



# 开箱：探索蓝牙新功能

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# 议程大纲

**xG27简介**

**xG27差异化特性**

**开发套件硬件和软件**

**GitHub演示**

**Simplicity Studio演示**



# EFR32BG27和EFR32MG27目标应用

互联健康

智能家居

工业和商业

- 互联健康
  - 便携式医疗设备
    - 连续血糖监测仪, 脉搏血氧仪, 医用贴片, 心电图
  - 临床医疗仪器
  - 穿戴设备
- 智能家居
  - 传感器, 开关
  - 门锁
  - 暖通空调, 恒温器
  - LED照明
  - 智能家电
- 工业和商业
  - 楼宇自动化
  - 商用照明
  - 门禁系统
  - 资产跟踪, 室内导航



# xG27: 适用于电池供电设备的多功能SoC



电池供电  
超低功耗  
多协议  
安全

## 设备规格

### 高性能 2.4 GHz 射频

- Up to +8 dBm TX
- -98.9 dBm RX @ BLE 1 Mbps
- -106.7 dBm RX @ BLE 125 kbps

### MCU内核

- ARM Cortex®-M33 (76.8 MHz with FPU & DSP)

### 内存

- Up to 64kB RAM
- Up to 768kB Flash

### 超低功耗

- 1.1  $\mu$ A EM2 with 8 kB RAM retention
- 4.1 mA TX @ 0 dBm
- 3.6 mA RX (BLE 1 Mbps)

### 多协议支持

- Bluetooth 5.3 (1M/2M/LR), Bluetooth mesh
- Zigbee 3.0
- Proprietary 2.4 GHz

### 功能丰富的外设

- 16-bit ADC, USARTs, I2C, I2S, PDM, Timers

### 封装

- 2.3x2.6 WLCSP (19 GPIO) +85°C
- 4x4 QFN32 (18 GPIO) +125°C
- 5x5 QFN40 (26 GPIO) +125°C

## 差异化特性

### 极小的外形尺寸

- 2.3 x 2.6 WLCSP package<sup>1</sup>

### 灵活的电池电源支持

- DCDC Buck/Boost
- Supports 1.7 to 3.6 volts
- Supports 0.8 to 1.7 volts

### 增强安全性

- Secure Vault™ Mid
- Tamper detect
- Customer Key Management w/PUF

### 电池管理

- Coulomb counter

### 唤醒引脚 (BOOST\_EN)

- Enables <20 nA for long-term storage
- Up to 10 years of shelf storage



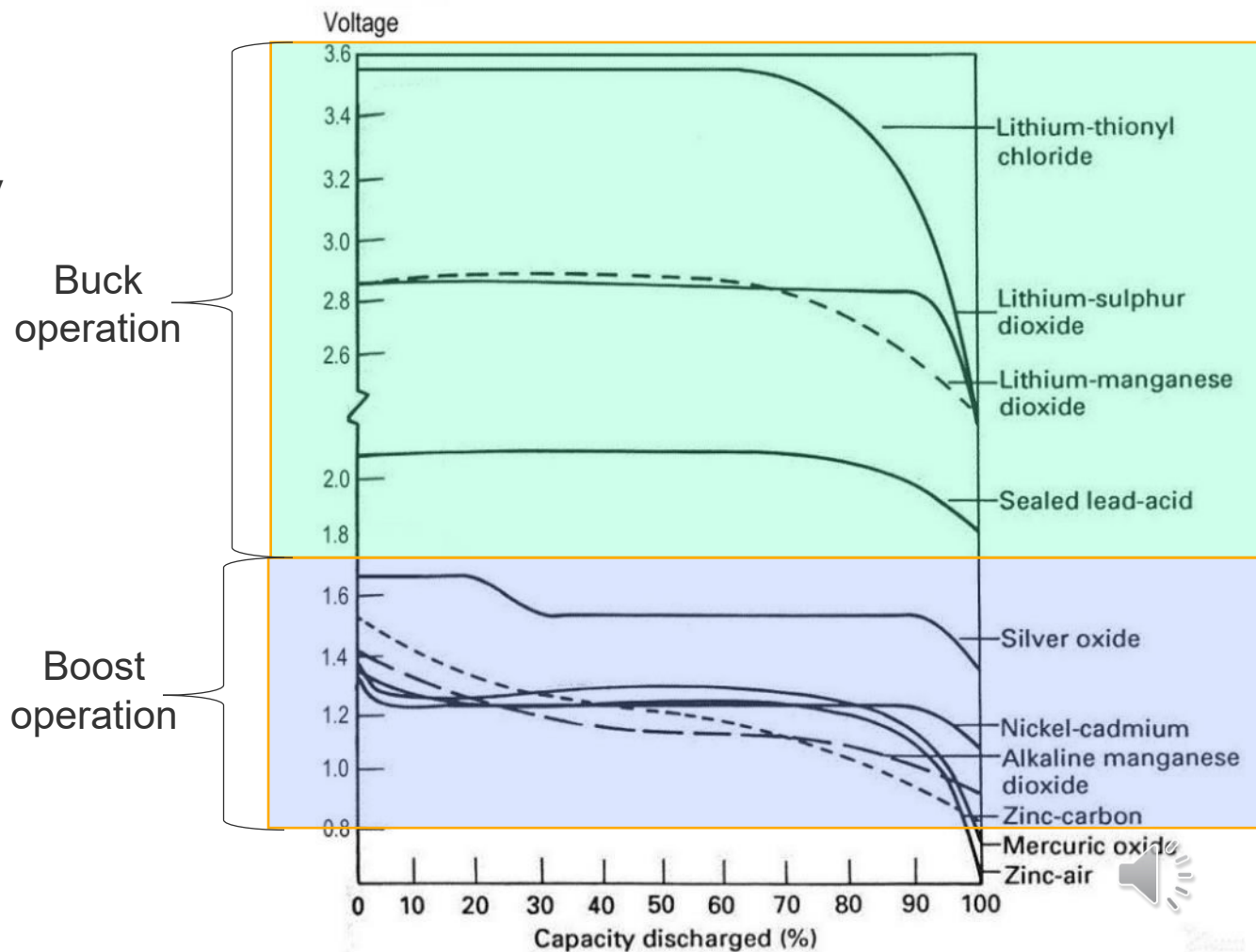
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# 差异化特性



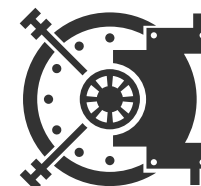
# DC-DC升压转换器

- 输入范围: 0.8 V ~ 1.7 V
  - 增加对低电压电池的支持
  - Silver Oxide: ~1.2 to 1.65 V
  - 碱性电池 / 可充电的2A/3A电池: ~0.9 to 1.5 V
- 库仑计数器
  - 实现准确的电池电量水平追踪
- 具有唤醒引脚的上架模式 (Shelf Mode)



# Secure Vault™ — 保护物联网设备

Base	Mid	High	Feature
✓	✓	✓	True Random Number Generator
✓	✓	✓	Crypto Engine
✓	✓	✓	Secure Application Boot
—	<b>VSE/HSE</b>	<b>HSE</b>	Secure Engine
—	✓	✓	Secure Boot with RTSL
—	✓	✓	Secure Debug with Lock/Unlock
—	<b>HSE &amp; xG27</b>	✓	DPA Countermeasures
—	<b>xG25, xG27</b>	<b>xG25</b>	E-Tamper
—	<b>xG27*</b>	✓	PUF Support (Seed Key to AES)
—	—	✓	Anti-Tamper
—	—	✓	Secure Attestation
—	—	✓	Secure Key Management
—	—	✓	Advanced Crypto
<b>EFR32BG27</b> <b>EFR32MG27</b>			



设计安全的物联网设备



# 增强安全性 – DPA Countermeasures

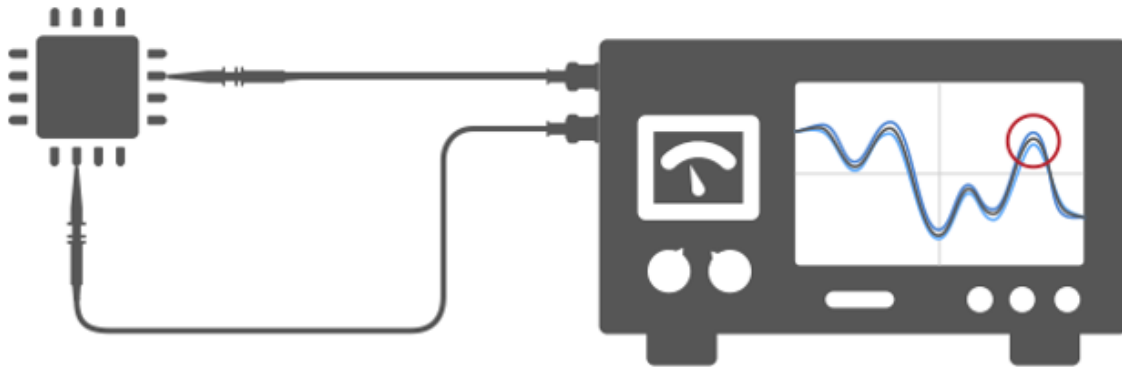
## LOCAL ATTACK VECTOR

1

A Differential Power Analysis (DPA) attack requires hands-on access to the device.

2

Monitoring electromagnetic radiation and fluctuations in power consumption during crypto operations may reveal security keys and other data.



## ■ 漏洞

- 观察给定内部操作期间的细微差异可以提供对加密函数的深入了解。

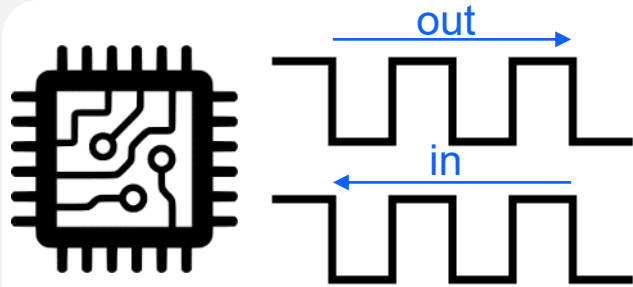
## ■ DPA Countermeasures

- 该解决方案为内部操作添加掩码 (masks) 和随机计时 (random timings), 并扭曲 DPA snooping

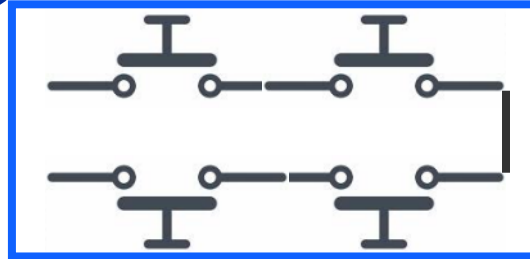




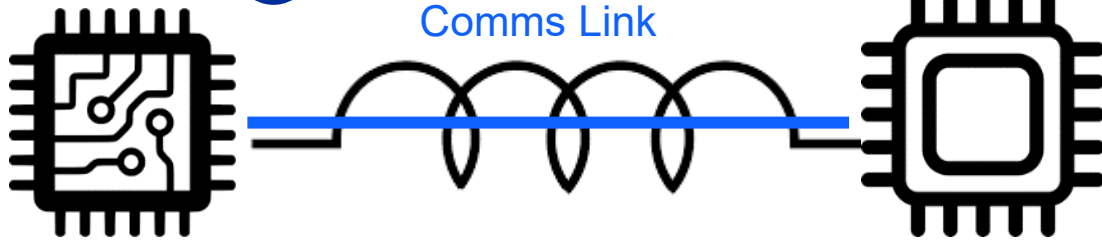
# E-Tamper



1 Tamper Pins on Case

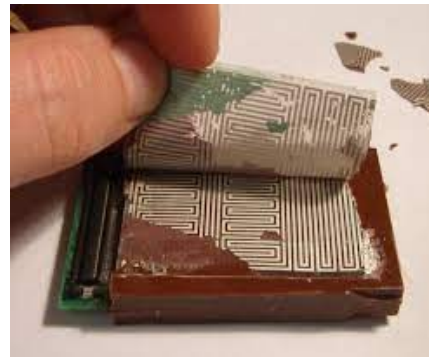


2 Tamper Trace Around Comms Link



3

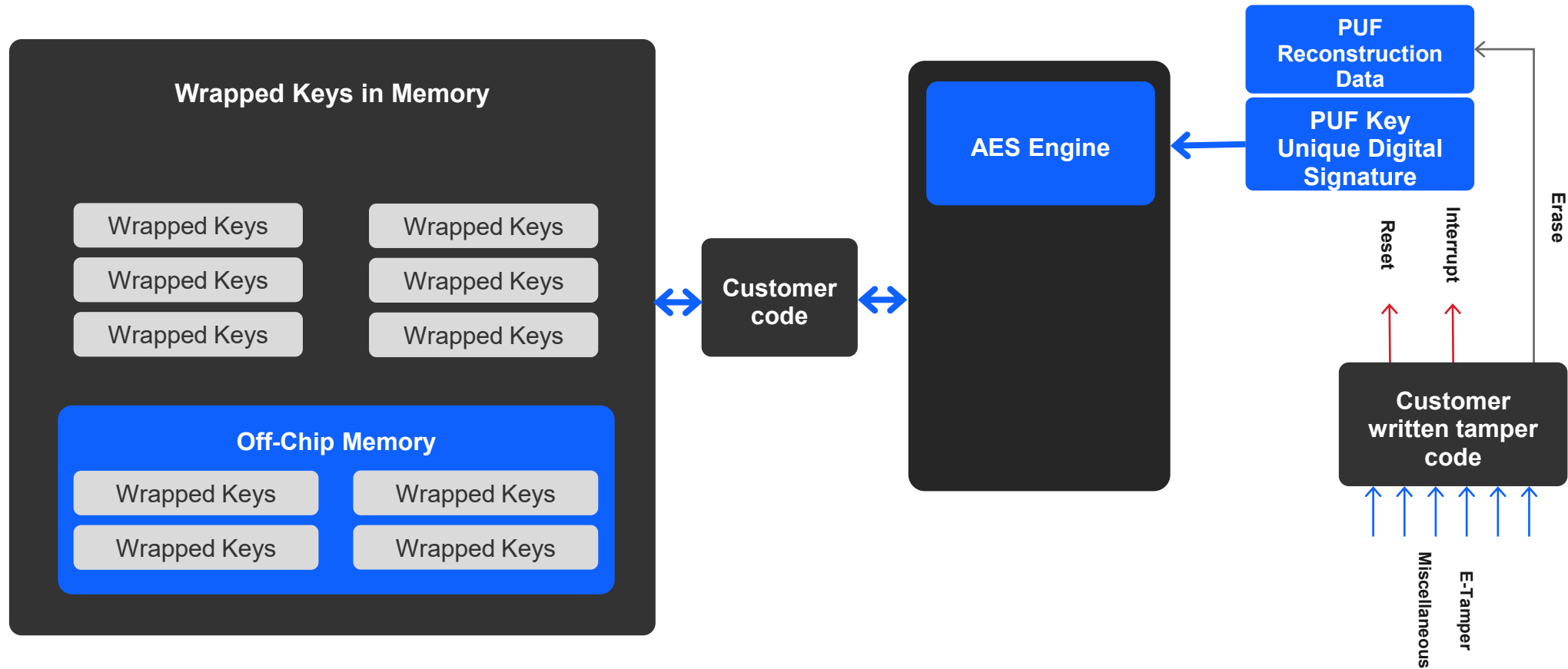
Purpose Built Tamper Shields



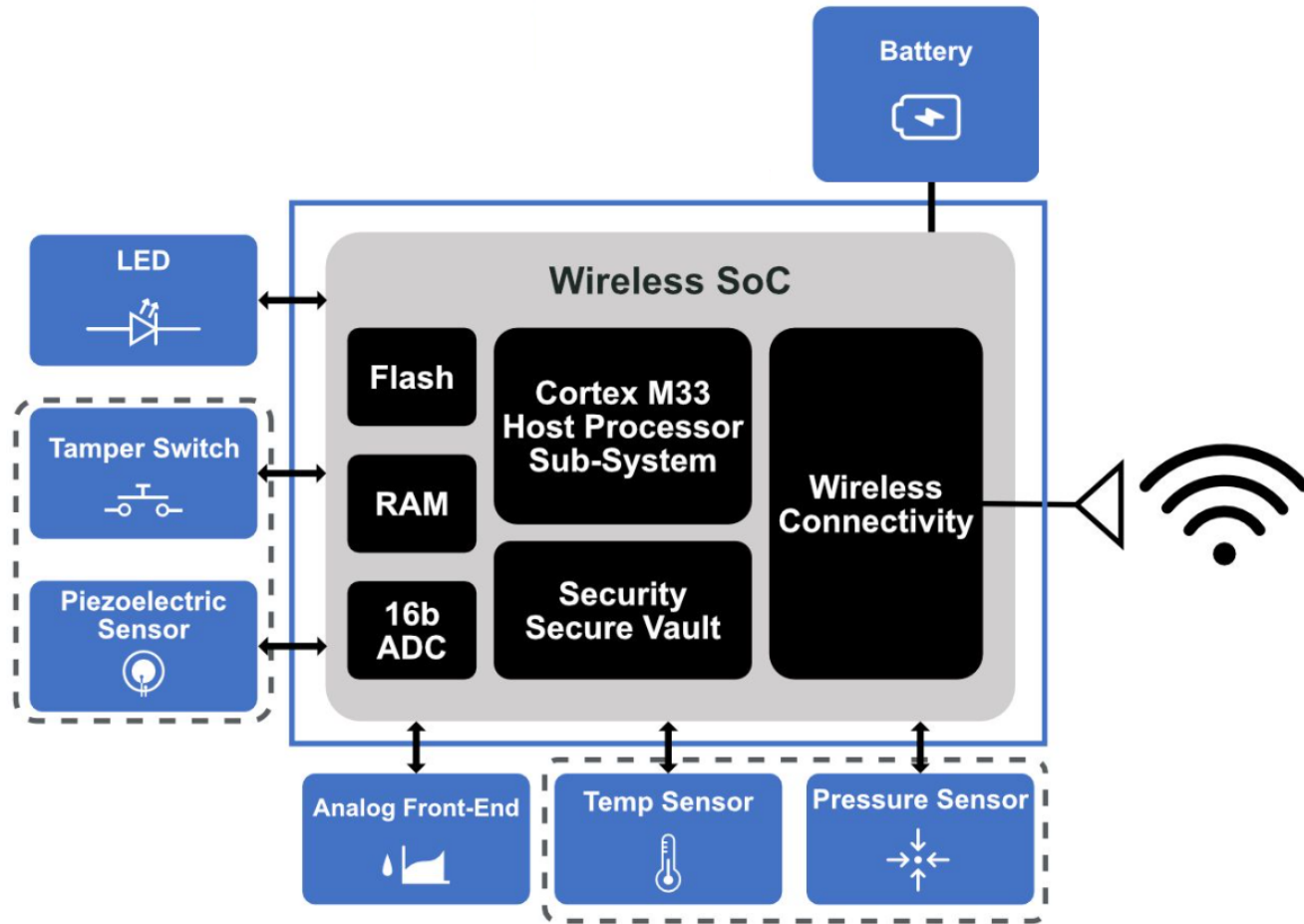
- 方波从一个引脚输出，而在另一个引脚输入时，断开的信号可以输入其他逻辑来采取篡改动作
- 应用案例：
  - 1) 在产品包装上连接篡改引脚，然后在包装打开时触发动作
  - 2) 在PC板上总线创建Wire trace, 以保护两个组件之间的通信
  - 3) 为防篡改屏蔽供电以保护PCB上多个组件



# 增强安全性—用户密钥管理与PUF



# 微型医疗设备设计实例—连续血糖监测仪







- 基于BG27 SoC

- 功能特点

- BG27 CSP 封装 / 尺寸
- DCDC 降压 / 升压
- 功耗优化
  - 低活动电流和睡眠电流
  - 上架模式 (Shelf Mode) (BOOST\_EN)
- Secure Vault
  - E-Tamper
- 模拟/串行外围设备
  - 16-bit ADC
- CGM示例应用



# 芯科科技2.4GHz SoC产品组合

	xG21	xG22	xG24	xG27
<b>Protocols</b>				
<b>Frequency Bands</b>	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz
<b>Core</b>	Cortex-M33 (80 MHz) Cortex-M0+ (Security)	Cortex-M33 (76.8 MHz) Cortex-M0+ (Radio)	Cortex-M33 (78 MHz) Cortex-M0+ (Radio) Cortex-M0+ (Security)	Cortex-M33 (76.8 MHz) Cortex-M0+ (Radio)
<b>Max Flash</b>	1024 kB	512 kB	1536 kB	768 kB
<b>Max RAM</b>	96 kB	32 kB	256 kB	64 kB
<b>Security</b>	Secure Vault Mid Secure Vault High	Secure Vault Mid	Secure Vault Mid Secure Vault High	Secure Vault Mid
<b>Rx Sensitivity (15.4)</b>	-104.5 dBm	-102.3 dBm	-105.4 dBm	-102.3 dBm
<b>Rx Sensitivity (BLE 1Mbps)</b>	-97.5 dBm	-98.9 dBm	-97.6 dBm	-98.9 dBm
<b>Active Current</b>	63.8 µA/MHz	26 µA/MHz	33.4 µA/MHz	29 µA/MHz
<b>Sleep Current (EM2, 16 kB ret)</b>	4.5 µA	1.2 µA (8 kB)	1.3 µA	1.6 µA (64 kB)
<b>TX Current @ +0 dBm (2.4 GHz)</b>	9.3 mA	4.1 mA	5.0 mA	4.1 mA
<b>TX Current @ +10 dBm (2.4 GHz)</b>	33.8 mA	8.2 mA @ +6 dBm	19.1 mA	11.3 mA @ +8 dBm
<b>TX Current @ +20 dBm (2.4 GHz)</b>	185 mA	N/A	156.8 mA	N/A
<b>RX Current (802.15.4)</b>	9.4 mA	3.9 mA	5.1 mA	3.9 mA
<b>RX Current (BLE 1 Mbps)</b>	8.8 mA	3.6 mA	4.4 mA	3.6 mA
<b>Serial Peripherals</b>	USART, I2C	USART, EUSART, I2C, PDM	USART, EUSART, I2C	USART, EUSART, I2C, I2S, PDM
<b>Analog Peripherals</b>	12-bit ADC, ACMP	16-bit ADC	20-bit ADC, ACMP, VDAC	16-bit ADC, ACMP, Coulomb Counter
<b>Other</b>	Die Temp Sensor	Die Temp Sensor	Die Temp Sensor	Temp Sensor, PLFRCO, Buck/Boost
<b>Operating Voltage</b>	1.71 V to 3.8 V	1.71 V to 3.8 V	1.71 V to 3.8 V	0.8 – 1.6 V 1.71 – 3.8 V
<b>GPIO</b>	20	18, 26	26, 28/32	26, 18, 19
<b>Package</b>	4x4 QFN32	4x4 QFN32 4x4 TQFN32 5x5 QFN40	5x5 QFN40 6x6 QFN48	5x5 QFN40 4x4 QFN32 2.3x2.6 WLCSP



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WEBINAR SERIES

# 蓝牙开发套件之硬件和软件 综合导览与演示

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芯科科技高级现场应用工程师



BLUETOOTH SERIES



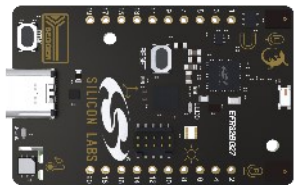
# 启用EFR32BG27和EFR32MG27 SoC

- 开发板

- ▶ Low-cost development board
- ▶ On-board debugger
- ▶ Signal breakouts
- ▶ On-board sensors
- ▶ 16-bit ADC

- 内容物

- ▶ 1x dev board



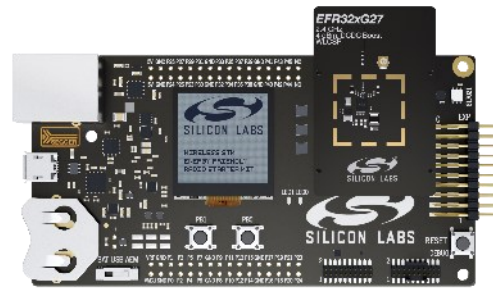
Part Number	Description
xG27-DK2602A	EFR32xG27 2.4 GHz +8 dBm dev board

- 高级套件

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

- 内容物

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



Part Number	Description
xG27-PK6017A	EFR32xG27 2.4 GHz +8 dBm Pro Kit (Buck)
xG27-PK6018A	EFR32xG27 2.4 GHz +4 dBm Pro Kit (Buck)
xG27-PK6019A	EFR32xG27 2.4 GHz +4 dBm Pro Kit (Boost)

- 无线开发套件

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

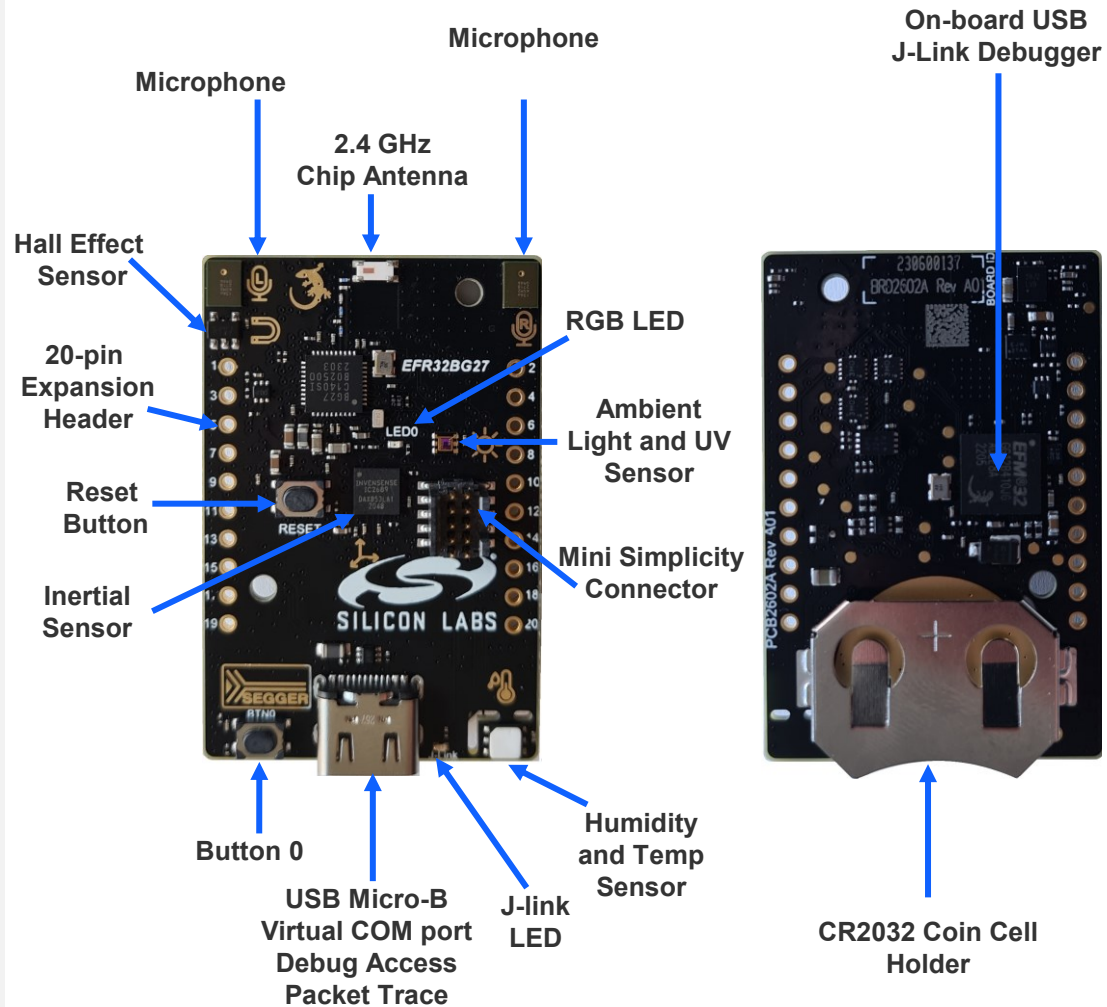
- 内容物

- ▶ 1x radio board



Part Number	Description
xG27-RB4194A	EFR32xG27 2.4 GHz +8 dBm Radio Board (Buck)
xG27-RB4110B	EFR32xG27 2.4 GHz +4 dBm Radio Board (Buck)
xG27-RB4111B	EFR32xG27 2.4 GHz +4 dBm Radio Board (Boost)

# 开发板功能特点



## ■ 特性

- EFR32BG27C140F768IM40 for +8 dBm Kit (Buck)
- Wireless SoC with multi-protocol radio
- Cortex-M33, 768 kB Flash and 64 kB RAM
- Coulomb counter

## ■ 广泛的传感器支持

- 9-axis Inertial Sensor
- 2 Digital Microphones
- Pressure Sensor
- Relative Humidity and Temperature Sensor
- UV and Ambient Light Sensor
- Hall-effect Sensor

## ■ 扩展选项和用户界面

- Breakout pads
- Qwiic connector
- LEDs and Push Buttons



# 射频开发板和主板功能特点

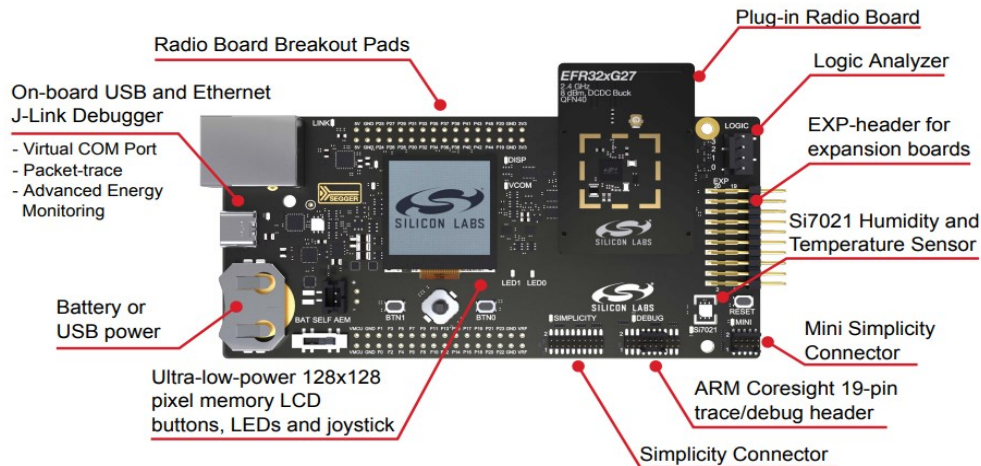


Figure 2.1. Hardware Layout With A Wireless Pro Kit Mainboard (BRD4002A)

## ■ 射频开发板特性

- EFR32MG27C140F768IM40 for +8 dBm Kit (Buck)
- EFR32BG27C320F768GJ39 for +4 dBm Kit (Buck)
- EFR32BG27C320F768GJ39 for +4 dBm Kit (Boost)
- Cortex-M33, 768 kB Flash and 64 kB RAM
- Secure Vault Mid
- U.FL for RF Measurements

## ■ 主板特性

- LEDs and Push Buttons
- Ethernet and USB connectivity
- Advanced Energy Monitor
- Packet Trace Interface
- Breakout pads and expansion header
- External debug support
- Si7021 Relative Humidity and Temperature sensor
- Low Power 128x128 pixel Memory LCD
- USB, CR2032, and battery pack options for power





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# Github演示





## Silicon Labs

Silicon Labs is a leading provider of solutions for a smarter, more connected world. The official GitHub account contains officially supported repositories.

283 followers Austin, TX http://www.silabs.com

- Overview
- Repositories 111
- Projects
- Packages
- People

### Pinned

**gecko\_sdk** Public

The Gecko SDK (GSDK) combines all Silicon Labs 32-bit IoT product software development kits (SDKs) based on Gecko Platform into a single, integrated SDK.

C 246 96

**application\_examples** Public

Start here to find code examples for Silicon Labs EFM32 and EFR32

166 58

**matter** Public

Forked from project-chip/connectedhomeip

Matter is creating more connections between more objects, simplifying development for manufacturers and increasing compatibility for consumers, guided by the Connectivity Standards Alliance.

C++ 114 37

**amazon-sidewalk** Public

This repository contains the code for the Silicon Labs extension for Amazon Sidewalk.

C 13 2

### People

This organization has no public members. You must be a member to see who's a part of this organization.

### Top languages

- C
- C++
- Python
- JavaScript
- Java

### Most used topics

- ble
- efm32
- efr32
- iot
- wi-sun

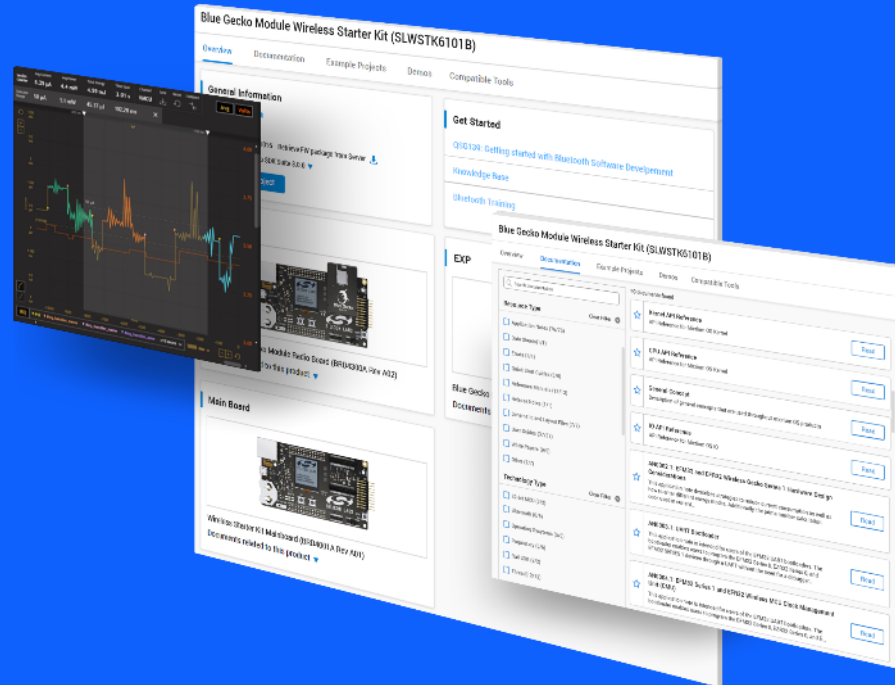
### Repositories

Find a repository... Type Language Sort

**ot-efr32** Public

C 6 BSD-3-Clause 25 0 2 Updated 2 days ago

# 简化开发人员体验



14  
**Simplicity**  
Silicon  
2019  
**Studio 5**

## Simplicity Studio 5

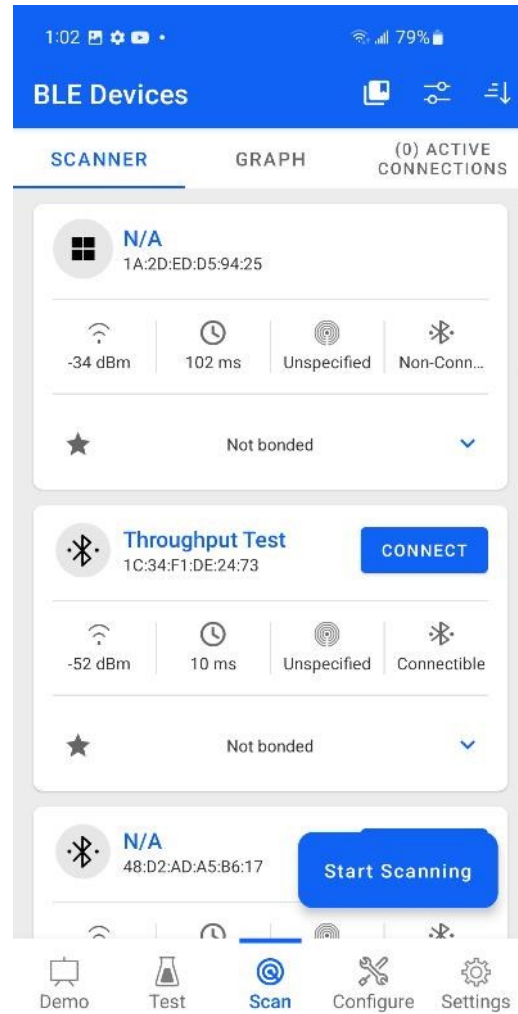
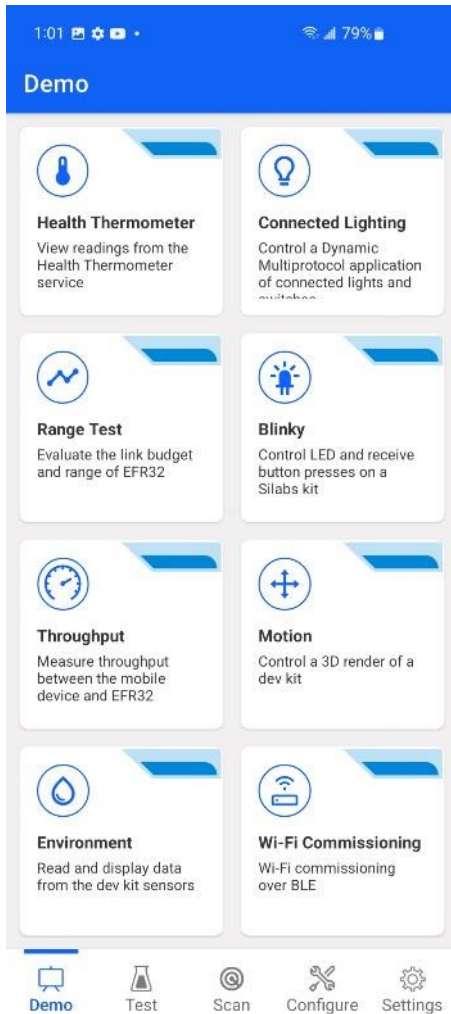
### • 界面

- ▶ Fresh, new & simplified
- ▶ Intuitive out-of-the-box experience
- ▶ Fast access to developer resources
- ▶ Linux, Mac & Windows

### • 工具

- ▶ Configuration utilities
- ▶ Compiler
- ▶ Error & validation
- ▶ IDE & command line support
- ▶ Graphical hardware configurator
- ▶ Energy Profiler – visual energy analysis
- ▶ Network Analyzer – packet capture & decode

# EFR Connect – 演示



- EFR Connect将最流畅的开箱即用体验与最先进的低功耗蓝牙开发功能结合在一个移动应用程序中
- 带有不同用途视图的主导航栏
  - Demo: 在GSDK上预编译了许多工具包, 包括现成的演示与匹配的样例应用程序
  - Scan: 用于搜索、连接和与远程设备交互
  - Configure: 为移动设备提供本地广播和GATT配置
  - Test: (IOP)评估针对Silicon Labs的蓝牙软件和硬件的行为
  - Settings: 用于系统配置和应用程序信息



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# xG27和Simplicity Studio 演示



# Simplicity Studio 实际操作演示

The screenshot displays the Simplicity Studio IDE interface. The main window title is "v5\_workspace - Simplicity Studio™". The menu bar includes "File", "Edit", "Navigate", "Search", "Project", "Run", "Window", and "Help". The toolbar contains icons for "Welcome", "Recent", "Tools", "Install", and "Preferences". The "Debug Adapters" panel on the left shows a list of adapters, with "EFR32xG27 2.4 GHz 8 dBm RB (ID:440267266)" selected. The main content area displays the configuration page for the selected adapter, titled "EFR32xG27 2.4 GHz 8 dBm RB, Wireless Pro Kit Mainboard (ID: 000440267266)". The page has tabs for "OVERVIEW", "EXAMPLE PROJECTS & DEMOS", "DOCUMENTATION", and "COMPATIBLE TOOLS". A "Create New Project" button is located in the top right corner. The "General Information" section shows "Connected Via: J-Link Silicon Labs" with a "Configure" link, "Debug Mode: Onboard Device (MCU)" with a "Change" link, "Adapter FW: 1v4p10b213" with a "Latest" label, and "Preferred SDK: Gecko SDK Suite v4.3.0" with a "Manage SDKs" dropdown. The "Recommended Quick Start Guides" section lists four guides: "QSG168: Proprietary Flex SDK v3.x Quick Start Guide" and "QSG183: Bluetooth Mesh SDK Quick-Start Guide for SDK v4.x", each with a "View Documents" link. An "All Quick Start Guides" button is also present. The "Board" section shows an image of the "Wireless Pro Kit Mainboard (BRD4002A Rev A06)" with a "View Documents" dropdown. The "Board" section shows an image of the "EFR32xG27 2.4 GHz 8 dBm Radio Board (BRD4194A Rev A04)" with a "View Documents" dropdown. The "Target Part" section shows an image of the "EFR32MG27C140F768IM40" chip with a "View Documents" dropdown. The bottom status bar shows "david.zhou@silabs.com" and "© 2023 Silicon Labs".

# 资源和链接

## BG27产品网页

- <https://www.silabs.com/bg27>

## MG27产品网页

- <https://www.silabs.com/mg27>

## Simplicity Studio 5

- <https://www.silabs.com/developers/simplicity-studio>

## EFR Connect

- <https://www.silabs.com/developers/efr-connect-mobile-app>

## GitHub

- <https://github.com/siliconlabs>



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WEBINAR SERIES

# 蓝牙产品介绍：BLE 5.4 的新特点和芯科科技对此的支持

方恒坚 (Kevin Fang)  
芯科科技高级现场应用工程师



BLUETOOTH SERIES





# 议程大纲

为何需要Bluetooth® 5.4?

Bluetooth® 5.4的新功能及特性



---

# Bluetooth® 5.4



# 为何需要Bluetooth 5.4?



## ■ 需要标准化的大规模星型网络

- 承载数千个节点的能力
- 加密数据流量
- 超低功耗
- 受电子货架标签(ESL)市场的推动

## ■ 增强特性

- 优化对安全数据的访问
- 为扩展广告(extended advertising)的LE编码PHY提供更好地控制



# Bluetooth 5.4 – 目标市场和应用案例



## 智能零售

- 电子货架标签
- 架上的传感器

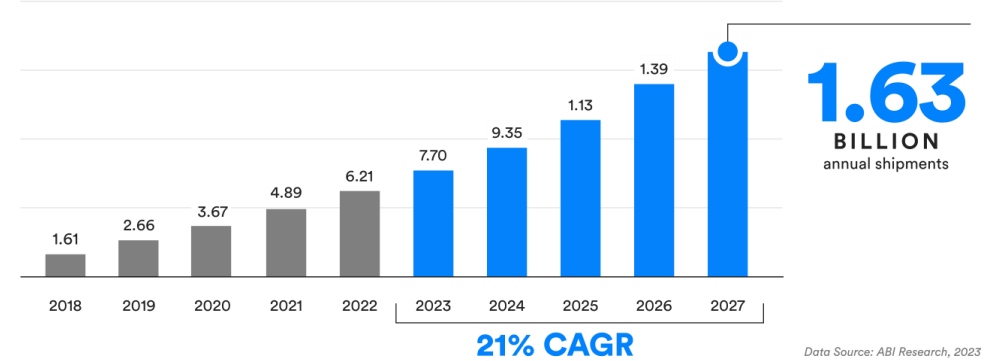


## 工业

- 制造和物流
- 数字标记
- 资产监控

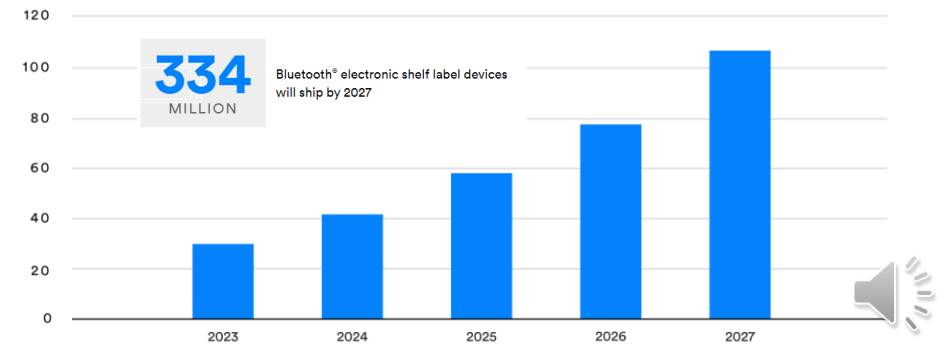
## Annual Bluetooth® Device Networks Device Shipments

NUMBERS IN BILLIONS



## Annual Bluetooth® ESL Shipments

NUMBERS IN MILLIONS



Source: <https://www.bluetooth.com/2023-market-update/>

# Bluetooth 5.4新特性



## 同步广告响应 (PAWR)

提供节能、大规模、双向的一对多通信拓扑



## 加密广播数据 (EAD)

具有在广告包中安全地广播数据的特点



## LE GATT 安全级别

设备可以指示所有GATT功能应用所需的安全模式和级别



## 广播编码选择

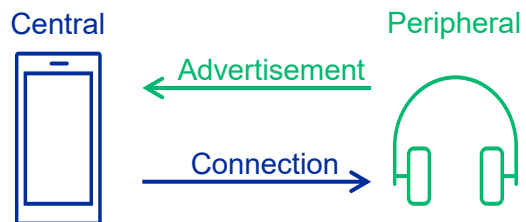
主机可指定LE扩展广告使用两个支持的远程编码选项中的其一



# 蓝牙5.4中的广播模式

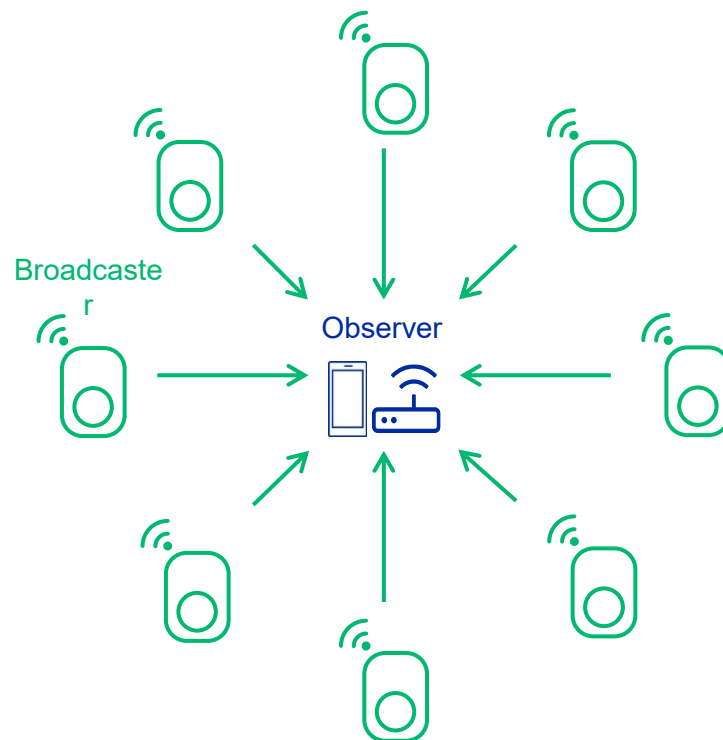
## 针对连接的广告

(不定期, 单向)



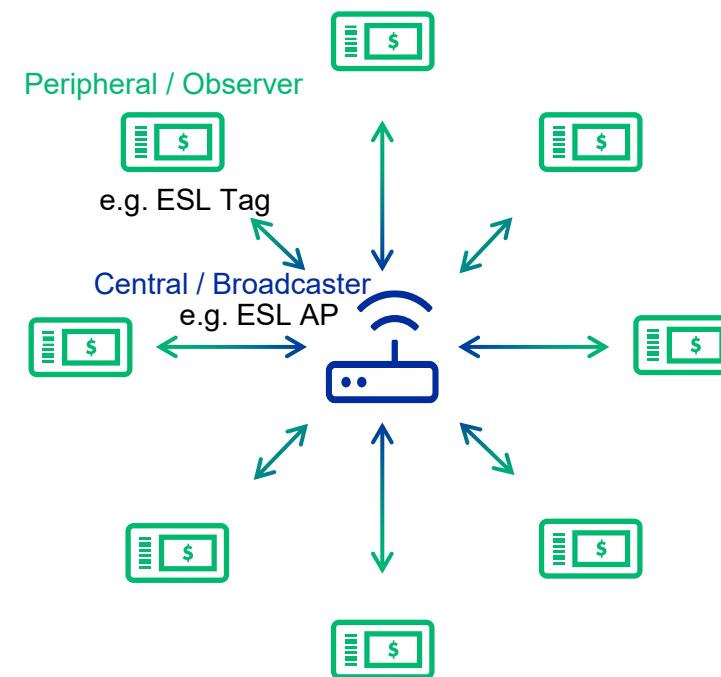
## 单向的“Beaconing”

(定期, 单向)



## 同步广播响应(PAwR)

(定期, 双向)



启用“同步”模式网络的新模式  
用于蓝牙ESL



# 同步广播响应(PAwR)的说明

## PAwR设置

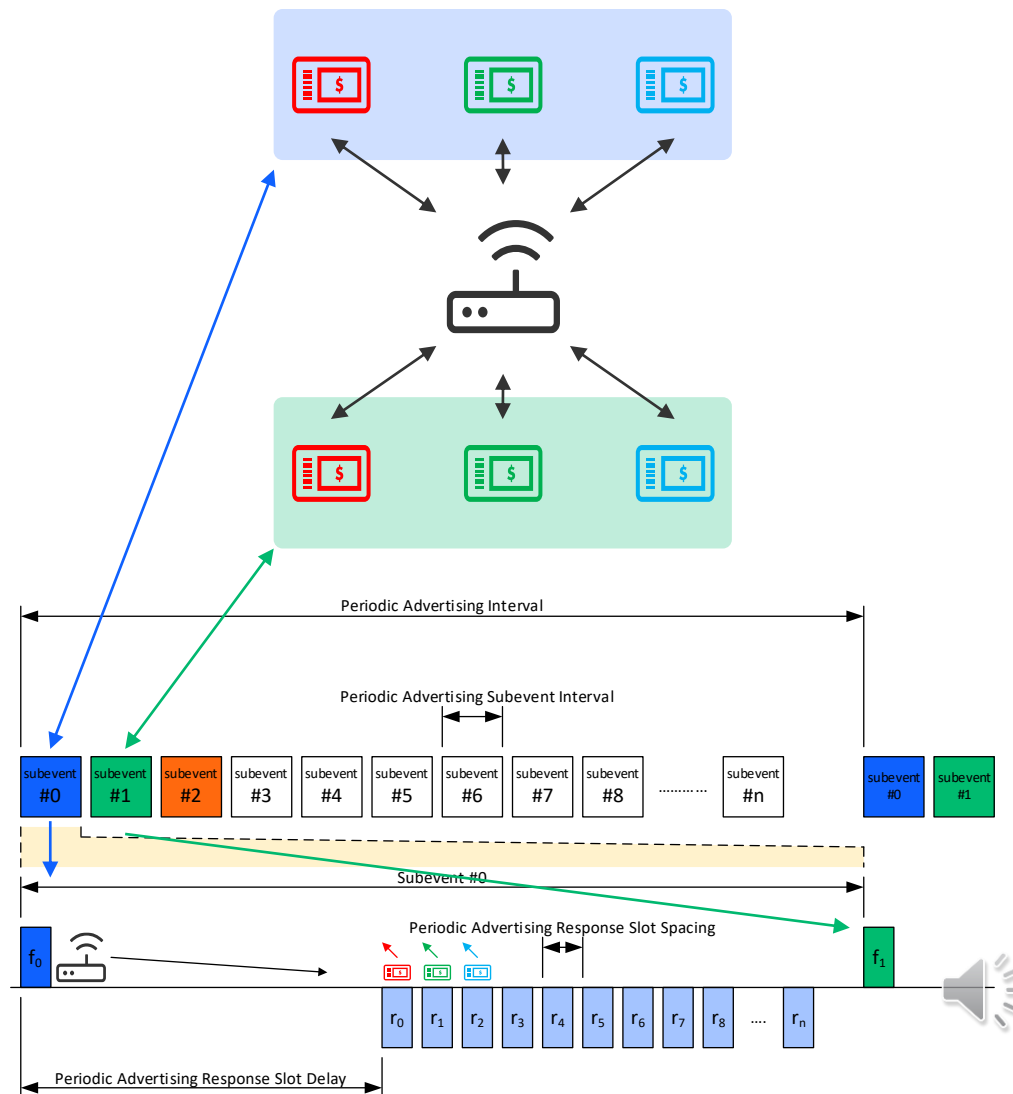
- 设置定时参数
- 配置子事件数和响应槽数

## 子事件(Subevents)

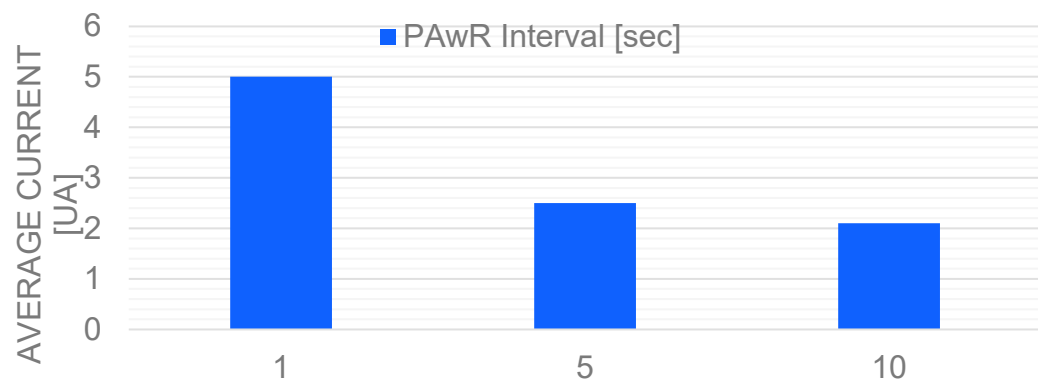
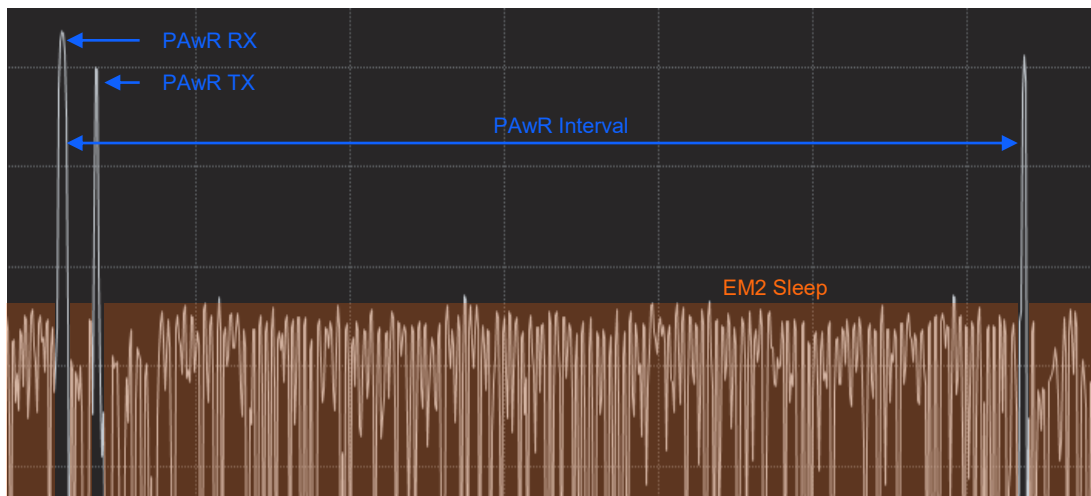
- 每个外设(ESL)属于一个子事件
- 最多128个子事件(ESL Group)
- 一个ESL Group中有255个专属的ESL
- 网络中最多有32,640个外设

## 在子事件中

- 一个子事件中的所有外设接收中心设备传输(下行链路)
  - 保持与PAwR序列的同步
  - 传输下行负载数据
- 每个外设都有自己的响应槽来应答(上行链路)



# PAwR电流消耗示例



## ■ 外围设备用例

- 在给定子事件时隙接收中央设备下行传输
- 响应给定响应槽的上行链路
- 其余时间保持睡眠模式

## ■ 测量条件

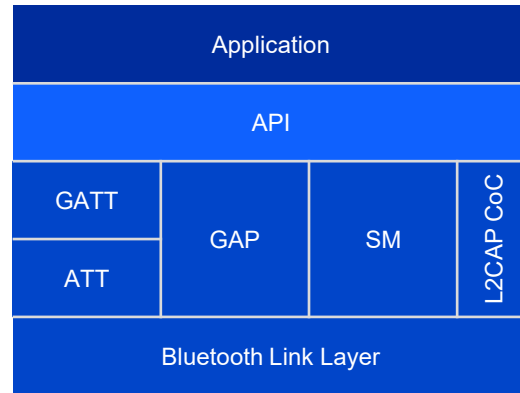
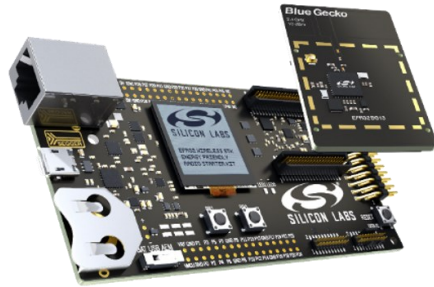
- MG22射频开发板
- Vinput 3.0V, DC/DC in use
- SoC Current only
- TX 0dBm
- LFXO accuracy 50ppm





# 完整的Bluetooth 5.4开发解决方案

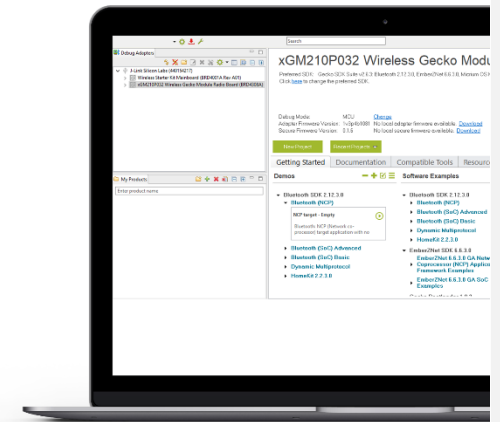
公开的GSDK版本已于6月发布



```

Python
2020-Jan-14 13:51:45: BLE - INFO - Write request, length: 2048
2020-Jan-14 13:51:45: BLE - INFO - Transfer finished, result: 0
2020-Jan-14 13:51:45: BLE - INFO - [Event] Image sent
2020-Jan-14 13:51:45: BLE - INFO - [Event] Connected
2020-Jan-14 13:51:45: AP - INFO - [Event] Image sent
2020-Jan-14 13:51:45: AP - INFO - Image sent to the device
Image_update: 1 Image/Device.png
2020-Jan-14 13:51:45: AP - INFO - Display type matches object type
2020-Jan-14 13:51:45: BLE - INFO - [Command] Write Image
2020-Jan-14 13:51:45: BLE - INFO - Starting image transfer using OTS
2020-Jan-14 13:51:45: BLE - INFO - Transfer finished, result: 0
2020-Jan-14 13:51:45: BLE - INFO - Write request, length: 2048
2020-Jan-14 13:51:45: BLE - INFO - [Event] Image sent
2020-Jan-14 13:51:45: BLE - INFO - [Event] Connected
2020-Jan-14 13:51:45: AP - INFO - [Event] Image sent
2020-Jan-14 13:51:45: AP - INFO - Image sent to the device
Bluetooth 2
2020-Jan-14 13:51:45: BLE - INFO - [Command] Initiate P2P
2020-Jan-14 13:51:45: BLE - INFO - Connection prepared for sync transfer
2020-Jan-14 13:51:45: BLE - INFO - Connection closed
2020-Jan-14 13:51:45: BLE - INFO - [Event] Sync
2020-Jan-14 13:51:45: BLE - INFO - Connection closed, reason: 0x0013
2020-Jan-14 13:51:45: AP - INFO - [Event] Connection closed
2020-Jan-14 13:51:45: AP - INFO - [Event] Sync
2020-Jan-14 13:51:45: AP - INFO - Image sent to the device
Bluetooth 2
[BT] BLE Address: 8C:FE:18:18:18:18
[BT] ESI Address: 2 (UNKNOWN)
[BT] ESI ID: 2
[BT] Group ID: 2
[BT] AP sync key: **** (Set)
[BT] Response key: **** (Set)
[BT] Absolute Time: Last time set to 78267
[BT] Display: [X] Width: 128 height: 128 type: ZSS
[BT] Max Image Index: 1
[BT] Sensors: [X] Present input voltage
                [X] Present device operating temperature
                [X] Device firmware version
                [X] Date of manufacture
                [X] Device operating temperature range specification
                [X] Silicon number master
                [X] Present ambient temperature
                [X] Present ambient temperature
                [X] Slabs button
[BT] LED Info: [X] Colored, current color: RGB(333)
[BT] PnP Info: Vendor: Silicon Labs Product ID: BWS5 Product version: BWS5
[BT] Last status: Synchronized (0x0000)

list b
There's no advertising tag.
list c
There's no connected tag.
list e
[BT] BLE Address: 8C:FE:18:18:18:18 ESI Address: 1
[BT] BLE Address: 8C:FE:18:18:18:18 ESI Address: 2
There are 2 synchronized tags.
4/10/2020, 13:51:45
2020-Jan-14 13:51:45: AP - INFO - [Event] P2P subevent data request
2020-Jan-14 13:51:45: BLE - INFO - [Command] Set periodic advertisement data
2020-Jan-14 13:51:45: BLE - INFO - [Event] P2P response
2020-Jan-14 13:51:45: AP - INFO - [Event] P2P response
2020-Jan-14 13:51:45: AP - INFO - Response received in subevent 0 slot 0
2020-Jan-14 13:51:45: AP - INFO - Reply from ESI ID 2, in group 0
2020-Jan-14 13:51:45: AP - INFO - [Event] Image request: 0/0/0/0/0/0/0/0 Image_Index: 0 (0x10000)
    
```



## SOC, 模块, 开发套件

Multiple physical interfaces to support advanced development and debugging

- UART, Ethernet, USB
- LCD, LED, buttons

## 软件协议栈

In-house developed stack

Bluetooth 5.4

Support for PAwR, EAD, PAST, CoC, BT ESL Service and Profile

All security features supported

## ESL接入点演示

Python based ESL AP

ESL Library (GATT, OTS & NCP Events)

EFR32 radio with NCP

## 开发工具

Simplicity Studio

BT 5.4 NCP and SoC

BT ESL Example Energy Profiler



# 基于低功耗蓝牙的高精度距离 测量(HADM)最新技术

黄良军 (Bruce Huang)  
芯科科技主任现场应用工程师



# 高精度距离测量(HADM) 应用



# 目标市场和应用



家居

寻物(Item Finding)  
无钥匙进入(Keyless Entry)  
宠物跟踪(Pet Tracking)



商业

门禁控制(Access Control)  
库存管理(Inventory management)  
资产跟踪(Asset Tracking)



# 对改进距离测量的需求—超越RSSI



## 精确性和可靠性

RSSI对室内多径环境过于敏感



## 简单易用

实现低成本器件的设计  
单天线设计  
减少系统资源



## 安全性

攻击者可通过射频信号放大来操纵RSSI



## 互操作性

基于标准化的特性



# HADM和信道探测

## LOCATION SERVICES

### Drivers for Tomorrow

#### Bluetooth® high-accuracy distance measurement will set a new bar for performance of location services solutions

Bluetooth® technology will soon add high-accuracy distance measurement (HADM), enabling item finding solutions to provide greater precision as users get closer to an item being located, allowing passive keyless entry solutions to add another layer of authentication and accuracy, and improving the performance of real-time locating systems.

**260**  
MILLION

Bluetooth® asset tracking devices  
will ship in 2027

**338**  
THOUSAND

Bluetooth® RTLS implementations  
by 2027



## 信道探测(CS)是启用HADM的蓝牙功能

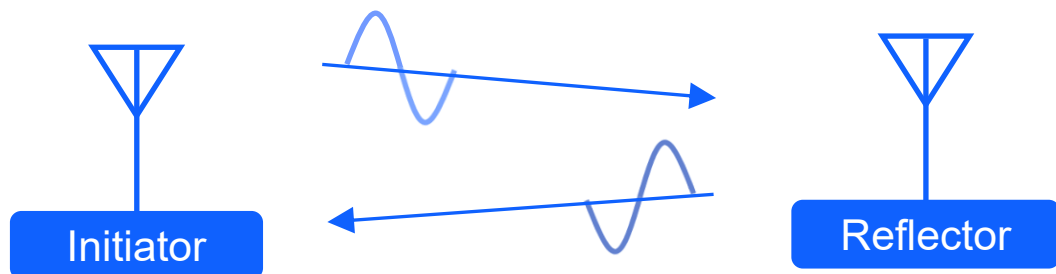
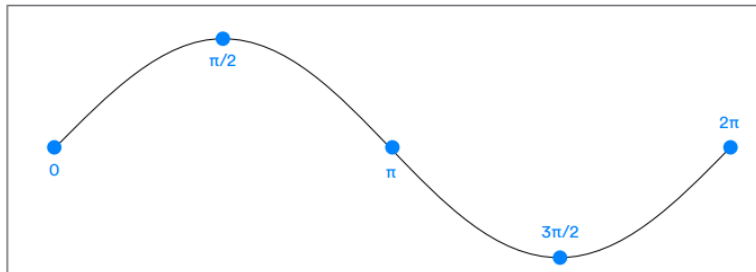
- CS目前正在由蓝牙技术联盟(Bluetooth SIG)定义
- 规范草案可通过下方链接查找:  
<https://www.bluetooth.com/specifications/specs/channel-sounding/>
- 定义对基于相位的测距(PBR)音调交换和/或往返路程时间(RTT)包交换的支持
- 还定义了过程、事件、子事件等, 以实现距离估算



# 相位测距(PBR)

## Phase

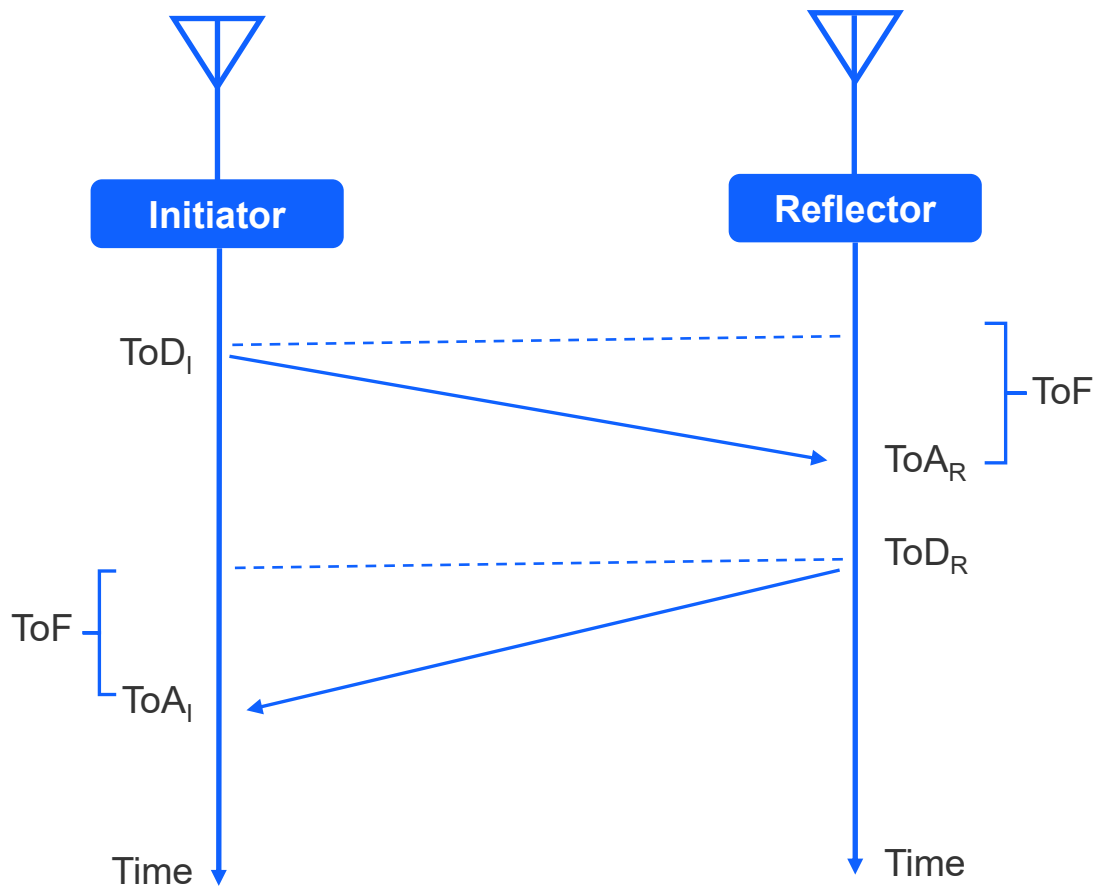
A specific point in a wave cycle, perhaps measured as the wave passes over an antenna, is known as its *phase*. Phase is measured as an angle from 0 at the start of the wave cycle to 360 degrees or  $2\pi$  radians at the end of the wave cycle. Figure 8 illustrates the concept of phase.



- 两个设备间的音调交换
- 射频信号的相位是载波频率和传输距离的函数
  - 由于空间传播确定的相位旋转
  - 在多个射频频率进行测量，以解决距离模糊的问题
- 距离是用发射和接收信号之间的相位差来计算的
- 安全性
  - 相位的操作比RSSI更为复杂
  - IQ样本质量
- 相较于RSSI更为精确
- 关键考量
  - Antenna radiation patterns
  - 电路板设计特定校准



# 往返时间(RTT)



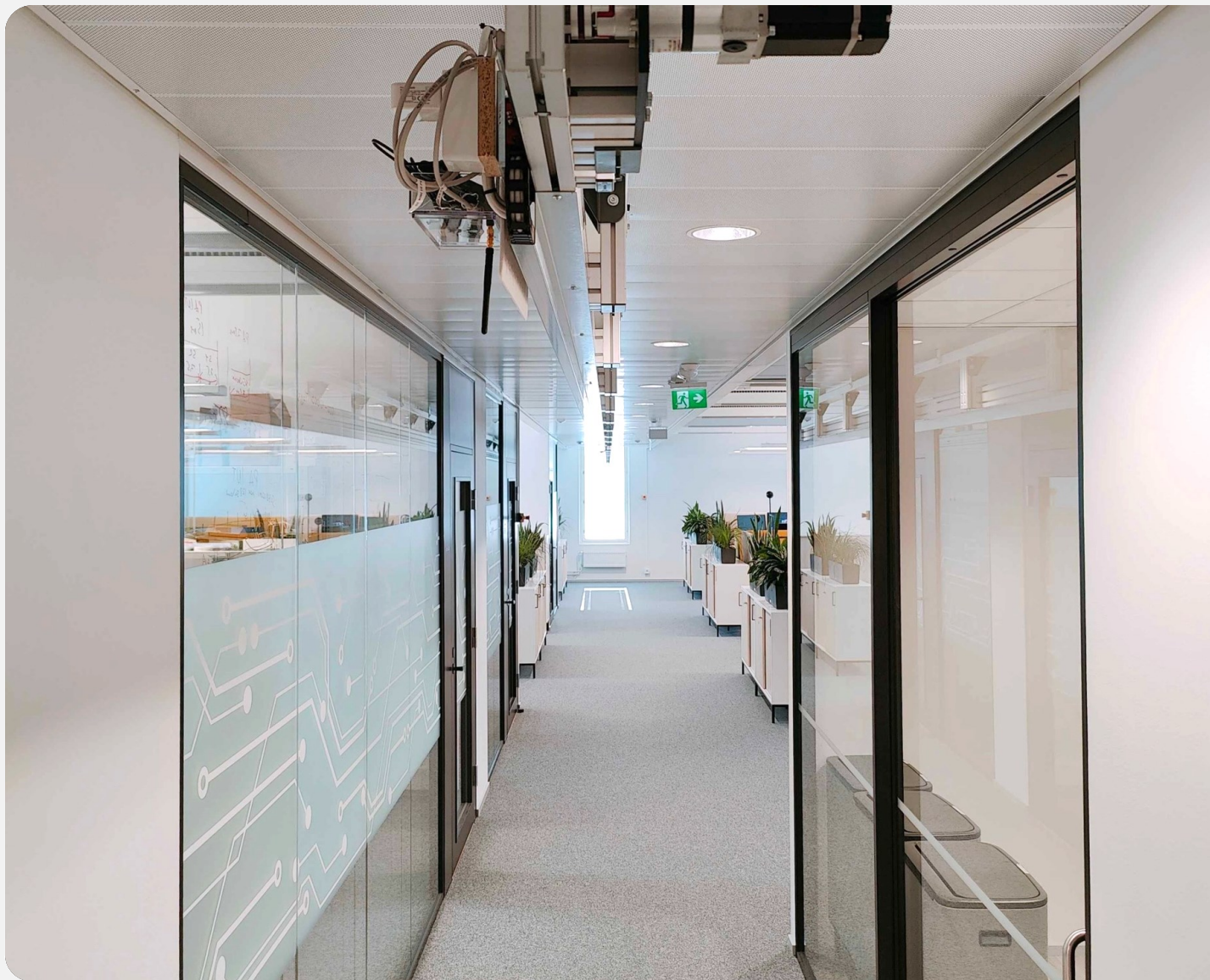
$$RTT = 2 ToF = (ToA_I - ToD_I) - (ToD_R - ToA_R)$$

- 数据包传输时间(ToF)是用到达时间(ToA)和离开时间(ToD)在发起方和反射方测量的
  - 在多个信道上交换的调制数据包, 以确定ToF和估计距离
  - 使用小数分频来解决采样不确定性和提高分辨率
- 时间不能倒转 -> RTT有助于提高安全性
- 相较于PBR较不准确





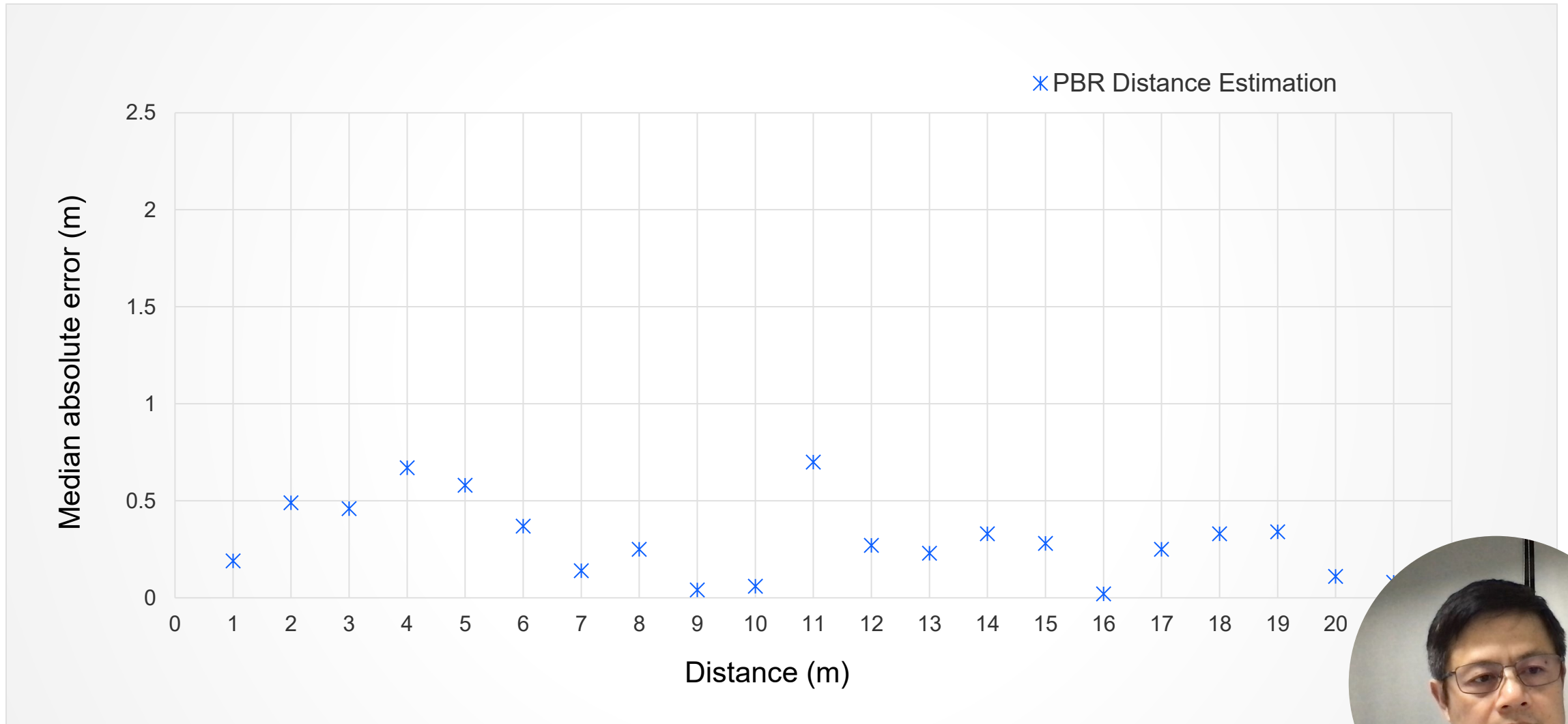
# 应用于室内办公环境的操作性能



- **天花板轨道基础设施**
  - 内部测试环境
  - 多个固定的EFR32设备放在不同的位置
  - 用于控制测量的移动EFR32装置(可重复性)
- **挑战—在室内办公室环境有复杂的多径问题**
  - 视距(LOS), 非视距(NLOS)
  - 非视距情况下的不同实体障碍 (金属, 塑料, 玻璃等)
- **统计分析**
  - 静态测量在多个距离可达300m
  - 每距离进行数百次测量, 数据量大, 平均值, 中位数, 标准差

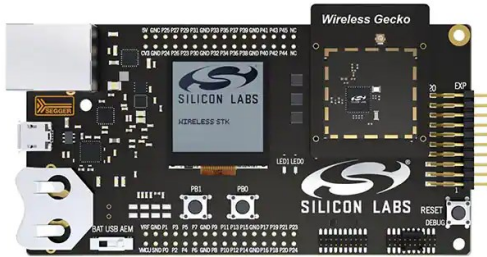


# 室内办公室HADBM性能测试结果



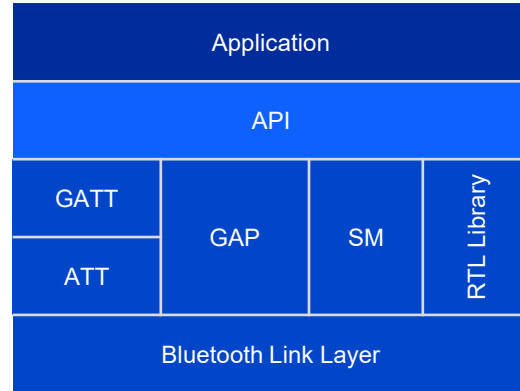
# 早期评估版本和应用开发

早期评估版本已经集成在最新的GSDK版本中



## SOC, 开发板

2x BRD4198A  
2x Dipole Antennas  
Wireless Pro Kit  
EFR32MG24 + 10dBm OPN



## 软件协议栈

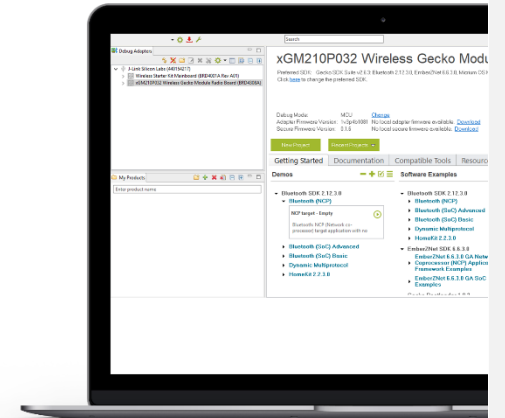
In-house developed stack  
Supports Bluetooth 5.4 features  
All security features supported  
New and improved Ranging features

```
vevarati@mac0015025 bt_abr_host_initiator % cd exe
vevarati@mac0015025 exe % ./bt_abr_host_initiator -u /dev/tty.usbmodem004402801
515
[E] Invalid operation mode selected. Please select either 1 (RTT) or 2 (PBR)
vevarati@mac0015025 exe % ./bt_abr_host_initiator -u /dev/tty.usbmodem004402801
515 -> 2 -r
[I] Accepting any suitable reflector.
[I] NCP host initialised.
[I] Resetting NCP target...
[I] Press Ctrl+C to quit

[I] Initialising RTL...
[W] abr_report_PBR.json already exist!
[W] Renaming abr_report_PBR.json -> abr_report_PBR.json_bkp31-5-2023-17_13_43
[I] Renamed successfully.
[I] File logger initialized.
[I] Bluetooth stack booted: v0.8.0-b37
[I] Bluetooth public device address: 34:25:84:A8:D8:15
[I] Scanning...
[I] Opening connection to Reflector
[I] Connection opened to the Reflector
[I] Encryption connection
[I] Connection encrypted
[I] Service found
[I] Service discovered
[I] Found remote value characteristic
[I] Characteristic discovered
[I] Creating ABR config...
[I] RTL process 48 channels
[I] Open file abr_report_PBR.json to write header...
[I] Config created
[I] Log measurement cycle 0000 ...
[I] Measurement result: 1051 mm | RSSI distance: 56 mm
[I] Log measurement cycle 0001 ...
[I] Measurement result: 1056 mm | RSSI distance: 40 mm
[I] Log measurement cycle 0002 ...
[I] Measurement result: 1068 mm | RSSI distance: 56 mm
[I] Log measurement cycle 0003 ...
[I] Measurement result: 1075 mm | RSSI distance: 107 mm
[I] Log measurement cycle 0004 ...
[I] Measurement result: 1082 mm | RSSI distance: 78 mm
[I] Log measurement cycle 0005 ...
[I] Measurement result: 1103 mm | RSSI distance: 107 mm
[I] Log measurement cycle 0006 ...
[I] Measurement result: 1111 mm | RSSI distance: 107 mm
[I] Log measurement cycle 0007 ...
[I] Measurement result: 1115 mm | RSSI distance: 56 mm
[I] Log measurement cycle 0008 ...
[I] Measurement result: 1114 mm | RSSI distance: 56 mm
```

## HADM 演示

Python based Visualization tool  
RTL Library  
(GATT, IQ reporting)  
EFR32xG24 NCP/SoC  
RSSI, PBR, RTT modes



## 开发工具

Simplified  
Initiator & P  
Energy Profile  
App  
Salesfo



# BG24和BGM241S: 面向蓝牙定位服务的2.4 GHz SoC理想选择

## SOC和模块



BG24 SoC



BGM241S SiP Module

## SOC设备规格

### 高性能射频

- Up to +19.5 dBm TX
- -97.6 dBm RX @ LE 1 Mbps
- -105.7 dBm RX @ Bluetooth LE 125 kbps

### 高效ARM® Cortex®-M33

- 78 MHz
- 1536kB Flash, 256kB RAM

### 低功耗

- 33.4  $\mu$ A/MHz
- 5.0 mA TX @ 0 dBm
- 5.1 mA RX (802.15.4)
- 4.4 mA RX (LE 1 Mbps)
- 1.3  $\mu$ A EM2 sleep

### 多协议支持

- Bluetooth (1M/2M/LR)
- Bluetooth mesh
- Proprietary 2.4 GHz

### SoC和模块

- 5x5 QFN40
- 6x6 QFN48
- 7x7 SiP Module
- 12.9x15.0 PCB Module

## 差异化特性

### +20 dBm输出功率

- Eliminates need for external power amplify

### 高精度距离测量 (HADM)

- Measures distance between connected LE devices w/ sub-meter accuracy

### AI/ML加速器

- Accelerates inferencing while reducing power consumption

### Secure Vault高级

- Protects data and devices from local and remote attacks

### 20-bit ADC

- 16-bit ENOB for advanced sensing

### 天线分集

- Provides 6-8 dBm better link budget

### 优化无线共存

- Ideal for gateways and hubs

### PLFRCO

- Eliminates need for 32 KHz xtal

## 细分市场及应用

### 智能家居

- HVAC
- Locks
- LED Lighting
- Switches
- Sensors
- Gateways, Hubs and Panels

### 互联健康

- Portable Medical

### 工业和智能建筑

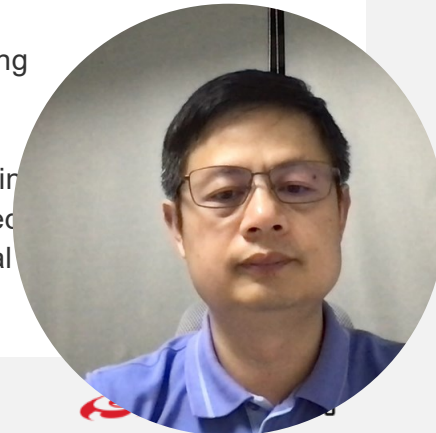
- Access Control
- HVAC
- Predictive Maintenance
- Asset Tracking

### 智慧城市

- EV Charging

### 商业应用

- Lighting
- Access Point
- Clinical Med
- Indoor Real



# 示例应用-开箱即用的体验

The image displays a user interface for a radio board application, a terminal window, and a distance measurement graph.

**Web Application Interface (BG24 Ranging Radio Board (BRD419))**

- Navigation: OVERVIEW, EXAMPLE PROJECTS & DEMOS, DOCUMENTATION
- Filter: Filter on keywords: abr
- 3 resources found:
  - Demo: Bluetooth - AB (ABR Network Co-P...)
  - Demo: Bluetooth - So (ABR initiator for Bl...)
  - Demo: Bluetooth - So (ABR reflector for B...)
- Filters:
  - Wireless Technology: Clear
  - Device Type: Clear
  - Ecosystem: Clear
  - MCU: Clear
  - Capability: Clear
  - Project Difficulty: Clear
  - Quality: Clear
- Checkboxes:
  - EVALUATION (0)
  - EXPERIMENTAL (3)

**Terminal Window (exe --zsh -- 116x44)**

```
vevarati@mac0015025 exe % ./bt_abr_host
[I] Accepting any suitable reflector.
[I] NCP host initialised.
[I] Resetting NCP target...
[I] Press Ctrl+C to quit

[I] Initialising RTL...
[I] File logger initialized.
[I] Bluetooth stack booted: v6.0.0-b37
[I] Bluetooth public device address: 34:
[I] Scanning...
[I] Opening connection to Reflector
[I] Connection opened to the Reflector
[I] Encrypting connection
[I] Connection encrypted
[I] Service found
[I] Service discovered
[I] Found remote value characteristic
[I] Characteristic discovered
[I] Creating ABR config...
[I] RTL process 40 channels
[I] Open file abr_report_PBR.jsonl to wr
[I] Config created
[I] Log measurement cycle 0000 ...
[I] Measurement result: 596 mm
[I] Log measurement cycle 0001 ...
[I] Measurement result: 530 mm
[I] Log measurement cycle 0002 ...
[I] Measurement result: 509 mm
[I] Log measurement cycle 0003 ...
[I] Measurement result: 516 mm
[I] Log measurement cycle 0004 ...
[I] Measurement result: 517 mm
[I] Log measurement cycle 0005 ...
[I] Measurement result: 515 mm
[I] Log measurement cycle 0006 ...
[I] Measurement result: 507 mm
[I] Log measurement cycle 0007 ...
[I] Measurement result: 509 mm
[I] Log measurement cycle 0008 ...
[I] Measurement result: 507 mm
[I] Log measurement cycle 0009 ...
[I] Measurement result: 508 mm
[I] Log measurement cycle 0010 ...
```

**Distance Measurement Graph**

- Y-axis: Distance (m)
- X-axis: Time (implied)
- Legend: HADM : 1.08 m
- Result: 1.08 m

**Person in Circle:** A circular inset image of a man with glasses, wearing a blue shirt, looking towards the camera.

# 反射器功耗示例

## ■ 测量条件

- BRD4198 w/ WSTK
- SoC mode
- TX power: 0 dBm
- Avg current consumption: ~792  $\mu$ A
- Connection interval : 20 ms
- Distance estimation procedure duration : ~360 ms



# 下一步进展



## Works With 2023

- 又一个关于HADM的专题会议



## 联系销售人员

- 与芯科科技销售人员以获取硬件



## 资源下载

- 下载Simplicity Studio 5



## HADM In Action

- 探索我们集精准、可靠和简单易用等特性的HADM解决方案



2023

tech **talks**  
WEBINAR SERIES

# Thank You



BLUETOOTH SERIES

Watch **ON DEMAND**





# Q&A



BLUETOOTH SERIES

