

BlueCoin, the Robotic Ear

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IoT Marketing Manager

STMicroelectronics



think

March 19-22, 2018
Las Vegas, NV

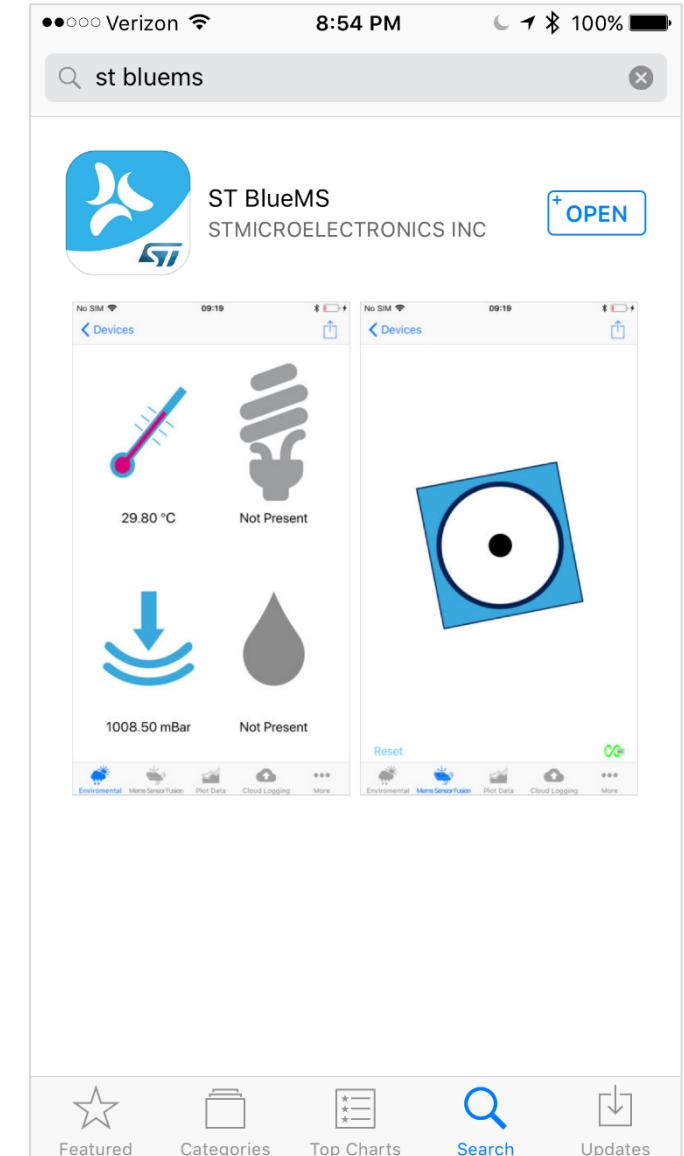
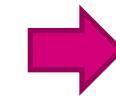
Session: 4104
Title: Beam Me Up, Watson!

LAB Preparation

2



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

Agenda

3

www.st.com/bluecoin

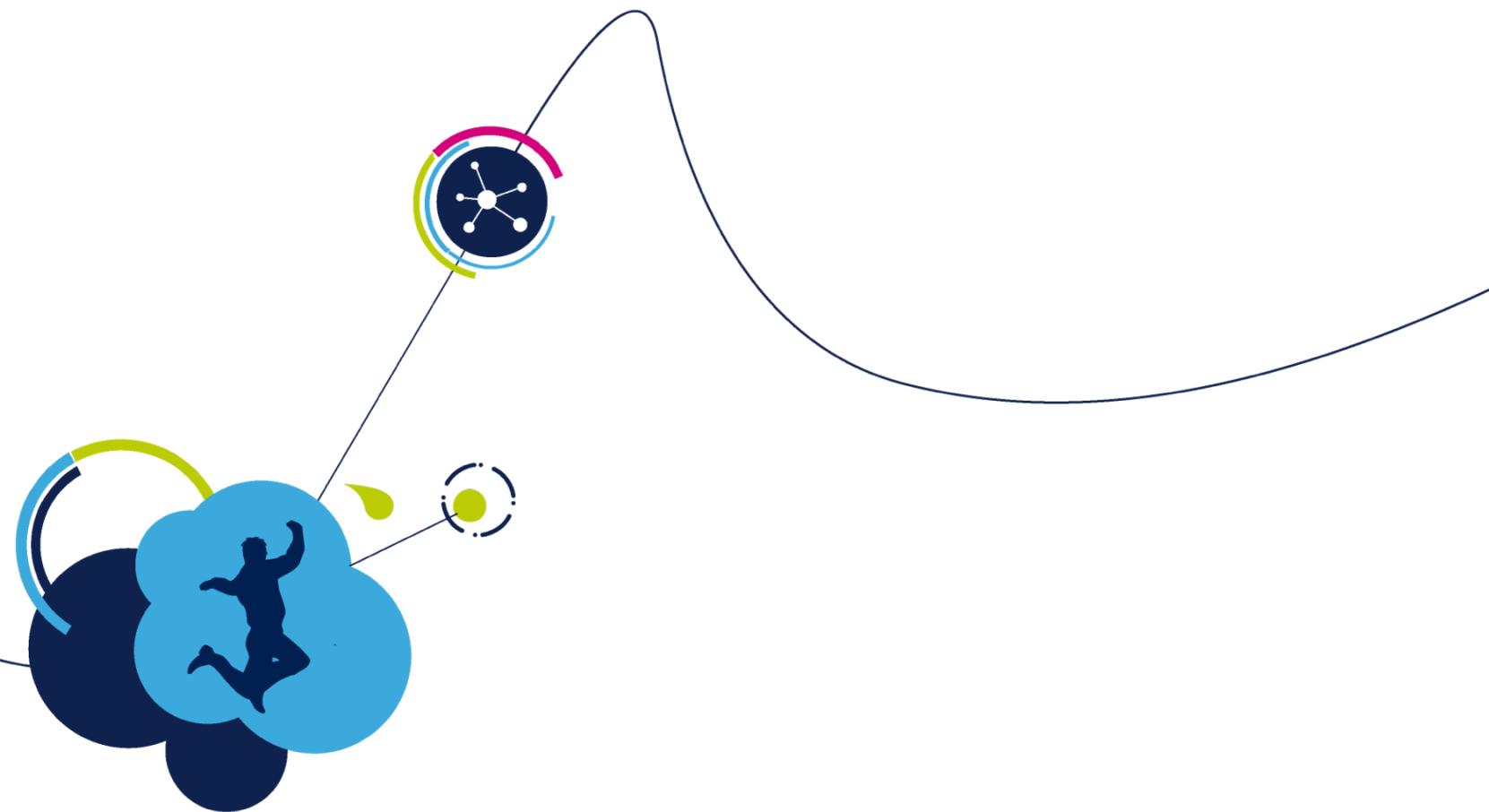


- **BlueCoin Overview**

- 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 Overview

ST: Products & Ecosystem

to match IoT market trends

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Market Trends

Smart Things



Smart Home



Smart City



Smart Industry



Ultra-low power, Form Factor, Sensors Performance...

Wifi, BTLE, sub-GHz, Sensors, Audio, Touch, Graphics...

LTE, Sub-GHz, Motion Sensors

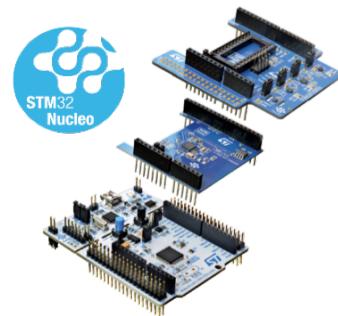
Longevity, Certification, motion sensors...

ST Offering

Broad Technology Offer



Ecosystem for application development



STM32 Nucleo development kits

STM32 Nucleo expansion boards for connectivity, sensing, actuating



Starter Kits and Form Factor Boards



STEVAL-BCNKT01V1

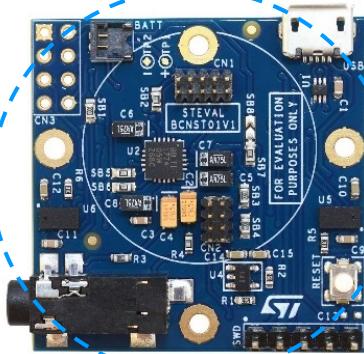
6

BlueCoin Starter Kit

**130mAh LiPo Battery
(UN38.3 Certified)**

**ST-Link SWD
Programming Cable**

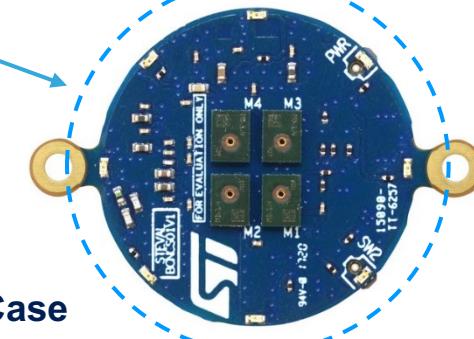
**STEVAL-BCNST01V1
CoinStation**



**STEVAL-BCNCR01V1
Cradle**



**STEVAL-BCNCS01V1
Core System**



BlueCoin - The Robotic Ear

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Core System: STEVAL-BCNCS01V1

LSM303AGR

3DAcc+3DMag
200 μ A @ 20 Hz (HR mode)
Accel/Mag independent power down mode

LPS22HB

Barometer
1-75Hz, 3-12 μ A @ 1Hz

4x MP34DT04-C1

Digital MEMS Microphones
64dB SNR, 120dBSPL

LSM6DSM

3DAcc+3DGyro
0.65mA @ 1.6kHz
9 μ A @ 12.5Hz

STBC03J

Li-Ion linear battery charger with LDO

STM32F446

Cortex-M4 up to 180MHz

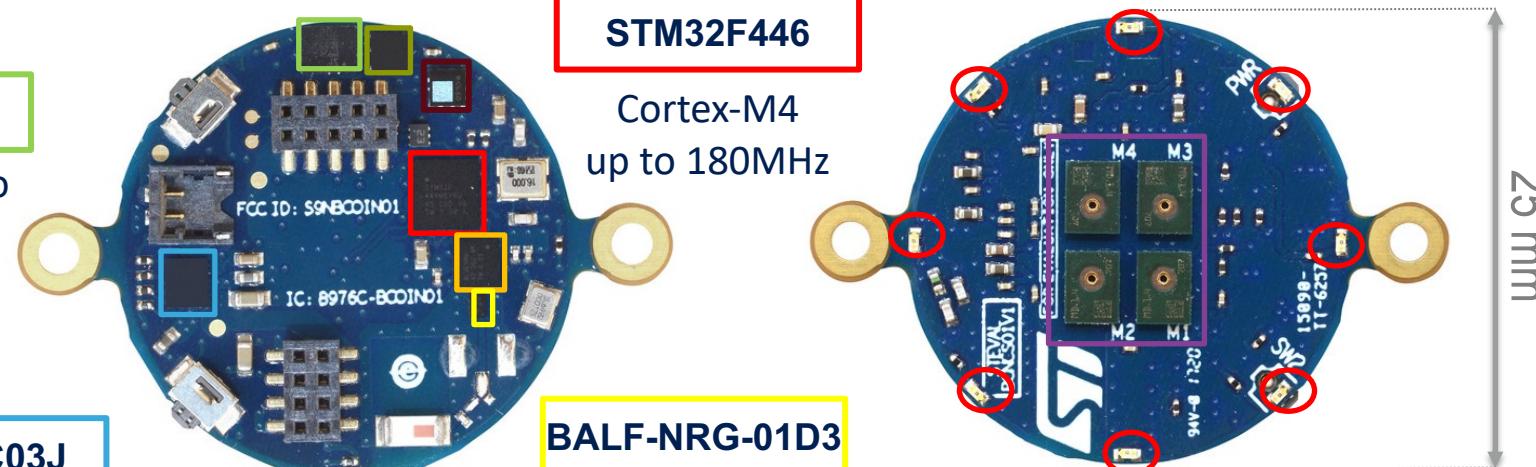
BALF-NRG-01D3

Balun Filter

BlueNRG-MS

Bluetooth low-energy Concurrent master/slave BT4.1

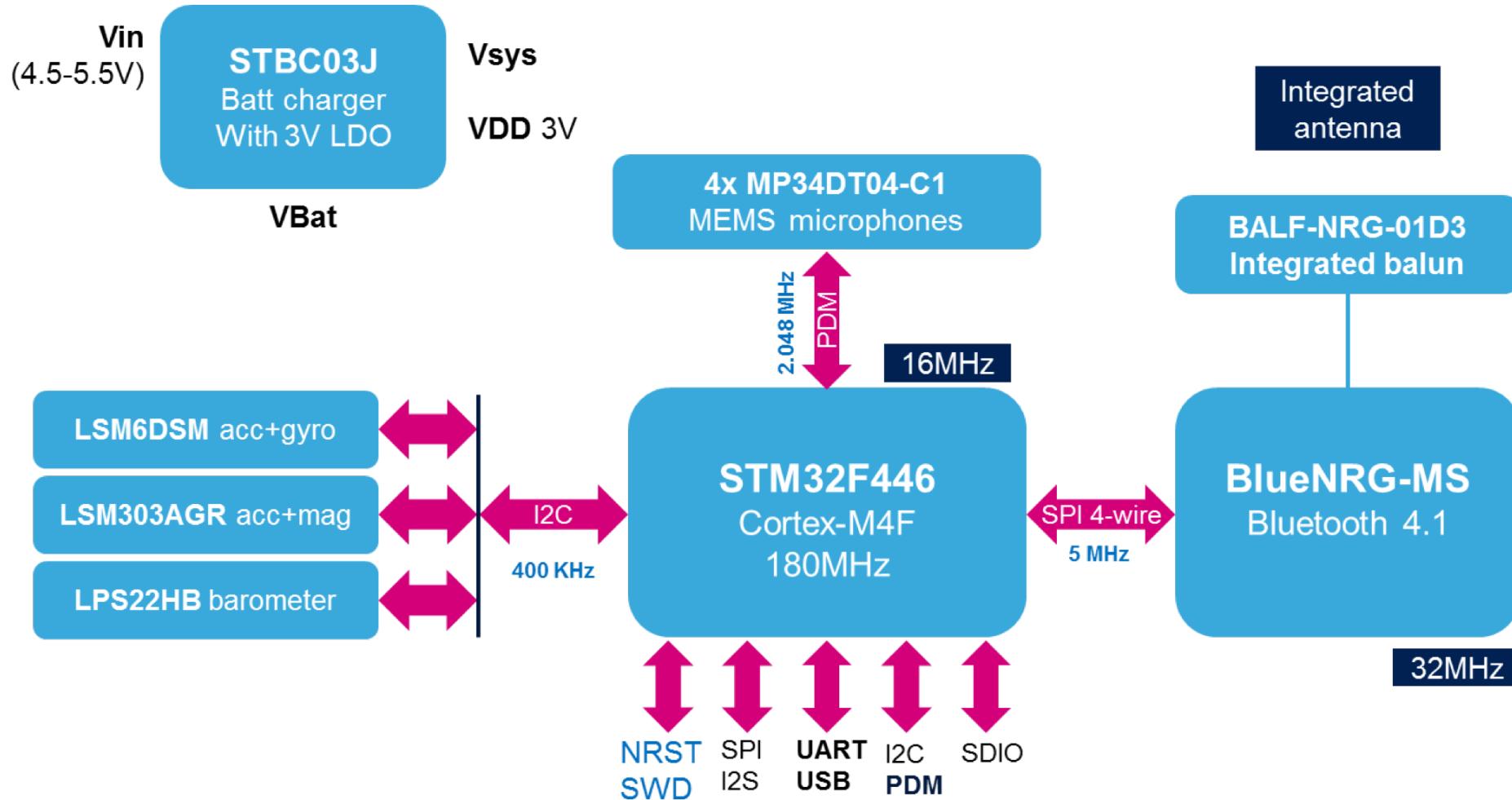
8 LEDs



BlueCoin Platform – Hardware overview

8

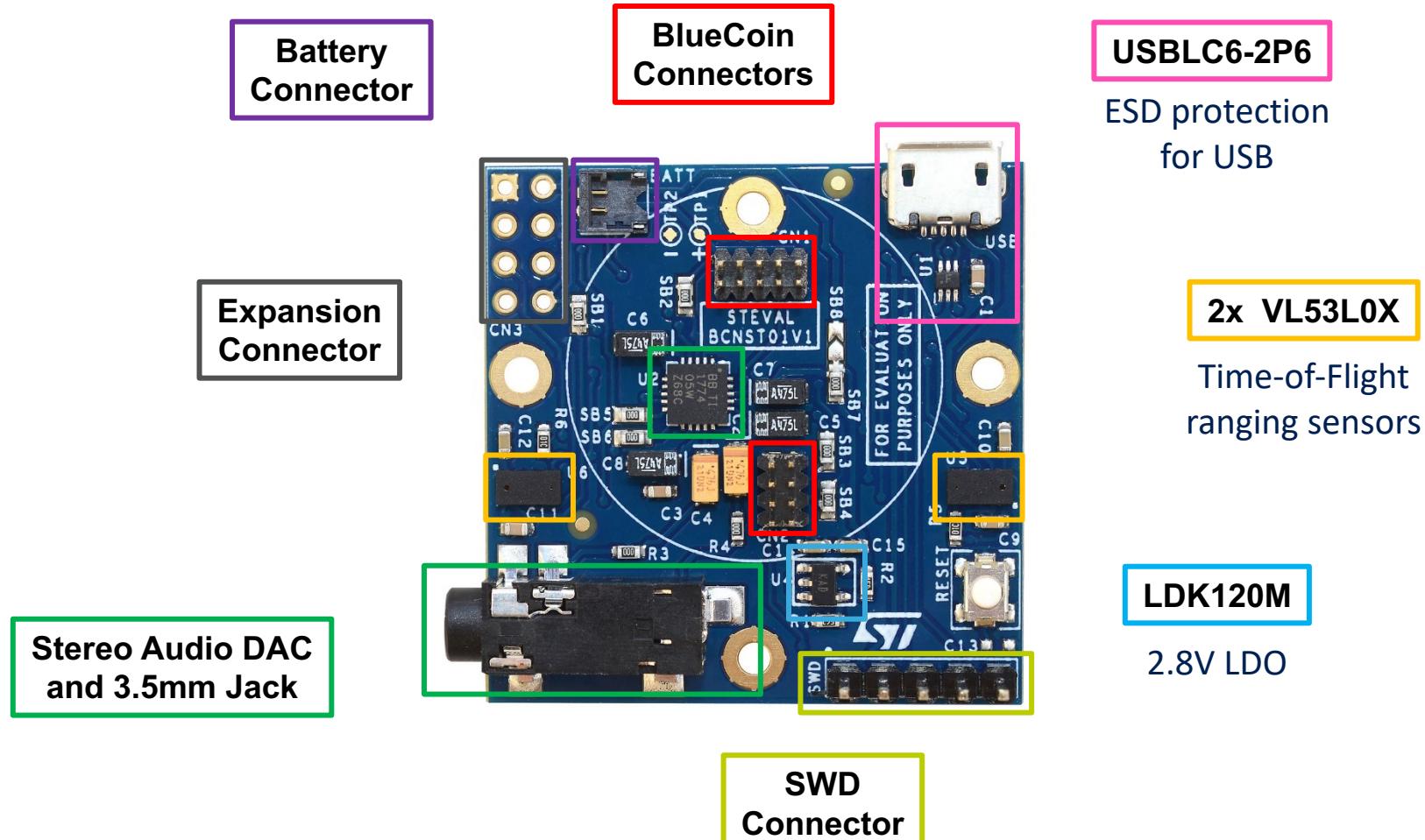
BlueCoin Block Diagram



BlueCoin CoinStation

9

CoinStation: STEVAL-BCNST01V1



BlueCoin Cradle

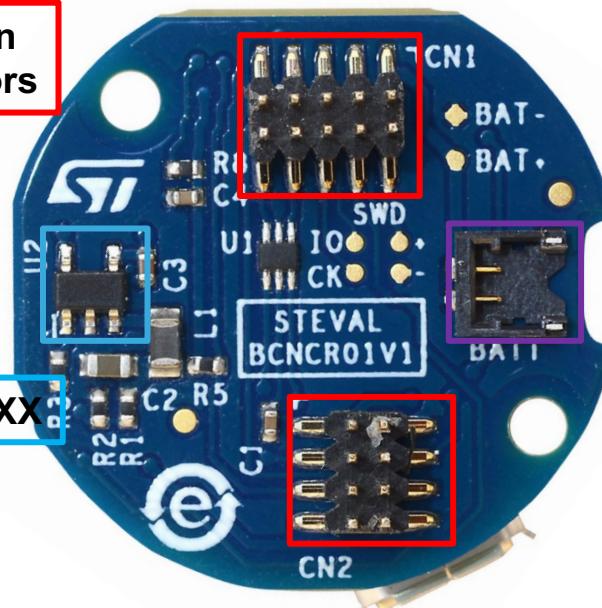
10

BlueCoin Cradle: STEVAL-BCNCR01V1

TOP VIEW

BlueCoin
Connectors

ST1S12XX



BOTTOM VIEW

Micro
SD Card

FOR EVALUATION
PURPOSES ONLY

RoHS
COMPLIANT
2002/95/EC

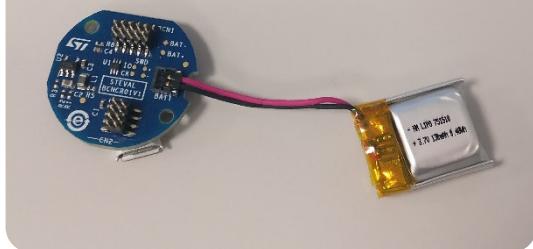


How to assemble the portable demo

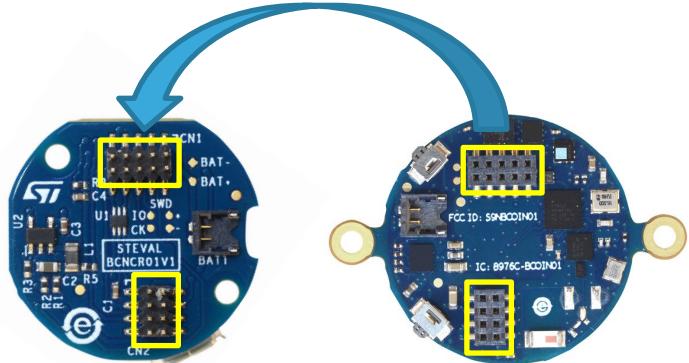
11



Plug the battery
on the Cradle



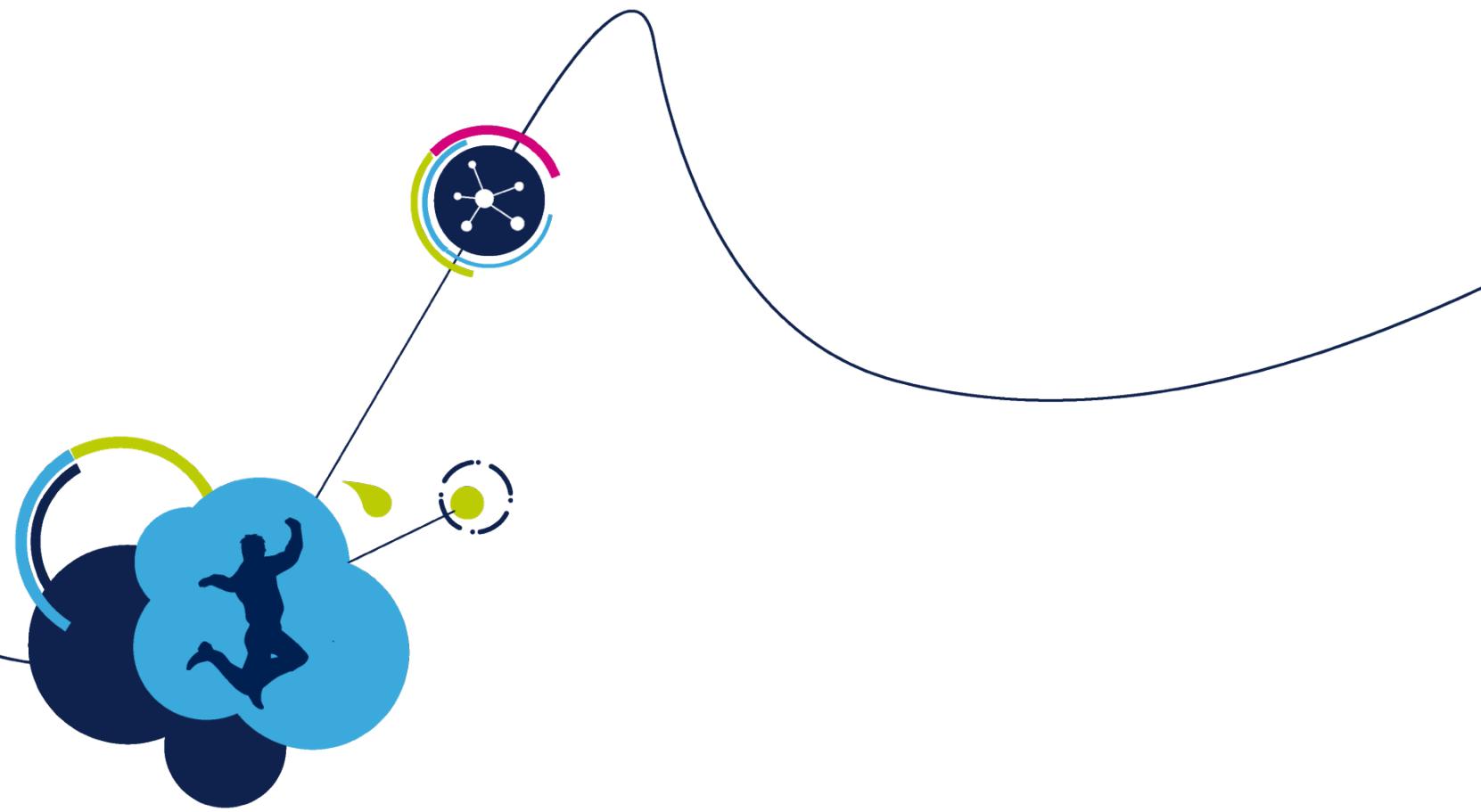
Fold the Battery below
the cradle, insert in the plastic case
and secure with the bolts



Warning: Connectors
are SMD mounted and
VERY delicate



Plug the BlueCoin
and secure with
the bolts

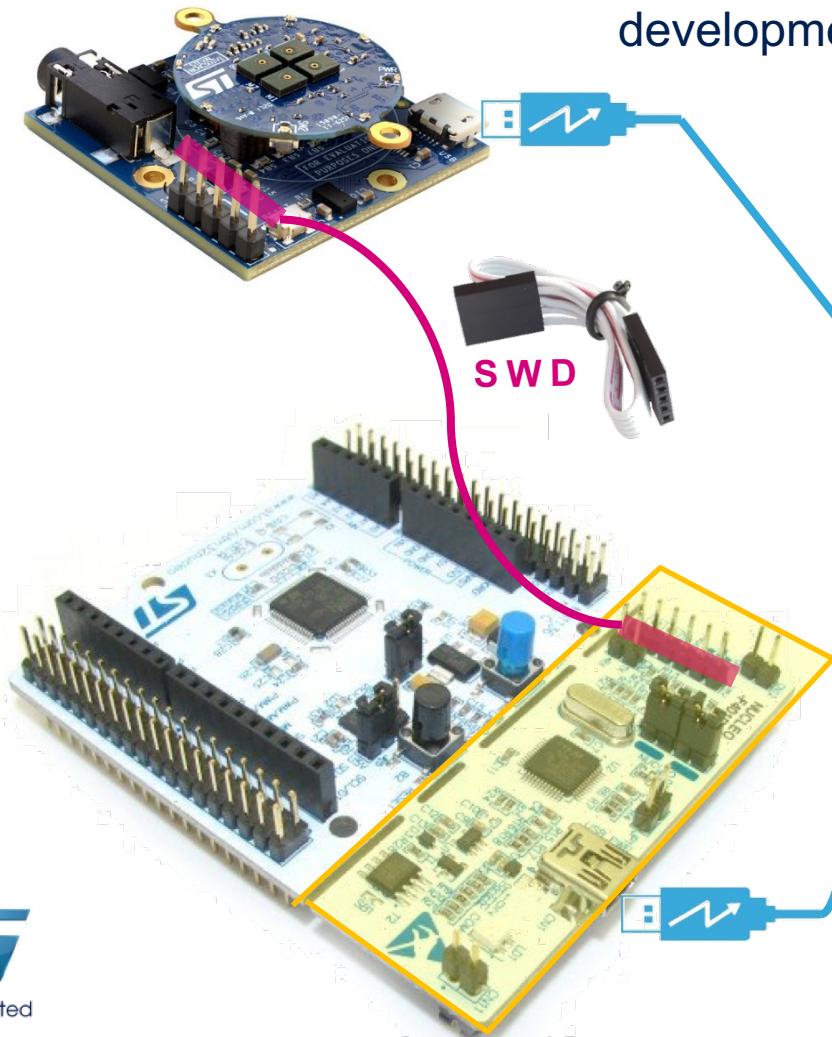


How to program the BlueCoin

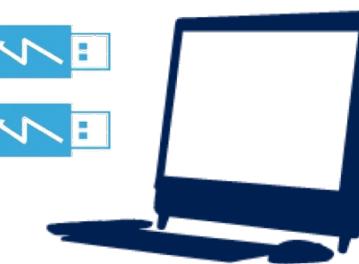
Jump Start Your Project

13

Plug the BlueCoin to its Cradle



Connect with your development environment



Compile & Run the your application



Field test your application



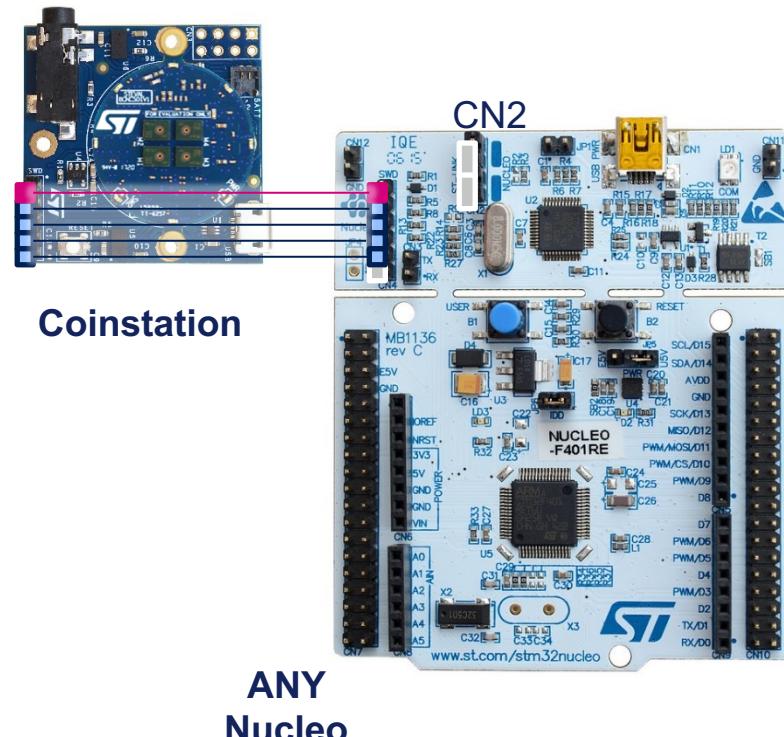
STLINK-V2 in Every Nucleo

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

How to Flash the BlueCoin

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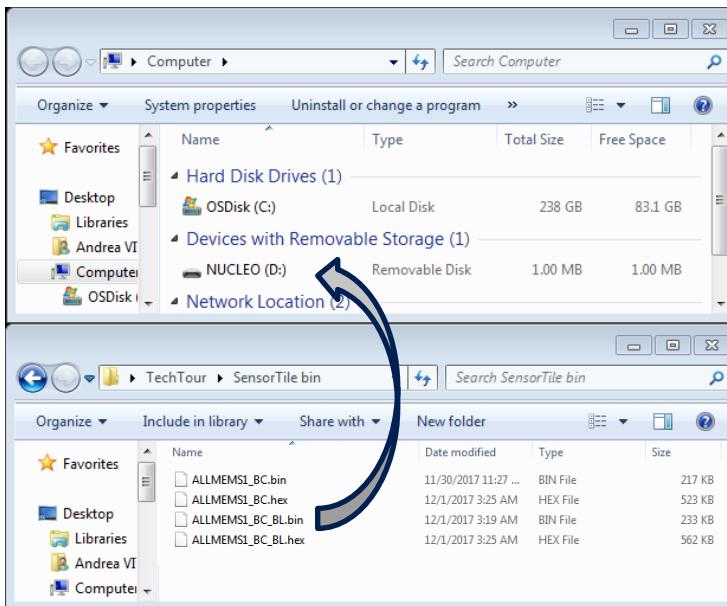
1. Remove two jumpers on CN2 of the Nucleo board
2. Plug the 5-pin cable to the SWD connectors (pin1 is square, highlight in red below)
3. Plug the USB cable of the cradle (if there is a switch: turn it ON) to power the target STM32F446
4. Plug the USB cable of the Nucleo board to power the ST-Link/V2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



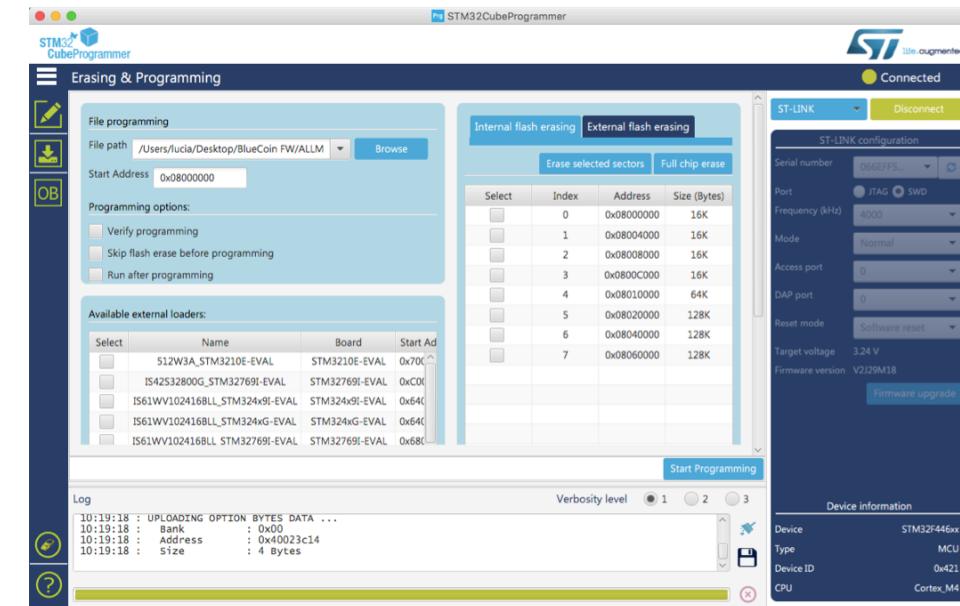
How to Flash the BlueCoin

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)

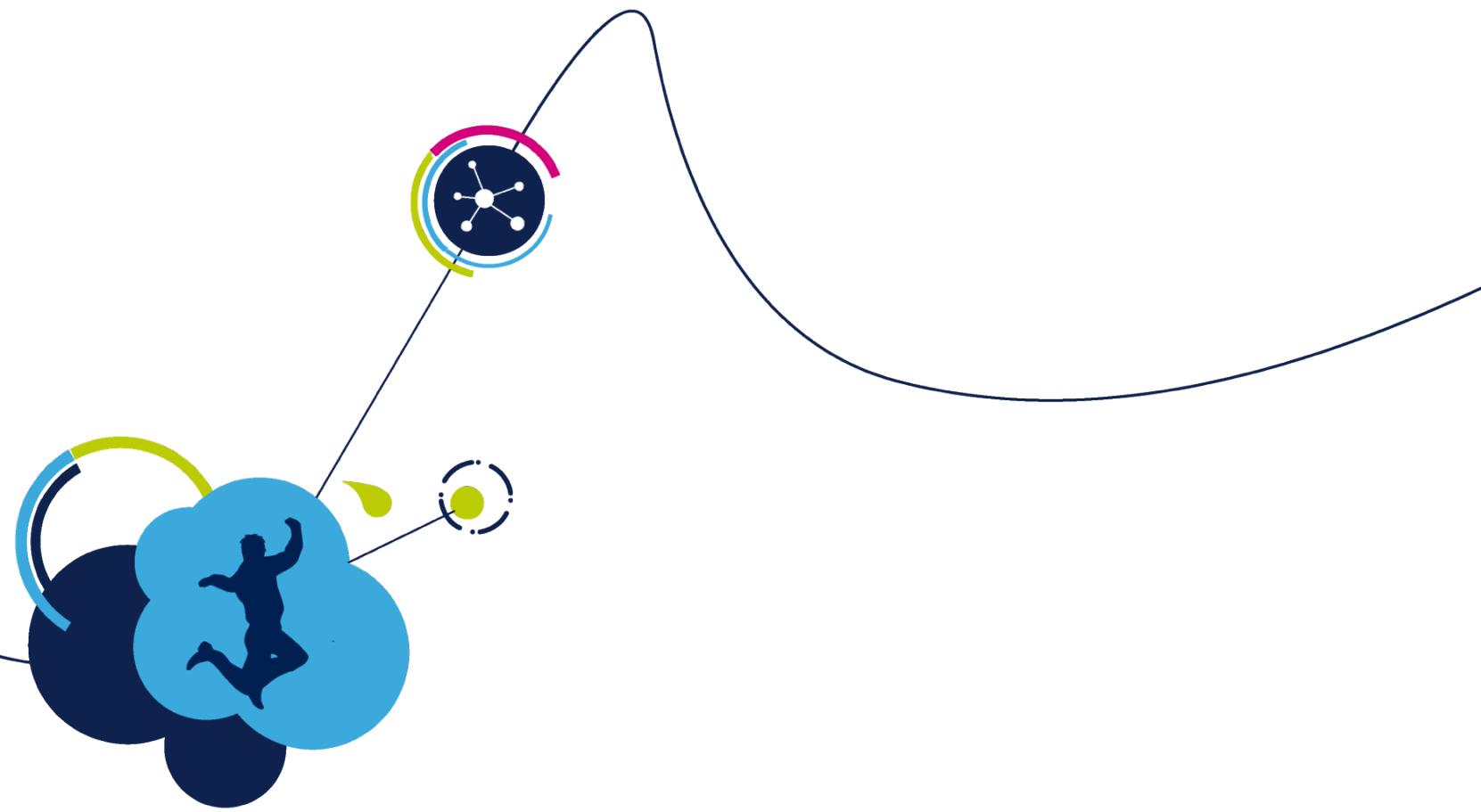
Drag and drop on virtual device (Windows Only)



STM32CubeProgrammer (Win, MacOS, Linux)



**Use ALLMEMS1_BC_BL.bin
(from FP-SNS-ALLMEMS1)**



Firmware and Software Overview

Datasheet



Product Specifications			
Description	Version	Size	
DB3258: BlueCoin Starter kit	3.0	474 KB	

User
Manual



User Manuals			
Description	Version	Size	
UM2240: Getting started with the STEVAL-BCNKT01V1 BlueCoin kit: augmented acoustics and motion sensing development platform	1.0	2 MB	

Presentations
(Quick start guide)



Presentations & Training Material			
Presentations			
Description	Version	Size	
STEVAL-BCNKT01V1 Quick start guide	1.0	1 MB	

3D CAD and
Gerbers



Board Manufacturing Specifications			
Description	Version	Size	
STEVAL-BCNKT01V1 3D cad files	1.0	3 MB	

BOM



Bill of Materials			
Description	Version	Size	
STEVAL-BCNKT01V1 BOM	1.0	207 KB	

Schematics



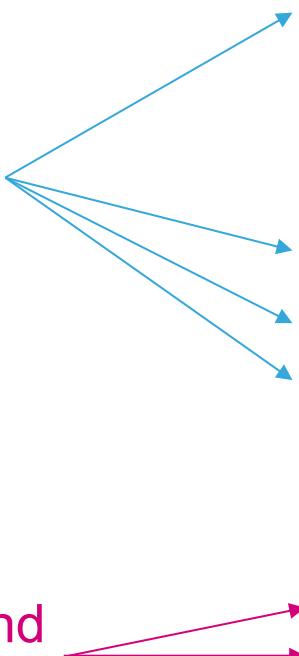
Schematic Pack			
Description	Version	Size	
STEVAL-BCNKT01V1 schematics	1.0	553 KB	

License agreements
and certifications



Legal			
License Agreement			
Description	Version	Size	
Evaluation products license agreement	1.4	128 KB	

Firmware packages



Android/iOS app and
corresponding SDK



Embedded Software		
EVALUATION TOOL SOFTWARE		
Part Number	▲ Manufacturer	◆ Description
STSW-BCNKT01	ST	Embedded software samples for BlueCoin: data streaming via USB and BLE, logging on SD card, gesture recognition, audio acquisition and playback
MCUS EMBEDDED SOFTWARE		
Part Number	▲ Manufacturer	◆ Description
FP-AUD-BVLINK1	ST	STM32 ODE function pack for half-duplex voice streaming over Bluetooth low energy
FP-AUD-SMARTMIC1	ST	STM32 ODE function pack for MEMS microphone acquisition, advanced audio processing and audio output
FP-SNS-ALLMEMS1	ST	STM32 ODE function pack for IoT node with BLE connectivity, digital microphone, environmental and motion sensors
WIRELESS CONNECTIVITY SOFTWARE		
Part Number	▲ Manufacturer	◆ Description
BlueMS	ST	BlueMS Application for Android and iOS
BlueST-SDK	ST	Bluetooth Low Energy and Sensors Technology Software Development Kit (SDK)

Hardware, Software, Documentation

HARDWARE

- **STEVAL-BCNKT01V1** BlueCoin kit

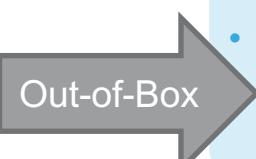
FIRMWARE

- **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

Today



Out-of-Box



APPS

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

DOCUMENTATION

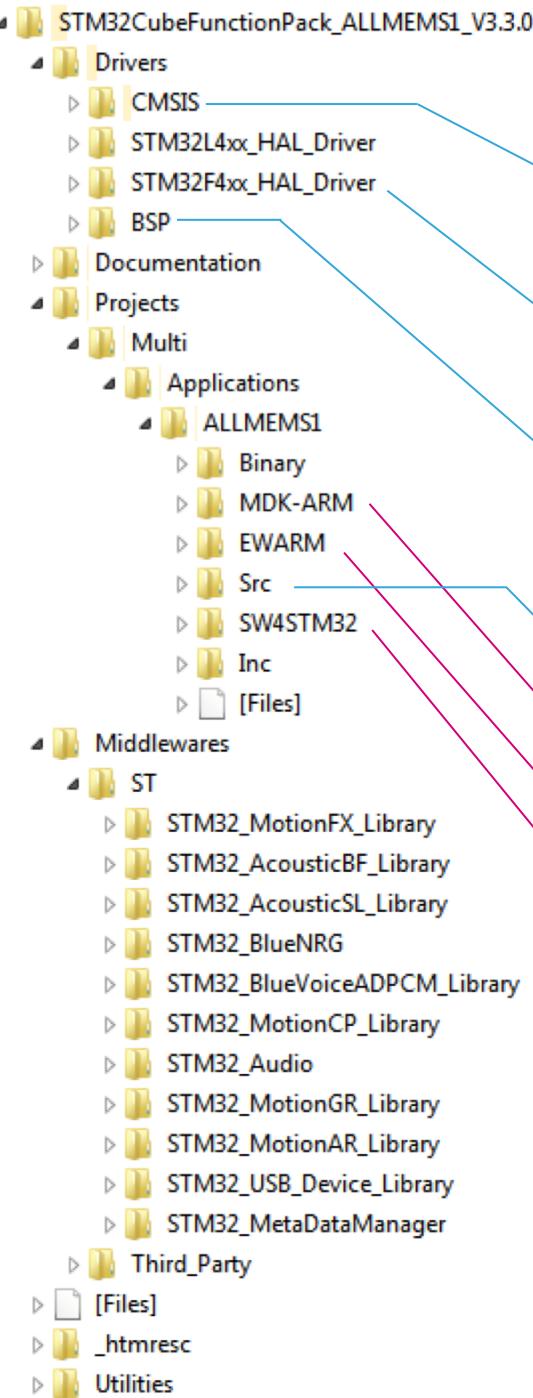
- **UM2240** getting started with BlueCoin kit
- **UM2249** getting started with STSW-BCNKT01
- **UM2059** getting started with FP-SNS-ALLMEMS1
- **UM2196**: Getting started with the FP-AUD-BLINK1 STM32 ODE function pack based on half-duplex voice streaming over BLE
- **UM2219**: Getting started with 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



MDK-ARM

EWARM

SW4STM32



Keil project files

IAR project files

SystemWorkbench

Software Library Licensing

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- 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

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STM32ODE software package

Open Development Environment – src code

- **FP-SNS-ALLMEMS1** BLE + MEMS + digital microphone
- **FP-AUD-BVLINK1** BLE + digital microphone
- **FP-AUD-SMARTMIC1** Digital microphone

Software Libraries

MotionFX, MotionAR, MotionCP, MotionGR,
AcousticSL, AcousticBF, BlueVoice

BlueVoice

AcousticSL, AcousticBF, AcousticEC

BlueVoice (Voice over BLE)

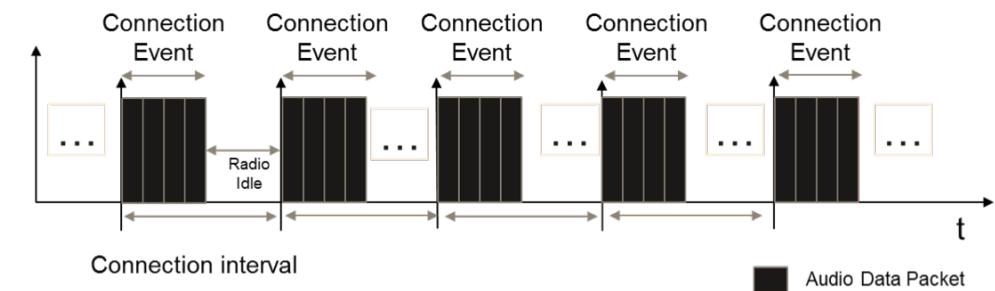
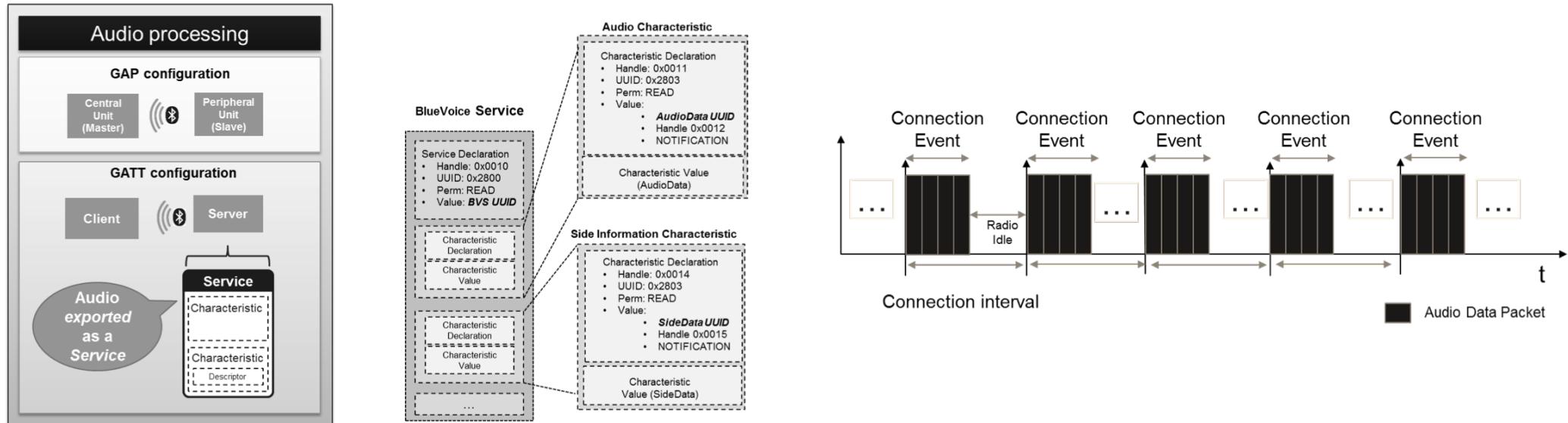
24

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)



AcousticBF and AcousticSL

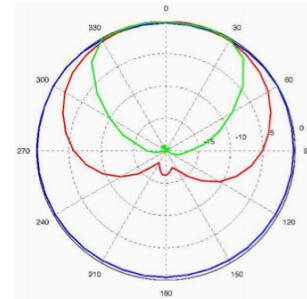
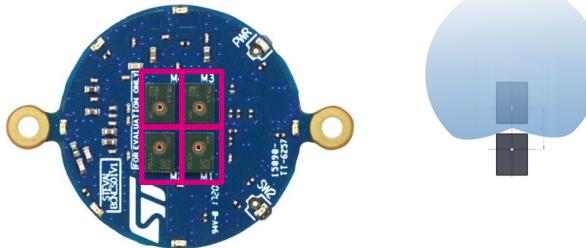
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BEAMFORMING



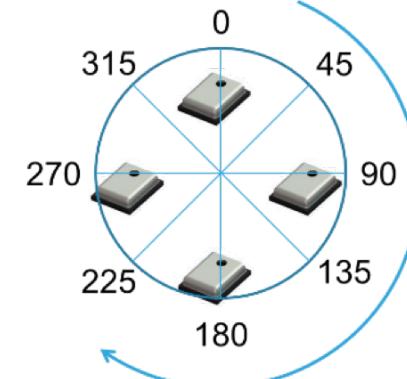
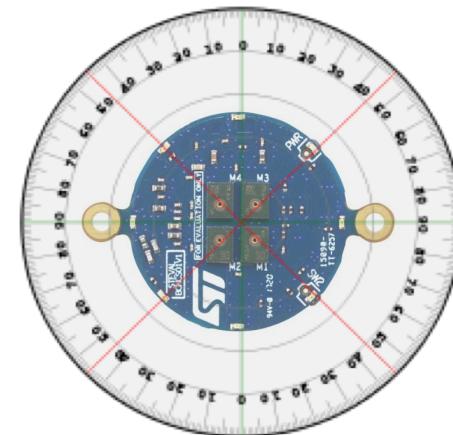
Beam pattern

Blue: omnidirectional microphone

Red: «Basic cardioid» mode

Green: «Strong» mode

SOURCE LOCALIZATION



2 mic 180deg, 4 mic 360 deg



BlueCoin Hands-on Using the ST BlueMS App

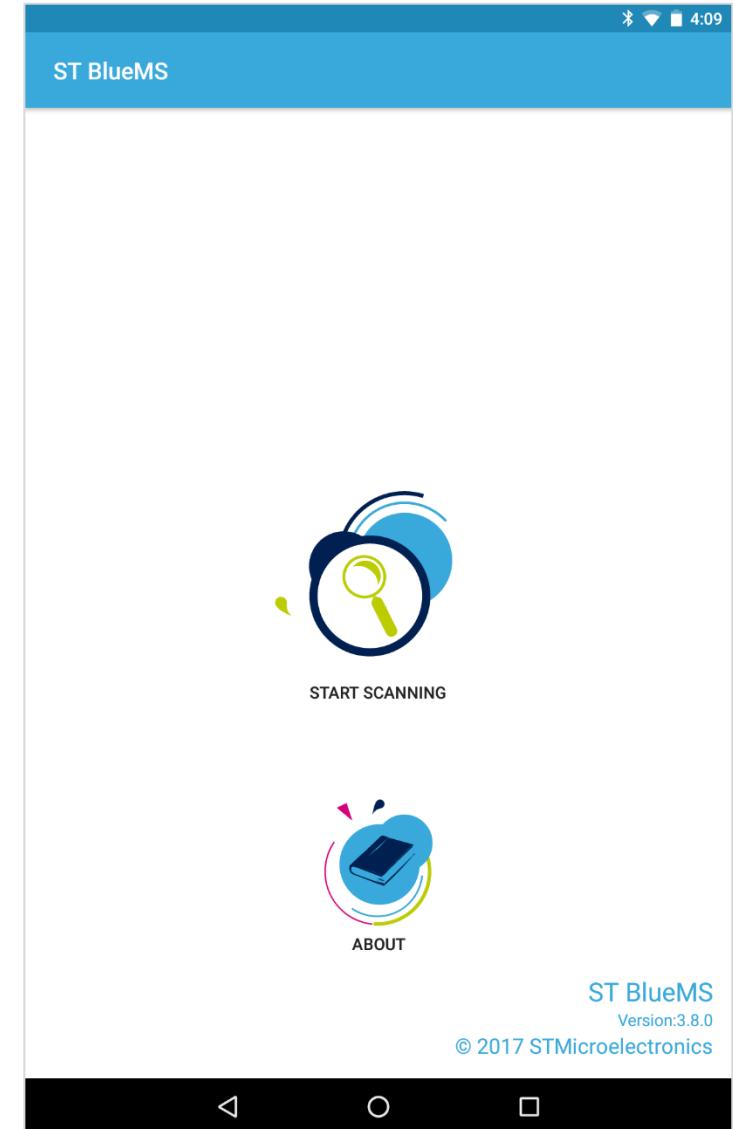
LAB1: BlueMS App

27



ST BlueMS
STMICROELECTRONICS INC

Launch the ST BlueMS app
previously installed



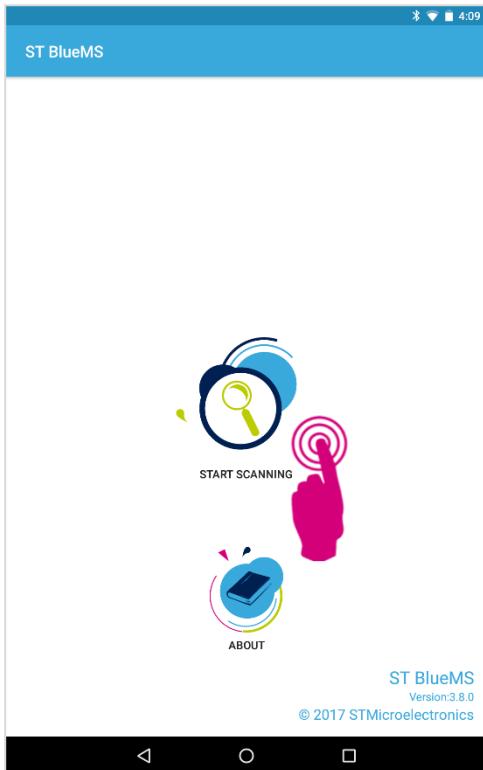
LAB1: BlueMS App

28



Press PWR for 1s
And wait for the 8
LED to start blinking

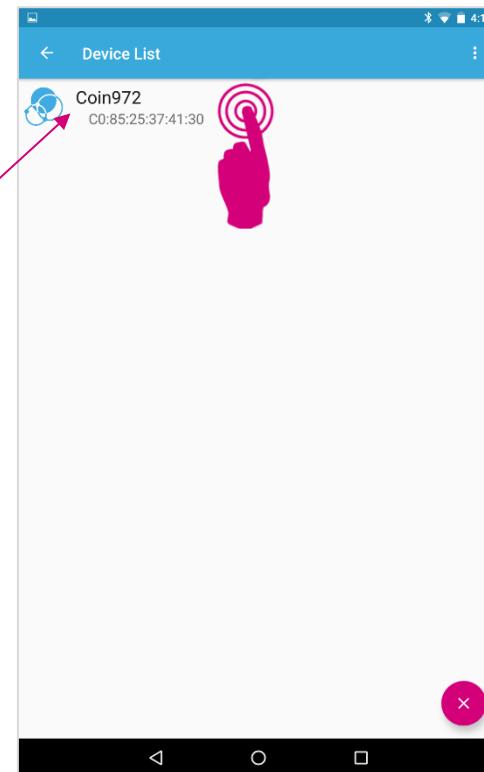
Touch
“Start discovering”



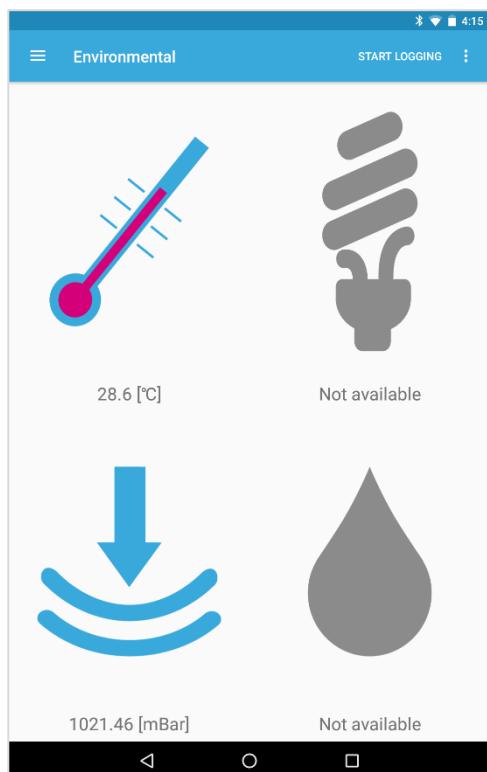
The name is
“CoinXXX”
(look at the label on the box)



Select your
BlueCoin



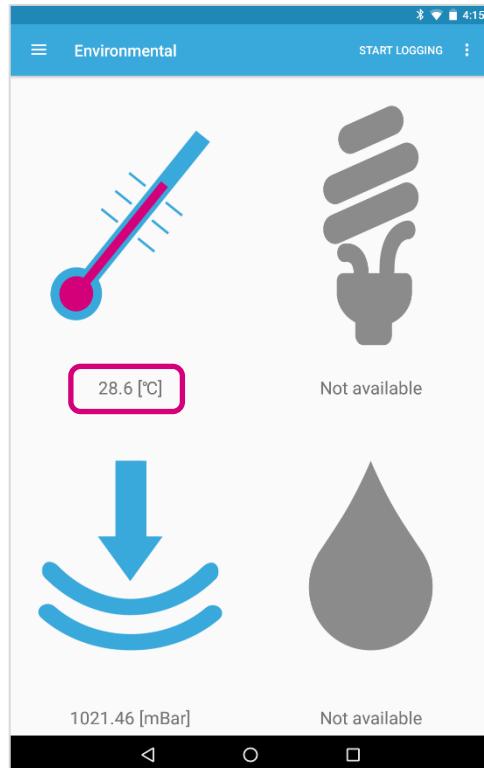
You are
connected



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

LAB1: BlueMS App

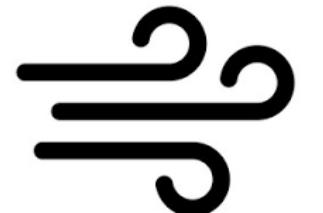
View the BlueCoin
Environmental sensor
real-time data



Swipe left
for more →

LAB: temperature

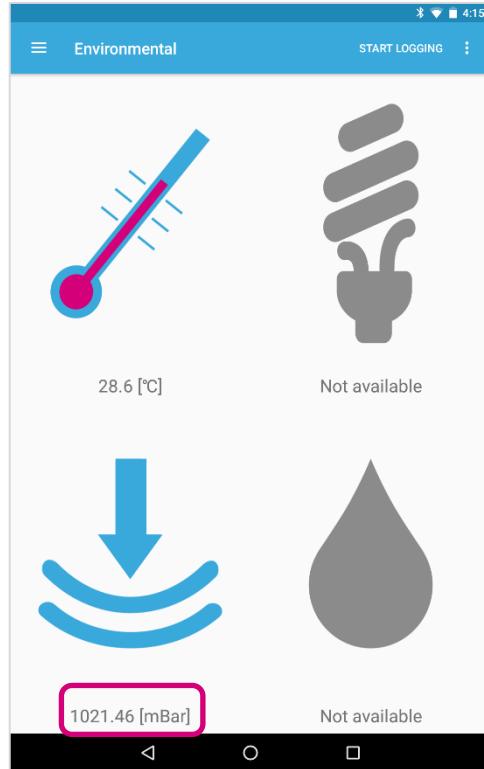
Try to blow some hot air on the BlueCoin to see temperature changes



- Temperature measured using:
 - Internal Temperature sensor of pressure sensor ($\pm 1.5\text{C}$ deg accuracy)

LAB1: BlueMS App

View the BlueCoin
Environmental sensor
real-time data



Swipe left
for more →

LAB: pressure sensor

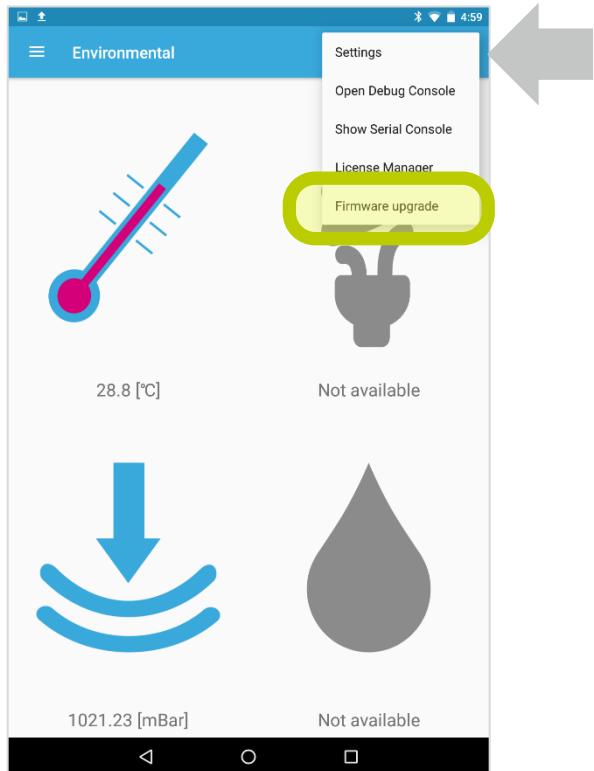
Try to move the BlueCoin up/down by
20-30cm (7-12in),

wait a few seconds and observe the
change in the barometer reading (mbar).

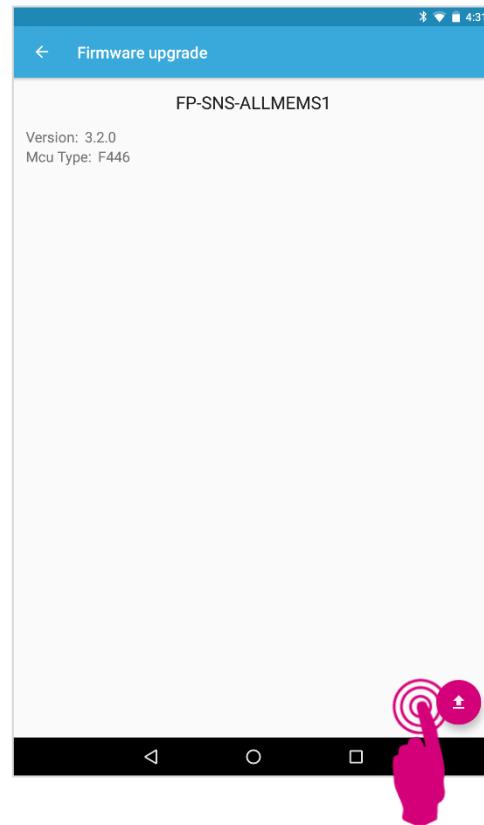


DEMO: Firmware Update Over-the-air

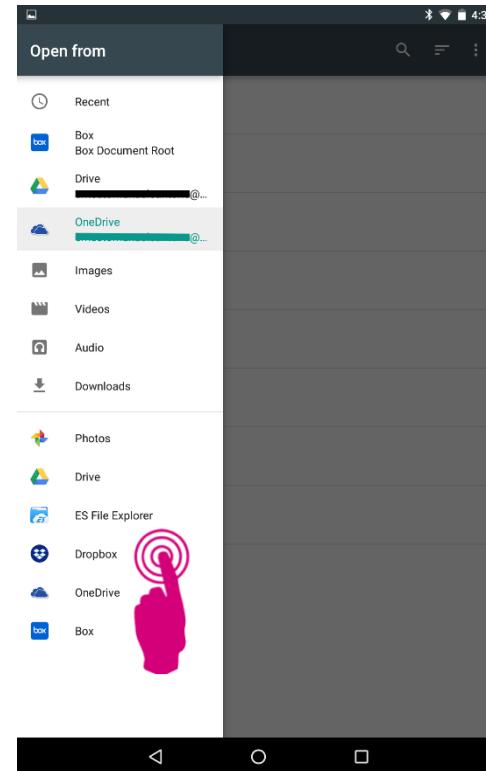
31



Select
“Download & Flash”



Enable and Select
the repository



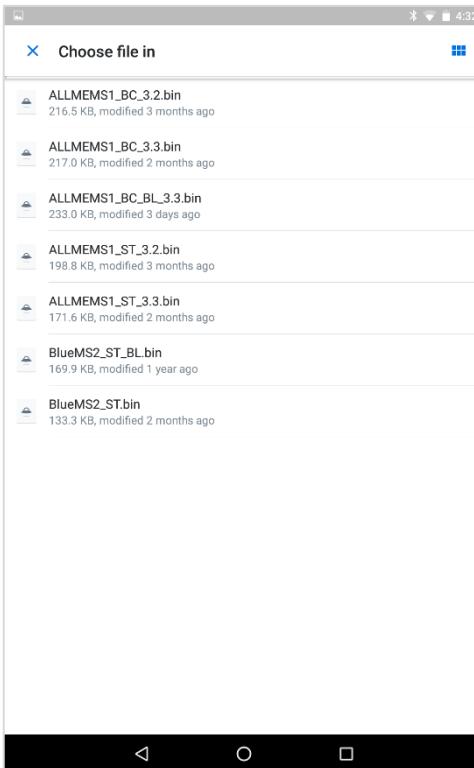
DEMO: Firmware Update Over-the-air

32

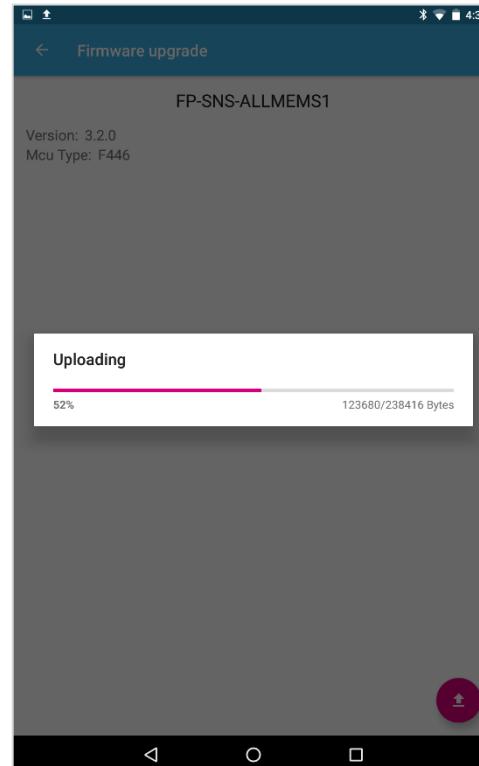
BlueCoin will confirm the integrity of the selected firmware binary before overwriting the current Flash memory image.

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

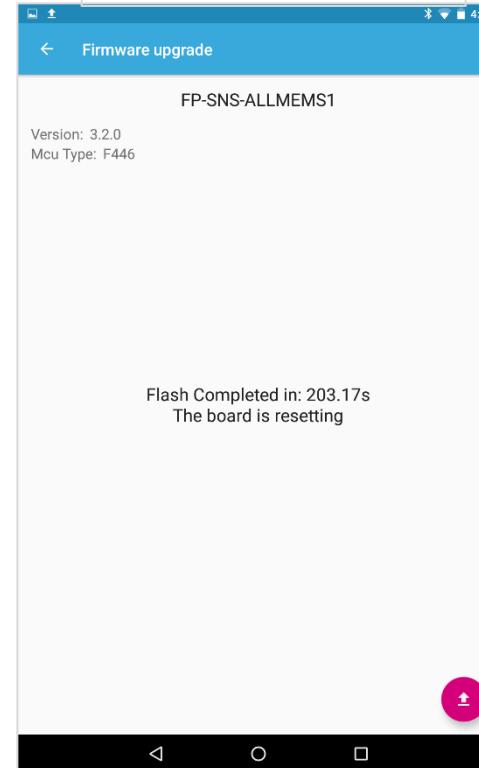
Select the firmware binary image



Uploading and Flashing



Confirmation!

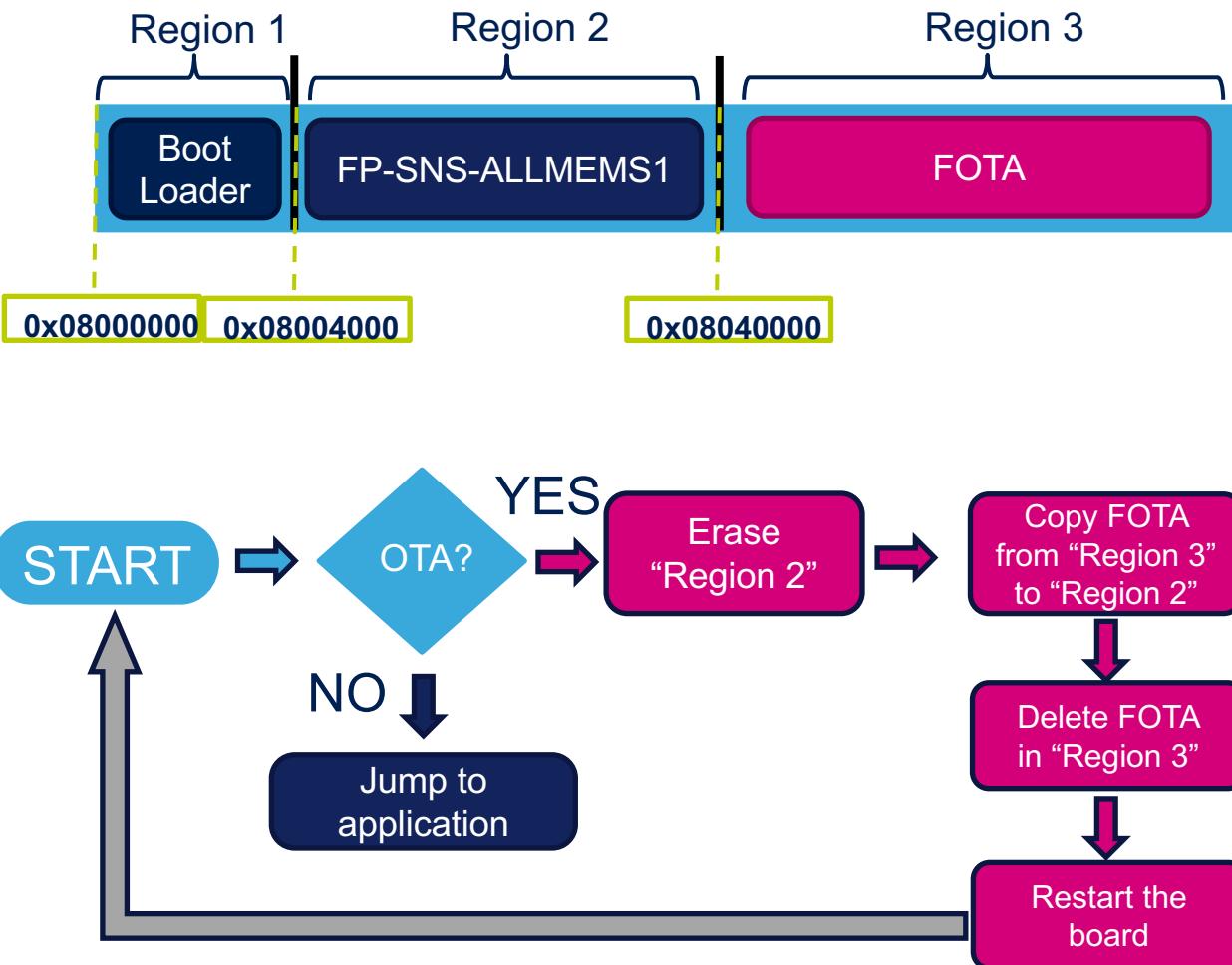


DEMO: Firmware Update Over-the-air

33

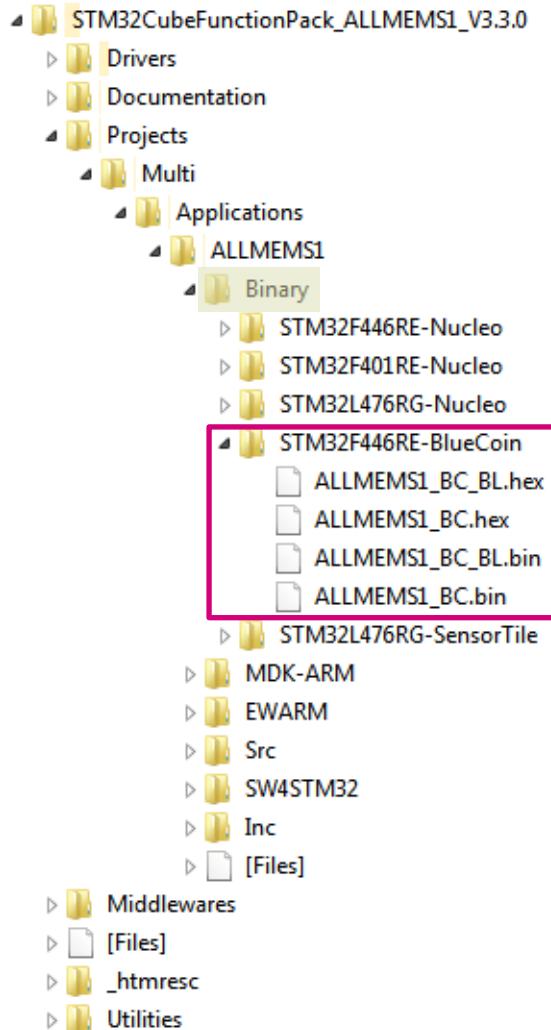
MEMORY ORGANIZATION

- 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



DEMO: Firmware Update Over-the-air

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

Bootloader + App, flash at 0x0800 0000

- **ALLMEMS1_BC_BL.bin**
- **ALLMEMS1_BC_BL.hex**

0x0800 0000
Bootloader (16kB)
0x0800 3FFF

Application, flash at 0x0800 4000

- **ALLMEMS1_BC.bin**
- **ALLMEMS1_BC.hex**

0x0800 4000

Current app (240kB)

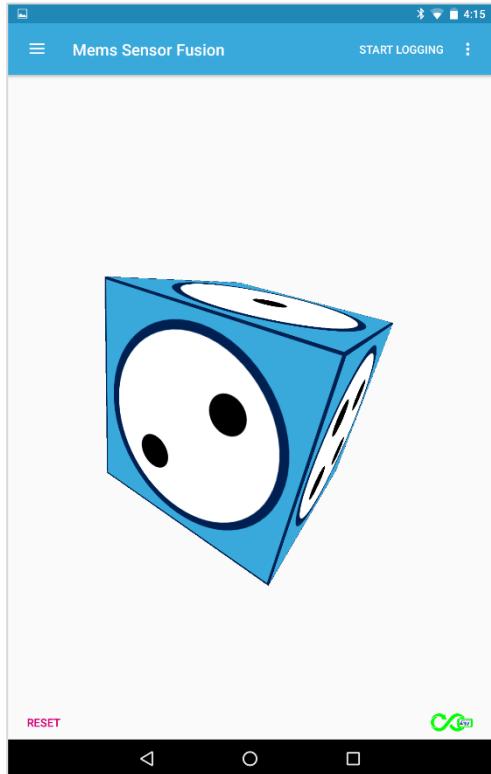
0x0803 FFFF

Use this for FOTA!

LAB2: Real-time Data Plot

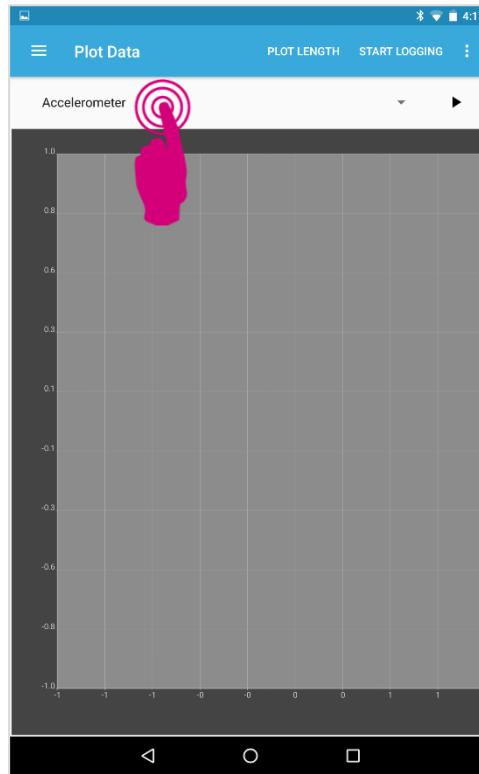
35

Swipe left to view the real-time data plot

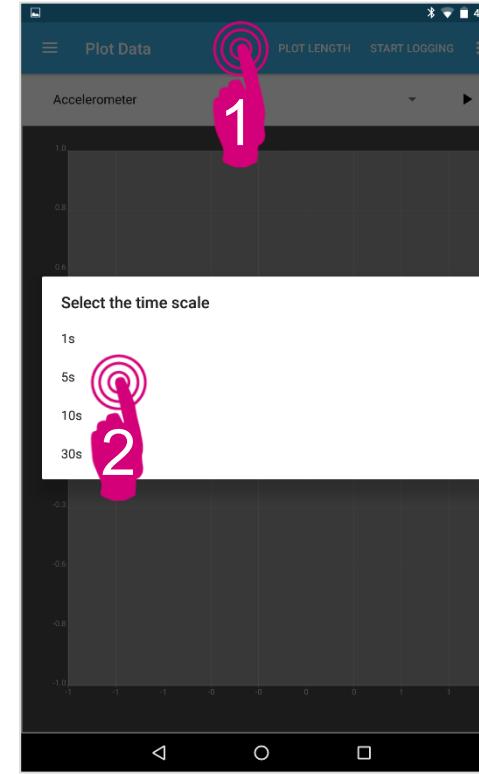


Swipe left
for more 

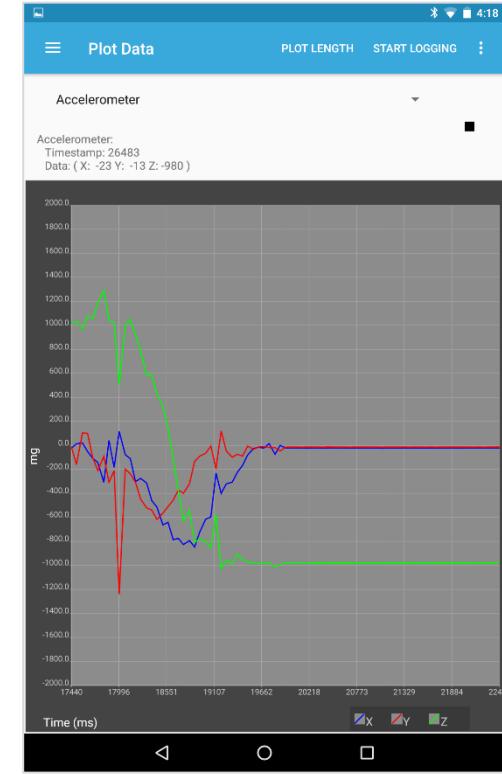
Select the sensor device to plot



Select the Plot length

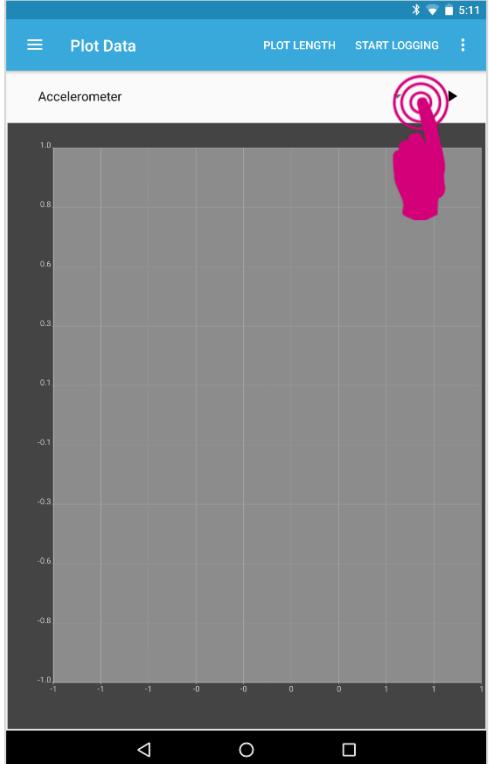


View the real-time data plot



LAB2: Real-time Data Log

Start
Streaming



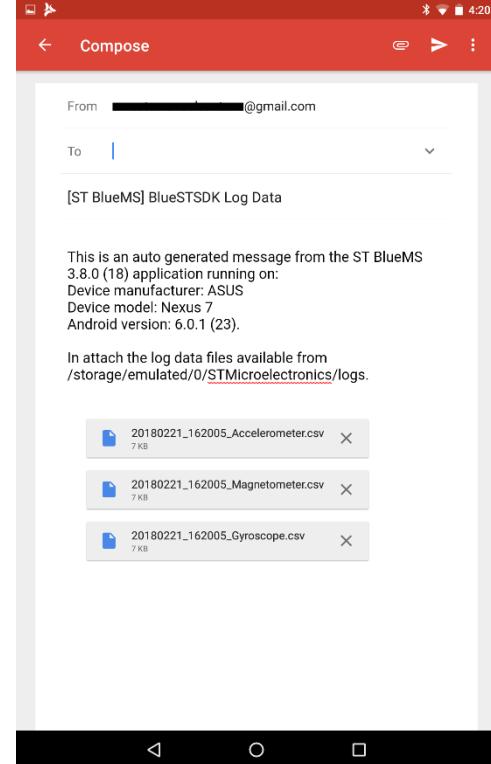
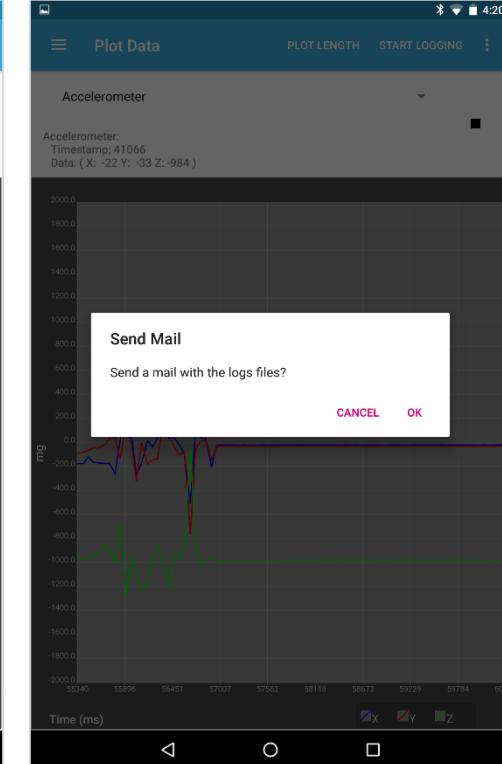
Start logging



Stop logging



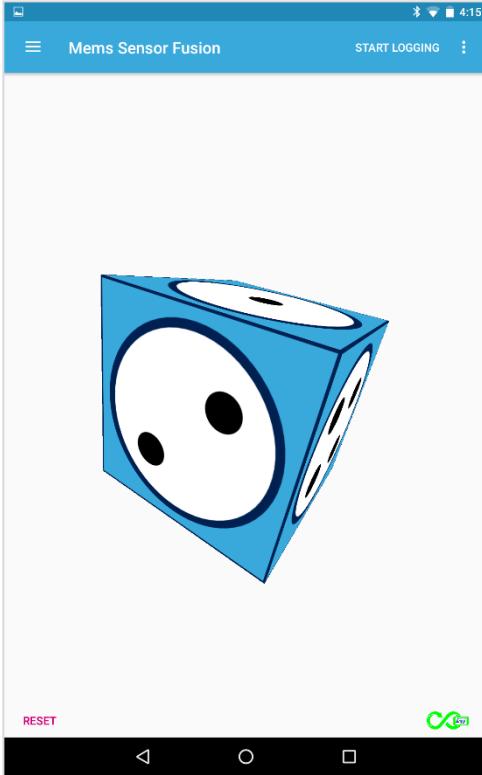
Send log data
using email



LAB2: Real-time Data Plot

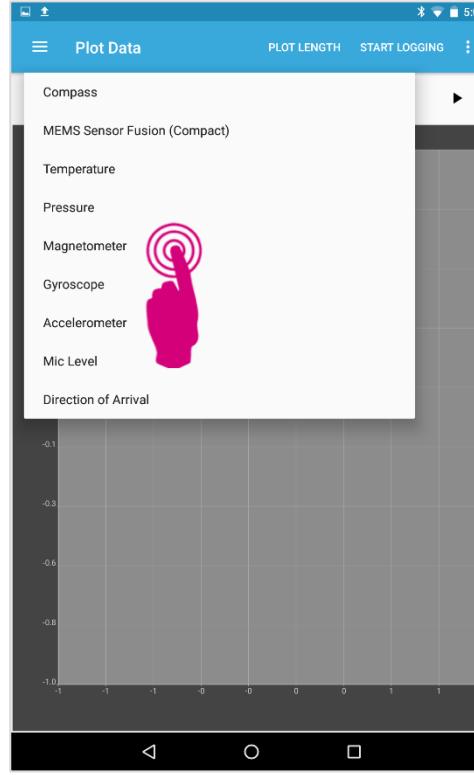
Effects of Magnetic Interference

Swipe left to view the real-time data plot



Swipe left
for more

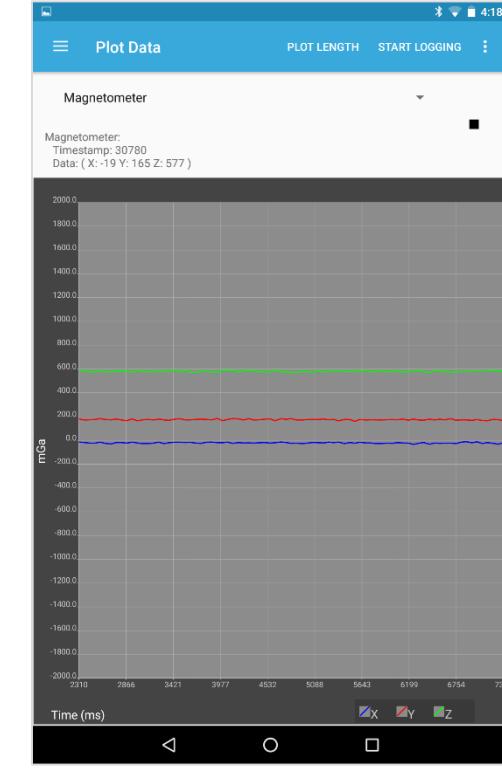
Select the magnetometer



Select the time frame



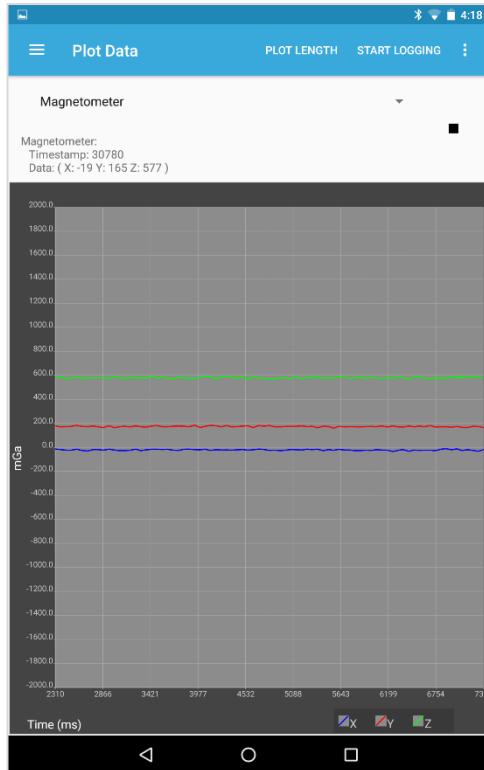
Magnetic field plot



LAB2: Real-time Data Plot

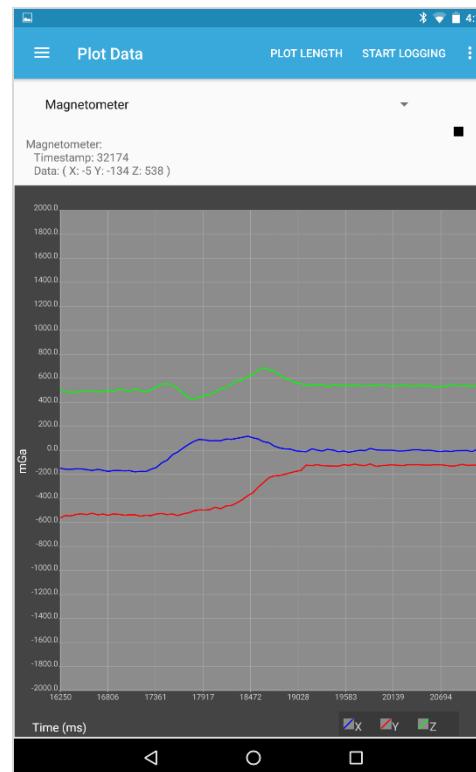
Effects of Magnetic Interference

38



LAB

Move the
smartphone over
the BlueCoin

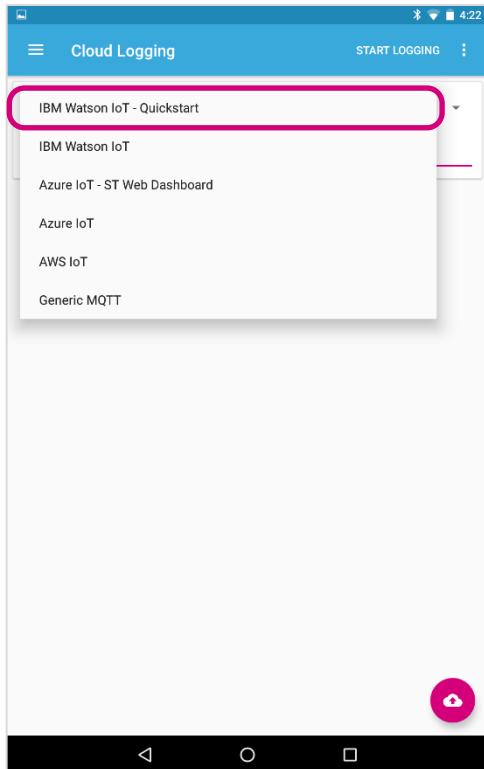


The magnetic field measured by the sensor has changed because of the magnetic field induced by the smartphone (speakers, antennas, battery, currents)

LAB3: IBM Watson IoT Quickstart

Post BlueCoin Sensor Data on IBM Watson

Select “IBMQuickstart”

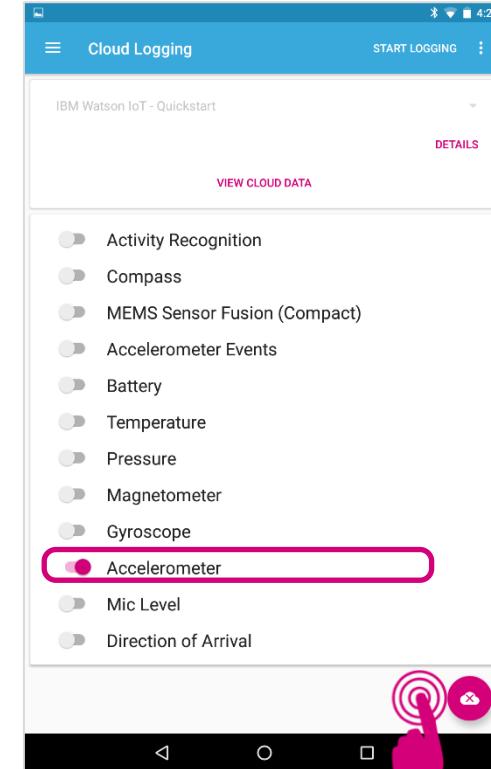


Click “Connect”



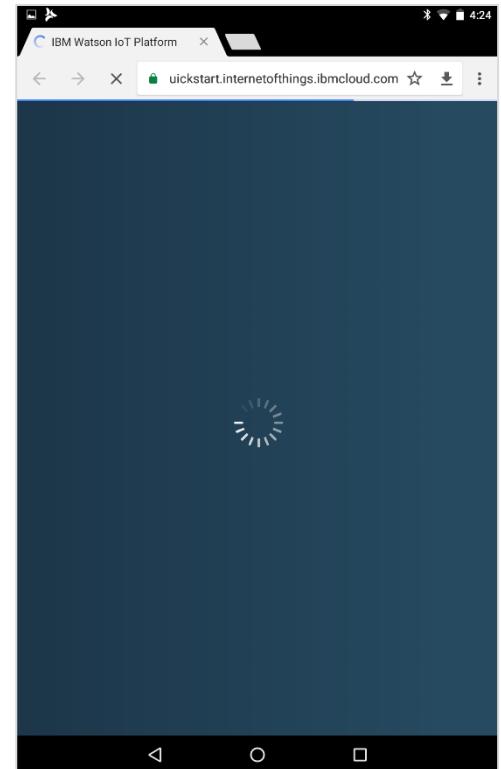
NOTE: MAC address is used
is Device Id (see slide 29)

Select a feature



Tap to View Data in
the Cloud”

Wait a few seconds

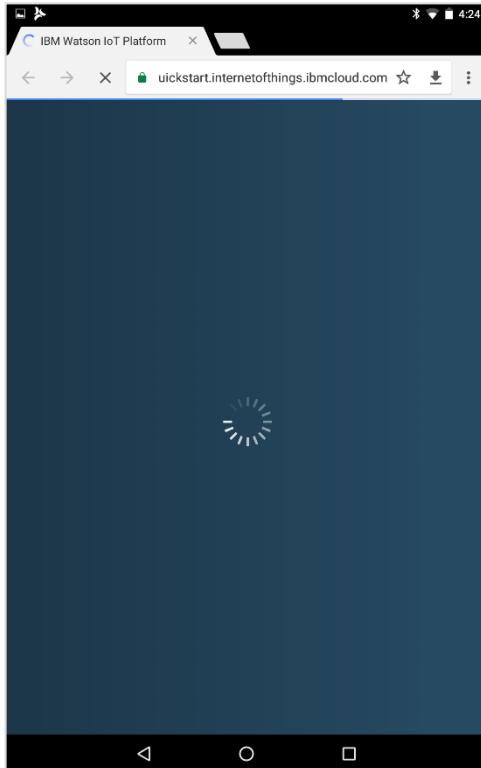


LAB3: IBM Watson IoT Quickstart

Post BlueCoin Sensor Data on IBM Watson

40

Quickstart will appear



You will see the Plot of selected feature

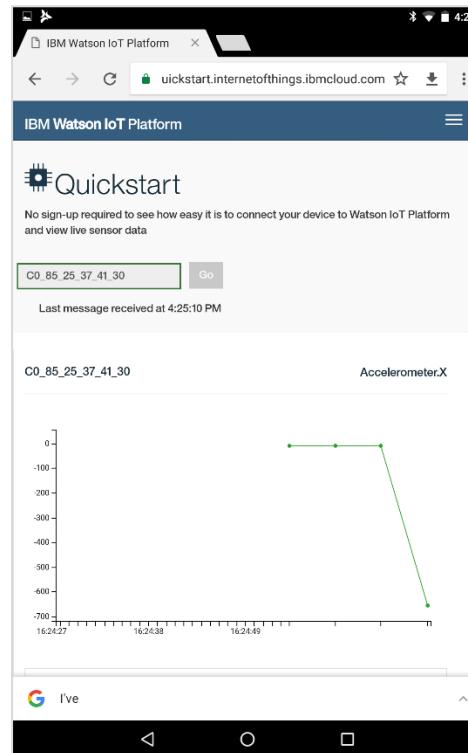


Table of available features

Event	Datapoint	Value
Accelerometer	timestamp	79478
Accelerometer	X	-655
Accelerometer	Y	670
Accelerometer	Z	362

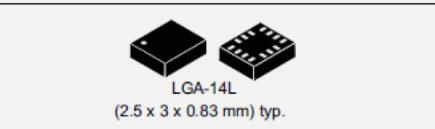
Scroll down to change sensor data or axes

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

LSM6DSM

iNEMO inertial module:
always-on 3D accelerometer and 3D gyroscope
[Datasheet - production data](#)



(2.5 x 3 x 0.83 mm) typ.

Description

The LSM6DSM is a system-in-package featuring a 3D digital accelerometer and a 3D digital gyroscope performing at 0.65 mA 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 batching.

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

The various sensing elements are manufactured using specialized micromachining 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 $\pm 2/\pm 4/\pm 8/\pm 16\text{ g}$ and an angular rate range of $\pm 125/\pm 245/\pm 500/\pm 1000/\pm 2000\text{ dps}$.

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.

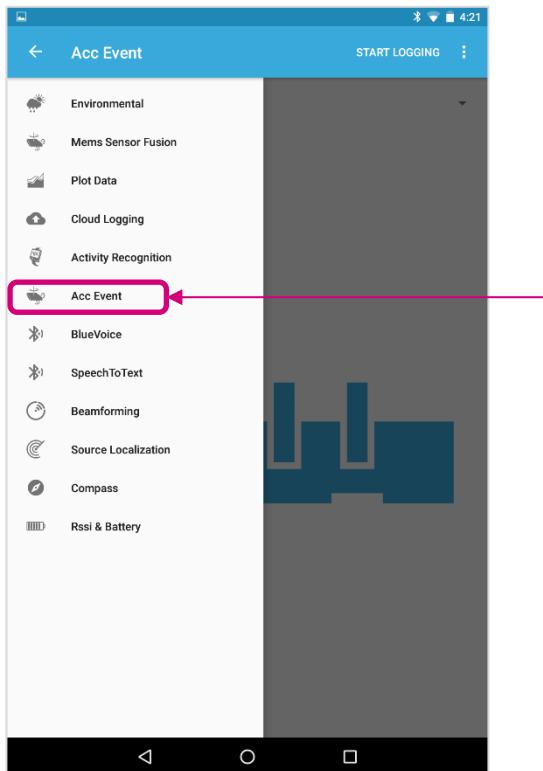
High robustness to mechanical shock makes the LSM6DSM the preferred choice of system designers for the creation and manufacturing of reliable products.

The LSM6DSM is available in a plastic lead grid array.

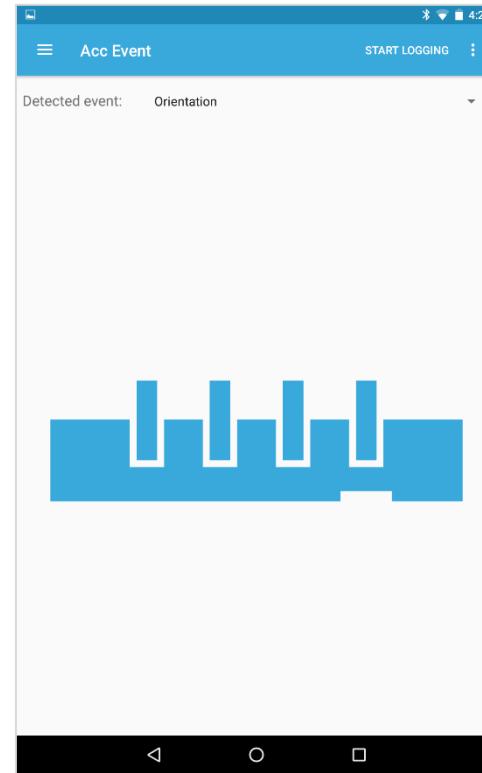
- $\pm 125/\pm 245/\pm 500/\pm 1000/\pm 2000\text{ dps}$ full scale
- Analog supply voltage: 1.71 V to 3.6 V
- SPI & I²C serial interface with main processor data synchronization
- Dedicated gyroscope low-pass filters for UI and OIS applications
- Smart embedded functions: pedometer, step detector and step counter, significant motion and tilt
- Standard interrupts: free-fall, wakeup, 6D/4D orientation, click and double-click

LAB4: Event Detection

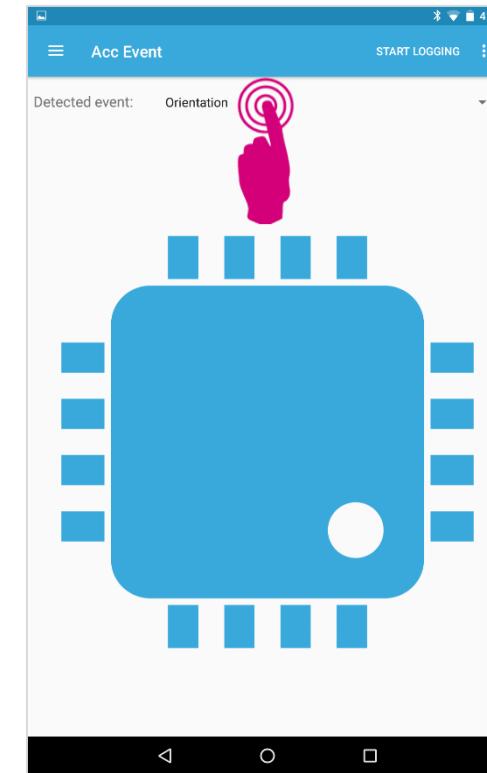
Select “more”
Select “Acc Event”



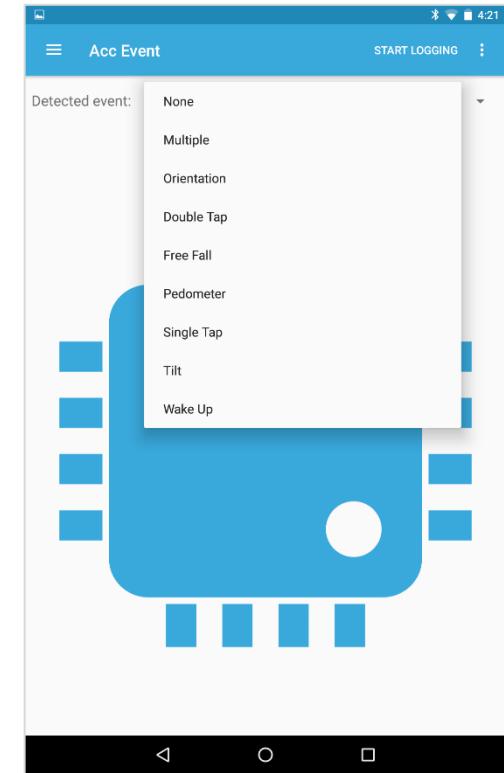
Change orientation



Touch “Event Enabled”



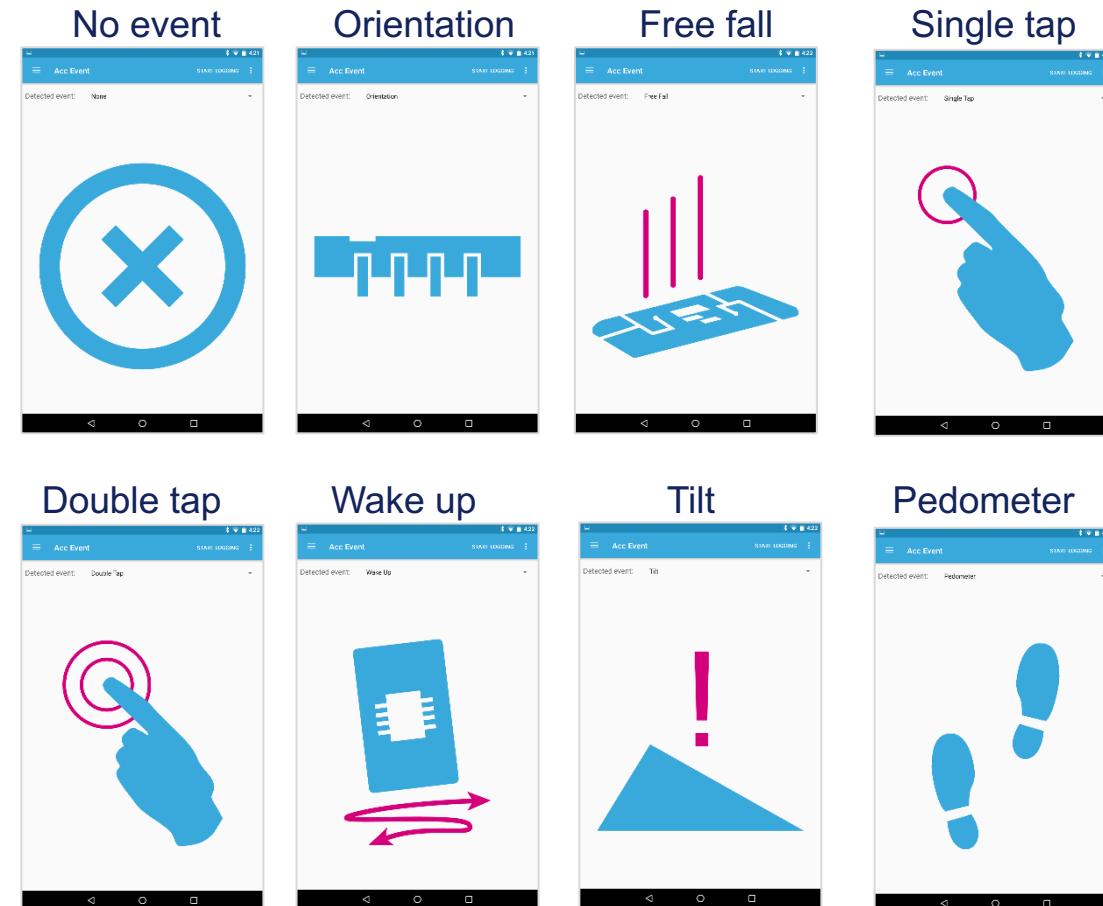
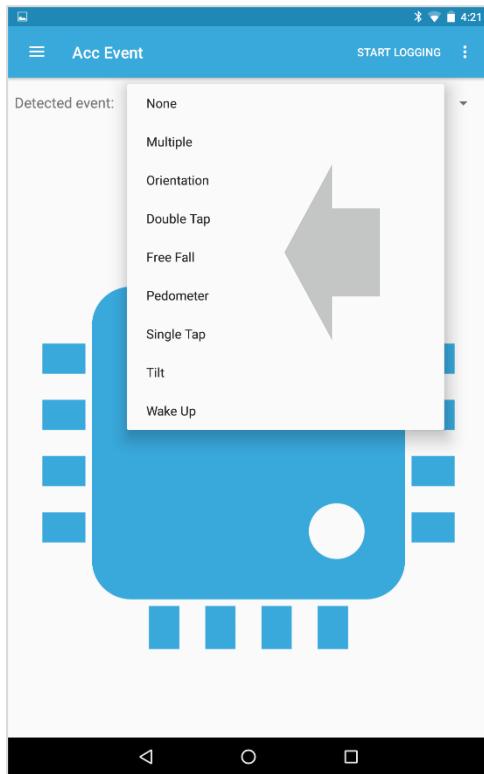
Select another event



LAB4: Event Detection

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

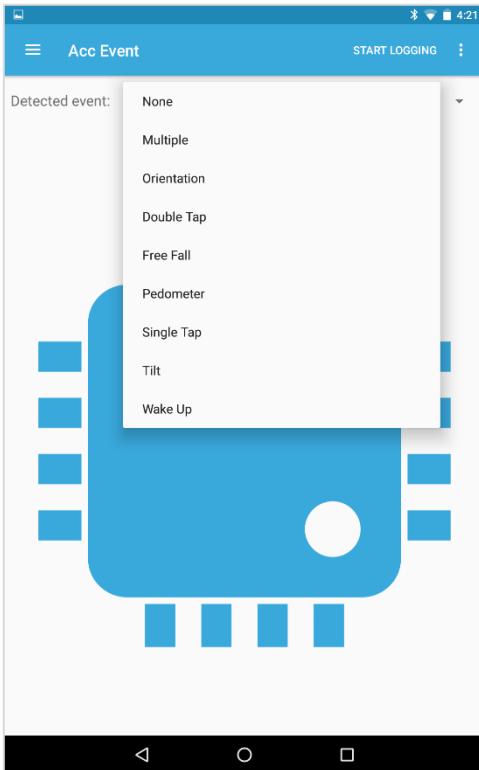
Select another event



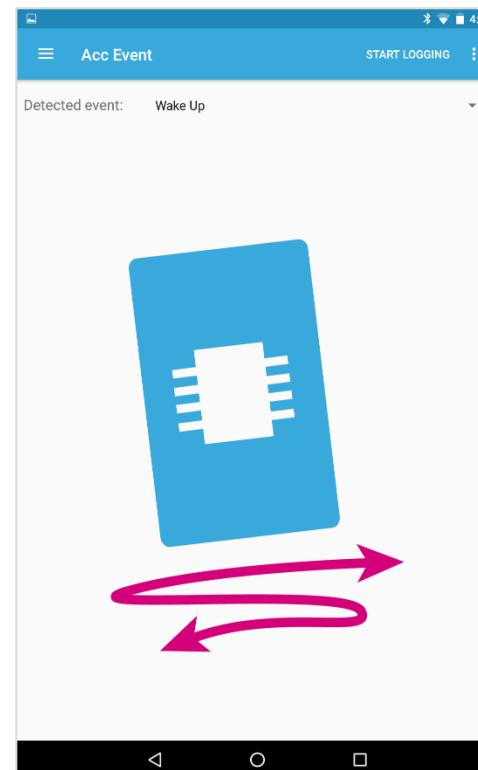
LAB4: Event Detection

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

Select another event



Wake Up



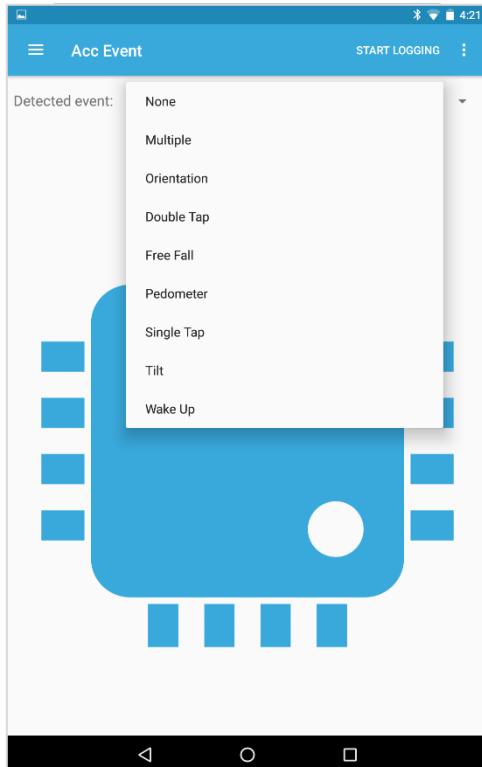
LAB

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)

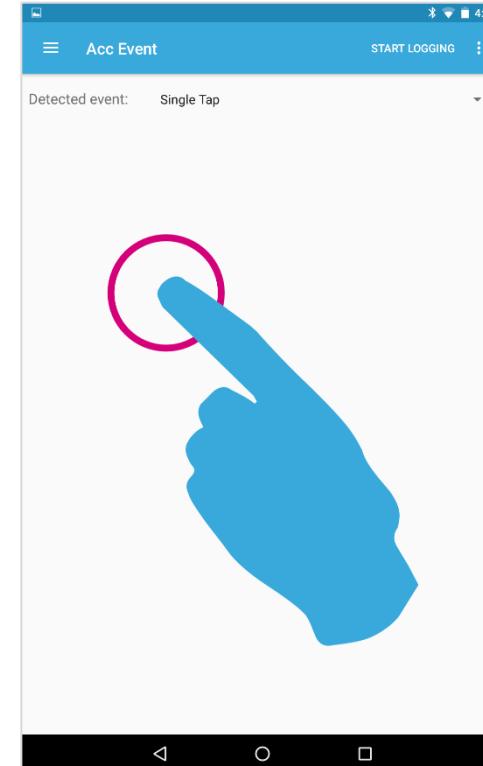
LAB4: Event Detection

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

Select another event



Single Tap



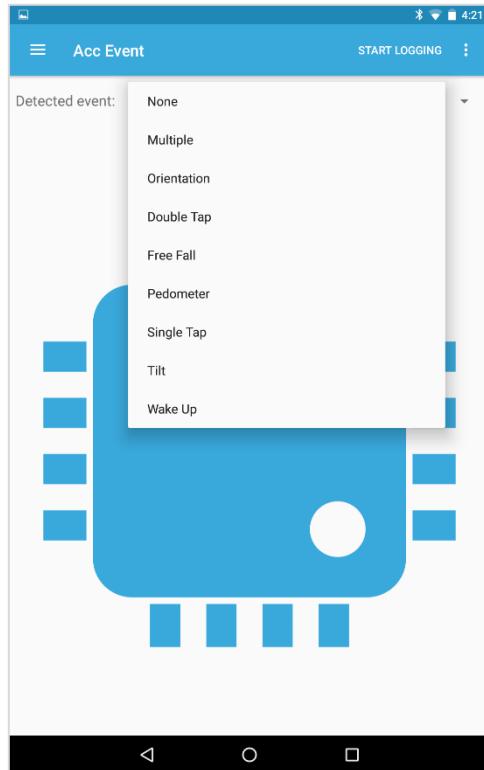
LAB

Tap the device. What happens for the double tap?

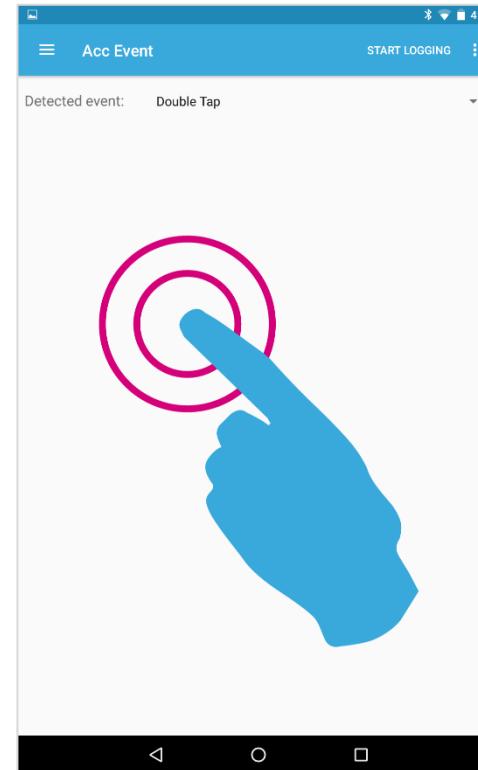
LAB4: Event Detection

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

Select another event



Double Tap



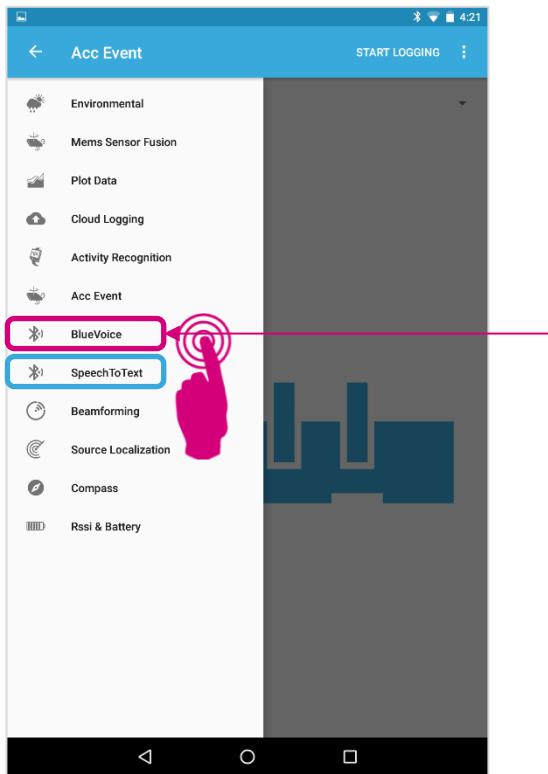
LAB

Double tap the device. What happens now for the single tap?

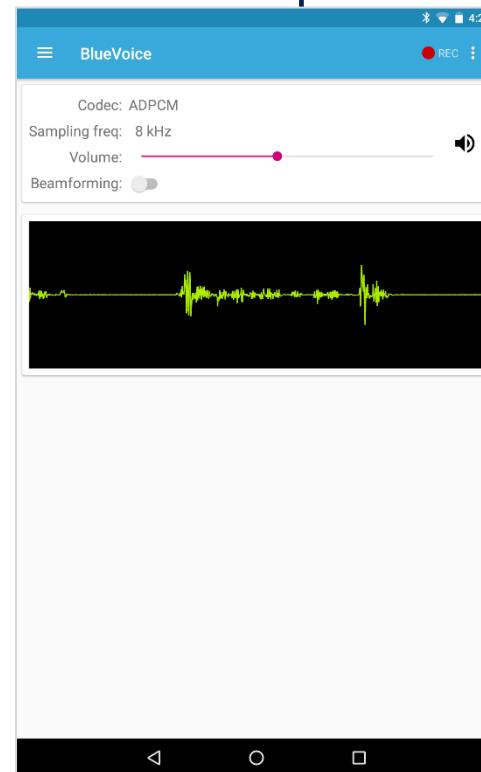
LAB5: Voice over Bluetooth LE

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!)

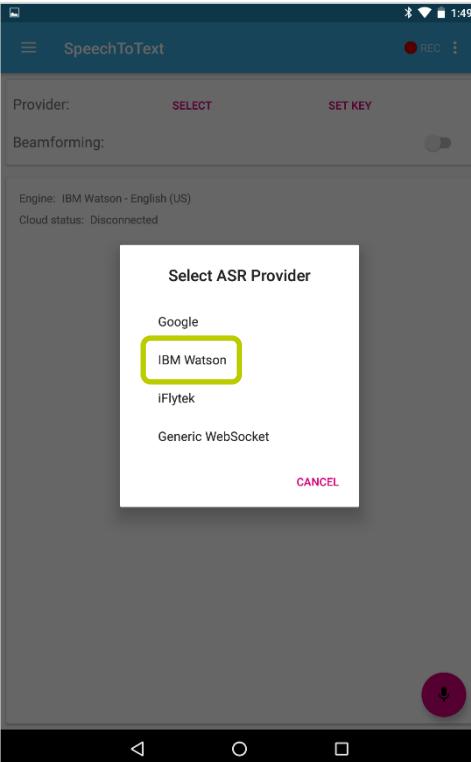
Do not silence your phone,
must not be vibration only!

LAB6: SpeechToText

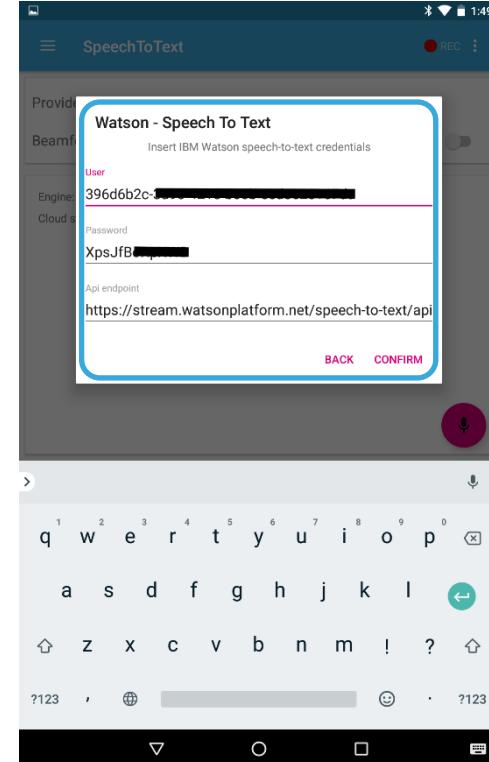
Select ASR Engine



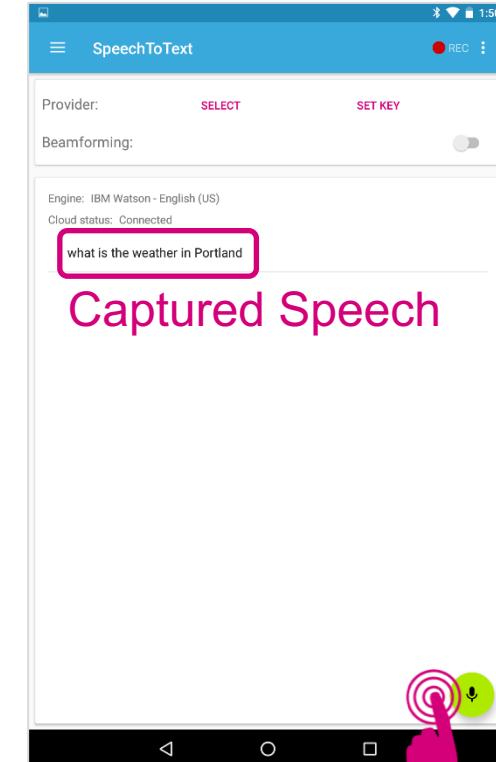
IBM Watson



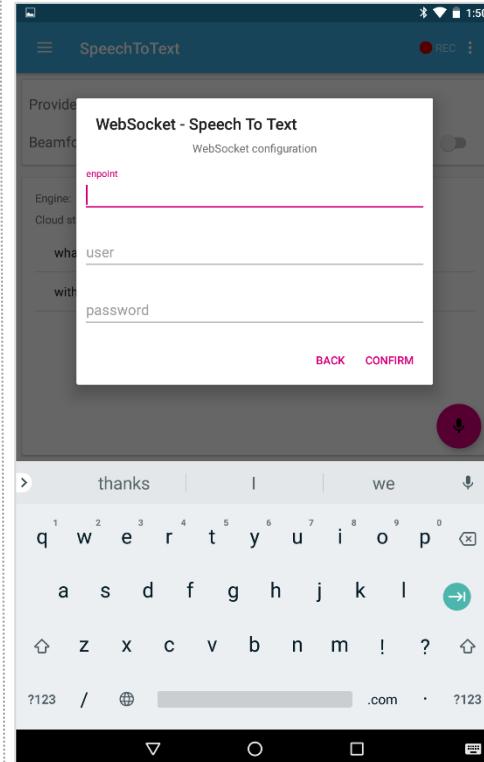
Add credentials



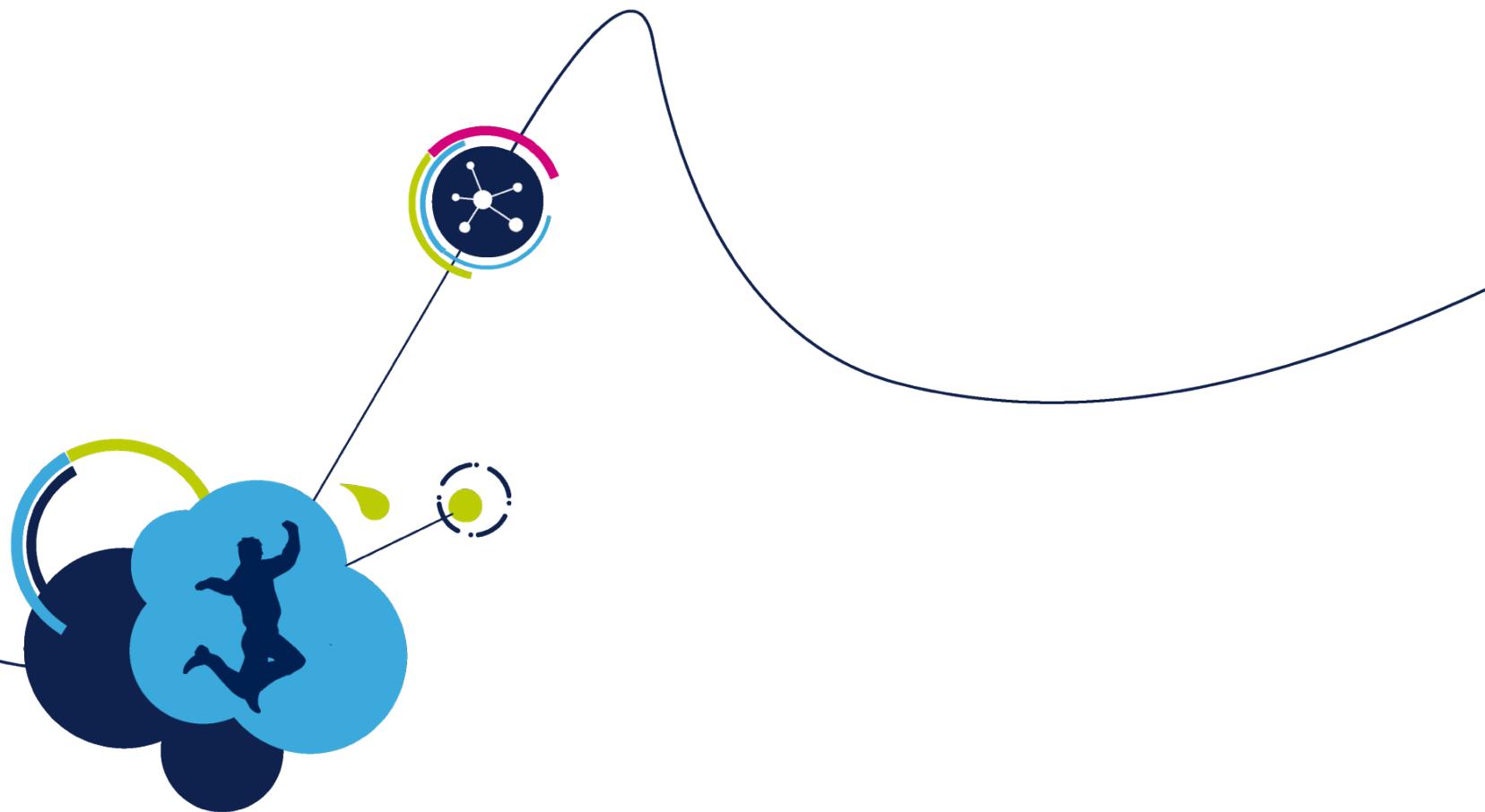
Start/Stop recognition and speak



Alternatively Use WebSocket



- Double Tap on BlueCoin
- Or Tap on Screen



Questions?