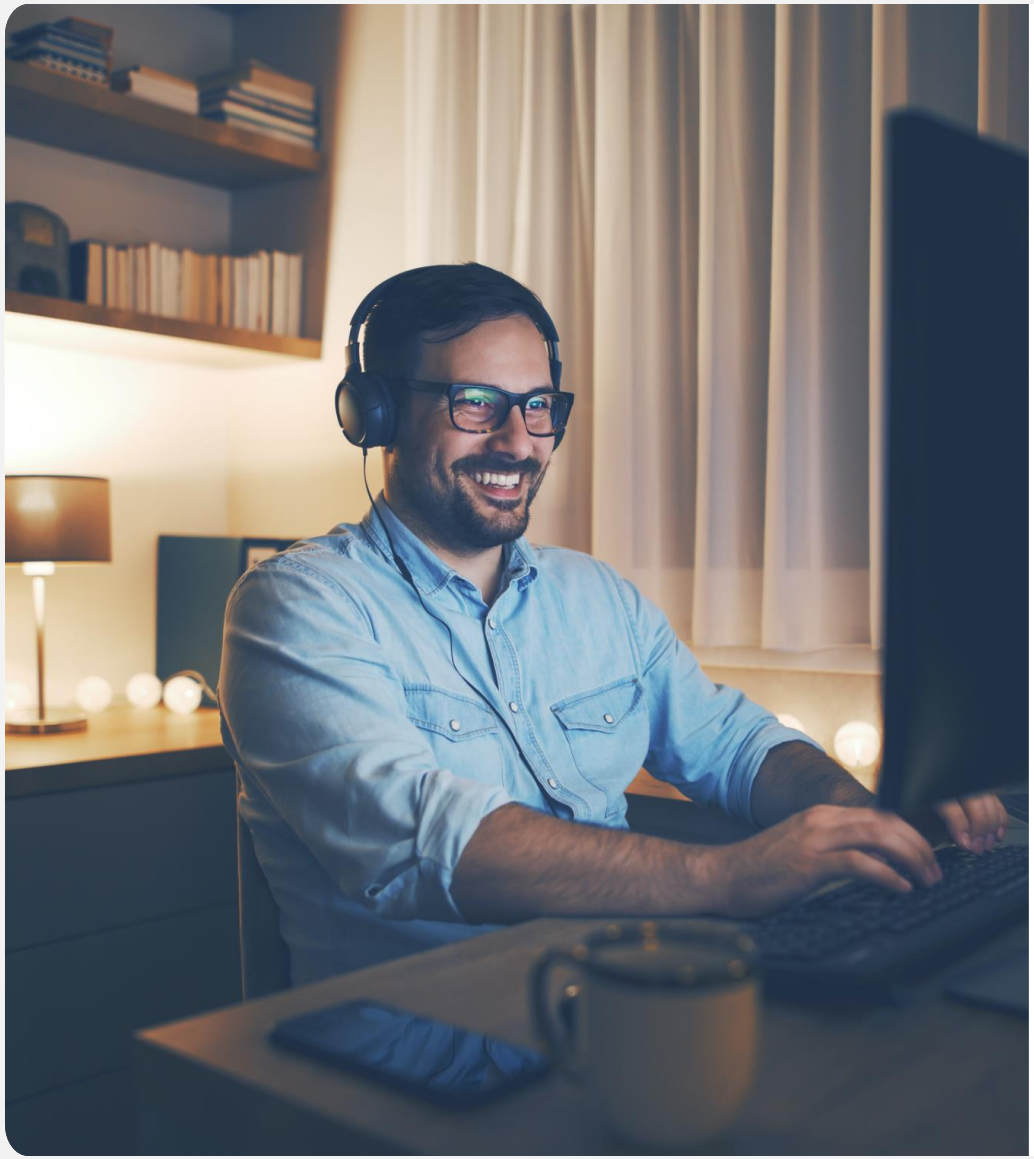
Tech Talks Upcoming Sessions – Presentation will begin shortly



tech talks

Tuesday, February 22	**Proprietary Sub-GHz: Leaping RF Performance and Improving Low Power Performance with FG23**
Tuesday, March 8	Wi-Fi: Developing with Matter over Wi-Fi on the RS9116
Tuesday, March 22	Z-Wave: Unboxing the New 800 Series
Tuesday, April 5	Bluetooth: The Latest in BLE Developments

We will begin in: 0:00

SILICON LABS | tech talks

Welcome

Proprietary Sub-GHz: Leaping RF Performance and Improving Low Power Performance with FG23

Antonio Trujillo

Proprietary Sub-GHz: Leaping RF Performance and Improving Low Power Performance with FG23

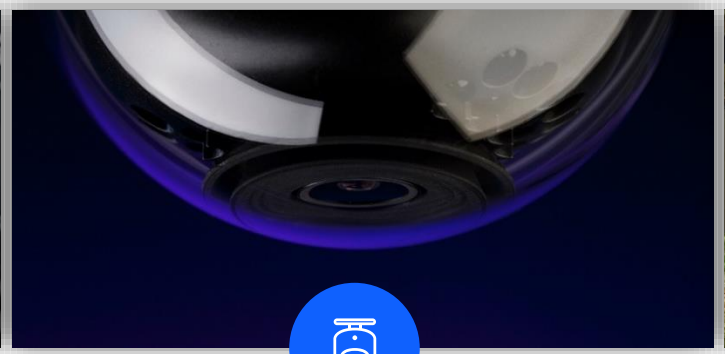
February 2022 | Antonio Trujillo

Agenda

1. Where does FG23 fit in the market?
2. Overview of the FG23 (MCU & RF)
3. How to develop with FG23 (HW and SW tools)
4. Demos

Positioning the FG23 in the Sub-GHz market

- Smart Meters



- Home Automation and Security

- Garage & Door Openers

- Public Infrastructure

- Agriculture

- Asset Tracking & ESL

An overview of the EFR32FG23

High Performance, low power and secure Sub-GHz Wireless SoC

High-Performance Sub-GHz Wireless SoC

Low Power.
Long Range.
Secure.

Sub-GHz SoCs Optimized for Metering & Home/Industrial Automation Applications

High Performance Radio

- Up to +20 dBm TX
- -110.1 dBm RX @ 920MHz, 50kbps GFSK
- -125.8 dBm RX @ 915MHz, 4.8kbps O-QPSK
- -125.3 dBm RX @ 868MHz, 2.4kbps GFSK
- RX Antenna Diversity
- Single-ended RF port, no balun, low BOM cost

Low Power

- 25 mA TX @ +14 dBm, 925 MHz
- 85.5 mA TX @ +20 dBm, 915 MHz
- 4.2 mA RX @ 920 MHz, 400 kbps 4-FSK
- 1.2 µA EM2 with 16 kB RAM
- Preamble Sense

Wireless Technologies

- Amazon Sidewalk
- Mioty
- Wireless M-BUS
- Proprietary

ARM® Cortex®-M33 with TrustZone®

- 78 MHz (FPU and DSP)
- 512kB of flash
- 26 uA/MHz active current @ 78 MHz
- 1.5 uA EM2 (full retention)
- 64kB of RAM

Security

- Up to Secure Vault High (selected OPNs)

Low-power Peripherals

- EUSART, USART, I^2C
- 16-bit ADC, 12-bit VDAC, ACMP
- 20 x 4 LCD Controller
- KEYSCAN
- LESENSE, Pulse Counter, PRS, LDMA

Compact Size

- 5x5 QFN40 (22/23 GPIO)
- 6x6 QFN48 (31 GPIO)

Secure Vault™

Series 2 (xG2xA/B)

Base	Mid	High	Feature
✓	✓	✓	True Random Number Generator
✓	✓	✓	Crypto Engine
✓	✓	✓	Secure Application Boot
—	✓	✓	Secure Engine
—	✓	✓	Secure Boot with RTSL
—	✓	✓	Secure Debug with Lock/Unlock
—	Optional	✓	DPA Countermeasures
—	—	✓	Anti-Tamper
—	—	✓	Secure Attestation
—	—	✓	Secure Key Management
—	—	✓	Advanced Crypto

Designing Secure IoT Devices

ARM PSA Level 2 & 3

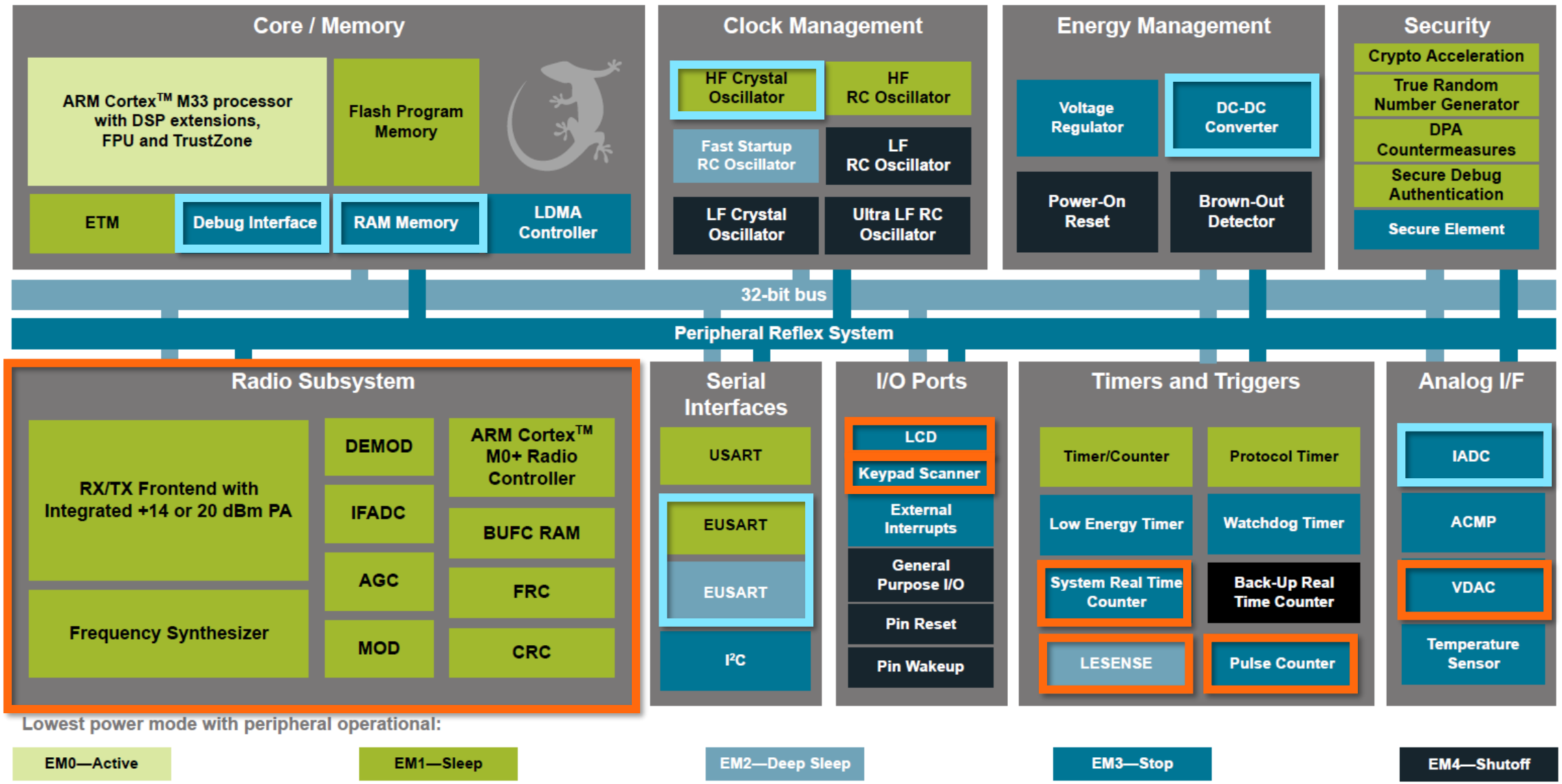
silabs.com/security
silabs.com/support/training

Silicon Labs Sub-GHz Wireless Portfolio Comparison

	Si4463	Si4467/8	xG13	xG23
Description	sub-GHz Transceiver	sub-GHz Transceiver	Dual Band SoC	sub-GHz SoC
Core (Max Frequency)	N/A	N/A	Cortex-M4 (38.4 MHz)	Cortex-M33 (78 MHz)
Max Flash	N/A	N/A	512 kB	512 kB
Max RAM	N/A	N/A	64 kB	64 kB
Security	N/A	N/A	Secure Vault Base	Secure Vault Mid Secure Vault High (select OPNs)
Supported Modulation	(G)FSK, 4(G)FSK, (G)MSK, OOK	(G)FSK, 4(G)FSK, (G)MSK, OOK	BPSK, (G)FSK, 4(G)FSK, (G)MSK, OOK	2(G)FSK, (G)MSK, OQPSK DSSS
Frequency Range (MHz)	142-175, 284-350, 420-525, 850-1050	142-175, 284-350, 350-525, 850-1050	110-191, 191-358, 358-574, 584-717, 779-956	110-191, 191-358, 358-574, 584-717, 779-970
Preamble Sense Mode (PSM)	Yes	Yes	No	Yes
RX Sensitivity	-110 dBm (40 kbps GFSK 450 MHz) -106 dBm (100 kbps GFSK 450 MHz)	-109 dBm (40 kbps GFSK 915 MHz) -104 dBm (100 kbps GFSK 915 MHz)	-108.2 dBm (50 kbps GFSK 915 MHz) -105.1 dBm (100 kbps GFSK 915 MHz)	-110.1 dBm (50 kbps GFSK 920 MHz) -107.1 dBm (100 kbps GFSK 920 MHz)
Active Current	N/A	N/A	87 µA/MHz	26 µA/MHz
Sleep Current (EM2, 16 kB ret)	0.9 µA (transceiver only)	0.7 µA (transceiver only)	1.3 µA	1.2 µA
TX Current @ +10 dBm (915 MHz)	18 mA	19.7 mA	20.3 mA (433 MHz)	21.8 mA, 13.2 mA (w/DCDC) (868 MHz)
TX Current @ +20 dBm (915 MHz)	85 mA	88 mA	90.2 mA	92 mA, 85.5 mA (w/DCDC)
RX Current	13.7 mA (40 kbps GFSK 915 MHz)	13.7 mA (40 kbps GFSK 915 MHz)	8.6 mA (38.4 kbps GFSK 868 MHz)	4.0 mA (50 kbps FSK 915 MHz)
PSM Current	1.95 mA	1.95 mA	N/A	0.74 mA
Selectivity (1-Ch Offset, 915 MHz)	53 dB	55 dB	48.1 dB (4.8 kbps)	49.6 dB (4.8 kbps)
Operating Voltage	1.8 V to 3.8 V	1.8 V to 3.8 V	1.8 V to 3.8 V	1.71 V to 3.8 V
GPIO	4	4	16, 31	22/23, 31
Package	4x4 QFN20	4x4 QFN20	5x5 QFN32, 7x7 QFN48	5x5 QFN40, 6x6 QFN48

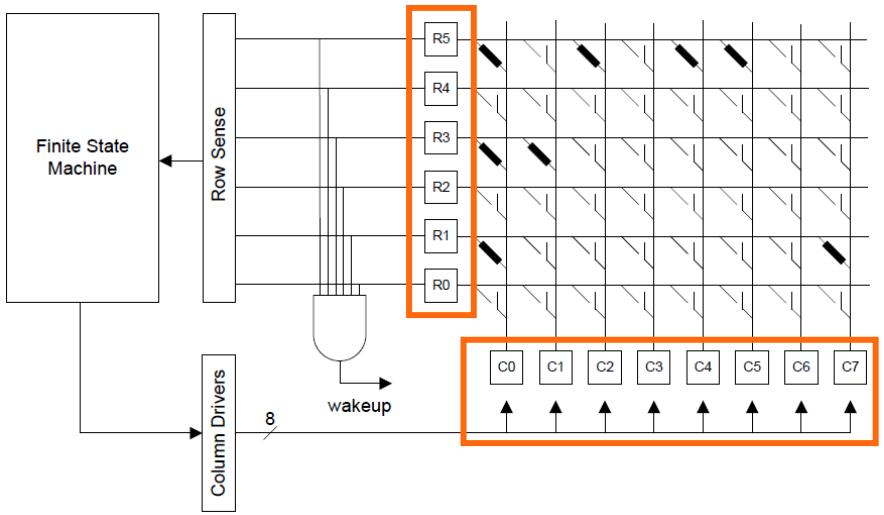
FG23 - New, returning, and improved peripherals

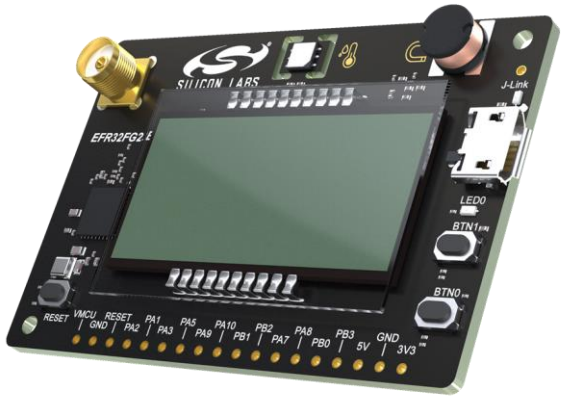
xG23 series Block Diagram



KEYSCAN & LCD controller

- New to EFRX32
- 1 - 8 columns (Drive) x 3-6 rows (Sense)
- 500 Hz (2ms) time base
- Hardware debounce FSM
- EM0/EM1 – Full scanning
- EM2/EM3 – Wake on any key press
- Modes of operation:
  - Single-press & multi-press





- EM2 mode operation
- Up to 4x20 segments
- Configurable biasing and contrast
- Charge redistribution
- Charge-pump for low-power supplies
- Autonomous blink and animations
  - Up to 8 segments
- RF retiming
- Frame and display counters

LESENSE – Low Energy Sensor Interface

Analog events

Capacitive, inductive or resistive sensors

Generic MCU

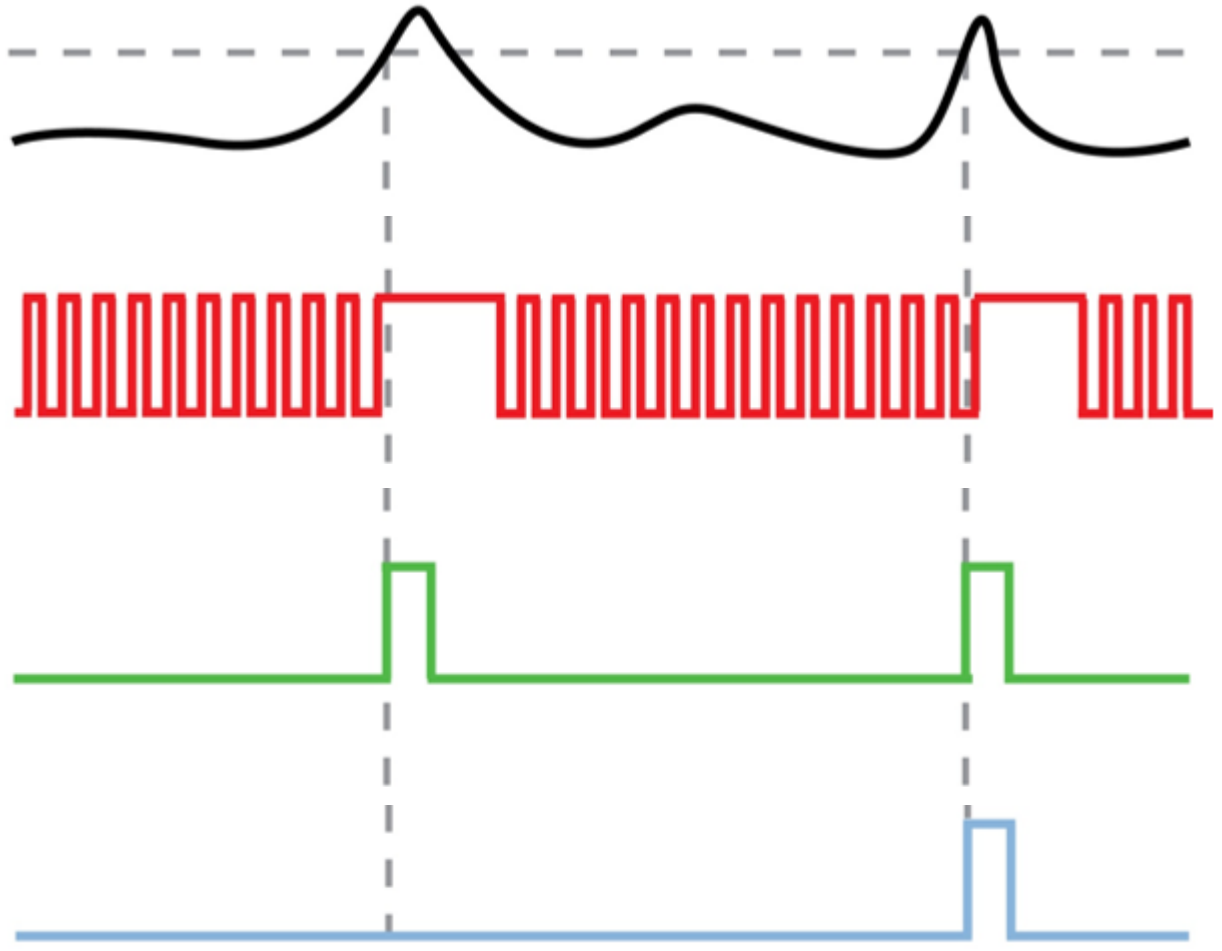
Wake-up periodically to detect the events

FG23 - LESENSE

Wake-up only on the events

FG23 - LESENSE

Conditional wake-up (e.g. on every 2nd event)



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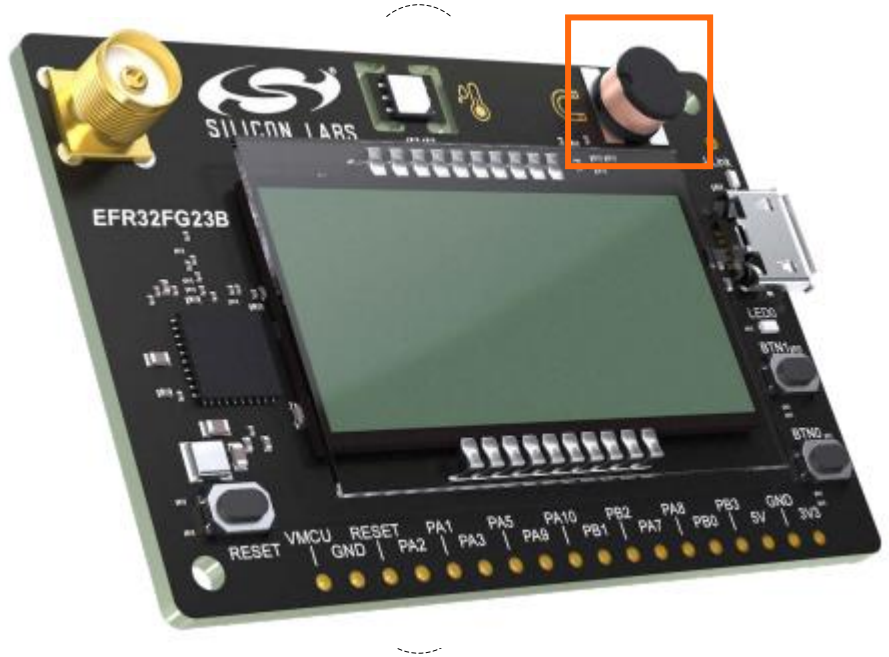


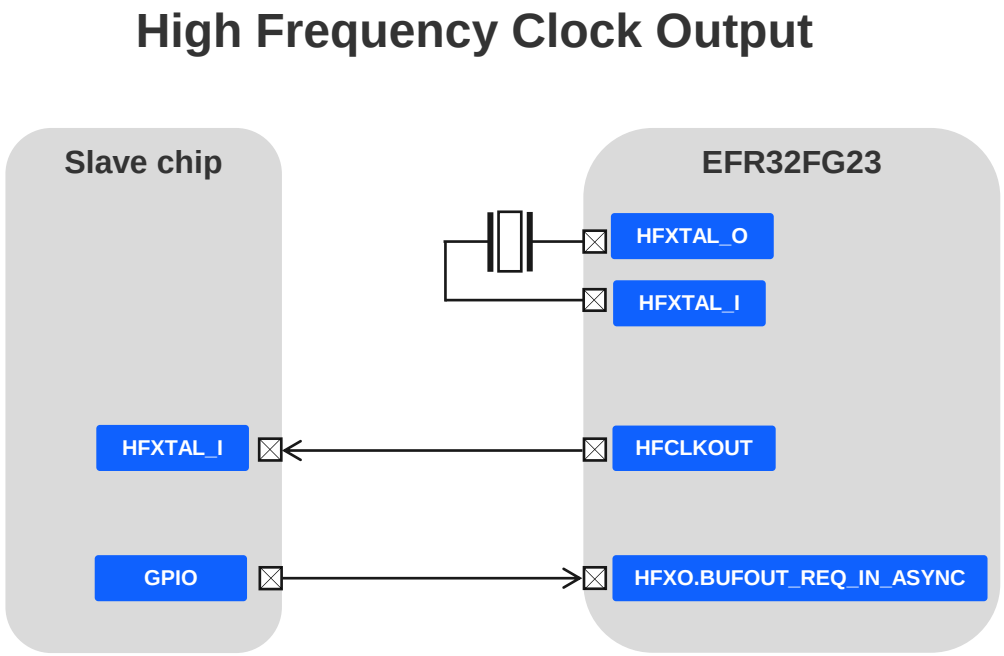
Lowest power, autonomous sensing

Resistive, inductive, capacitive

Configurable and scalable

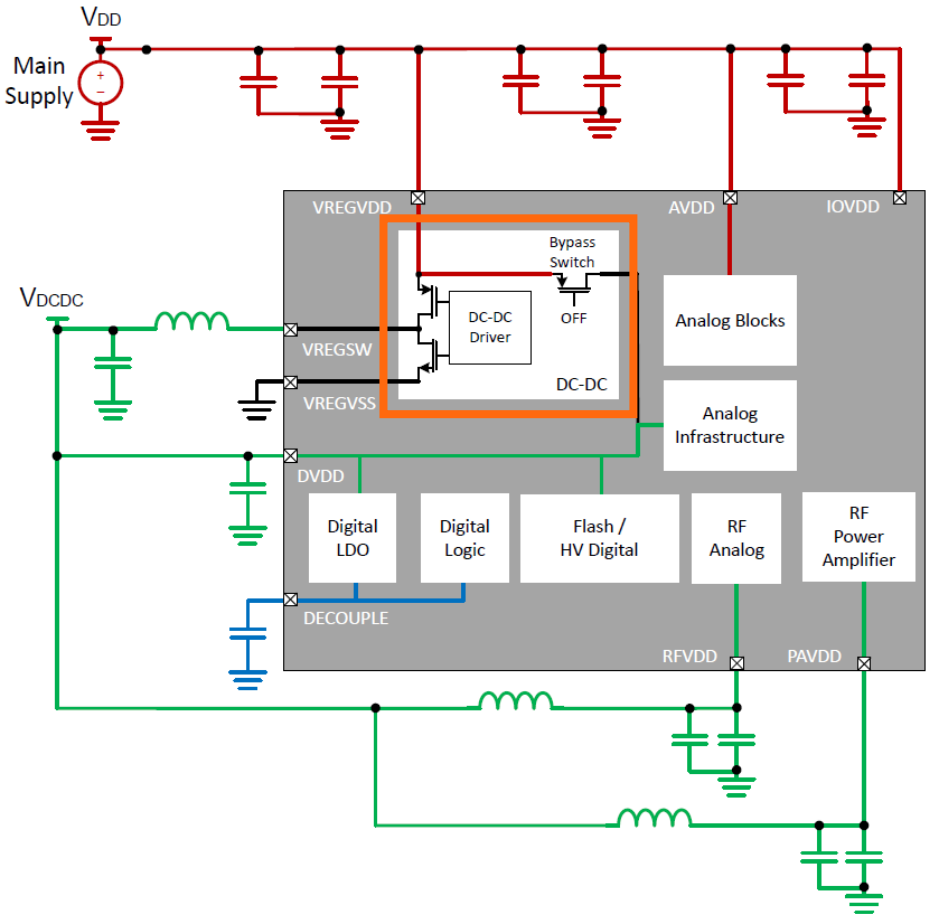
- **Autonomous sensing in Deep Sleep**
  - Up to 16 configurable channels
  - Leverage MCU peripherals
    - GPIO/VDAC for sensor excitation
    - ACMP/ADC for sensor measurement
  - Multiple trigger sources
  - 16 entry result buffer
  - Up to 4 sensor measurement evaluation
    - Threshold comparison, step detection or sliding window
- **Programmable state machine**
  - Automatically track system state
  - IRQ or PRS signal on state transition
  - PCNT for counting state machine transitions (PRS)
- **Operates down to EM2, can wake-up CPU on configurable events**

Honorable mentions



- **HFXO**
  - Buffered sinewave output
    - Single crystal for dual-chip design
    - On-demand GPIO request (down to EM3)
  - Early wake-up
    - Through PRS signal

Honorable mentions



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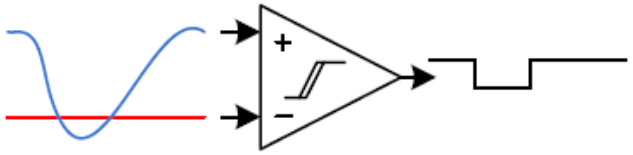
  - Buffered sinewave output
    - Single crystal for dual-chip design
    - On-demand GPIO request (down to EM3)
  - Early wake-up
    - Through PRS signal
- **DCDC**
  - 2 new operation modes (RAIL controlled)
    - Higher current for TX
    - Minimize RX interference (beneficial for <500 MHz PHYs)
- **iADC**
  - 12-bit resolution (11.7 ENOB) @ 1Msps (OSR = 2)
  - 16-bit resolution (14.3 ENOB) @ 76.9 Ksps (OSR = 32)
  - Increased FIFO size (7 words)
  - Internal routing to VDAC output

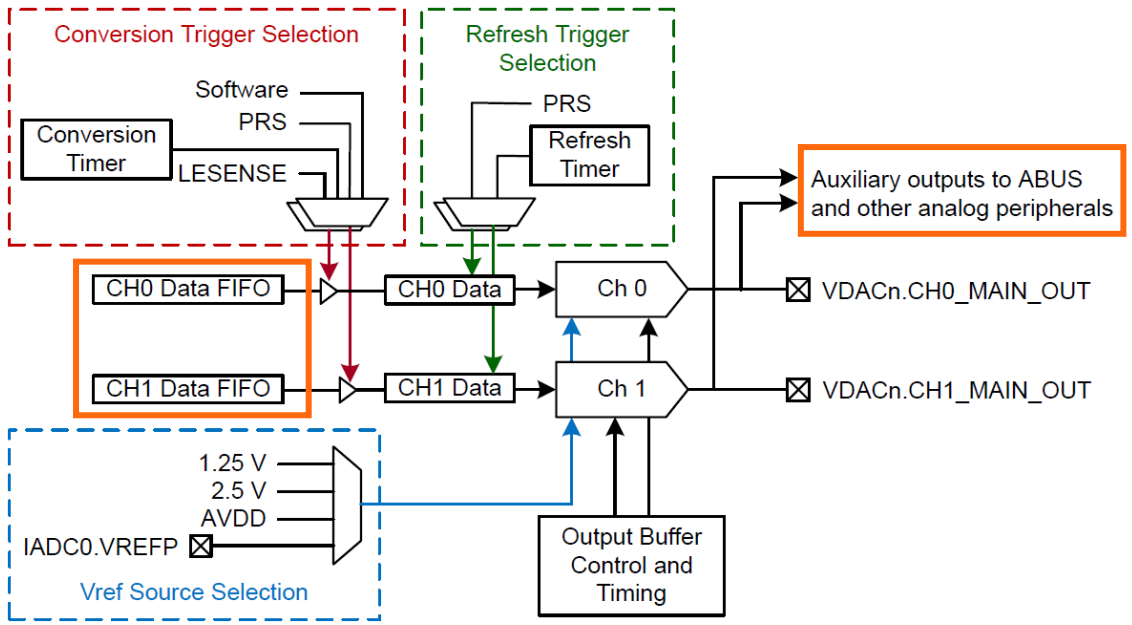
Honorable mentions (continuation)



Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
ACMP Supply current from AVDD pin	I_{ACMP}	BIAS = 2, HYST = DISABLED	—	520	—	nA
		BIAS = 3, HYST = DISABLED	—	1.9	—	µA
		BIAS = 4, HYST = DISABLED	—	4.4	—	µA
		BIAS = 5, HYST = DISABLED	—	9.4	—	µA
		BIAS = 6, HYST = DISABLED	—	24	—	µA
		BIAS = 7, HYST = DISABLED	—	46	TBD	µA
ACMP Supply current from AVDD pin with Hysteresis	I_{ACMP_WHYS}	BIAS = 2, HYST = SYM30MV	—	780	—	nA
		BIAS = 3, HYST = SYM30MV	—	2.8	—	µA
		BIAS = 4, HYST = SYM30MV	—	6.3	—	µA
		BIAS = 5, HYST = SYM30MV	—	14	—	µA
		BIAS = 6, HYST = SYM30MV	—	35	—	µA
		BIAS = 7, HYST = SYM30MV	—	66	—	µA

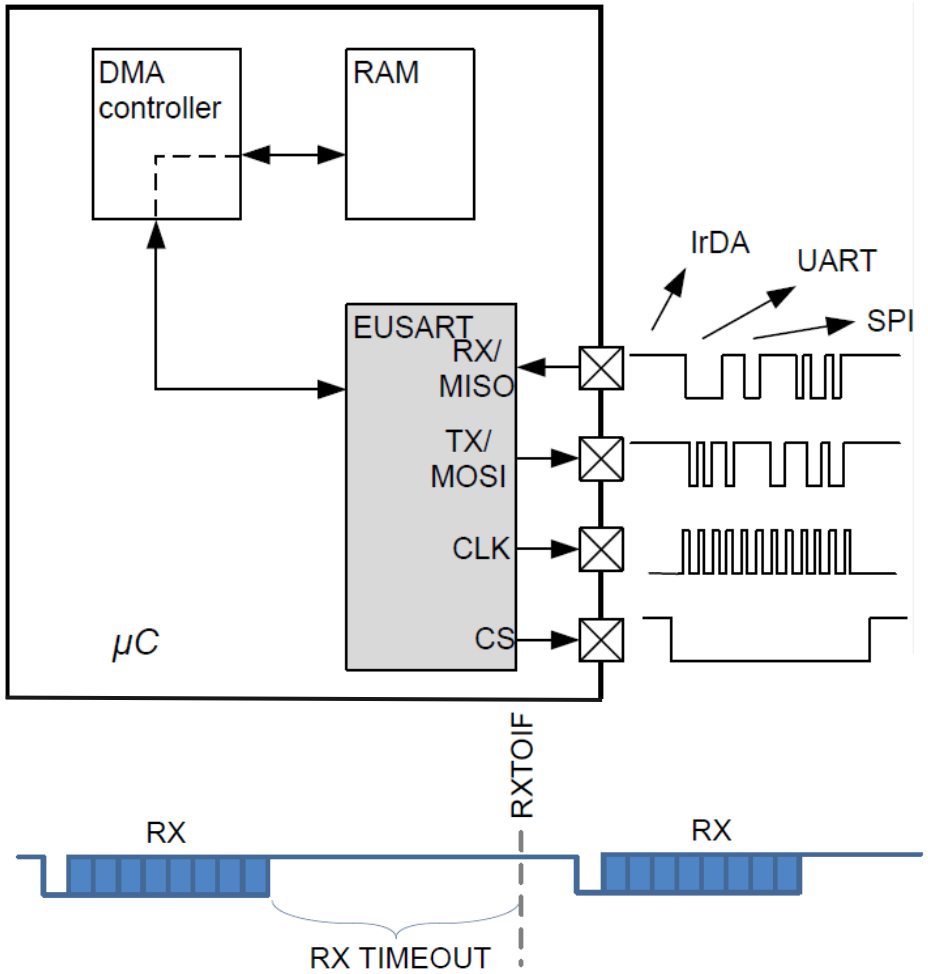
- **ACMP**
  - 4 new bias levels
    - Low power & slow response

Honorable mentions (continuation)



- **ACMP**
  - 4 new bias levels
    - Low power & slow response
- **VDAC**
  - Dedicated output buffer
  - 4-word conversion FIFO
  - iADC and ACMP routing
  - Sensor excitation (LESENSE)

Honorable mentions (continuation)



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  - Dedicated output buffer
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  - Sensor excitation (LESENSE)
- **EUSART**
  - Adds SPI functionality
    - @ 20 MHz Master mode
    - @ 10 MHz Slave mode
  - Timeout function
- **PCNT**
  - 16-bit counter (up/down)
  - Single input counter and quadrature decoder

FG23 - RF improvements

EFR32FG23 RF Improvements

Improved Sensitivity

- Sensitivity improvement up to ~4 dBm

Simplified RF matching network

- Single-ended output
- No Balun required (Reduced BOM cost and footprint)

Antenna Diversity

- Switchless through internal RF switch and single-ended paths
- External switch through GPIO control

Collision Restart

- Receiver demodulates the stronger packet

OOK modulation improvements

EFR32FG23 RF Improvements (continuation)

Overall radio IP improvements

- Improved Radio Configurator PHY calculation
- Improved baudrate tolerance ~12%
- Better support for short preambles in 2(G)FSK modulations
- Improved SNR (Signal to Noise Ratio)
- Improved AGC (Automatic Gain Control)

Direct mode improvements

- Available for 2(G)FSK and OOK modulations
- Demodulated signal on GPIO or buffer
- Two operation modes
  - Async and Sync
- Event on RSSI above threshold

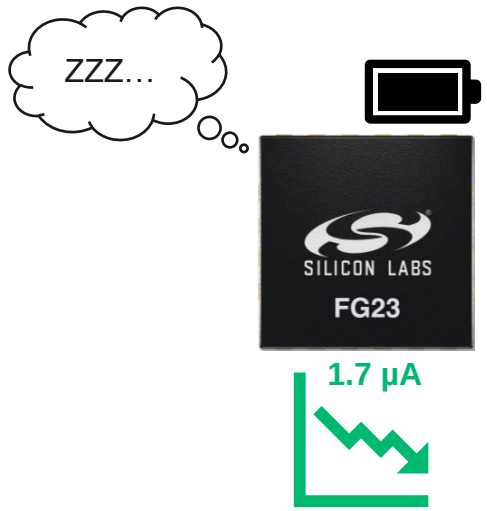
PSM (Preamble Sense Mode)

Preamble Sense Mode

Hardware enabled long-preamble duty cycling

Preamble Sense Mode (PSM) – Low energy listening

- **Why Preamble Sense Mode?**
  - IoT devices are idle/sleep most of the time
  - Data should be received occasionally
    - RX current (4-5 mA) vs sleep current (1.7 µA)
  - Reduce time spent in RX
- **What is Preamble Sense Mode?**
  - Duty-cycled RX mode with timely wake-up so that no packet is missed
  - Energy is saved by entering a Low Power mode (LP) when the receiver is not used
    - Higher consumption on TX device
  - Maximum allowed latency determines preamble length



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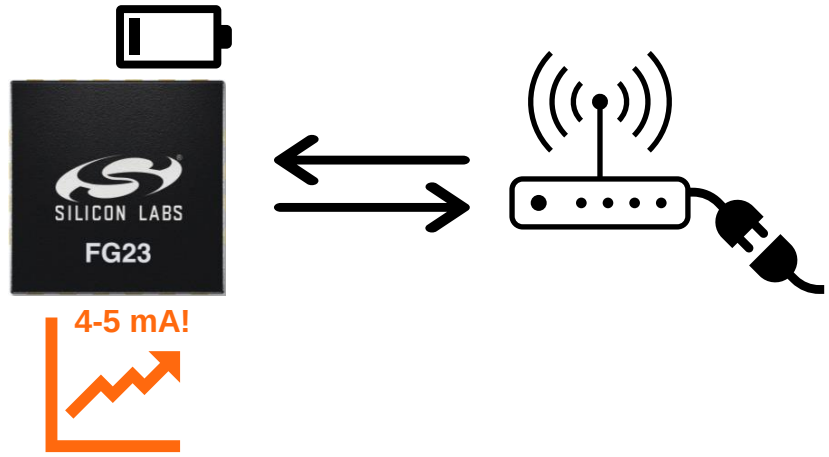

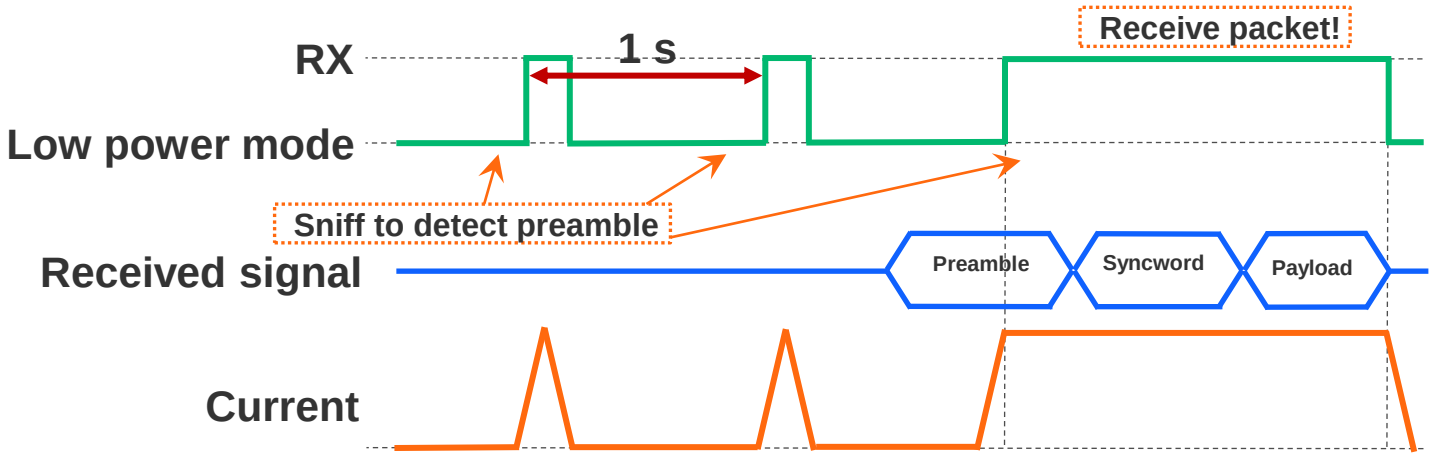

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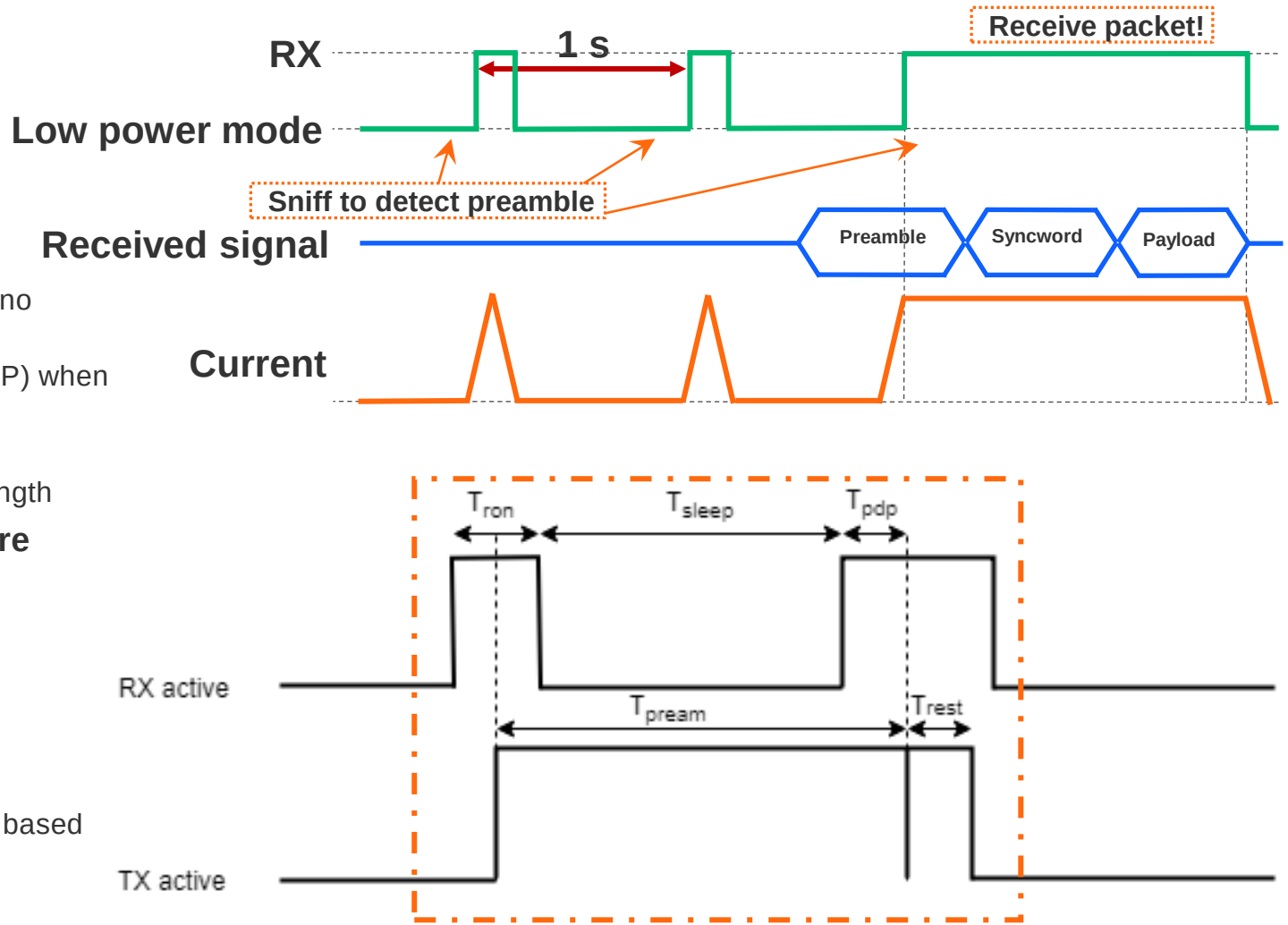
- **Signal qualifier: 3-stage detector in hardware**
  - 1st: Quick detection with high false rate
  - 2nd: Filter false detect
  - 3rd: Timeout if sync-word is not detected
- **CFE engine to perform pattern recognition**
- **Configuration**
  - Currently the radio configurator calculates timeout based on preamble length (maximum latency)
- **Currently supports only 2(G)FSK PHYs**



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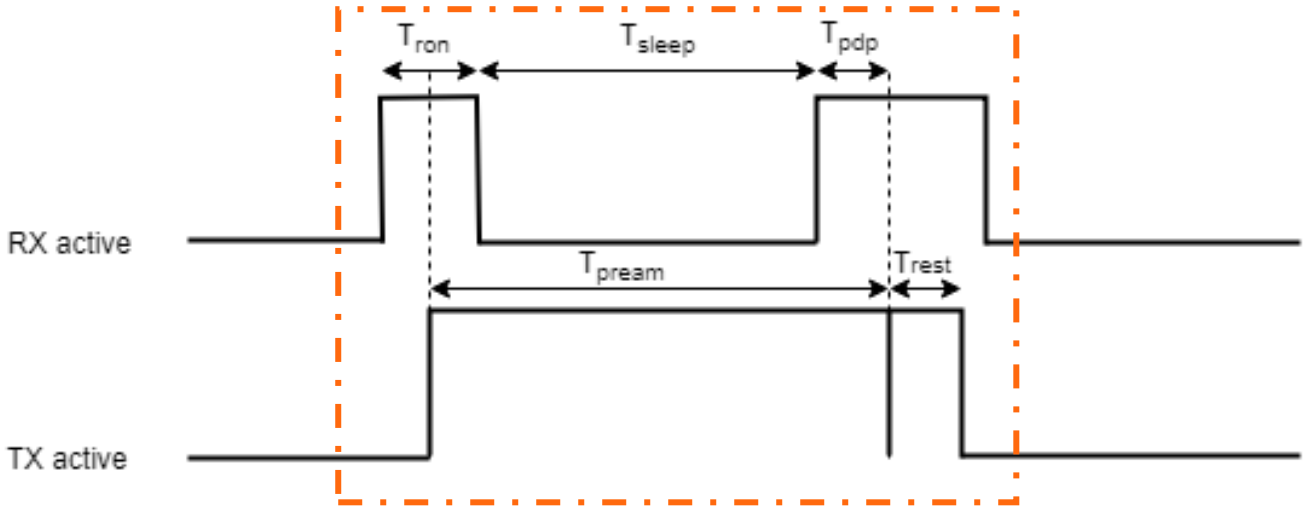
16 symbols @ 10 kbps = 1.6 ms = **Rx_{on}**

RX_{duty} = 1.6 ms/1 s = **0.16 %**

$RX_{consumption}$ = ~5mA -> ~ **8µA**

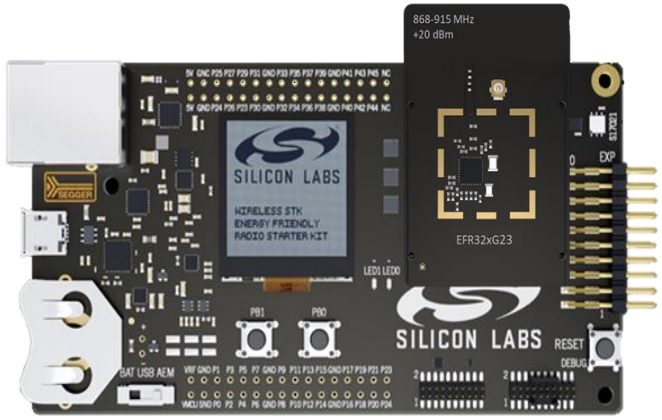


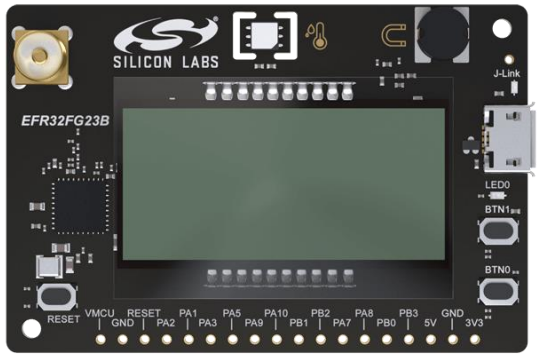
Developing with FG23

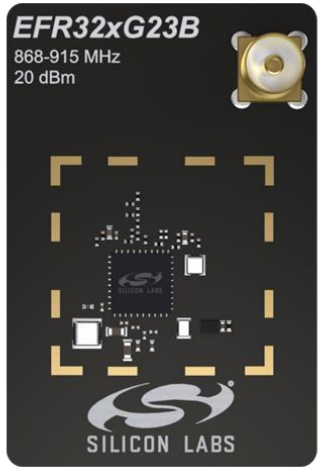
Hardware and software tools

EFR32FG23 development kits

SIMPLIFIED DEVELOPMENT KITS







Consult the user guide of your kit: **silabs.com/support/resources**

CONTENTS

- **Pro kits**
  - 1x WSTK main board
  - 1x Radio board
  - Antenna(s)
  - USB cable
- **Dev kit**
  - 1x dev board
  - Antenna(s)
  - USB cable

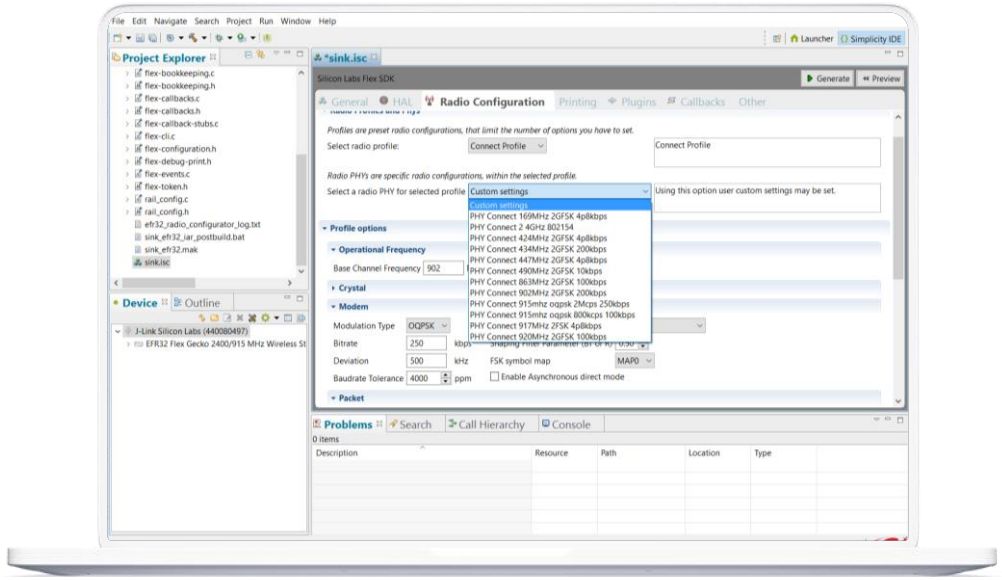
AVAILABLE OFFERINGS

Order Part Number	Description	Resale
xG23-PK6067A	xG23 868-915 MHz +14 dBm Pro Kit	$139
xG23-PK6068A	xG23 868-915 MHz +20 dBm Pro Kit	$139
xG23-RB4204D	xG23 868-915 MHz +14 dBm Radio Board	$49
xG23-RB4210A	xG23 868-915 MHz +20 dBm Radio Board	$49
FG23-RB4265B	FG23 433 MHz +10 dBm Radio Board	$49
FG23-DK2600B	FG23 868-915 MHz +14 dBm Dev Kit	$39

Simplified Developer Experience

- **Simplicity Studio 5**
  - Interface
    - Fresh, new & simplified
    - Intuitive out-of-the-box experience
    - Fast access to developer resources
    - Linux, Mac & Windows
  - Tools
    - Configuration utilities
    - Compiler
    - Error & validation
    - IDE & command line support
    - Graphical hardware & software configurator
      - Project Configurator
      - Pintool, Radio configurator and GATT configurator
    - Energy Profiler – visual energy analysis
    - Network Analyzer – packet capture & decode

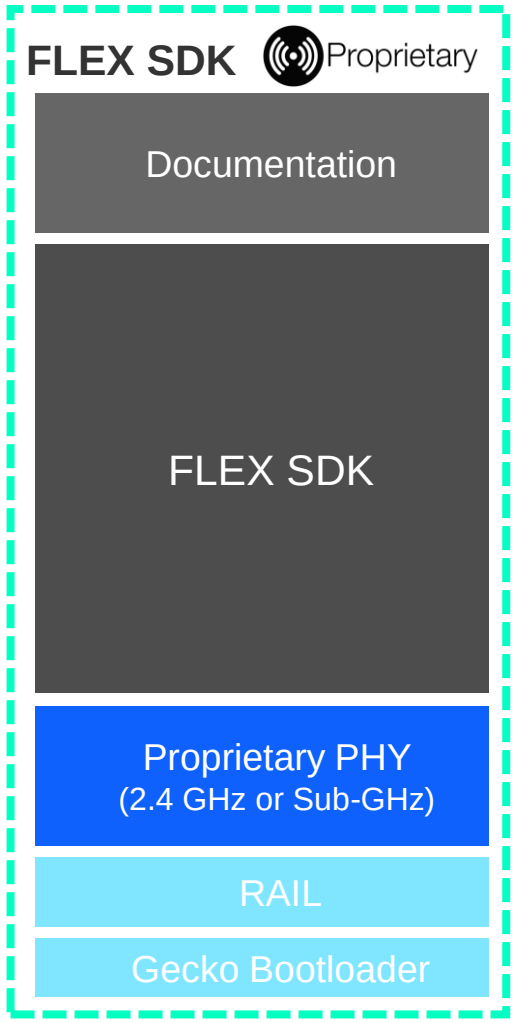
Radio Configurator – PHY customization and optimization



Tool to configure and optimize radio performance

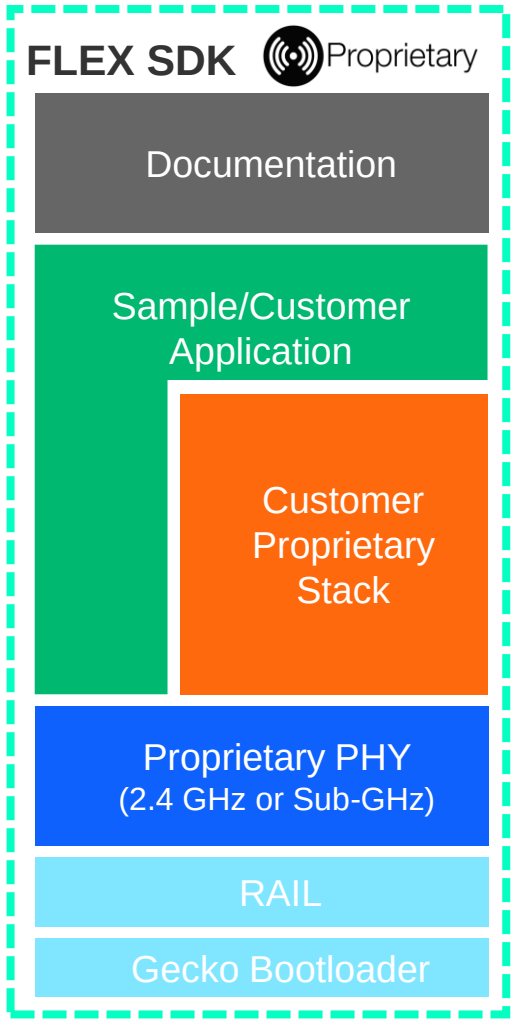
- **Rapid Radio configuration and prototyping**
  - Predefined PHYs are tuned and tested by Silicon Labs for optimal performance
  - Custom PHYs can be configured via the Radio Configurator
- **Intuitive GUI to configure PHY parameters**
  - Frequency bands, channel spacing, modulation
  - Bit rate, symbol maps, symbol coding, filtering
  - Timing detection, AFC, AGC and many other
- **Quick learning curve for new radio engineers**
  - Human readable configurations
  - No need to learn specific radio registers and other IC internal information
- **See AN1253 for technical details on the Radio Configurator**

Flex SDK offerings



- **Flex SDK**
  - Complete software development suite for proprietary wireless applications
  - Flexible, easy-to-use
    - Radio Abstraction Interface Layer (RAIL)
    - Sample applications and extensive documentation
  - Available through Simplicity Studio

Flex SDK offerings



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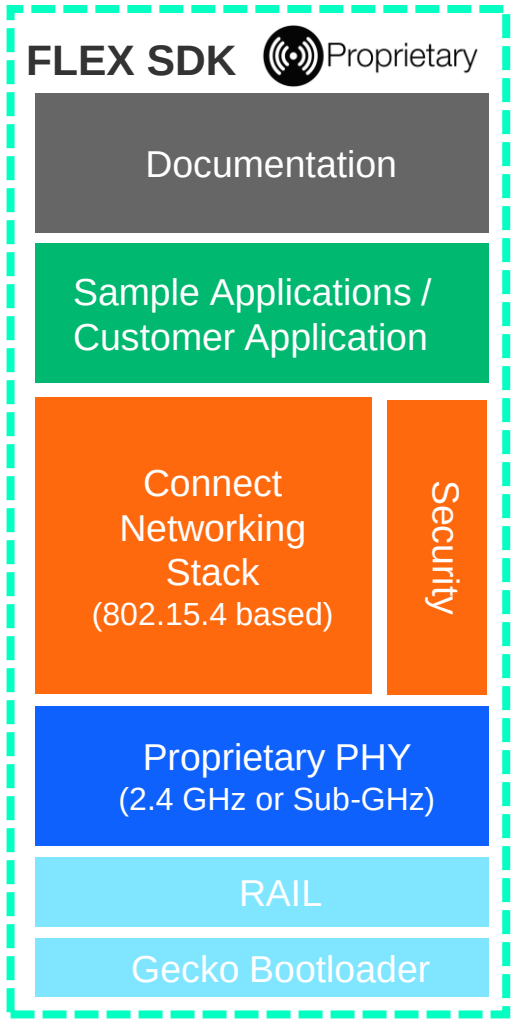
    - Radio Abstraction Interface Layer (RAIL)
    - Sample applications and extensive documentation
  - Available through Simplicity Studio
- **Dev Path 1 - RAIL**
  - Simplified Radio API to access radio hardware
    - Common radio API across SoCs (Application portability)
    - Application portability across Silicon Labs products
    - No need to learn complex low-level radio registers
    - Silicon Labs wireless stacks are implemented on top of RAIL

Flex SDK offerings



- **Flex SDK**
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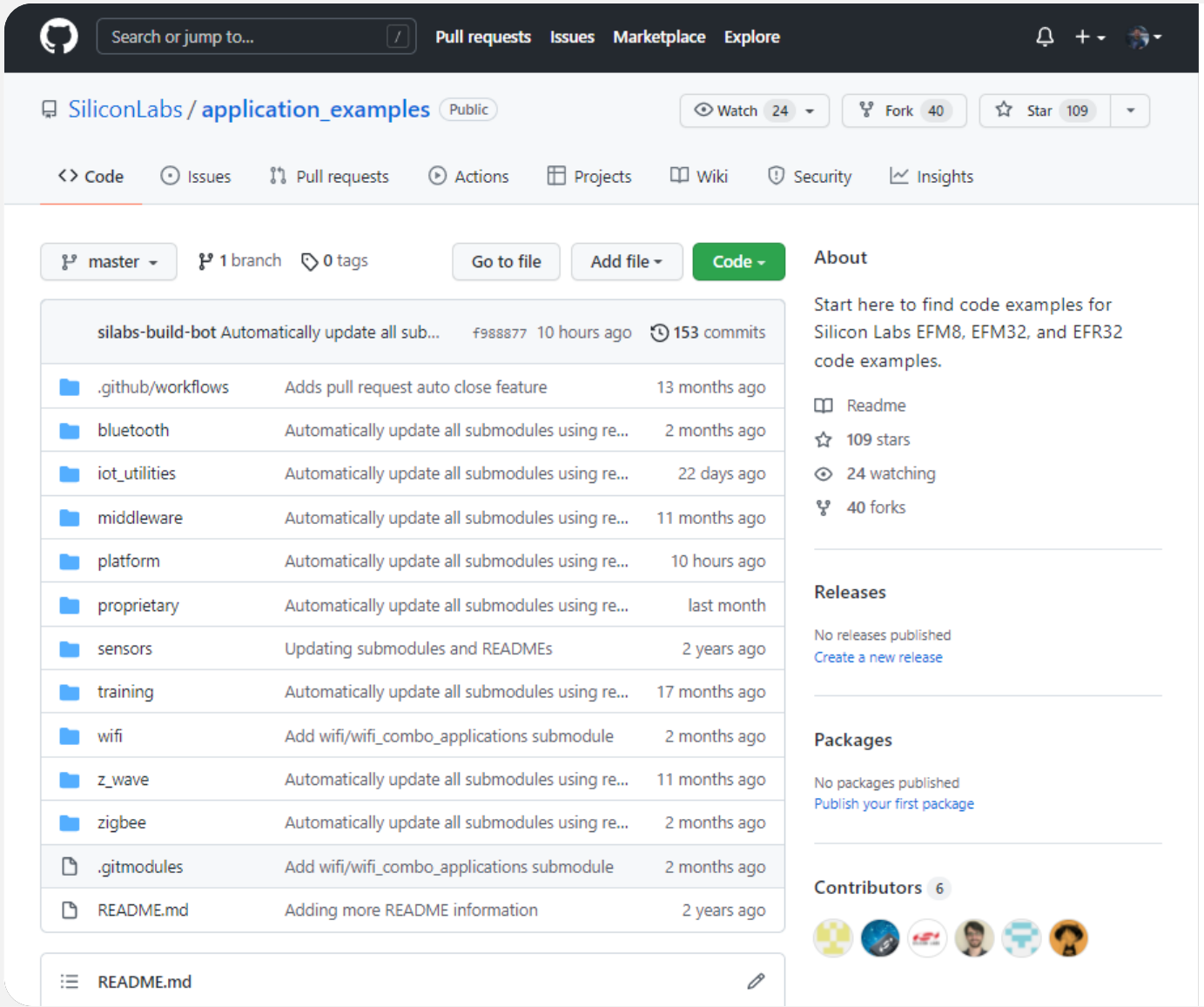
    - Silicon Labs wireless stacks are implemented on top of RAIL
- **Dev Path 2 - Connect Stack**
  - Proprietary Wireless Networking Stack
    - Small memory footprint (~75 kB Flash/~10 kB RAM)
    - Scalable up to 2,000 network nodes
    - Support for low power nodes
    - Over-the-air firmware updates
    - Security layer implemented

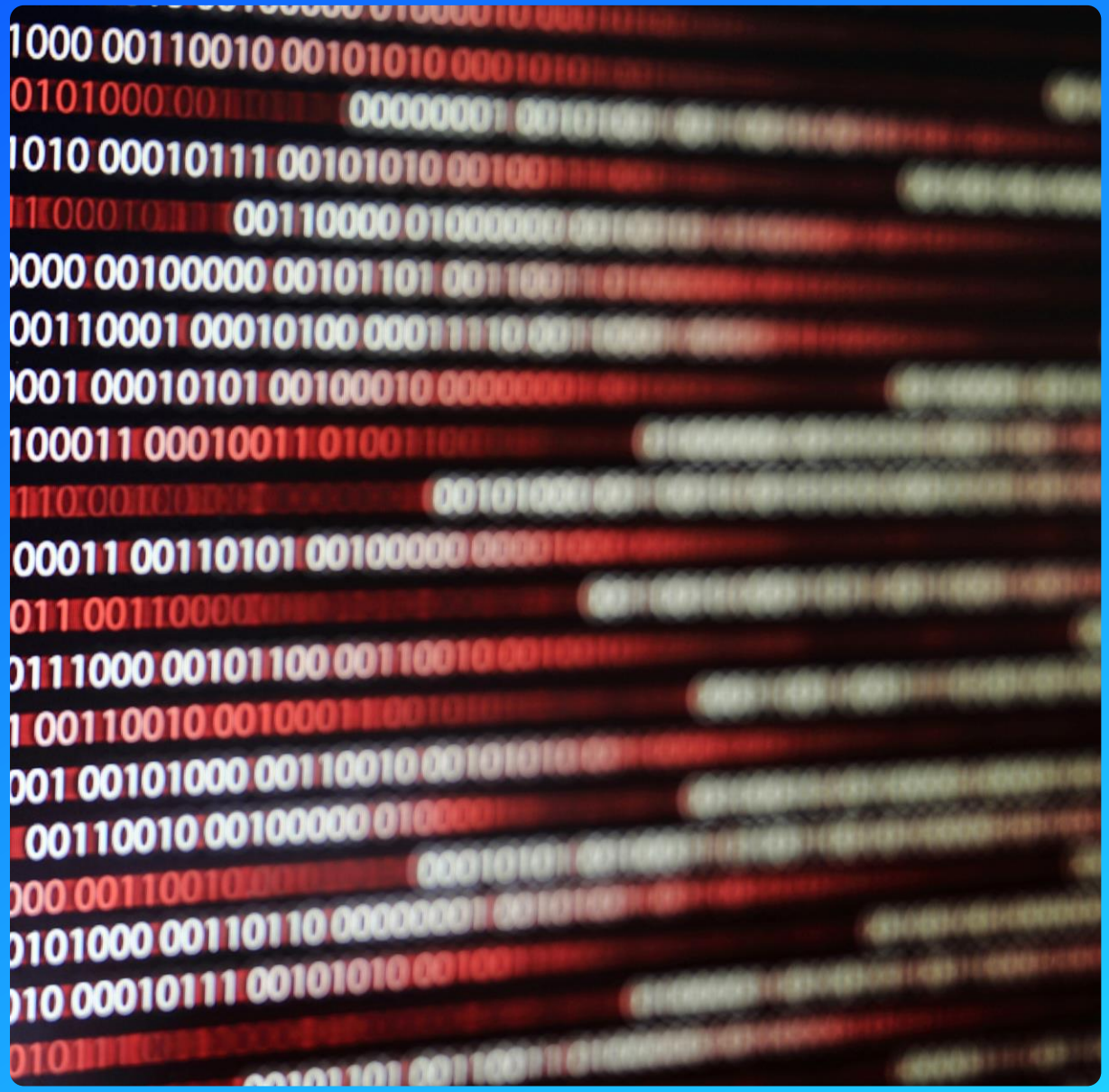
Beyond Studio – GitHub repositories



GitHub

- **Relevant repositories**
  - Proprietary
    - Proprietary_connect
    - Proprietary_rail
  - Platform
    - Peripheral_examples
    - Platform_applications
    - Platform_hardware_drivers

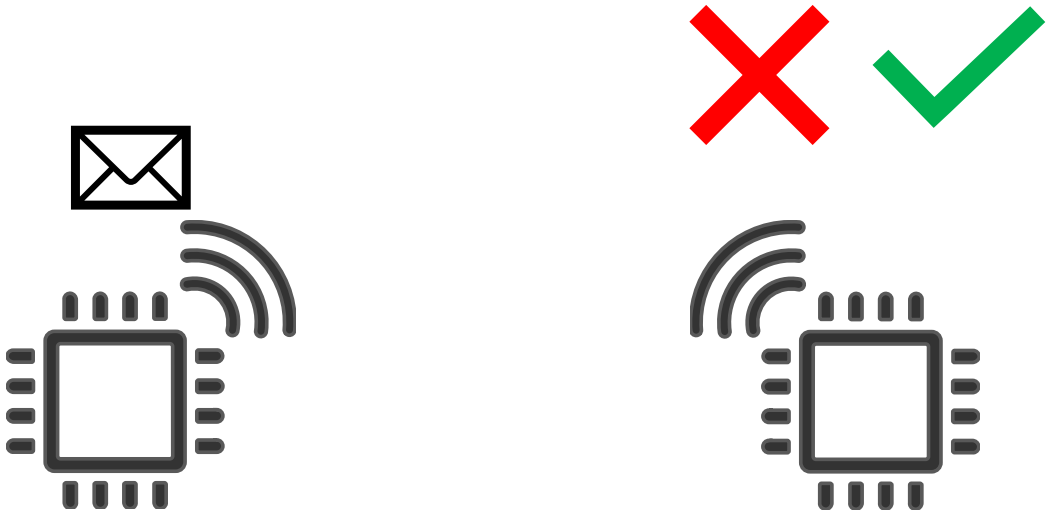
Demos



RX Sensitivity demo

Background

- **PER – Packet Error Rate**
  - Ratio of loss vs received packets
  - Performance of radio configuration

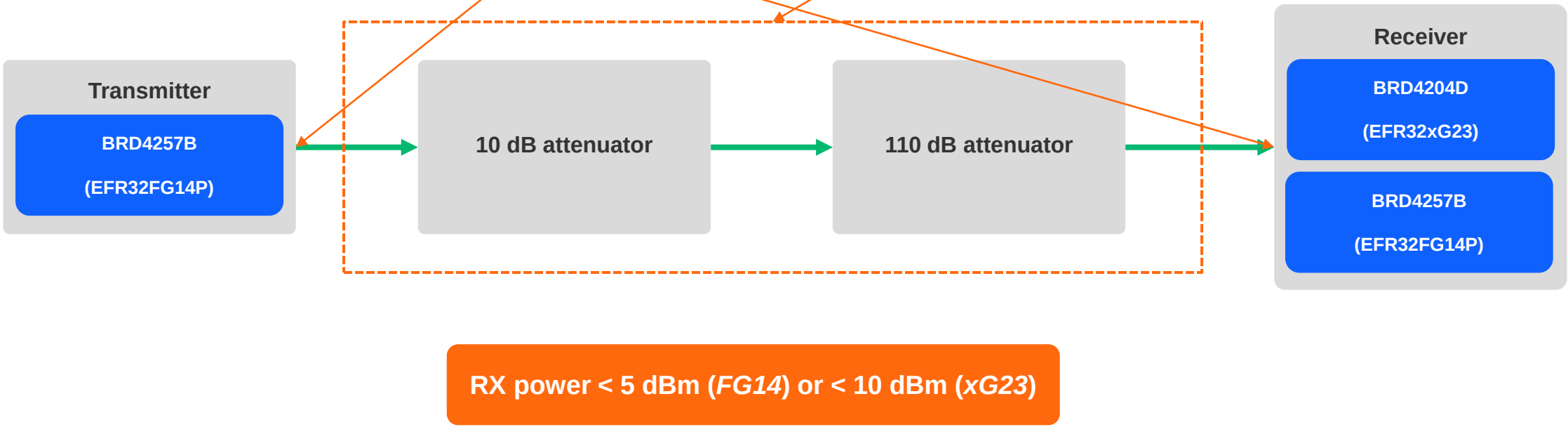


- **Relevant values**
  - Perror - Reception error
  - Psent - Total packets sent

$$PER\ [\%] = \frac{P_{error}}{P_{sent}} * 100$$

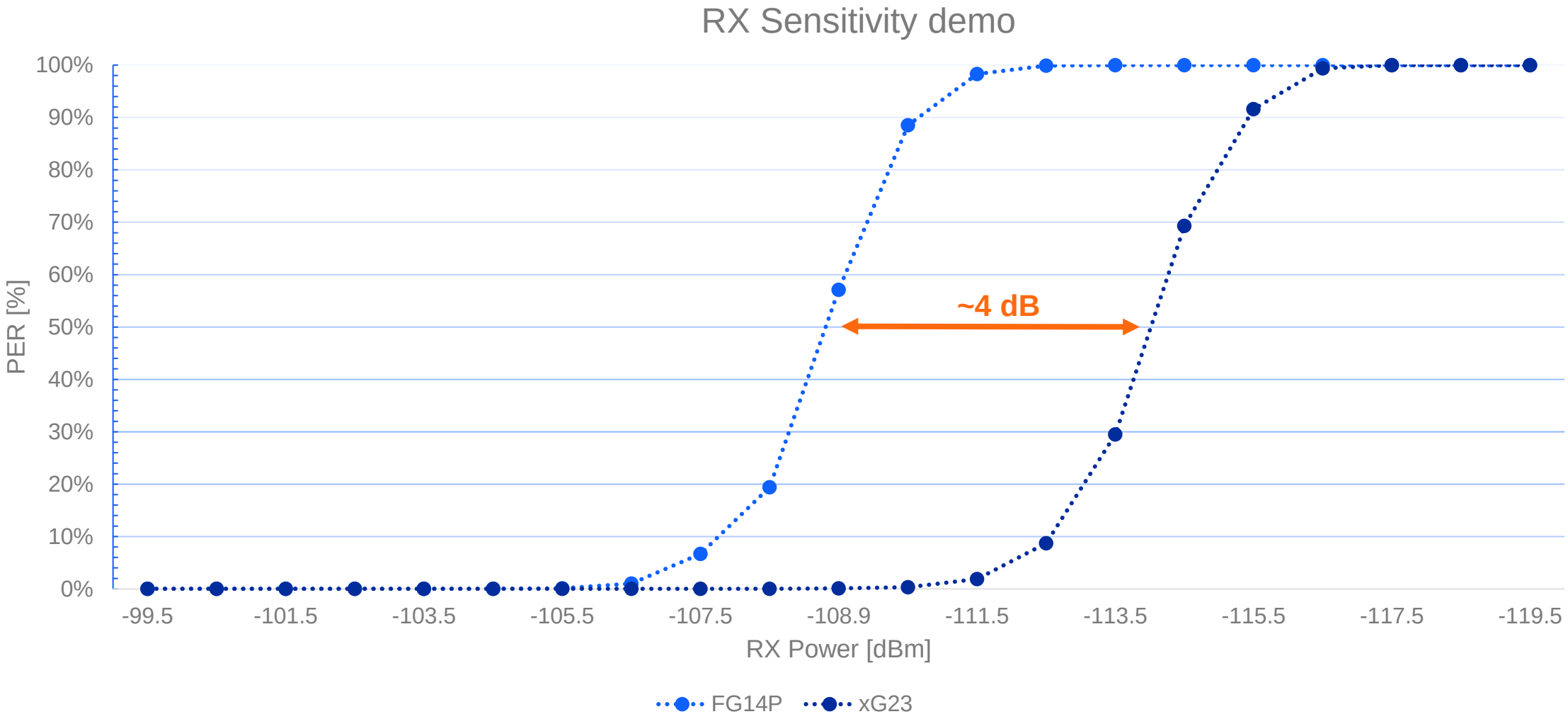
RX power calculation

$$Rx\ power\ (dBm) = Transmitter\ TX\ power\ (dBm) + losses\ (-dB) + gains\ (dB)$$



RX power < 5 dBm (*FG14*) or < 10 dBm (*xG23*)

xG23 vs FG14


RX Sensitivity demo
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
PER [%]
~4 dB
-99.5
-101.5
-103.5
-105.5
-107.5
-108.9
-111.5
-113.5
-115.5
-117.5
-119.5
RX Power [dBm]
FG14P
xG23

Preamble Sense Mode (PSM) demo

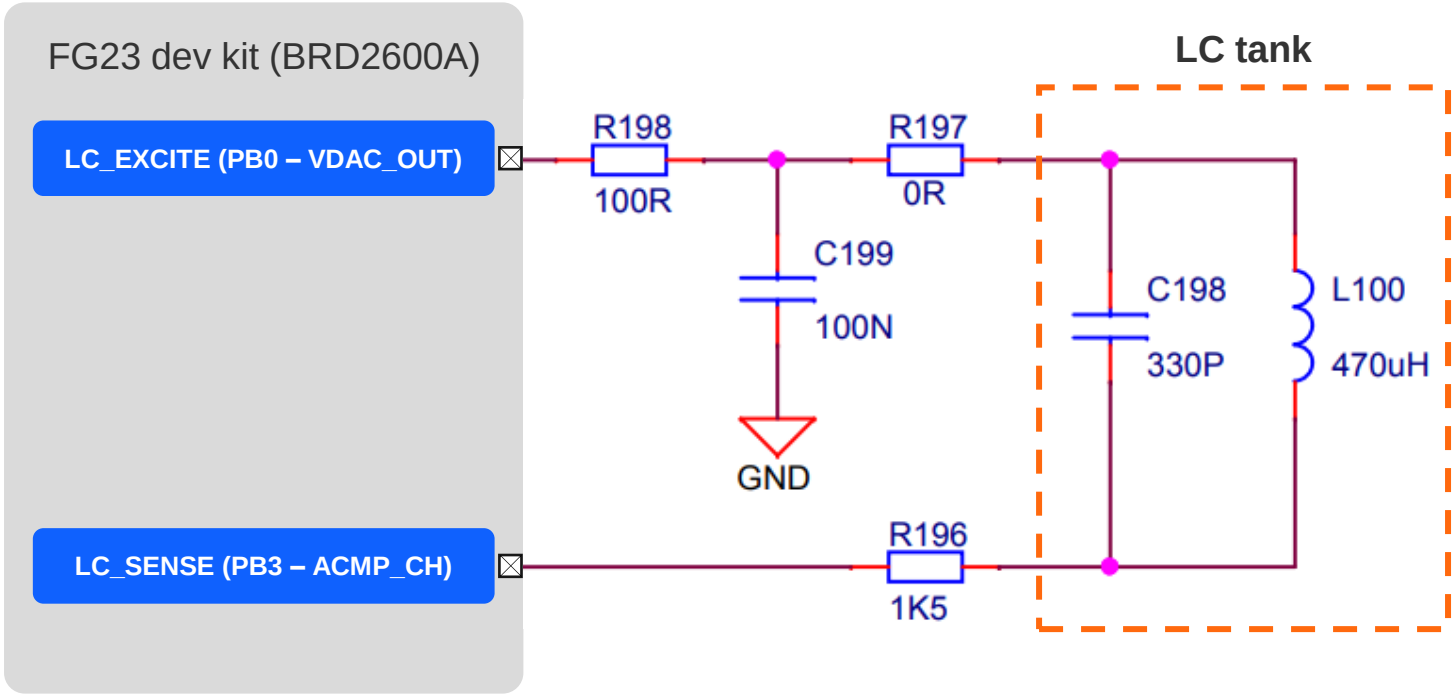
Further references

- **Radio configuration**
  - AN1253: EFR32 Radio Configurator Guide for Simplicity Studio 5
- **RAIL API documentation**
  - https://docs.silabs.com/rail/2.12/group-r-a-i-l-a-p-i

MCU demo

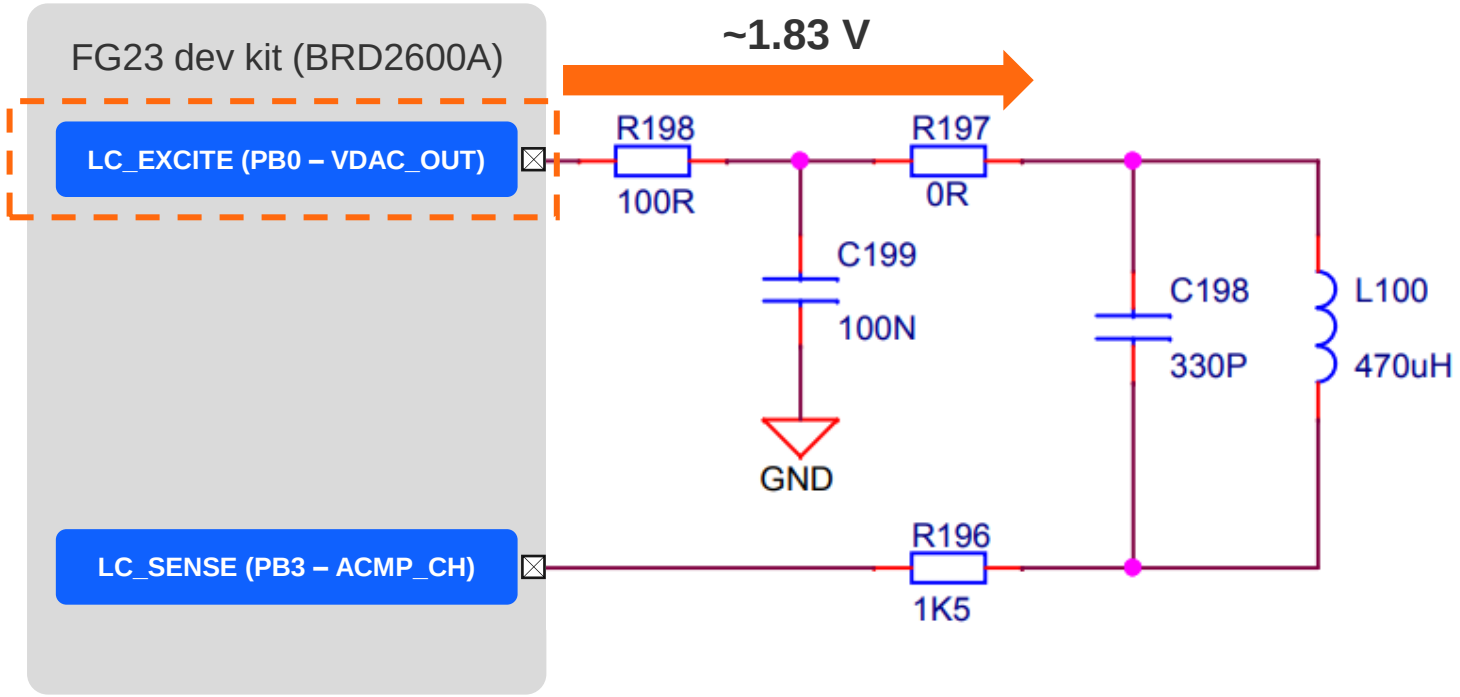
Metallic Object Detection Example Overview

- **LESENSE LC-Sensor circuit**



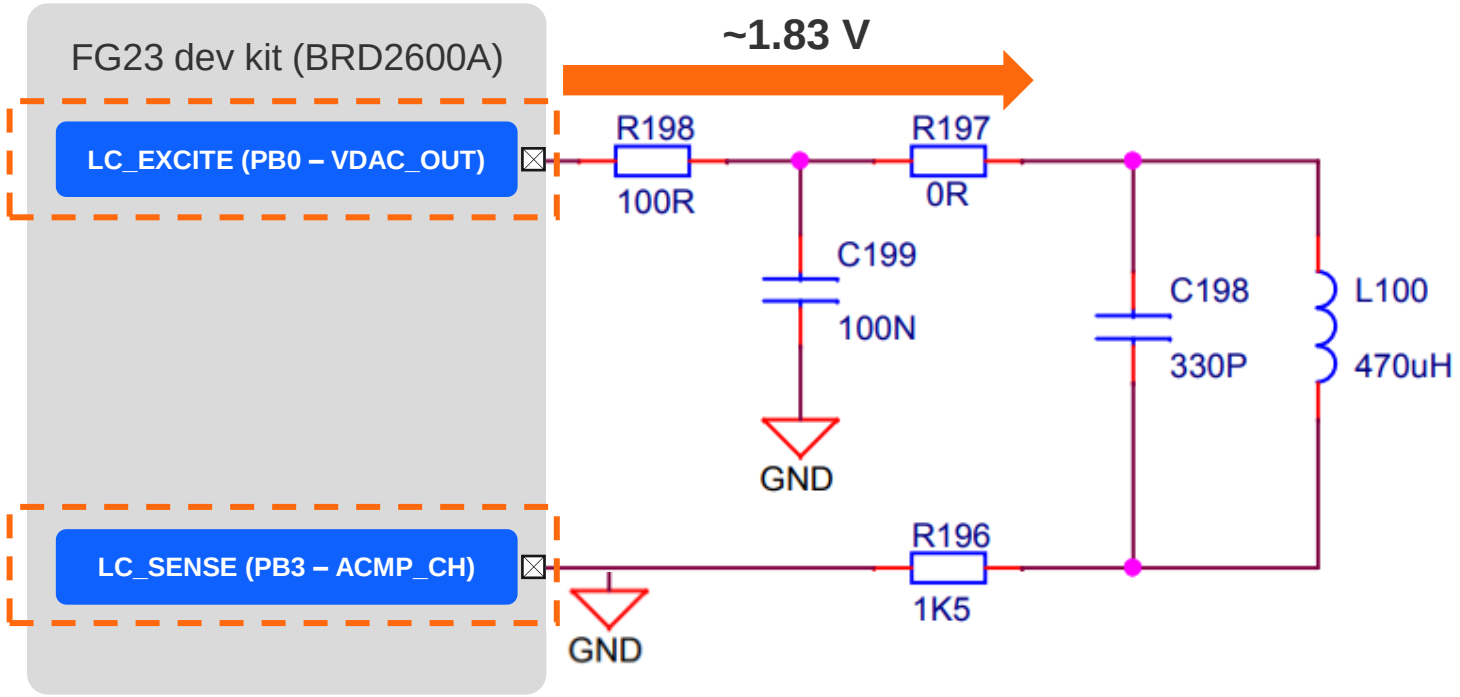
Metallic Object Detection Example Overview

- **LESENSE excitation phase**



Metallic Object Detection Example Overview

- **LESENSE excitation phase**



Metallic Object Detection Example Overview

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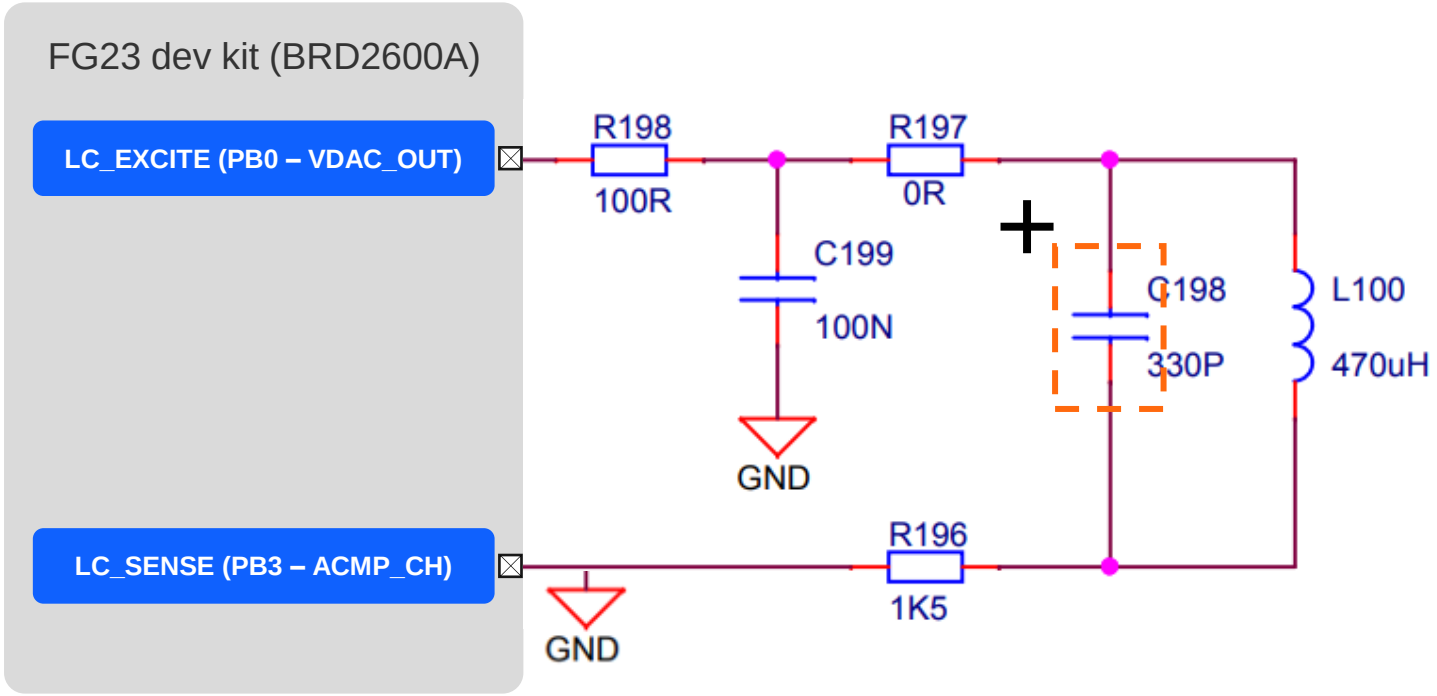

Metallic Object Detection Example Overview

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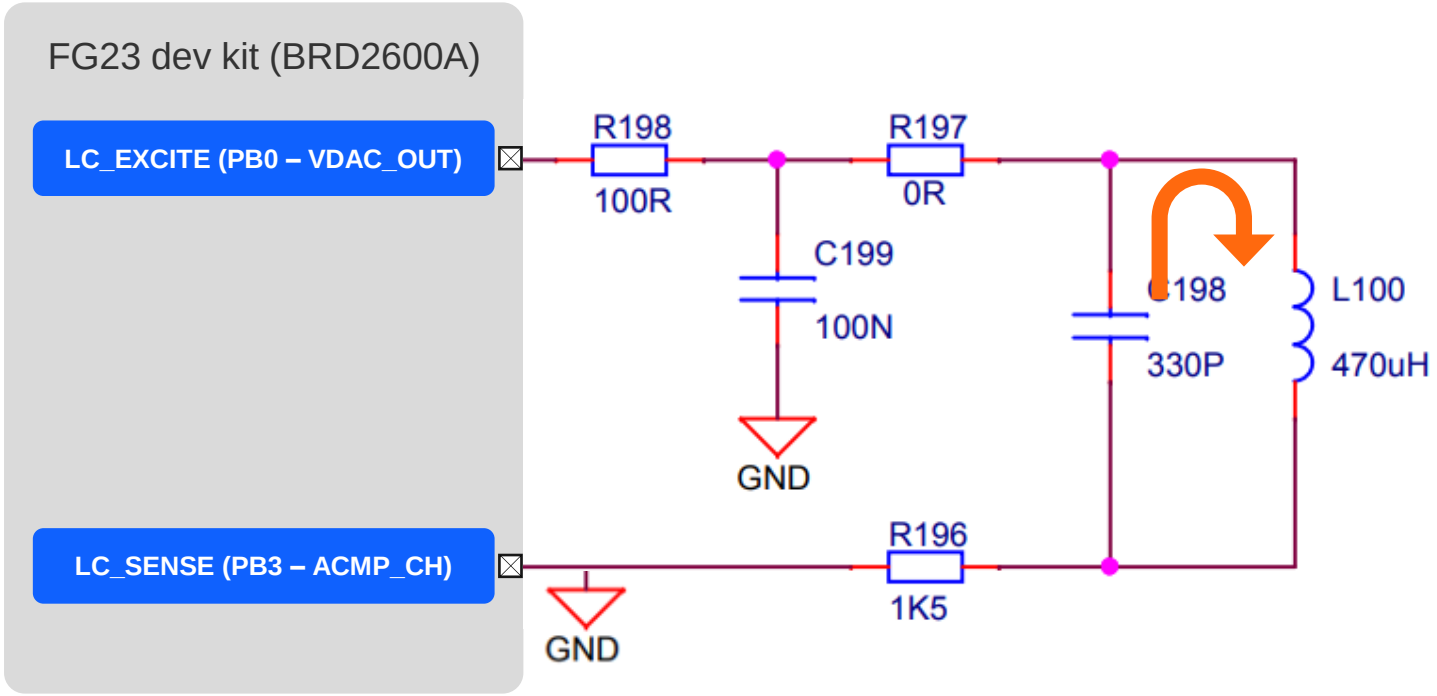

Metallic Object Detection Example Overview

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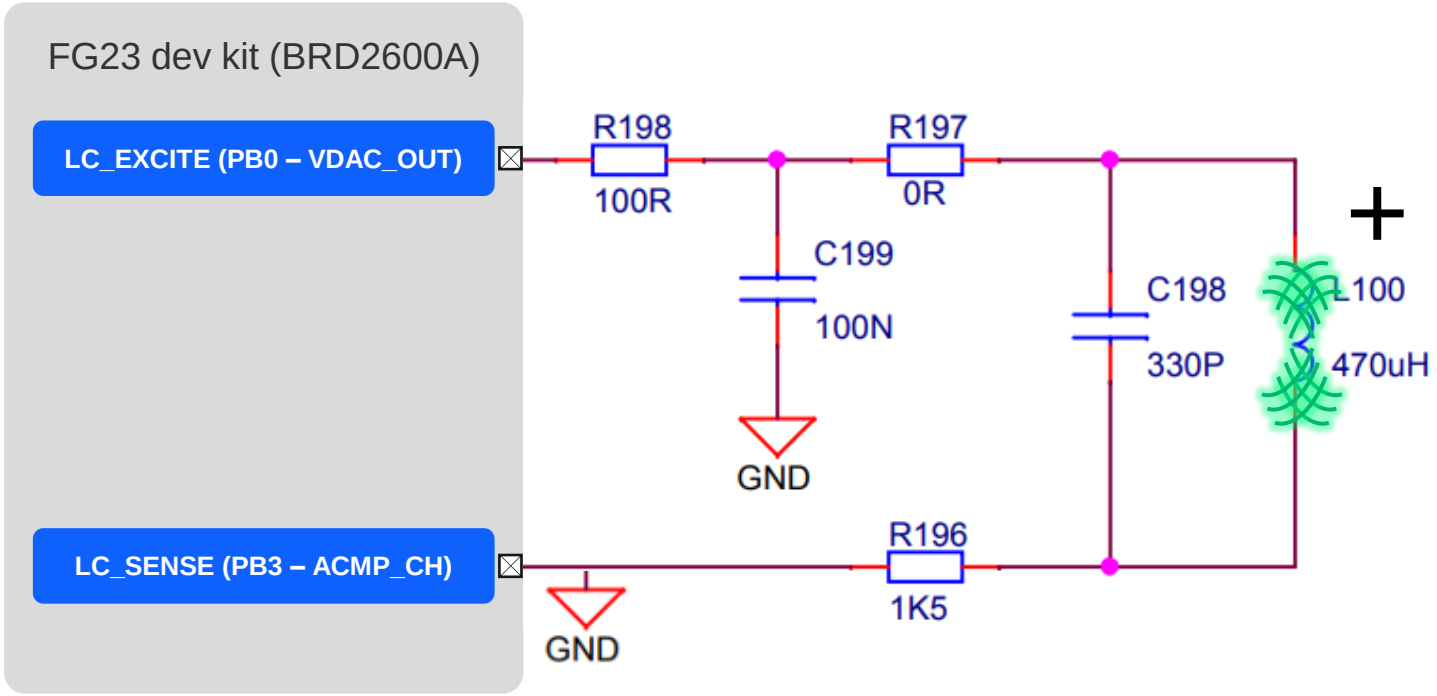
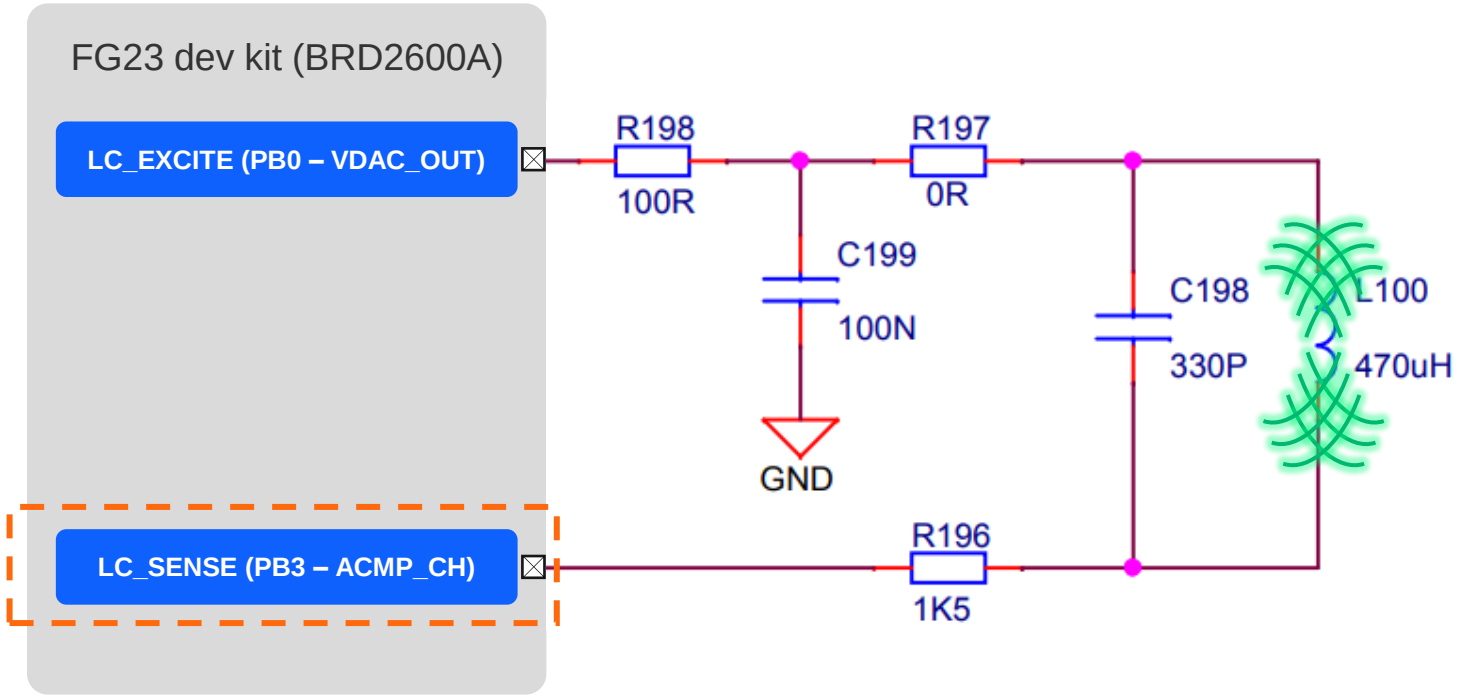


Metallic Object Detection Example Overview

- **LESENSE measurement phase**



Metallic Object Detection Example Overview

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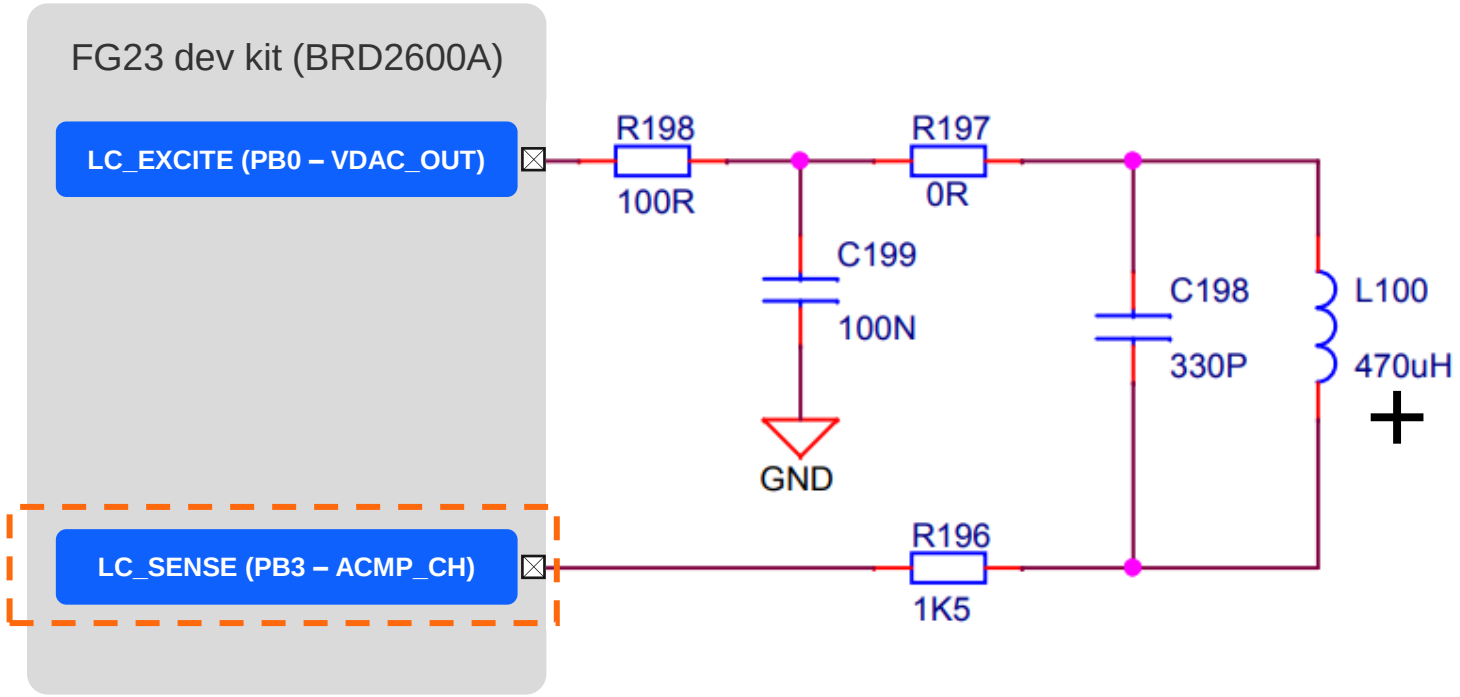

Metallic Object Detection Example Overview

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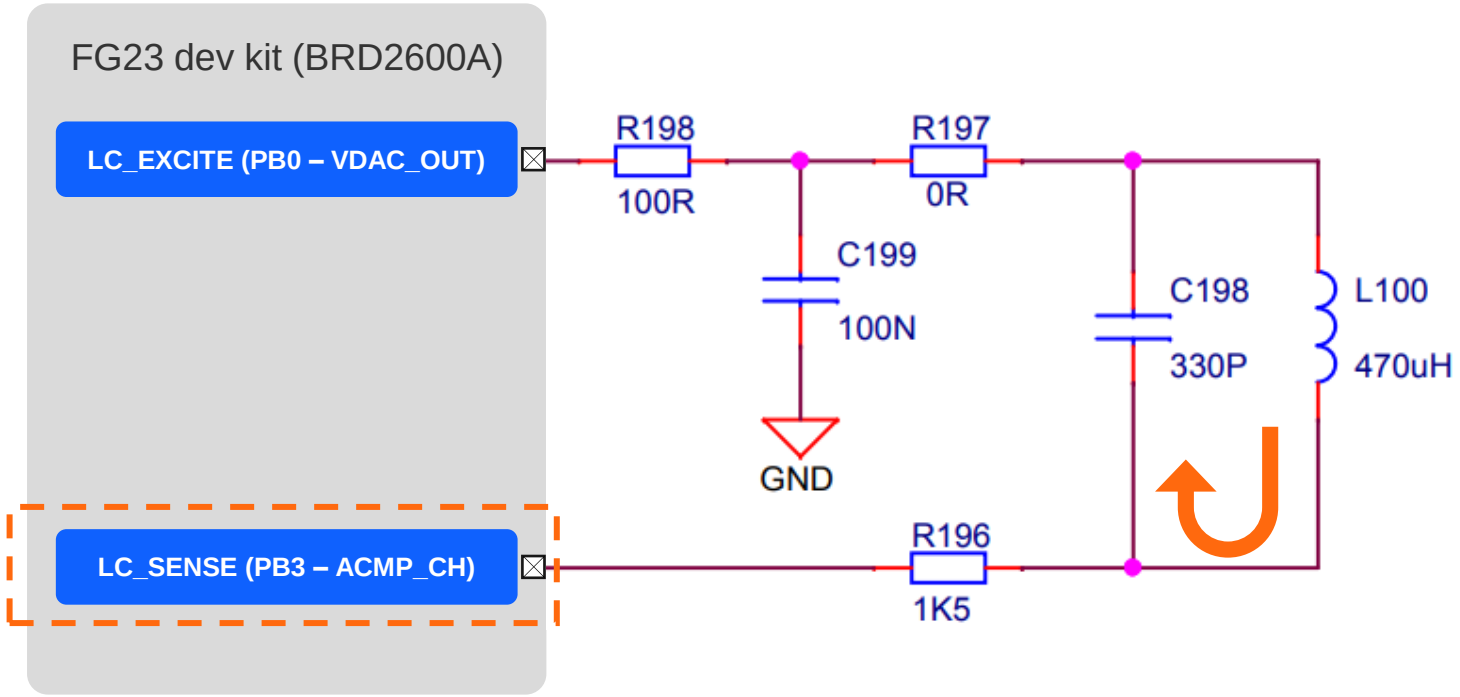

Metallic Object Detection Example Overview

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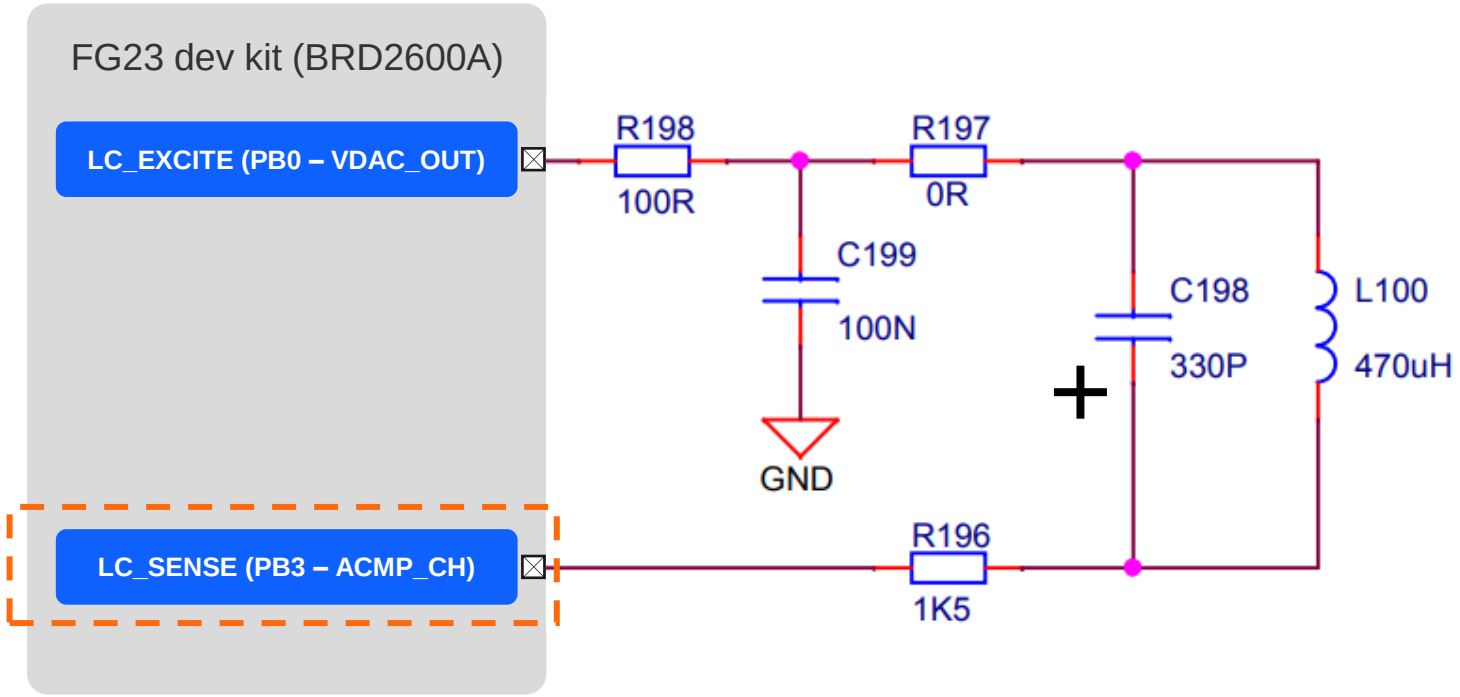

Metallic Object Detection Example Overview

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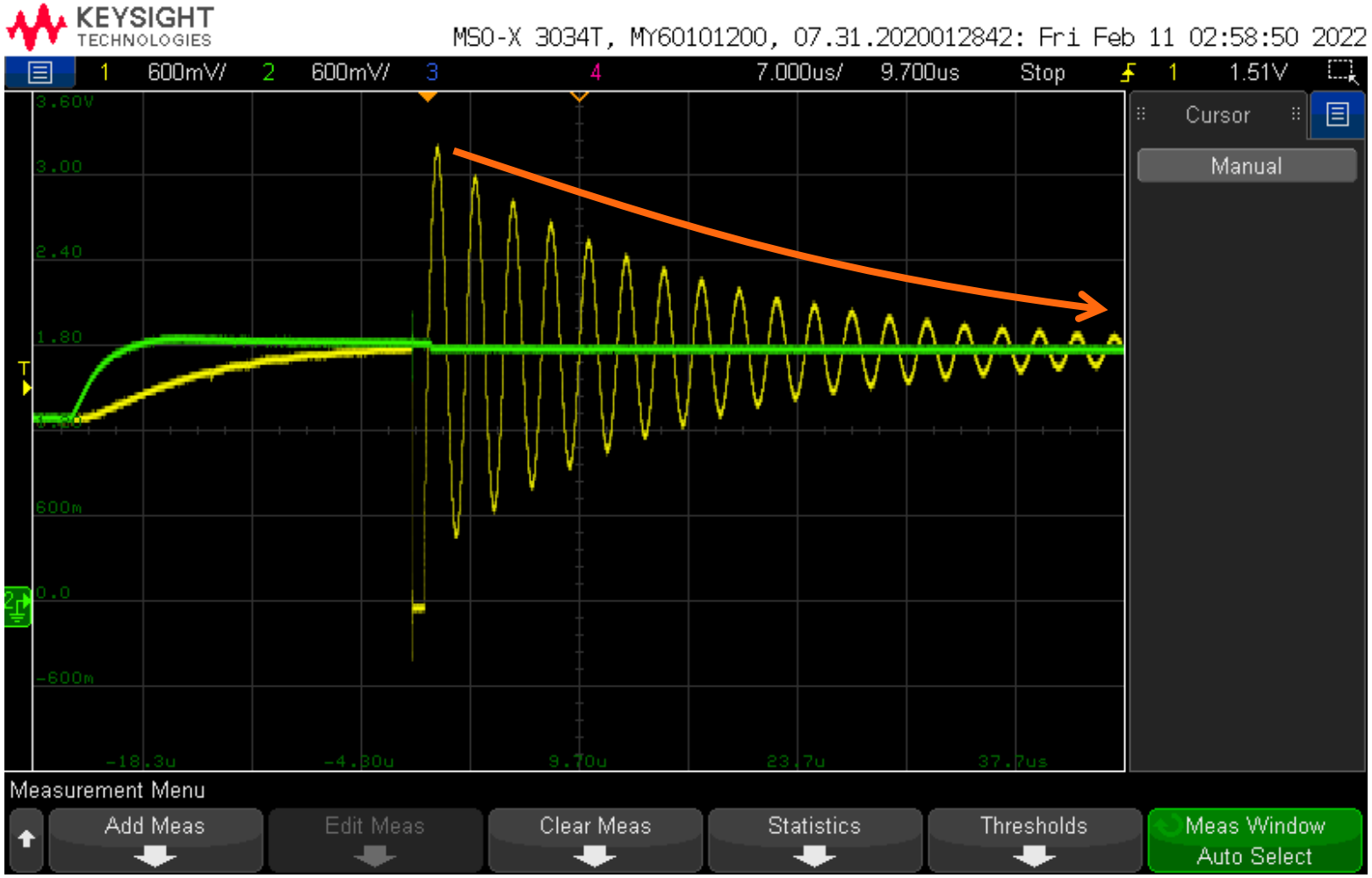
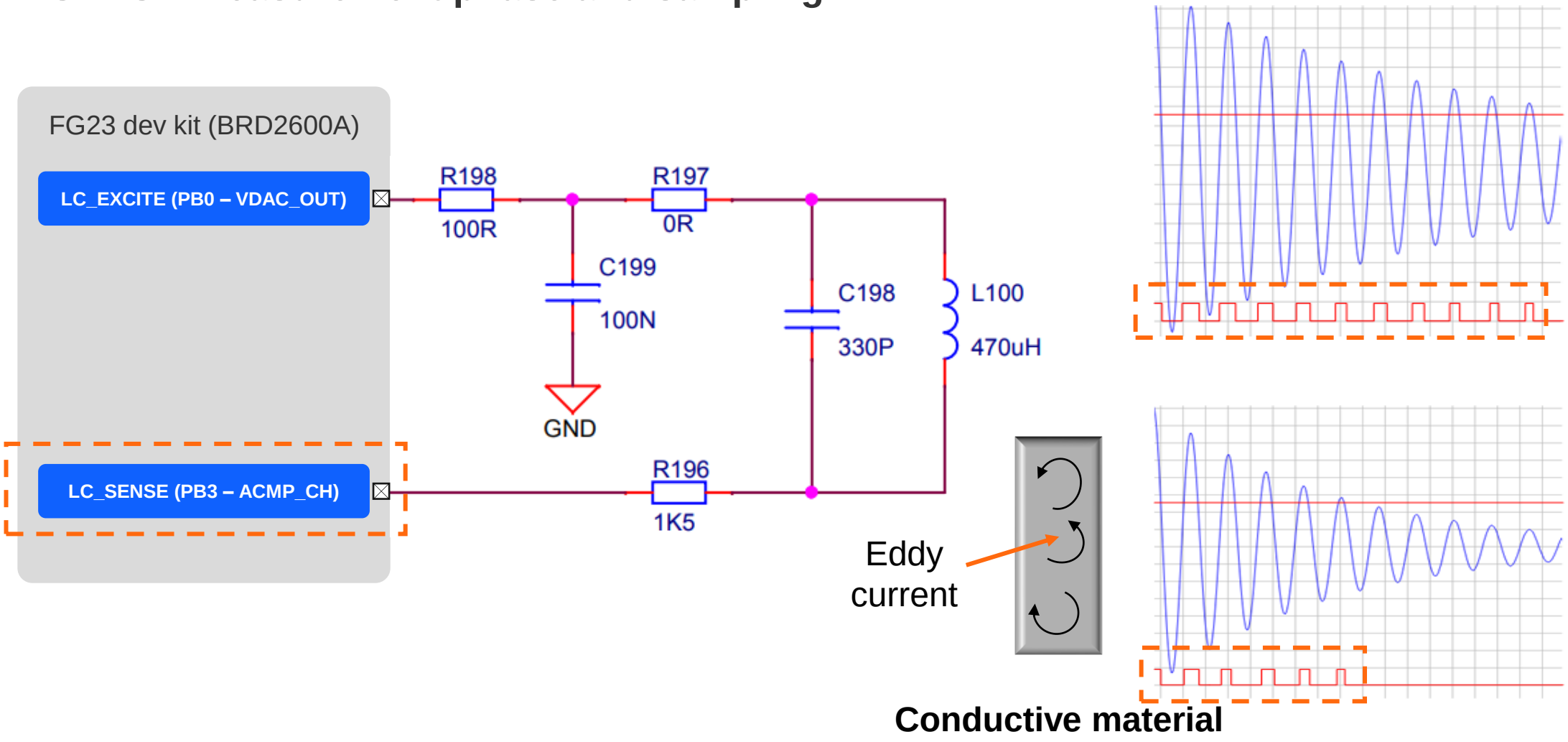


Metallic Object Detection Example Overview

- **LESENSE measurement phase and sampling**



Further references

- **GitHub repository**
  - SiliconLabs/Platform_applications
- **Examples used in this demo**
  - platform_lcd_si70xx
  - platform_lcsense_segmentLCD

Summary

- **The following topics were covered today:**
  - FG23 market
  - FG23 overview
    - Great solution for Sub-GHz applications
  - A look into the FG23 – MCU perspective
    - New and returning peripherals (KEYSCAN, LCD, LESENSE…)
  - A look into the FG23 – RF improvements
    - Preamble Sense Mode (PSM) discussion
  - Developing with FG23
    - Available kits
    - Available software (Flex SDK, GitHub examples)
  - Demos
    - RX sensitivity
    - PSM
    - MCU GitHub examples

References

- **Here is a list of references relevant to this presentation:**
  - EFR32FG23 landing page
    - Specs, Kits, technical documentation
  - Security
    - Secure vault, tech talks and webinars
  - docs.silabs.com
    - Main software documentation source including Studio and RAIL and Connect stacks
  - AN1253
    - Radio configurator in Simplicity Studio v5
  - GitHub application examples repository
    - Branch into other relevant repositories from here
  - AN972
    - EFR32 RF Evaluation Guide (RX sensitivity demo)
  - FG23 GitHub examples (MCU demo)
    - Platform_lcd_si70xx
    - Platform_lcsense_segmentLCD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tech talks
Thank You

SILICON LABS | tech talks

Q&A

Next Session

tech talks

Developing with Matter over Wi-Fi on the RS9116

March 8th, 2022 | 10AM CST

Save Your Seat

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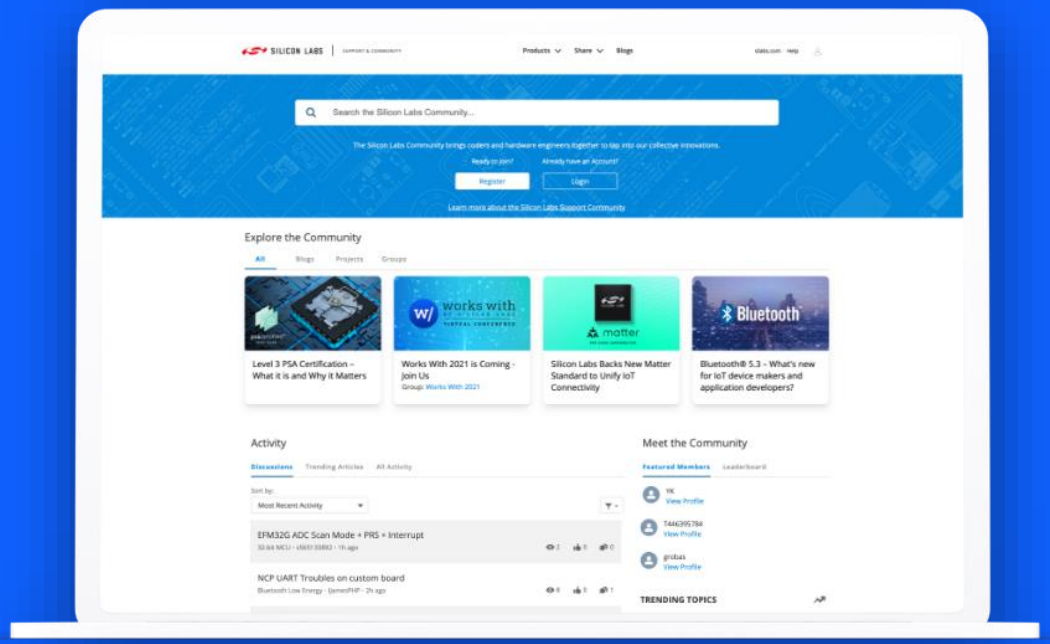
Continue Discussion in Our Community!



How to Navigate:

- “Products” to troubleshooting forums
- “Applications” to discuss IoT
- “Share” to view example projects and existing groups
- “Blogs” to view and discuss thoughts from our specialists