WHITEPAPER

Enable Secure, Fine-ranging Measurements with Bluetooth-Based Channel Sounding

You're already designing Bluetooth® into your device. Maximize its potential with Channel Sounding.

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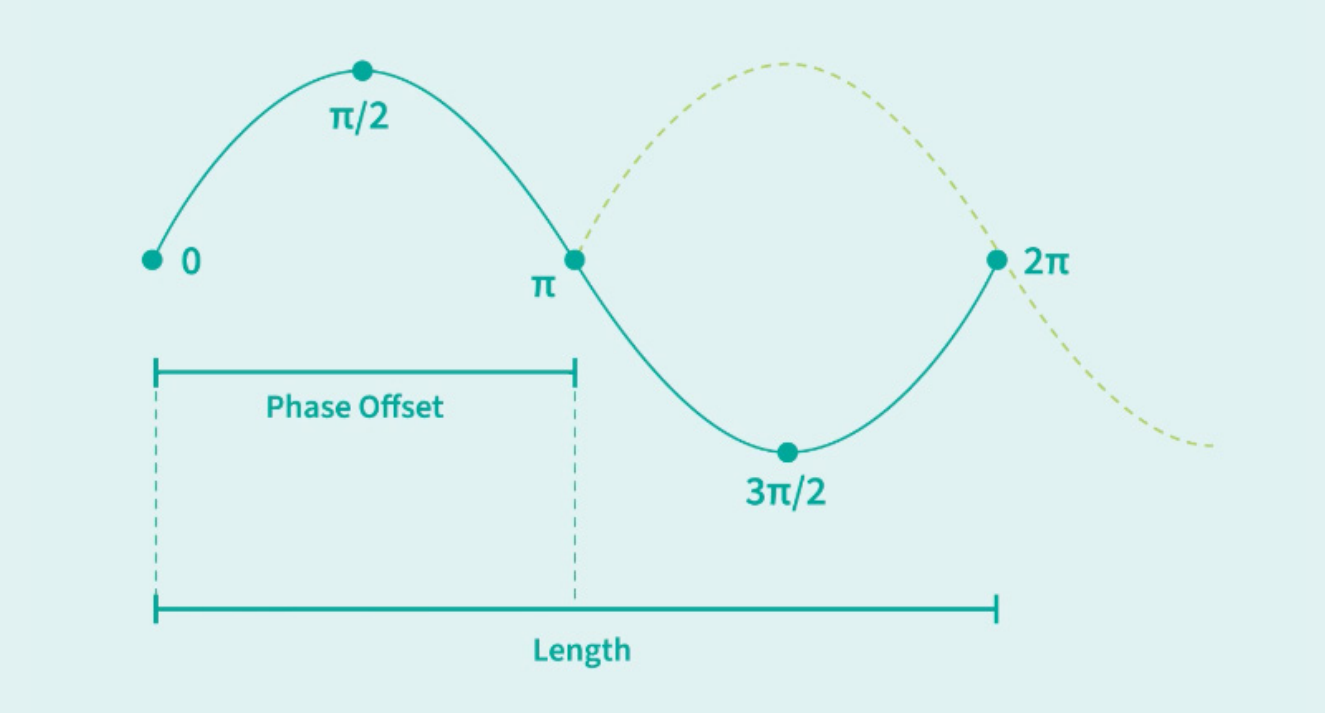
The Basics of Channel Sounding

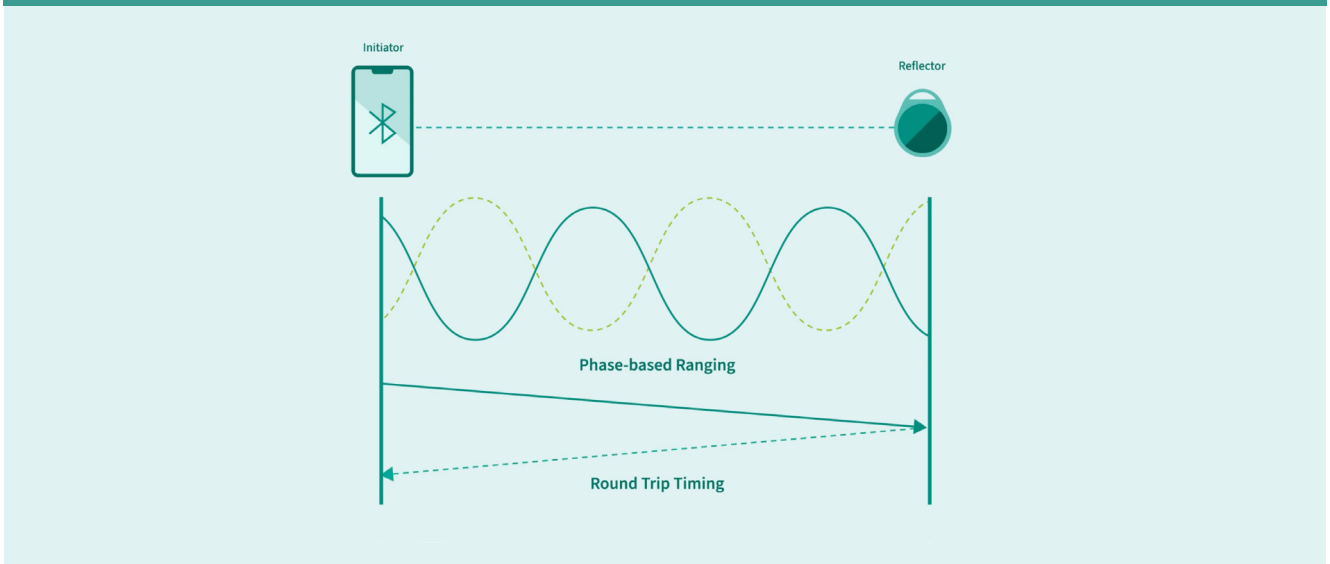
Channel Sounding is a technique that's used in wireless communications to characterize the radio channel between a transmitter and receiver. That's a technical way of saying that it's used to measure distance. Bluetooth® Channel Sounding is a secure, centimeter-level accurate distance measurement technology for Bluetooth LE devices, using Phase-Based Ranging (PBR) and Round-Trip Time (RTT) together to determine the distance between a paired "initiator" and "reflector" device.

With Phase-Based Ranging, the paired devices exchange tones that are sent across up to 72 Bluetooth Low Energy channels. Then an algorithm examines the phase of each tone when sent back from the reflector device and generates an estimate of distance.



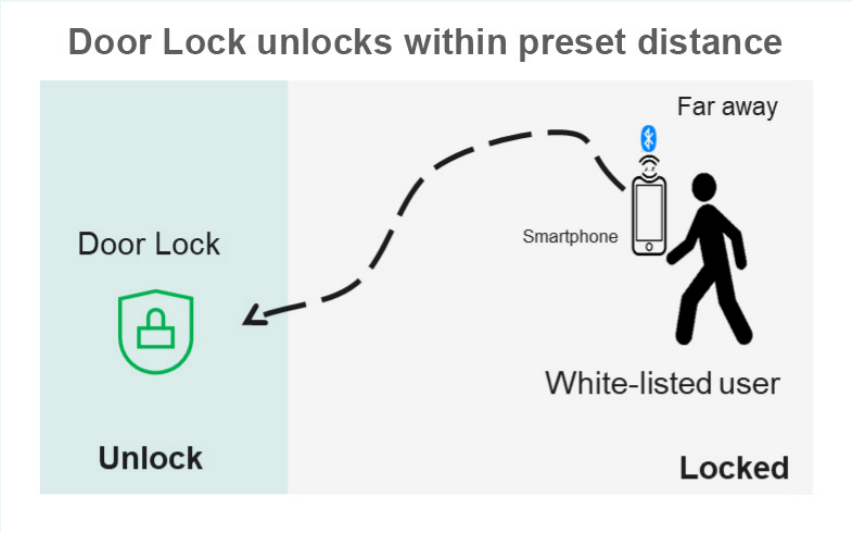
PBR (Phase Based Ranging)

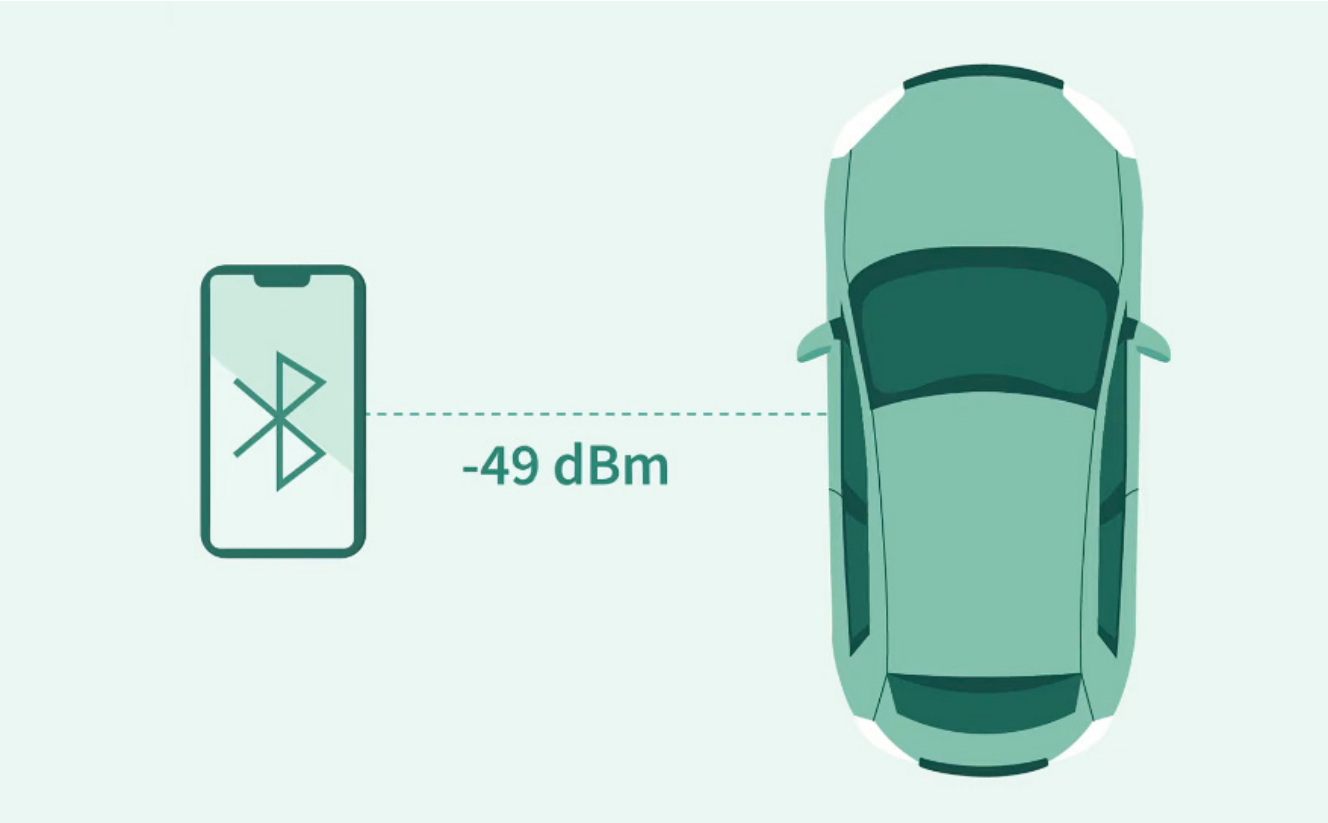
Range measurements based on the phase estimation by transmitting tones at multiple frequencies



With the second distance calculation called Round-Trip Time, the paired devices also exchange tones, but in this case the distance is measured in time traveling between the initiator and reflector.

In addition to Channel Sounding, Bluetooth devices utilize Received Signal Strength Indication (RSSI) for coarse distance measurement. RSSI is a method for estimating the proximity of a Bluetooth device by analyzing the power level of the radio signal it receives. The fundamental principle is that signal strength decreases as the distance between the transmitter and receiver increases. RSSI is prone to significant inaccuracies due to environmental interference. Obstacles like walls, metal objects, furniture, and even human bodies can absorb, reflect, or diffract the radio signals, causing the signal strength to fluctuate and distorting the distance estimation.





However, RSSI can be used for coarse ranging as a preliminary step before using Channel Sounding for a more accurate reading. This hybrid approach leverages the strengths of both technologies to optimize both efficiency and accuracy.

While not a new technique, Channel Sounding has actually been around for a couple of decades. Its uses are now being maximized thanks to its connection to Bluetooth, and its relatively low-cost silicon solutions. It came into play with the Bluetooth® Core 6.0 specification, which was released last year. So, while the principles (Phase Based Ranging and

Round-Trip Time) are decades old, their integration into everyday wireless protocols like Bluetooth is relatively recent.

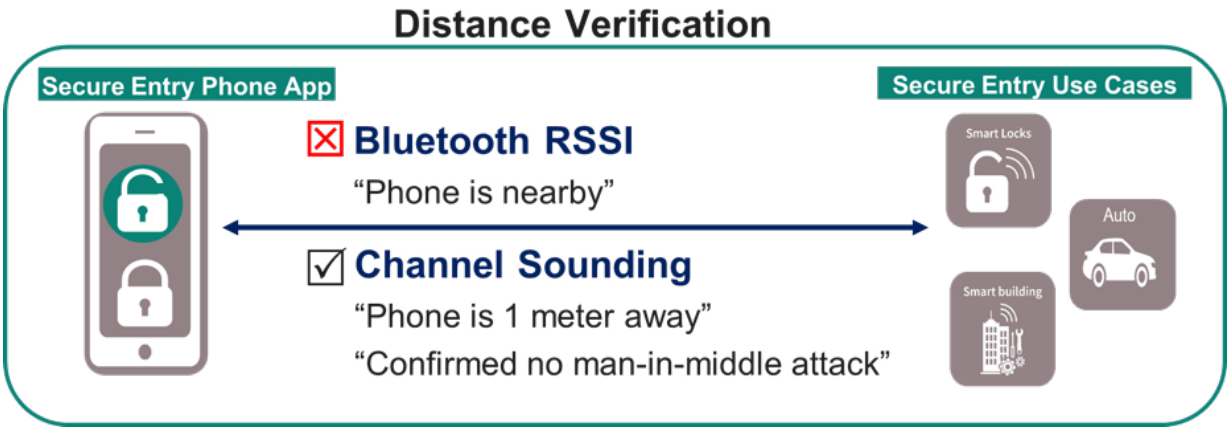
Applications that are prime targets for Bluetooth-based Channel Sounding include:

- Access control and security, such as proximity-based authentication (e.g., unlocking doors or devices only when a trusted tag/phone is at a specific distance. This can be used for consumer smart locks, commercial smart building entry, or automotive key fobs.)
- Indoor navigation and asset tracking in warehouses, hospitals, factories, and retail spaces to locate equipment, inventory, or people.

A No-Brainer for Consumer, Automotive Applications

From a security perspective, Channel Sounding offers an attractive solution, and that's welcome when you're discussing applications like consumer and automotive door locks. This is where Phase Based Ranging augmented with Round Trip Time can be used to measure distance while detecting potential man-in-the-middle (MitM) relay attacks. This ensures that Channel Sounding data cannot be injected or spoofed by unauthorized devices, thereby maximizing security.

In automotive applications such as digital car keys, Channel Sounding resists relay attacks by verifying not only the device identity but also its physical location. With the security features provided by Infineon's Channel Sounding solutions, an attacker can't simply forward signals, as the RTT distance measurement is a verification of the PBR measurement. Also keep in mind that the automotive design can be somewhat more complex than a residential door lock in that there are multiple anchors that allow you to track where the key fob is relative to the various car doors.



It's RF, But Don't Be Afraid

From a design perspective, Channel Sounding comes with some challenges, partly related to the channel impairments and multipath that are inevitable in over the air device communication. Look for a partner with proven deep RF expertise when selecting a solution. For applications demanding the best accuracy and locationing, such as car access, multiple Channel Sounding 'anchors' can be used to triangulate a user's position.

Alternative Options

While Bluetooth is quickly becoming the medium of choice for consumer and automotive distance measurement applications, there are other options, namely Wi-Fi, and Ultra-Wideband (UWB). Each comes with different tradeoffs in accuracy, cost, and power. In some cases, UWB and Channel Sounding will be used together.

Bluetooth Low Energy is attractive because it's already integrated into most smartphones. Wi-Fi solutions are also widely available, but they require more power than Bluetooth LE and are less accurate.

UWB offers high levels of precision and is in place in many automotive applications. However, it requires dedicated silicon for implementation and thus carries the associated cost. It's also a higher-powered option compared to Bluetooth Low Energy.

Conclusion and Recommendations

We've shown here that Bluetooth-based Channel Sounding enables precise distance with two complementary distance measurement techniques in the existing Bluetooth LE 2.4 GHz band. Location accuracy can also be improved when multiple connection points are available such as in automotive applications. Compared to competitive techniques, it offers accuracy and security, while maintaining low power consumption. It also has the huge advantage that Bluetooth is already available in multiple applications and it is therefore low-cost to add Channel Sounding distance capability when compared to discrete solutions, such as UWB.

If you're not already maximizing the potential of this technology, now is the time to start planning for it. The experts at Infineon can help with this initiative. The company is already a leader in Bluetooth and other communications media, and Channel Sounding is simply an extension of those technologies.

The advice here is to evaluate your product's needs as early as possible, then contact Infineon to understand how the company's product roadmap fits in with your plans. Contact Infineon today.

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