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Challenges for integration of Power Management solutions on STM32 μ Controllers

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Power SoC 2023

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Introduction

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STM32 power management

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Reliability & Robustness

3

Ultra low power features

4

Noise Integrity in STM32

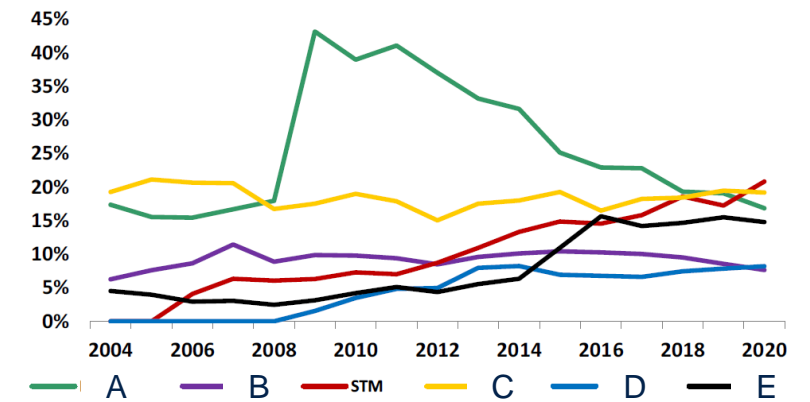
Introduction

- STM32 over the last 15 years
 - Focus on Performances
 - Focus on Analog ... & RF
 - Focus on Low Power
 - Focus on Quality



- Strong growth of STM32 shipment
- Regular increase of market share

32-Bit MCU Market Share Trend



Source: Gartner, Morgan Stanley Research

STM32 Power Management



STM32 Family

High Performance

- STM32F2 (C-M3 120MHz)
- STM32F2 (C-M3 120MHz)
- STM32F4 (C-M4 180MHz)
- STM32H5 (C-M33 250MHz)
- STM32F7 (C-M7 216MHz)
- STM32H7 (C-M7 550MHz, C-M4 240MHz)

Mainstream

- STM32C0 (C-M0+ 48MHz)
- STM32F0 (C-M0 48MHz)
- STM32F1 (C-M3 72MHz)
- STM32F3 (C-M4 72MHz)
- STM32G4 (C-M4 170MHz)

Ultra-low-power

- STM32L0 (C-M0+ 32MHz)
- STM32L4 (C-M4 80MHz)
- STM32L5 (C-M33 110MHz)
- STM32L4+ (C-M4 120MHz)
- STM32U5 (C-M33 160MHz)

Wireless

- STM32WL (C-M0+ 48MHz, C-M4 48MHz)
- STM32WB (C-M0+ 32MHz, C-M4 64MHz)
- STM32WBA (C-M33 100MHz)

- Low Cost
 - Many LQFP packages
 - Few external components
 - Simple Printed Circuit Boards
- Ease of use

STM32 MCU Developer Zone
Everything for STM32 MCU developers, in one place.

- Boards & Hardware Tools
- Software tools
- Embedded software
- Solutions
- Resources



STM32 Power Management

Robustness & Reliability

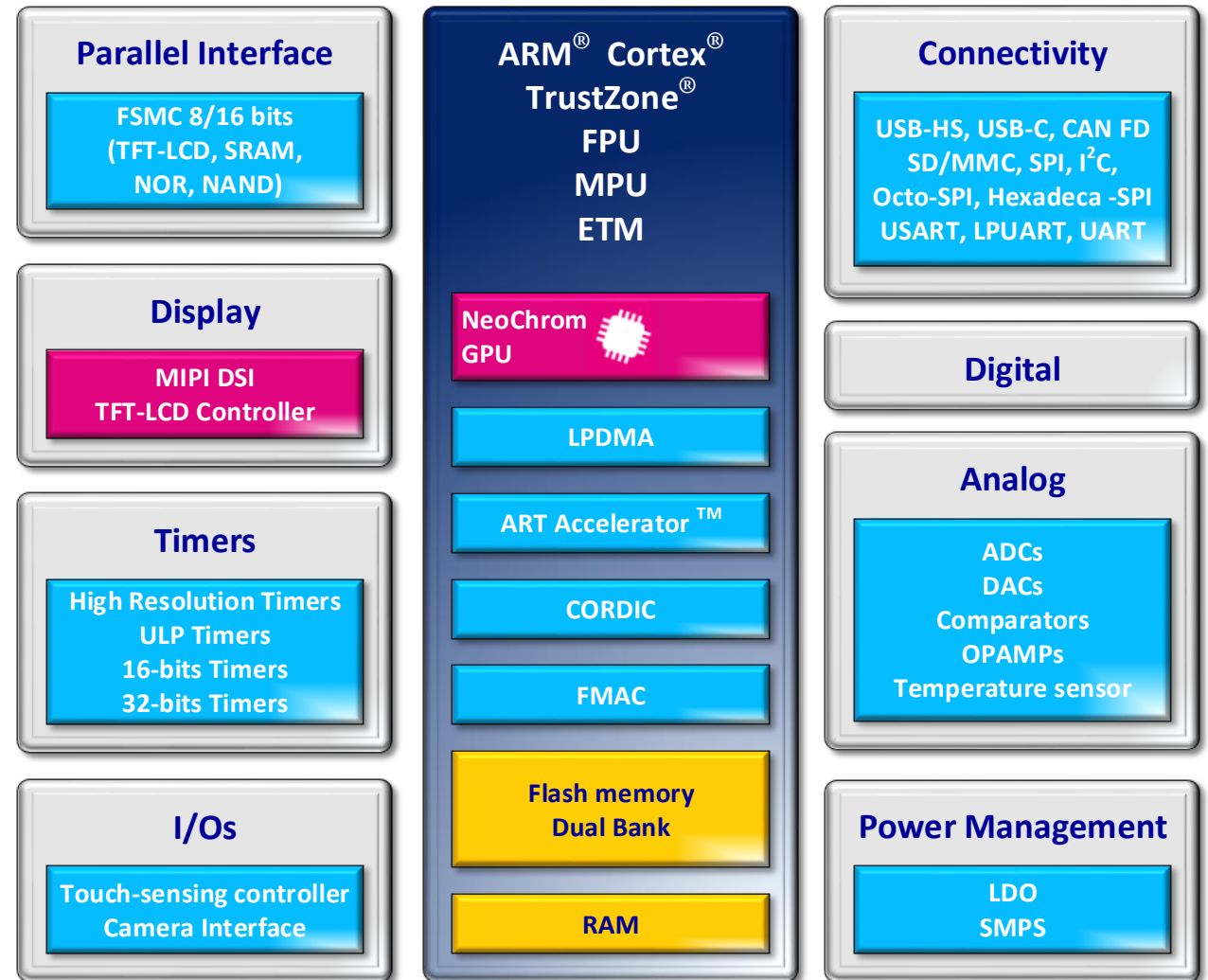
Low Power Features

Power & Noise Integrity

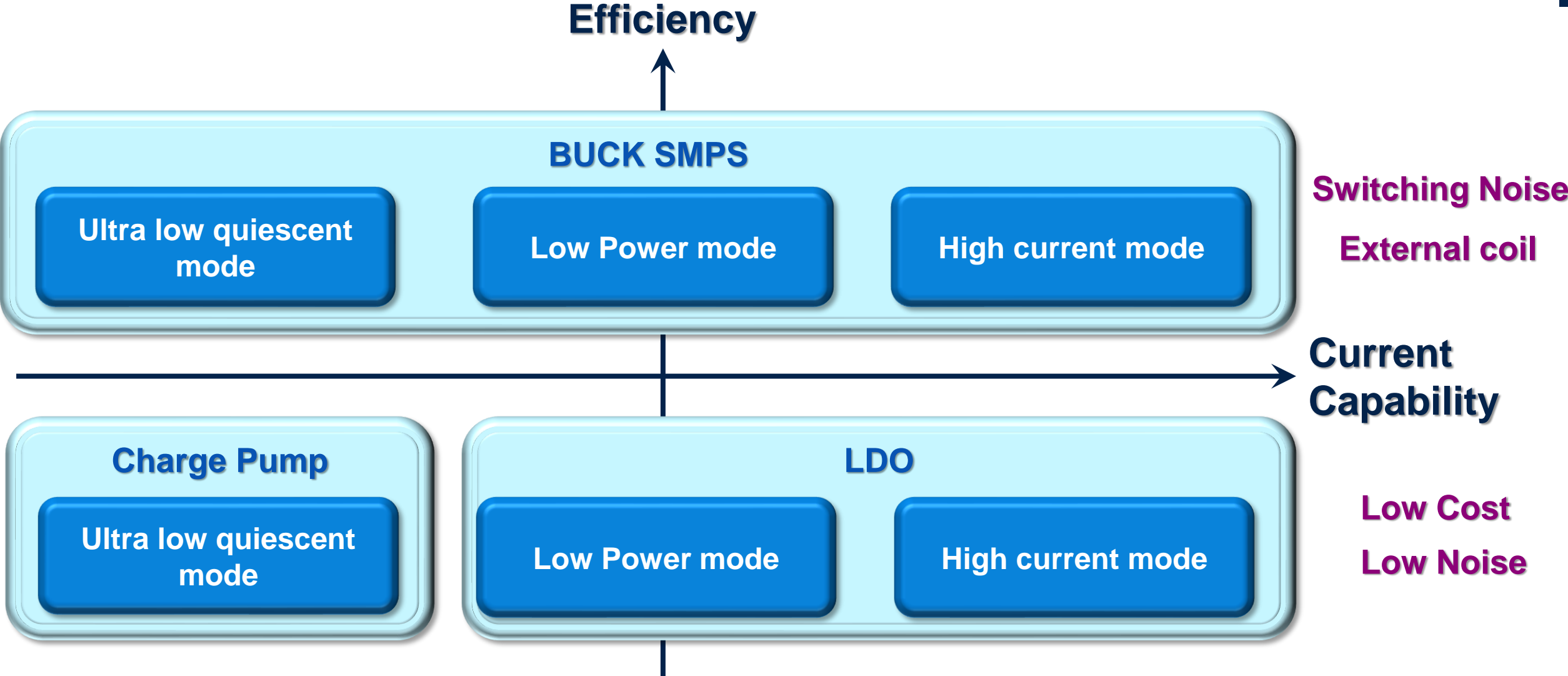
Typical content of STM32

- Mixed Digital / Analog SoC
- Embedded Power Management

- Low cost
 - CMOS Process
 - PCB
 - External components
- High volume production
 - 100s Munits / Year



Voltage regulators



STM32 Power Management

Robustness & Reliability

Low Power Features

Power & Noise Integrity

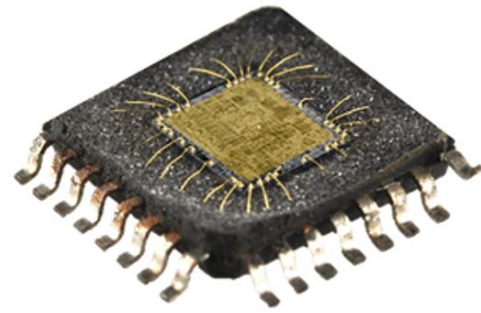
Reliability & Robustness



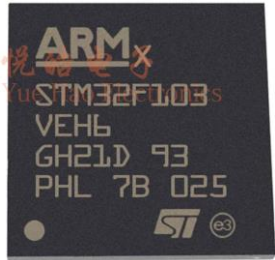
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Wide package family

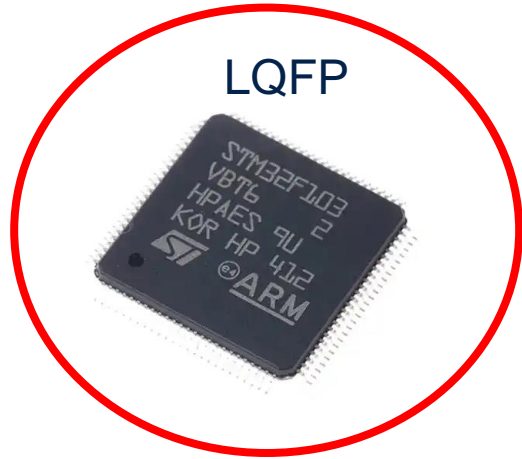
QFN



BGA



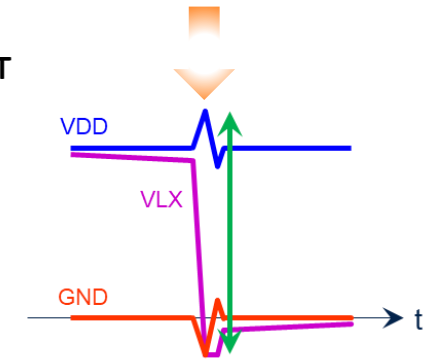
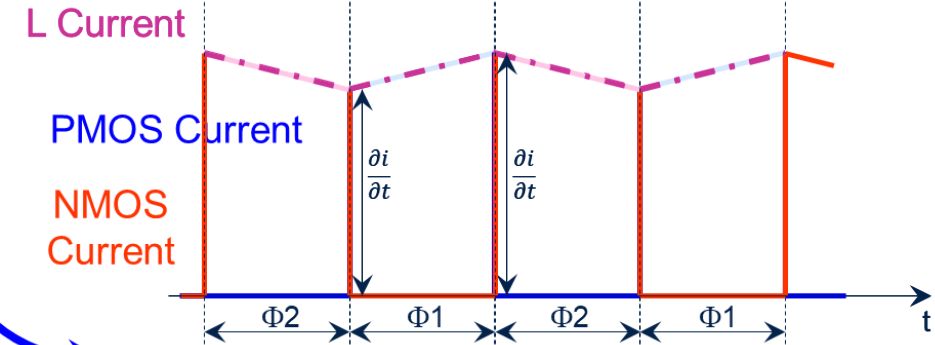
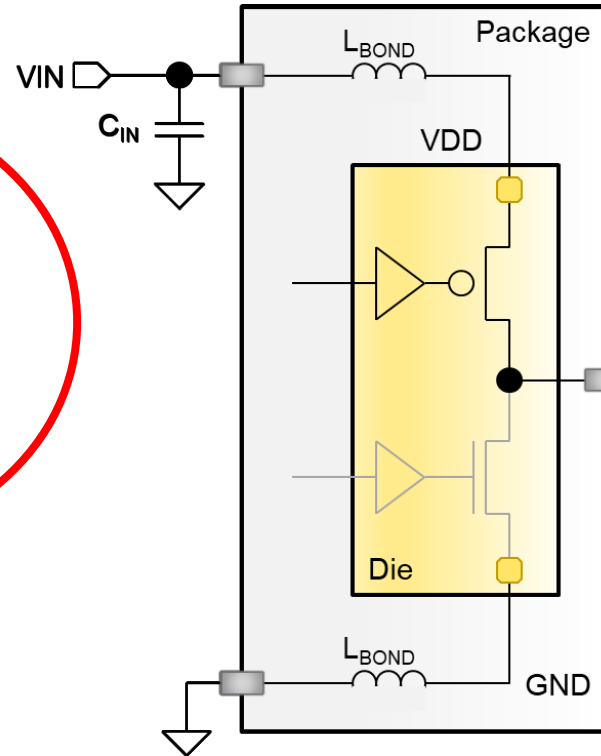
LQFP



WLCSP



Module



Maximum Stress
on PMOS V_{DS}



STM32 Power Management

Robustness & Reliability

Low Power Features

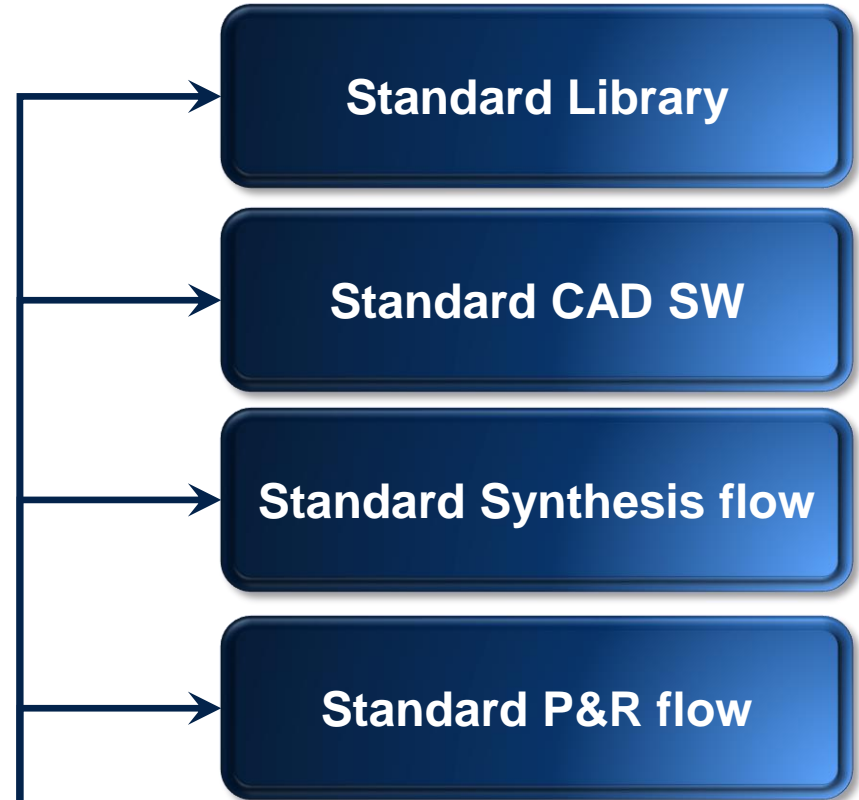
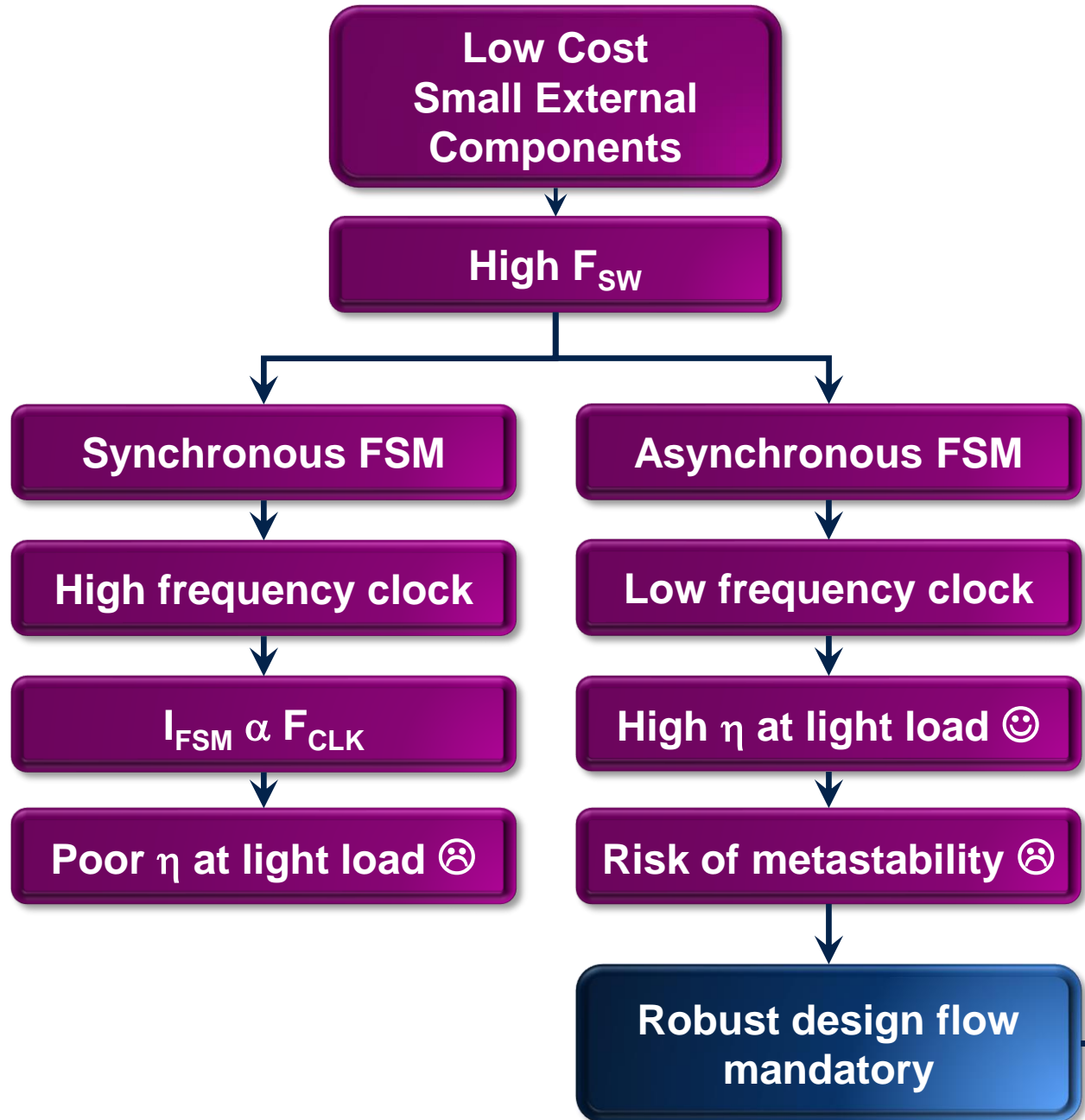
Power & Noise Integrity

Low Voltage CMOS stress **RELIABILITY**

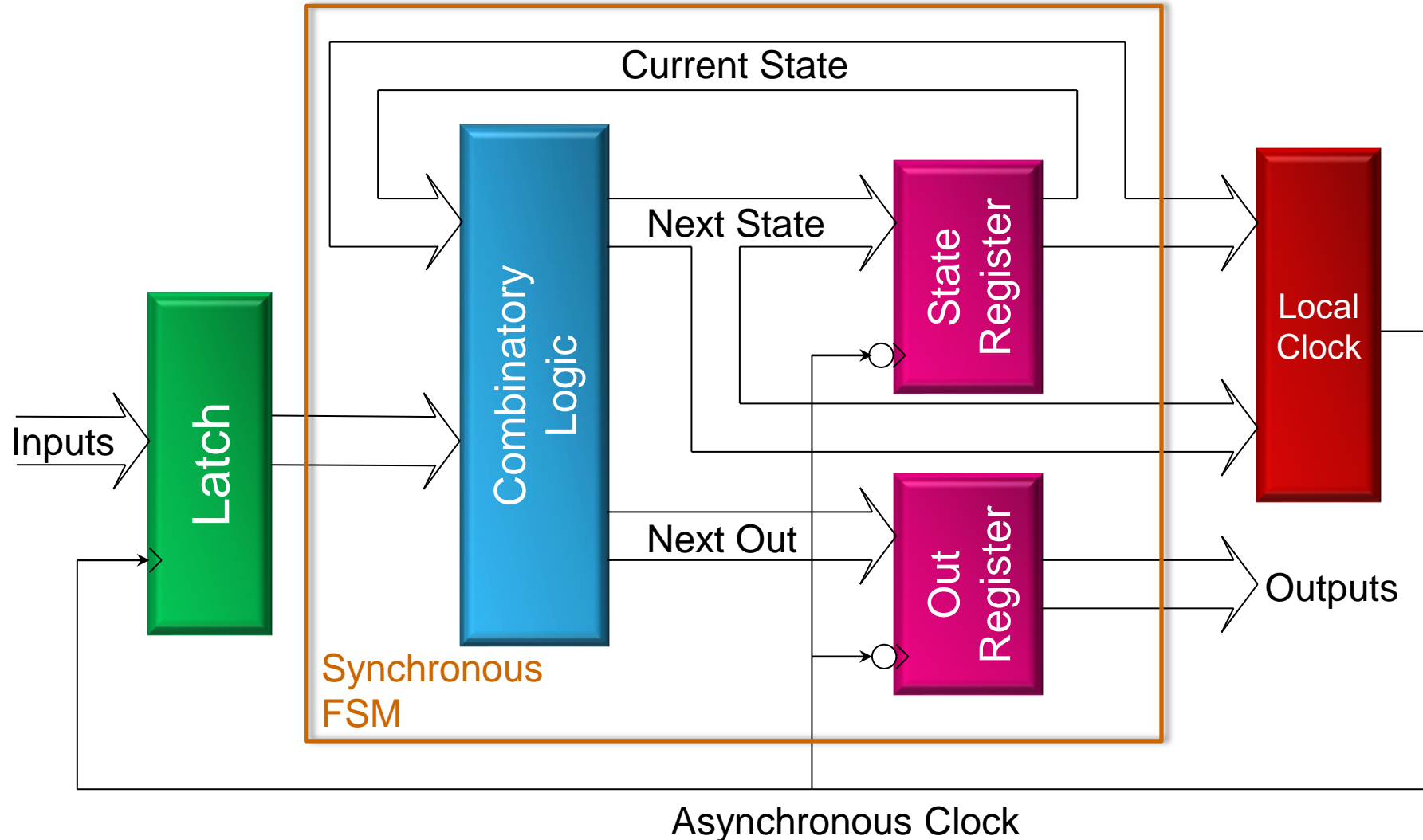
- Devices stressed for very short durations
- Care with dynamic stress effects
 - Depend on duty cycle
 - Depend on switching frequency
 - Depend on rise and fall times
- Extensive rigorous **Operating Life Test** experiments



Buck FSM **ROBUSTNESS**



Globally **A**synchronous / **L**ocally **S**ynchronous FSM

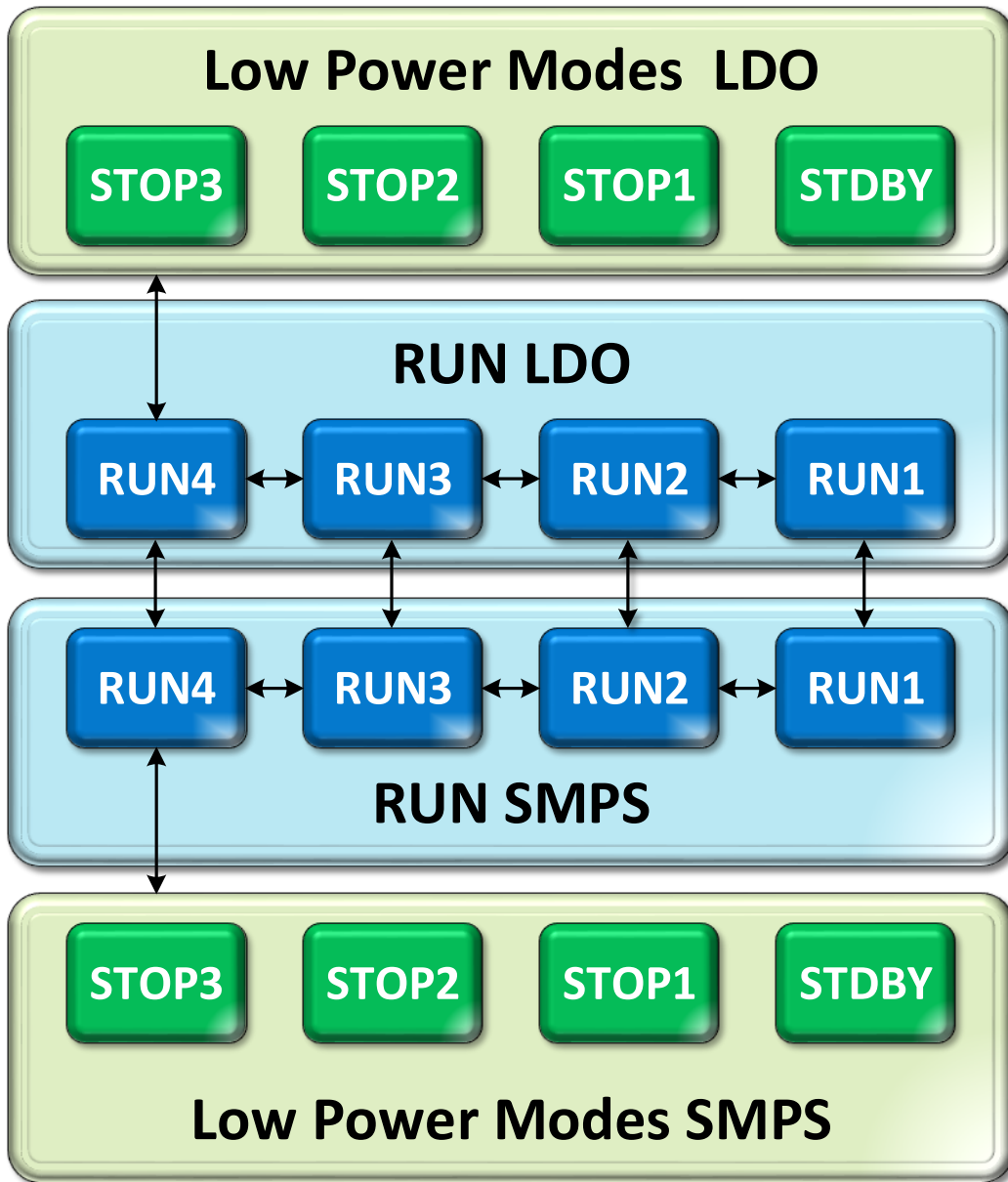


Ultra Low Power features

If only my smartwatch
could last longer when I am
active



Power Modes **FLEXIBILITY**



- Various Operating Points
- Flexibility
- Agility
- Various Low Power Modes

- Best Trade off Speed/Power

PCC Tool on STM32 CubeMX: **Ease of Use!**

Power Mode →
Power Range →
Supply Voltage →
CPU Frequency →

Step Duration →

Power/Memory

Power Mode: RUN
Power Range: Range4-VeryLow
Memory Fetch Type: FLASH_PwrDwnBank2/ART/Cache1Way
V_{DD}: 3.0
Voltage Source: Battery

Clocks

CPU Frequency: 24 MHz
Interpolation Ranges: [dropdown]
User Choice (Hz): [input]
Clock Configuration: MSI ALL_RAM_RETENTION
Clock Source Frequency: 24 MHz

Optional Settings

Step Duration: 1 ms
Additional Consumption: 0 mA

Results

Step Consumption: 2.86 mA
Without Peripherals: 2.1 mA
Peripherals Part: 757.2 µA (A: 0 nA - D: 757.2 µA)
Ta Max (°C): 104.7

Peripherals Selection

- LPTIM2
- LPTIM3
- LPTIM4
- LPUART1
- MDF1
- OCTOSPI1
- OCTOSPI2
- OPAMP1
- OPAMP2
- OTFDEC1
- OTFDEC2
- PKA
- PSSI
- PWR
- RAMCFG
- RNG
- RTC
- SAES
- SAH1
- SAI2
- SDMMC1
- SDMMC2
- SPI1
- SPI2
- SPI3
- SRAM3
- SRAM4
- SYS
- TAMP
- TIM4

Enabled Peripherals

ADC1 ADC4 CORDIC SDMMC1 SDMMC2 USB_OTG_FS

OK Cancel

← **Peripheral Selection**

PCC Tool on STM32 CubeMX: Sequence results

STM32CubeMX Untitled*: STM32U585AIlx

File Window Help

Home STM32U585AIlx Untitled - Tools LPBAM Scenario & Configuration GENERATE CODE CHECK LPBAM DESIGN

Pinout & Configuration Clock Configuration Project Manager Tools

Power

Step Sequence -Transitions Checker-

New Step

Steps Sequence

Step	Mode	Vdd	Range/Scale	Memory	CPU/Bus Freq	Clock Config	Peripherals	Step Current	Duration
1	RUN	3.0	Range1-High	FLASH_PwrDwnBank...	160 MHz	HSE BYP PLL ALL_R...		13.5 mA	1 ms
2	RUN	3.0	Range4-VeryLow	FLASH_PwrDwnBank...	8 MHz	HSE BYP ALL_RAM...		14.5 μ A	500 μ s
3	STOP3	3.0	NoScale	FLASH	0 Hz	ALL_RAM_RETENTION		1.8 μ A	5 ms
4	RUN	3.0	Range4-VeryLow	FLASH_PwrDwnBank...	24 MHz	MSI ALL_RAM_RETE...	ADC1 ADC4 OCTOSP...	14.5 μ A	1 ms

Display Selection

Select your Preferred Display Plot: All Steps

Consumption Profile by Step

Graphical Results

Sequence Time / Ta Max 8 ms / 103.54 °C
Battery Life Estimation 2 months, 2 days, 13 hours

Average Consumption 2.23 mA
Average DMIPS 31 DMIPS

Generator

Generate RUN + STOP3

Back To Default Sequence

Enable Auto Refresh Auto Refresh OFF

Results at Ta 25°C / 3.0V

Sequence Type Default
Typ. Average Current 1.45 mA
DMIPS 200

Sequence Configuration

RUN Consumption 14.5 mA

High Power Mode RUN

CPU Frequency 160 MHz

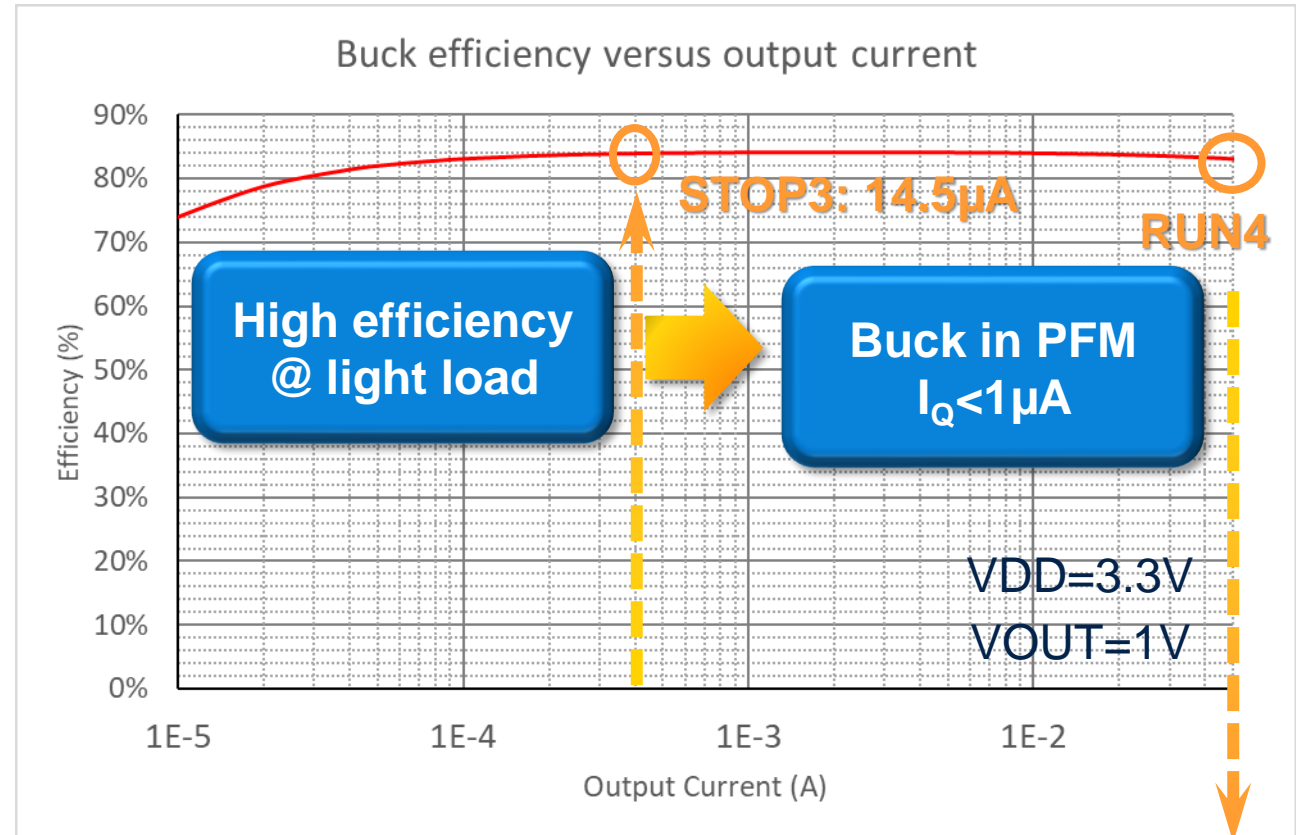
STOP3 Consumption 1.8 μ A

Impact of input voltage range on SMPS **EFFICIENCY**

IL Peak ???

VOUT Ripple ???

Coil size ???

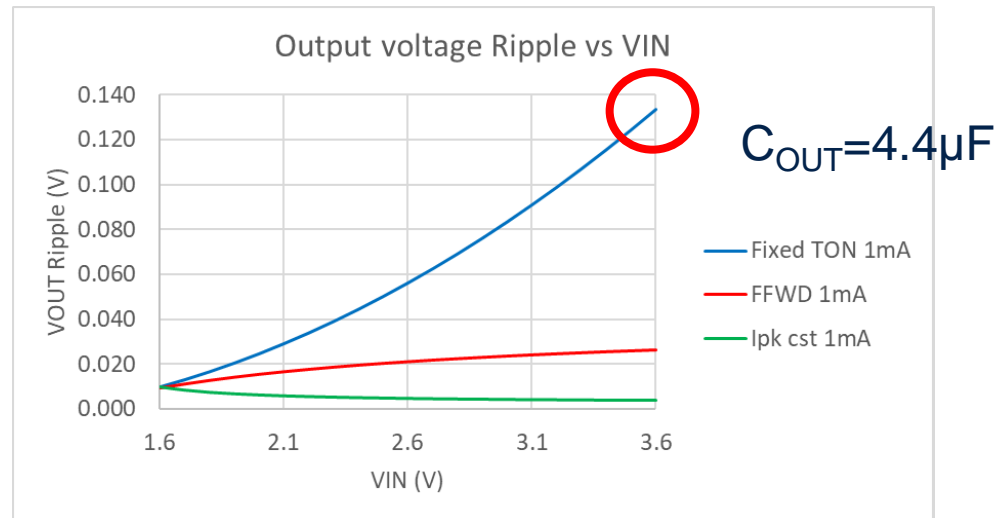
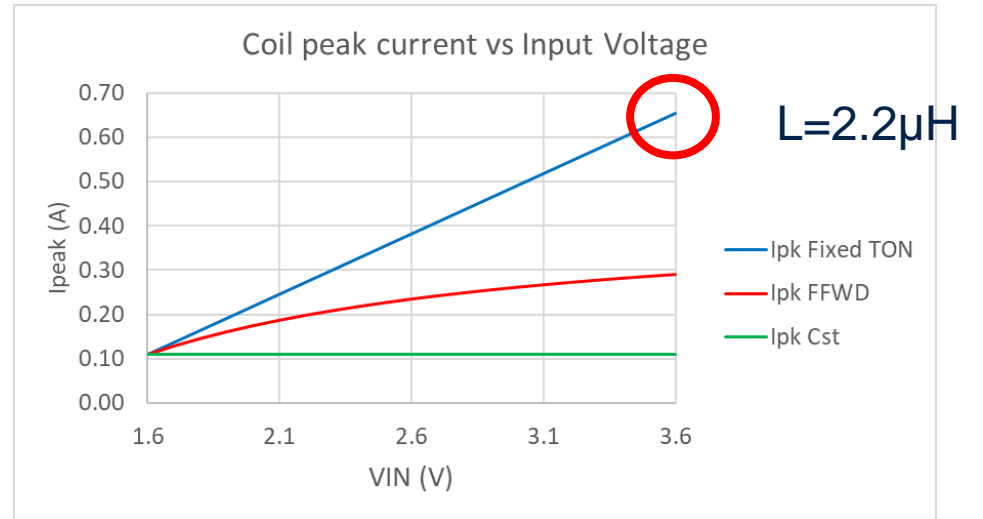
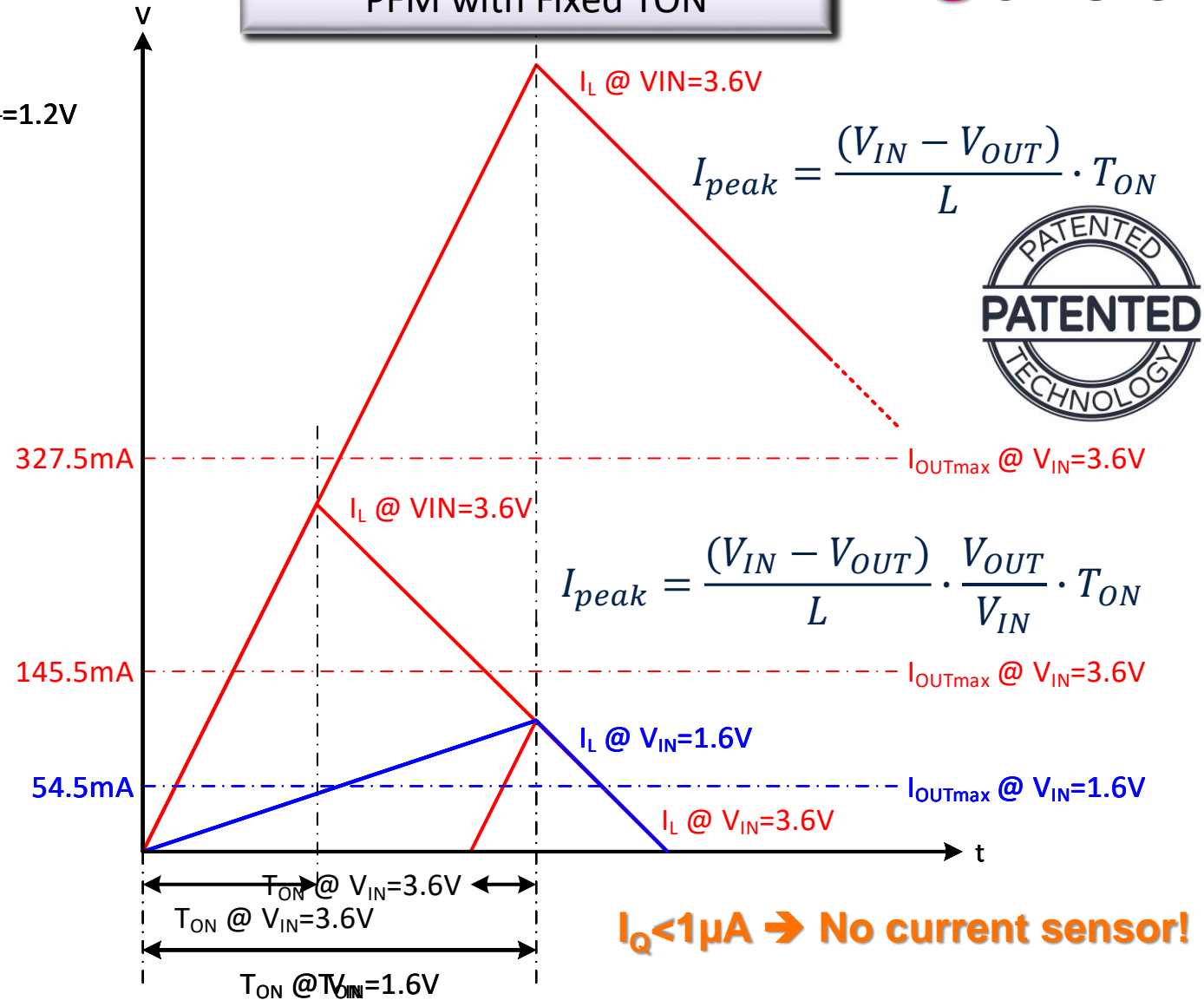


$1.6V < VDD < 3.6V$

I_{OUT} up to 50mA
@ $T_J = 140^\circ C$

Constant Peak Current Control

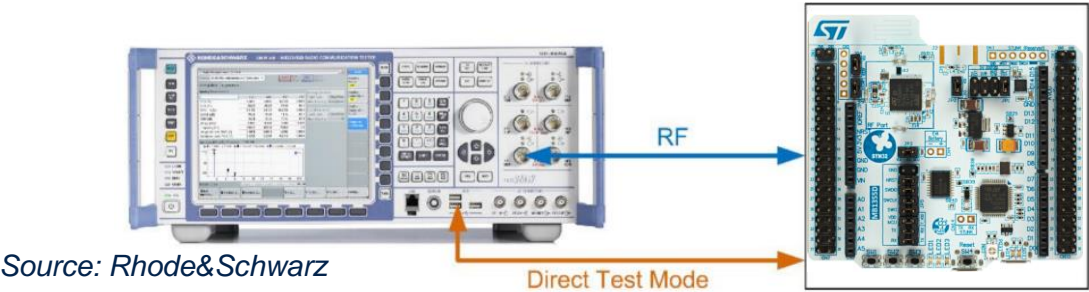
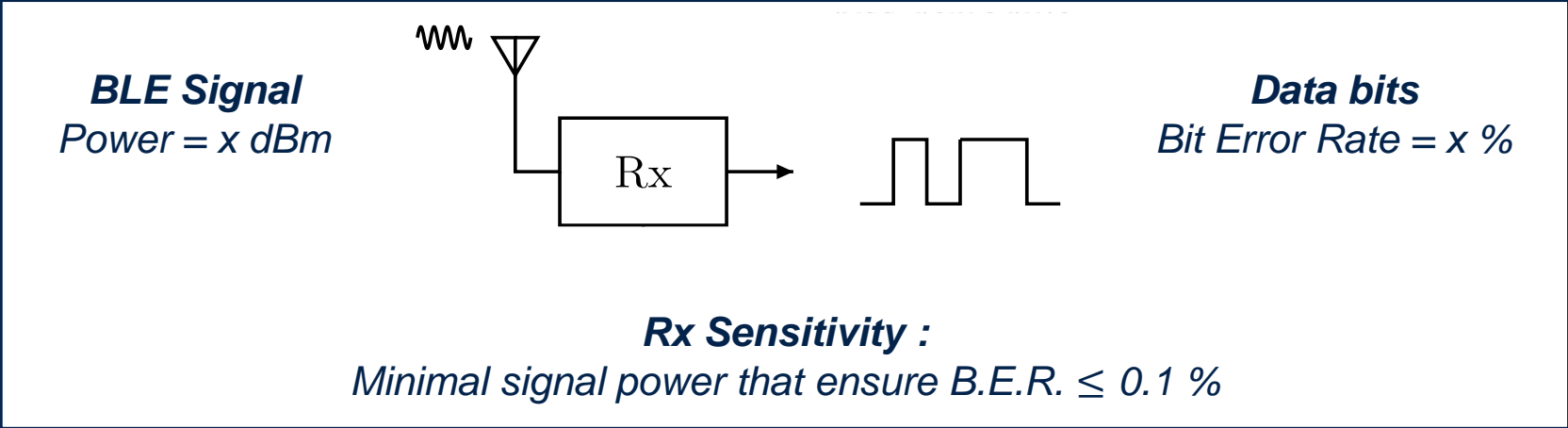
PFM with Fixed TON



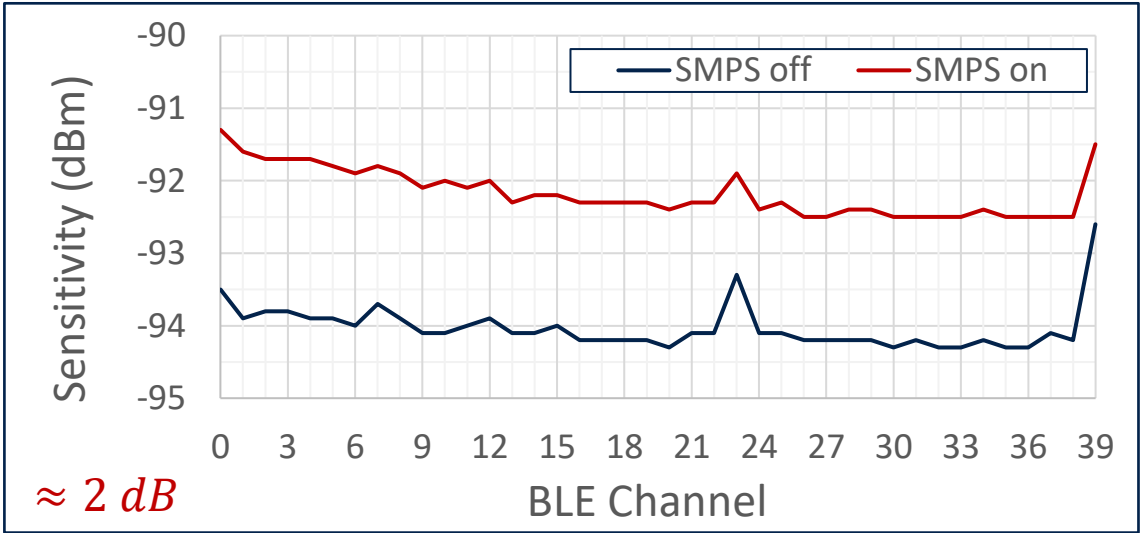
Noise Integrity



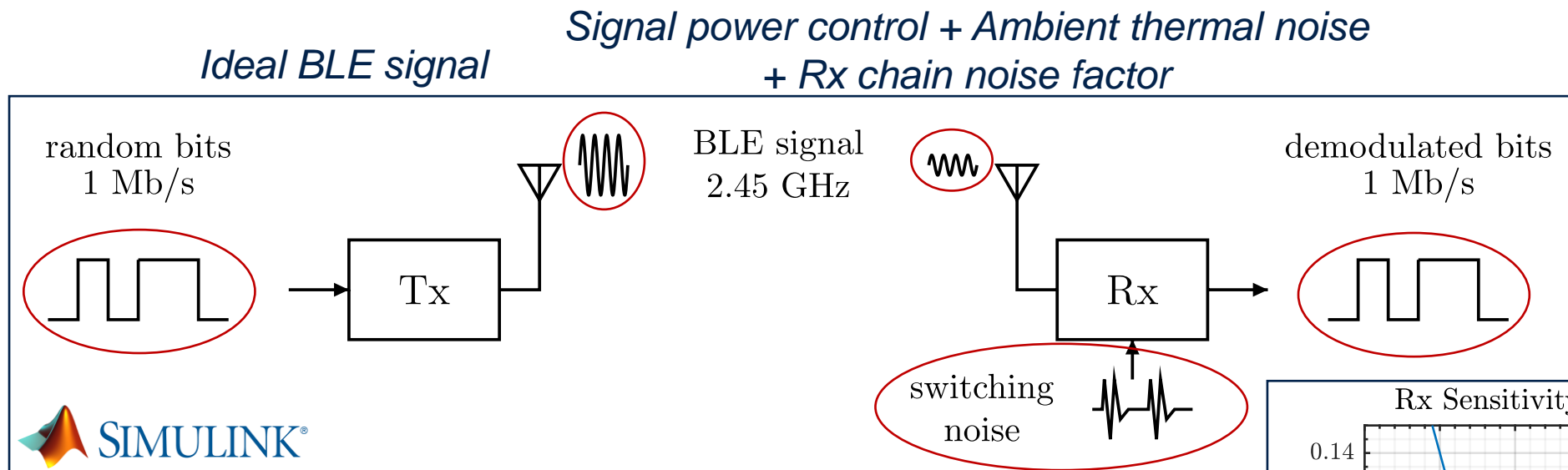
SMPS noise impact on BLE transceiver



Sensitivity measurement on a Nucleo-WB55 board

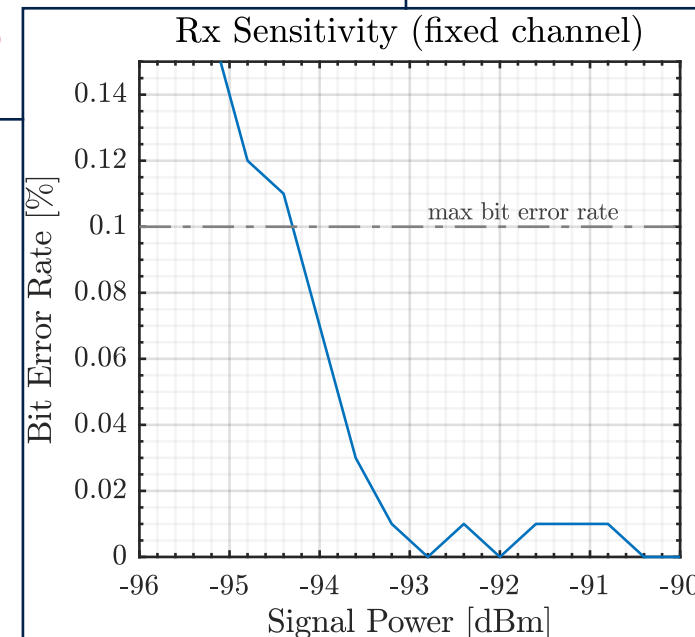


Bluetooth receiver noise model

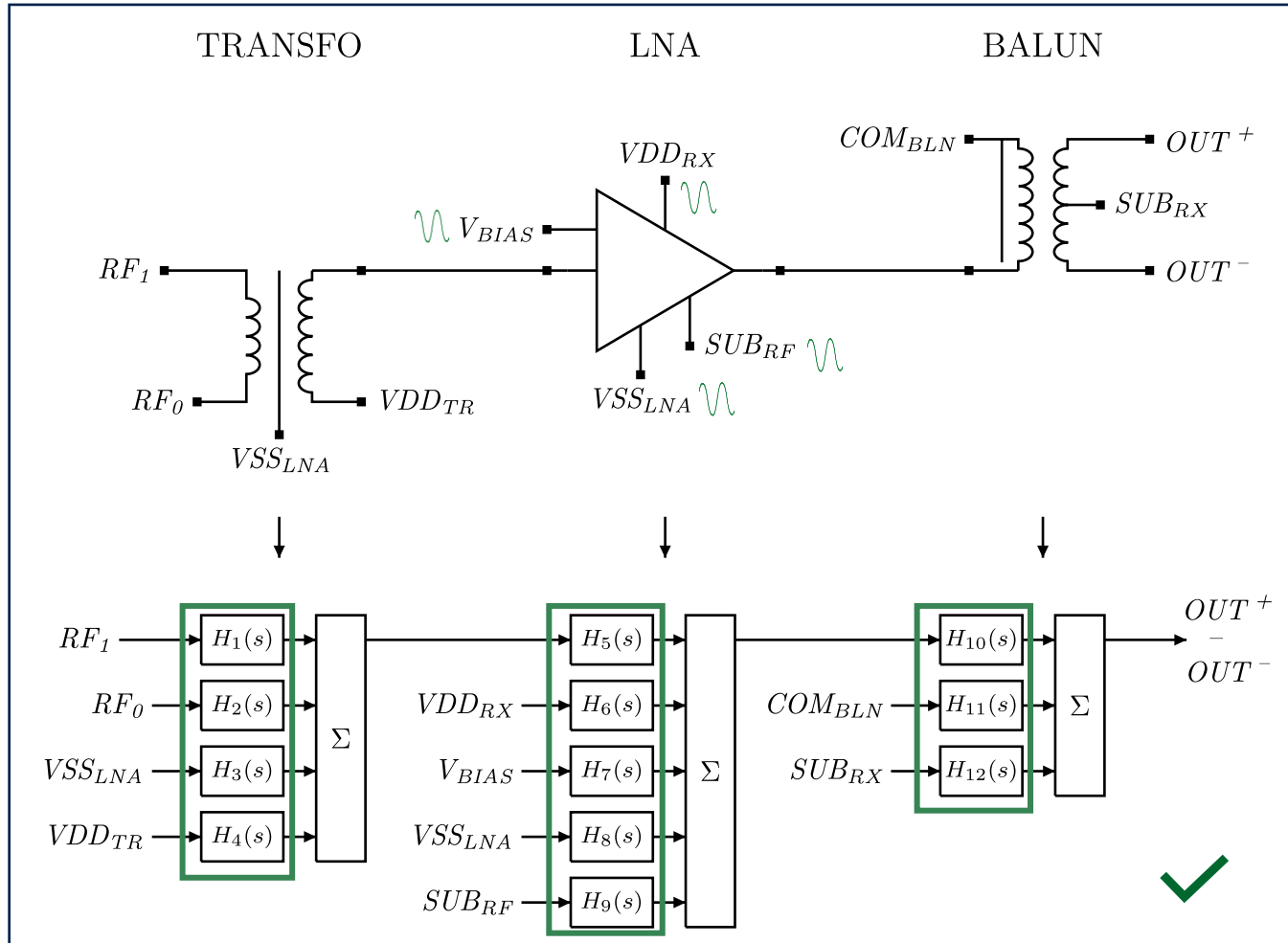


+ Rx Noise Transfer Functions

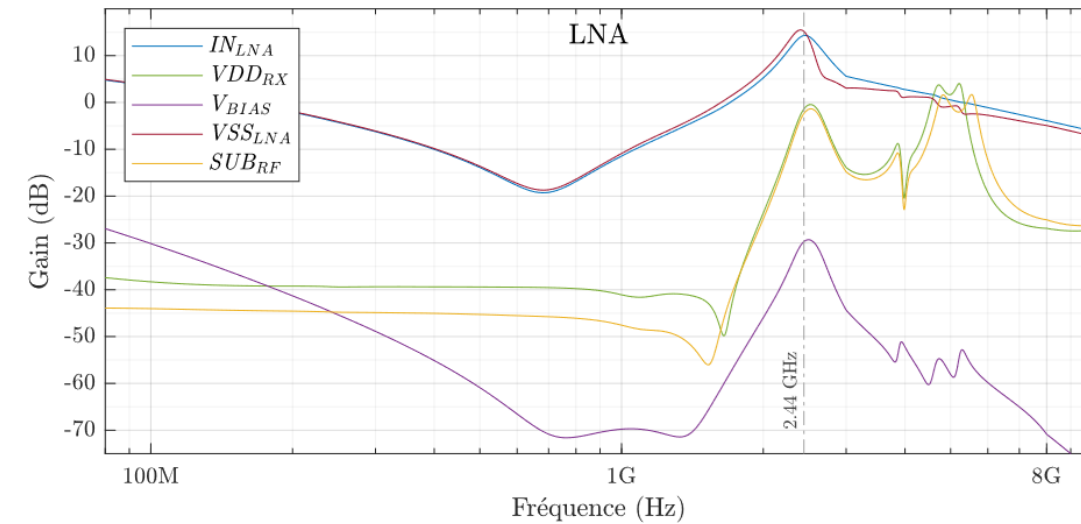
Bits comparison : B.E.R.



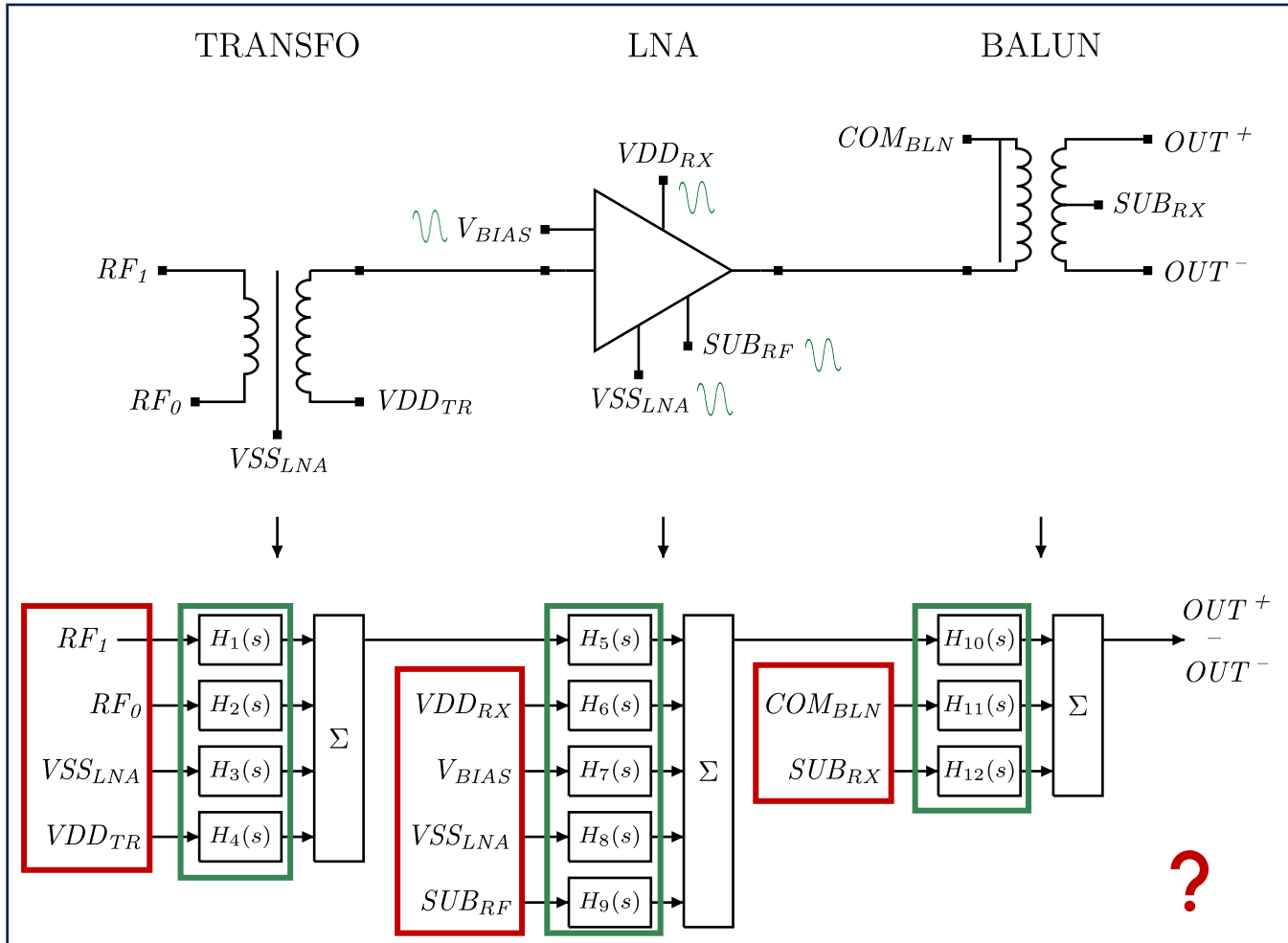
Noise transfer function extraction



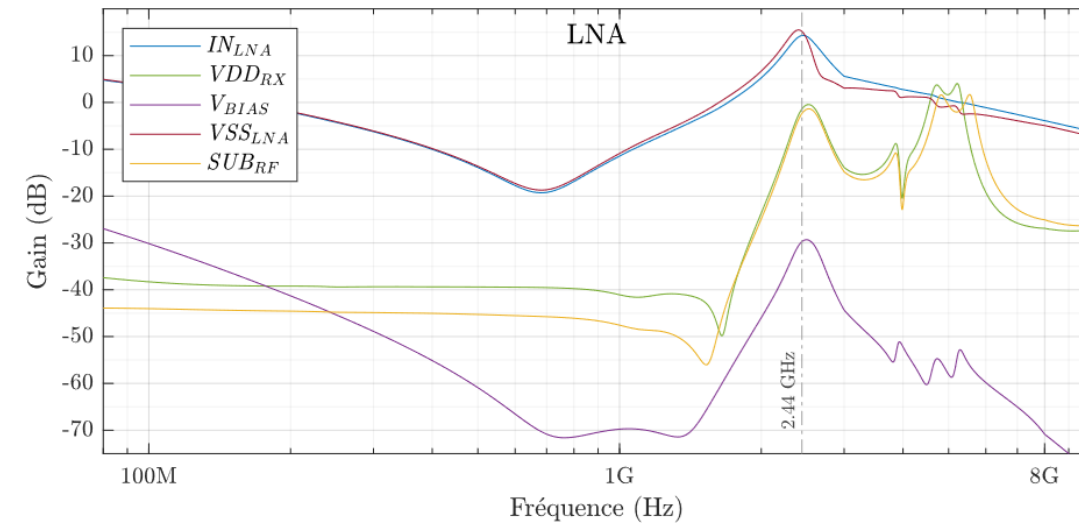
AC simulation



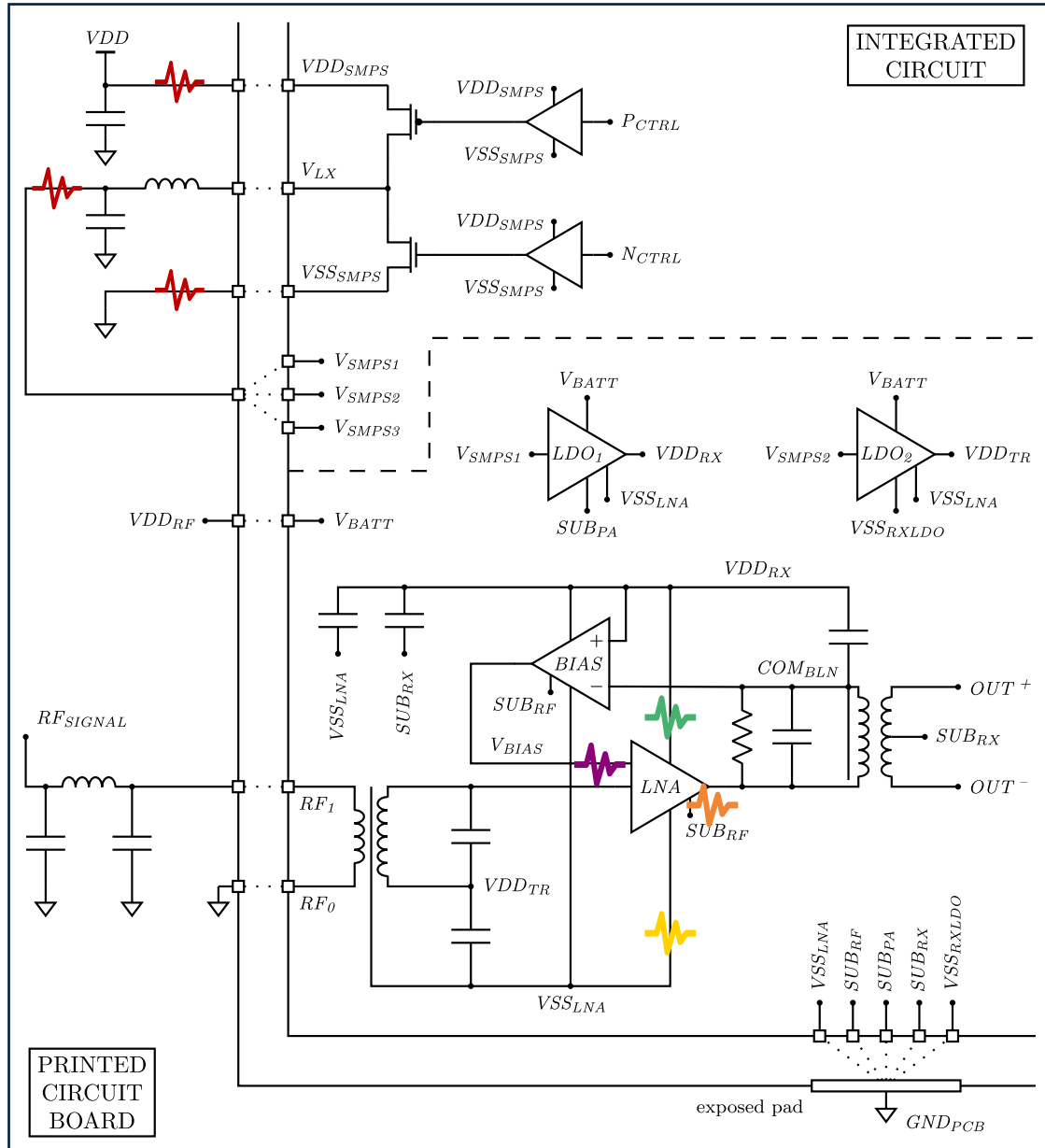
Noise transfer function extraction



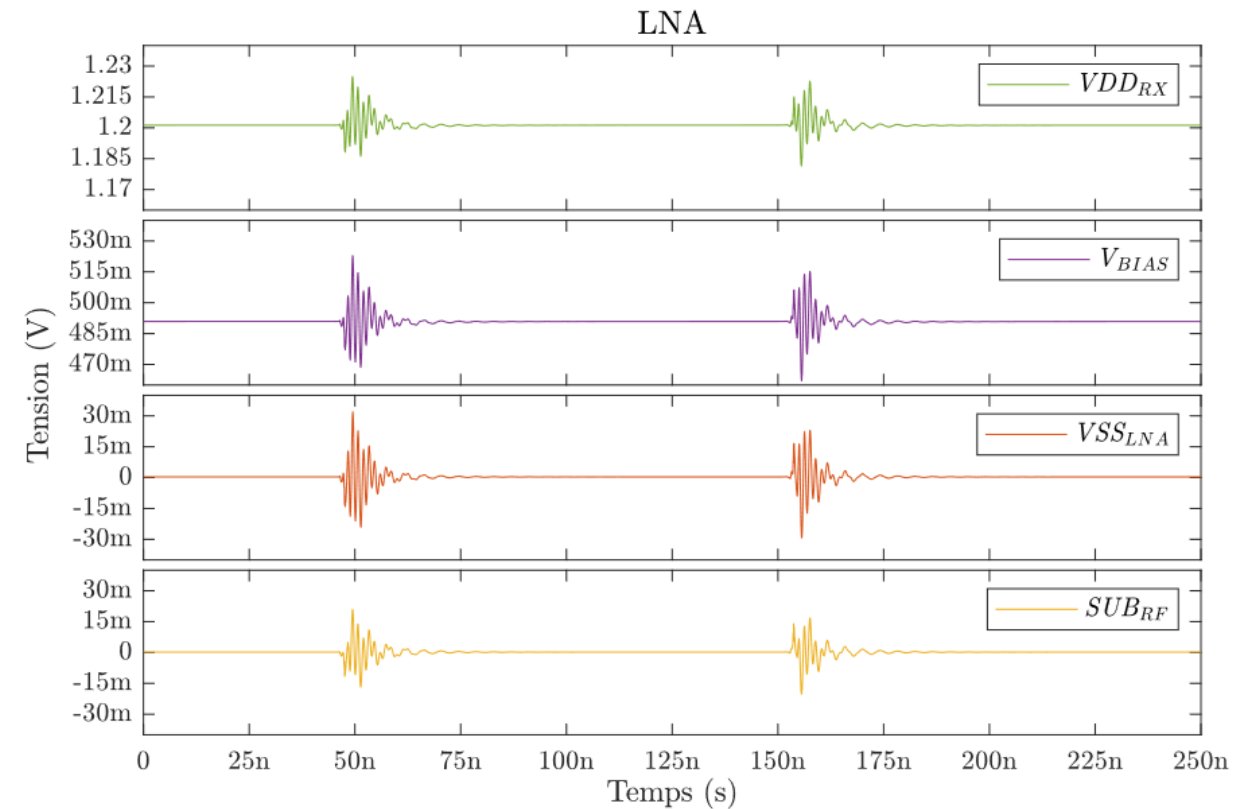
AC simulation



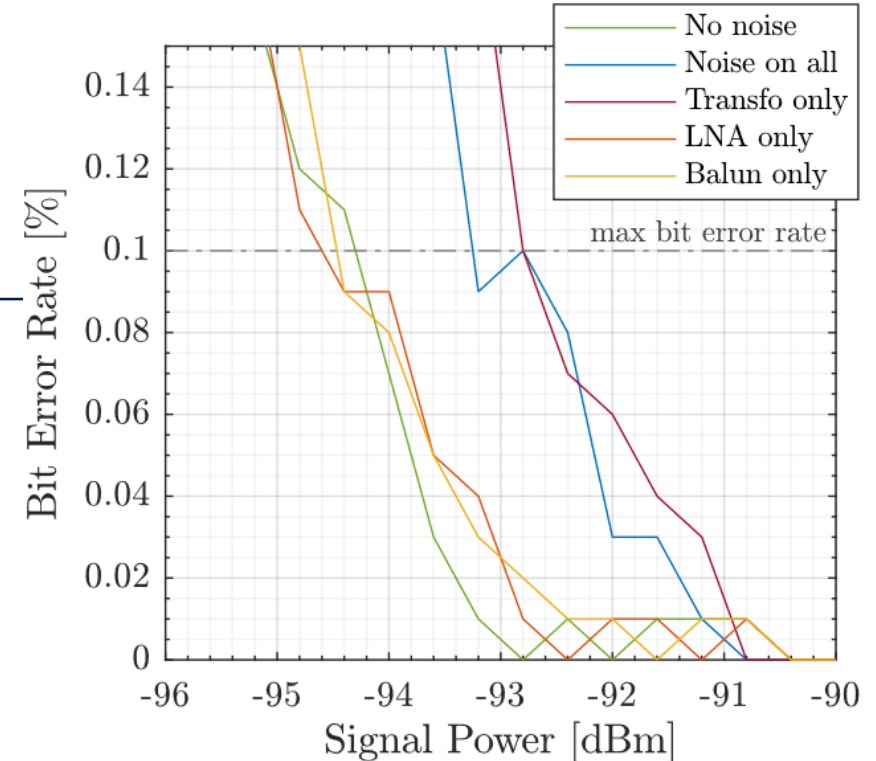
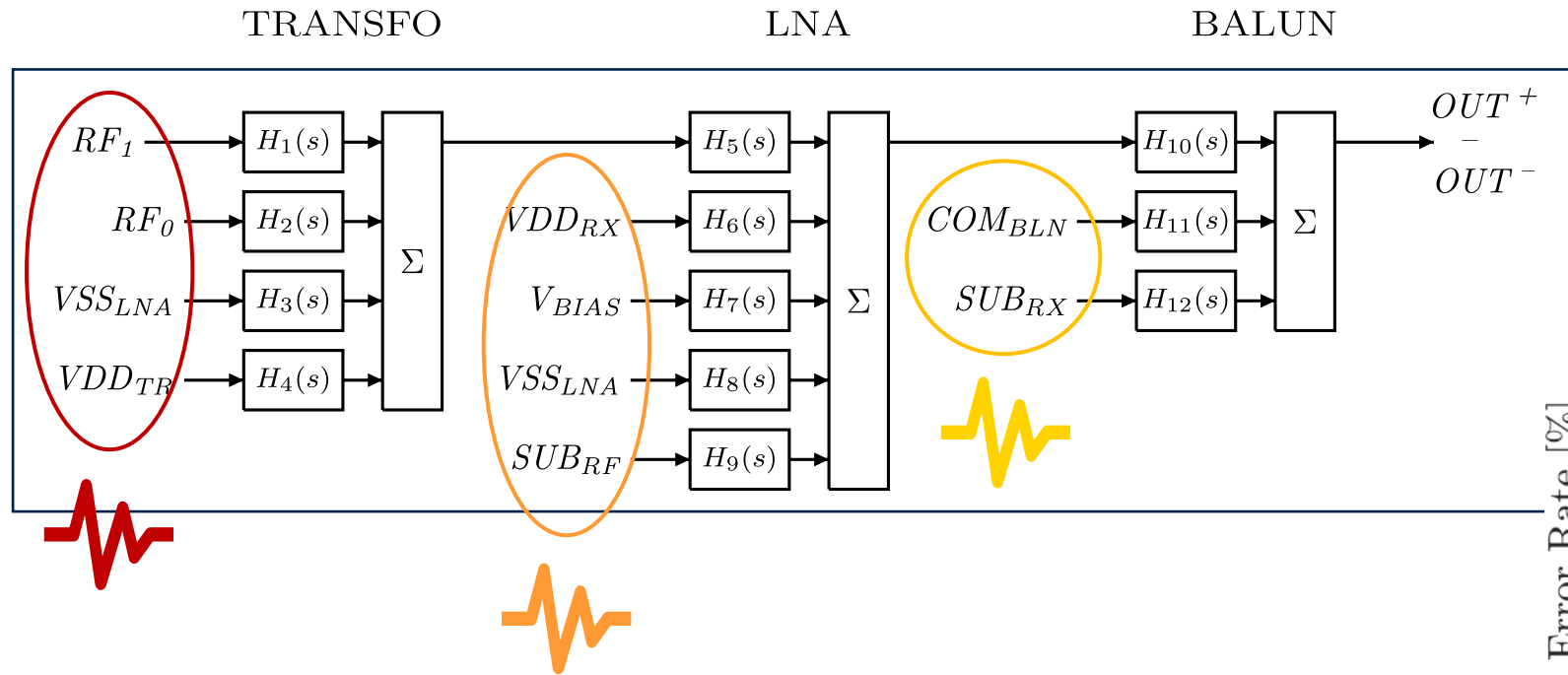
Noise sources



Transient simulation



Simulated noise impact on sensitivity



Conclusion & Summary



STM32

#1 GP MCU Worldwide

Low-cost constraints



Reliability

Robustness

Flexibility

Efficiency

Integrity

 High Performance	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 Mainstream	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 Ultra-low-power	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 Wireless	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

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