AKER TECHNOLOGY

SEPTEMBER 2023 | AKER TECHNOLOGY WHITEPAPER

How Frequency Control Ensures Reliable, Secure UWB Applications

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Like other short-range wireless communications protocols, such as Bluetooth and WiFi, ultra-wideband (UWB) enables the creation of a personal area network (PAN) that interconnects electronic devices and facilitates data transmission within an individual's immediate vicinity. Instead of sending data through a LAN or WAN, a PAN transmits information between devices within a person's proximity.

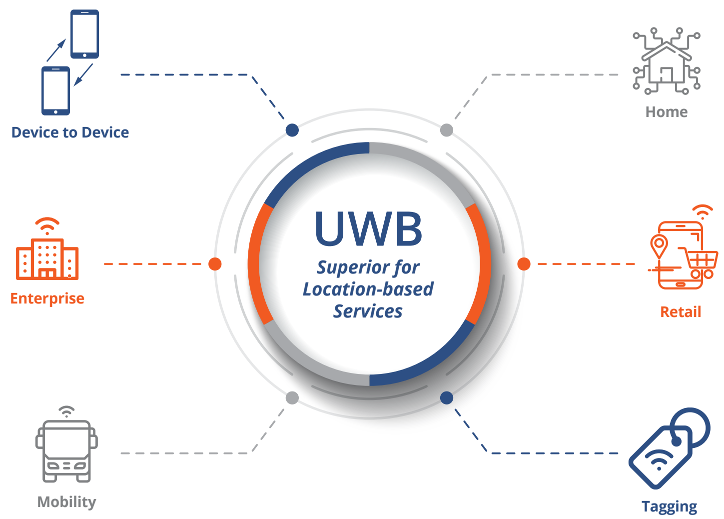
History of UWB

Developed during World War II for secure communications and radar systems, UWB was banned from commercial use, leaving it largely untapped for many decades. Federal regulations released in 2002 enabled wider use of UWB. Since then, it has gained significant traction in a growing number of commercial applications, including industrial, consumer, communication and automotive, which are exploiting its precise positioning and location-tracking capabilities as well as the high-speed data transmission and minimal power consumption that come along with this wireless protocol.

But UWB differs from other transmission technologies in several key aspects, which are fueling UWB's implementation across a growing number of mainstream wireless applications. **(Figure 1)**

UWB operates at a very high frequency and does not interfere with other wireless protocols. It facilitates attributes like spatial audio, smart home integration and contactless payment systems, making it especially useful in vehicles, mobile and consumer devices, like smart phones and tagging. This technology helps to enable advanced features like secure hands-free access, indoor navigation, contactless payments, credential sharing and item tracking.

FIGURE 1: UWB Location-based Services



UWB's secure, wide frequency range and precision sensing enable a number of mainstream wireless applications.

The Benefits UWB Brings to the Table

While both Bluetooth and WiFi have secured a place in the wireless communications world, UWB is poised to dominate in applications that operate in the 10-20 meter range because it is faster, more secure and extremely accurate. This is largely due to time-of-flight (ToF) measurements. **(Table 1)**

By accurately measuring the time it takes for a signal to travel between devices, UWB's ToF capability makes it more difficult for an external attacker to access or manipulate UWB communications due to its cryptographic nature, generation of random numbers and other security techniques.

In addition to high security, UWB technology offers low power, good noise immunity, precise positioning and location tracking as well as signals that can easily penetrate a variety of materials. UWB allows the transmission of a large amount of signal energy without interfering with conventional narrowband and carrier wave transmission in the same frequency band.

TABLE 1: Wireless Technology Comparison

	Wi-Fi	Bluetooth	UWB
Spectrum Band	2.4/5 GHz	2.4/5 GHz	3.1~10.6 GHz
Nominal Range	250 m	100 m	10~20 **m**
Accuracy	2~3 m	1~5 m	**10~30 cm**
Data Rate	600 Mbps	24 Mbps	460 Mbps
Security	Medium	Medium	**High**

The 3.1~10.6 GHz spectrum band of UWB dwarfs that of WiFi and Bluetooth, which tops out at 2.4~5 GHz. By operating in a higher frequency range with more bandwidth, UWB can carry more data more securely, making it ideal for high-speed, short-range data transmission.

Wireless Speed (real-time data, precision timing):

Although the data rate of WiFi is a bit higher than UWB, at 600 Mbps and 460 Mbps respectively, the radar-like detection capabilities of UWB make it an effective choice in wireless applications. (For reference, Bluetooth's data rate is 24 Mbps.) And with a lower nominal range than Bluetooth or WiFi, UWB is best suited for those short-range applications that require precision timing and real-time data transmissions.

Accuracy (positioning, location tracking):

UWB's accuracy is unmatched by any other wireless technology at short distances to ensure more precise device location. The lack of interference with other radio transmissions and radio burst technology means UWB effectively measures distances with an accuracy down to 10~30 cm, far better than the ranges of WiFi (2~3 m) and Bluetooth (1~5 m).

Security (data integrity, secure transmission):

UWB's pulse transmission technology is resistant to noise and reflection, making it highly secure for a range of applications. The direct connection between two devices and precise measurement properties enables UWB to connect with and authenticate the legitimacy of a device in real-time without radio waves being recorded or relayed over.

Power Efficiency (low leakage, optimum consumption):

Thanks to its fast transmission speed and well-defined timing frame, UWB conserves power better than most short-range protocols. It can support several low power modes, including hibernate for even further power optimization. For small battery-powered devices, like those found in UWB environments, power consumption is a crucial factor.

Crystal Oscillators Enable UWB Applications

UWB fulfills many needs of short-range wireless applications across a wide frequency range, but this also brings into play the need for accurate frequency control to ensure the precise positioning, location-tracking and high-speed data transmissions that makes UWB so useful. **(Table 2)**

TABLE 2: Current Aker Products Used in UWB Applications

Application	Description	Aker Product
Anchor	UWB Transceiver Automotive Grade XTAL 2016 55.2MHz	C1E-55.200-8-1035-A-X2-R
Anchor	UWB Transceiver XTAL 2016 55.2MHz	C1E-55.200-8-1035-X-R
Anchor	MCU Automotive Grade XTAL 2016 40MHz	C1E-40.000-8-1030-A-X2-R
Tag	UWB Transceiver XTAL 2016 55.2MHz	C1E-55.200-8-1020-R
Tag	BLE XTAL 2016 16MHz	C1E-16.000-10-1520-X-R
Car Key	UWB Transceiver Automotive Grade XTAL 2016 38.4MHz	C1E-38.400-10-1010-A-X-R
Car Key	BLE Automotive Grade XTAL 2016 32MHz	C1E-32.000-10-1010-A-X-R

Typical high-performance crystals that meet the frequency control needs of UWB.

Quartz crystals are popular frequency control devices used to ensure the signal and timing control necessary to transmit information at the right time and speed. The stability, phase noise characteristics and power efficiency of the crystal can impact the quality and reliability of UWB communications and positioning systems.

A stable oscillator provides a reliable and accurate clock signal, which ensures that the UWB pulses maintain their desired shape and spectrum. In other words, the pulse shape generated by the UWB transmitter is influenced by the timing provided by the oscillator.

Frequency drift or instability in the oscillator can lead to signal distortion and poor performance, so choosing a crystal with the correct frequency range, tolerance and stability is critical. Other key parameters include package type, operating temperature and load capacitance.

FIGURE 2: UWB Applications

Main UWB Markets

First appearing in the iPhone 11, UWB has quickly gained ground in a large number of PAN-based applications including smart tags and in-vehicle reference points, or anchors. UWB technology helps advance smart wireless technology innovations and better automate our world. Here are a few other ways UWB is revolutionizing various short-range wireless markets: **(Figure 2)**

Industrial – UWB is used in asset tracking, indoor localization, monitoring systems, wireless sensor networks and smart grid applications. The technology can provide accurate location information for personnel and equipment.

Consumer Communications – The technology is used in smartphones, wearables, IoT, smart home systems and smart tags for fast and reliable wireless connections between short-range devices. UWB offers more accurate spatial tracking, like precise indoor positioning.

Automotive – Keyless entry systems, secure vehicle access, advanced driver-assistance systems (ADAS) and tracking all use UWB in the automotive industry for precise positioning.

Frequency Control Helps Wireless Innovations

The increasing demand for wireless connectivity, especially with the proliferation of Internet of Things (IoT) devices and the deployment of 5G networks, is pushing the data moving across frequency bands to new limits. The growing wireless infrastructure relies on the critical performance parameters that UWB offers.

Operating across a wide frequency range, UWB allows the transmission of a large amount of signal energy without interfering with conventional narrowband and carrier wave transmission in the same frequency band. This wide bandwidth allocation requires accurate frequency control to avoid interference with other wireless systems operating in the same frequency bands as well as to synchronize data transfers and maintain reliable communication.

UWB technology enables secure ranging and precision sensing, creating a new dimension of spatial context for wireless devices. UWB is the way of the future for IoT, wearables, in-time locating, smart car access, home control panel, peer-to-peer communication, automatic unlocking and access management; and Aker is there to be a part of it.

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