



安全、智能的EFR32无线平台加速工业自动化应用

Bruce Huang, Staff FAE

June 2022



The Leader in IoT Wireless Connectivity



100%
Revenue Based on IoT

Bluetooth® Multiprotocol Proprietary
 4THREAD WiFi WISUN zigbee
 ZWAVE amazon sidewalk matter
 Breadth and Depth of Wireless IoT Protocols



#1
Share in Mesh



1st
To Market with Multiprotocol, BLE Mesh, BLE 5.1



Innovation
Performance, Power, CoEx, Modules, SecureVault™

ember
2012
Software ZigBee SoC

ENERGY
micro
2013
Low-power 32-bit MCUs

bluegiga
2015
BT Smart Modules

telegesis
2015
ZigBee/Thread Modules

Micrium®
2016
Software RTOS

ZENTRI
2017
Cloud Connected Wi-Fi

ZWAVE
2018
Smart Home Protocol

REDPINE SIGNALS
2020
Ultra Low Power Wi-Fi

IoT Trends Driven by Silicon Labs

IOT LEADERSHIP



#1 provider of Smart Home IoT wireless software and silicon solutions

Unmatched breadth and depth of IoT wireless technologies



Industry Collaborations



WIRELESS PRODUCT SOLUTIONS



Our product portfolio allows deployments across any device type and application



1000's of Applications



10,000's of Customers



WORKS WITH ANY ECOSYSTEM

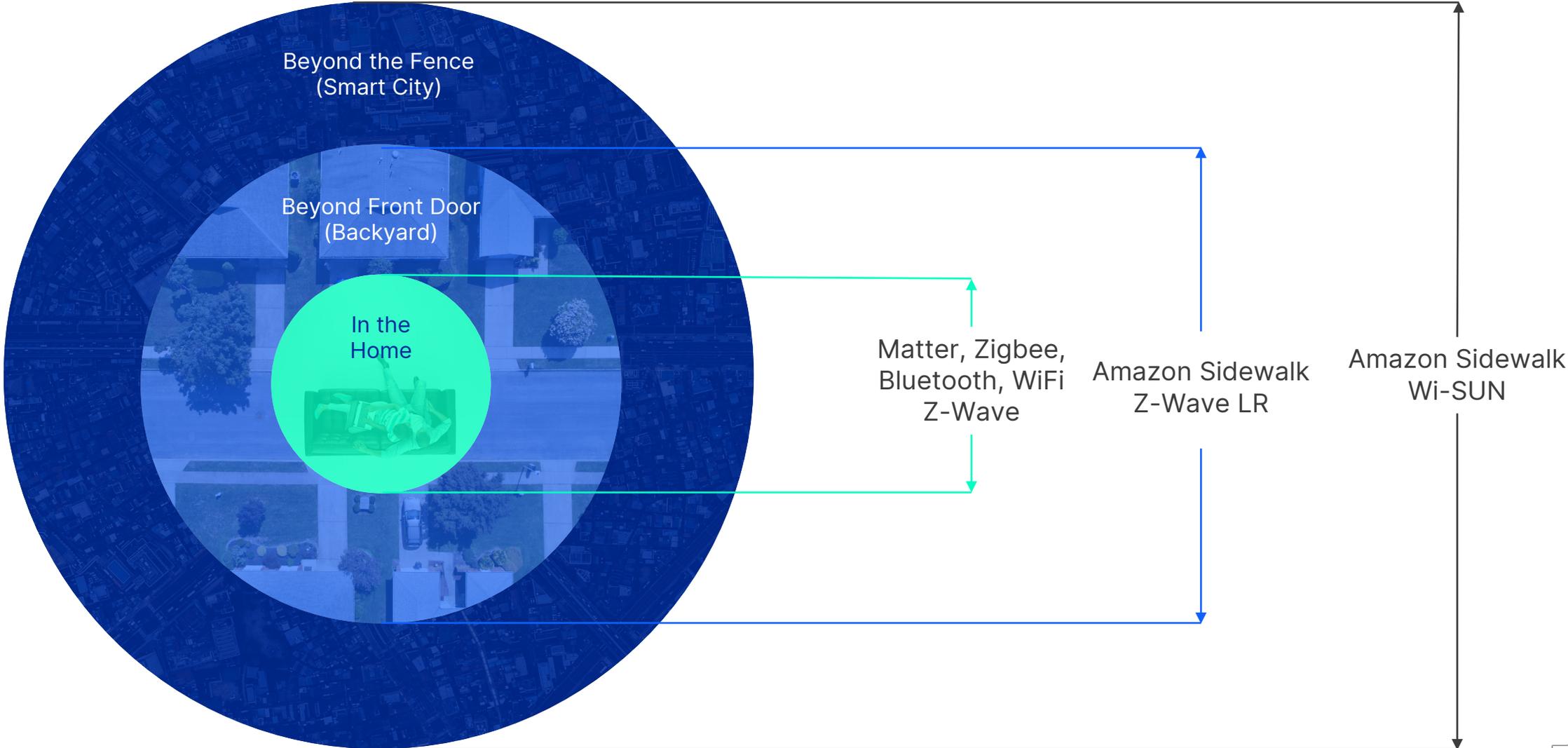


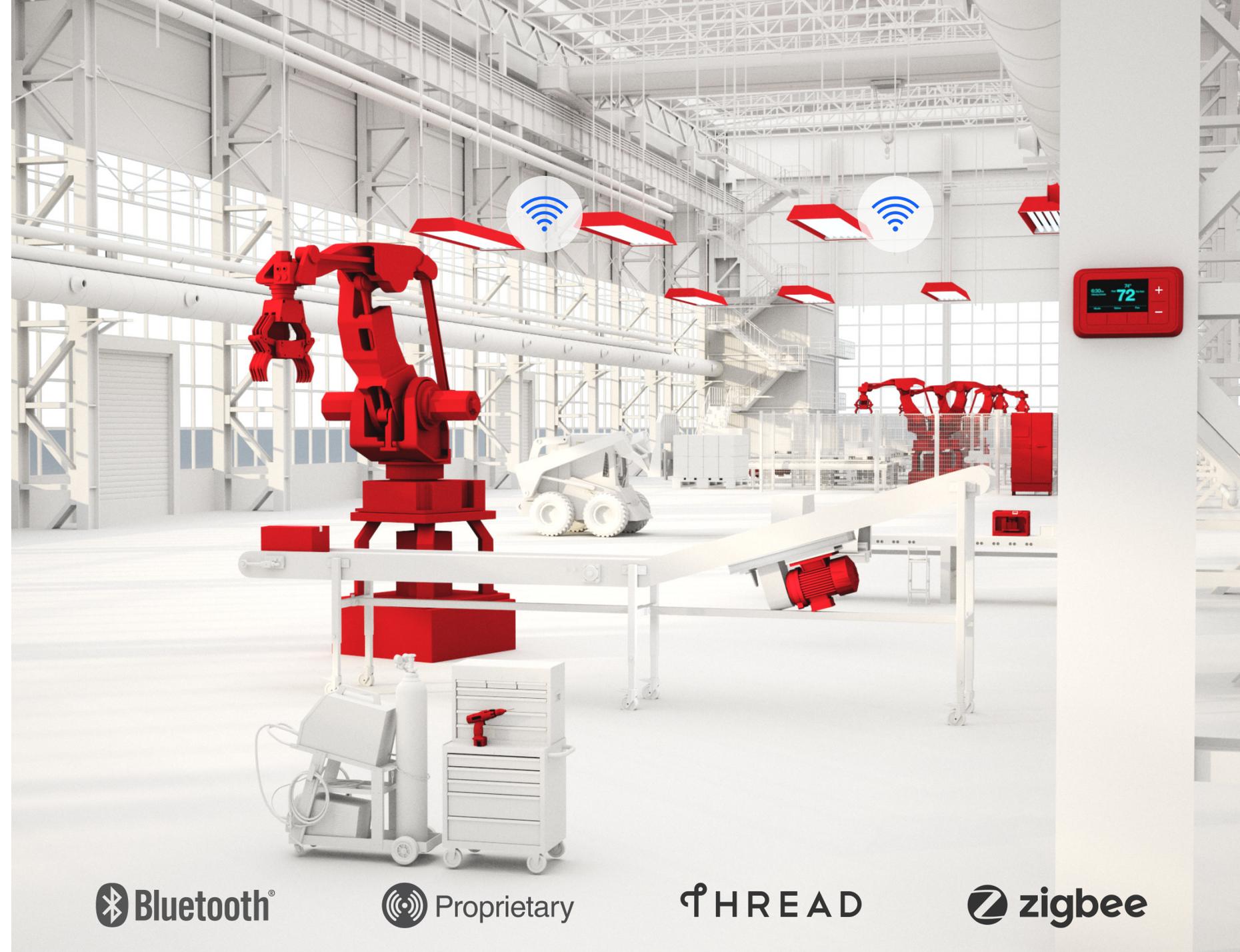
Silicon Labs wireless platform works with any smart home ecosystem

Actively engaged with all ecosystems helping end-device and gateway partners to market



Wireless Range Extension is Happening Across the Board



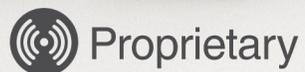


Connected Lighting

Reduce energy consumption, customize settings by work area, and control lighting from remote locations

How It Works

- ▶ Large scale mesh network connects lights, luminaires, controls and switches
- ▶ Bluetooth mesh, Sub-GHz, Thread or Zigbee technologies are ideal for mesh networking
- ▶ Multiprotocol connectivity enables a multi-function IoT wireless backbone



Asset Tracking

- ▶ Protect your workforce, equipment and inventory across large areas with advanced, reliable wireless devices that power real-time location systems (RTLS)

How It Works

- ▶ Asset tags broadcast Bluetooth beacons in manufacturing facilities
- ▶ Bluetooth mesh or Sub-GHz nodes receive beacons and passes location data to a gateway
- ▶ Gateway sends relevant asset location information to a cloud application



Process Automation

Connect machines, devices, sensors and people to a system that automates factory tasks including production, maintenance, quality control, and reporting

How It Works

- ▶ LPWAN or mesh networks provide the wireless reach to factory automation sensors located throughout the premises
- ▶ Bluetooth mesh, Sub-GHz, Thread or Zigbee all meet the needs of low-power sensor applications
- ▶ IoT gateways provide cloud connectivity and enable remote management



Technical solutions to the key care abouts



EXTENDED BATTERY LIFE

Ultra low-power chips & power-efficient communication stacks

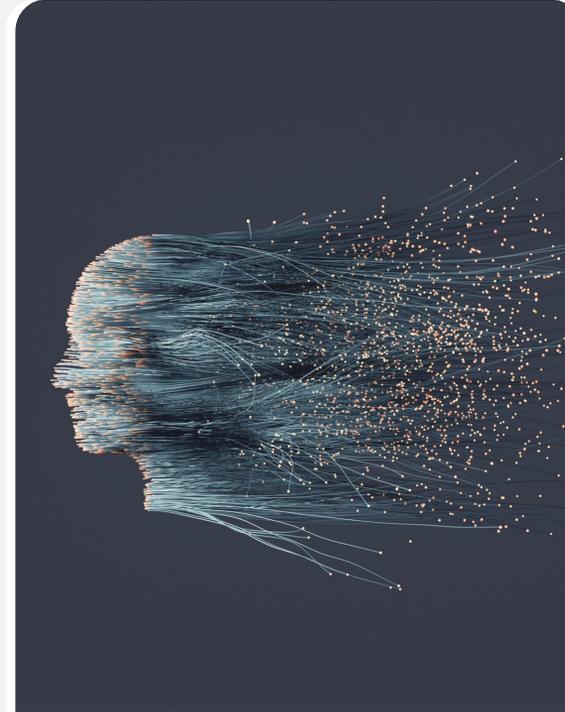
Utilization of energy harvesting technologies



RELIABLE CONNECTIVITY

Using stacks with high forward error correction rate

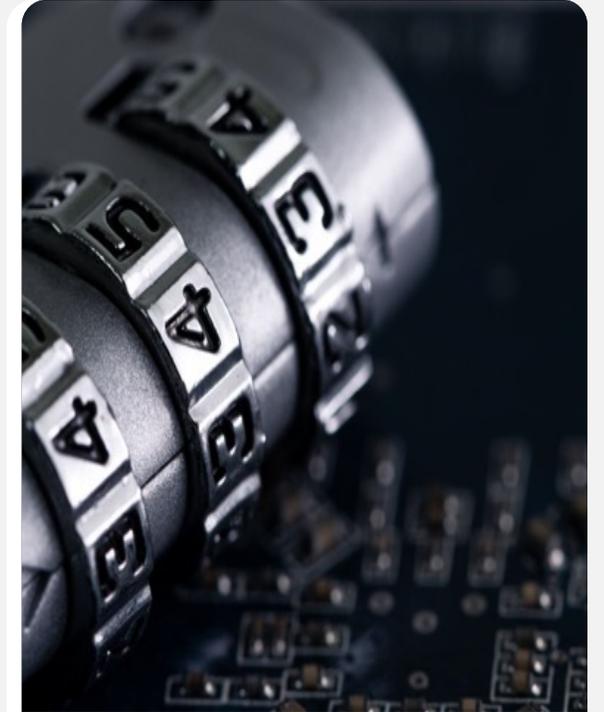
Leveraging frequency hopping and dual-band technologies



EMBEDDED INTELLIGENCE

Reducing power consumption by pre-processing the data locally

Using embedded AI/ML to mitigate network congestion



BUILT-IN SECURITY

Designing in parts that prevent rogue FW execution, detect tampering, meet the latest IoT security standards and have upgradable security features



Industrial automation segmentation



MONITORING



INTERFACING



NETWORKING

 BT Mesh

 Proprietary

 Proprietary

 BLE

 Wi-Fi

 802.15.4 Mesh

 802.15.4 Mesh

Secure Vault



Series 2 FG23 SoCs



The first sub-GHz SoCs to combine long-range RF & energy efficiency with PSA™ Level 3 security

- **Simultaneous 1+ mile wireless connectivity & 10+ year battery operation**
- **Secure Vault™ (certified PSA Level 3) safeguards against hardware and software attacks**
- **Broad support for sub-GHz frequencies, modulations and wireless protocols**

FG23: Industry Leading Sub-GHz Wireless Connectivity

Smart Metering



Industrial Automation



Smart Lighting



Building Automation



Hubs & Gateways



High-Performance

- + 20 dBm output power & -125.6 dBm RX
- Arm Cortex-M33 processor core

Low Power

- 10+ years coin cell battery operation
- Preamble Sense Mode, LESENSE

Secure

- Secure Vault™
- Arm PSA certified

Optimized

- Highly integrated MCU, PMU, RF & peripherals
- Flexible GPIO mapping

Advanced Wireless

- Amazon Sidewalk, Wireless M-Bus, mioty & Proprietary

High-Performance Sub-GHz Wireless SoCs

**Low Power.
Long Range.
Secure.**



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

High Performance Radio

- Up to +20 dBm TX
- -110dBm RX @ 920MHz, 50kbps GFSK*
- -126dBm RX @ 915MHz, 4.8kbps O-QPSK*
- RX Antenna Diversity*

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*
- 26 μ A/MHz*
- 1.2 μ A 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
- 64kB of RAM

Security

- Secure Vault Mid
- Secure Vault High (select OPNs)

Low-power Peripherals

- EUSART, USART, I²C
- 16-bit ADC, 12-bit VDAC, ACMP
- 20 x 4 LCD Controller
- LESENSE, Pulse Counter
- Temperature sensor +/- 1.5°C

Compact Size

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

Orderable Part Number

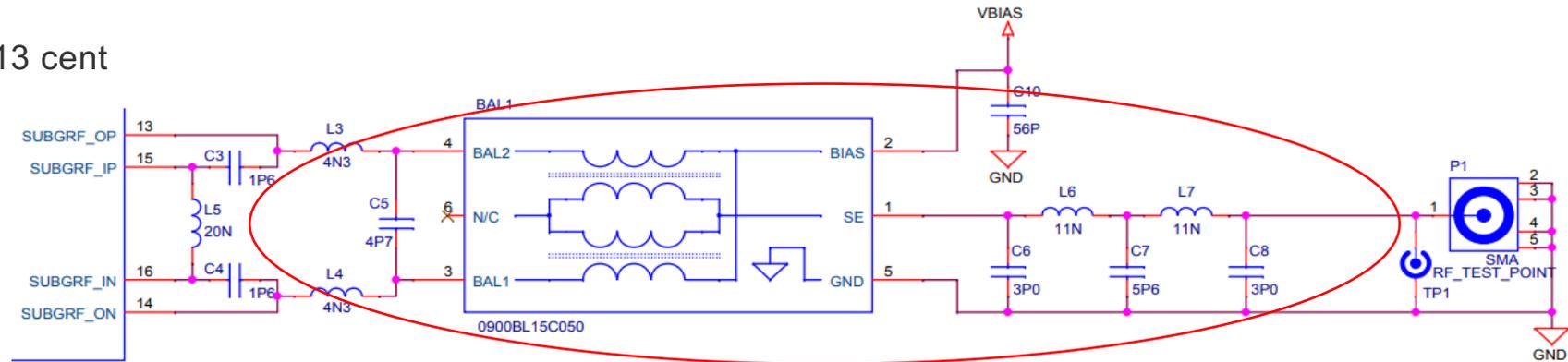
- EFR32FG23A/B

* Feature enhancements compared to EFR32xG13

Simplified Single Ended Match – Optimized BOM

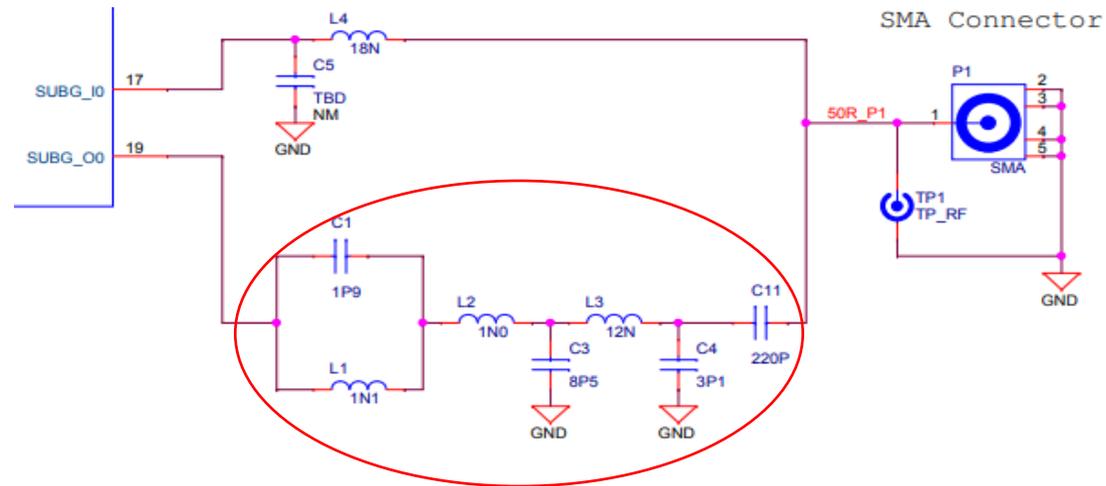
Series 1 match:

BOM price example: 13 cent



FG23 match:

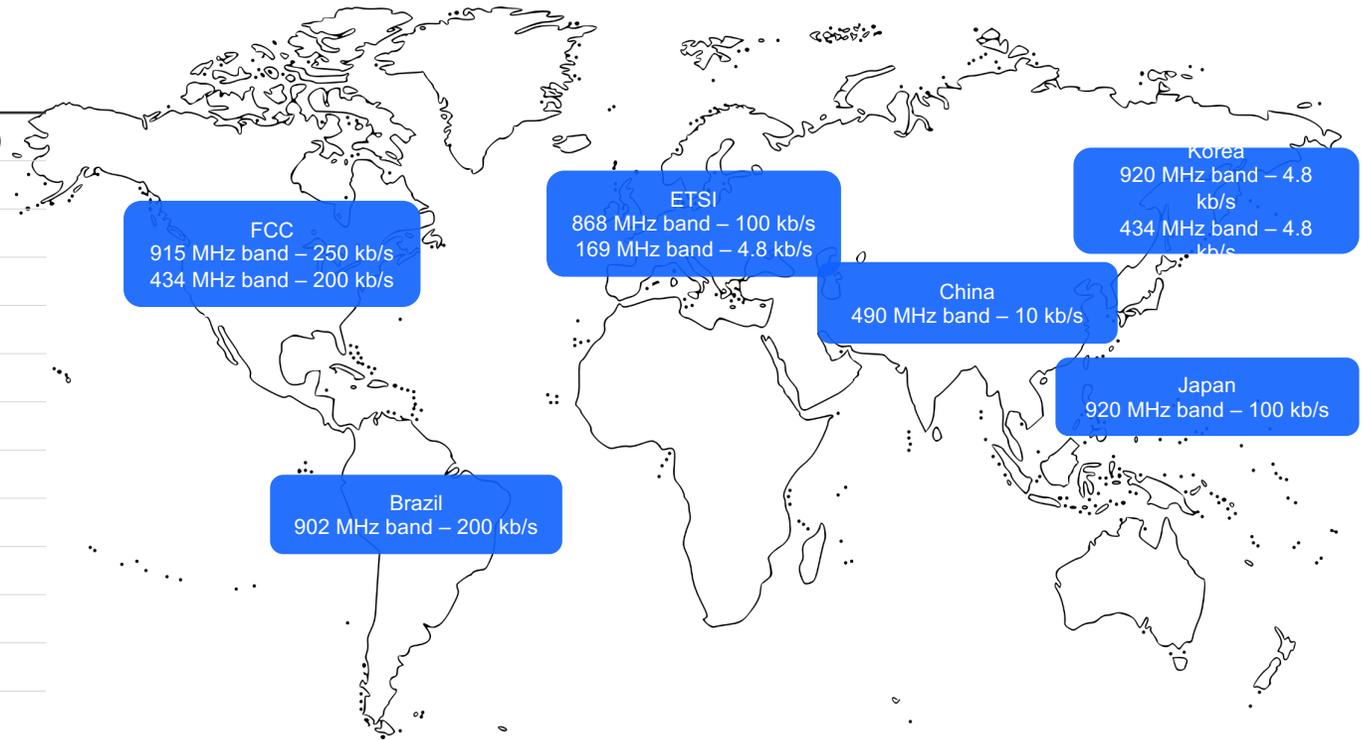
BOM price example: 4 cent



Worldwide PHYs

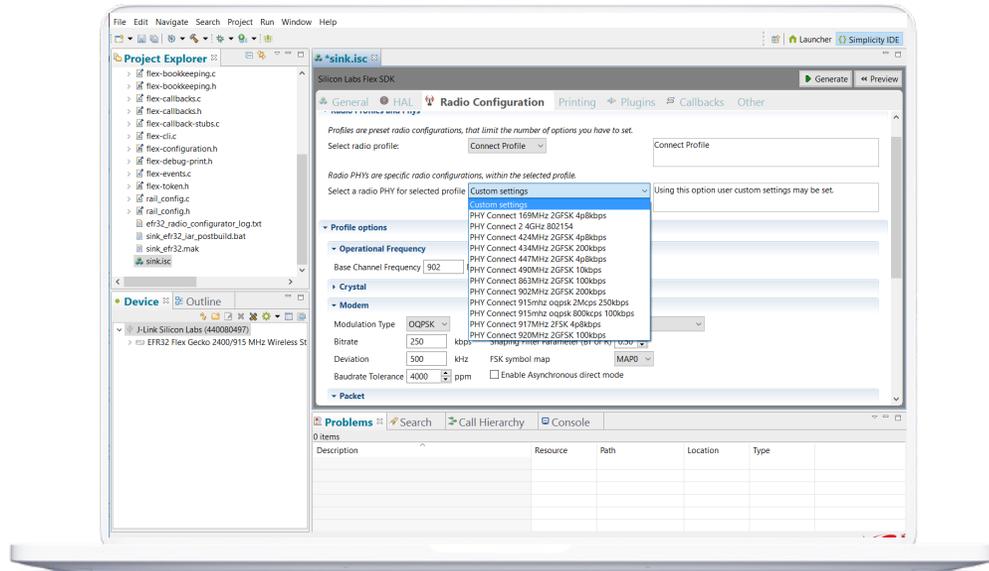
- Regional standards compliant

PHY profile	Frequency	Modulation	Bitrate
DSSS 915-100	915 MHz	OQPSK	100 kbps (0.8Mcps)
DSSS 915-250	915 MHz	OQPSK	250 kbps (2Mcps)
915-500	915 MHz	2GFSK	500 kbps
DSSS 915-500	915 MHz	OQPSK	500 kbps
China 490	490 MHz	2GFSK	10 kbps
Europe 169	169 MHz	2GFSK	4.8 kbps
Europe 868	863 MHz	2GFSK	100 kbps
Japan 915	920 MHz	2GFSK	100 kbps
Korea 424	424 MHz	2GFSK	4.8 kbps
Korea 447	447 MHz	2GFSK	4.8 kbps
Korea 915	917 MHz	2GFSK	4.8 kbps
US FCC 434	434 MHz	2GFSK	200 kbps
US FCC 902, Brazil 902	902 MHz	2GFSK	200 kbps



- Predefined PHYs are tuned and tested by Silicon Labs for optimal performance
- Custom PHYs can be configured via Radio Configurator in Simplicity Studio

Radio Configurator



Tool to configure and optimize radio performance

Rapid Radio configuration and prototyping

- Predefined PHY settings for most common world regions
- Ability to create custom PHY settings for proprietary wireless applications

Intuitive GUI to configure PHY parameters

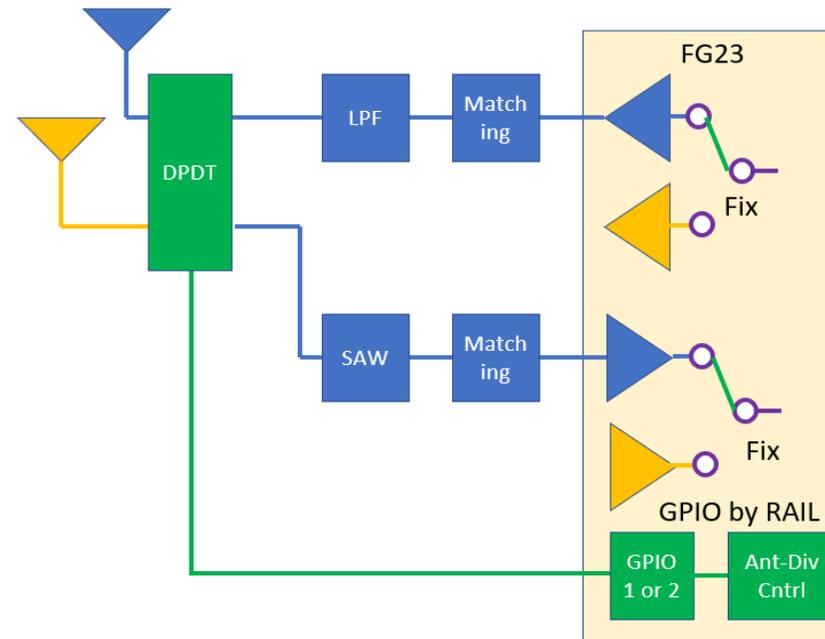
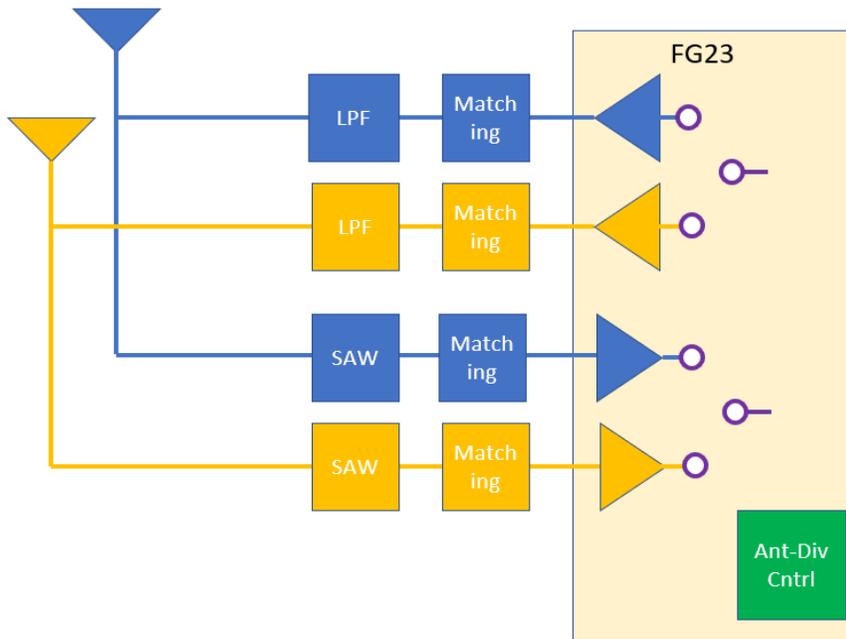
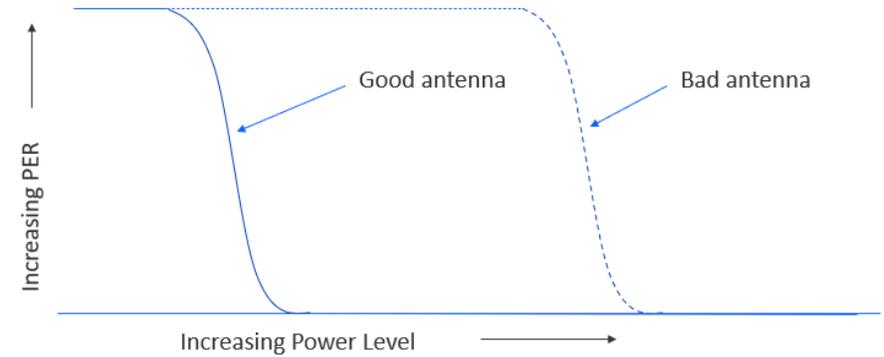
- Frequency bands, channel spacing, modulation
- Bit rate, symbol maps, symbol coding, filtering
- Timing detection, AFC, AGC and many other

Quick learning curve for new radio engineers

- Human readable configurations
- No need to learn specific radio registers and other IC internal information

Optional Antenna Diversity

- XG23 can support two modes of Antenna Diversity
 - Direct Connect
 - GPIO Switched



Common RF Issues that can Affect Performance

▪ Fading

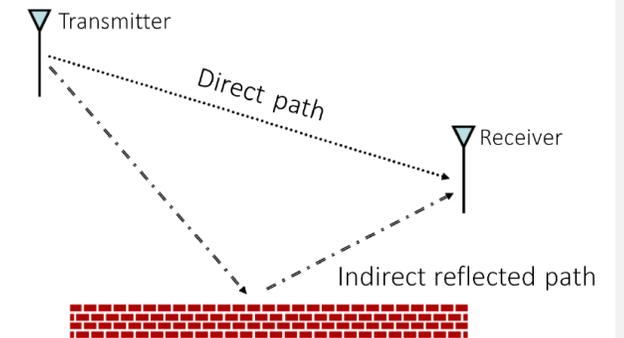
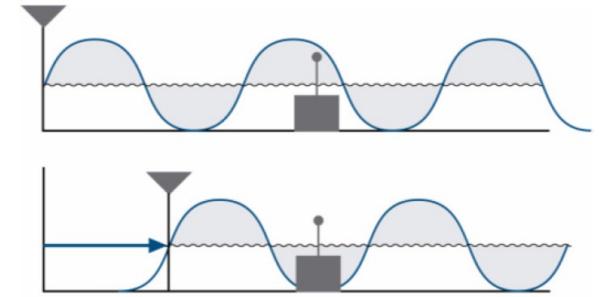
- Occurs when an antenna moves in and out of the peaks of an RF signal
 - Can happen with small movements in the transmitter or receiver

▪ Multipath

- Occurs when a signal comes from multiple paths through reflections off objects
 - Can be static objects like walls, trees, etc
 - Can be mobile objects like people, cars, etc
 - Multipath is a subset of fading
 - When multipath combines destructively at the antenna, a deep fade is observed

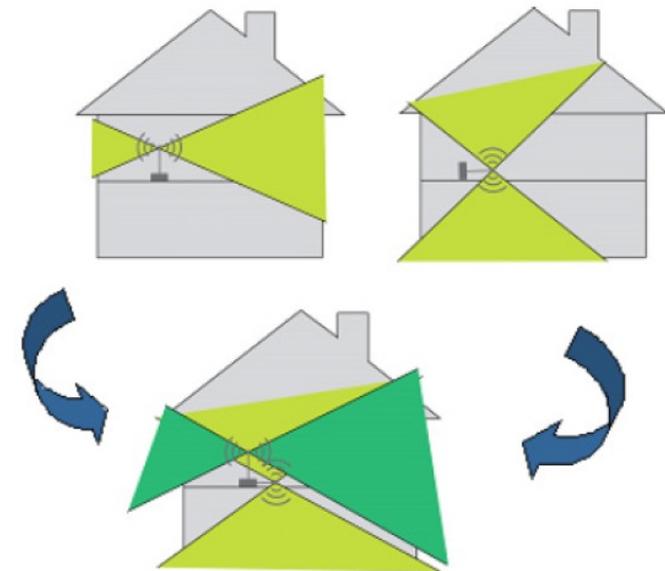
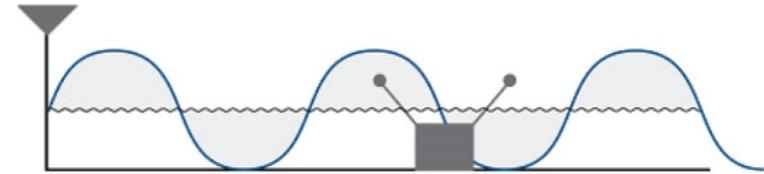
▪ Antenna Polarization

- Occurs because most antennas don't have omnidirectional coverage
- Can result in nulls and poor coverage
- Signal polarization can also arise from receiving a reflection



How antenna diversity can improve performance

- **Antenna diversity is a Technique for using multiple antenna to improve performance during blocking and multipath fading conditions**
 - Spatial diversity
 - Separation of the antenna by at least $\frac{1}{4}$ wave
 - Allows one antenna to be out of the null
- **Can also be used to provide better antenna coverage**
- **Polarization**
 - Most antennas have some type of polarization
 - Antennas are placed at 90 degrees to compensate for polarization
 - Provides better coverage vs same plane
 - May not be as big of an issue in buildings due to the multipath



Secure Vault™ – Formally recognized by industry leaders



Threats evolve.
So should your device security.
Introducing Secure Vault.



■ IoXT SmartCert

- Independent security alliance
- Focused on Consumer products and Services

■ ARM PSA Level 2 & 3

- First SoC to achieve Level 3 certification
- Assures a proven hardware root of trust

■ Independent Security Evaluation by Riscure

- Comprehensive analysis report from Riscure can be shared with customers under NDA

Secure Vault™

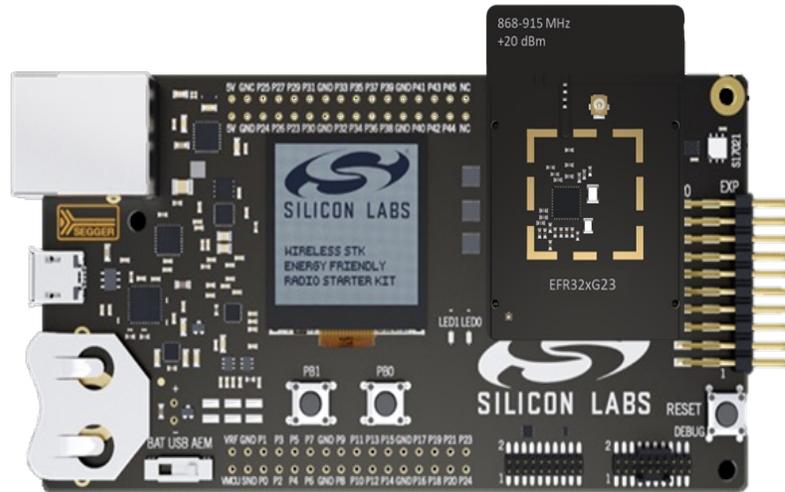
Series 1 (xG1x)	Series 2 (xG2xA/B)		Feature
Base	Mid	High	
✓	✓	✓	True Random Number Generator
✓	✓	✓	Crypto Engine
✓	✓	✓	Secure Application Boot
—	✓	✓	Secure Engine
—	✓	✓	Secure Boot with RTSL
—	✓	✓	Secure Debug with Lock/Unlock
—	Optional	✓	DPA Countermeasures
—	—	✓	Anti-Tamper
—	—	✓	Secure Attestation
—	—	✓	Secure Key Management
—	—	✓	Advanced Crypto



Designing
Secure
IoT Devices
**ARM PSA Level 2
& 3**



Getting Started with EFR32FG23 SoCs



Simplified Development Kits for Better User Experience

Simplifies Development

Pro kits contain:

- 1 x WSTK main board
- 1 x radio board
- Antenna(s)
- USB cable

Radio Board kits contain:

- 1x x radio board
- Antenna(s)

Out-of-Box Application

- Boards are pre-programmed with the range test application
- Configure & control from the development board via buttons and LCD

Order Part Number	Description	Resale
xG23-PK4204D	xG23 868-915 MHz +14 dBm Pro Kit	\$139
xG23-PK4210A	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

Introducing EFR32xG24



Target Applications

- **Smart Home**
 - Gateways, sensors, switches, door locks, smart plugs
- **Building Automation**
 - Gateways, sensors, switches, location services
- **Lighting**
 - LED bulbs, luminaires
- **Portable Medical Devices**
 - Blood glucose meters, pulse oximeters
- **AI/ML**
 - Predictive maintenance, glass break detection

Industry's Only Wireless SoC with AI/ML accelerator, 20-bit ADC, and Secure Vault for IoT Edge Devices



BG24 and MG24: Optimized for Battery Powered IoT Mesh Devices



▪ High Performance Radio

- Up to +19.5 dBm TX
- -97.5 dBm RX @ BLE 1 Mbps
- -104.9 dBm RX @ BLE 125 kbps
- -104.5 dBm RX @ 15.4
- Wi-Fi Coexistence
- RX Antenna Diversity

▪ ARM® Cortex®-M33

- 78 MHz (FPU and DSP)
- TrustZone®
- Up to 1536kB of Flash
- Up to 256kB of RAM

▪ Low Power

- 5.1 mA TX @ 0 dBm
- 20 mA TX @ +10 dBm
- 4.4 mA RX (BLE 1 Mbps)
- 32 μ A/MHz
- 1.3 μ A EM2 with 16 kB RAM

▪ Dedicated Security Core

- Secure Vault™ - Mid / High

▪ AI/ML

- AI/ML Hardware Accelerator

▪ Low-power Peripherals

- EUSART, USART, I2C
- 20-bit ADC, 12-bit VDAC, ACMP
- Temperature sensor +/- 1.5°C

▪ World Class Software

- Matter*
- OpenThread*
- Zigbee*
- Bluetooth (1M/2M/LR)
- Bluetooth mesh
- Dynamic multiprotocol*

▪ SoCs and Modules

- 5x5 QFN40 (26 GPIO)
- 6x6 QFN48 (28/32 GPIO)
- 7x7 SiP Module (+10 dBm)
- 12.9x15.0 PCB Module (+10 dBm)

* Requires MG24

Secure Vault™ Support in BG24 and MG24 Protecting the IoT Device

Base	Mid	High	Feature
✓	✓	✓	True Random Number Generator 
✓	✓	✓	Crypto Engine
✓	✓	✓	Secure Application Boot
—	HSE	HSE	Secure Engine 
—	✓	✓	Secure Boot with RTSL
—	✓	✓	Secure Debug with Lock/Unlock
—	✓	✓	DPA Countermeasures
—	—	✓	Anti-Tamper 
—	—	✓	Secure Attestation
—	—	✓	Secure Key Management
—	—	✓	Advanced Crypto
EFR32BG24 EFR32MG24			

Industry Leading
IoT Security



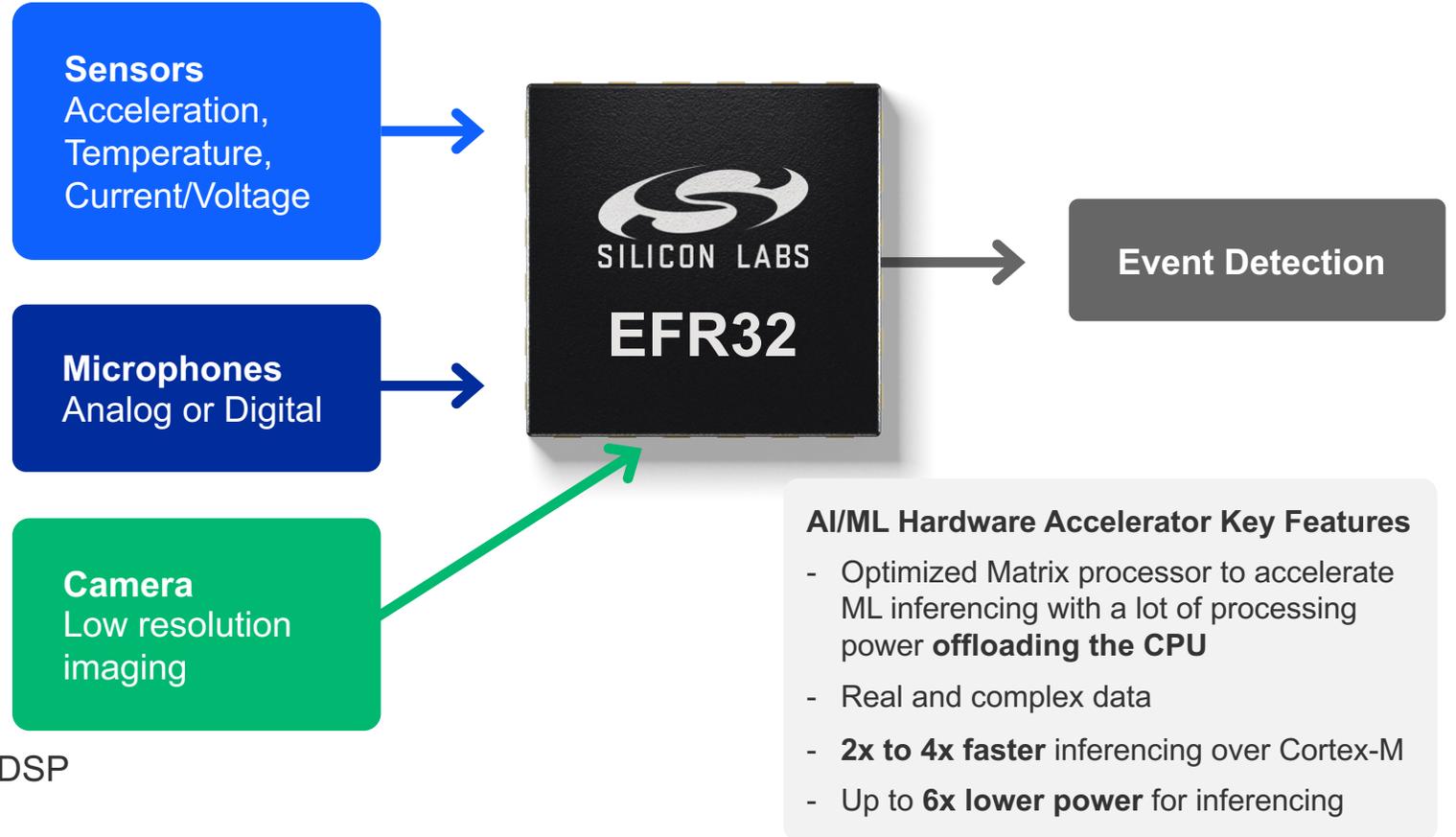
First Silicon Labs IC with AI/ML on Edge Devices

Benefits of processing AI/ML in device

- Lower power
- Save Bandwidth
- Lower Latency
- Ensure Privacy
- Higher Security
- Lower Cost

Use Cases for AI/ML

- Timeseries data on ADC or GPIO
- Audio mic array with beamforming
- Audio mic input with Audio Front End, DSP
- Image capture (incl. fingerprint reader)



AI/ML Hardware Accelerator enables efficient Edge ML inferencing



xG24 ADC Performance vs Mode

■ Normal Mode

- 12-bit output resolution, 11.7 ENOB @ 1 Msps (OSR = 2)
- 16-bit output resolution, 14.3 ENOB @ 76.9 ksps (OSR = 32)

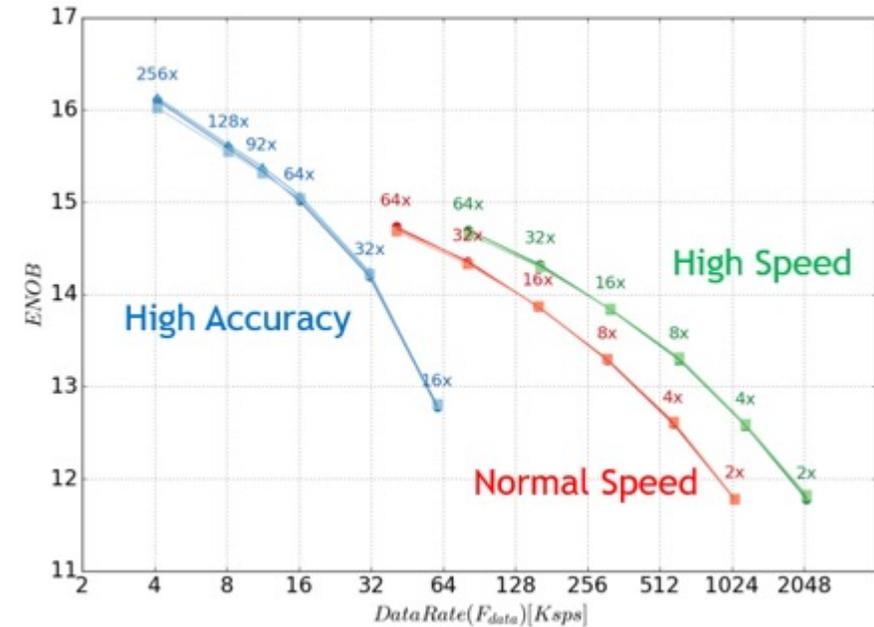
■ High-Speed Mode – Double speed, Similar Performance

- 12-bit output resolution, 11.7 ENOB @ 2 Msps (OSR = 2)
- 16-bit output resolution, 14.3 ENOB @ 153.8 ksps (OSR = 32)

■ High-Accuracy Mode – Highest performance

- Dedicated inputs for full performance across temperature
- 20-bit output resolution, 15 ENOB @ 15.3 ksps (OSR = 64)
- 20-bit output resolution, 16 ENOB @ 3.8 ksps (OSR = 256)

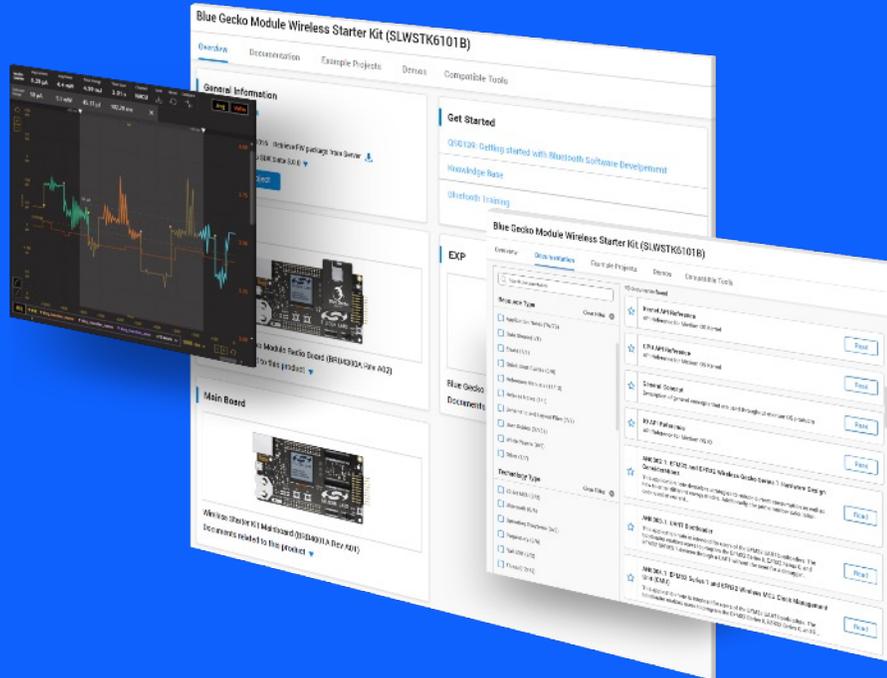
Effective Number of Bits, External VREF



Silicon Labs' Series 2 Bluetooth SoC Portfolio

	BG21	BG22	BG24
Target Applications	Mains powered Bluetooth LE and mesh end nodes and gateways/hubs	Lowest power Bluetooth LE, Direction Finding and Bluetooth mesh LPNs	Advanced Bluetooth LE Bluetooth mesh end nodes
Protocols	Bluetooth LE 5.3 1Mbps, 2 Mbps, Long Range Bluetooth Mesh	Bluetooth LE 5.3 1Mbps, 2 Mbps, Long Range Bluetooth Mesh	Bluetooth LE 5.3 1Mbps, 2 Mbps, Long Range Bluetooth Mesh
Frequency Bands	2.4 GHz	2.4 GHz	2.4 GHz
Core	Cortex-M33 (80 MHz)	Cortex-M33 (76.8 MHz)	Cortex-M33 (78 MHz)
Max Flash	1024 kB	512 kB	1536 kB
Max RAM	96 kB	32 kB	256 kB
Security	Secure Vault™ Mid Secure Vault™ High	Secure Vault™ Mid	Secure Vault™ Mid Secure Vault™ High
Max TX Output Power	+20 dBm	+6 dBm	+19.5 dBm
Rx Sensitivity (BLE 1Mbps)	-97.5 dBm	-98.9 dBm	-97.5 dBm
Active Current	63.8 µA/MHz	26 µA/MHz	32.2 µA/MHz
Sleep Current (EM2, 16 kB ret)	4.5 µA	1.2 µA (8 kB)	1.3 µA
TX Current @ +0 dBm (2.4 GHz)	9.3 mA	4.1 mA	5.1 mA
TX Current @ +10 dBm (2.4 GHz)	33.8 mA	8.2 mA @ +6 dBm	20 mA
RX Current (BLE 1 Mbps)	8.8 mA	3.6 mA	4.4 mA
Serial Peripherals	USART, I2C	USART, EUSART, I2C, PDM	USART, EUSART, I2C
Analog Peripherals	12-bit ADC, ACMP	16-bit ADC	20-bit ADC, ACMP, VDAC
Other	Die Temp Sensor	Die Temp Sensor	Die Temp Sensor, AI/ML Accelerator
Operating Voltage	1.71 V to 3.8 V	1.71 V to 3.8 V	1.71 V to 3.8 V
GPIO	20	18, 26	26, 28/32
Package	4x4 QFN32	4x4 QFN32 4x4 TQFN32 5x5 QFN40	5x5 QFN40 6x6 QFN48

Simplified Developer Experience



14
Simplicity
Silicon
Studio 5

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 configurator
 - ▶ Energy Profiler – visual energy analysis
 - ▶ Network Analyzer – packet capture & decode

Getting Started with EFR32BG24 and EFR32MG24 SoCs

▪ Dev Board

- ▶ Low-cost development board
- ▶ On-board debugger
- ▶ Signal breakouts
- ▶ On-board sensors
- ▶ 20-bit ADC
- ▶ AI/ML hardware accelerator

▪ Contents

- ▶ 1x dev board



Part Number	Description
xG24-DK2601B	EFR32xG24 2.4 GHz +10 dBm dev board

▪ Pro kits

- ▶ Modular development platform
- ▶ Advanced development
- ▶ RF measurements
- ▶ Energy profiling
- ▶ External device debug
- ▶ Ethernet for large network test

▪ Contents

- ▶ 1 x WSTK main board
- ▶ 1 x radio board



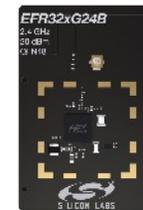
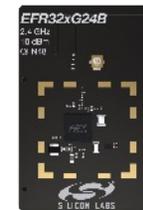
Part Number	Description
xG24-PK6009A	EFR32xG24 2.4 GHz +10 dBm Pro Kit
xG24-PK6010A	EFR32xG24 2.4 GHz +20 dBm Pro Kit

▪ Radio Board kits

- ▶ Uses existing WSTK boards
- ▶ Uses existing software tools

▪ Contents

- ▶ 1x radio board



Part Number	Description
xG24-RB4186C	EFR32xG24 2.4 GHz +10 dBm Radio Board
xG24-RB4187C	EFR32xG24 2.4 GHz +20 dBm Radio Board
xG24-RB4188A	EFR32xG24 +20 dBm Antenna Diversity Board

CPMS

- **What is CPMS?**

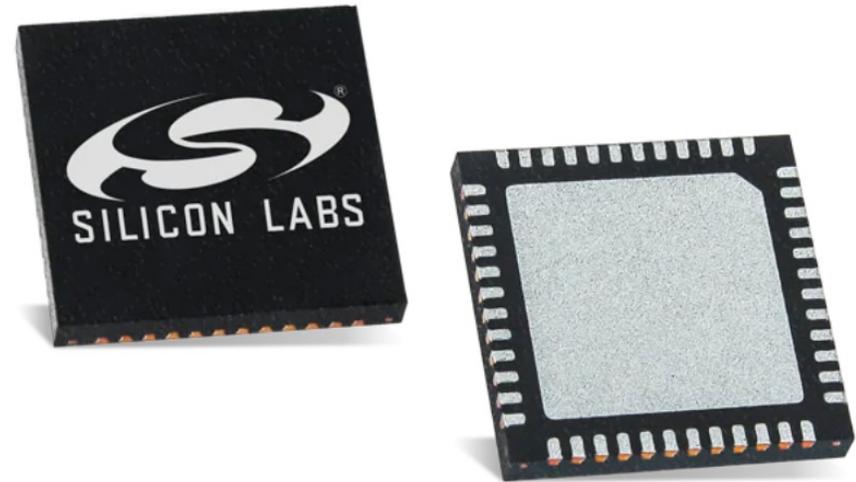
- CPMS (Custom Part Manufacturing Service) is a service offered by Silicon Labs that allows you to order custom parts that have your firmware and security settings programmed into them before they are sent to the CM

- **Why is this important?**

- IoT devices are at their most vulnerable during production. CPMS allows you to secure your parts from the moment they're shipped
- IoT security is complex, and it's easy to accidentally leave a system vulnerable. CPMS provides a secure-by-default "checklist" of easily enabled security features

- **Where is it?**

- <https://cpms.silabs.com/> (make sure you can log in, if you haven't tried yet)





works with

BY SILICON LABS

VIRTUAL CONFERENCE | SEPTEMBER 13 - 15TH

REGISTRATION NOW OPEN

9 Workshops

70+ Sessions

3 Full Days

Scan to Register





—
谢谢大家!

Silicon Labs
官方网站



Silicon Labs
微信公众号



Silicon Labs
在线社区

