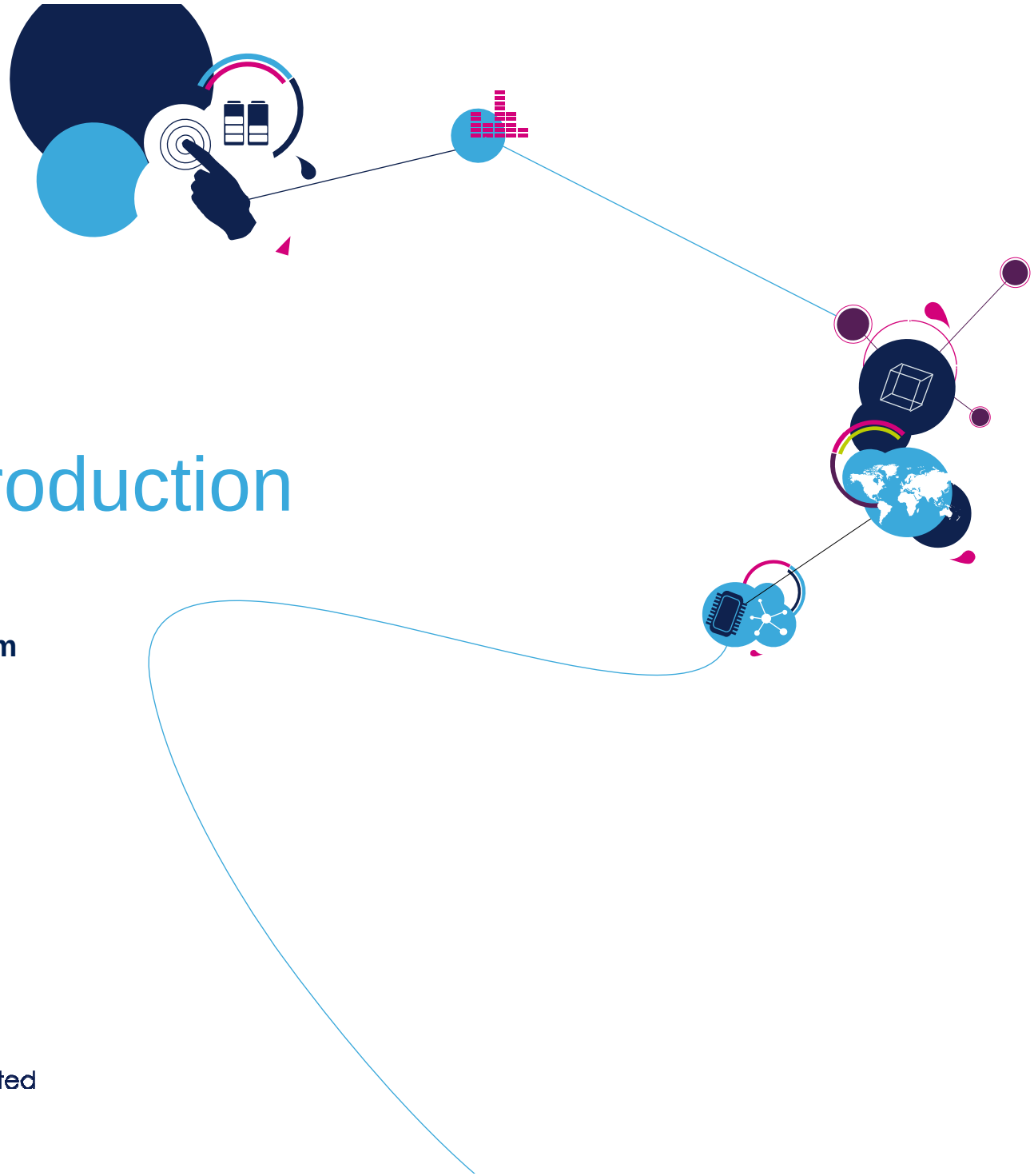

S2-LP Introduction

AMG RF Application team

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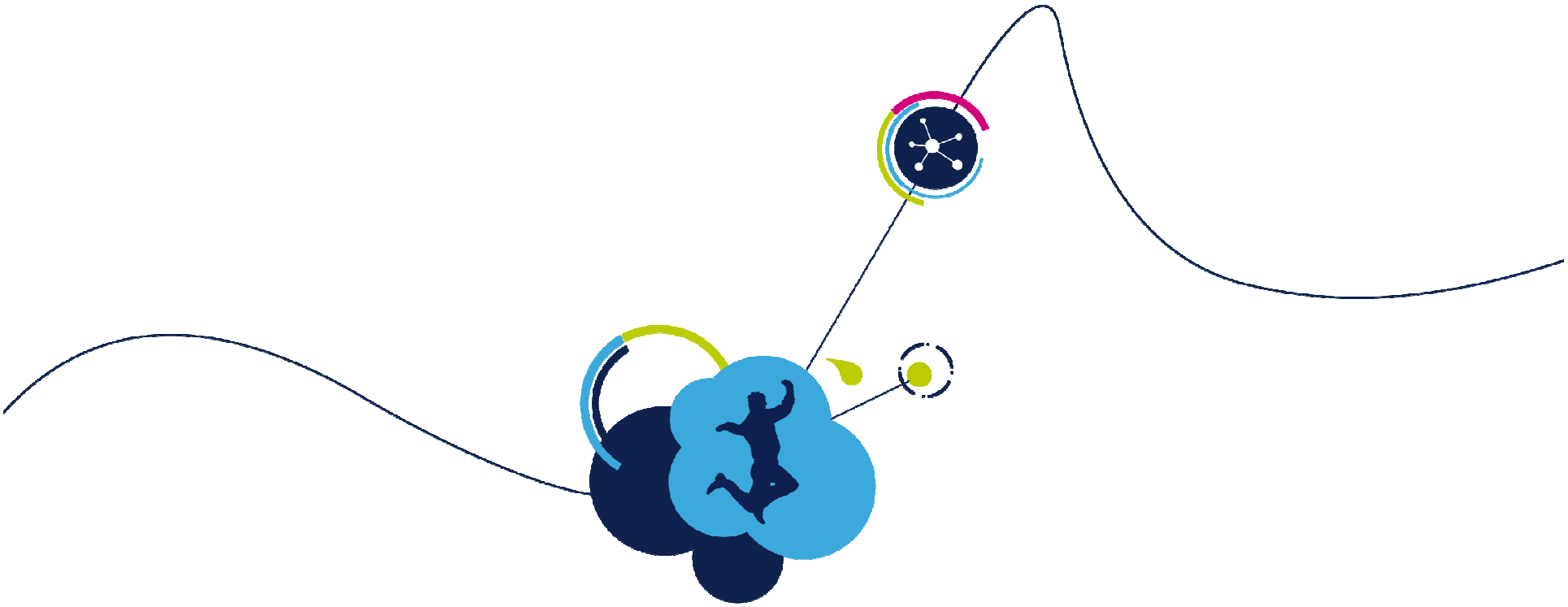
Contents



S2-LP overview

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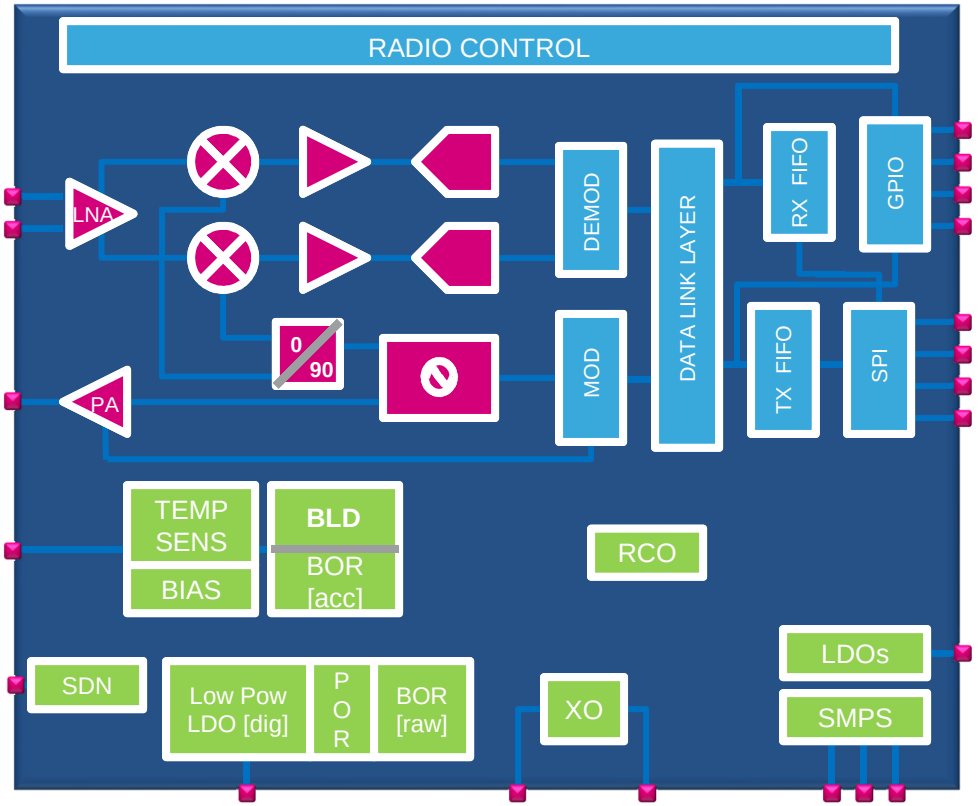
What is the S2-LP?

- The S2-LP is a high performance ultra-low power RF transceiver, intended for RF wireless applications in the sub-1 GHz band (proprietary radio).
- It is not a SOC. It is an SPI slave and an external microcontroller is always needed to drive it.
- The user can implement its own protocol, controlling the timings and the active phases (RX or TX) according to its proprietary protocol.



The S2-LP is not compliant to any standard protocol (like the *BlueNRG* family products)!

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Key points of the S2-LP

- It is designed to operate in both the license-free ISM and SRD frequency bands at **433, 868 and 920 MHz**, but can also be programmed to operate at other additional frequencies in the 430-470 MHz, 860-940 MHz bands

- It supports the following **modulation schemes** with datarate from 0.3 to 250kbps:
  - **Frequency modulations**: 2-FSK, 2-GFSK, 4-FSK, 4-GFSK
  - **Amplitude modulations**: OOK and ASK
  - **Custom modulations**: low level control of the ***SYNTHESIZER*** and ***PA*** (**polar mode**). This feature is used to implement the **SigFox** modulation)

- It has an integrated **SMPS** which allows very low power consumption outperforming all competitors and can be supplied in the range [1.8 , 3.6]V and [-40 , 85] °C

- A packet handler engine is integrated in the chip to assemble and decode packets with PREAMBLE, SYNC WORD, CRC check words, whitening and FEC

- It is possible to configure the device to stay in **low power mode** (SLEEP) and automatically wake-up every an amount of time to transmit or receive. An integrated RCO is used for this scope.

- (Linked to the previous point) It is possible to have a fast RX termination algorithm (SNIFF MODE).

- It is possible to configure the device in a **Listen Before Talk** (even called **CSMA**) configuration to minimize the number of collisions while transmitting.

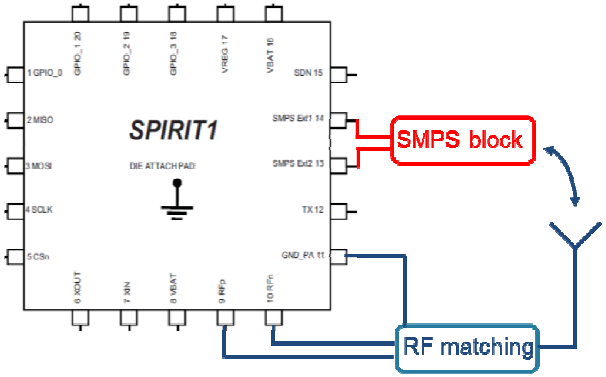
S2-LP consumption

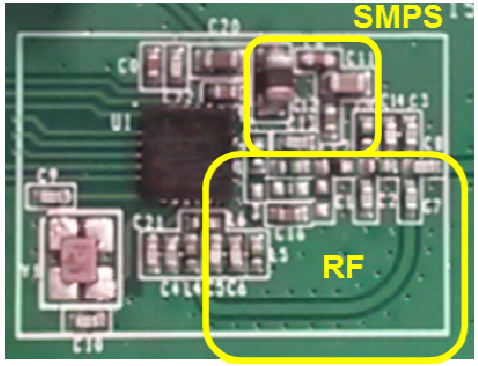
STATE	CURRENT
Shutdown	2.5nA
Standby	350nA
Sleep A (no FIFO retention)	600nA
Sleep B (FIFO retention)	900nA
Ready	350uA
TX (@14dBm)	20.6mA
TX (@10dBm)	10mA
RX	8mA
RX (LPM)	6.7mA

S2-LP vs SPIRIT1

Main differences	S2-LP	SPIRIT1
Frequency bands	One VCO – Bands are 433, 868 and 915 MHz	Two VCOs – Possibility to address the 169 and 315 MHz bands also
Sniff low power mode	Fully supported thanks to the timings mechanism the device embeds.	Only partially supported. The MCU needs to be involved to implement this mode.
SigFox modulation support	It is possible to generate the BPSK modulation thanks to the low level control of the SYNTH and PA.	Not possible
Max Power	14dBm (16dBm in boost mode)	11dBm (16dBm in boost mode)
4(G)FSK modulations	Supported	Not supported
RSSI read while in RX	Supported	Not supported
VCO online calibration	VCO calibration available	Not supported
PA interpolation and PA filters	Supported	Not supported
Data coding	Manchester, 3o6, UART, FEC, whitening, CRC	FEC, whitening, CRC
Dual SYNC	Supported	Not supported
802.15.4g	Supported	Not supported

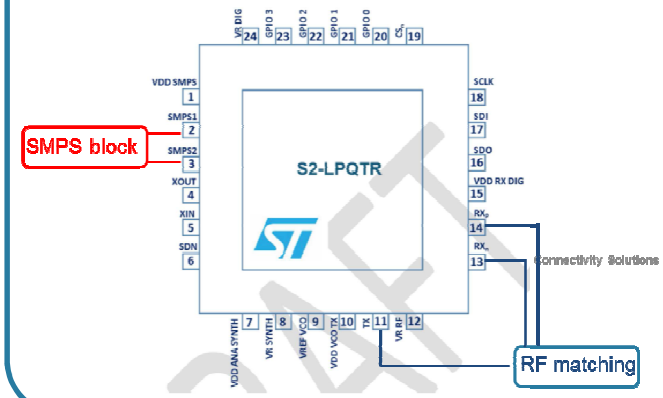
S2-LP vs Spirit1 sensitivity (1/2)

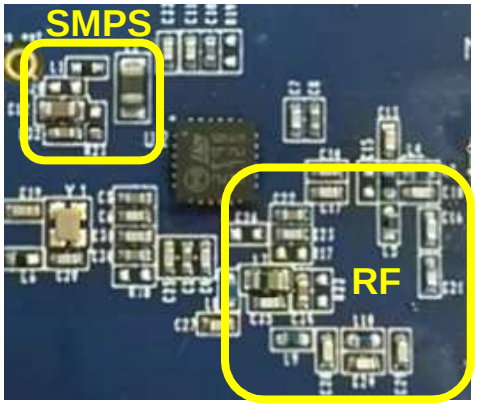




Spirit1

- SMPS block close to RF
  - 2dB noise in conducted mode
- Unique decoupling for all internal voltages (Vreg)
  - 1dB noise in conducted mode
- -121dBm @ 1,2Kbps





S2-LP

- SMPS block further from RF
- Separate decoupling for all internal voltages
- Sensitivity ?

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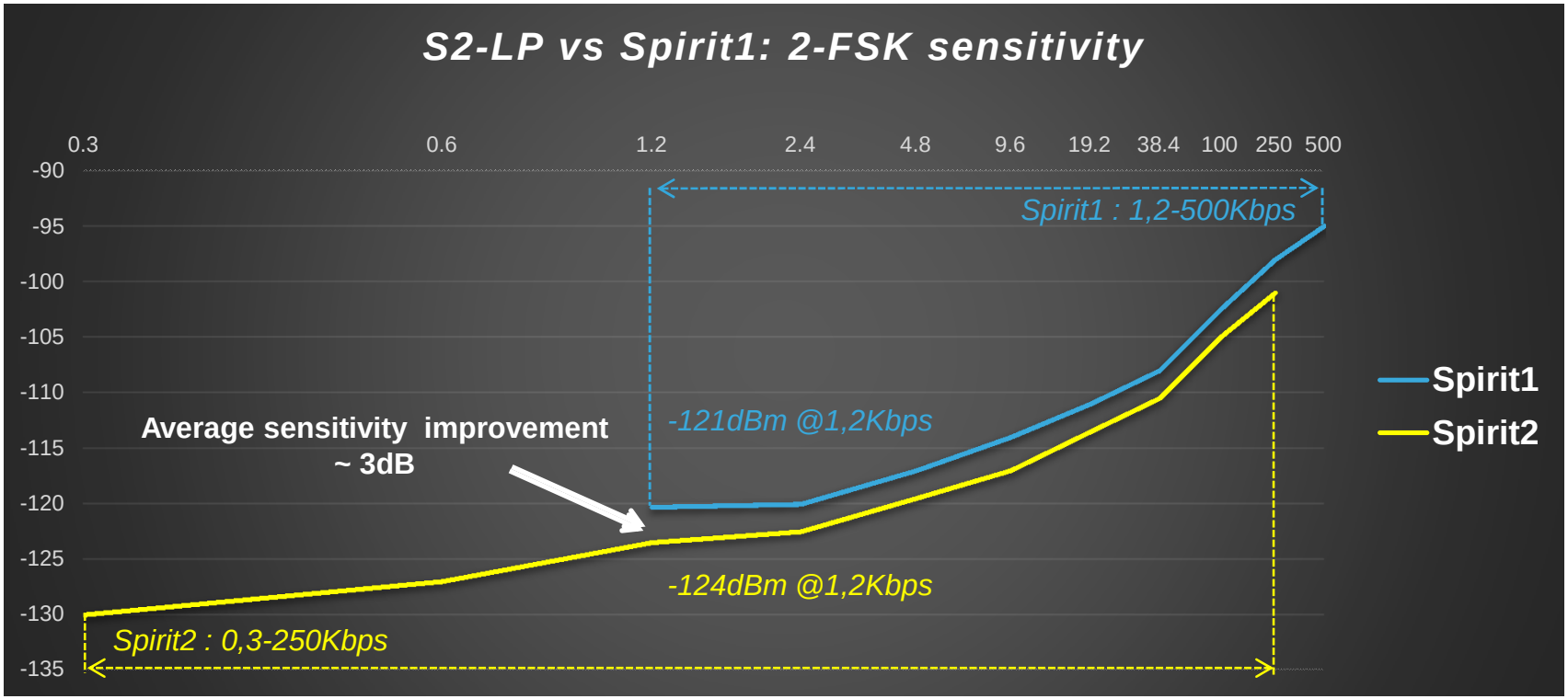
S2-LP vs Spirit1 sensitivity (2/2)



Spirit1 : 1 – 500Kbps
Spirit2 : 0,3 – 250 Kbps

~3dB improvement vs Spirit1

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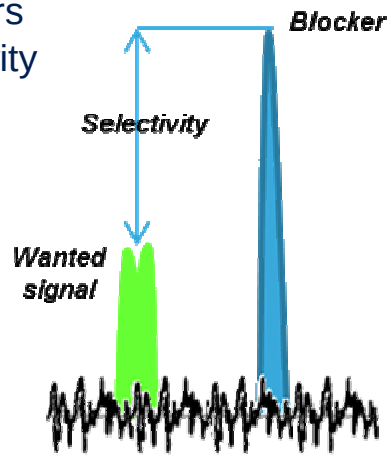
S2-LP selectivity (1/2)

- **Selectivity**: Capability to decode signals in presence of strong nearby interferers
  - Same frequency band (w/ other ISM systems) ➔ Adjacent channel selectivity
  - Nearby frequency band (LTE / GSM) ➔ Blocking selectivity
  - Differentiator : Interferer frequency offset from wanted signal



- **RF regulatory:** defines receiver categories upon required rejection
  - EN300-220 / EN303-131 : Most stringent “category 1”
    - Adjacent rejection ≥ 60dB & 2MHz / 10MHz : ≥ 84dB

More and more people on ISM / New LTE allocation ➔ Selectivity is important !

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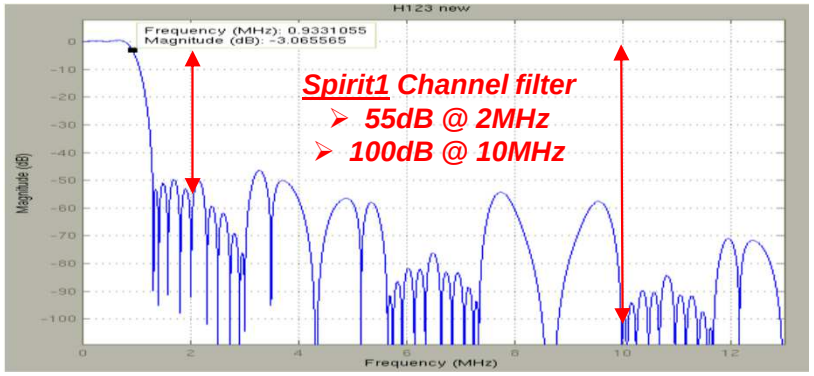
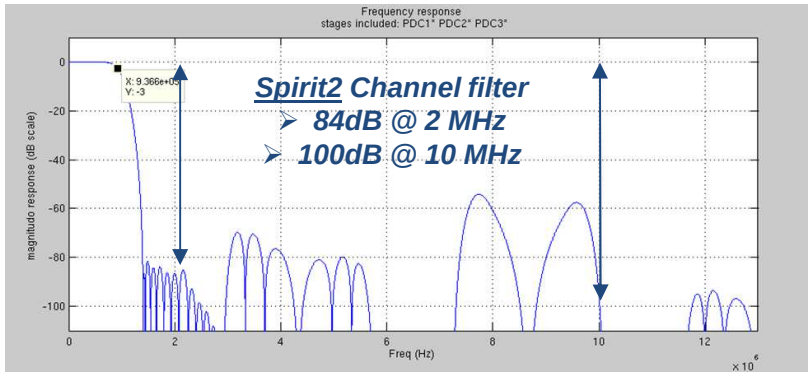
S2-LP selectivity (2/2)

- *Channel filtering improved @ 2MHz compared to Spirit1*





- *S2-LP channel filter is programmable down to 1KHz*

S2-LP		Cat 1	433MHz	868MHz
300 bps	Adjacent	60	/	64
	+/- 2MHz / 10MHz	84	/	87/90
1,2Kbps	Adjacent	60	67	59
	+/- 2MHz / 10MHz	84	84/84	81/84

S2-LP is in *cat1* in these configurations

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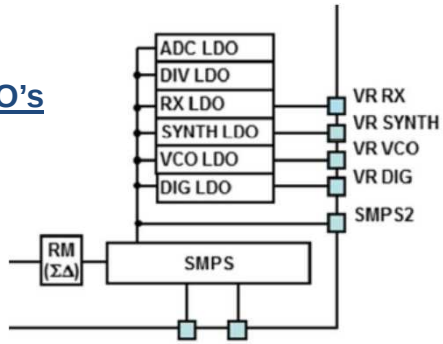
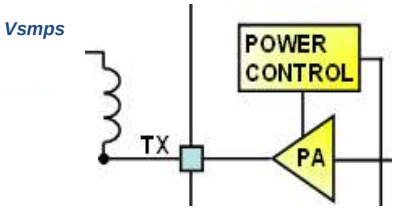
S2-LP Power management

S2-LP LDO tree

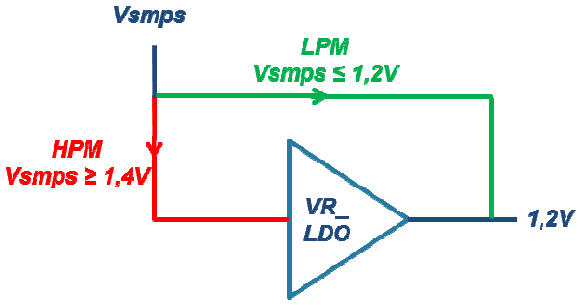
Internal LDO's



PA Bias



S2-LP power modes



- **BM = Boost mode (**Vsmps = 1,8V**)**
  - ➔ Enables to get +16dBm @ antenna connector

- **HPM = High Performance Mode** (Vsmps = 1,5V)
  - ➔ Internal LDO's used to supply different blocks
  - ➔ Best possible isolation and minimum noise level/ SMPS ripple

- **LPM = Low Power mode** (Vsmps = 1,2V)
  - ➔ Internal LDO's **by-passed** ➔ Blocks are directly supplied by Vsmps
  - ➔ Better regulation efficiency (+16%) but higher noise & reduced isolation

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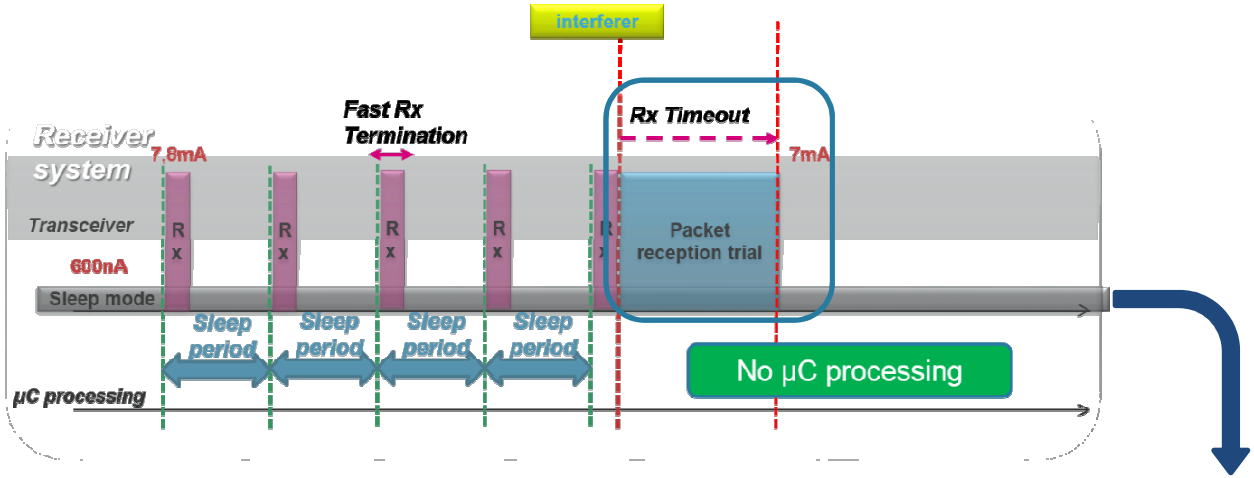
RX fast termination



- S2-LP can automatically do SLEEP-RX and ***sniff*** for the power on the air:
  - RCO can be calibrated to be precise in waking up the device
  - If power is NOT detected, the device goes again to sleep
  - If power is detected, the device remains in RX with the RX timeout or until the SYNC is detected
  - If SYNC is detected, the RX is kept so that the packet is fully received

S2-LP allows to do the channel power sniffing without involvement of the external MCU

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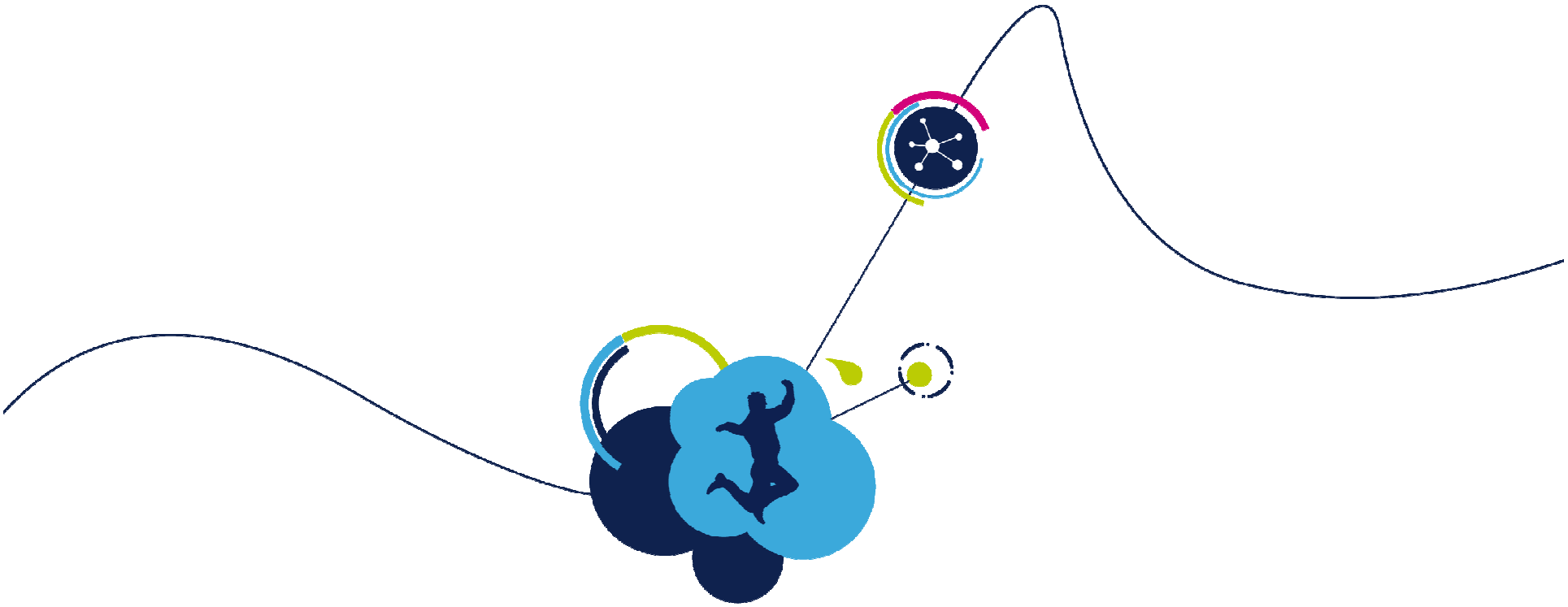

S2-LP kits description

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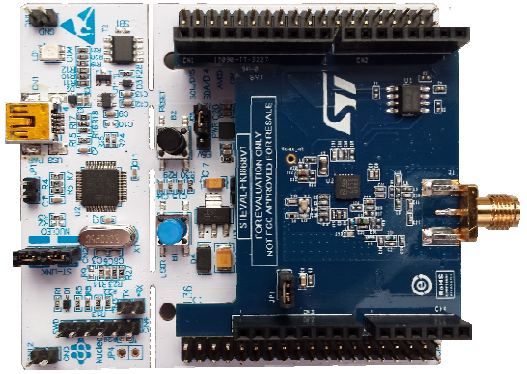
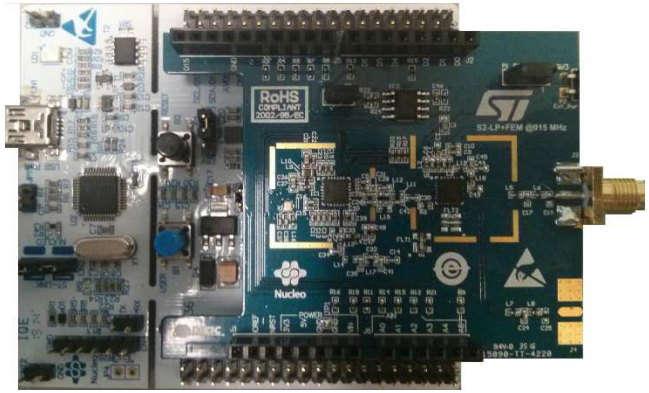
S2-LP Evaluation kits

- The S2-LP evaluation kit is composed by 2 boards:
  - 1 Daughterboard: a shield Arduino connectors compatible
  - 1 Motherboard: STM32L152RE_NUCLEO or STM32L053R8_NUCLEO
  - 1 Antenna tuned for the band used by the board



- The motherboard can be plugged to a PC and driven with a specific software delivered by ST



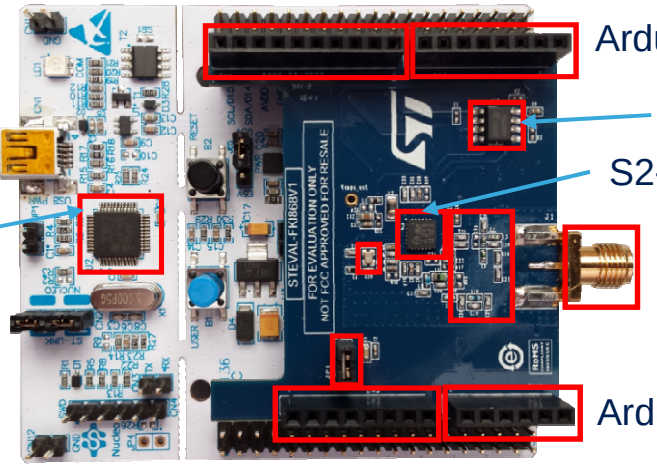
http://www.st.com/content/st_com/en/products/evaluation-tools/solution-evaluation-tools/communication-and-connectivity-solution-eval-boards/steval-fkiXXXv1.html

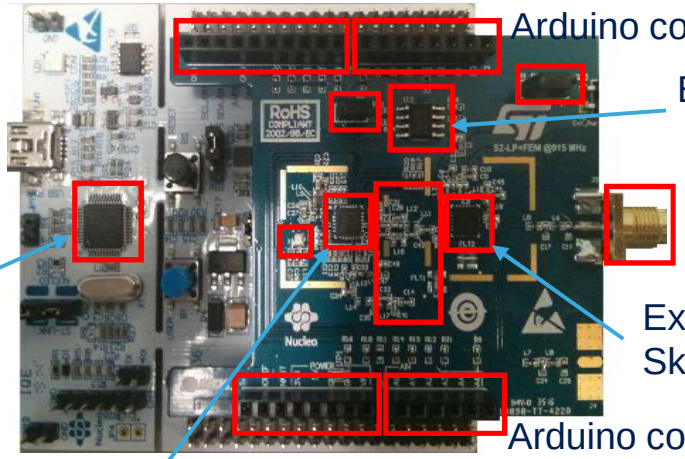
XXX=433,868,915

S2-LP Kits Part Number

Kit part number	Daughter Board	Mother Board	Sub-1GHz STD compliancy	SigFox support
STEVAL-FKI433V1	S2-LP + 433MHz band matching network	STM32L152RE_NUCLEO	**China**: SRCC	-
STEVAL-FKI868V1	S2-LP + 868 and 915 MHz bands matching network	STM32L152RE_NUCLEO	**Europe**: ETSI EN 300 220, ETSI EN 303 131 **US**: FCC part 15 and part 90 **Japan:** ARIB STD T67, T108	Could be used also for SigFox in the RCZ1/3 configurations
STEVAL-FKI915V1	S2-LP + 868 and 915MHz bands matching network	STM32L152RE_NUCLEO	**US**: FCC part 15 and part 90	Could be used also for SigFox in the RCZ2/4 configurations

Kits Hardware





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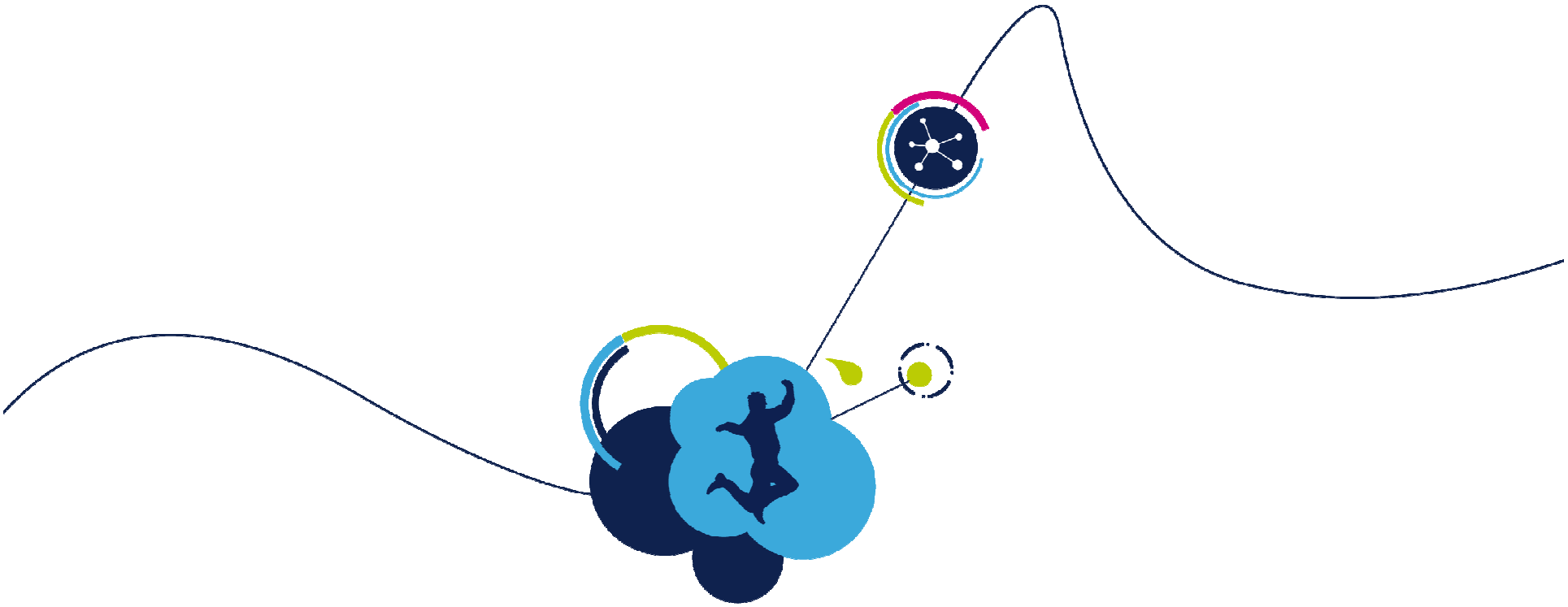

S2-LP software packages

STSW-S2LP-DK

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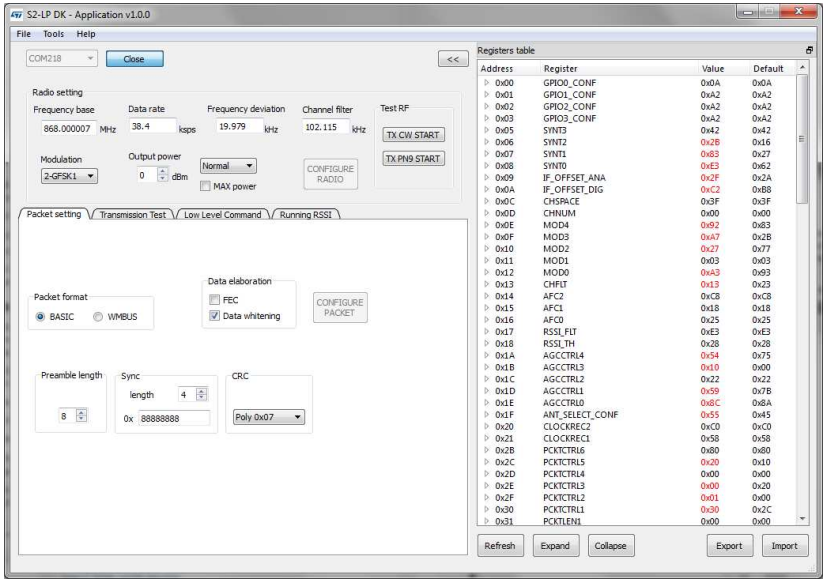
S2-LP DK Application

- A GUI allowing:
  - Radio and packet handler easy configuration
  - RF tests (TX of unmodulated carrier, TX PN9 sequence, RX activation)
  - Packet transmission/reception test with PER evaluation
  - Packet transmission/reception test with Sniff low power mode
  - Register read/write and dump
  - C-code generation for fast configuration



- Firmware examples:
  - Demonstrating how to use the S2-LP features in an STM32 embedded application
  - In a single IAR workspace
  - Each program (A and B roles of each example) is an *IAR* and *MDK-ARM Keil* configuration and can be compiled and flashed on the NUCLEO board using the embedded ST-Link.

- Documents:
  - *UM2149*: Getting started with the S2-LP development kits
  - Schematics, gerber file and BOM of each *STEVAL-FKI* board
  - Firmware doxygen documentation

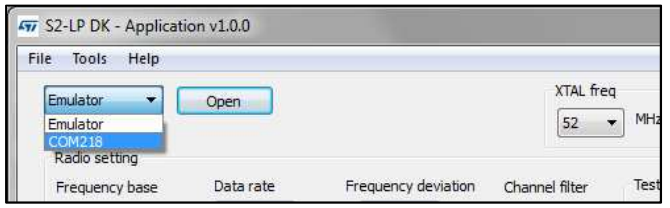
STSW-S2LP-DK Setup

1. Download the STSW-S2LP-DK from http://www.st.com/en/embedded-software/stsw-s2lp-dk.html

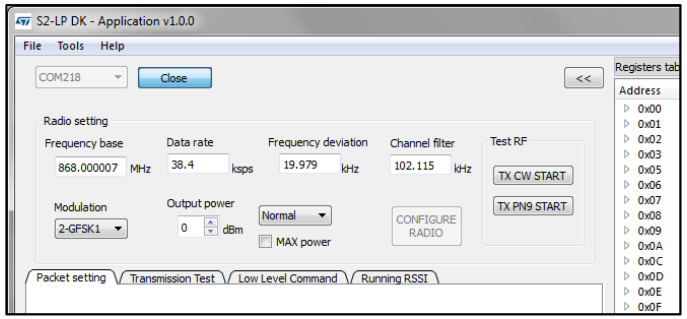
2. Unzip the package and launch *S2-LP DK-Setup-1.0.0.exe*

3. Launch the *S2-LP DK GUI*

4. Plug the board via USB. The port combo-box will detect the COM where the S2-LP is connected.



5. Click on *Open* . At this stage the GUI is ready to perform the actions defined in the user manual.



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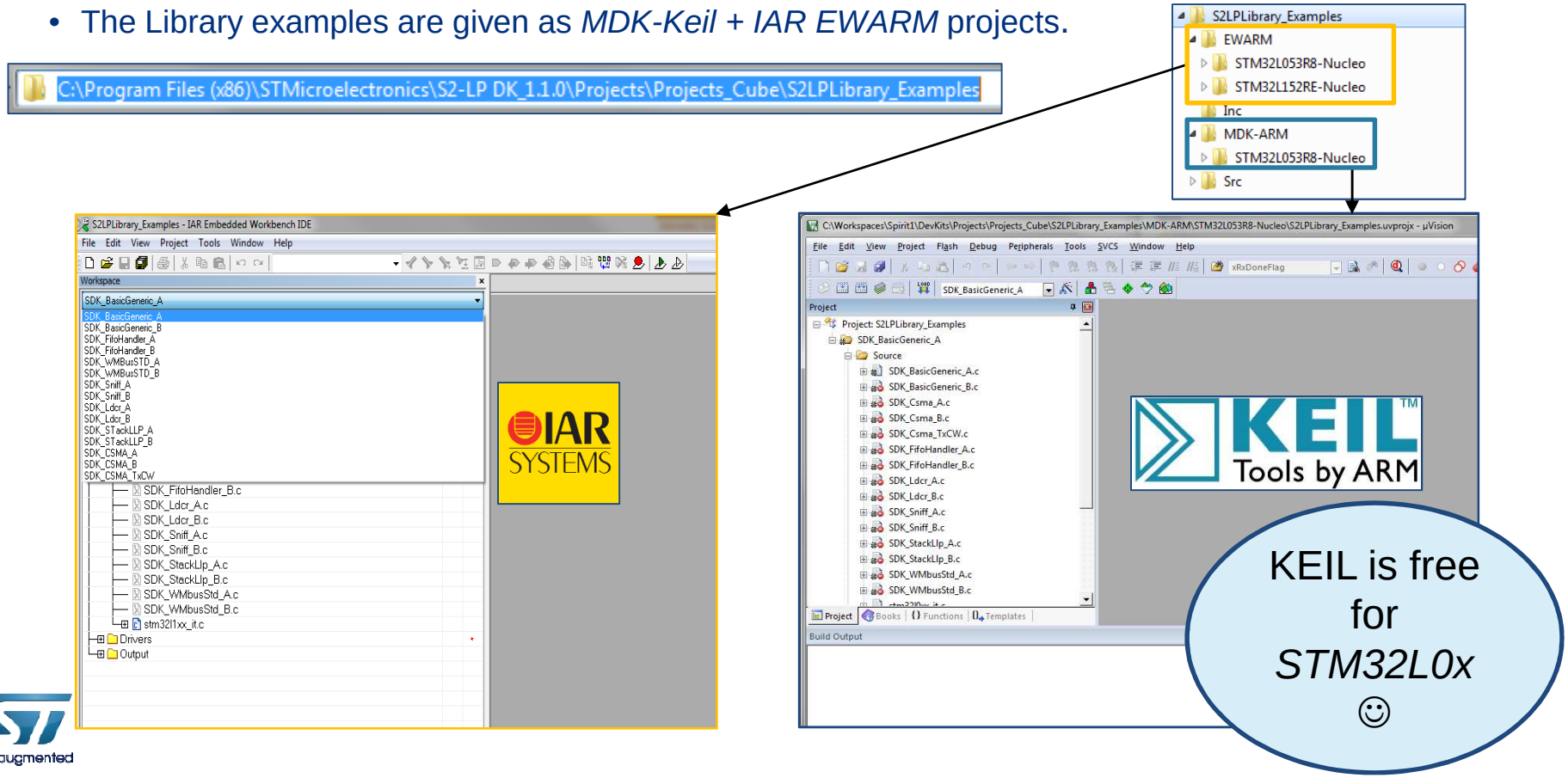
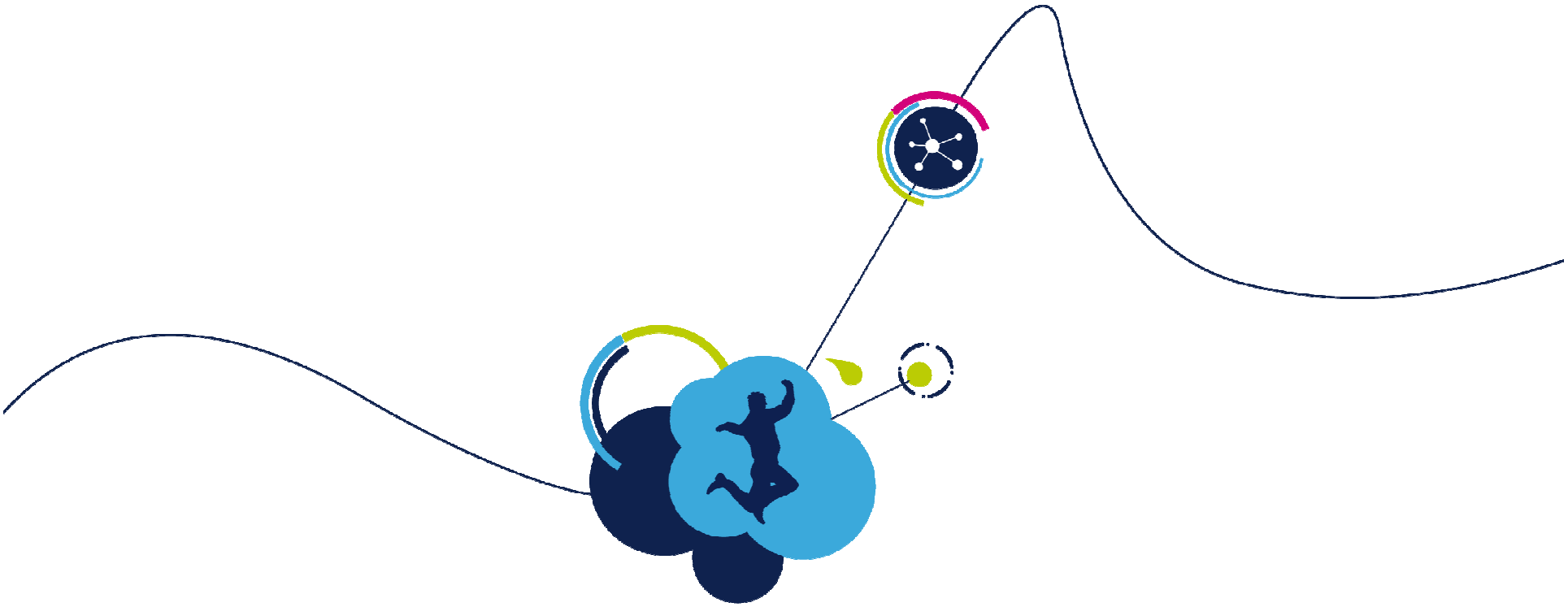
Firmware examples

- S2-LP DK 1.0.0 supports only STM32L152RE (*ARM-CM3* core).
  - The Library examples are given as an *IAR EWARM* project.
- From **S2-LP DK v1.1.0**, the STM32L053R8 (*ARM-CM0+* core) is also supported.
  - The Library examples are given as *MDK-Keil + IAR EWARM* projects.



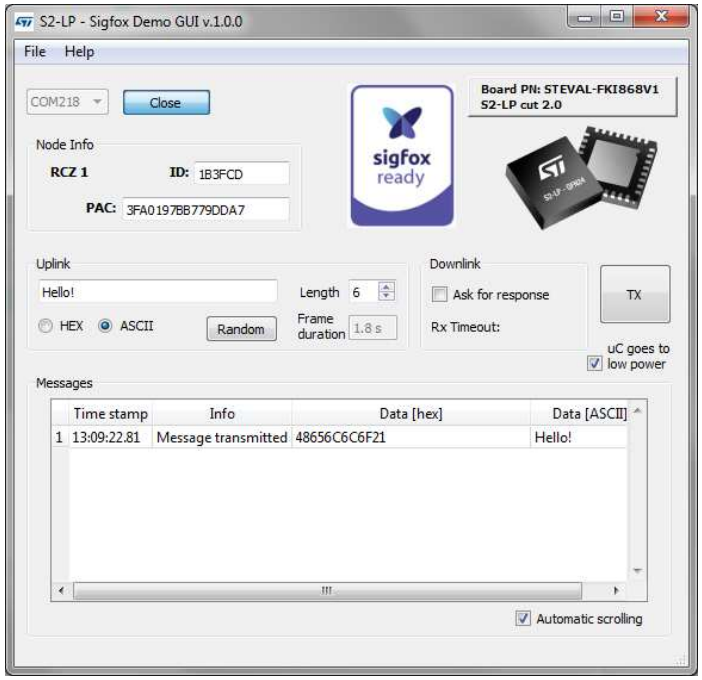


S2-LP software packages

STSW-S2LP-SFX-DK

S2-LP SigFox GUI Application

- S2-LP SigFox Demo GUI PC application :
  - Quick SigFox messages exchange
  - Choose the message payload
  - Set the downlink mode
  - Perform the node registration



- Documents:
  - *SigFox Dev Kits User Manual*
  - *SigFox Firmware User Manual (including the current consumption profiles for each RCZ)*
  - A Doxygen including guidelines to write a SigFox application and to do a quick porting to another platform

- ST-SigFox API for S2-LP:
  - C embedded libraries to develop that can be easily ported to other platforms
  - One simple embedded application to send uplink messages
  - IAR and Keil workspaces

STSW-S2LP-SFX-DK Setup

1. Download the STSW-S2LP-DK from http://www.st.com/en/embedded-software/stsw-s2lp-sfx-dk.html

2. Unzip the package and launch *S2-LP_SigFox_DK-Setup-1.0.0.exe*

3. Launch the *S2-LP - SigFox Demo GUI*

4. Plug the board via USB. The port combo-box will detect the COM where the S2-LP is connected.

5. Click on *Open* . If the board hasn't the SigFox ID info, the GUI will launch a wizard procedure to register the node.