

Bluetooth Channel Sounding: From Performance to Real-World Applications

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2026
tech talk
WEBINAR SERIES



BLUETOOTH®

Agenda

- 01** Technology Overview
- 02** Silicon Labs Algorithm Variants
- 03** Performance Comparison and Trade-Offs
- 04** Application Demos
- 05** Mobile Support
- 06** Silicon Labs Channel Sounding Offering
- 07** Q&A

Why Bluetooth® Channel Sounding?

THE CHALLENGE:

IOT applications need 'spatial' awareness to be more secure, reliable, and responsive



Earlier Bluetooth LE versions lack native support for precise ranging



RSSI-based ranging is noisy and unreliable in real-world use



Direction Finding needs multiple antennas, adding cost & complexity



UWB is accurate but often requires a dedicated chip, adding cost for IoT

THE OPPORTUNITY:

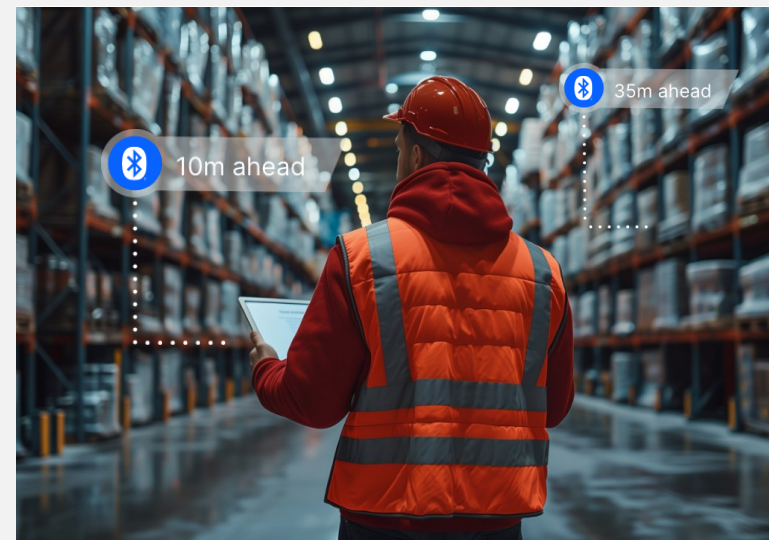
Channel Sounding for Bluetooth

Standardized approach introduced in Bluetooth 6.0 for accurate, interoperable, and secure ranging

Enables sub-meter accuracy with robust performance, even in NLOS

Works with single or dual antenna setups - flexible for different form factors

More cost efficient than UWB; requires minimal external components



Built on existing Bluetooth infrastructure, simplifying adoption and ecosystem integration

Bluetooth® Channel Sounding Overview

- **Measure distance between two devices using**
 - Phase-based Ranging (PBR)
 - Round Trip Time (RTT)
- **RTT and PBR operates across 2.4 GHz band**
 - Standard specifies up to 72 channels
 - Random channel hopping pattern
- **Connection-Oriented 2-way ranging with two roles**
 - Initiator: device that wishes to calculate distance from itself to another device
 - Reflector: device responding to initiator
- **Supports up to 4 antenna paths between devices**
- **Multiple security features included in the standard**
- **Can be combined with Angle of Arrival / Departure (AoA/AoD)**
 - Enables position estimation with single locator/tag pair

Additional Resources

- [Webpage](#) – Learn more about Silicon Labs offerings and demos
- [Tech Talk](#) – Explore Bluetooth Channel Sounding
- [Workswith 2024](#) - Enable Accurate Distance Estimation Using Channel Sounding
- [Workswith 2025](#) - Bringing Bluetooth® 6.0 Channel Sounding to Market: Precision Ranging for Secure & Smart Applications
- [Blog](#): Learn more about Antenna Switching with Silicon Labs Channel Sounding
- [API Spec](#): Getting Started with Silicon Labs Bluetooth Channel Sounding

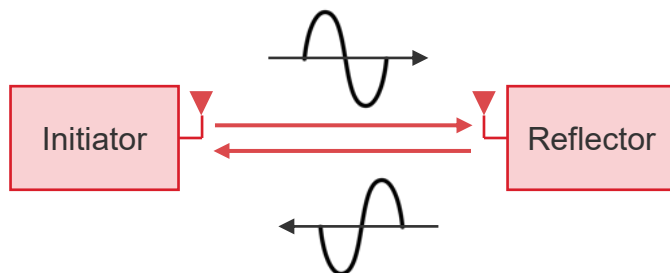
Channel Sounding Step Modes

Mode-0: Calibration

- Compensates for clock drift and frequency offset
- Results in fractional frequency offset table

Required

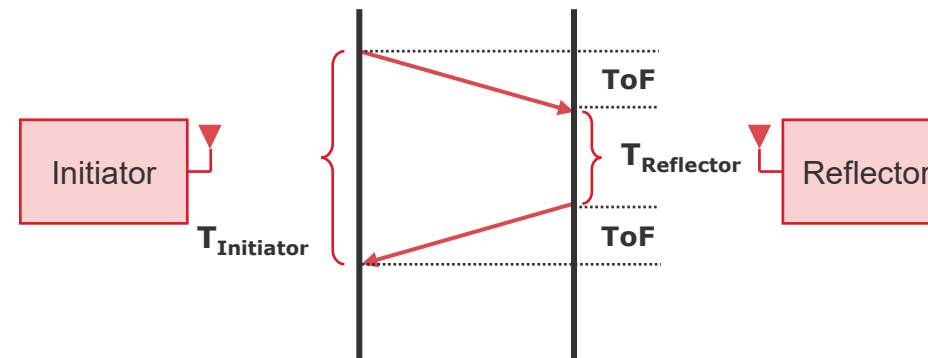
Mode-2: Phase based ranging



- CS Tone exchanged between initiator and reflector
- Each antenna path exercised in each step

Required

Mode-1: Round trip time



- CS SYNC packets exchanged between initiator and reflector

Required

Mode-3: PBR+RTT

- Combined PBR and RTT in each step
- RTT distance measurement can be cross-checked with PBR results
- Provides higher security as a mismatch in distance estimation can indicate relay attack

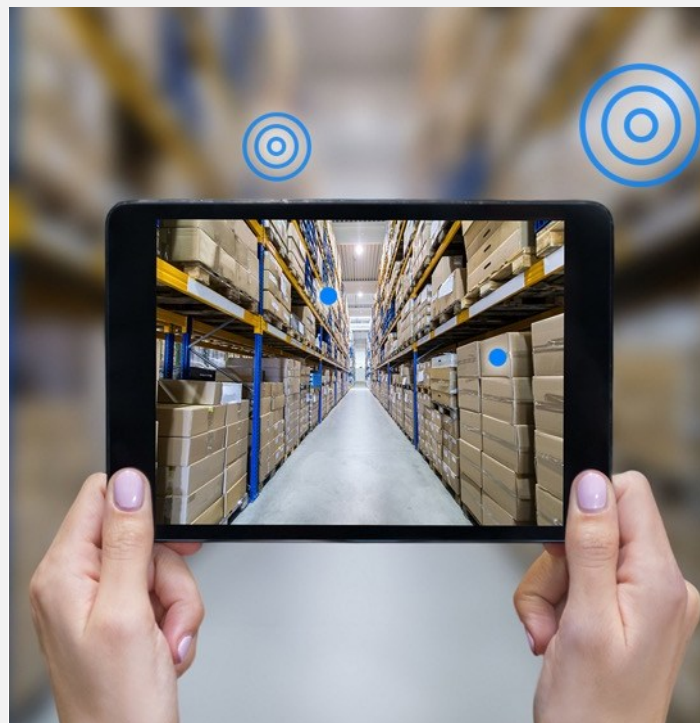
Optional

Bluetooth Channel Sounding - Target Markets & Use Cases



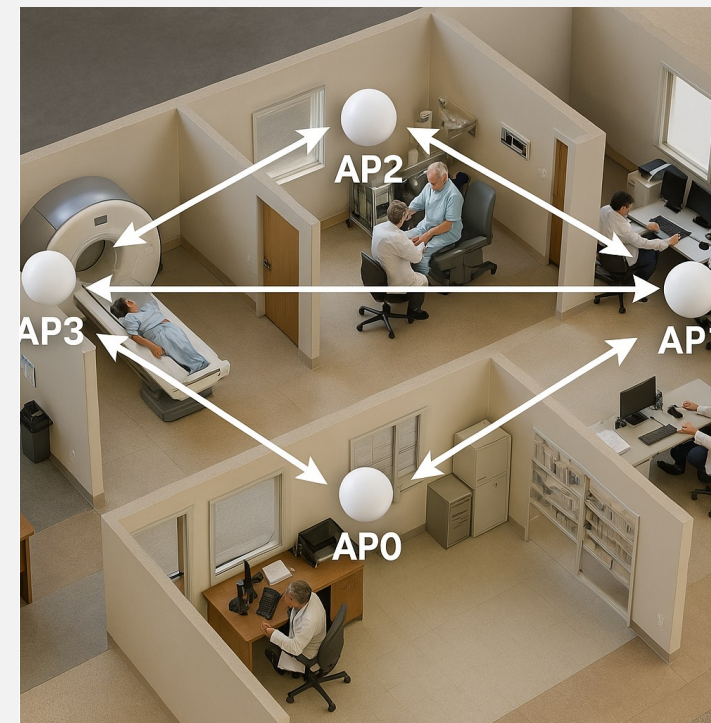
PROXIMITY AWARENESS

Door locks
Keyless entry
Building access systems
Geofencing - security alerts



LOCALIZATION

**Indoor asset management -
hospitals, warehouses**
Pet tracking inside home
Item finding - wallet, keys



AUTOMAPPING

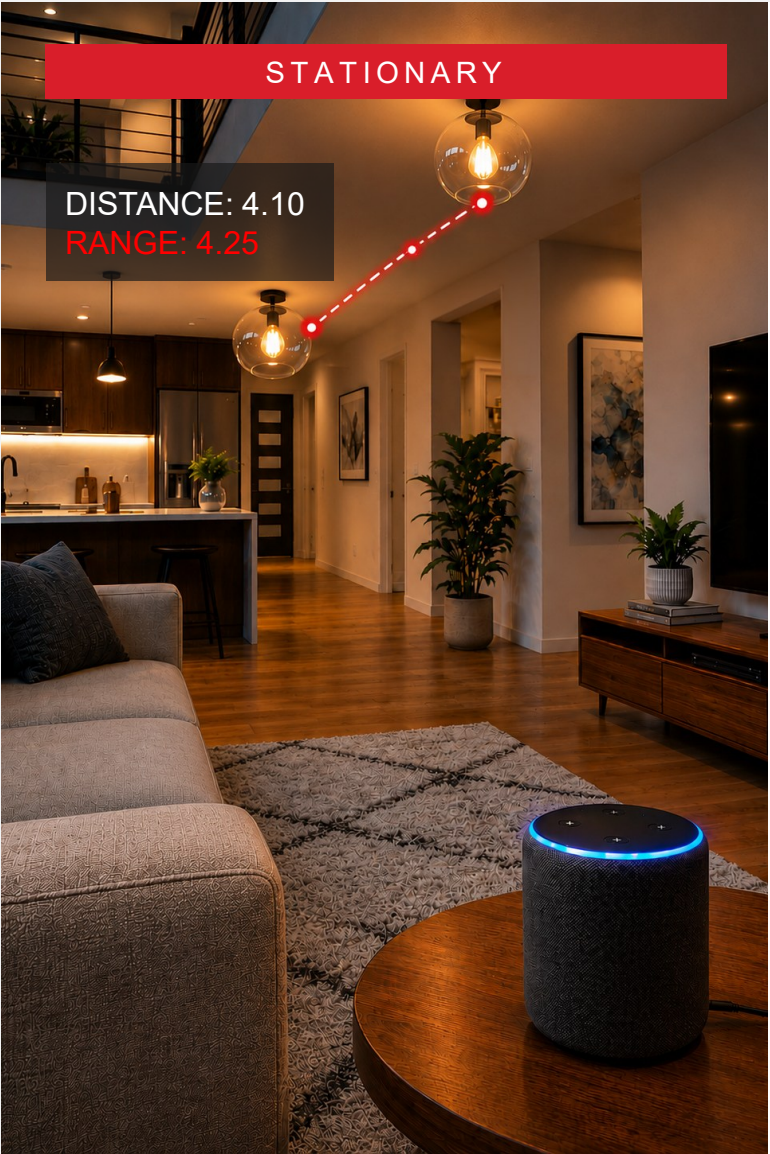
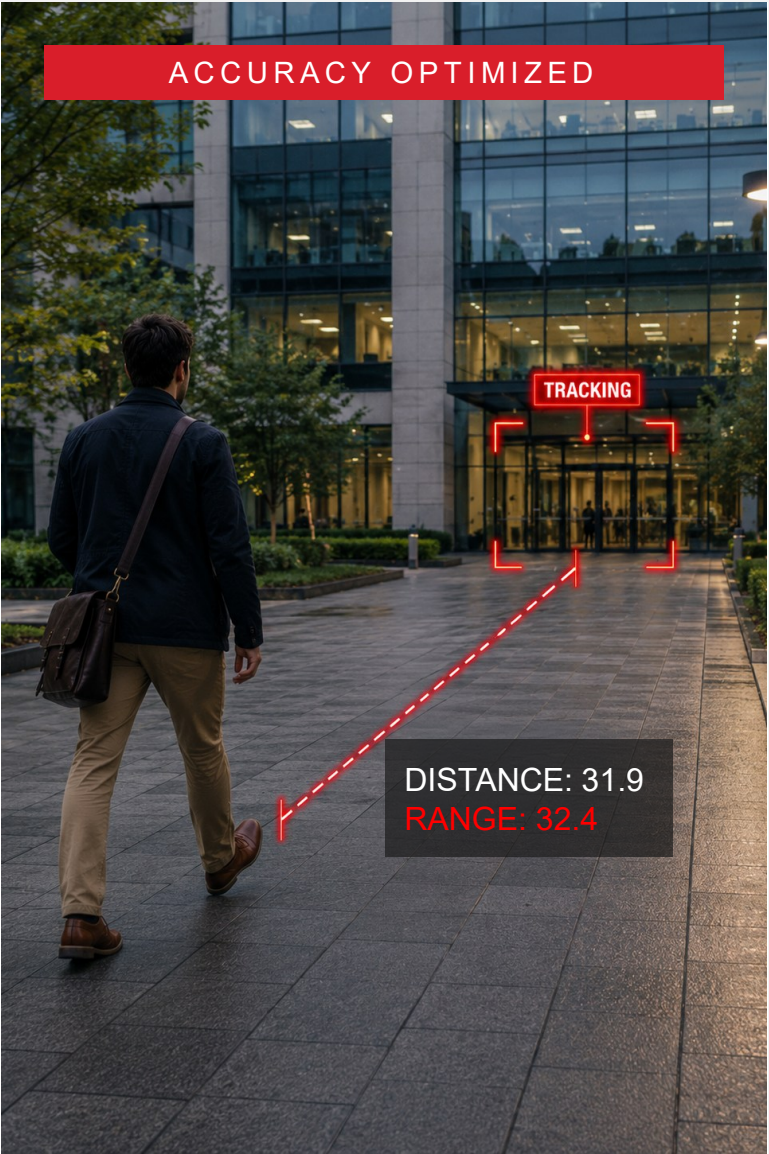
Solar Trackers
Luminaires, Access Points
**Accurate Mapping for Battery
Storage**

Bluetooth® Ranging

Category	Bluetooth® RSSI	Bluetooth® Direction Finding	Bluetooth® Channel Sounding	UWB
Method	RSSI	AoA/AoD	PBR/RTT	ToF/AoA
Measurement Type	Distance Only	Direction + Distance	Distance Only	Direction + Distance
Ranging Accuracy	1-5 m	1-5 m	< 0.5m – PBR 1-5 m – RTT	~10–30 cm
Connection Mode	Connection-oriented or Connectionless	Connection-oriented or Connectionless	Connection-oriented only	Connection- oriented or Connectionless
Measurement Latency	20 ms (typical)	20 ms (typical)	100 ms (typical, PBR)	1 ms (typical)
Reliability	Very sensitive to multi-path and interference	Very sensitive to multi-path and interference	Sensitive to multi-path and interferences	Strong immunity to multi-path and interference
Security	Not secure, prone to relay attacks	Not secure, prone to relay attacks	Secure, several security features as countermeasure for relay attacks	Very Secure
Scalability	1000's of tags	1000's of tags	10's tags	1000's of tags
Smartphone Support	Yes	No	Yes	Yes
Device Cost	\$	\$	\$	\$\$

1. Android 16 already supports Channel Sounding Ranging API. Google Pixel 10 officially supports Channel Sounding.

Ranging algorithm modes in the RTL library



Channel Sounding Algorithm Modes

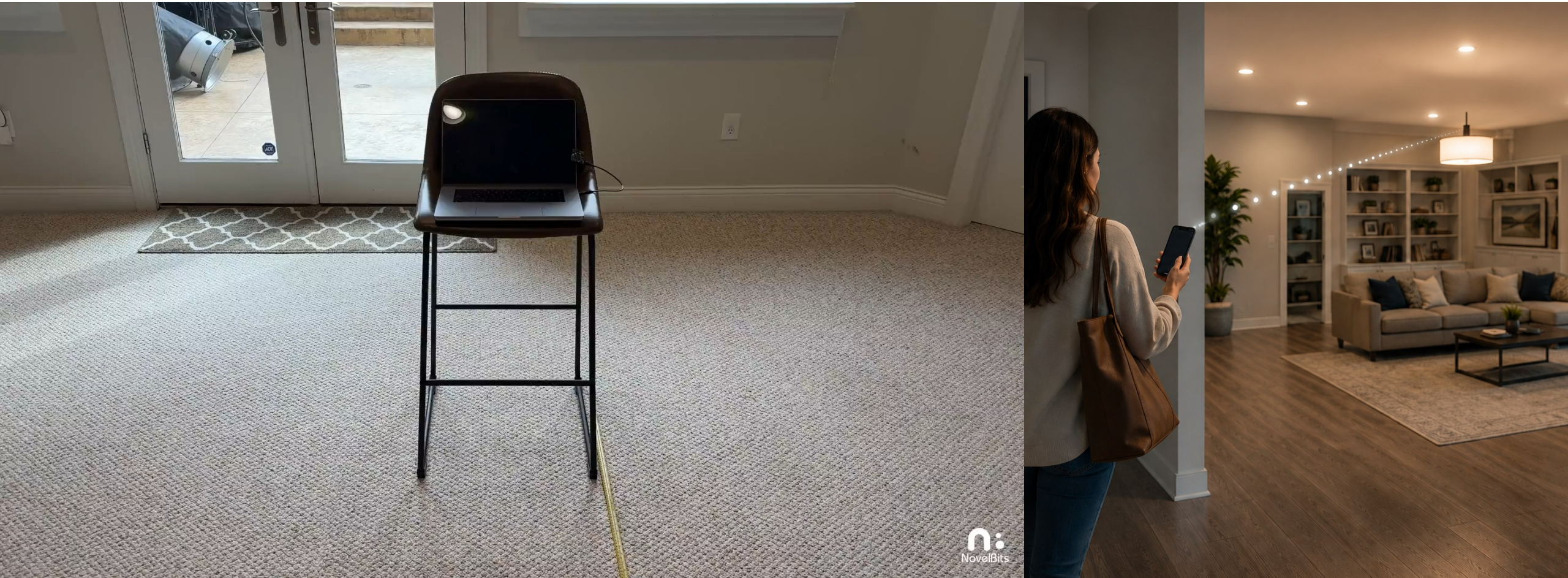
Mode	Tracking		Stationary
	Latency-optimized	Accuracy-optimized	
• Config: 1 connection, 4 AP and 72 channels • HW/SW: DK2606A, SiSDK 2026.6 (coming soon)			
LOS accuracy (Typical)	-1.0...+1.5m	-0.5...+1.0m	-0.5...+1.0m
NLOS	 Body blocking (e.g. back pocket)		 Walls, glass doors, various objects
Max. range	40m	> 75m	> 75m
Moving target speed	< 2.1m/s	< 1.0m/s	N/A
Distance measurement rate	~10Hz	~4Hz	N/A
RAM	~8 KB	~30 kB	~30 kB
Flash	~7 KB	~16 kB	~16 kB

Point-to-Point Channel Sounding for "Wake-On Approach"

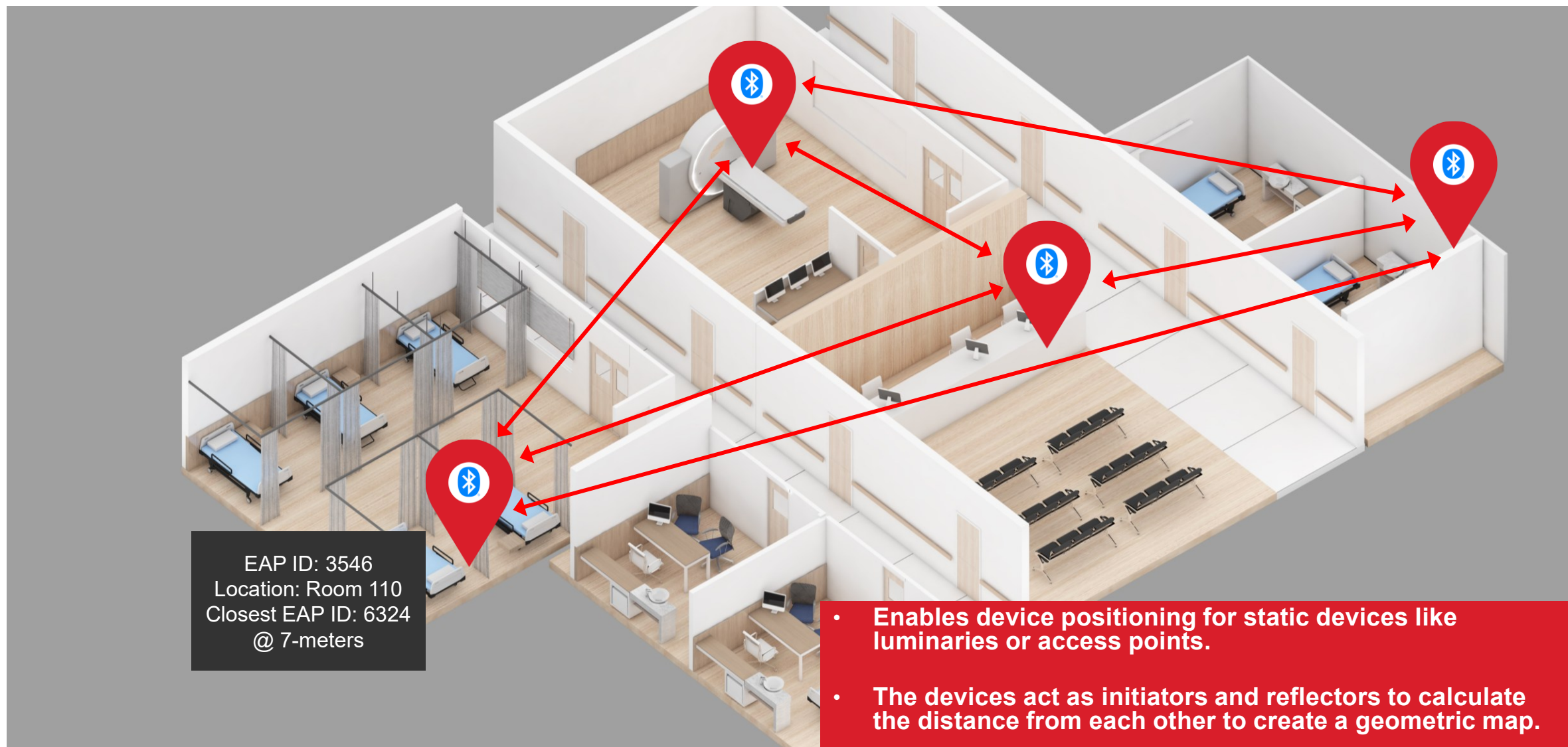
- Enables distance measurement between a phone and stationary product
- Channel Sounding improves upon RSSI-based "wake on approach" designs
- Compared to RSSI, CS delivers more accurate, reliable, and secure ranging
- Compatible with CS-enabled smartphones using Bluetooth Ranging Service/Profile
- Radial zone entry/exit detection enables improved UI and security features



Point-to-Point Channel Sounding for "Wake-On Approach"



Channel Sounding for Static Device Positioning



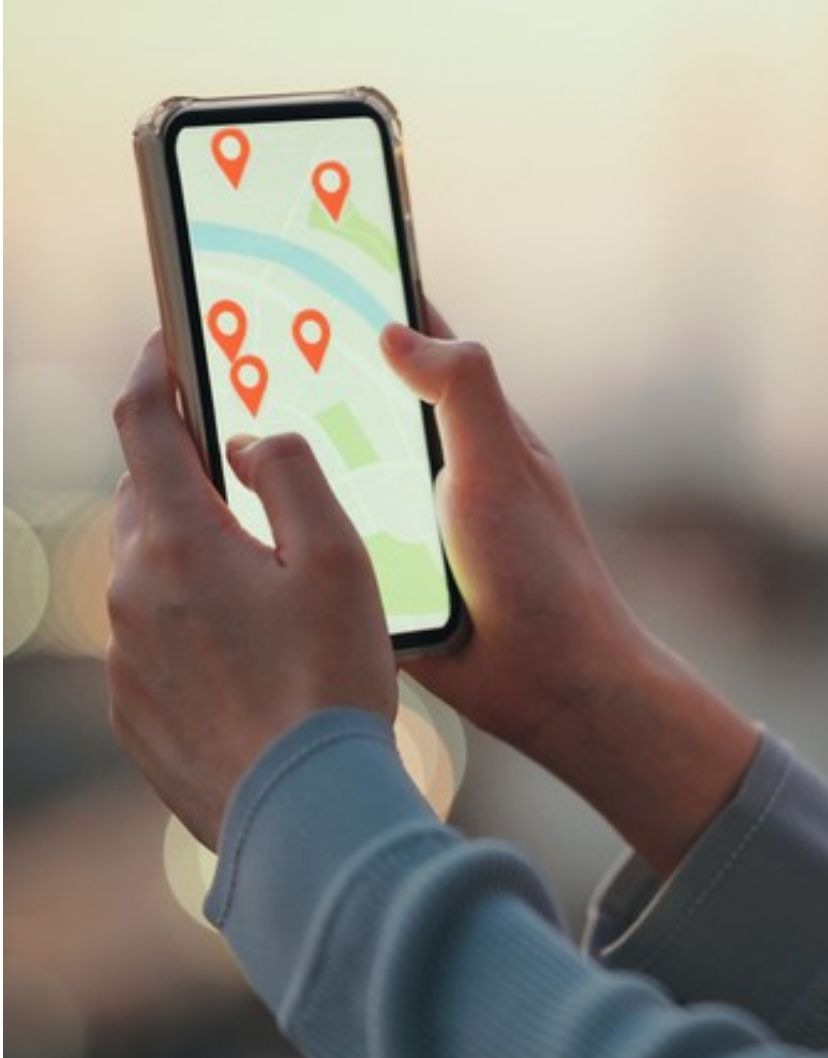
Automapping Demo



Static Device Positioning



Smartphones enable Bluetooth Channel Sounding at scale



- **Smartphone ecosystem is enabling Channel Sounding**

- Channel Sounding API support available since Android 16
- Commercial devices beginning to support Channel Sounding
- Expanding into Find My / asset tracking ecosystems

- **Interoperability across devices is critical**

- Phones can act as initiator / reflector
- Interoperate with automotive and IoT endpoints
- Standardized behavior ensures scalable deployments



Smartphones accelerate adoption of Bluetooth Channel Sounding across consumer and automotive ecosystems

Mobile Demo



BG24: Optimized for Battery Powered, Channel Sounding-enabled IoT Devices



- 5x5 QFN40 (26 GPIO), AEC-Q100
- 6x6 QFN48 (32 GPIO), AEC-Q100
- 3.1x3.0 WLCSP42

DIFFERENTIATED FEATURES

- **Ultra small form-factor**
 - 3.1 x 3.0 WLCSP package
- **+20 dBm output power**
 - Eliminates need for external power amplify
- **AI/ML accelerator**
 - Accelerates inferencing while reducing power consumption
- **Secure Vault High**
 - Protects data and device from local and remote attacks
- **20-bit ADC**
 - 16-bit ENOB for advance sensing
- **Improved Coexistence**
 - Ideal for gateways and hubs
- **PLFRCO**
 - Eliminates need for 32 KHz xtal

DEVICE SPECIFICATIONS

- **High Performance Radio**
 - Up to +19.5 dBm TX
 - -97.6 dBm RX @ BLE 1 Mbps
- **Efficient ARM® Cortex®-M33**
 - Up to 78 MHz
 - 1536kB Flash, 256kB RAM
- **Low Power**
 - 49.1 µA/MHz (CoreMark)
 - 5.0 mA TX @ 0 dBm
 - 5.1 mA RX (802.15.4)
 - 4.4 mA RX (BLE 1 Mbps)
 - 1.3 µA EM2 sleep
- **Multiple protocol support**
 - Bluetooth 6.0 (1M/2M/LR), Bluetooth mesh, Proprietary 2.4 GHz

Dual-Antenna Channel Sounding board



■ xG24 Channel Sounding Development Kit

- Available since March 2025
- Development Kit with two PCB antennas
 - Antenna diversity offers increased robustness and accuracy
- Intra-event antenna switching for optimal non-line of sight performance
- Includes IMU sensor to detect movement & wake-up the tag
- Small form factor
 - Ideal for size-constrained applications like key fobs
- AEC-Q100 Compliant
- SoC/NCP Sample Apps
 - Initiator and Reflector examples supported
- Ranging Library
 - Process IQ samples, post-filtering, and compute distance using configurable algorithm

BGM241S: High Accuracy Bluetooth Ranging with Channel Sounding

Coming
Soon



7x7 SiP Module

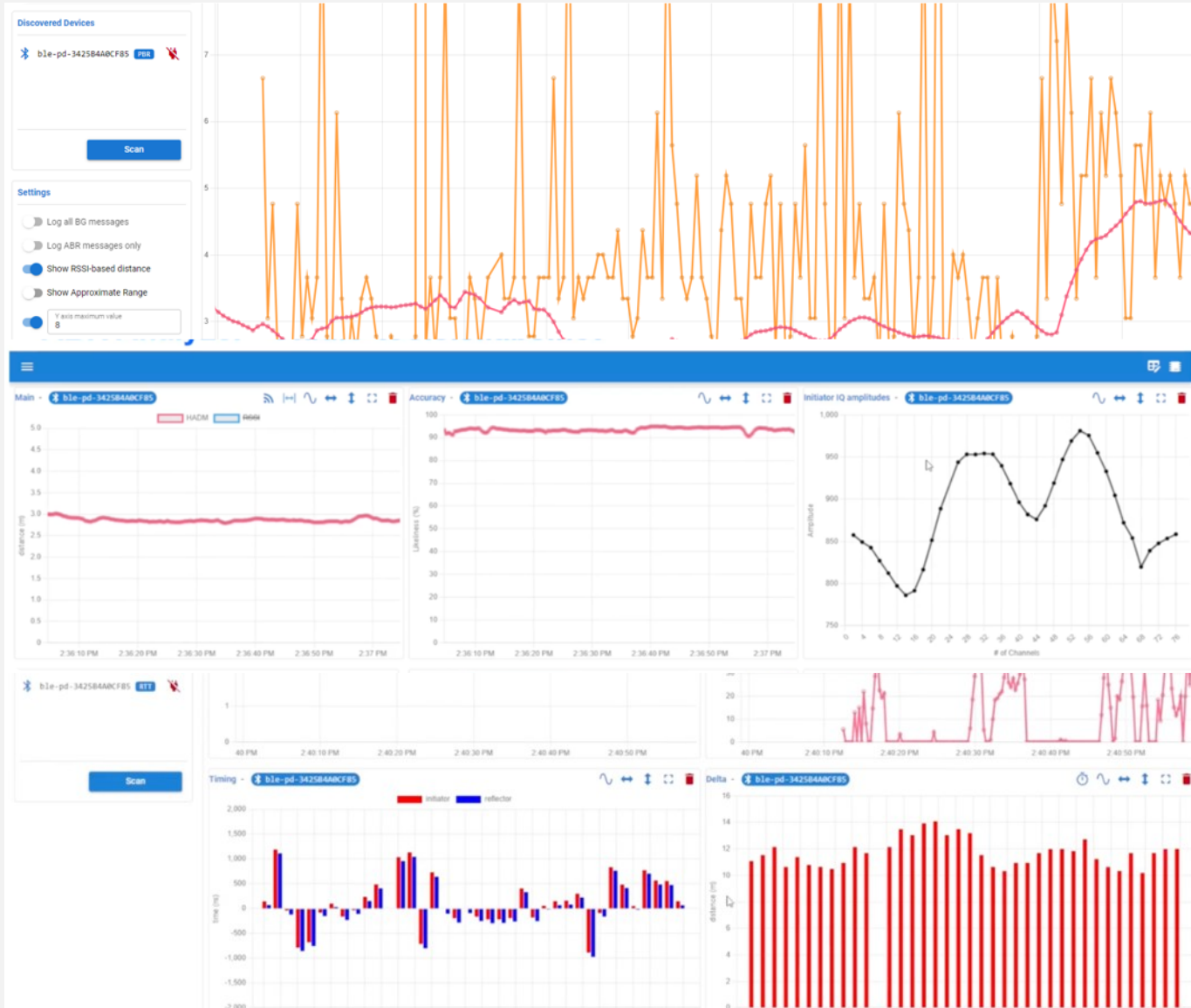
DIFFERENTIATED FEATURES

- **Integrated Power Amplifier**
 - +10 dBm output power
- **AI/ML accelerator**
 - Accelerates inferencing while reducing power consumption
- **Security**
 - Secure Vault High, ARM® TrustZone®
 - Protects data and device from local and remote attacks
- **16-bit ADC**
 - Up to 14-bit ENOB for advance sensing
- **Antenna Diversity**
 - Supports antenna diversity for Channel Sounding using an external 50-ohm terminated SP2T switch.
- **Certifications**
 - CE, UKCA, FCC, ISSED, MIC, KC – Shielded, Fully Certified
 - Integrated antenna and worldwide RF certifications reduce product development costs
- **PLFRCO**
 - Eliminates need for 32 KHz XTAL

DEVICE SPECIFICATIONS

- **Memory**
 - 1536 kB Flash, 256 kB RAM
- **High Performance 2.4 GHz Radio**
 - -97 dBm RX @ BLE 1 Mbps
- **Efficient ARM® Cortex®-M33**
 - Up to 80 MHz
- **Low Power**
 - 49.1 µA/MHz (CoreMark)
 - 4.6 mA TX @ 0 dBm
 - 5.1 mA RX (BLE 1 Mbps)
 - 1.3 µA EM2 sleep with 16 kB RAM retained
- **Wide Operating Range**
 - 1.8 to 3.8 V
 - -40 to +105 C
- **Multiple protocol support**
 - Bluetooth Low Energy 6.x, Bluetooth Mesh, Direction Finding

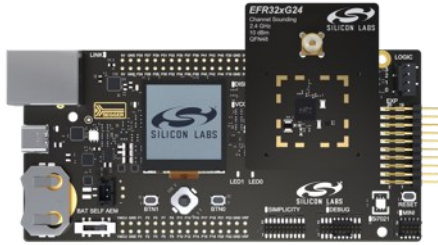
Visualizer Tool



Visualizer Tool displays real-time CS data

- CS configuration
 - Channel map selection
 - Antenna path configuration
 - Algorithm mode selection
- CS data visualization
 - RSSI based distance for comparison
 - Raw distance estimate and likelihood
 - Filtered distance estimate
 - IQ data visualization
- Interfaces with CS enabled EVKs

Silicon Labs Bluetooth® Channel Sounding Offering – Complete Solution



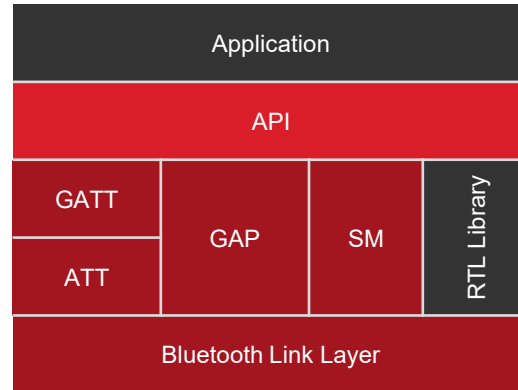
ICS & DEVELOPMENT KITS

Channel Sounding Supported by **B/MG24**

Kits:

xG24-DK2606A dual antenna kit

BGM241-DK2610A dual antenna kit

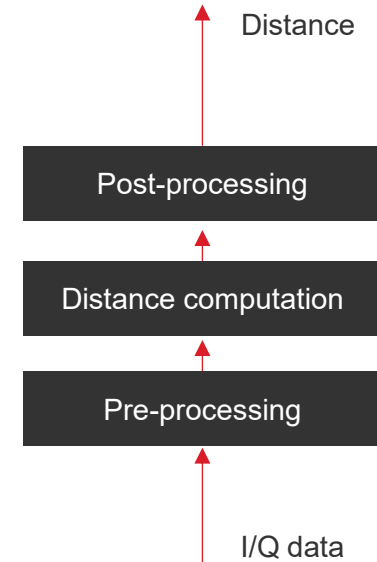


BLUETOOTH 6.0 STACK

Purpose-built stack, developed and maintained in-house

Bluetooth 6.x qualified

PBR & RTT Modes



RTL LIBRARY

Computes distance from raw I/Q data

Developed and supported by Silicon Labs

New features added based on market needs

No 3rd party license fees



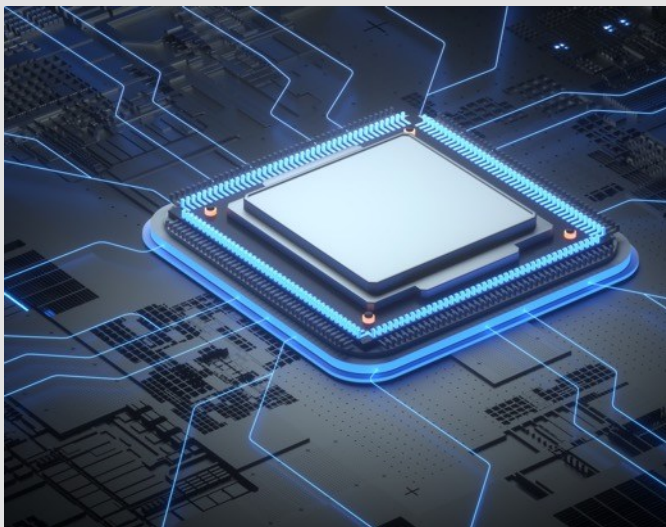
SDK & TOOLS

Initiator & Reflector examples

Real-time visualization tool for Bluetooth Channel Sounding

Energy Profiler, Network Analyzer etc.

Learn More About Silicon Labs Channel Sounding



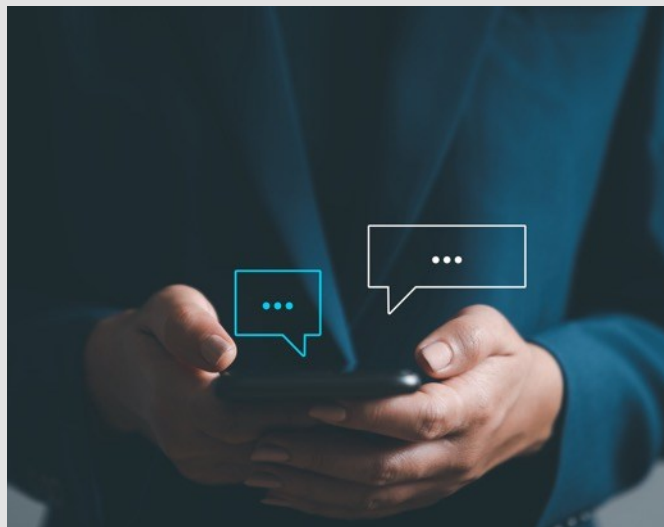
GETTING STARTED

Channel Sounding Kits Available at:

[Visit site](#)

Channel Sounding Developer Guide:

[Visit site](#)



FOR MORE INFORMATION

Learn About Channel Sounding Technology:

[Visit site](#)

Explore Bluetooth Channel Sounding Webinar:

[Visit site](#)



CALL TO ACTION

For any questions about SiLabs offerings, please contact our Sales team, or reach out to our developer community.

[Developer Community](#)

Q&A

- Select the Q&A button in the bottom control bar to open the Q&A window and submit your questions.

