BlueCoin, the Electronic Ear
Hands-on LABs using BlueMS mobile app

STMicroelectronics
ON YOUR PHONE/TABLET

- Install **ST BlueMS app** on your smartphone
- On Google Play or iOS App Store look for “ST BlueMS”

**ST BlueMS**
STMICROELECTRONICS INC
Version 3.8.0 (or newer)
• BlueCoin Overview
  • How to program the BlueCoin
  • Firmware and Software Overview

• BlueCoin Hands-on Using the ST BlueMS App
  • LAB1: Install the ST BlueMS app
  • DEMO: Firmware Over The Air Update
  • LAB2: Real-Time Data Plot and Log
  • LAB3: IBM Watson IoT
  • LAB4: Event Detection
  • LAB5: Voice over Bluetooth Low Energy
  • LAB6: IBM Watson Speech To Text
BlueCoin Starter Kit

- 130mAh LiPo Battery (UN38.3 Certified)
- ST-Link SWD Programming Cable
- STEVAL-BCNST01V1 CoinStation
- STEVAL-BCNCR01V1 Cradle
- STEVAL-BCNCS01V1 Core System
- Plastic Case
BlueCoin - The Robotic Ear

Core System: STEVAL-BCNCS01V1

- **LSM303AGR**
  - 3DAcc+3DMag
  - 200µA @ 20 Hz (HR mode)
  - Accel/Mag independent power down mode

- **LPS22HB**
  - Barometer
  - 1-75Hz, 3-12µA @ 1Hz

- **STM32F446**
  - Cortex-M4
  - up to 180MHz

- **4x MP34DT04-C1**
  - Digital MEMS Microphones
  - 64dB SNR, 120dBSPL

- **LSM6DSM**
  - 3DAcc+3DGyro
  - 0.65mA @ 1.6kHz
  - 9µA @ 12.5Hz

- **STBC03J**
  - Li-Ion linear battery charger with LDO

- **BALF-NRG-01D3**
  - Balun Filter

- **BlueNRG-MS**
  - Bluetooth low-energy
  - Concurrent master/slave BT4.1

- **8 LEDs**

- **25 mm**
BlueCoin Platform – Hardware overview

BlueCoin Block Diagram

- **Vin (4.5-5.5V)**
- **STBC03J**
  - Batt charger
  - With 3V LDO
- **Vsys VDD 3V**
- **VBat**

**STM32F446**
- Cortex-M4F
- 180MHz
- 512KB Flash/128KB RAM

- **4x MP34DT04-C1**
  - MEMS microphones

- **2.048 MHz PDM**
- **16MHz**

- **I2C**
  - 400 KHz

- **SPI 4-wire**
  - 5 MHz

- **NRST SWVD**
- **SPI I2S UART I2C PDM SDIO**

- **CSM303AG**
  - acc+mag

- **LPS22HB**
  - barometer

- **Integrated antenna**

- **BALF-NRG-01D3**
  - Integrated balun

- **BlueNRG-MS**
  - Bluetooth 4.1
  - 32MHz
BlueCoin CoinStation

CoinStation: STEVAL-BCNST01V1

- Battery Connector
- BlueCoin Connectors
- Expansion Connector
- Stereo Audio DAC and 3.5mm Jack
- SWD Connector
- USBLC6-2P6
  - ESD protection for USB
- 2x VL53L0X
  - Time-of-Flight ranging sensors
- LDK120M
  - 2.8V LDO
BlueCoin Cradle: STEVAL-BCNCR01V1

- **TOP VIEW**
  - BlueCoin Connectors
  - ST1S12XX
  - Battery Connector

- **BOTTOM VIEW**
  - Micro SD Card
  - Micro USB
How to assemble the portable demo

1. **Plug the battery on the Cradle**
2. **Fold the Battery below the cradle, insert in the plastic case and secure with the bolts**
3. **Plug the BlueCoin and secure with the bolts**

**Warning:** Connectors are SMD mounted and VERY delicate
How to program the BlueCoin
Jump Start Your Project

Plug the BlueCoin to its Cradle

Connect with your development environment

Compile & Run the your application

Field test your application

STLINK-V2 in Every Nucleo

Note: The preloaded firmware on BlueCoin Kit is the FP-AUD-SMARTMIC1
How to Flash the BlueCoin

1. Remove two jumpers on CN2 of the Nucleo board
2. Plug the 5-pin cable to the SWD connectors (pin1 is square, highlight in red below)
3. Plug the USB cable of the cradle (if there is a switch: turn it ON) to power the target STM32F446
4. Plug the USB cable of the Nucleo board to power the ST-Link/V2
5. Drag and drop the *_BL.bin on the virtual device (or flash the .bin/.hex using STM32CubeProgrammer)
How to Flash the BlueCoin

1. Remove two jumpers on CN2 of the Nucleo board
2. Plug the 5-pin cable to the SWD connectors (pin1 is square, highlight in red below)
3. Plug the USB cable of the cradle (if there is a switch: turn it ON) to power the target STM32L4
4. Plug the USB cable of the Nucleo board to power the ST-Link/V2
5. Drag and drop the *_BL.bin on the virtual device (or flash the .bin/.hex using STM32CubeProgrammer)

Use ALLMEMS1_BC_BL.bin
(from FP-SNS-ALLMEMS1)
Firmware and Software Overview
## Technical Documentation

### Product Specifications

<table>
<thead>
<tr>
<th>Description</th>
<th>Version</th>
<th>Size</th>
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<tbody>
<tr>
<td>D83258 BlueCoin Starter kit</td>
<td>3.0</td>
<td>474 KB</td>
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### User Manuals

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<tr>
<th>Description</th>
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<tr>
<td>UM2240: Getting started with the STEVAL-BCNKT01V1 BlueCoin kit augmented acoustics and motion sensing development platform</td>
<td>1.0</td>
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### Presentations & Training Material

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>STEVAL-BCNKT01V1 Quick start guide</td>
<td>1.0</td>
<td>1 MB</td>
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</table>
# Hardware Resources

## 3D CAD and Gerbers

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>STEVAL-BQNKT01V1 3D cad files</td>
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## BOM

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## Schematics

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<th>Description</th>
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<tr>
<td>STEVAL-BQNKT01V1 schematics</td>
<td>1.0</td>
<td>553 KB</td>
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## Legal

<table>
<thead>
<tr>
<th>Description</th>
<th>Version</th>
<th>Size</th>
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<tbody>
<tr>
<td>Evaluation products license agreement</td>
<td>1.4</td>
<td>128 KB</td>
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</tbody>
</table>
## Tools and Software

### Firmware packages

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Manufacturer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSW-BCHNT01</td>
<td>ST</td>
<td>Embedded software samples for BlueCoin data streaming via USB and BLE, logging on SD card, gesture recognition, audio acquisition and playback</td>
</tr>
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</table>

### MCUs Embedded Software

<table>
<thead>
<tr>
<th>Part Number</th>
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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP-AUD-BLINK1</td>
<td>ST</td>
<td>STM32 ODE function pack for half-duplex voice streaming over Bluetooth low energy</td>
</tr>
<tr>
<td>FP-AUD-SMARTMIC1</td>
<td>ST</td>
<td>STM32 ODE function pack for MEMS microphone acquisition, advanced audio processing and audio output</td>
</tr>
<tr>
<td>FP-SNS-ALLMEMS1</td>
<td>ST</td>
<td>STM32 ODE function pack for IoT node with BLE connectivity, digital microphone, environmental and motion sensors</td>
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</table>

### Wireless Connectivity Software

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<tr>
<th>Part Number</th>
<th>Manufacturer</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>BlueMS</td>
<td>ST</td>
<td>BlueMS Application for Android and iOS</td>
</tr>
<tr>
<td>BlueST-SDK</td>
<td>ST</td>
<td>Bluetooth Low Energy and Sensors Technology Software Development Kit (SDK)</td>
</tr>
</tbody>
</table>

[www.st.com/bluecoin](http://www.st.com/bluecoin)
Hardware, Software, Documentation

**HARDWARE**
- **STEVAL-BCNKT01V1** BlueCoin kit

**FIRMWARE**
- **STSW-BCNKT01** FW for beginners (bin + src code)
- **FP-SNS-ALLMEMS1** recommended FW (bin + src code)
  - IoT node with BLE connectivity, digital microphone, environmental and motion sensors
- **FP-AUD_BCLINK1** (bin + src code)
  - Half Duplex Voice Streaming over BLE
- **FP-AUD_SMARTMIC1** (bin + src code)
  - MEMS Microphone acquisition, advanced audio processing and audio output

**APPS**
- **ST BlueMS** iOS/Android app (bin)
- **BlueST-SDK** iOS/Android app dev kit (src code)

**DOCUMENTATION**
- **UM2240** getting started with BlueCoin kit
- **UM2249** getting started with STSW-BCNKT01
- **UM2059** getting started with FP-SNS-ALLMEMS1
- **UM2196**: Getting started with the FP-AUD-BVLINK1 STM32 ODE function pack based on half-duplex voice streaming over BLE
- **UM2219**: Getting started with STM32 ODE function pack for MEMS microphones acquisition, advanced audio processing and audio output
- **UM1997** getting started with ST BlueMS app
FP-SNS-ALLMEMS1
Folder Structure

CMSIS = Cortex Microcontroller Software Interface Standard
- DSP library collection (fixed / float)

HAL = Hardware Abstraction Layer
- STM32 specific hardware drivers

BSP = Board Support Package
- Components (typ. MEMS sensors)
- Boards (BlueCoin, SensorTile, Nucleo, Nucleo-expansion)

Main.c is in Applications\...\Src\n
- MDK-ARM Keil project files
- EWARM IAR project files
- SW4STM32 SystemWorkbench
Software Library Licensing

• The software libraries are distributed as binaries, with example source code on how to use them.

• A free license agreement is granted.

• The Libraries can run on any STM32 microcontroller, with a generic STM32 MCU locking.
## SW Libraries in Function Packages

**STM32ODE software package**

<table>
<thead>
<tr>
<th>Open Development Environment – src code</th>
<th>Software Libraries</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>FP-SNS-ALLMEMS1</strong> BLE + MEMS + digital microphone</td>
<td>MotionFX, MotionAR, MotionCP, MotionGR, AcousticSL, AcousticBF, BlueVoice</td>
</tr>
<tr>
<td>• <strong>FP-AUD-BVLINK1</strong> BLE + digital microphone</td>
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Audio libraries are distributed as binaries, with example source code on how to use them. A free license is granted. They can run on every STM32 microcontroller.

This library is included in the FP-AUD-BVLINK1 and in the FP-SNS-ALLMEMS1 software package.

- **BlueVoice** (in FP-AUD-BVLINK1) voice streaming over BLE (needs 1 digital microphone, 8kHz PCM, ADPCM compression)
- AcousticBF (in X-CUBE-MEMSMIC1) beam-forming (needs 2 digital mic, cardioid or narrow cardioid, denoise optional filter)
- AcousticSL (in X-CUBE-MEMSMIC1) sound source localization (needs 2/4 mic for 180/360 deg range, three DOA algo)
- AcousticEC (in FP-AUD-SMARTMIC1) echo cancellation (adaptive filter to subtract noise-ref signal, SPEEX MDF algo)
Audio libraries are distributed as **binaries**, with example source code on how to use them. A **free license** is granted. They can run on every STM32 microcontroller.

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**Beam pattern**
- Blue: omnidirectional microphone
- Red: «Basic cardioid» mode
- Green: «Strong» mode

**2 mic 180deg, 4 mic 360 deg**
BlueCoin Hands-on
Using the ST BlueMS App
Launch the ST BlueMS app (V3.8.0 or newer) previously installed
Press PWR for 1s
And wait for the 8 LED to start blinking

Touch “Start discovering”

The name is “CoinXXX”
(look at the label on the box)

Select your BlueCoin

You are connected

NOTE: 2nd line is the MAC address of the specific sample
LAB1: BlueMS App

View the BlueCoin Environmental sensor real-time data

**LAB**: temperature

Try to blow some hot air on the BlueCoin to see temperature changes

- Temperature measured using:
  - Internal Temperature sensor of pressure sensor (±1.5°C deg accuracy)
LAB1: BlueMS App

**LAB:** pressure sensor

Try to move the BlueCoin up/down by 20-30cm (7-12in),

wait a few seconds and observe the change in the barometer reading (mbar).
DEMO: Firmware Update Over-the-air

Select “Download & Flash”

Enable and Select the repository
BlueCoin will confirm the integrity of the selected firmware binary before overwriting the current Flash memory image.

- **Bootloader at** 0x 0800 0000
- **Current application at** 0x 0800 4000
- **New application at** 0x 0804 0000

**Select the firmware binary image**

**Uploading and Flashing**

**Confirmation!**

Flash Completed in: 203.17s
The board is resetting
MEMORY ORGANIZATION

• By default, all BlueCoin FW applications use a bootloader that resides in the first part of the flash memory of the STM32.

• For this reason the memory is organized into 3 different regions

• The **bootloader** manages the installation of On-The-Air upgrades, if any.

• Otherwise it jumps to the application
DEM0: Firmware Update Over-the-air

FP-SNS-ALLMEMS1 software package: Binary folder contains two binaries

Bootloader + App, flash at 0x0800 0000
- ALLMEMS1_BC_BL.bin
- ALLMEMS1_BC_BL.hex

Application, flash at 0x0800 4000
- ALLMEMS1_BC.bin
- ALLMEMS1_BC.hex

Use this for FOTA!
LAB2: Real-time Data Plot

Swipe left to view the real-time data plot

Select the sensor device to plot

Select the Plot length

View the real-time data plot

1. Select the sensor device to plot
2. Select the time scale

Swipe left for more
LAB2: Real-time Data Log

Start Streaming

Start logging

Stop logging

Send log data using email

[Images of LiDAR data graphs and email interface for sending log data]
LAB2: Real-time Data Plot
Effects of Magnetic Interference

Swipe left to view the real-time data plot

Select the magnetometer

Select the time frame

Magnetic field plot

Swipe left for more
LAB2: Real-time Data Plot

Effects of Magnetic Interference

LAB

Move the smartphone over the BlueCoin

The magnetic field measured by the sensor has changed because of the magnetic field induced by the smartphone (speakers, antennas, battery, currents)
LAB3: IBM Watson IoT Quickstart
Post BlueCoin Sensor Data on IBM Watson

Select “IBMQuickstart”

Click “Connect”

Select a feature

Wait a few seconds

NOTE: MAC address is used is Device Id (see slide 29)

Tap to View Data in the Cloud”
LAB3: IBM Watson IoT Quickstart

Post BlueCoin Sensor Data on IBM Watson

Quickstart will appear

You will see the Plot of selected feature

Table of available features

Scroll down to change sensor data or axes

IBM Watson IoT Registered Mode

Organization ID and Authentication Token needed
LAB4: Event Detection

- Smart embedded functions: pedometer, step detector and step counter, significant motion and tilt
- Standard interrupts: free-fall, wakeup, 6D/4D orientation, click and double-click

INEMO inertial module: always-on 3D accelerometer and 3D gyroscope

Description

The LSM6DSM is a system-in-package featuring a 3D digital accelerometer and a 3D digital gyroscope, performing at 0.65 m/s² in high-performance mode and enabling always-on low-power features for an optimal motion experience for the consumer.

The LSM6DSM supports main OS requirements, offering real, virtual and batch sensors with 4 kbyte for dynamic data buffering.

ST's family of MEMS sensor modules leverages the robust and mature manufacturing processes already used for the production of micro-machined accelerometers and gyroscopes.

The various sensing elements are manufactured using specialized micro-machining processes, while the IC interfaces are developed using CMOS technology that allows the design of a dedicated circuit which is trimmed to better match the characteristics of the sensing element.

The LSM6DSM has a full-scale acceleration range of ±2 g/4 g/8 g and an angular rate range of ±100°/200°/400°/2000°/2000° dps.

The LSM6DSM fully supports EIS and OIS applications as the module includes a dedicated configurable signal processing path for OIS and auxiliary SPI configurable for both the gyroscope and accelerometer.

High robustness to mechanical shock makes the LSM6DSM the preferred choice of system designers for the creation and manufacturing of reliable products.

The LSM6DSM is available in a retail ready roll-to-use and eco-packaged.
Select “more”
Select “Acc Event”

Change orientation

Touch “Event Enabled”

Select another event
LAB4: Event Detection

The MEMS sensor hardware performs event detection recognition using a programmable interrupt logic block.
LAB4: Event Detection

The MEMS sensor hardware performs event detection recognition using a programmable interrupt logic block.

Select another event

Wake Up

LAB

Shake the device, the acceleration will trigger an interrupt to wake up the MCU (in the meanwhile captured data can be saved to internal FIFO).
LAB4: Event Detection

The MEMS sensor hardware performs event detection recognition using a programmable interrupt logic block.

Single Tap

Tap the device. What happens for the double tap?
LAB4: Event Detection

The MEMS sensor hardware performs event detection recognition using a programmable interrupt logic block.

Select another event

LAB

Double Tap

Double tap the device. What happens now for the single tap?
LAB5: Voice over Bluetooth LE

BlueVoice
(voice over Bluetooth LE)

Select “more”
Select “BlueVoice”

Speak to device, hear on phone

LAB

Speak into the BlueCoin mic and listen to your phone
(if the mic captures the audio from the phone speaker, a very high pitch sound can happen!)

Do not silence your phone, must not be vibration only!
BlueVoice
(voice over Bluetooth LE)

LAB6: SpeechToText

Select ASR Engine

IBM Watson

Add credentials

Start/Stop recognition and speak

Alternatively Use WebSocket

- Double Tap on BlueCoin
- Or Tap on Screen

BlueVoice (voice over Bluetooth LE)
ST stands for life.augmented