...
Address = 0x08000000
Memory Size = 0x00031F14

Saving file [BlueMS2_NucleoF4_BL.bin] ... 100%
Dumping memory to BlueMS2_NucleoF4_BL.bin succeeded

/*****
Reset STM32
*****/
STM32 ST-LINK CLI v2.3.0
STM32 ST-LINK Command Line Interface

ST-LINK SN : 0671FF545552867067015725
ST-LINK Firmware version : U2J24M11
Connected via SWD.
SWD Frequency = 4000K.
Target voltage = 3.3 V.
Connection mode : Normal.
Device ID:0x433
Device flash Size : 512 Kbytes
Device family :STM32F401xE
MCU Reset.

Press any key to continue . . .

```

For the Linux and iOS operating systems, there are similar scripts that use OpenOCD instead of the ST-LINK command line. These scripts are available for each supported platform, but only work with System Workbench IDE:

- CleanBlueMS2_SW4STM32_IKS01A1_F4.sh or CleanBlueMS2_SW4STM32_IKS01A2_F4.sh.
- CleanBlueMS2_SW4STM32_IKS01A1_L4.sh or CleanBlueMS2_SW4STM32_IKS01A2_L4.sh.
- CleanBlueMS2_SW4STM32_ST.sh.

In order to function, the script must be modified with:

- the installation path for OpenOCD
- the installation path for STM32 OpenOCD scripts
- the Library path for OpenOCD

Below is the section of the OpenOCD script to edit:

```

# 1) Set the Installation path for OpenOCD
# example:
#OpenOCD DIR="C:/Ac6/SystemWorkbench/plugins/fr.ac6.mcu.externaltools.openocd.win32
1.11.0.201610101338/tools/openocd/"
OpenOCD DIR=""

# 2) Set the installation path for stm32 OpenOCD scripts
# example:
#OpenOCD_CFC="C:/Ac6/SystemWorkbench/plugins/fr.ac6.mcu.debug_1.11.0.201610101240/re

```

```
sources/openocd/scripts"
OpenOCD_CFC=""

# 3) Only for Linux/iOS add openocd library path to _LIBRARY_PATH:
# For iOS example:
#export DYLD_LIBRARY_PATH=${DYLD_LIBRARY_PATH}:${OpenOCD_DIR}"lib/"

# For Linux example:
#export LD_LIBRARY_PATH=${LD_LIBRARY_PATH}:${OpenOCD_DIR}"lib/"
```

1.7 Firmware-over-the-air (FOTA) update

With the X-NUCLEO-IDB05A1 Bluetooth low energy expansion board, the BLUEMICROSYSTEM2 firmware may be updated over-the-air (FOTA) through the connected Android or iOS device via Bluetooth using the BlueMS application (ver. 3.0.0 and above) available on the corresponding application market stores.

The application sends the update and associated CRC (cyclic-redundancy-check) value, which BLUEMICROSYSTEMS2 checks against the hardware cyclic redundancy check calculation unit on the STM32F401/STM32L476 processor to ensure the update integrity. If the CRC calculation matches the BlueMS CRC value, the new firmware is written from the beginning of the third Flash region. A “magic number” setting signals the boot loader that a Firmware update has been received and checked, and is ready to replace the current BLUEMICROSYSTEM2 firmware (see [Section 1.12: "Firmware-over-the-air update with BlueMS"](#)).

1.8 APIs

Detailed user-API function and parameter descriptions are compiled in an HTML file in the package Documentation folder.

1.9 Sample application description

A sample application is provided in the Projects folder for:

- the X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2, X-NUCLEO-CCA02M1 and X-NUCLEO-IDB04A1 or X-NUCLEO-IDB05A1 expansion boards with the NUCLEO-F401RE or NUCLEO-L476RG board
- STEVAL-STLKT01V1.

Ready to build projects are available for multiple IDEs.

With the NUCLEO-F401RE and NUCLEO-L476RG boards, you can set up a terminal window for the appropriate UART communication port (use the baud, data, parity and stop settings below) to control the initialization phase.

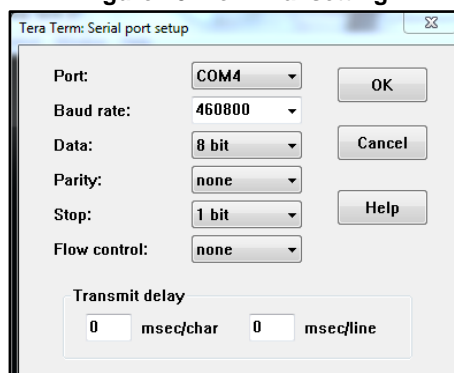
The same feature is available for the STEVAL-STLKT01V1 when connecting the micro-USB port is connected to a PC. However, as it is necessary to register the USB device, this is only possible when the STEVAL-STLKT01V1 starts. In fact, a 10-second delay has been added to the initialization phase to allow you to follow its progress.

This feature for STEVAL-STLKT01V1 is disabled by default. To enable it, you must modify the `osx_bms_config.h` file by enabling the `//#define OSX_BMS_ENABLE_PRINTF` line below.

```
#ifndef STM32_SENSORTILE
/* Enabling this define for SensorTile..
 * it will introduce a delay of 10Seconds before starting the application
 * for having time to open the Terminal
 * for looking the BlueMicrosystem Initialization phase */
#if (!defined ( CC_ARM))
//#define OSX_BMS_ENABLE_PRINTF
```

```
#endif /* ( CC ARM) */
#else /* STM32_SENSORTILE */
/* For Nucleo it's enable by default */
#define OSX_BMS_ENABLE_PRINTF
#endif /* STM32_SENSORTILE */
```

Figure 10: Terminal setting



When you first press the reset button on the NUCLEO-F401RE or NUCLEO-L476RG board, the application:

1. initializes the UART, I²C and SPI interfaces
2. checks whether all the sensors are present and working
3. writes whether the FW is compiled for X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2
4. For X-NUCLEO-IKS01A1, checks whether the LSM6DS3 DIL24 extension is present
5. checks whether the osxMotionFX, osxMotionAR, osxMotionCP, osxMotionGR, osxAcousticSL and OSXBLUEVOICE libraries have been initialized properly with valid licenses read from Flash
6. determines which BlueNRG expansion board is connected to the STM32 Nucleo board (X-NUCLEO-IDB04A1 or X-NUCLEO-IDB05A1) and hardware and firmware version information
7. creates a random BLE MAC address
8. initializes the BLE hardware service (adding the temperature, humidity, pressure, 3D gyroscope, 3D magnetometer, 3D accelerometer and microphone characteristics) and the BLE software service (adding the osxMotionFX, osxMotionAR, osxMotionCP, osxMotionGR, osxAcousticSL and OSXBLUEVOICE if present in FLASH).
9. initializes the BLE console service adding the stdin/stdout and stderr characteristics
10. initializes the BLE config service transmitting/resetting the calibration status and enabling the hardware features:
 - a. if LSM6DS3 is mounted on the DIL24 on X-NUCLEO-IKS01A1.
 - b. for LSM6DSL on X-NUCLEO-IKS01A2 (for only Nucleo L4).

If the LSM6DS3 DIL24 extension is present, or if the X-NUCLEO-IKS01A2 is mounted (Nucleo L4 only), it can generate an interrupt signaling a free fall, tilt, wake up, single tap, double tap, 6D position or pedometer event, which is transmitted over Bluetooth to the attached Android™/iOS™ device.

Figure 11: Initialization phase

```

COM4 - Tera Term VT
File Edit Setup Control Window Help

UART Initialized
I2C Initialized
SPI Initialized

STMicroelectronics BLUEMICROSYSTEM2:
  Version 2.2.0
  STM32F401RE-Nucleo board
  Code compiled for X-NUCLEO-IKS01A2
  OK Accelerometer Sensor
  OK Gyroscope Sensor
  OK Magnetometer Sensor
  OK Humidity Sensor
  OK Temperature Sensor1
  OK Temperature Sensor2
  OK Pressure Sensor
  Enabled Accelerometer Sensor
  Enabled Gyroscope Sensor
  Enabled Magnetometer Sensor
  Enabled Humidity Sensor
  Enabled Temperature Sensor1
  Enabled Temperature Sensor2
  Enabled Pressure Sensor
  OK Audio Init
  OK Audio Volume

  Meta Data Manager read from Flash
  Meta Data Manager version=0.8.0
  Licenses found:
    MotionFX Init <ST osxMotionFX x9/x6 v1.0.7>
    MotionAR Init <ST osxMotionAR v1.1.0>
    MotionCP Init <ST osxMotionCP v1.0.0>
    MotionGR Init <ST osxMotionGR v1.0.0>
    AcousticSL Init <ST osxAcousticSL v1.1.0>
    AudioBU Init <ST osxBlueVoice v2.0.0>

  Enabled ST osxMotionFX x9/x6 v1.0.7
  Enabled ST osxMotionAR v1.1.0
  Enabled ST osxMotionCP v1.0.0
  Enabled ST osxMotionGR v1.0.0
  Enabled ST osxAcousticSL v1.1.0
  Enabled ST osxBlueVoice v2.0.0
  <HAL 1.5.1.0>
  Compiled Dec 13 2016 10:53:10 (IAR)
  Send Every 30ms 3 Short precision Quaternions
  Send Every 500ms Temperature/Humidity/Pressure
  Send Every 50ms Acc/Gyro/Magneto
  Send Every 50ms dB noise

  Debug Connection Enabled
  Debug Notify Transmission Enabled
  SERVER: BLE Stack Initialized
    Board type=IDB05A1 HWver=49, FWver=7.2.a
    BoardName= BM2U220
    BoardMAC = c0:7a:25:39:4e:30

  HW & SW Service W2SI added successfully
  Console Service W2SI added successfully
  Config Service W2SI added successfully
  Magneto Calibration Not present
  Initialized osxMotionFX
  Initialized osxMotionAR
  Initialized osxMotionCP
  Initialized osxMotionGR
  Initialized osxAcousticSL (17452 bytes allocated)
  Initialized osxBlueVoice

```

As shown in the console output above, the application sends:

- 3 short precision quaternions every 30 ms
- Temperature/Humidity/Pressure data every 500 ms
- 3D Accelerometer, 3D Gyroscope and 3D Magnetometer data every 50 ms
- signal noise microphone levels every 50 ms



You can change the transmission frequency of the sensor value through the BlueMS Android/iOS application.

This application reads the accelerometer, magnetometer and gyroscope values at 100 samples/second. The osxMotionFX (iNEMOEngine PRO) library combines these sensor

values to produce and transmit 100 quaternions/second to the client connected via Bluetooth low energy to reflect real motion using a vendor-specific BLE service.

The above also applies to the STEVAL-STLKT01V1.

These definitions in `osx_bms_config.h` control how many quaternions the application sends to the Bluetooth client:

- `QUAT_UPDATE_MUL_10MS`: defines the transmission rate for each set of quaternions by multiple of 10 ms.
- `SEND_N_QUATERNIONS`: defines how many quaternions are sent on each Bluetooth package.

By default, the application sends 3 quaternions every 30 ms.

The same `osx_bms_config.h` file also defines:

- `OSX_BMS_DEBUG_CONNECTION` and `OSX_BMS_DEBUG_NOTIFY_TRANSMISSION` to enable some debugging information for BLE communication

The `osxMotionFX` (INEMOEngine PRO) library has an auto-calibrating procedure and the calibration status is transmitted via BLE to the client:

- On the NUCLEO-F401RE or NUCLEO-L476RG boards, you can press the user button to reset the library calibration status and force a new auto-calibration procedure.
- With the STEVAL-STLKT01V1, you can only do this through the BlueMS application.

The `osxMotionAR` (INEMOEngine PRO) library is able to recognize the following activities:

- Stationary
- Walking
- fast walking
- jogging
- biking
- driving

The `osxMotionCP` (INEMOEngine PRO) library recognizes and provides real-time information about how the user is carrying the board, which equates to the phone carry position:

- on desk
- in hand
- near head
- shirt pocket
- trouser pocket
- arm swing

The `osxMotionGR` (INEMOEngine PRO) library is able to recognize gestures like:

- pick up
- glance
- wake up in hand

The `osxAcousticSL` library can localize audio sound sources using the data acquired from microphones.

The `OSXBLUEVOICE` library implements a vendor-specific profile enabling voice communication with Bluetooth low energy.

When an Android/iOS device is connected to the NUCLEO-F401RE, NUCLEO-L476RG or STEVAL-STLKT01V1 board, you can (if `#define OSX_BMS_ENABLE_PRINTF` is enabled) control what the board transmits.

Figure 12: UART console output when one device is connected to the board

```

COM4 - Tera Term VT
File Edit Setup Control Window Help

UART Initialized
I2C Initialized
SPI Initialized

STMicroelectronics BLUEMICROSYSTEM2:
  Version 2.2.0
  STM32F401RE-Nucleo board
  Code compiled for X-NUCLEO-IKS01A2
  OK Accelerometer Sensor
  OK Gyroscope Sensor
  OK Magnetometer Sensor
  OK Humidity Sensor
  OK Temperature Sensor1
  OK Temperature Sensor2
  OK Pressure Sensor
  Enabled Accelerometer Sensor
  Enabled Gyroscope Sensor
  Enabled Magnetometer Sensor
  Enabled Humidity Sensor
  Enabled Temperature Sensor1
  Enabled Temperature Sensor2
  Enabled Pressure Sensor
  OK Audio Init
  OK Audio Volume

Meta Data Manager read from Flash
Meta Data Manager version=0.8.0
  Licenses found:
    MotionFX Init <ST osxMotionFX v9/x6 v1.0.7>
    MotionAR Init <ST osxMotionAR v1.1.0>
    MotionCP Init <ST osxMotionCP v1.0.0>
    MotionGR Init <ST osxMotionGR v1.0.0>
    AcousticSL Init <ST osxAcousticSL v1.1.0>
    AudioBU Init <ST osxBlueVoice v2.0.0>

  Enabled ST osxMotionFX v9/x6 v1.0.7
  Enabled ST osxMotionAR v1.1.0
  Enabled ST osxMotionCP v1.0.0
  Enabled ST osxMotionGR v1.0.0
  Enabled ST osxAcousticSL v1.1.0
  Enabled ST osxBlueVoice v2.0.0
  <HAL 1.5.1.0>
  Compiled Dec 13 2016 10:53:10 <IAR>
  Send Every 30ms 3 Short precision Quaternions
  Send Every 500ms Temperature/Humidity/Pressure
  Send Every 50ms Acc/Gyro/Magneto
  Send Every 50ms dB noise

Debug Connection Enabled
Debug Notify Transmission Enabled
SERVER: BLE Stack Initialized
  Board type=IDB05A1 HWver=49, FWver=7.2.a
  BoardName= BM2U220
  BoardMAC = c0:7a:25:39:4e:30

HW & SW Service W2ST added successfully
Console Service W2ST added successfully
Config Service W2ST added successfully
Magnetometer Calibration Not present
Initialized osxMotionFX
Initialized osxMotionAR
Initialized osxMotionCP
Initialized osxMotionGR
Initialized osxAcousticSL (17452 bytes allocated)
Initialized osxBlueVoice
>>>>>CONNECTED 7a:3b:c5:d:6f:53
--->Calib=ON
--->Env=ON
Sending: Cal=0 Press=102314 Hum=465 Temp=242 Temp2=235
--->Env=ON
--->Env=ON
--->Env=ON
Sending: Press=102304 Hum=465 Temp=242 Temp2=235
Sending: Press=102311 Hum=465 Temp=242 Temp2=235
Sending: Press=102307 Hum=465 Temp=242 Temp2=235
Sending: Press=102311 Hum=465 Temp=242 Temp2=235

```

1.10 Open.MEMS and Open.Audio licenses

The BLUEMICROSYSTEM2 includes:

1. osxMotionFX (iNEMOEngine PRO) real-time motion sensor data fusion algorithm
2. osxMotionAR (iNEMOEngine PRO) real-time activity-recognition algorithm
3. osxMotionCP (iNEMOEngine PRO) real-time carry-position recognition algorithm
4. osxMotionGR (iNEMOEngine PRO) real-time gesture recognition algorithm
5. osxAcousticSL real-time sound source localization algorithm
6. OSXBLUEVOICE real-time voice communication algorithm over Bluetooth low energy.

The algorithms are released under Open.MEMS and Open.Audio limited license agreement (LLA) and are node-locked to a specific STM32 board; you need to obtain a license from

STMicroelectronics to use them. Licenses can be requested via the Android/iOS device BlueMS application (ver. 3.0.0 and above) available on their respective application market stores, or with the OSX License Wizard if `OSX_BMS_LICENSE_H_FILE` in `Inc\osx_bms_config.h` is enabled.

Licenses are saved in the last section of the third Flash region so they are not lost on board resets.

Refer to [Section 1.13: "Open.MEMS and Open.Audio license activation"](#) for more information regarding license requests.

1.11 Android and iOS sample client application

The BLUEMICROSYSTEM2 software for STM32Cube is compatible with the BlueMS Android/iOS applications (ver. 2.2.0 or higher) available at the respective Play/iOS stores. Version 3.0.0 and above is required for over-the-air firmware updates (for X-NUCLEO-IDB05A1 Bluetooth low energy expansion boards only) and to request and enable the Open.MEMS and Open.Audio licenses. Version 3.2.0 and above is required for display Gas Gauge battery information (remaining charge, voltage and charge status) for the STEVAL-STLKT01V1 board.

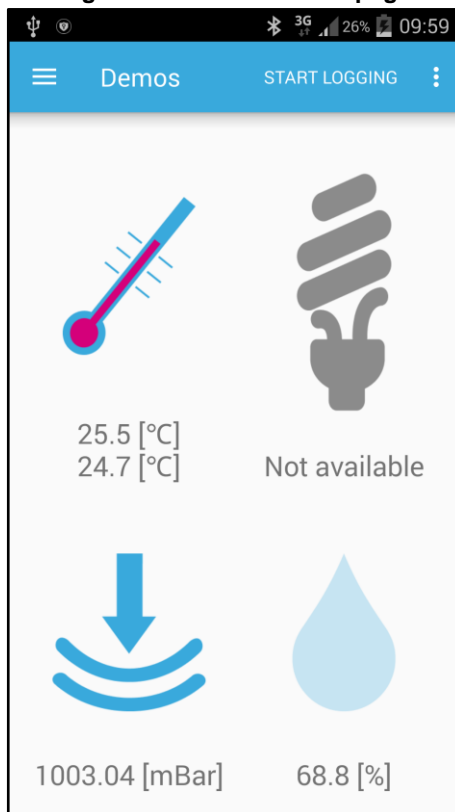
We will use the Android application for this demonstration.

1.11.1 Main page

Following connection, BlueMS starts with the main page shown below, where the values of temperature, pressure and humidity are displayed.

- 1 Click on an image to force the data reading.

Figure 13: Environmental page

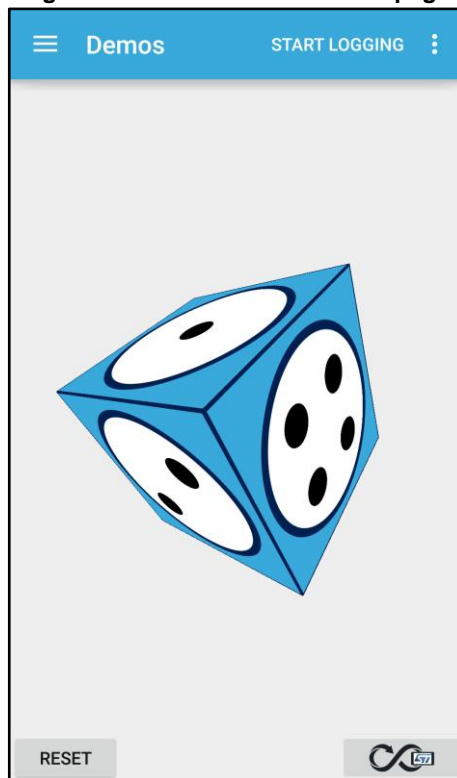


1.11.2 MEMS Sensor Fusion

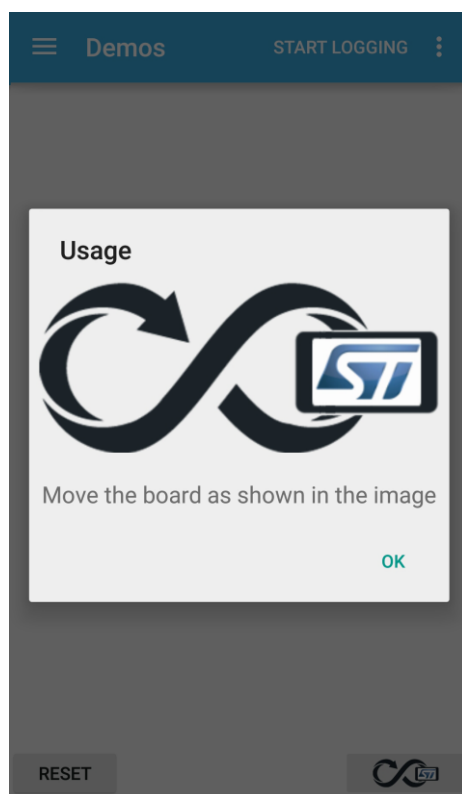
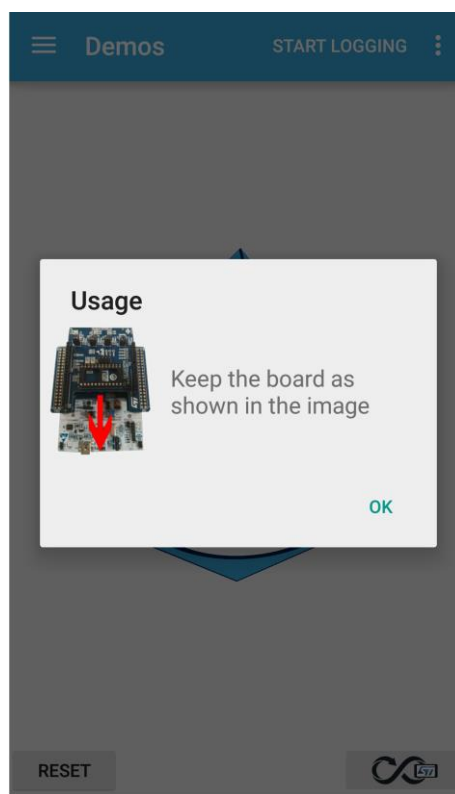
This demo requires firmware that can only be obtained with a valid osxMotionFX license.

This page shows a 3D cube that reflects board motion thanks to the output of the sensor fusion algorithm on the STM32 Nucleo board that calculates rotation using the magnetometer, accelerometer and gyroscope data from the X-NUCLEO-IKS01A1 (or X-NUCLEO-IKS01A2) expansion board.

Figure 14: MEMS Sensor Fusion page



- 1 Run the calibration process to improve the precision of the sensor fusion algorithm; pushing the right button deletes existing calibration data and starts a new calibration process.
As the dialog suggests, you must rotate the board in a figure 8 pattern.
The board is calibrated when the right button becomes green.
- 2 Align the starting position to ensure coherent movement between the board and the cube: press the reset button and keep the board as shown in the image.
With the default configuration, the application sends three quaternions every 30 ms. So when the board is moved, the application harmonizes the sampling rate (the number of quaternions received every second) and the number of rendered frames per second that the smartphone/tablet is capable of processing (60 frames per second is typically the maximum allowed by the GPU). These two values are normally not visible, but can be shown by touching the screen on the top left and on the top right of the display window.

Figure 15: MEMS Sensor fusion calibration dialog**Figure 16: MEMS Sensor fusion reset board position**

1.11.3 Plot data

In this page, you can plot all the data exported by the device.

- 1 In order to achieve this user has to select the data to plot and press the Play button.
By clicking on the Plot length menu item, you can set the time scale in seconds to display.

Figure 17: Selecting the data to plot

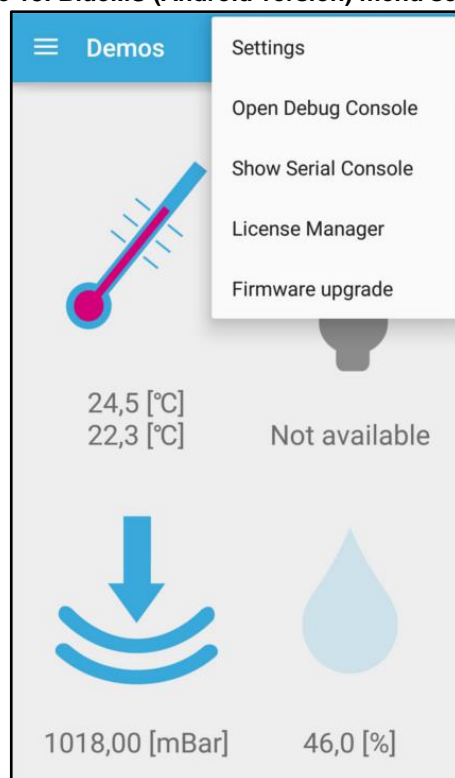


1.11.4 Serial and debug console

In the option menu below, you can open:

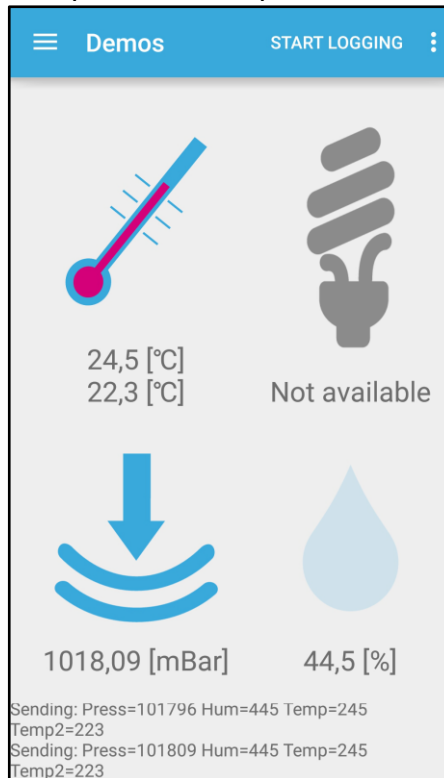
- Serial or Debug (with stdin) console
- License manager
- Firmware upgrade

Figure 18: BlueMS (Android version) menu selection



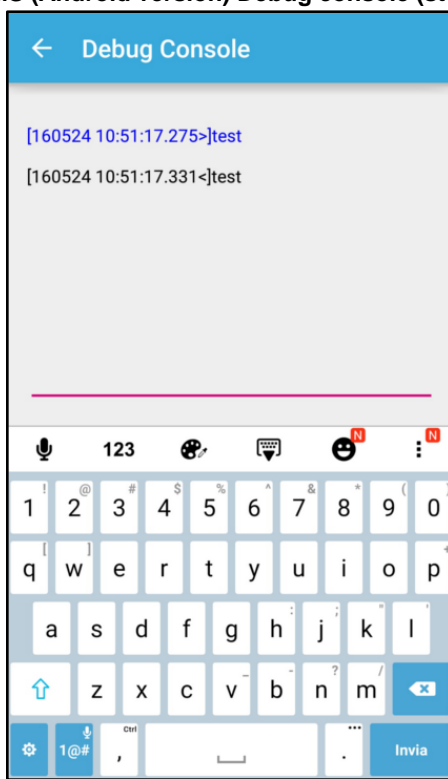
- 1 Enable the Serial console to display stdout/stderr.

Figure 19: BlueMS (Android version) Serial console (stdout/stderr)



- 2 Enable the Debug console to display stdin.
Any message written in the Debug console triggers a reply from the board with the same message.

Figure 20: BlueMS (Android version) Debug console (stdin/stdout/stderr)



You can change the transmission frequency of the sensor values through the debug console:

- for temperature/humidity/pressure with the command:
 - @TM: the application sends environmental data every 5 s
 - @TH: the application sends environmental data every 1 s
 - @TL: the application sends environmental data every 100 ms
 - @TD: the application sends environmental data at the default rate (500 ms)
- for 3D accelerometer, 3D gyroscope and 3D magnetometer with the command:
 - @AM: the application sends the data every 5 s
 - @AH: the application sends the data every 1 s
 - @AL: the application sends the data every 100 ms
 - @AD: the application sends the data at the default rate (50 ms)
- for signal noise microphone levels with the command:
 - @MM: the application sends the data every 5 s
 - @MH: the application sends the data every 1 s
 - @ML: the application sends the data every 100 ms
 - @MD: the application sends the data at the default rate (50 ms)

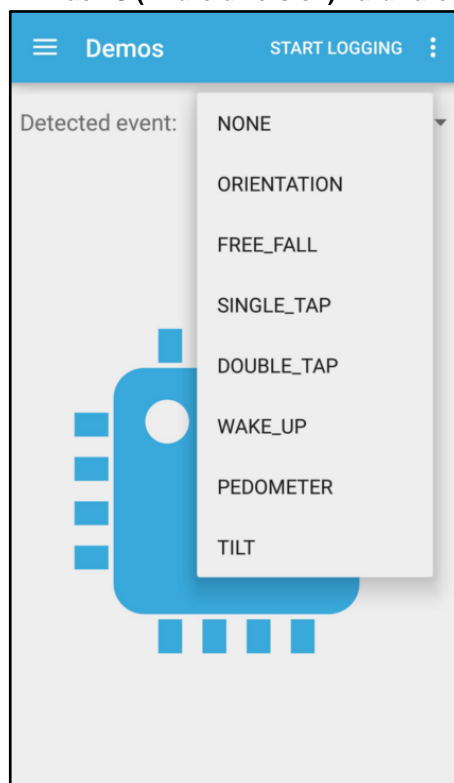
1.11.5 Enable hardware features

There is another page where you can enable single hardware features on:

- LSM6DS3, if mounted on DIL24 on X-NUCLEO-IKS01A1 for STM32 Nucleo F4 and L4 expansion boards
- LSM6DSL on X-NUCLEO-IKS01A2 for STM32 Nucleo L4 expansion boards only
- LSM6DSM for STEVAL-STLKT01V1

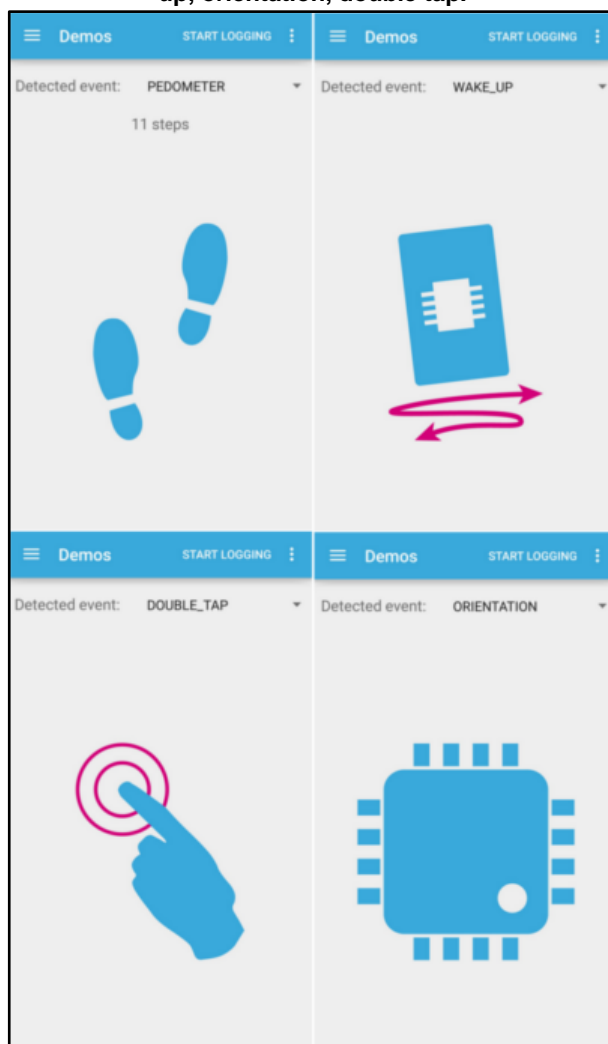
The Orientation hardware feature is the default setting.

Figure 21: BlueMS (Android version) hardware features



- 1 Select a hardware feature from those available and view the results on the same page.

Figure 22: BlueMS (Android version) hardware feature examples: pedometer, wake up, orientation, double tap.



1.11.6 Activity recognition

This demo requires compatible firmware and you must obtain and load a valid osxMotionAR license.

This page starts the activity recognition algorithm, which can recognize six different activities: standing, walking, fast walking, running, driving and biking.

When the algorithm detects a new activity, the associated image turns black. If all the images are grey, the algorithm has not detected any known activities.



As the algorithm must first collect data before recognizing any activities, all the images will be greyed out for a few seconds after the demo starts.

Figure 23: Activity recognition demo page



1.11.7 Carry position

This demo requires compatible firmware and you must obtain and load a valid osxMotionCP license.

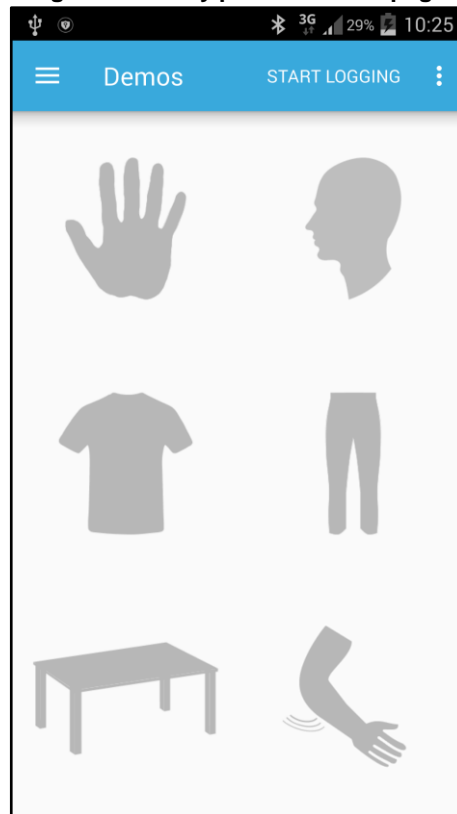
This page starts the carry position recognition algorithm, which detects where the user is carrying the device: on a desk, in hand, near head, in a shirt pocket, in trouser pocket and on swinging arm.

When the algorithm detects a carry position, the corresponding icon turns black. If all the images are grey, the algorithm is detecting a change in the position.



As the algorithm must first collect data before recognizing any activities, all the images will be greyed out for a few seconds after the demo starts.

Figure 24: Carry position demo page



1.11.8 Gesture recognition

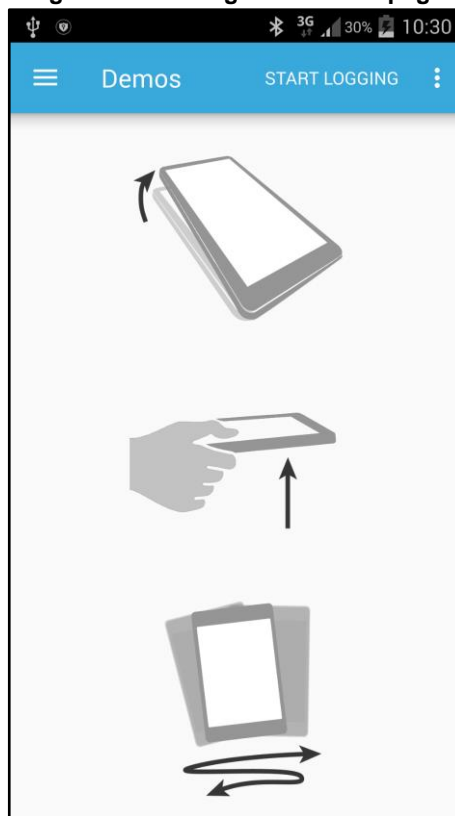
This demo requires compatible firmware and you must obtain and load a valid osxMotionGR license.

This demo starts the gesture recognition algorithm that uses the information coming from the MEMS sensors to detect certain user gestures:

- Glance: the user moves the device to look at the display (in our case to look at the sensor)
- Pick up: the user picks up the device
- Wake up: the user shakes the device

Each time an event is detected, the icon animates and becomes colored. After three seconds, or when a new event arrives, the icon goes grey again.

Figure 25: Mems gesture demo page

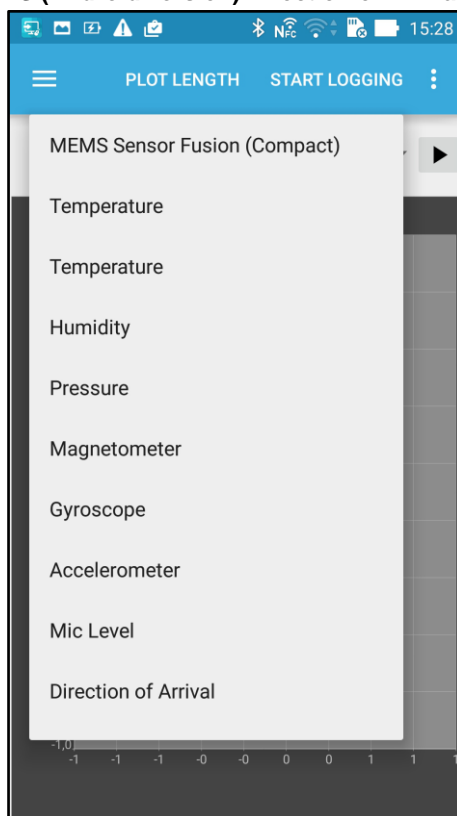


1.11.9 Direction of Arrival

This demo requires compatible firmware and you must obtain and load a valid osxAcousticSL license.

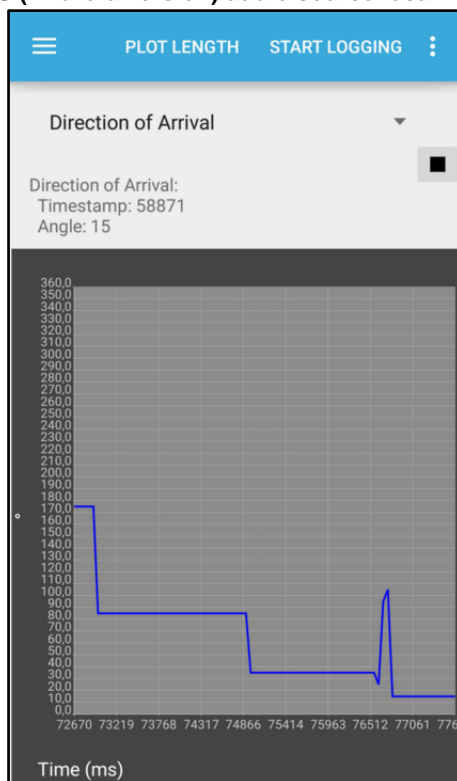
- 1 Select the Direction of Arrival menu item

Figure 26: BlueMS (Android version) Direction of Arrival menu selection



The audio sound source localization algorithm is activated and the associated plot is shown

Figure 27: BlueMS (Android version) audio source localization plot example

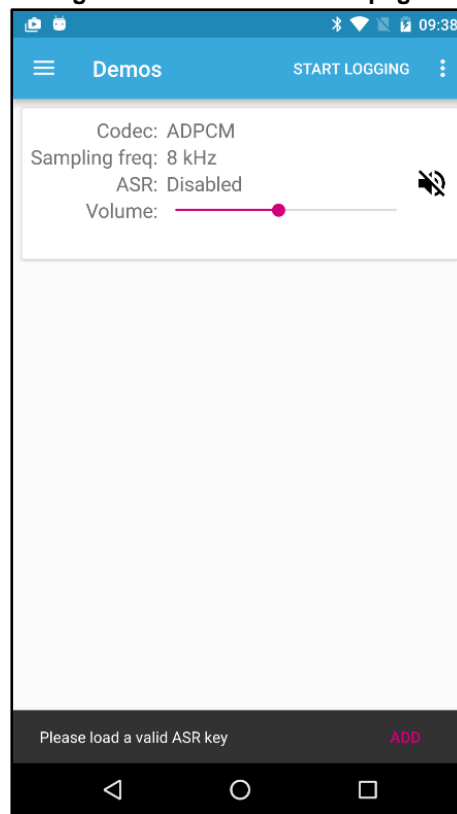


1.11.10 BlueVoice

This demo requires compatible firmware and you must obtain and load a valid OSXBLUEVOICE license.

If the OSXBLUEVOICE voice over BLE library is enabled, the following page is also available.

Figure 28: BlueVoice Demo page



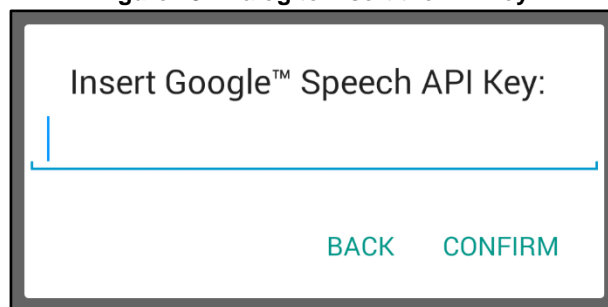
Supported functions are:

- Playback of the audio stream received from the connected device
- Cloud-hosted ASR service. Please note that speech recognition only supports English language.

Audio playback begins as soon as the page is displayed

- 1 Adjust the volume level using the slider or mute by clicking on the speaker icon.
- 2 Press the “ADD” button on the bottom of the screen to allow the insertion of the key to enable the ASR feature, see [Section 1.11.12: "Google speech ASR Key generation"](#).
The application displays a popup window that allows the insertion of a valid API key for ASR service activation.

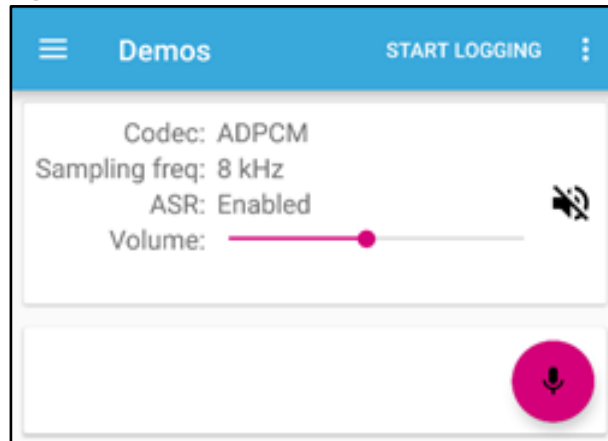
Figure 29: Dialog to insert the API key



3

Enter a valid key and the following screen will appear.

Figure 30: BlueVoice Demo with ASR service enabled

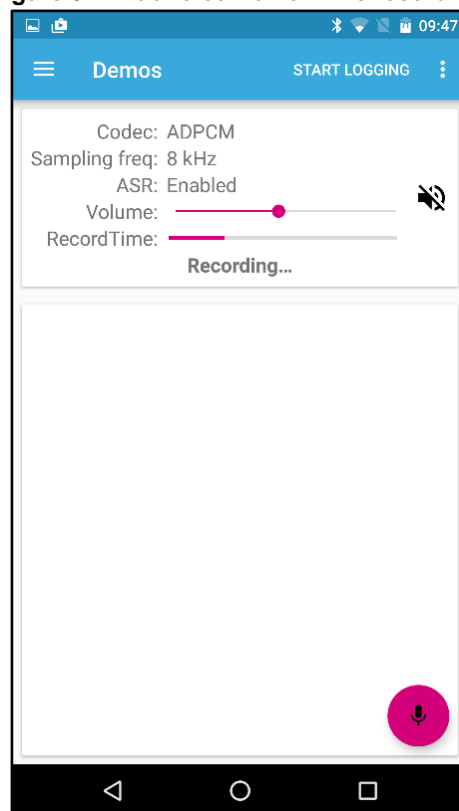


4

Hold the recording button to register your voice and let the app recognize what you are saying.

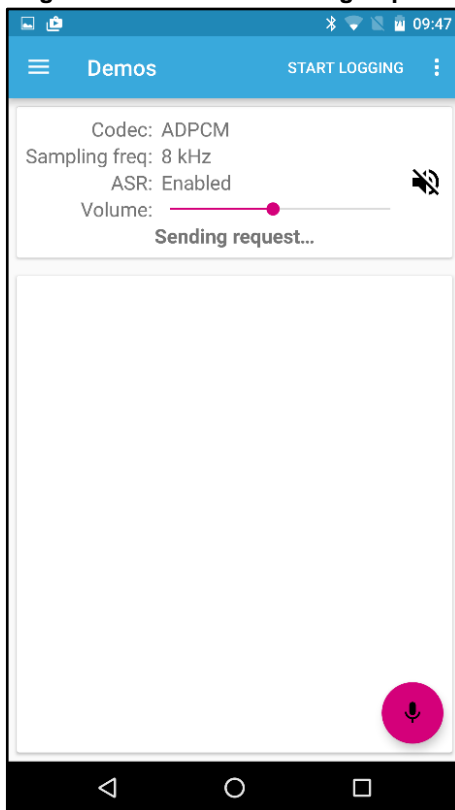
While the button is pressed, a bar shows the elapsed recording time. The maximum message length is 5 seconds.

Figure 31: BlueVoice Demo while recording

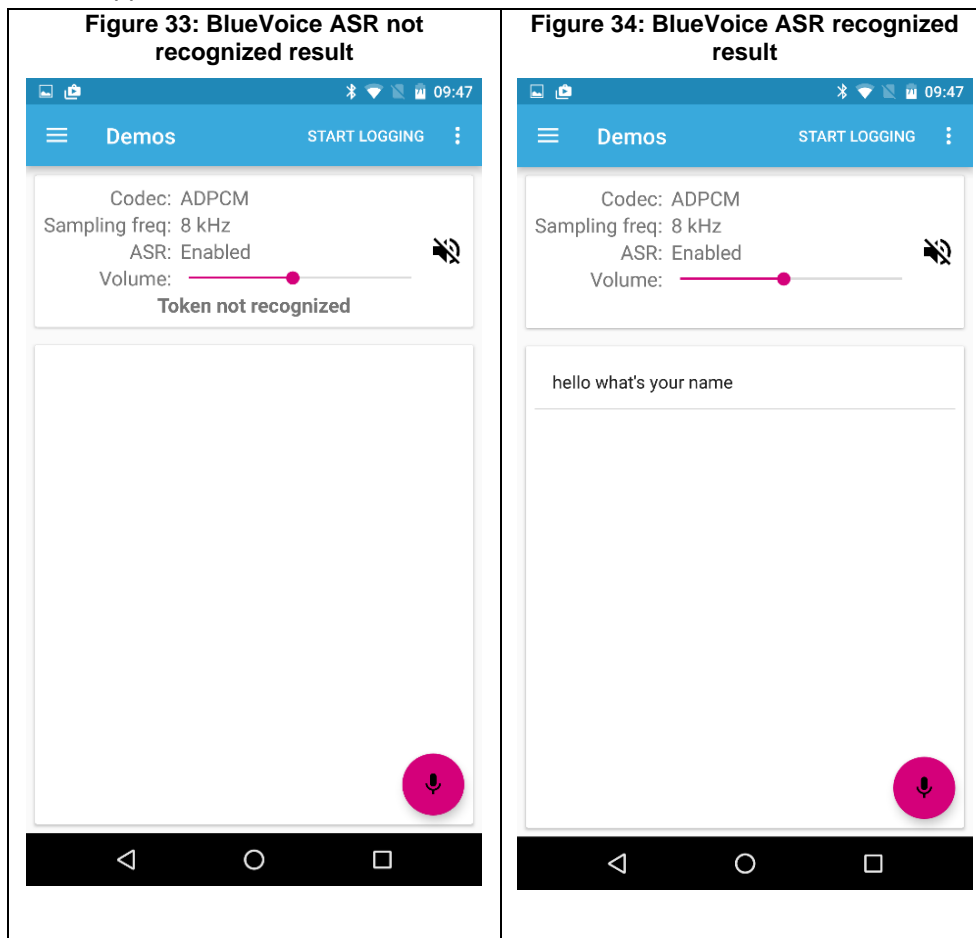


- 5 Release the button and wait until the words appear.
A “Sending request...” message appears.

Figure 32: BlueVoice sending request



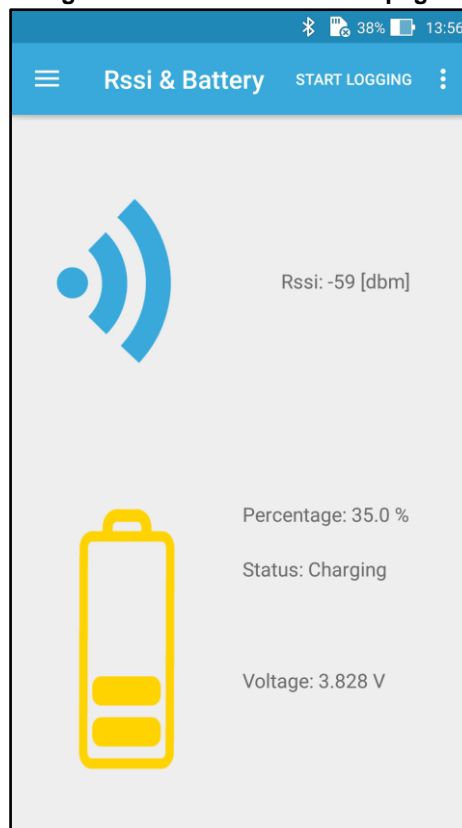
- 6 When the speech can't be recognized an alert text ("Token not recognized") is shown below the volume bar. Otherwise, the speech recognized by the ASR service appears in the box.



1.11.11 Rssi and battery

This page shows RSSI of the Bluetooth signal strength and, for STEVAL-STLKT01V1 if the battery is connected, the charge percentage, measured voltage and battery status (charging/discharging/low battery).

Figure 35: Board status demo page



The RSSI value is updated every 0.5 seconds.

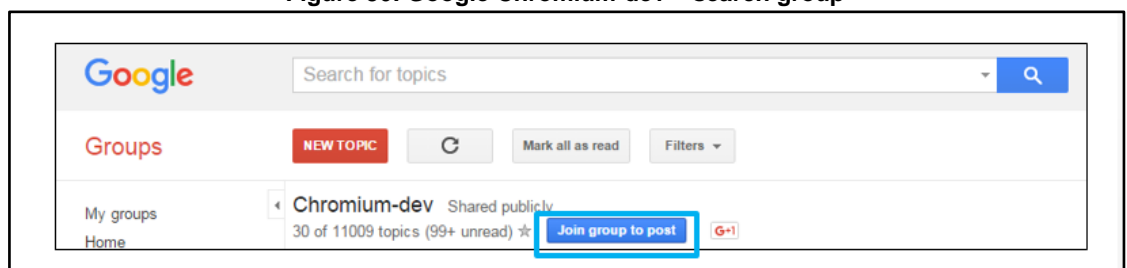
1.11.12 Google speech ASR Key generation

The Google Speech APIs require a key to access the web-based service. You need a Google account to complete the procedure and to access the service.

To generate a key:

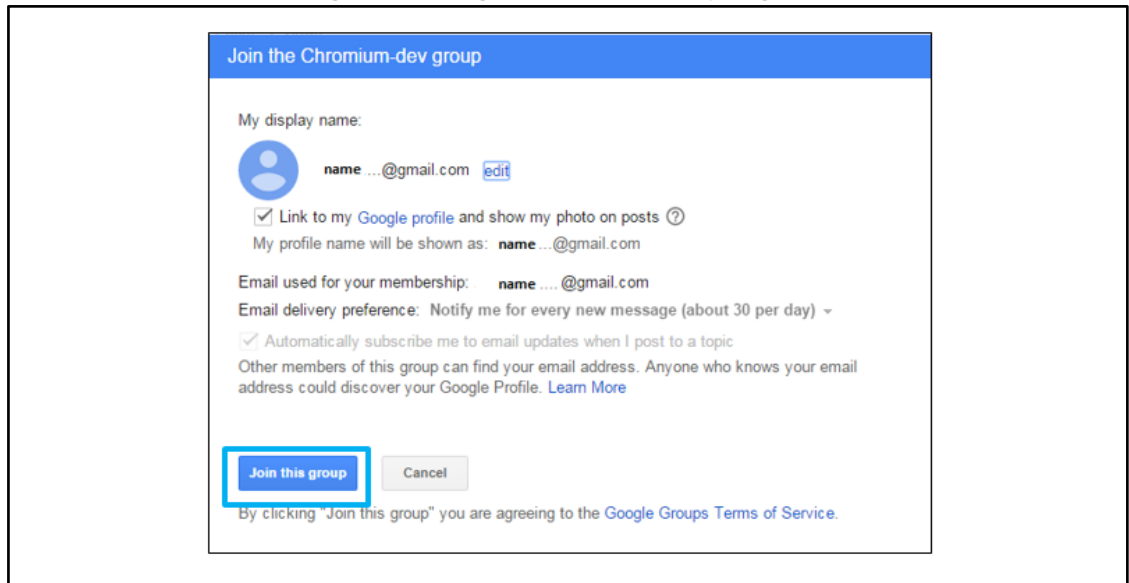
- 1 Login with your own Gmail account.
- 2 Subscribe to Chromium-dev at <https://groups.google.com/a/chromium.org/forum/?fromgroups#!forum/chromium-dev>. Write "Chromium-dev" in the search box, and select the appropriate group.
- 3 Click on "Join group to post" button

Figure 36: Google Chromium-dev – search group



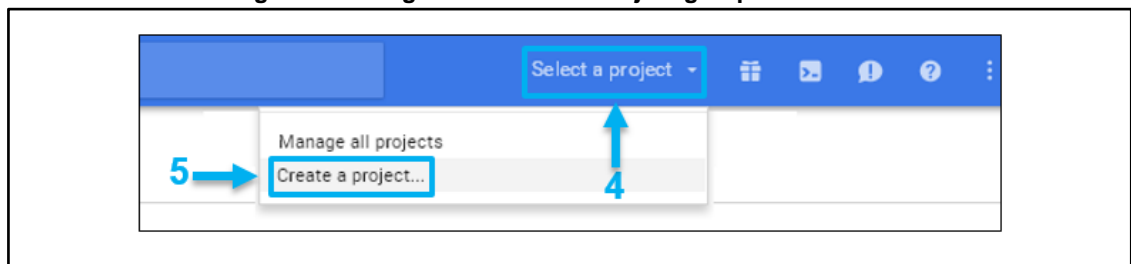
- 4 Click on “Join this group” button to join the Chromium-dev group.

Figure 37: Google Chromium-dev - join group



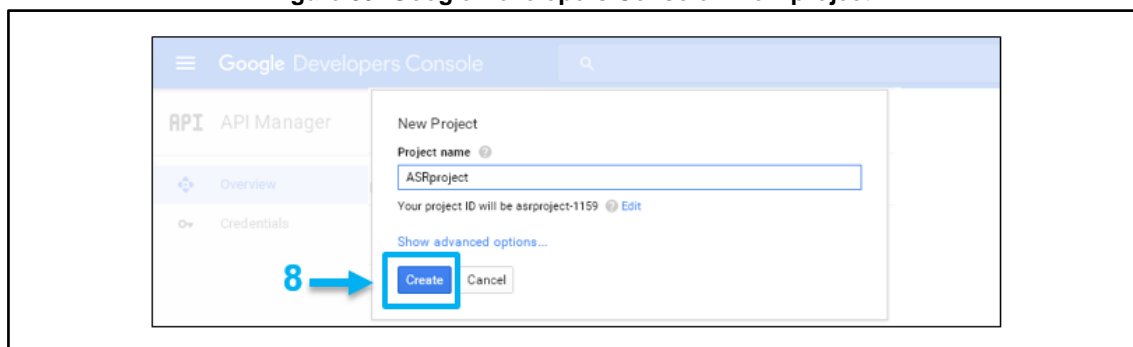
- 5 Go to <https://console.developers.google.com/project>
- 6 Open the "Select a project" menu in the upper toolbar.
- 7 Click on “Create a project...”

Figure 38: Google Chromium-dev - join group confirmation



- 8 Choose the Project name.
- 9 Click on “Create” button.

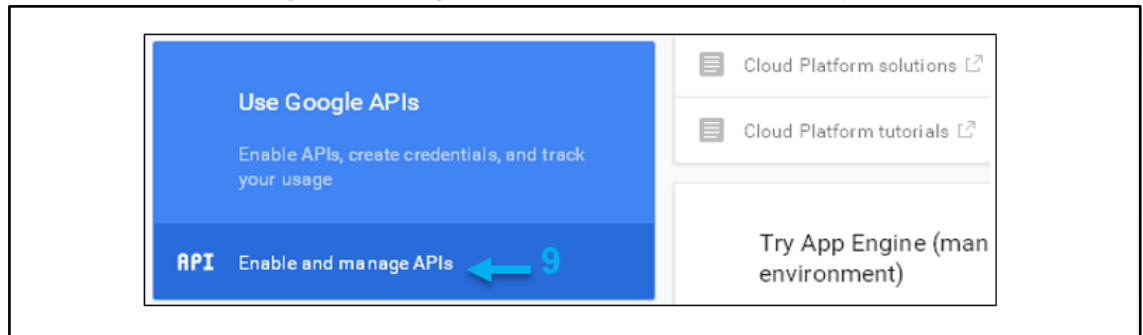
Figure 39: Google Developers Console – new project



- 10 Open the project you've created.

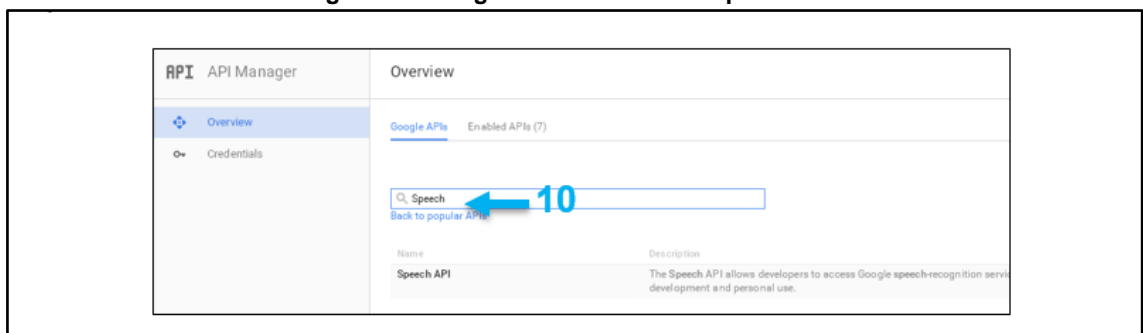
- 11 In the dashboard, click on “Enable and manage APIs”.

Figure 40: Google Developers Console - create project



- 12 Write “Speech API” in the search box, and select the correct result.

Figure 41: Google APIs - search for speech API



- 13 Enable the Speech API clicking on the blue button.

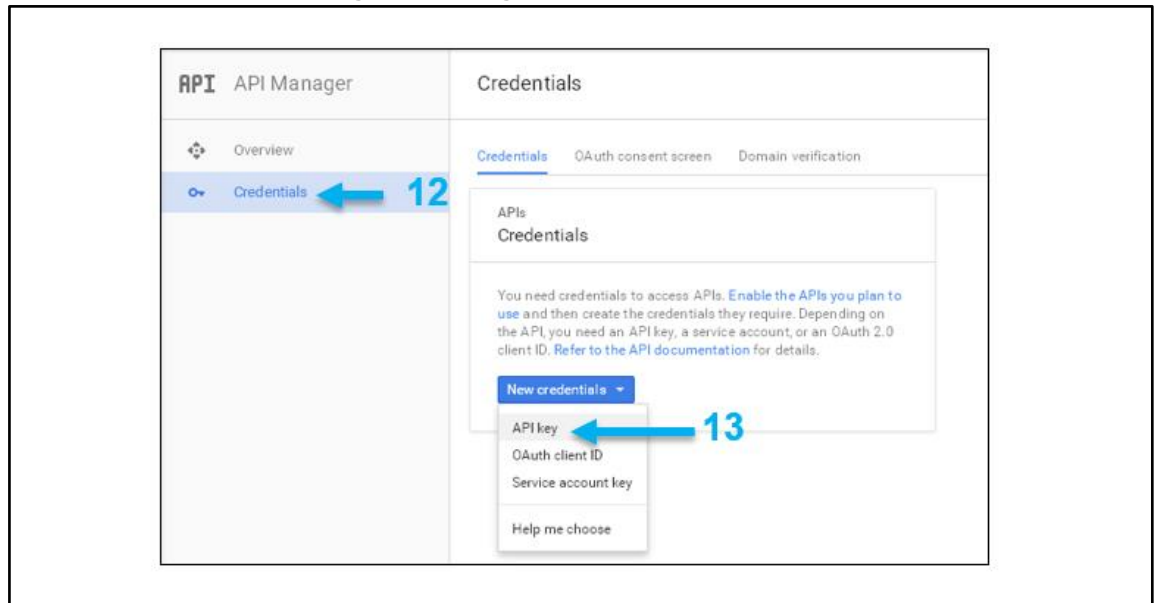
Figure 42: Google APIs – enable APIs



- 14 Move from the “Overview” tab to “Credentials” tab.

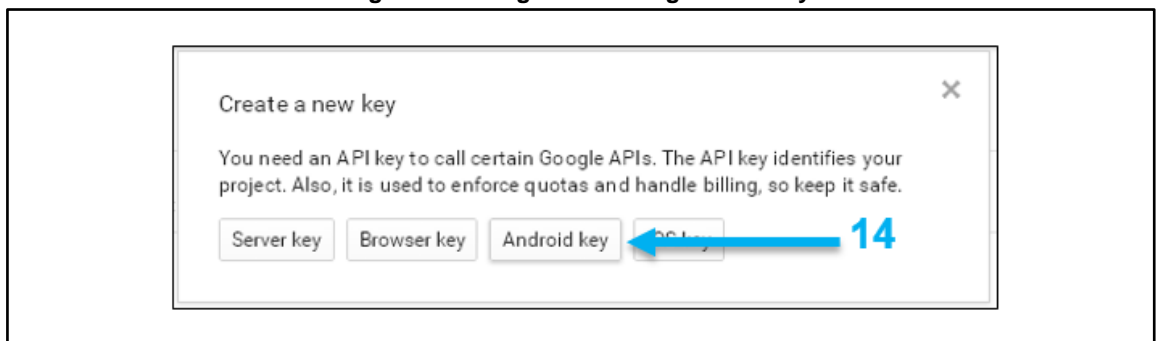
- 15 Open the “New credentials” menu and select “API key”.

Figure 43: Google APIs - enable speech API



- 16 Select the Android key button from the pop-up window.

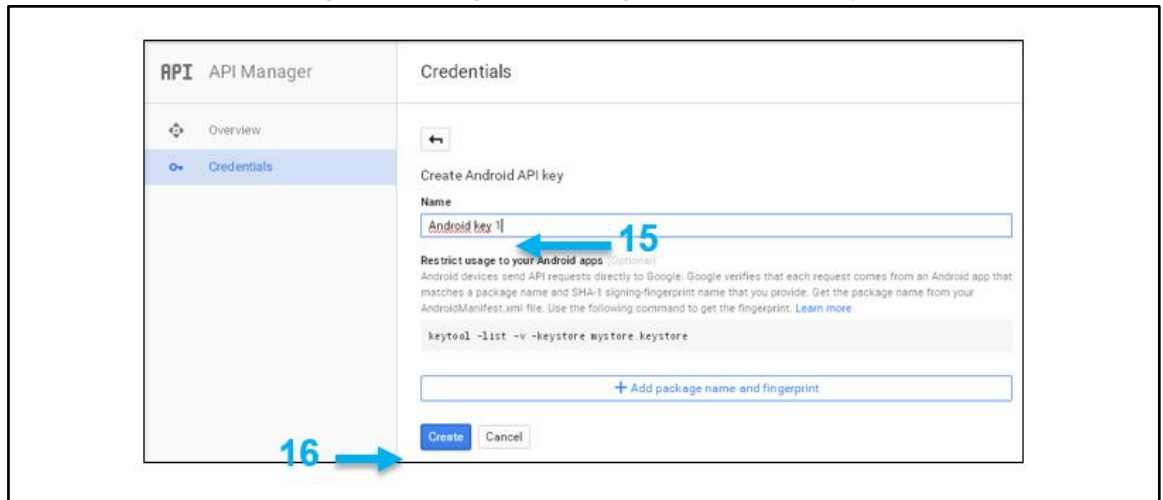
Figure 44: Google API Manager - API key



- 17 Write a valid name for the Android API key.

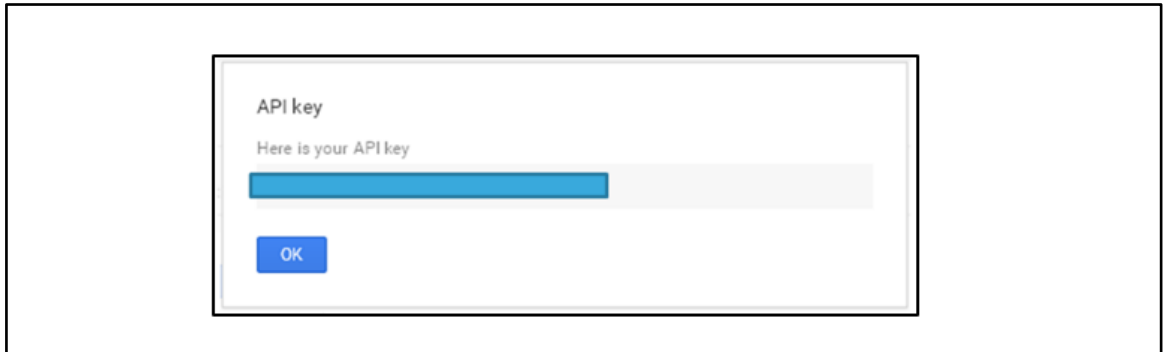
- 18 Click "Create" button.

Figure 45: Google API Manager - Android API key



- 19 A pop-up window will appear with your key.

Figure 46: Google API Manager - Android API key confirmation



1.12 Firmware-over-the-air update with BlueMS

If the 'Firmware upgrade' menu option is selected on the BlueMS main application page (*Figure 18: "BlueMS (Android version) menu selection"*), the page below appears.

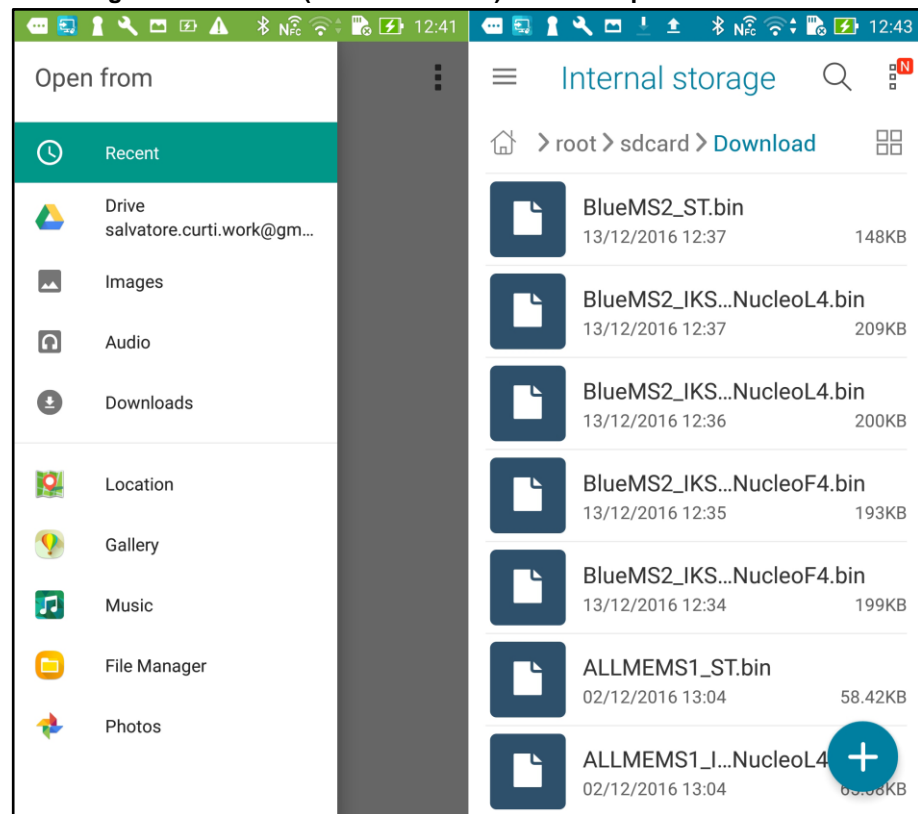
Figure 47: BlueMS (Android version) firmware upgrade page



The BlueMS application shows which version of the BLUEMICROSYSTEM2 software is running and the board type.

- 1 To apply an update, press the red button and choose the right file.

Figure 48: BlueMS (Android version) firmware update file selection



- 2 BlueMS sends the BLUEMICROSYSTEM2 a command communicating that it is going to send an update of a certain byte size and corresponding CRC value.
- The figure below shows the terminal window with the debug information returned during FOTA for an STM32 Nucleo platform when we use a UART to control BLUEMICROSYSTEM2 behavior.

Figure 49: Terminal window information during FOTA

```

COM4 - Tera Term VT
File Edit Setup Control Window Help
UART Initialized
I2C Initialized
SPI Initialized

STMicroelectronics BLUEMICROSYSTEM2:
  Version 2.2.0
  STM32F401RE-Nucleo board
Code compiled for X-NUCLEO-IKS01A2
OK Accelerometer Sensor
OK Gyroscope Sensor
OK Magnetometer Sensor
OK Humidity Sensor
OK Temperature Sensor1
OK Temperature Sensor2
OK Pressure Sensor
Enabled Accelerometer Sensor
Enabled Gyroscope Sensor
Enabled Magnetometer Sensor
Enabled Humidity Sensor
Enabled Temperature Sensor1
Enabled Temperature Sensor2
Enabled Pressure Sensor
OK Audio Init
OK Audio Volume

Meta Data Manager read from Flash
Meta Data Manager version=0.8.0
  Licenses found:
    MotionFX Init <ST osxMotionFX x9/x6 v1.0.7>
    MotionAR Init <ST osxMotionAR v1.1.0>
    MotionCP Init <ST osxMotionCP v1.0.0>
    MotionGR Init <ST osxMotionGR v1.0.0>
    AcousticSL Init <ST osxAcousticSL v1.1.0>
    AudioBU Init <ST osxBlueVoice v2.0.0>
Enabled ST osxMotionFX x9/x6 v1.0.7
Enabled ST osxMotionAR v1.1.0
Enabled ST osxMotionCP v1.0.0
Enabled ST osxMotionGR v1.0.0
Enabled ST osxAcousticSL v1.1.0
Enabled ST osxBlueVoice v2.0.0
  <HAL 1.5.1_0>
  Compiled Dec 13 2016 10:53:10 <IAR>
  Send Every 30ms 3 Short precision Quaternions
  Send Every 500ms Temperature/Humidity/Pressure
  Send Every 50ms Acc/Gyro/Magnetometer
  Send Every 50ms dB noise

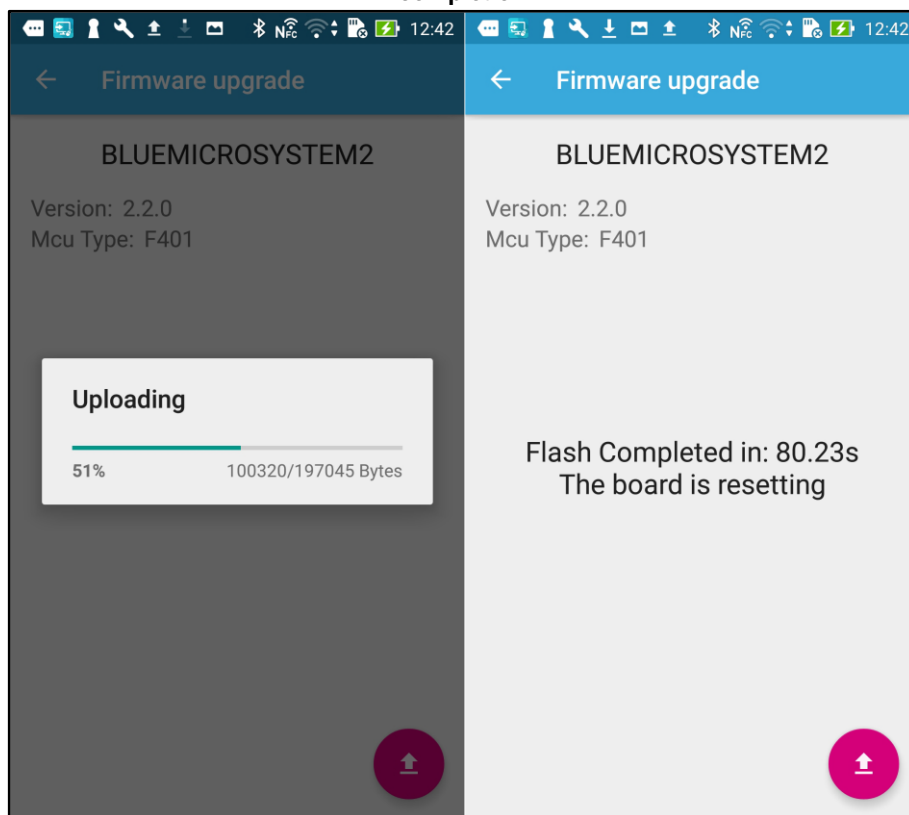
Debug Connection Enabled
Debug Notify Transmission Enabled
SERVER: BLE Stack Initialized
  Board type=IDB05A1 HWver=49, FWver=7.2.a
  BoardName= BM2U220
  BoardMAC = c0:7a:25:39:4e:30

HW & SW Service V2SI added successfully
Console Service V2SI added successfully
Config Service V2SI added successfully
Magnetometer Calibration Read
Initialized osxMotionFX
Initialized osxMotionAR
Initialized osxMotionCP
Initialized osxMotionGR
Initialized osxAcousticSL (17452 bytes allocated)
Initialized osxBlueVoice
>>>>>CONNECTED 60:94:35:4e:da:5
-->Calib=ON
-->Env=ON
Sending: Cal=1 Press=102247 Hum=449 Temp=248 Temp2=242
-->Env=ON
-->Env=ON
-->Env=ON
Sending: Press=102266 Hum=447 Temp=247 Temp2=242
Sending: Press=102259 Hum=447 Temp=247 Temp2=242
-->Env=OFF
OTA BLUEMICROSYSTEM2 SIZE=197205 uwCRCValue=2d80c40
Meta Data Manager Saved in FLASH
BLUEMICROSYSTEM2 will restart in 5 seconds

```

During the FOTA procedure, the BlueMS application shows the remaining packets that need to be sent, and the total update time when the procedure has finished.

Figure 50: BlueMS (Android version) application page during FOTA and on completion

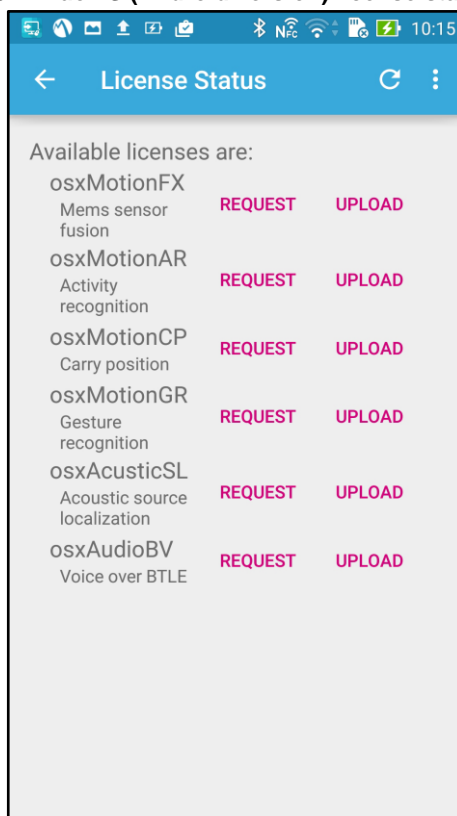


1.13 Open.MEMS and Open.Audio license activation

If `OSX_BMS_LICENSE_H_FILE` define in `Inc/osx_bms_config.h` is not defined, the Open.MEMS and Open.Audio licenses must be requested and enabled through the BlueMS android/iOS application.

If no Open.MEMS or Open.Audio licenses are active, BLUEMICROSYSTEM2 can still read and transmit sensor data values to the Android/iOS BlueMS application.

- 1 Select License Manager from the options menu in the BlueMS start page.

Figure 51: BlueMS (Android version) license status page

- 2 Click the REQUEST button to opens the legal agreement page, which continues to the license request page if you accept.

Figure 52: BlueMS (Android version) osxMotionCP license request

← Approve license

osxMotionCP

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DISAGREE AGREE

← Approve license

osxMotionCP

Username

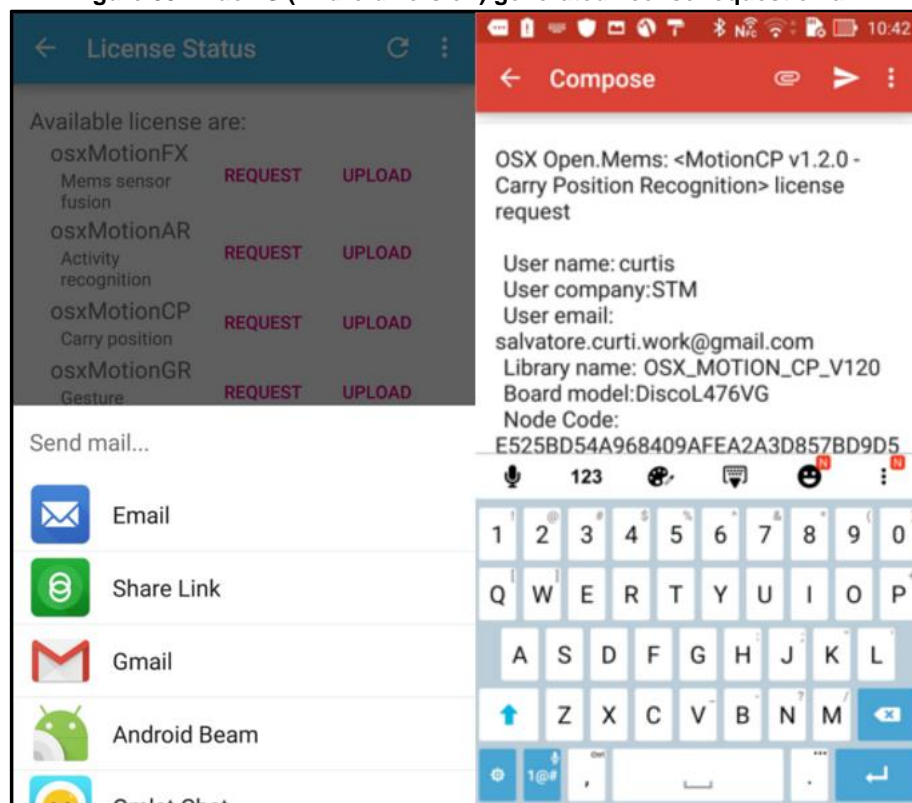
E-Mail

Company Name

➤

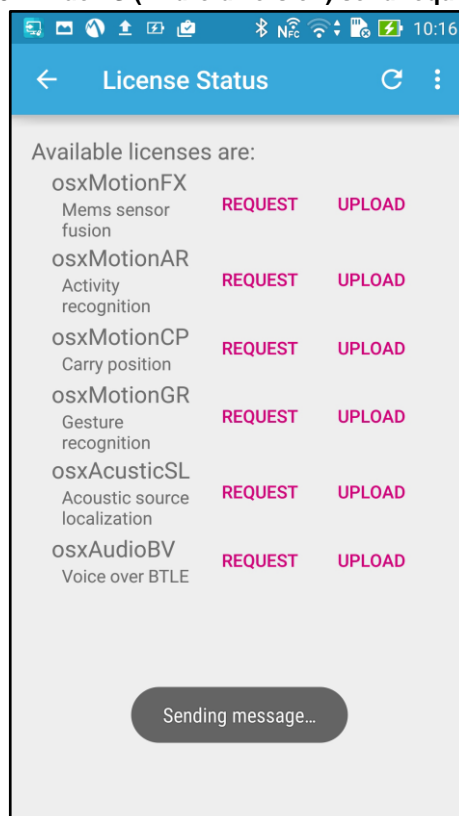
- 3 Enter a username, valid email address and company name, and click the red arrow button to generate the email request.

Figure 53: BlueMS (Android version) generated license request email



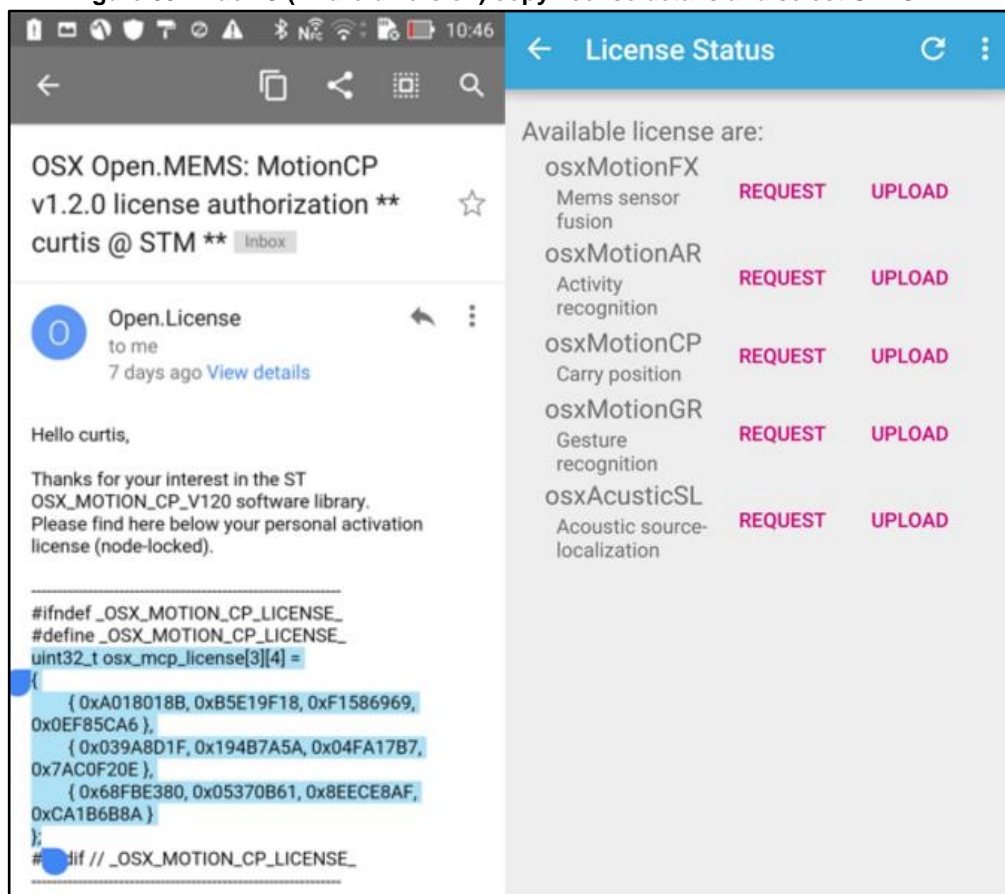
- 4 The following page is shown when the email has been sent.

Figure 54: BlueMS (Android version) send request email



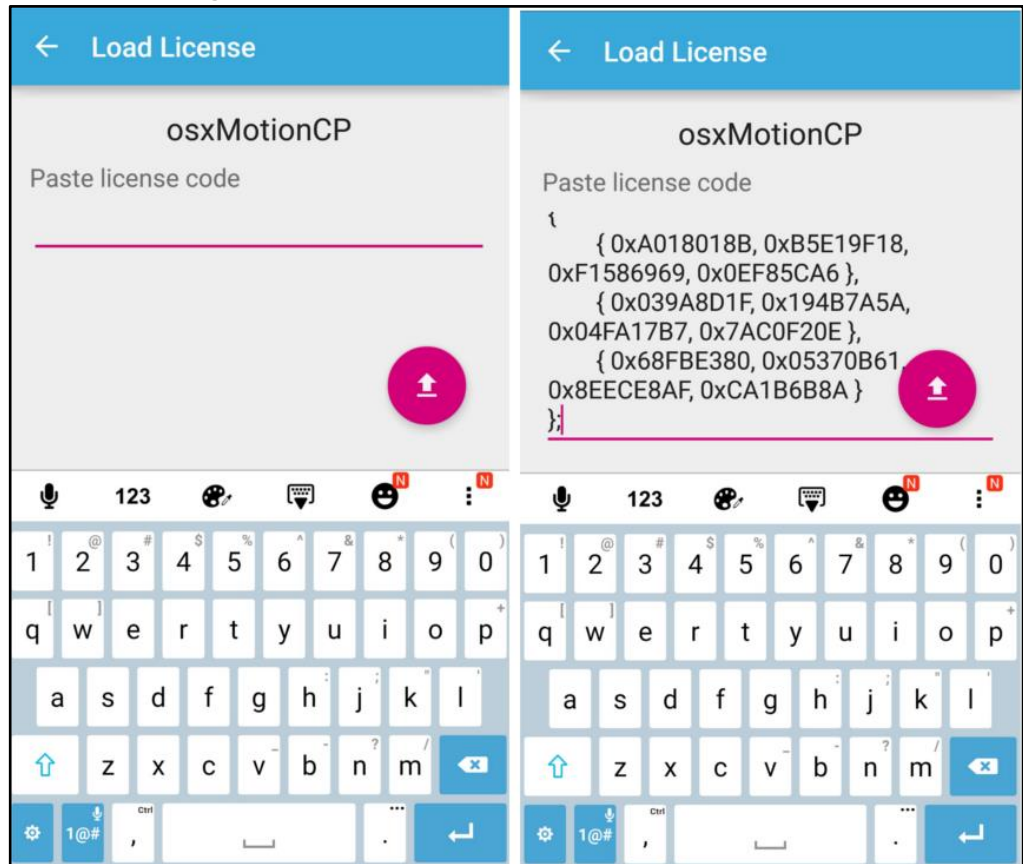
- 5 If you receive an email response with license details, select and copy the details shown below and press UPLOAD in the License Status page.

Figure 55: BlueMS (Android version) copy license details and select UPLOAD



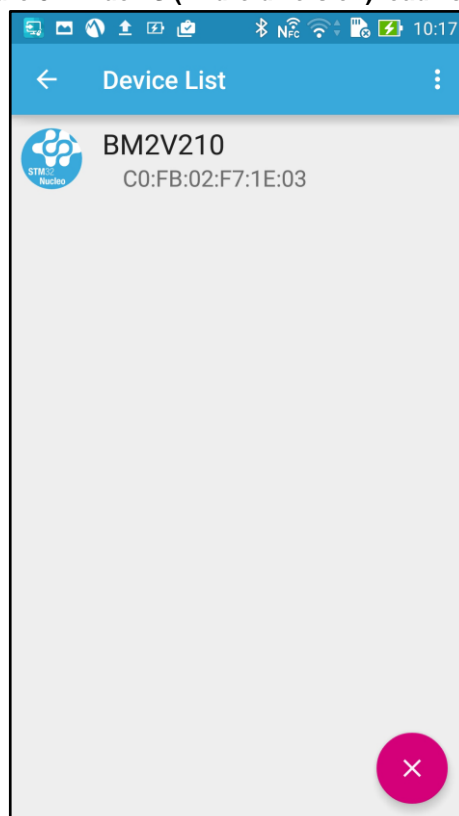
- 6 Paste the license code in the Load License page and click the red upload button.

Figure 56: BlueMS (Android version) paste license details



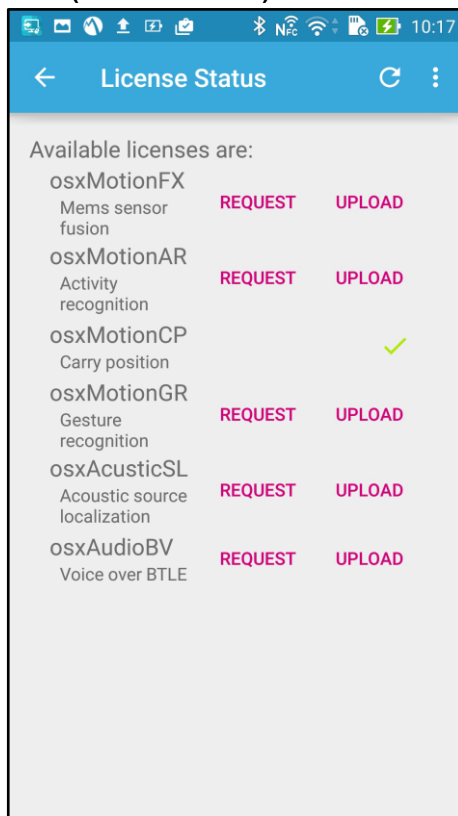
- 7 Once the correct license code is loaded, you can proceed to reconnect the board.

Figure 57: BlueMS (Android version) load license



- 8 A green tick mark indicates license acknowledgment.

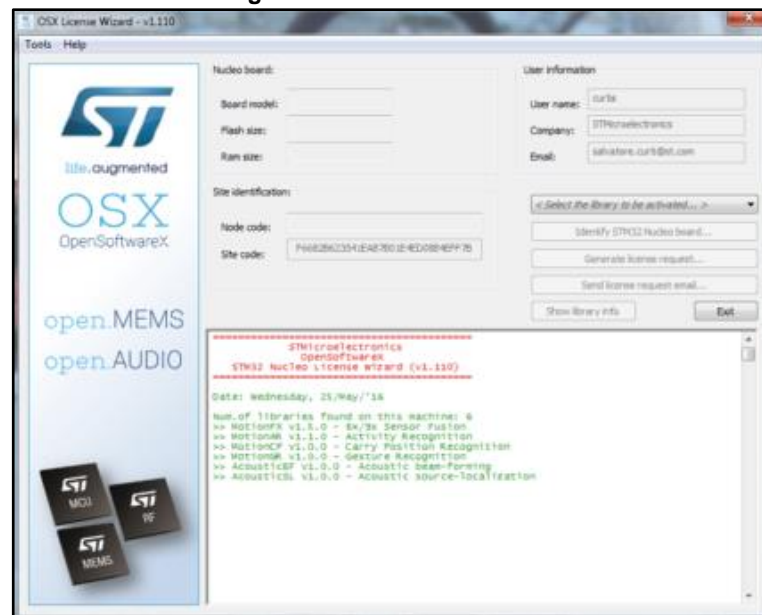
Figure 58: BlueMS (Android version) osxMotionCP license enabled



1.13.1 Open.MEMS and Open.Audio license activation with osxLicenseWizard

If `OSX_BMS_LICENSE_H_FILE` define in `Inc/osx_bms_config.h` is defined, the Open.MEMS and Open.Audio licenses must be requested and enabled through the OSX license wizard.

Figure 59: osxLicenseWizard

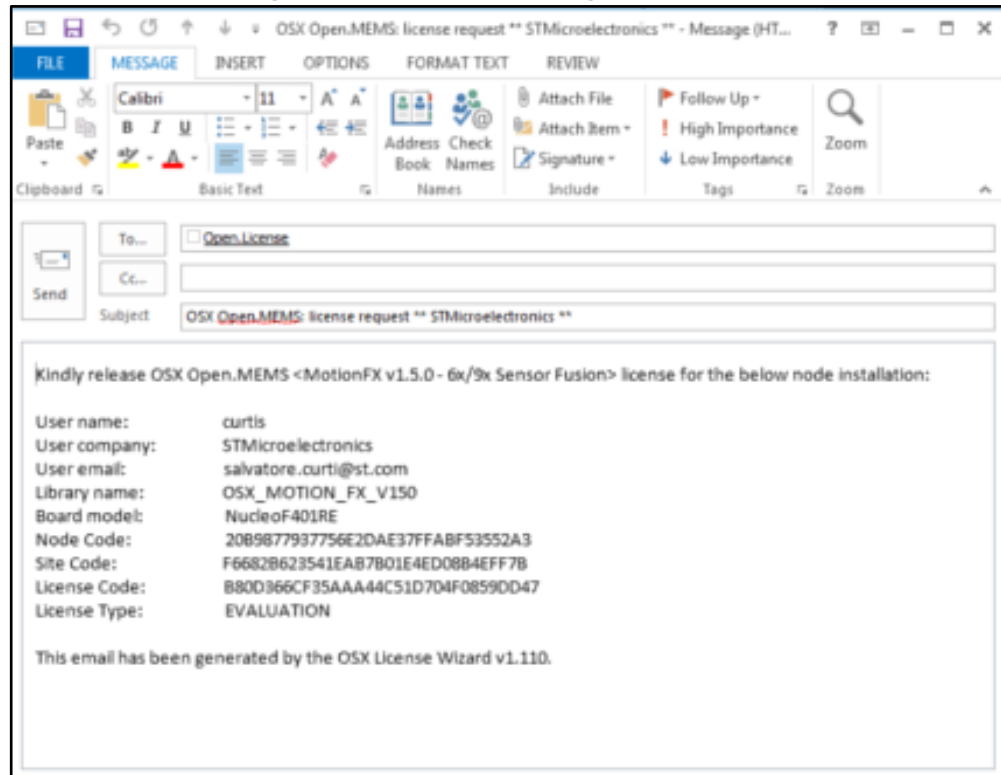


For each license:

- 1 Open osxLicenseWizard
- 2 Selected the library to be activated (osxMotionFX, osxMotionAR, osxMotionCP, osxMotionGR, osxAcousticSL or OSXBLUEVOICE)
- 3 Click 'identify STM32 Nucleo board...'
- 4 Click 'generate license request...' and accept the terms in the license agreement
- 5 Click 'send license request email...'

6 Send the email

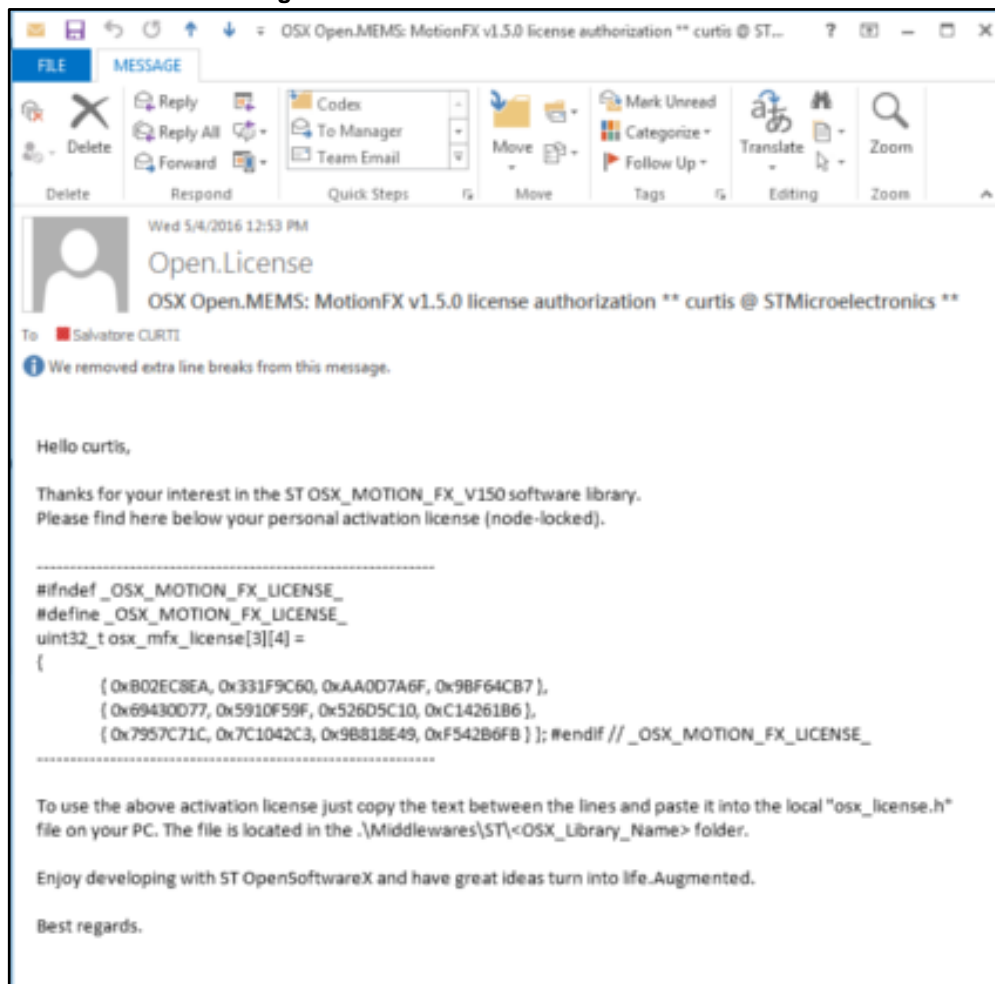
Figure 60: osxLicenseWizard generated email



- 7 Open the received email and place the license details in the respective `osx_license.h` files in the Middlewares directory.

For example, to enable the `osxMotionFX` license, place the code in `Middlewares\ST\STM32_OSX_MotionFX_Library\osx_license.h` file.

Figure 61: Received license activation email



- 8 You must then compile the BLUEMICROSYSTEM2 to enable any new licenses.

2 System setup guide

2.1 Hardware description

This section describes the hardware components needed for developing a sensors based application.

2.1.1 STM32 Nucleo platform

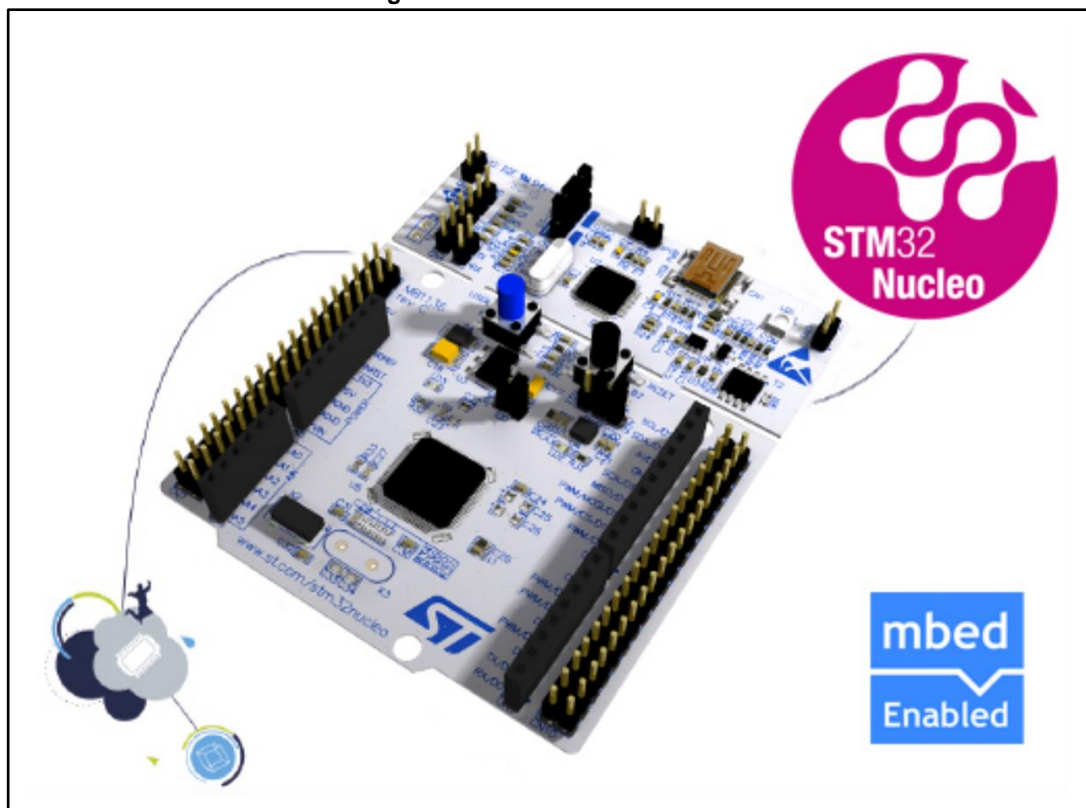
STM32 Nucleo development boards provide an affordable and flexible way for users to test solutions and build prototypes with any STM32 microcontroller line.

The Arduino™ connectivity support and ST morpho connectors make it easy to expand the functionality of the STM32 Nucleo open development platform with a wide range of specialized expansion boards to choose from.

The STM32 Nucleo board does not require separate probes as it integrates the ST-LINK/V2-1 debugger/programmer.

The STM32 Nucleo board comes with the comprehensive STM32 software HAL library together with various packaged software examples.

Figure 62: STM32 Nucleo board



Information regarding the STM32 Nucleo board is available at www.st.com/stm32nucleo

2.1.2 X-NUCLEO-CCA02M1 expansion board

The X-NUCLEO-CCA02M1 is an expansion board based on digital MEMS microphones. It is compatible with the morpho connector layout, and is designed around

STMicroelectronics' MP34DT01-M digital microphones. There are two microphones soldered onto board and it offers the possibility to plug in additional microphones using MP32DT01 (or MP34DT01-M) based coupon evaluation board STEVAL-MKI129V3 (or STEVAL-MKI155V3).

The X-NUCLEO-CCA02M1 allows the acquisition of up to two microphones using the I²S bus and up to four coupon microphones using I²S and SPI together. In addition, it offers a USB output for the STM32 Nucleo board. It represents a fast and easy solution for the development of microphone-based applications as well as a starting point for audio algorithm implementation.

Figure 63: X-NUCLEO-CCA02M1 expansion board

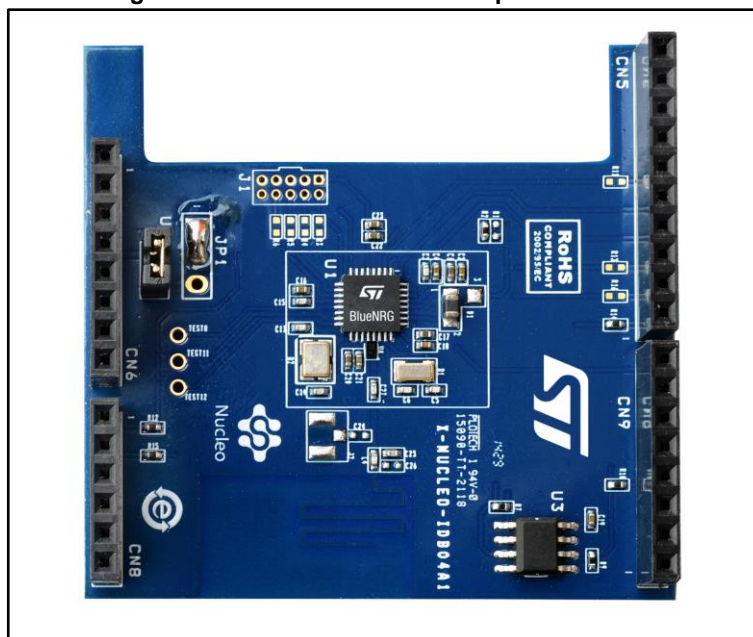


Information regarding the X-NUCLEO-CCA02M1 expansion board is available on [www.st.com](http://www.st.com/x-nucleo) at <http://www.st.com/x-nucleo>.

2.1.3 X-NUCLEO-IDB04A1 expansion board

The X-NUCLEO-IDB04A1 is a Bluetooth BlueNRG expansion board usable with the STM32 Nucleo system. The BlueNRG is a very low power Bluetooth low energy (BLE) single-mode network processor, compliant with Bluetooth specifications core 4.0.

Figure 64: X-NUCLEO-IDB04A1 expansion board

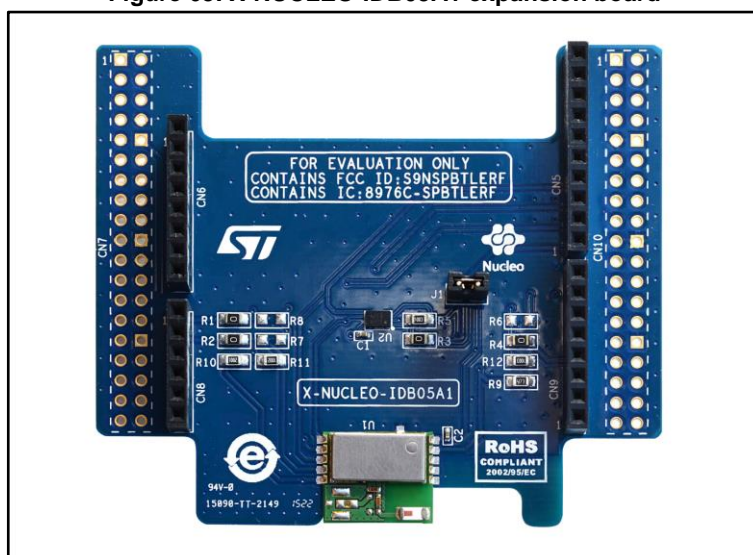


Information regarding the X-NUCLEO-IDB04A1 expansion board is available on www.st.com at <http://www.st.com/x-nucleo>.

2.1.4 X-NUCLEO-IDB05A1 expansion board

The X-NUCLEO-IDB05A1 is a Bluetooth low energy expansion board based on the SPBTLE-RF BlueNRG-MS RF module to allow expansion of the STM32 Nucleo boards. The SPBTLE-RF module is FCC (FCC ID: S9NSPBTLERF) and IC certified (IC: 8976C-SPBTLERF). The BlueNRG-MS is a very low power Bluetooth low energy (BLE) single-mode network processor, compliant with Bluetooth specification v4.2. X-NUCLEO-IDB05A1 is compatible with the ST morpho and Arduino™ UNO R3 connector layout. This expansion board can be plugged into the Arduino UNO R3 connectors of any STM32 Nucleo board.

Figure 65: X-NUCLEO-IDB05A1 expansion board



Information about the X-NUCLEO-IDB05A1 expansion board is available on www.st.com at <http://www.st.com/x-nucleo>

2.1.5 X-NUCLEO-IKS01A1 expansion board

The X-NUCLEO-IKS01A1 figured below is a sensor expansion board for use with the STM32 Nucleo board. It is also compatible with the Arduino UNO R3 connector layout, and is designed around the STMicroelectronics humidity (HTS221), pressure (LPS25HB) and motion sensors (LIS3MDL and LSM6DS0). The X-NUCLEO-IKS01A1 interfaces with the STM32 MCU via an I²C pin, and the user can change the default I²C address and the device IRQ by changing one resistor on the evaluation board.

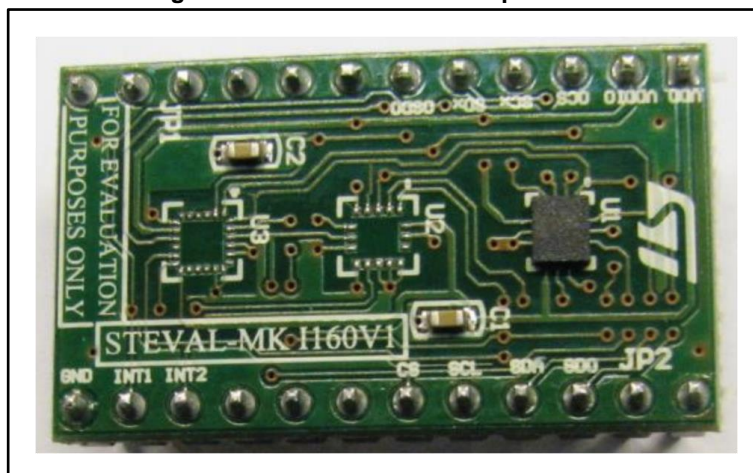
Figure 66: X-NUCLEO-IKS01A1 expansion board



Information about the X-NUCLEO-IKS01A1 expansion board is available on www.st.com at: <http://www.st.com/x-nucleo>.

The LSM6DS3 DIL24 adapter board in the figure below can be plugged on top of the X-NUCLEO-IKS01A1 expansion board.

Figure 67: LSM6DS3 DIL24 adapter board



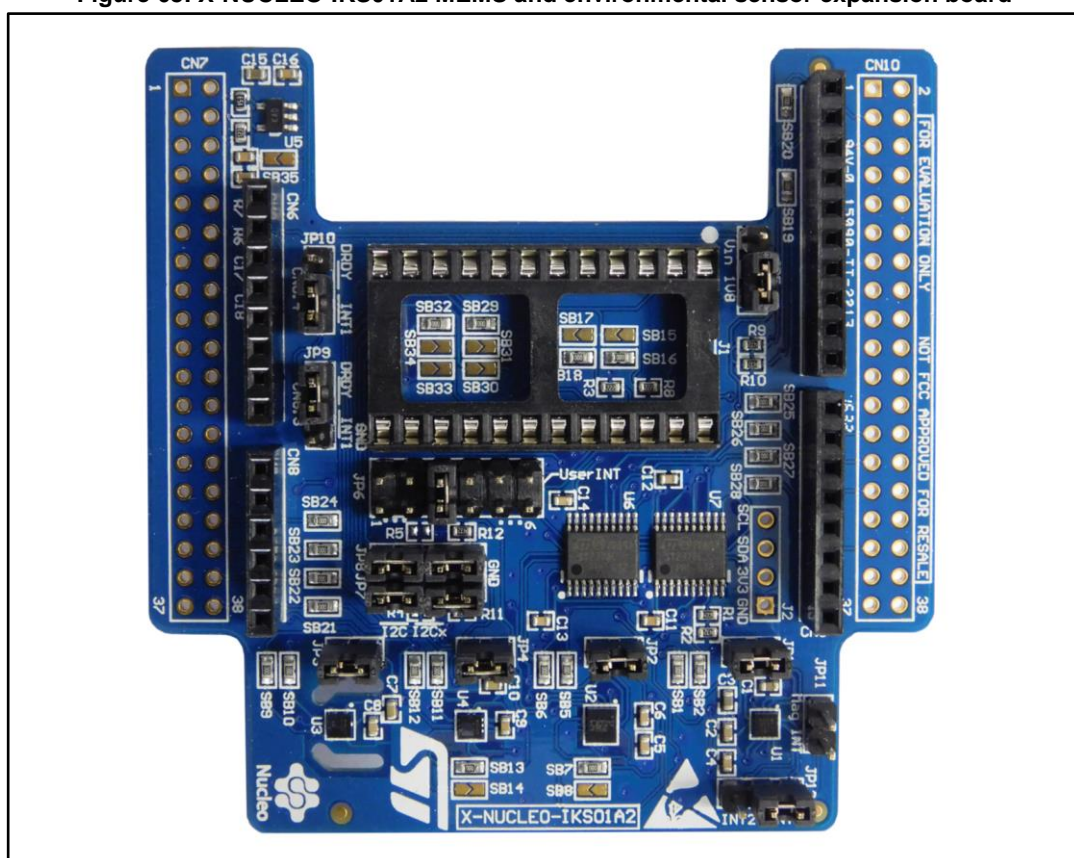
2.1.6 X-NUCLEO-IKS01A2 expansion board

The X-NUCLEO-IKS01A2 is a motion MEMS and environmental sensor expansion board for the STM32 Nucleo.

It is equipped with Arduino UNO R3 connector layout, and is designed around the LSM6DSL 3D accelerometer and 3D gyroscope, the LSM303AGR 3D accelerometer and 3D magnetometer, the HTS221 humidity and temperature sensor and the LPS22HB pressure sensor.

The X-NUCLEO-IKS01A2 interfaces with the STM32 microcontroller via the I²C pin, and it is possible to change the default I²C port.

Figure 68: X-NUCLEO-IKS01A2 MEMS and environmental sensor expansion board



2.1.7 STEVAL-STLKT01V1 SensorTile development kit

2.1.7.1 Description

The STEVAL-STLKT01V1 is a comprehensive development kit designed to support and expand the capabilities of the SensorTile and comes with a set of cradle boards enabling hardware scalability. The development kit simplifies prototyping, evaluation and development of innovative solutions. It is complemented with software, firmware libraries and tools, including a dedicated App.

The SensorTile is a tiny, square-shaped IoT module that packs powerful processing capabilities leveraging an 80 MHz STM32L476JGY microcontroller and Bluetooth low energy connectivity based on BlueNRG network processor as well as a wide spectrum of motion and environmental MEMS sensors, including a digital microphone.

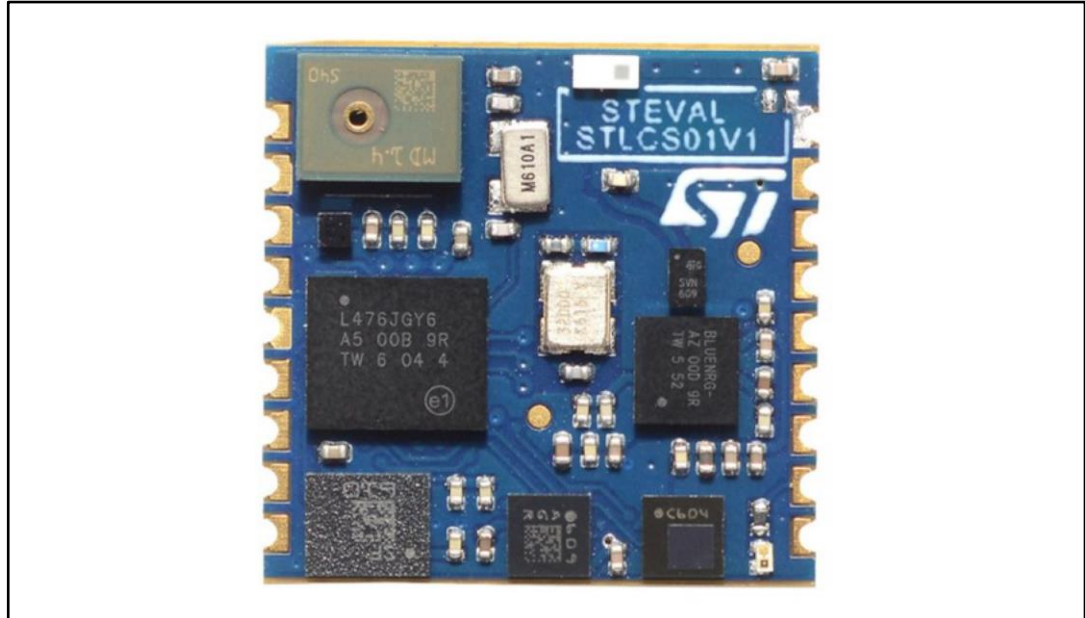
SensorTile can fit snugly in your IoT hub or sensor network node and become the core of your solution.

2.1.7.2 Features

- FCC (ID: S9NSTILE01) and IC (IC: 8976C-STILE01) certified
- Included in the development kit package:
 - SensorTile module
 - SensorTile expansion Cradle board equipped with audio DAC, USB port, STM32 Nucleo, Arduino UNO R3 and SWD connector
 - SensorTile Cradle with battery charger, humidity and temperature sensor, SD memory card slot, USB port and breakaway SWD connector
 - 100 mAh Li-Ion battery
 - Plastic box for housing the SensorTile cradle and the battery
 - SWD programming cable
- Software libraries and tools
 - STSW-STLKT01: SensorTile firmware package that supports sensors raw data streaming via USB, data logging on SDCard, audio acquisition and audio streaming. It includes low level drivers for all the on-board devices
 - BLUEMICROSYSTEM1 and BLUEMICROSYSTEM2: STM32Cube expansion software package, supporting different algorithms tailored to the on-board sensors
 - FP-SNS-ALLMEMS1 and FP-SNS-MOTENV1: STM32 ODE functional packs
 - ST BlueMS: iOS and Android demo Apps
 - BlueST-SDK: iOS and Android Software Development Kit
 - Compatible with STM32 ecosystem through STM32Cube support

2.1.7.3 Boards included in the kit

Figure 69: STLCS01V1 board photo



STLCS01V1 SensorTile component board features

- Very compact module for motion, audio and environmental sensing and Bluetooth low energy connectivity with a complete set of firmware examples

- Supported by the BLUEMICROSYSTEM1 and BLUEMICROSYSTEM2 software expansion package for STM32Cube and the STM32 ODE functional pack FP-SNS-ALLMEMS1
- Mobile connectivity via the ST BlueMS app, available for iOS and Android
- Main components:
 - STM32L476 – 32-bit ultra-low-power MCU with CortexM4F
 - LSM6DSM – iNEMO inertial module: 3D accelerometer and 3D gyroscope
 - LSM303AGR – Ultra-compact high-performance eCompass module: ultra-low power 3D accelerometer and 3D magnetometer
 - LPS22HB – MEMS nano pressure sensor: 260-1260 hPa absolute digital output barometer
 - MP34DT04 – 64dB SNR Digital MEMS Microphone
 - BlueNRG-MS – Bluetooth low energy network processor
 - BALF-NRG-01D3 – 50 Ω balun with integrated harmonic filter
 - LD39115J18R – 150 mA low quiescent current low noise LDO 1.8 V
 - 2 V-5.5 V power supply range
 - External interfaces: UART, SPI, SAI (Serial Audio Interface), I²C, DFSDM, USB OTG, ADC, GPIOs
- Pluggable or solderable interface
- SWD interface for debugging and programming capability

STLCS01V1 SensorTile component board description

STEVAL-STLCS01V1 (SensorTile) is a highly integrated reference design that can be plugged into form-factor prototypes and add sensing and connectivity capabilities to new designs through a smart hub solution. It can also easily support development of monitoring and tracking applications as standalone sensor node connected to iOS/Android smartphone applications.

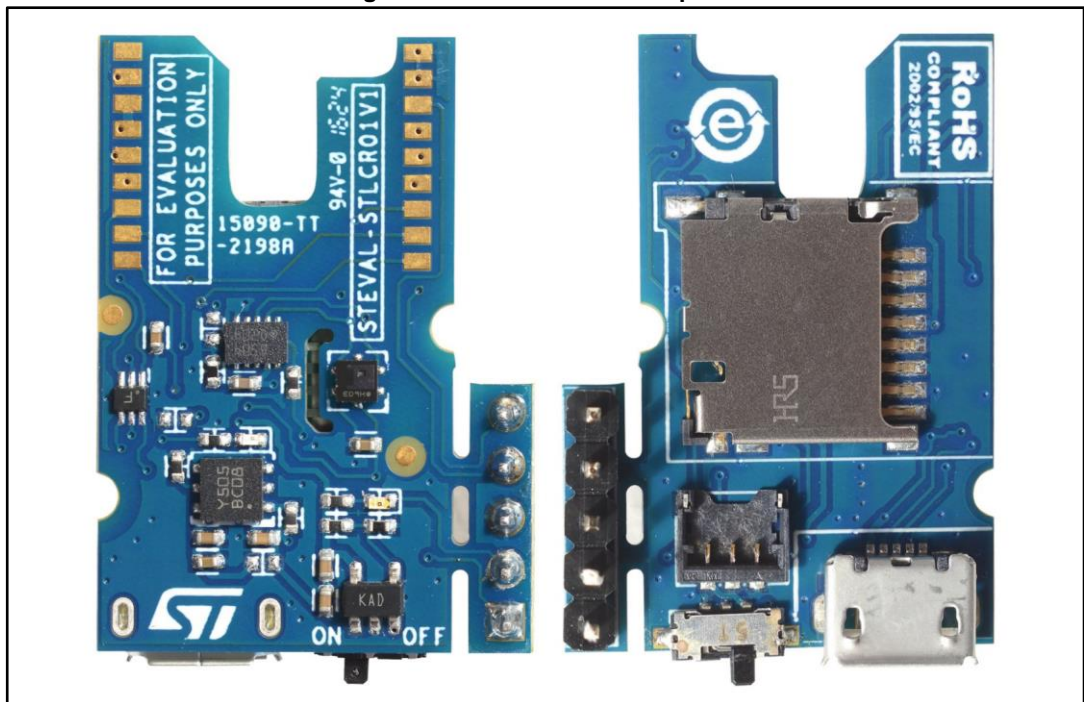
The SensorTile comes in a very small square shape 13.5 x 13.5 mm. All the electronic components are on the top side of the pcb, while the bottom side has a small connector through which it is possible to easily plug and unplug it from a motherboard. The connector pinout is also replicated on 18 pcb pads that render the SensorTile a solderable system on module as well.

The module comes with pre-loaded BLUEMICROSYSTEM2 software that initializes all the sensors and the Bluetooth low energy radio. The “ST BlueMS” app, available free of charge on Apple Store™ and Google Play™, is the easiest and fastest way to start using the SensorTile board and to experience a real activity monitoring system.

The SensorTile firmware package STSW-STLKT01, built on the STM32Cube software technology, includes all the low level drivers to manage the on-board devices and system-level interfaces. It has been designed in order to be easily extended and personalized as starting point for development and customization of new dedicated applications.

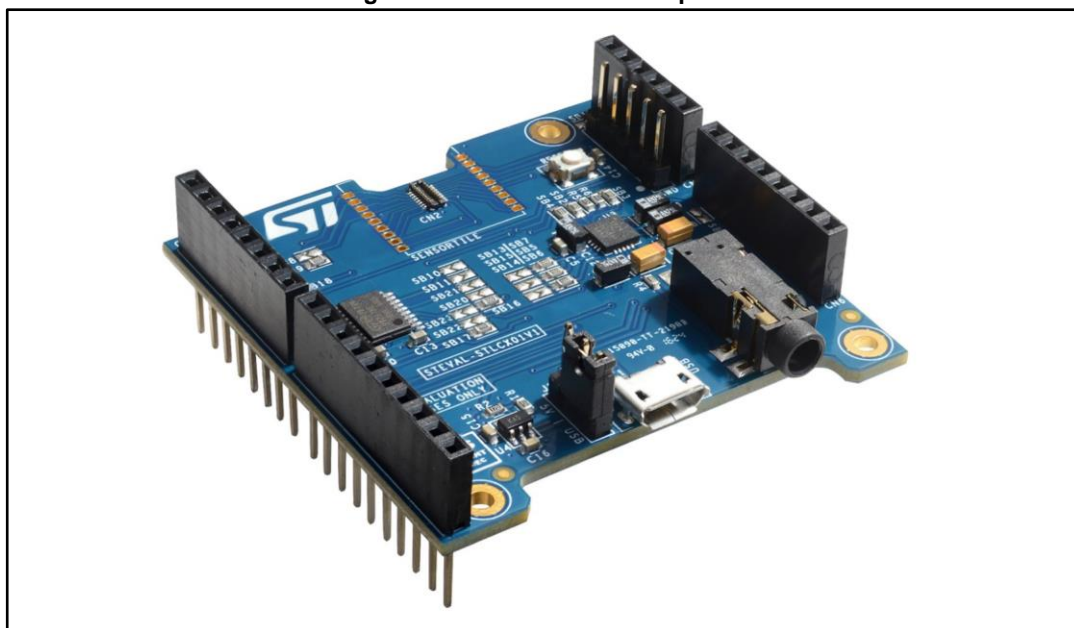
All the firmware packages are freely available on www.st.com.

Figure 70: STLCR01V1 board photo

**STLCR01V1 SensorTile component board features**

- Sensortile Cradle board with SensorTile footprint (solderable)
- STBC08PMR – 800 mA standalone linear Li-Ion battery charger
- HTS221 – capacitive digital sensor for relative humidity and temperature
- LDK120M-R – 200 mA low quiescent current very low noise LDO
- STC3115 – Fuel gauge IC
- USBLC6-2P6 – very low capacitance ESD protection
- USB type A to Mini-B USB connector for power supply and communication
- microSD card socket
- SWD connector for programming and debugging

Figure 71: STLCX01V1 board photo



STLCX01V1 SensorTile component board features

- Sensortile Cradle expansion board with SensorTile plug connector
- Compatible with STM32 Nucleo boards through Arduino UNO R3 connector
- LDK120M-R – 200 mA low quiescent current very low noise LDO
- ST2378ETTR – 8-bit dual supply 1.71 V to 5.5 V level translator
- USBLC6-2P6 – very low capacitance ESD protection
- 16-Bit, low-power stereo audio DAC
- Micro-USB connector for power supply and communication
- Reset button
- SWD connector for programming and debugging

2.2 Software description

The following software components are needed in order to set up a suitable development environment for creating applications with the STM32 Nucleo equipped with the sensors, microphones and Bluetooth low energy expansion boards and the STEVAL-STLKT01V1:

- BLUEMICROSYSTEM2: Bluetooth low energy and sensors software for STM32Cube. BLUEMICROSYSTEM2 firmware and related documentation is available on www.st.com.
- Development tool-chain and Compiler; the STM32Cube expansion software supports:
 - IAR Embedded Workbench for ARM® (EWARM) toolchain + ST-LINK
 - RealView Microcontroller Development Kit (MDK-ARM) toolchain + ST-LINK
 - System Workbench for STM32 + ST-LINK

2.3 Hardware and software setup

This section describes the hardware and software setup procedures. It also describes the system setup needed for the above.

2.3.1 Hardware setup

The following hardware components are needed:

- for STM32 Nucleo expansion boards:
 - One STM32 Nucleo development platform (order code: NUCLEO-F401RE or NUCLEO-L476RG)
 - One microphone expansion board (order code: X-NUCLEO-CCA02M1)
 - One sensor expansion board (order code: X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2)
 - One BlueNRG Bluetooth low energy expansion board (order code: X-NUCLEO-IDB04A1 or X-NUCLEO-IDB05A1)
 - One USB type A to Mini-B USB cable to connect the STM32 Nucleo to the PC
- for STEVAL-STLKT01V1:
 - STEVAL-STLKT01V1 development kit
 - ST-LINK/V2-1 debugger/programmer integrated on STM32 Nucleo board
 - One USB type A to Mini-B USB cable to connect the STM32 Nucleo to the PC
 - One USB type A to Micro-B USB cable to connect the STEVAL-STLKT01V1 to the PC

2.3.2 Software setup

This section lists the minimum requirements necessary to set up the SDK, run the sample testing scenario based on the GUI utility and customize applications.

2.3.2.1 Development tool-chains and compilers

Select one of the integrated development environments supported by the STM32Cube expansion software and follow the system requirements and setup information provided by the selected IDE provider.

2.3.3 System setup guide

This section describes how to setup different hardware parts before writing and executing an application:

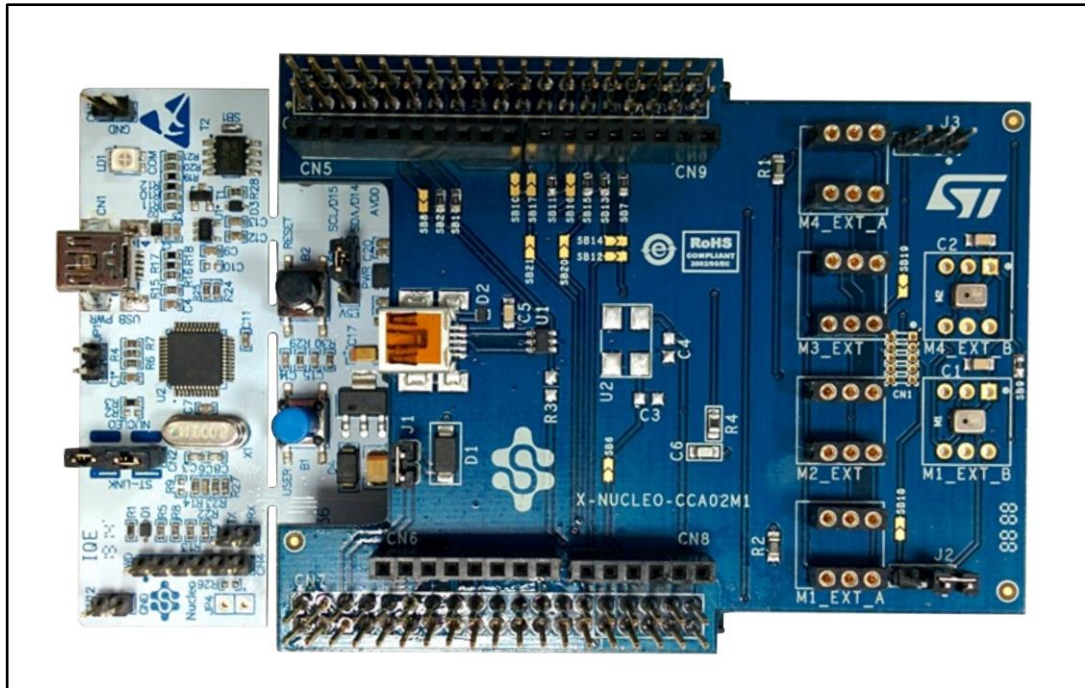
- on the STM32 Nucleo board with the expansion boards
- on STEVAL-STLKT01V1 development kit

2.3.3.1 STM32 Nucleo and expansion boards setup

The STM32 Nucleo board integrates the ST-LINK/V2-1 debugger/programmer. The developer can download the relevant version of the ST-LINK/V2-1 USB driver by searching STSW-LINK008 or STSW-LINK009 on www.st.com.

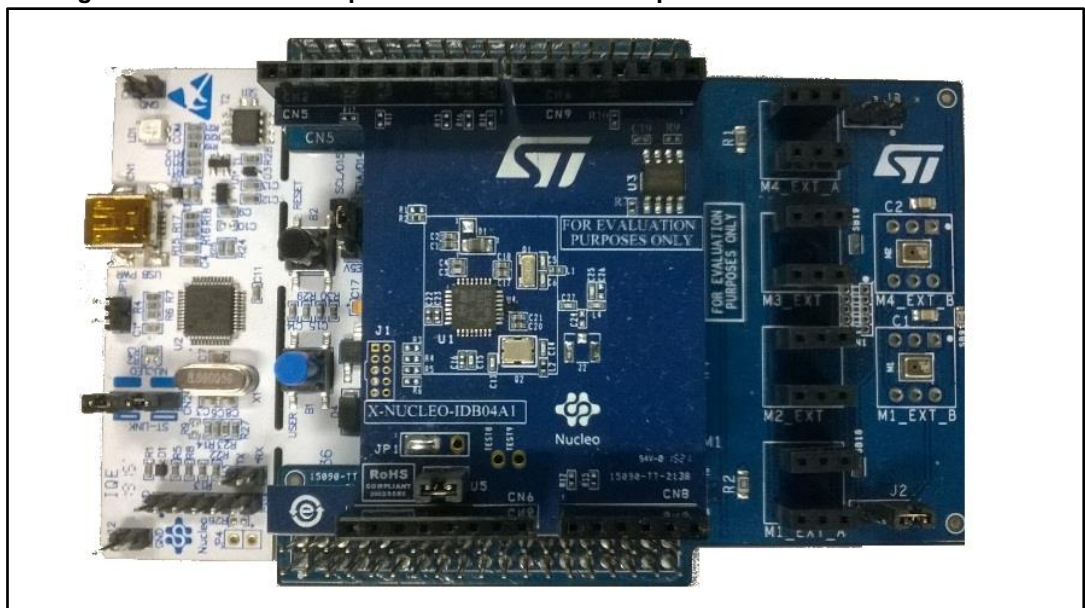
The X-NUCLEO-CCA02M1 sensor board is easily connected to the STM32 Nucleo board through the morpho connector, as shown below.

Figure 72: STM32 Nucleo plus X-NUCLEO-CCA02M1 boards



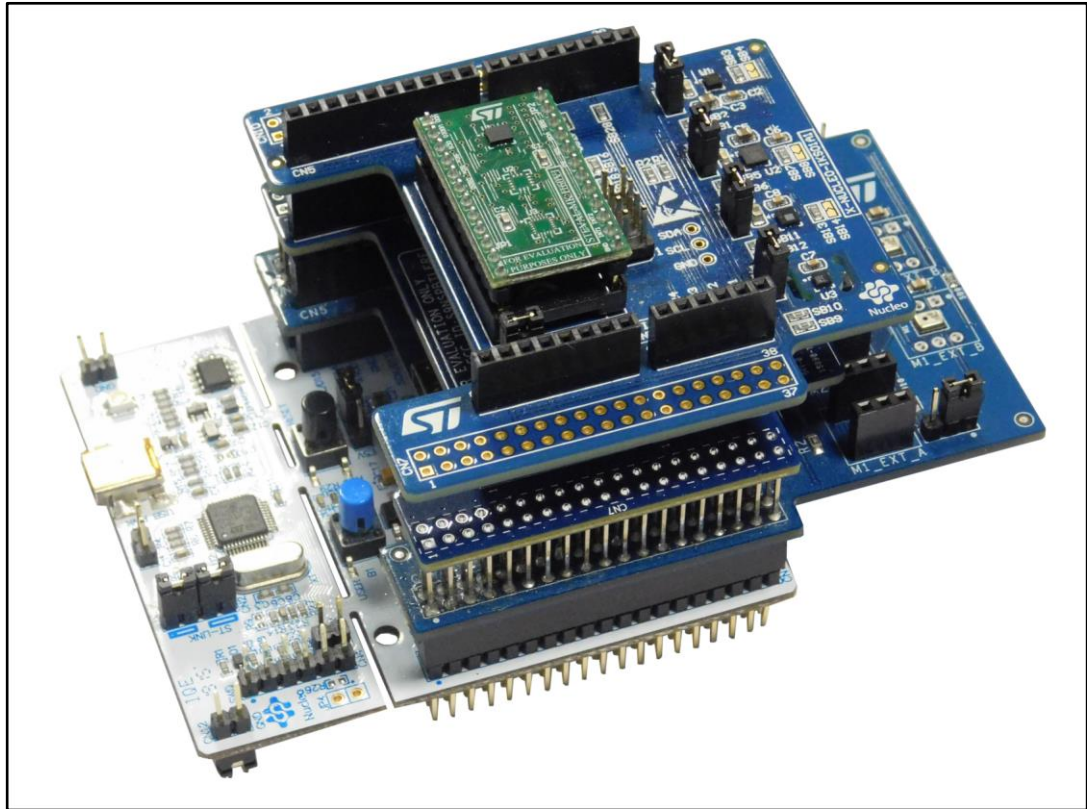
The X-NUCLEO-IDB04A1 or X-NUCLEO-IDB05A1 BlueNRG BLE expansion board is easily connected to the X-NUCLEO-CCA02M1 board through the Arduino UNO R3 extension connector, as shown below.

Figure 73: STM32 Nucleo plus X-NUCLEO-CCA02M1 plus X-NUCLEO-IDB04A1 boards



Finally, the X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2 sensors board is easily connected to the X-NUCLEO-IDB04A1 or X-NUCLEO-IDB05A1 expansion board through the Arduino UNO R3 extension connector, as shown below.

Figure 74: STM32 Nucleo plus X-NUCLEO-CCA02M1 plus X-NUCLEO-IDB04A1 plus X-NUCLEO-IKS01A1 plus LSM6DS3 DIL24 boards



The stacking sequence shown above is necessary to optimize the performance of the SPBTLE-RF module on the X-NUCLEO-IDB05A1 expansion board, and to reduce interference from its antenna

2.3.3.2 STEVAL-STLKT01V1 setup

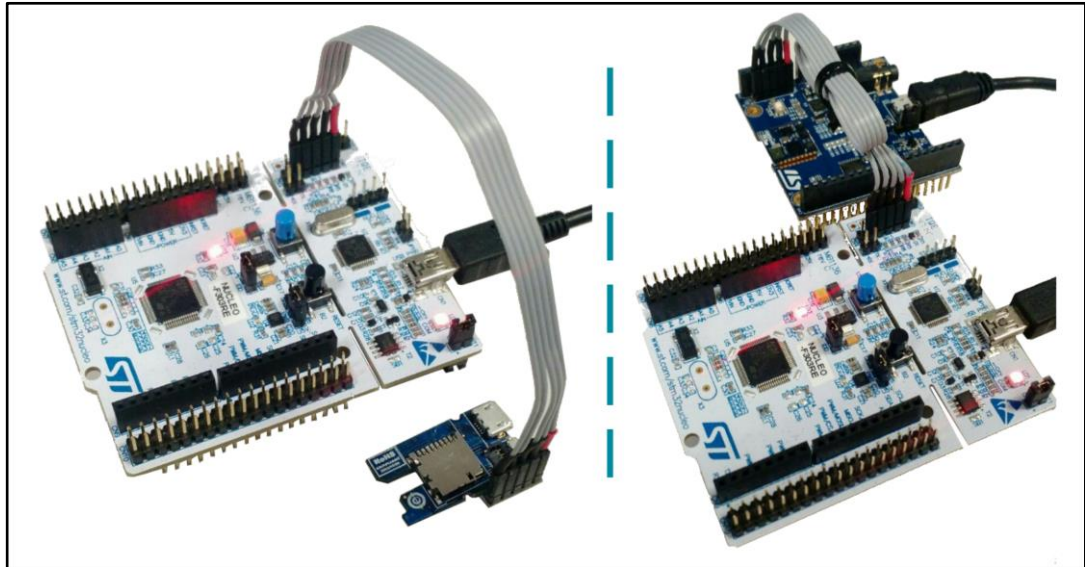
The ST-LINK/V2-1 debugger/programmer integrated on STM32 Nucleo board must be used to program the STEVAL-STLCS01V1 (SensorTile). The developer can download the relevant version of the ST-LINK/V2-1 USB driver by searching STSW-LINK008 or STSW-LINK009 on www.st.com.

Connect STEVAL-STLCS01V1 (SensorTile) on the STEVAL-STLCR01V SensorTile Cradle board or on the STEVAL-STLCX01V1 Sensortile Cradle Expansion board.

Use the SWD connector to connect the Sensortile Cradle board to ST-LINK/V2-1 debugger/programmer integrated on the STM32 Nucleo board for programming.

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).

Figure 75: SensorTile Cradle expansion board and Sensor Tile Cradle board connected to ST-LINK/V2-1

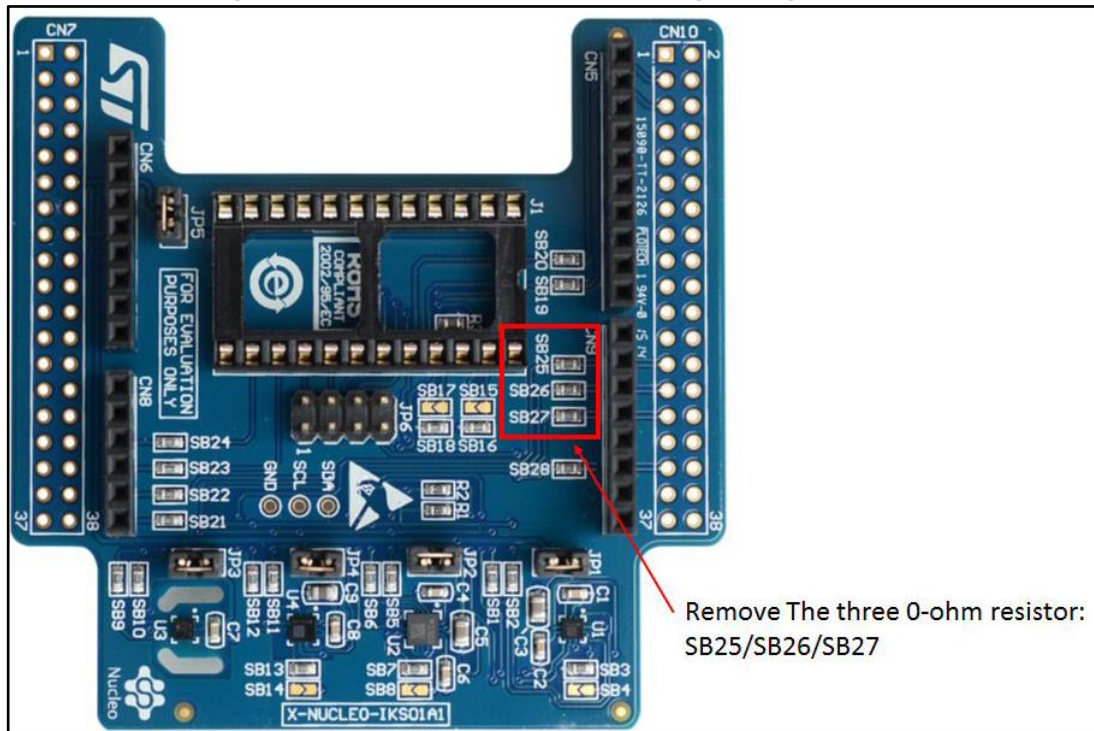


2.3.3.3 Important additional hardware information

For either STM32 Nucleo board: before connecting the X-NUCLEO-IKS01A1 board to the X-NUCLEO-CCA02M1 expansion board through the Arduino UNO R3 extension connector, remove these 0-Ω resistors on the X-NUCLEO-IKS01A1 board:

- SB25
- SB26
- SB27

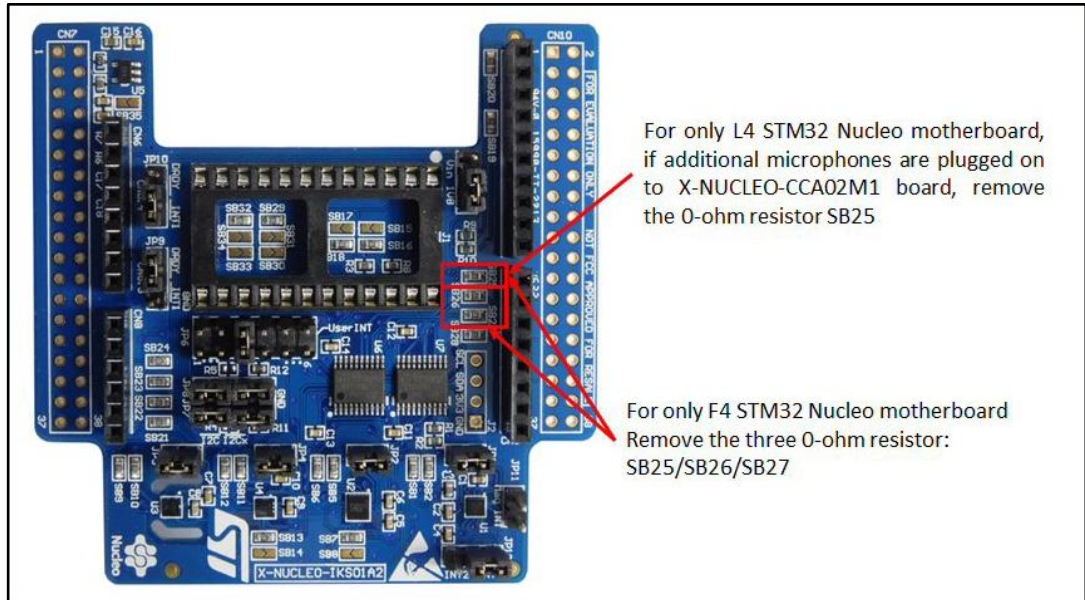
Figure 76: X-NUCLEO-IKS01A1 solder bridge configuration



Before connecting the X-NUCLEO-IKS01A2 to the X-NUCLEO-CCAM02M1 expansion board through the Arduino UNO R3 extension connector, remove these 0-Ω resistors on the X-NUCLEO-IKS01A2 board:

- for F4 STM32 Nucleo motherboard remove SB25, SB26 and SB27
- for L4 STM32 Nucleo motherboard remove SB25 if additional microphones are plugged on to X-NUCLEO-CCA02M1 board.

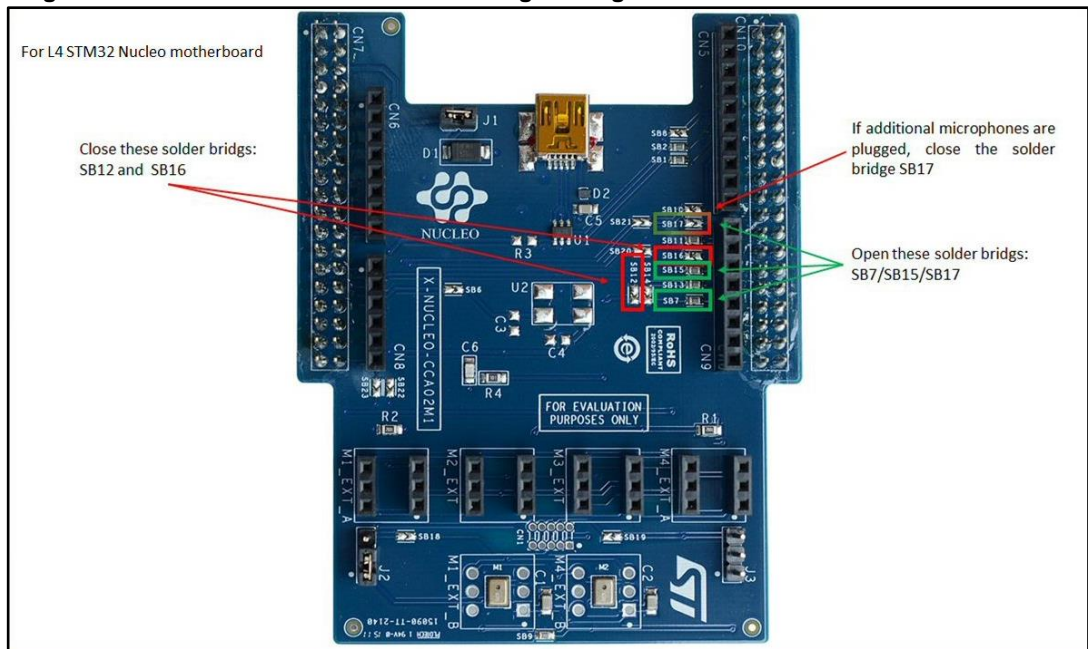
Figure 77: X-NUCLEO-IKS01A2 solder bridge configuration



For the NUCLEO-L476RG board only: before connecting the X-NUCLEO-CCA02M1 board to the STM32 Nucleo L4-series development board through the ST morpho connector layout, on the X-NUCLEO-CCA02M1 board:

- close the solder bridges SB12, SB16 and open the solder bridges SB7, SB15 and SB17
- if additional microphones are plugged, close the solder bridge SB17.

Figure 78: X-NUCLEO-CCA02M1 solder bridge configuration for the NUCLEO-L476RG board



3 Revision history

Table 1: Document revision history

Date	Version	Changes
12-Apr-2016	1	Initial release.
06-May-2016	2	Minor text edits
01-Jul-2016	3	Text and formatting changes throughout document Added STEVAL-STLKT01V1 board use details Added Section 1.3: "Flash management" Added Section 1.5: "The boot process" Added Section 1.6: "Firmware-Over-The-Air (FOTA) update" Added Section 1.9: "Open.MEMS and Open.Audio licenses" Added Section 1.11: "Firmware-Over-The-Air update with BlueMS" Added Section 1.12: "Open.MEMS and Open.Audio License activation" Added Section 2.1.6: "STEVAL-STLKT01V1 SensorTile development kit"
19-Oct-2016	4	Throughout document: - text and formatting changes - added new support information for: OSXBLUEVOICE software real-time voice communication over Bluetooth low energy, STEVAL-STLKT01V1 VCOM, Gas Gauge for STEVAL-STLKT01V1 Added Section 1.6: "Firmware update" Added Section 1.11.12: "Google speech ASR Key generation" Changed Section 1.12: "Firmware-over-the-air update with BlueMS"
10-Jan-2017	5	Throughout document: - minor text and image updates and enhancements - added X-NUCLEO-IKS01A2 support information - added e-Compass functionality information - replaced references to License Manager with Meta Data Manager Added Section 2.1.6: "X-NUCLEO-IKS01A2 expansion board"

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