Sens’it device
all you need to know

Overview of the Sens’it device
Find quickly what you need

- Hardware
- Casing
- Firmware
- Certifications
- Test Bench

Sens’it Hardware
Sens’it versions

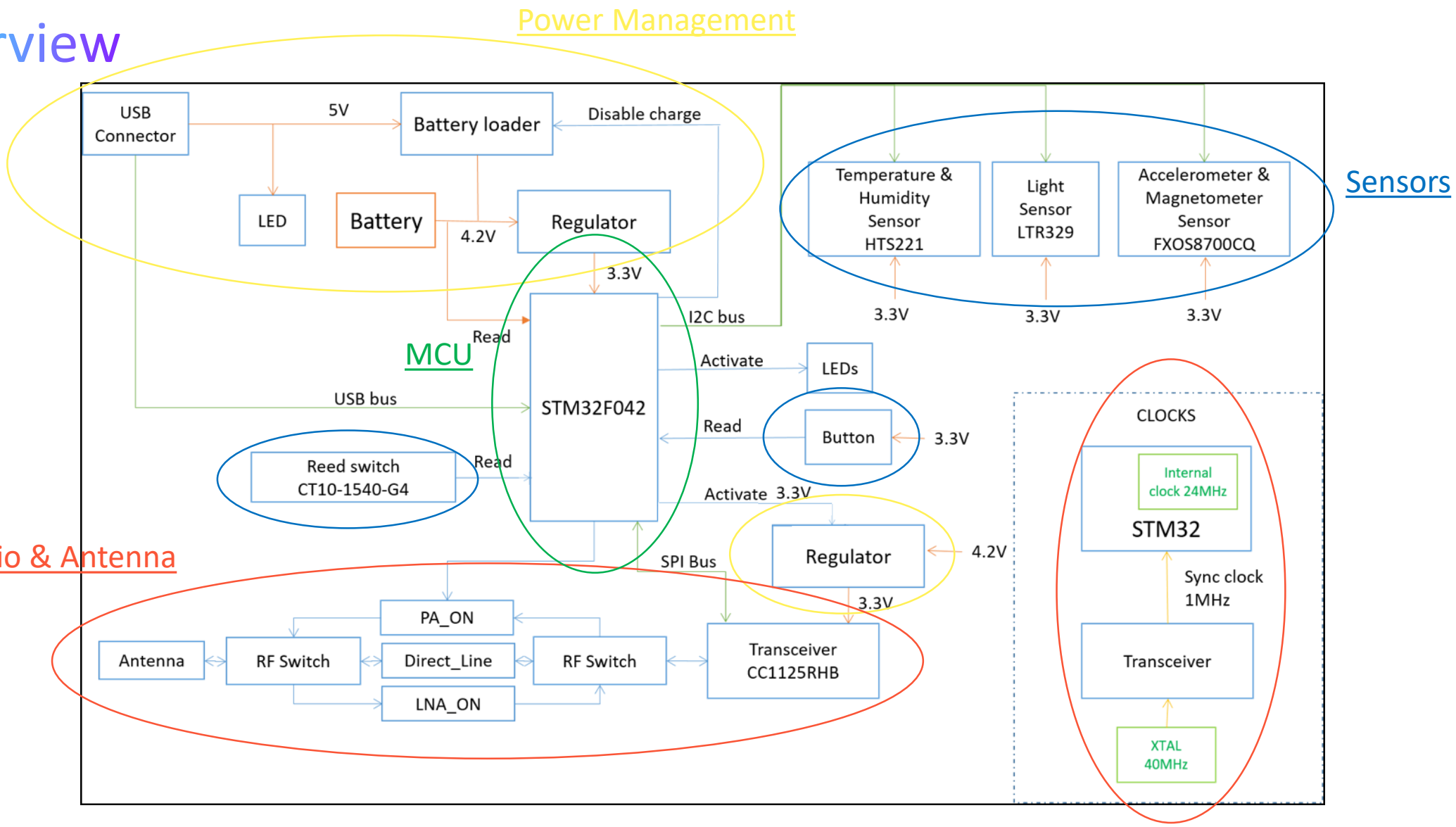
There are 2 PCBs and a lot of “middle” changes :
Sens’it device evolved because of the solution Sens’it discovery evolutions

- Sens’it 1: first version of the Sens’it only for RC1
  Goody focused

- Sens’it 2 & 3: same PCB for all the Sigfox RCs (discrete radio design)
  Choice to keep the same PCB to avoid certification heavy process; but certification is based on the product name so we had to do them anyway.

Sens’it 2 & 3 Hardware

Overview



Sens’it 2 & 3 Hardware
MCU

- MCU is STM32F042
  - ST microelectronics offers a lot of sample code for drivers => faster development
  - Most of the IDE are including ST microelectronics products

- Pin I/O number: all used on this hardware, it is optimized
- Internal clock: not very precise RTC, it limits real time accuracy
- Memory size: includes the Sigfox Library, the USB and I2C stacks and we are using a non-volatile part of the memory to store data (including Sigfox Credential). The memory size is getting to small (on Sens’it discovery, there is no USB usage and no test-bench code because of the lack of space ; they are in detached binary code)
  Consumption: This is not a low power microcontroller but it is not always mandatory to use one in IoT. Idle current and capacity to wake up from low power mode are more important
- Flashing process: you can reflash the MCU. It was a requirement for the devkit possibilities on the Sens’it discovery (no possibility to flash remotely). Bootloader is not custom (provided by ST microelectronics) and there are some flashing issues sometime

Sens’it 2 & 3 Hardware
Sensors

There are 6 Sensors, 1 button and 3 informative Leds: a real study (benchmark) was done to choose them

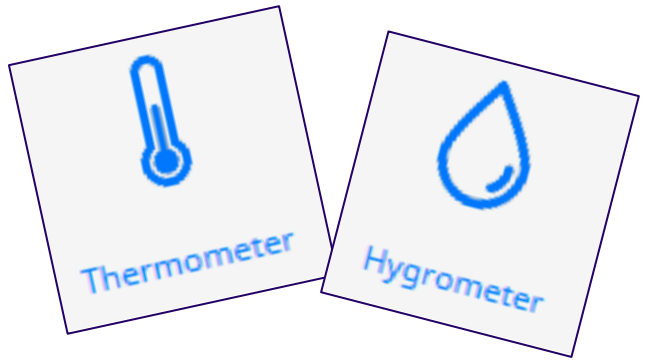
- Temperature and Humidity Sensor
- Light Sensor
- Accelerometer and Magnetometer Sensor
- Reed Switch

Wired on an I2C bus : good choice to limit pin usage

They are used in Sens’it Discovery solution in the modes slide 9

Sens’it doesn’t embed a pressure sensor: it is a limitation for Monarch use cases (no trigger detection)

Sens’it 2 & 3 Hardware
Temperature and Humidity



- Thermometer and hygrometer are included in the same sensor HTS221

- The accuracy of the thermometer is 0,5°C (32.9°F)
  So, value can be slightly different from a Sens’it to another. Up to 1°C

- Be careful, **Sens’it 2** is not water resistant, using it outside can break the hygrometer and it can be stuck at 100%

- Casing impacts the value measurement (Sens’it 2 is not as accurate as the Sens’it 3)

- Sensor choice:
  - Good for consumption: can send an alert via interruption
  - Intelligence: Threshold can be set in the sensor
  - Accuracy is good enough for the use case (but no industrial usage possibility)

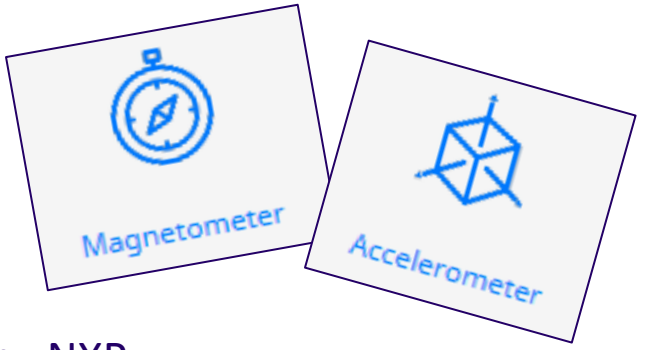
Sens’it 2 & 3 Hardware
Luminosity

- The luxmeter is a LTR329.
- The value provided by this component depends on 3 constraints
  - Temperature
  - Wavelength: there is two channel on the device IR and visible light, we are using the second one. Depending on the wavelength, we can see on the datasheet that the value can be attenuated. To be accurate you need to add a calibration
  - Angle with the light source: depending on the angle there is an attenuation of the value

  The value provided on sensit.io is the direct value. You can be more precise following the datasheet specifications. With the Sens’it Discovery you have a view of the average changes and you know if there is light or not (that is the basic usage)
- Difference between Sens’it 2 and 3: Casing impact
  - Sens’it 2: casing off-the-shelf, no hole for the light sensor, sensor get the data through the casing, not very accurate
  - Sens’it 3: casing adapted to the sensors, better but light source should be above the sensor
- Sensor choice:
  - No interruption pin: not optimized consumption
  - Infrared detection not needed for the use case

  → This sensor might be to performant for the use case: could have use a passive photo diode less expensive

Sens’it 2 & 3 Hardware
Accelerometer and Magnetometer



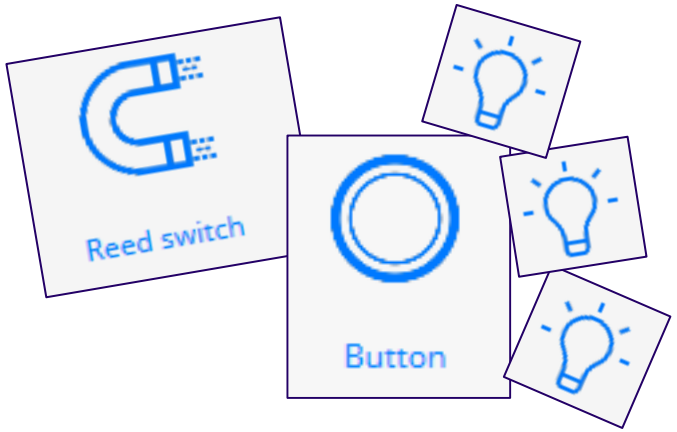
- Accelerometer and Magnetometer are included in the same sensor FXOS8700 provided by NXP

This is a 3-axes accelerometer : range can be chosen between $\pm 2g$ $\pm 4g$ and $\pm 8g$
This is a 3-axes Magnetometer which has a range between $\pm$ 1200 μT

- We are using it in the solution Sens’it Discovery for 2 modes:
  - Vibration detection: using only the accelerometer with the transient detection based on a threshold we defined. We are using an interruption process, each time the accelerometer detects a vibration the Sens’it sends a message. There is a timer between 2 detections to avoid sending to many messages, it is 30 minutes but can be changed in the platform.
  - Door opening detection: using accelerometer and magnetometer with hybrid mode detection
    Read : Sens’it Discovery modes slide 9
- Sensor Choice
  - Smart phone component: a lot of functionalities are not used
  - Magnetometer not very useful for the use case: less complicated with the magnet for the door opening detection
  - Bigger range of “g” is required for some use cases (more industrial)

  → This sensor might be to performant for the use case

Sens’it 2 & 3 Hardware
Reed switch, Button and Leds



- Reed Switch: magnet detector used as a simple button, very low consumption
  There are 2 foot-prints for several Reed switch size, it is easy to change

- Button: They are different for the Sens’it 2 & 3 (less high for the Sens’it 3 because of the casing)
  There is a mechanical security and good pressing sensation
  The Sens’it 3 casing is more adapted to the button
  Bootloader is plugged on the button: cause errors and it is not a good idea at all.

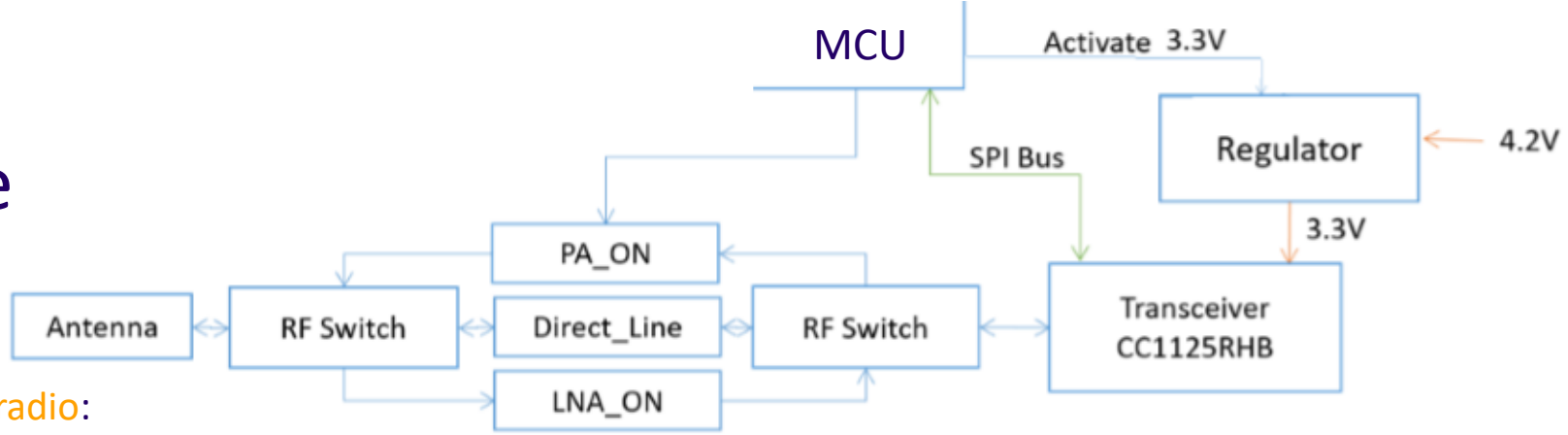
- Leds: There are 3 leds
  - Main RGB led: on Sens’it 2 and first firmware version of the Sens’it 3 SDK, it is not possible to change the intensity of the leds, on the new SDK you can adapt it: it reduces consumption
  - Secondary led: nothing to say
  - Red led: charging information

Sens’it 2 & 3 Hardware
Power management

- Battery Choice:
  - Rechargeable battery: chemical choice Lithium Ion (which is now an issue for air plane use cases)
  - The battery size is small. It was limited on the Sens’it 1 and 2 by the off-the-self casing size. But regarding communication, it was hard to explain that the Sens’it needs to be recharged when Sigfox speech says that Sigfox protocol doesn’t consumes
    Not changing the battery size was an error on the Sens’it 3

- Power management architecture:
  - Rechargeable: battery charger used (issue on that there is no direct link between USB and MCU we don’t know if there is an alimentation.
    USB connector not robust: frequently broken
  - PCB powered in blocks to limit consumption: 2 LDR to separate radio and sensor/MCU alimentation

Sens’it 2 & 3 Hardware
Radio and Antenna



- This is a discreet implementation of the radio:

Advantages

  - No module used: more customizable and we have the flexibility to implement new RC or services (Monarch, Bubble)
  - Interesting for learnings purpose to see the composition of a Sigfox radio chip

Disadvantages

  - Transceiver CC1125 was offered by TI at the beginning of the development but not any more, it is expensive and consumes a lot ; at that time it was the only one with a design proposed to communicate on Sigfox on RC2.
  - Front end Rf is not integrated: PA and LNA consumes and it takes space on the PCB (Today can be less expensive)

- How does it work?
  - We use the Direct line for TX and RC on RC 1, 3, 5 and 6 and the PA for TX and LNA for RX on RC 2 and 4
  - Data are provided via SPI communication from the MCU to the transceiver; to avoid delays and wrong transmission all the interruption are stopped. The SPI delays takes part in the modulation
  - Implementation of the Sigfox library is described in the firmware part
- Oscillator used for the frequency isn’t a TCXO. We had a frequency drift issue therefore on Sens’it 3 there is a Thermal Pad above the MCU, oscillator and Transceiver for equal temperature
- Antenna was modified during Sens’it 2 life to switch to RC4 (more expanded frequency band), it is a semi PCB integrated antenna and the previous one was a cork screw. Antenna has good performances but is complicated to produce industrially (beginning of Sens’it 3 we had to add more precision on the folding tools)

Sens’it Casing
Sens’it versions

There are 2 Casings:

- Sens’it 1 & 2: first version of the Sens’it
  Goody focused and no a lot of quantity predicted
  Off-the-shelf casing

- Sens’it 3: new version
  Done by our partner Altyor on a custom mold
  Custom design
  Adapted to the PCB

Sens’it 1 & 2 Casing
All you need to know

Not accurate for the temperature and the luminosity sensors

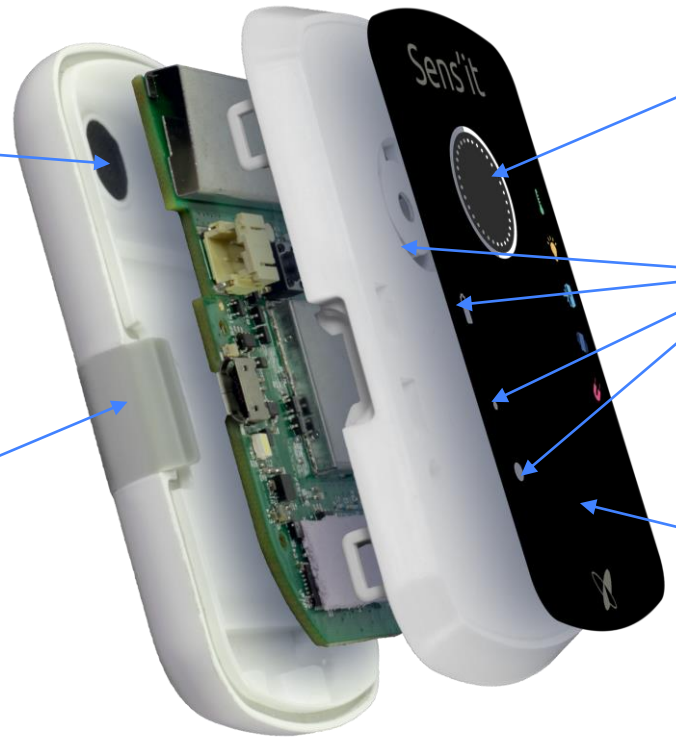
- Casing off-the-shelf: directly bought to Takashi (Japanese company)
- To adapt it to the PCB: we were able to print whatever we needed on the Casing and we did a specific hold for the button
- No water resistant: some clients have destroyed their Sens’it putting it outside
- Issues with shipping delay and cost: everything was increasing and it became not interesting enough for the quantity we were producing.
  Therefore we signed for a custom mold for Sens’it 3

Sens’it 3 Casing
All you need to know

Custom mold designed by Altyor for the Sens’it PCB
Ownership of the mold is on Altyor side

Hole behind the casing to avoid humidity and wrong temperature value

Water resistant casing IP54: specific coverage for USB connector and seals
See certificate



Real button with real pressing sensation

Light guides
For leds propagation and Lux meter

Customizable Lexan: specific offer

Error in the design: bigger battery anticipation

Sens’it Firmware
Sens’it versions

There are different firmware organization:

- Sens’it 1: It was a different PCB so totally different firmware
- Sens’it 2: Code has been done by Axible, it is a spaghetti code
- Sens’it 3: new version
  Based on a Sens’it SDK developed by Sens’it Team.
  Very modular and downloadable for free for a devkit usage

How to flash a Sens’it?

Sens’it 2 Firmware
Organization

Sens’it 2 firmware is organized around the Sens’it Discovery application
To switch from AT command to Test bench to Sens’it Discovery application there are compilation flags
There are not a lot of different files (.h or .c) and it is very confusing “Spaghetti code”
It was done very fast (because of the quick development)
Radio modulation is coded in “Assembly-language programming” good for timings but very hard to maintain

→ **Hard to maintain, Hard to modify**

Sens’it 3 Firmware
Organization

Sens’it 3 firmware has been fully reworked

Sens’it 3 firmware is an SDK:

- First layer: sdk lib compilated when provided in the SDK on build.sigfox.com (file called: Lib)
  It is in charge of all the deep layers, it integrates the Sigfox libraries (including the verified test modes)
  It integrates the different peripheral configurations, the buses drivers and the MCU settings.
  As an output it creates a Sensit_API and a Sigfox_API in the SDK archive
- Second layer: is open when given in the SDK on build.sigfox.com (file called: sdk)
  It gives the codes to creates the AT commands, the payload of the Sens’it Discovery solution, the battery management, the sensors management etc.

When you download the SDK archive you get 3 files:

doc – firmwares (upgrade and SensitDiscovery binary file) – sdk

Inside the SDK, you have all the files from the second layer and the first layer compiled sources. You can start developing your **applicative firmware** in this last file

Having the “Lib” not accessible prevent modifications of the Sigfox management files (modulations, etc.)

→ **Easier to maintain and to modify**

Sens’it 2 & 3 Firmware
How to reflash a Sens’it?

/!\ Warning for Sens’it 2: you need to upgrade the memory organization before flashing any firmware based on the Sens’it 3 SDK

Find here the explanation and the firmware

To flash the Sens’it you need to go in bootloader mode,

What is bootloader?

The tutorial to flash the Sens’it is here (same process for Sens’it 2 & 3)

Main questions:

- Be careful depending on your computer to use the binary or the dfu file
- On MAC OS several dfu targets can be found: take care to chose the correct one

Sens’it Firmware

Sens’it 2 is compatible with the Sens’it 3 SDK

Sens’it 2 and 3 are very similar

- Based on the same PCB organization
  - Same I/O configuration
  - Same drivers/communication buses
  - Same registers, etc.

Only difference:

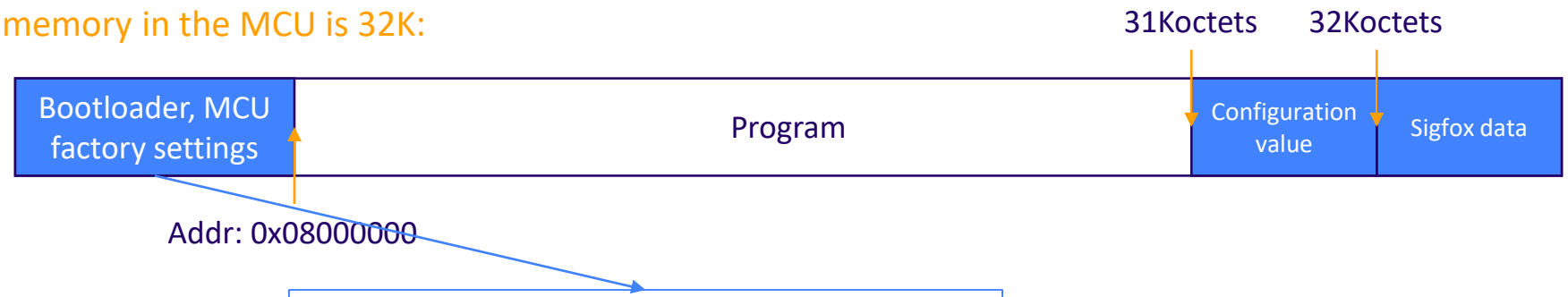
- Memory pages organization:
  Sens’it memory size is 32Koctets.
  On the Sens’it 2 the page to store the Sigfox ID and Key was on the [28K,30K[pages
  The Sigfox Library size has increased since the Sens’it 2 first firmware, there is a size issue
  Therefore, we moved the memory pages to the last ones [31K,33K[. We have now 2 more pages for the Sens’it 3 firmware
  Linkerscript has been upgraded to avoid writing on the last pages

→ SDK is based on this new organization: **Need to upgrade the memory of a Sens’it 2 if you want to use SDK**

WARNING : For Sens’it 2, Flash the Upgrade file before any other file on build.sigfox.com

Sens’it 3 firmware
Memory organization

Sens’it flash memory in the MCU is 32K:



Bootloader and MCU factory settings:
Developed by ST microelectronics, the bootloader redirects your program to the correct area in the memory. It allows the developer to configure/reflash the MCU
You can enter the bootloader mode when the pin of the MCU Boot0 is “high” when the device resets. This pin on the Sens’it is PF11 and it is wired to the button
To enter the bootloader, you need to reset the Sens’it (shortcut or 4 clicks on the button on the Sens’it discovery implementation slide 14) and to press the button at the same time

Sens’it Certifications

Type of certifications

There are several certification to pass to be able to communicate on Sigfox and export Sens’its in the world

Certifications delivered by Sigfox

- Validation that the modem is compliant with the Sigfox radio specifications (good communication performances)
- Certificate Verified is delivered
- For Sens’it we have 1 “Modem certificate” for Sens’it 3 and 1 for Sens’it 2
- It allows us to ask for a batch of Id&PAC (and Key) for the production

- Validation that the casing does not impact the communication, gives a Class to the device Certificate Ready is delivered
- For Sens’it 3, we have a “Product certificate” for each RC and one for the Generic on Sens’it 2 we have one “Product certificate” for all the RC
- Associating the ID&PAC to this certificate allows us to register the device in the Sigfox Cloud for communication

Certifications delivered by countries governments

- Provided by each country independently
- Test if we respect their countries communication rules (emission power etc.)
- For Sens’it we have a “Type approval” for various countries (different for Sens’it 2 and 3)
- It allows us to import (customs at the border) the Sens’it in the targeted counties

Sens’it Certification
Sigfox Verified

1 contract for all the RC

Sens’it 2 : M_0011_A051_01

Sens’it 3 : M_0056_6296_01

The certificates allows us to get batches of ID/PAC/Key to communicate on Sigfox network

- The Sens’it 2 certificate was owned by Axible : we have no visibility on it
- The Sens’it 3 certificate is owned by Sigfox and until now we have ordered 2 batches :
  - 149 ID for pre-series
  - 9000 ID for series

We gives the crypted file taken in the CRA to Altyor and they put the credential on the test bench 3 in the production

Before getting the certificates, we need to performs specific tests

Sens’it Certifications
Sigfox Ready

Number of certificates changes along Sigfox organizations

Sens’it 2: only one for all the RCs
P_001E_CCCA_01

Sens’it 3:
Sens’it Discovery (sold by Sigfox)
RC1: P_0006_321A_01
RC2: P_0006_077E_01 (derived)
RC3: P_0006_DAD8_01 (derived)
RC4: P_0006_1A21_01 (derived)
Generic (sold by Altyor)
RC1: P_0006_6EBD_01 (similarity)

When a order is made to Altyor, we associate the ID&PAC delivered to Geodis (when Altyor is selling a Sens’it Generic, it provides the same way the ID&PAC list to associate to the Generic product certificate) to the corresponding product certificate. This is an other information mandatory to enter the Sigfox Cloud

Before getting the certificates, we need to performs specific tests

Sens’it Certifications

Type approval

Specification different for each country (group of countries)

To complete the certification, tests and paper work are requires, it can take 3 months and cost 3000€ (price depends on coutry). Therefore on Sens’it, Sigfox is taking in charge the process only if the order number is above 300 units

Usually, it is mandatory to add a specific logo and number on the product, and/or the legal manual, and/or the packaging. Sticker on the product is very small, so when requiring a new certification ask the country committee not to put the logo on the packaging
Careful, back stickers are standards, per RC. If a new certification is required, it can create a specific shipping flow (batch number) *Example: South Africa (different legal manual and packaging), it is a specific “product” so a specific flow. As Geodis is working in FIFO, if it is not tracked standard RC1 from the stock will be shipped. Thanks to the “lot” number there is no issue*

Certifications
Standards

There are standard certifications mandatory to pass the type approvals and for the distributors

Reach
Rosch
IP54
Battery MSDS
Safety
EAN
UL certifications

They all have a cost and are provided by our EMS Altyor
If you need a specific certificate contact the Production Team (Industrialization Team)

Sens’it Certifications
Do I keep the certifications using the SDK?

Ready and Verify (Sigfox Certification)
SDK allows you only to change the application of the Sens’it Discovery
You will keep the Sigfox certification
The only exception: You change the name of the product : you will need to ask Sigfox for a Similar and get a specific certificate for it. → We have done it for the Sens’it Generic

Type Approval (Given by the country where you want to sell)
We don’t master the modification so we disengage ourselves on that
We can provide all the test reports the required certificates
For CE, only need is to declare the conformity with the Sens’it product

Test Bench
Sens’it version

Test bench were very different :

- Sens’it 1: it was a different PCB so totally different Test bench. It was produced by Axible and they did not shared the specifications

- Sens’it 2: it was done by Axible and specifications were not clear at all

- Sens’it 3: we started the Sens’it 3 test bench from scratch.
  It is based on 3 tests benches to test PCB, product and to implement the credentials (customization)

  We were not test bench specialist and we have done many mistakes. The Sens’it 3 test bench is not efficient
  For example the battery should be removed between to flash the firmware on the last test bench (it creates errors)

Any questions ?

Go to ask.sigfox.com