FROM RESEARCH TO INDUSTRY

cea tech

L-IOT : A FLEXIBLE PLATFORM FOR ULTRA LOW POWER IOT

Ivan MIRO-PANADES, Edith BEIGNE | Workshop NVRAM | May 2017

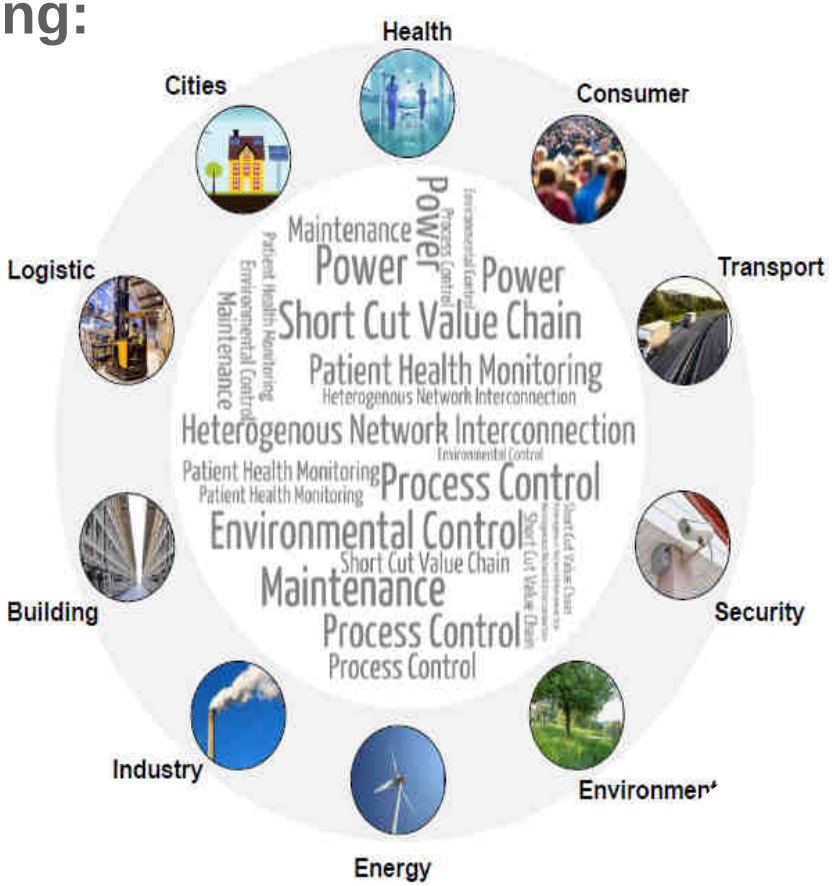
OUTILE

- Motivation
- L-IOT architecture
- Case study: Wake-Up Radio
- LIOT available offer
- Conclusions

VARIABLE ENERGY AND APPLICATIVE NEEDS

- **Many different applications:**
  - … with variable Energy needs

- **Changing environments impacting:**
  - Energy harvesting
  - Communication channels
  - Sensing
  - Image
  - Security level

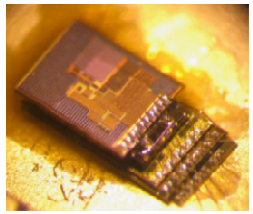


USUAL SMART DEVICE ARCHITECTURE AND APPLICATIONS

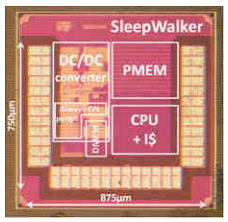
Applications

- Video surveillance Smart Camera
- Secure wireless communications
- Data Fusion
- Tracking and Monitoring

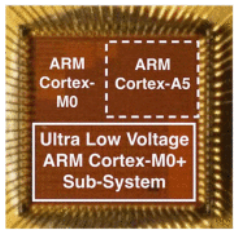
Perf./
Energy needs



Micro Mote M³
15nW stdby
304nW (motion detection)
180nm
Kim, G. et al, VLSI'14



SleepWalker
1.7µW stdby
7µW/MHz@0.4V(25MHz)
65nm
Bol, D. et al, JSSC'13



ARM M0+ SubSyst
80nW stop
2mW@0.85V(30MHz)
65nm
Myers, J. et al, ISSCC'15

ST STM32L0
0.27µA stdby
139 uA/MHz(32 MHz)
130nm
STM, STM32L053C8,'14

TI CC2650
1µA stdby
6mA (RX/TX mode)

TI, CC2650,'15

pW-µW area

mW area

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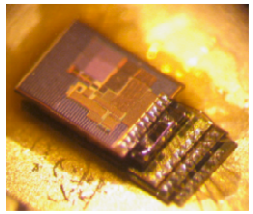

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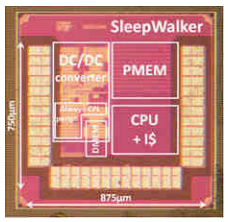

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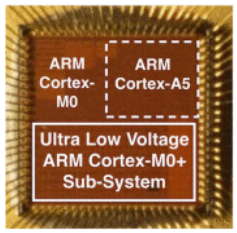

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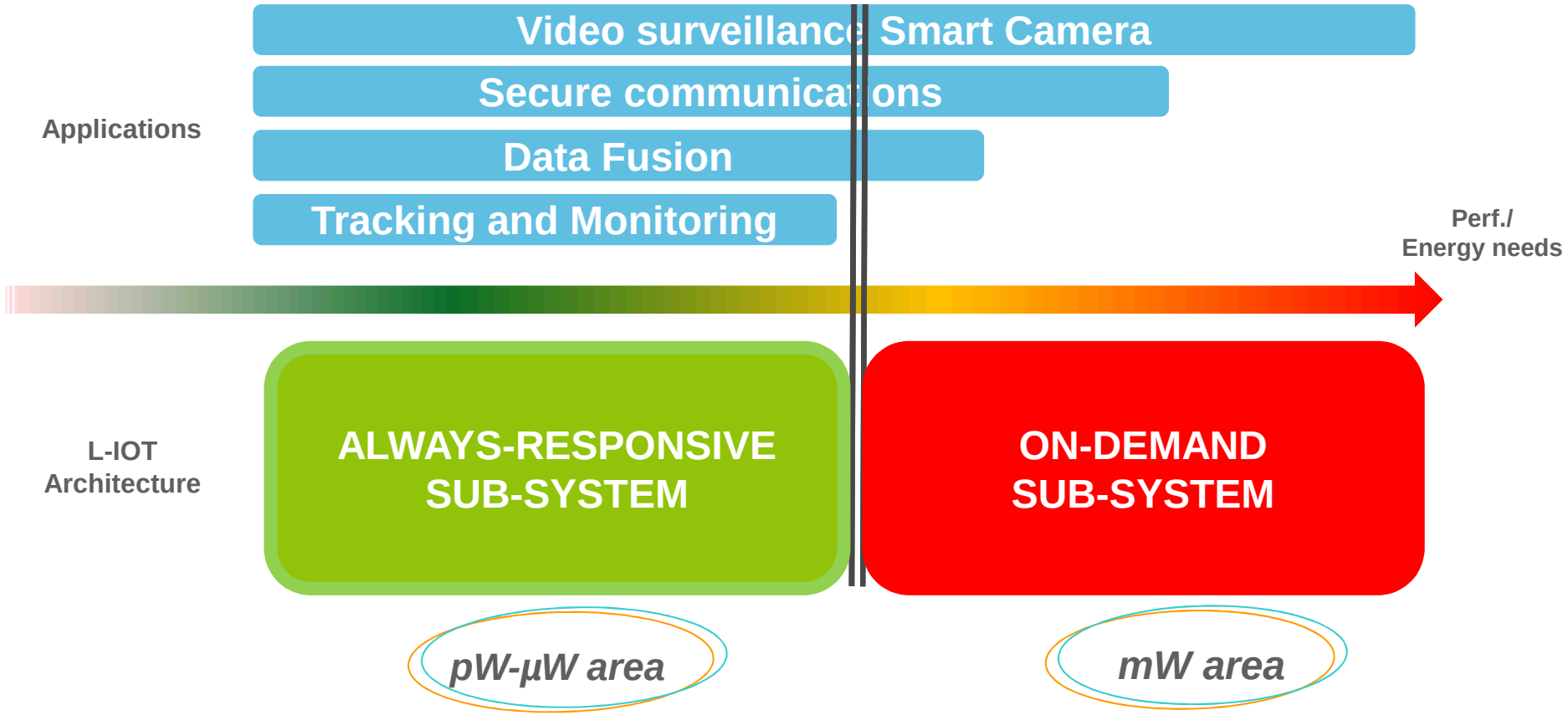
A flexible System is required to cover energy & applicative IoT needs

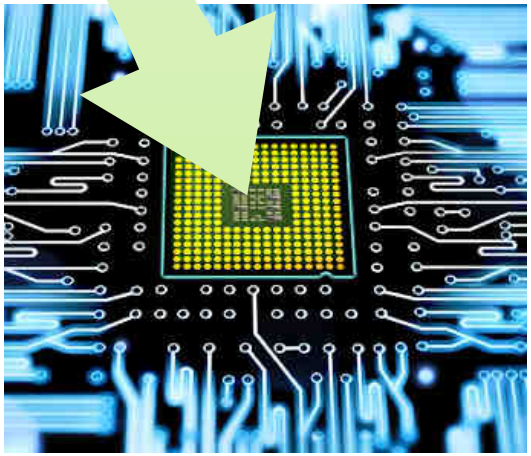
L-IOT : A FLEXIBLE PLATFORM IN FDSOI28

- A flexible and fully integrated platform for a fragmented market
- FDSOI technology brings more flexibility
- Autonomous system
- Low power consumption and adaptive blocks

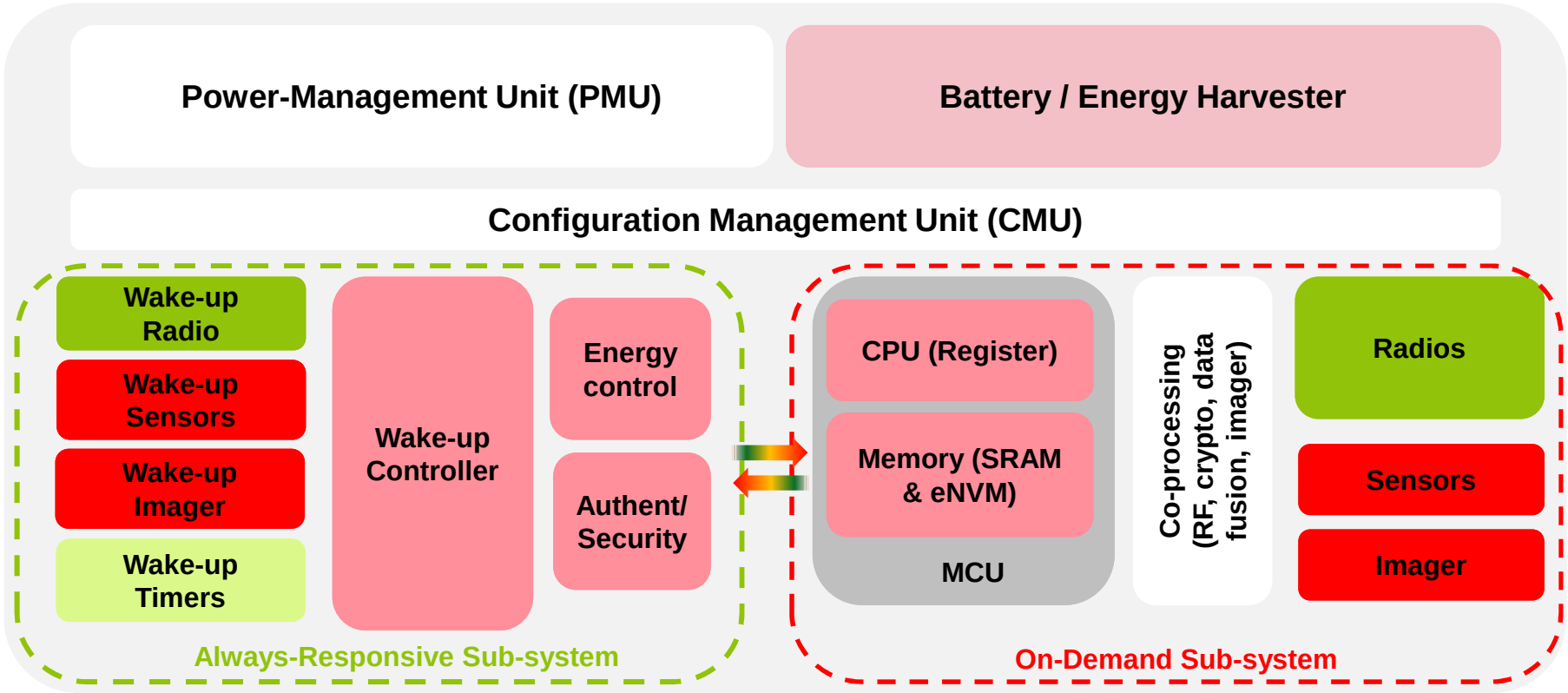


L-IOT : A FLEXIBLE PLATFORM IN FDSOI28

- Radio
- Wake-Up
- Energy management
- Computing
- Sensing



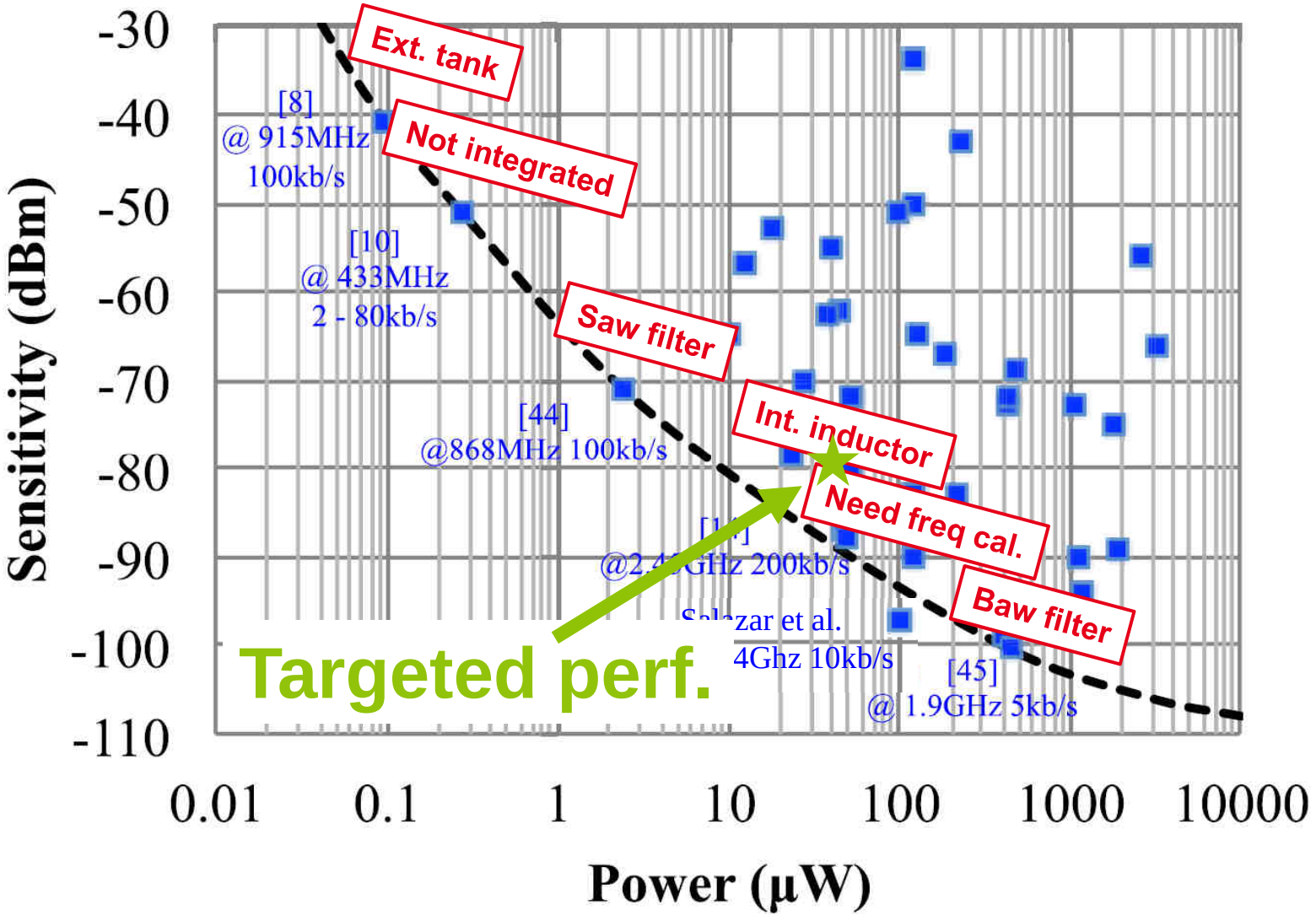
L-IOT: A FLEXIBLE PLATFORM



⇨ Adaptive Always-Responsive/On-Demand according to energy levels

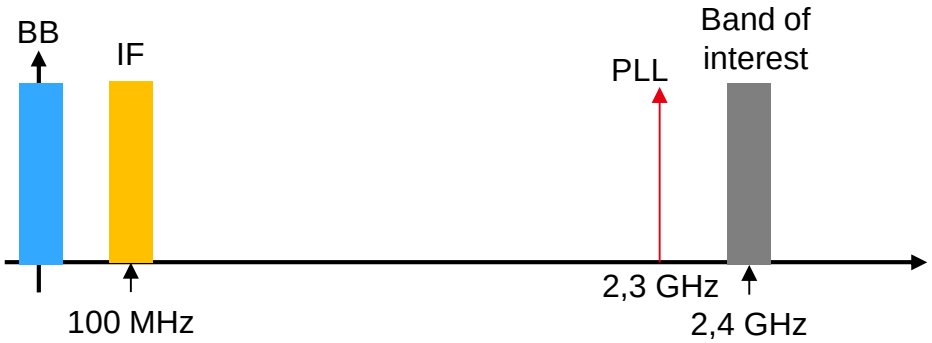
- **Case study: Wake-Up Radio**

STATE OF THE ART OF RADIO RECEIVERS

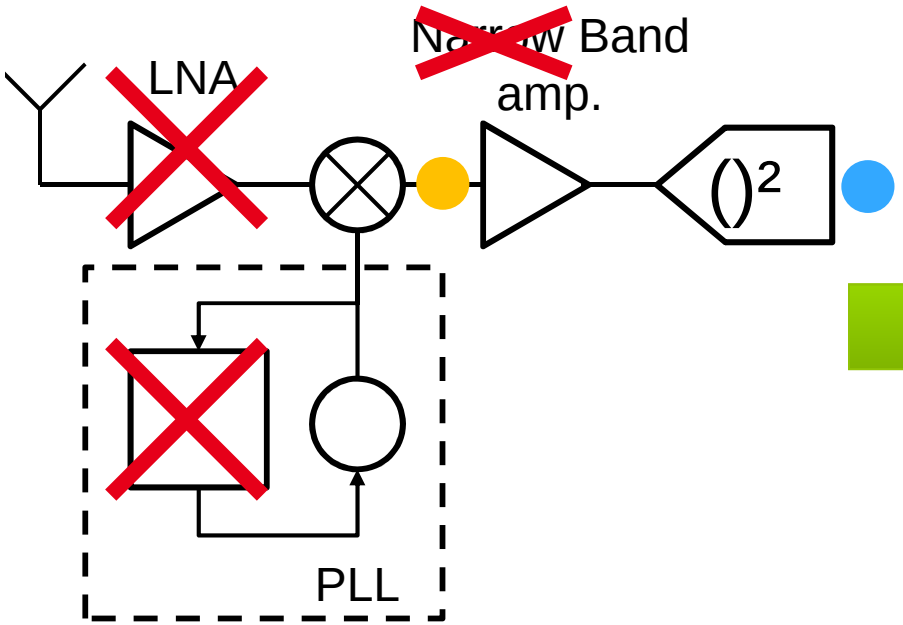


Source : C. Salazar et al., "A 2.4 GHz Interferer-Resilient Wake-Up Receiver Using A Dual-IF Multi-Stage N-Path Architecture," in *IEEE Journal of Solid-State Circuits*, vol. 51, no. 9, pp. 2091-2105, Sept. 2016.

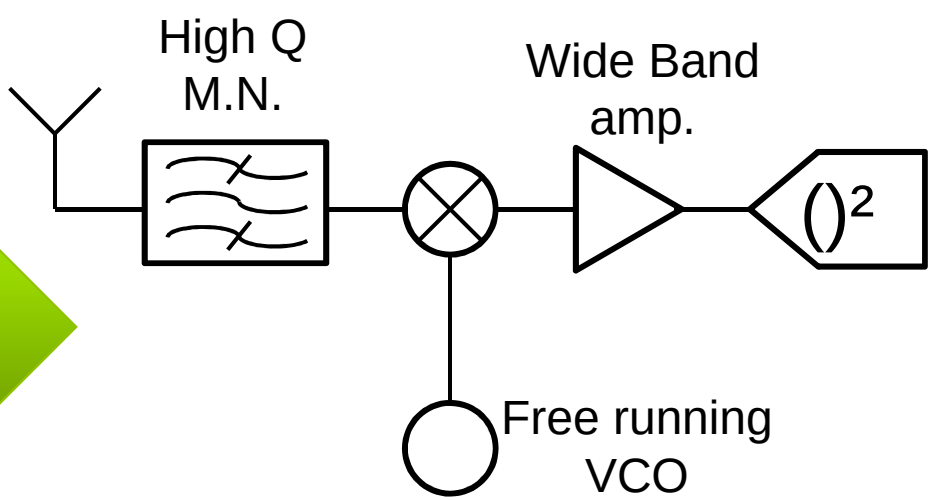
UNCERTAIN IF TECHNIQUE



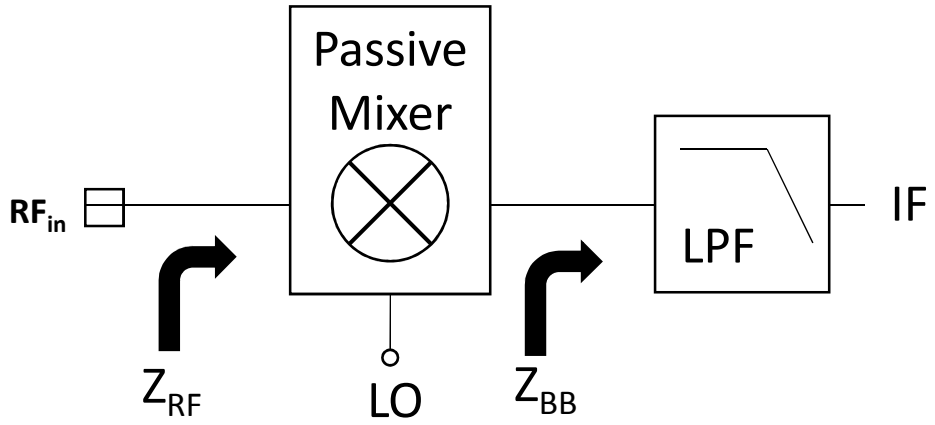
Classic Receiver

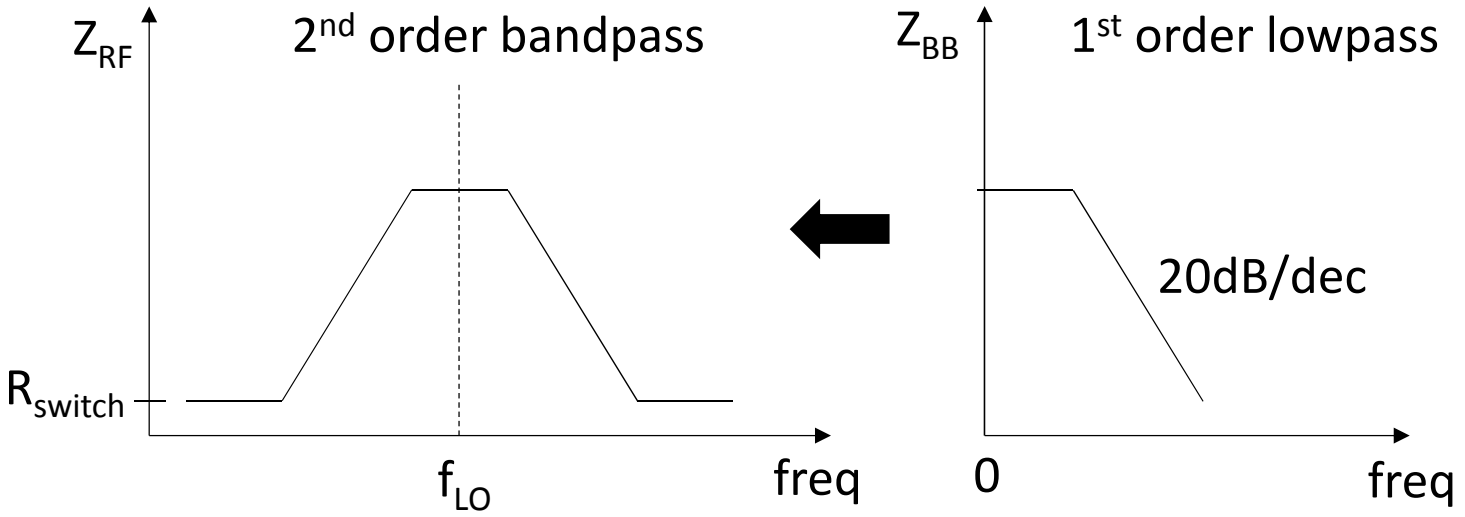


Uncertain IF receiver

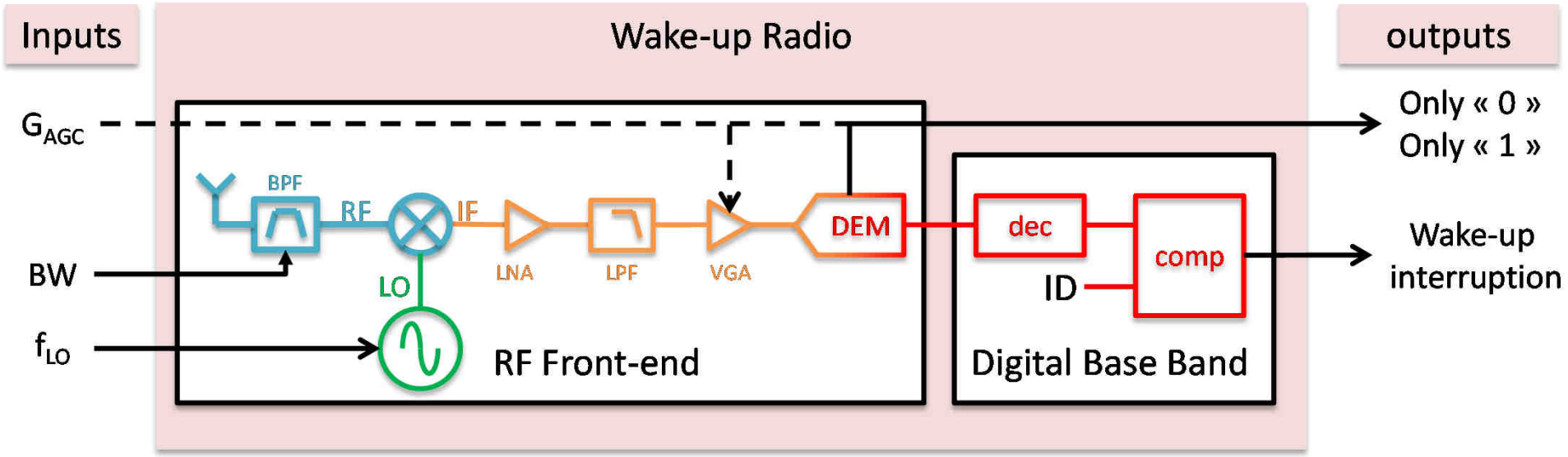


NPATH FILTERING

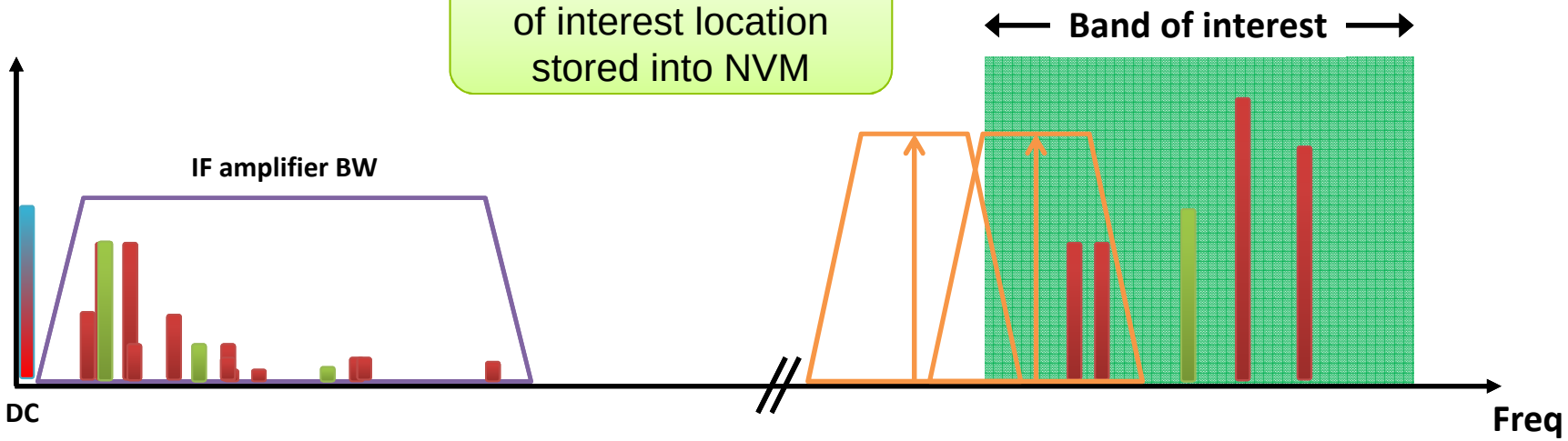




THE SLIDING LO TECHNIQUE



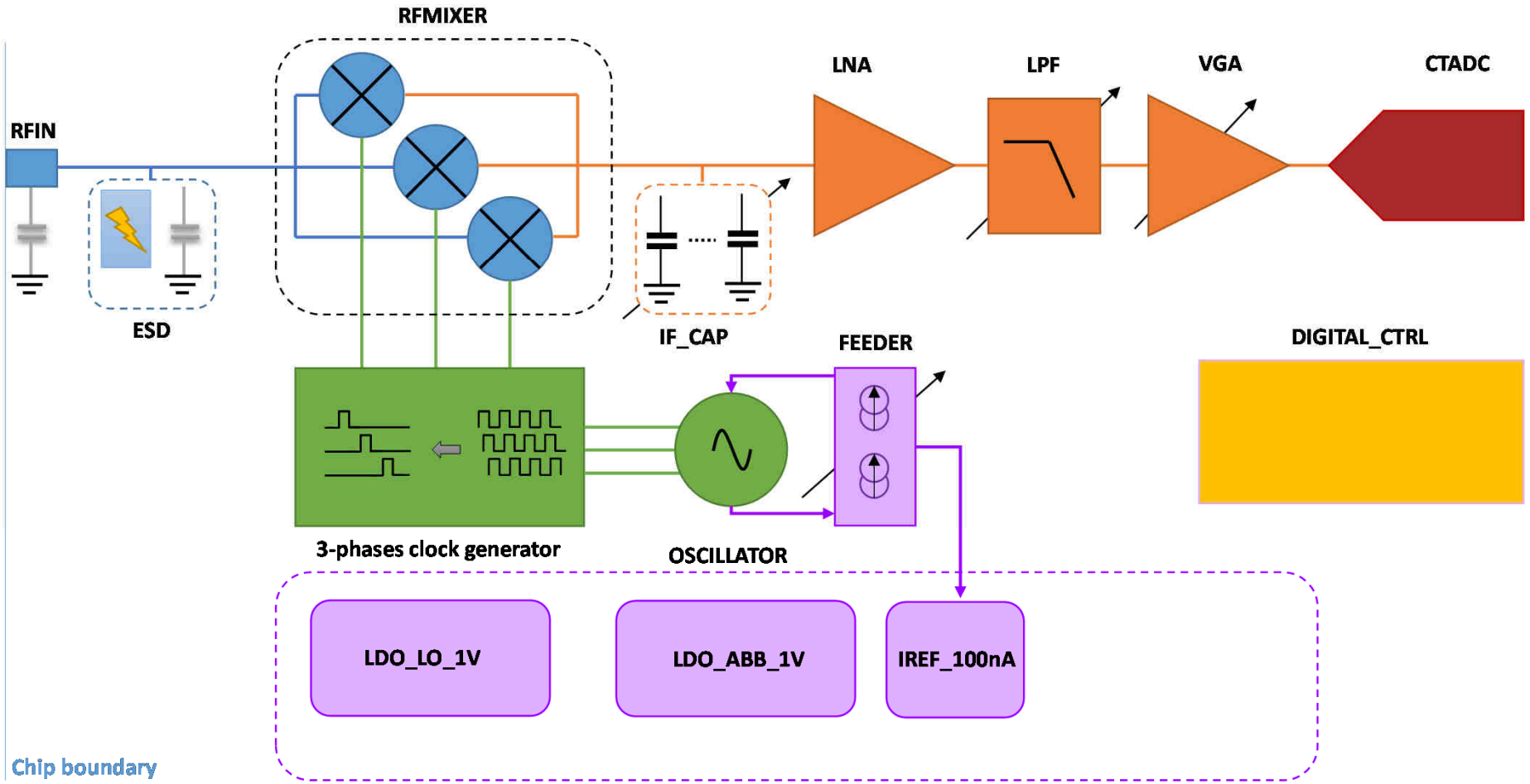
Context-aware, band of interest location stored into NVM



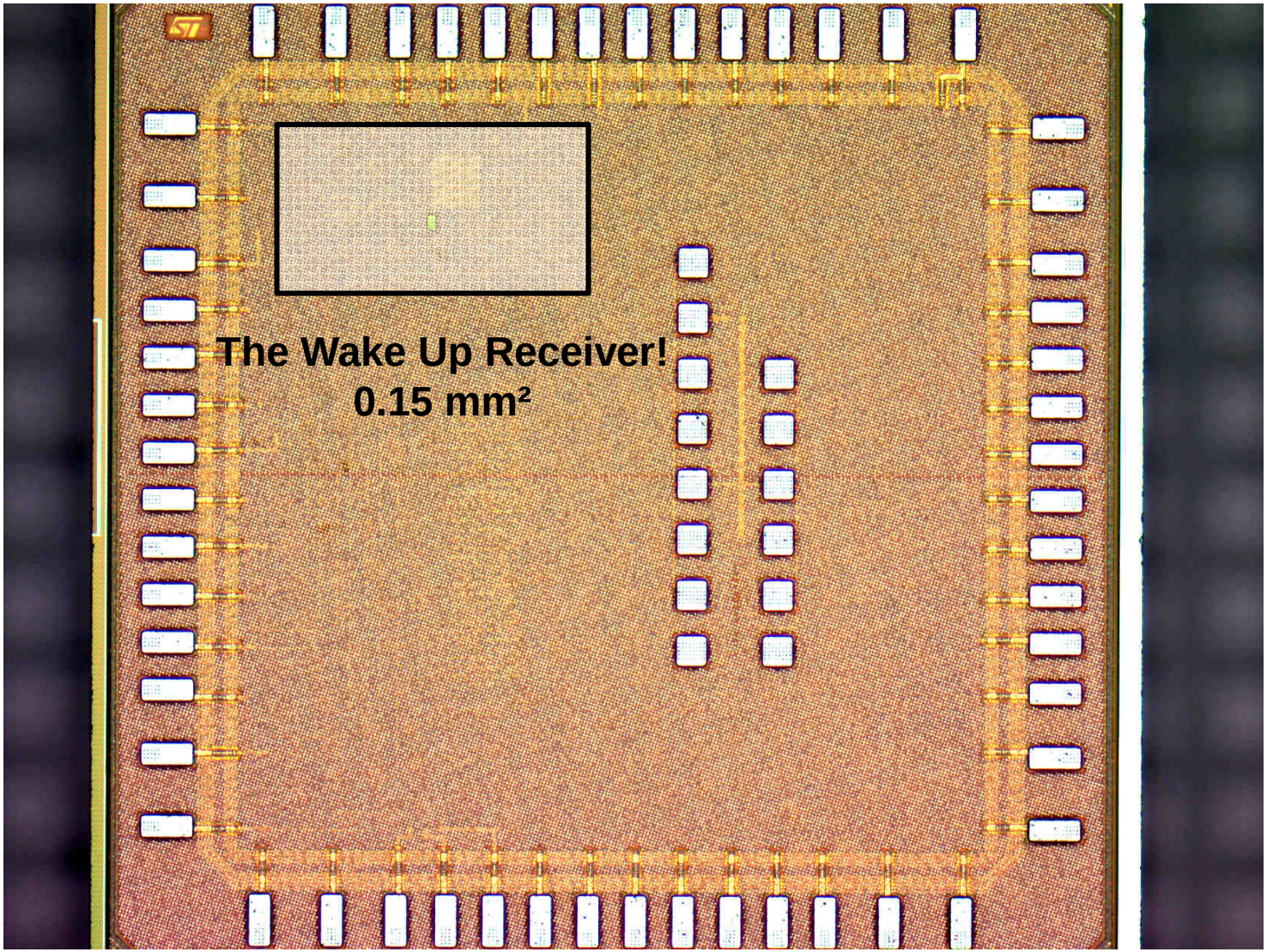
TARGETED FEATURES

- **Uncertain IF N-path filter Receiver**
  - 28 nm FDSOI technology
  - Sensitivity -80 dBm
  - 50 µW power consumption
  - Frequency bands : 433MHz -> 2,4G
  - No ext. matching
  - OOK modulation
  - Standards : Proprietary

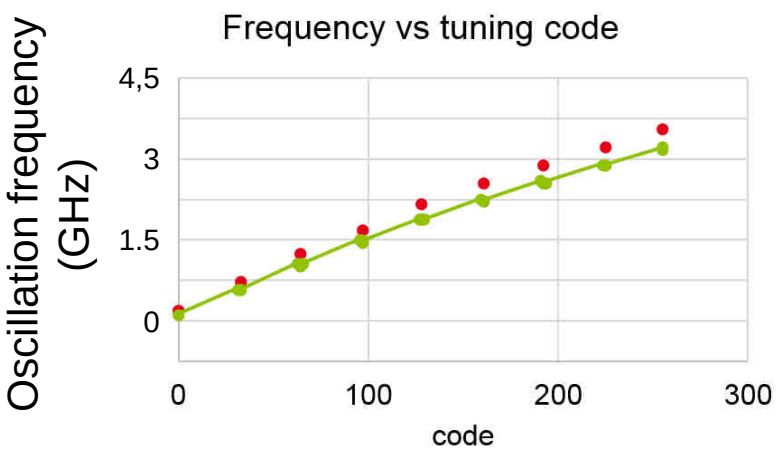
THE PROPOSED ARCHITECTURE

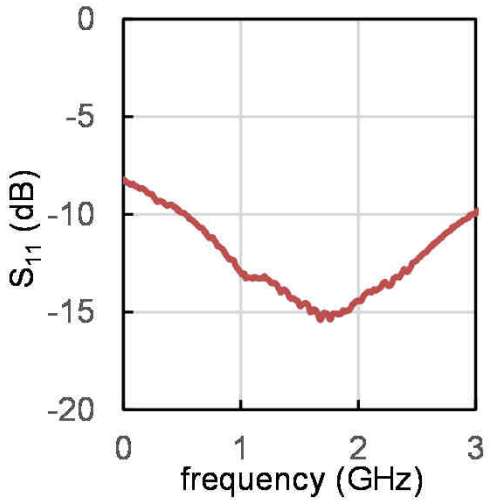


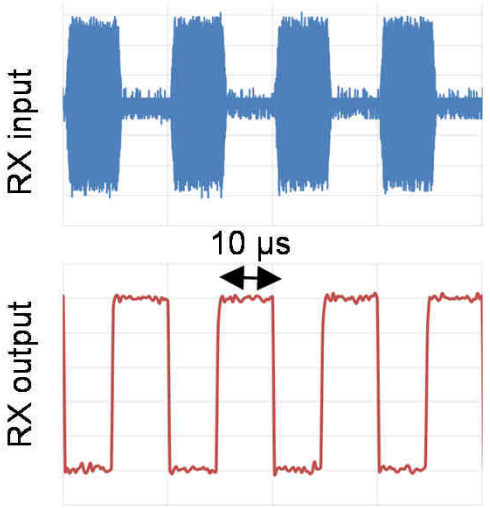
THE WAKE-UP RADIO CIRCUIT



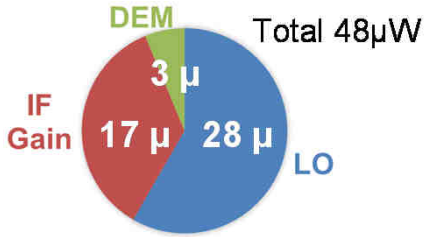
FIRST MEASUREMENT RESULTS







POWER ON



POWER OFF

STANDBY (LDOs ON, RX OFF)	**1 µW**
DEEP SLEEP (LDOs OFF)	**300 nW**

Application scenario

Duty-Cycle	$P_{AVERAGE}$
0,1 %	0,54 µW
1 %	1 µW
5 %	3 µW

Duty-cycle needed!

- **LIOT available offer**

L-IOT AVAILABLE OFFER

Wake-Up

- Wake-up Controller
- Wake-Up radio
- Energy controller
- ULP/ULL memory

Power Management

- Distributed Back Bias Generator
- LDO
- Frequency generation FLL
- Real Time Clock
- Voltage Hopping
- Asynchronous service Network

Security

- AES encryption
- PRESENT encryption
- Polymorphism algorithms

Computing

- Cortex M0+
- Adequate computing
- Coming Next

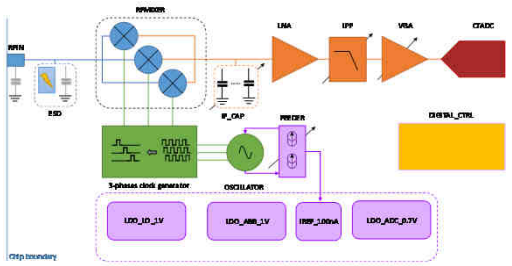
LIOT AVAILABLE OFFER

Wake-Up

- Wake-up Controller
- Wake-Up radio
- Energy controller
- ULP/ULL memory

Asynchronous Wake-Up Controller for very fast wake-up (55ns@0.6V)
Computing capabilities at low voltage
With compiler and debugger

Wake-Up radio for less than 50µW
Covers all bands from 433MHz to 2.4GHz
Embedded LDO and oscillator (no PLL)
-60 dBm sensitivity for 48µW power consumption and 1µW when using 1% duty-cycling
Area 0.15mm²



Energy controller based on energy harvesters control for less than 1µW
Select the best source of energy in function of the circuit needs
Unused harvested energy is used to charge the battery

Self-timed SRAM memory
Suited for Wake-up Controller
Working down to 0.4V
Leakage of 1pA/bit at retention mode

L-IOT AVAILABLE OFFER

Power Management

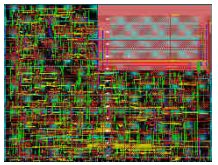
- Distributed Back Bias Generator
- LDO
- Frequency generation FLL
- Real Time Clock
- Voltage Hopping
- Asynchronous service Network

Low area and low power Back Bias generator with automatic process and temperature circuit compensation

Ultra low power LDO for 0.95V delivery for 100µA current
Power OFF capability

Fast reprogramming Frequency Locked Loop *delivering between 50MHz and 2GHz*

Low area footprint 2100µm²



Real Time Clock without external component and low power 60nW @1V

Area footprint 0.01mm² including voltage regulation and clock trimming

Voltage selector between three voltages ex. 0.5V - 0.8V – 1V with power gating capability

Transition in less than 100ns transition with ~nW leakage power consumption

Area 0.045mm²

Dedicated service network for reconfiguration

Automatic flow control mechanism when crossing multiple power domains

Serial or parallel interface

L-IOT AVAILABLE OFFER

Security

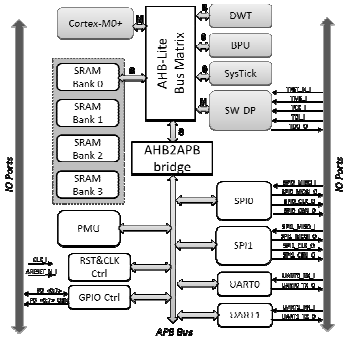
- **AES encryption**
  AES algorithm implemented in hardware
  128 bit key
  Variable data length
- **PRESENT encryption**
  PRESENT algorithm implemented in hardware
  128 bits key
  Variable data length
- **Polymorphism algorithms**
  Polymorphism algorithms for software security

L-IOT AVAILABLE OFFER

Computing

- Cortex M0+
- Adequate computing
- Coming Next

Volatile (and Non volatile) Cortex M0+
20MHz up to 250MHz @ 0.6V using Back Biasing

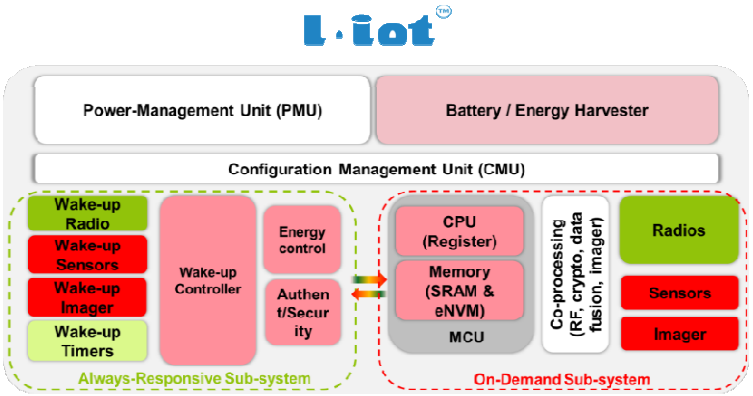


Adequate computing arithmetic units
Using Back Biasing up to 60% power gains

Imagers
Neurocomputing
RISC V processor implementation

CONCLUSION

- A flexible platform suitable for a fragmented market
- Ultra low energy and adaptability are key technologies provided by L-IOT
- NVM will further reduce the power consumption thanks to instant-ON/OFF capabilities and context information
- Full integration and global optimization in FDSOI technology



ACKNOWLEDGEMENTS & REFERENCES

- **Contributors:**
  - A. Valentian, J.F. Christmann, S. Bacles-Min, A. Verdant, G. Sicard, C. Jany, B. Martineau, D. Morche, C. Bernier, A. Molnos, D. Couroussé, S. Lesecq, G. Pillonnet, A. Quelen, F. Badets

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  - ST Microelectronics

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