Ultra Wideband (UWB) Delivers Accurate Ranging and Positioning

Ultra Wideband (UWB) for Accurate Ranging and Positioning

Agenda

- UWB Overview
- Application Examples
- How UWB Ranging Works
- UWB Test Solution Overview

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UWB Overview

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UWB Technology is <u>not</u> New…

1901: Marconi transmits Morse code across the Atlantic with UWB

1960: UWB used in military RADAR

2002: FCC approves UWB for commercial applications

FCC Federal Communications Commission

1900

1950

2000

IEEE

802.15.3 → 802.15.4

WiMedia

Low-Speed Data Transmission

Detecting Distance & Direction

High-Speed Data Transmission

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This Time it is about Accurate Ranging and Positioning

2019: FiRa Consortium founded to harmonize UWB certification

fira | The Power to Be Precise

2000

2020

IEEE

802.15.4z

Accurate Relative Position Tracking

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Why is UWB for Ranging Needed?

Security

- UWB can be used for user authentication based on location
- Compared to RSSI ranging, UWB uses Time-of-Flight (ToF). RSSI is easy to hack, time is difficult to fake

Application Examples for UWB Ranging

Likely UWB applications are in three main use cases across a variety of verticals

	Smart Home and Enterprises	Smart Cities and Mobility	Smart Transportation	Consumer	Smart Retail	Industry 4.0 and Healthcare
Hands-Free Access Control	• Residential access control • Restricted enterprise access	• Parking garage • Vehicle digital key (standardized by CCC)	• Rider identification (private transport services)	• Logical access control	• Unmanned store access	• Barrier-free and restricted access control
Location-Based Services	• Employee mustering in emergencies	• Bike sharing	• Ride sharing • Reserved seat validation	• AR gaming	• Indoor navigation • Foot traffic and shopping behavior analytics	• Asset tracking • Patient tracking
Device-to-Device (Peer-to-Peer) Applications	• Conference systems	• Drone-controlled delivery • V2X*, autonomous driving	• Ticket validation (public transport services)	• VR gaming and group play • Find someone nearby	• Targeted marketing • Tap-free remote payment	• Proximity-based patient data sharing • Find equipment

Source: FiRa Consortium

UWB Applications: Access Control

WIRED

ANDY GREENBERG SECURITY 03.21.16 10:33 AM

Radio Attack Lets Hackers Steal 24 Different Car Models

Source: Wired

Key Fob Relay Hacking?! What it is and how a Faraday Bag can help

- Verify Identify ***and*** Verify Location
- Key fob or UWB enabled smart phone

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UWB Applications: Location Based Services

UWB technology brings GPS-style positioning functionality to indoor environments.

UWB offers **highly precise** positioning (<10 cm)

UWB operates even in crowded, multipath signal environments, and can pass through walls, machinery, and other obstacles.

UWB makes it easier to navigate large spaces, such as airports and shopping malls

UWB Applications: Peer-to-Peer Communication

Industrial Safety:
- What if hard hats contained wireless sensors?


Worker Dies After Being Run Over By Truck At West Englewood Construction Site

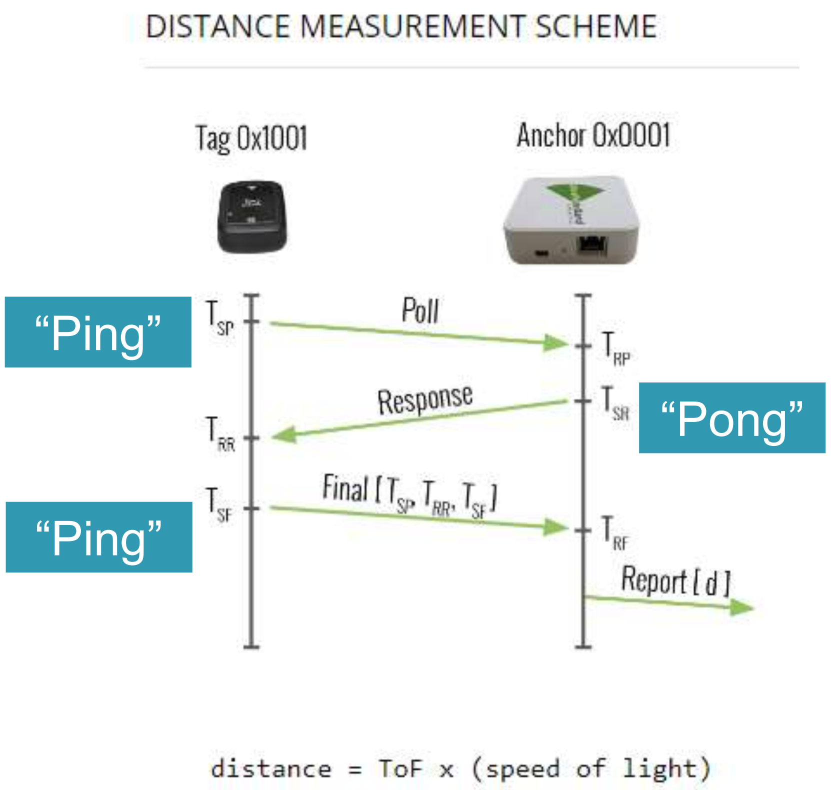
APRIL 26, 2019 - 12:36 PM

CATEGORIES: Local, News

How UWB Ranging Works

How UWB Ranging Works - Time of Flight (ToF)

1st – you need to measure distance



UWB uses “Time of Flight” to measure distance between an Anchor and a Tag

1. Tag sends out a poll (“Ping”) and measures the time required to receive a response (“Pong”).
2. The delay in the Anchor is known
3. The Tag calculates the actual ToF and uses this to calculate distance
4. The Tag can send an additional “Ping” back to the Anchor to compare the times

This measurement technique is called “Ping – Pong” or “Ping – Pong – Ping”

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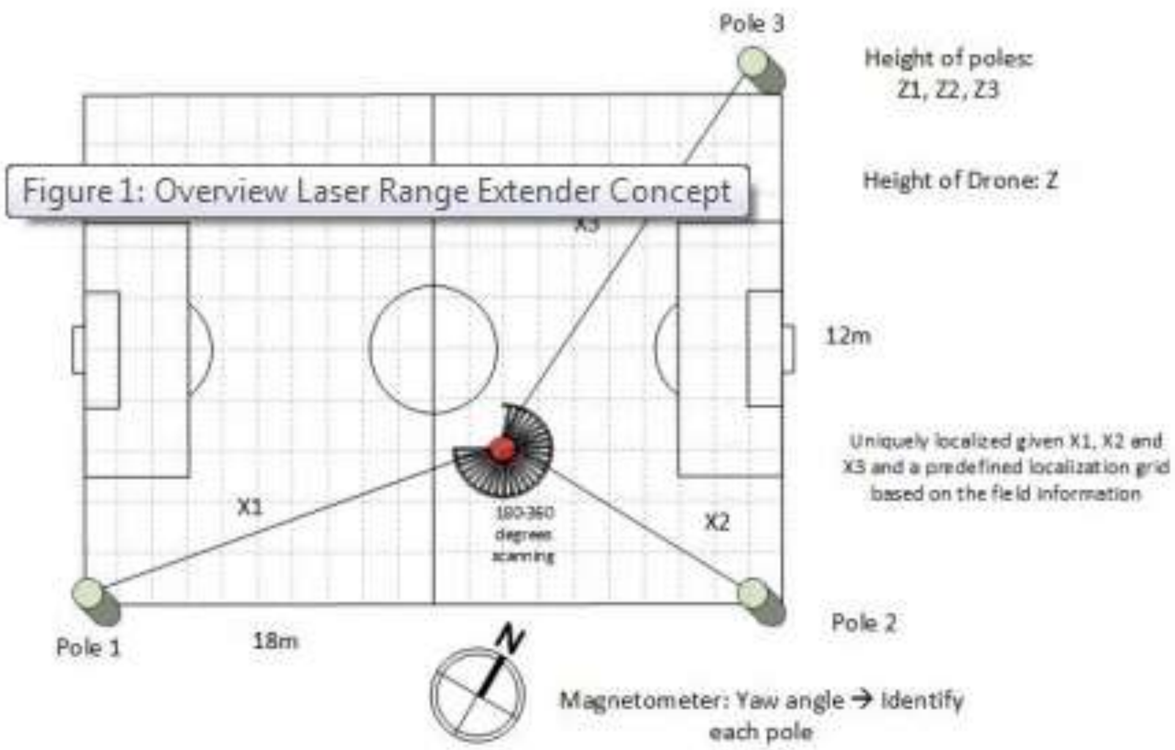
How UWB works

Determining location requires multiple receivers. The technique is called "trilateration" (not triangulation)



In a **2-dimensional world**, with 3 distance measurements you can accurately determine location.

In this example, if the target is on the playing field, we can tell it's location with 3 transceivers placed in the corners.

If the target is above or below the playing field, we need a **4th receiver** that is above or below the playing field.

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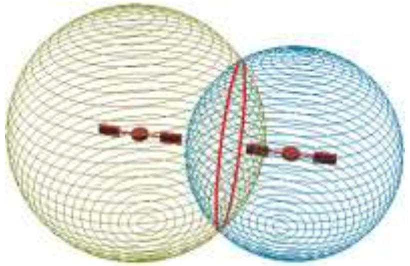
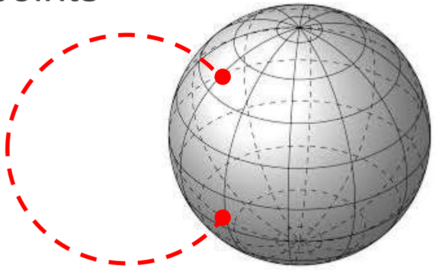
For 3D location calculations

With **1 receiver**, I know my location is on a sphere

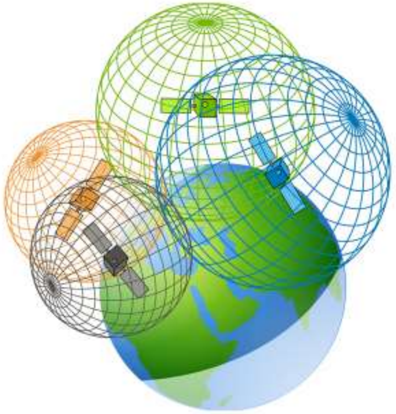
With **2 receivers**, I know my location is on a circle



With **3 receivers**, I know my location is one of 2 points



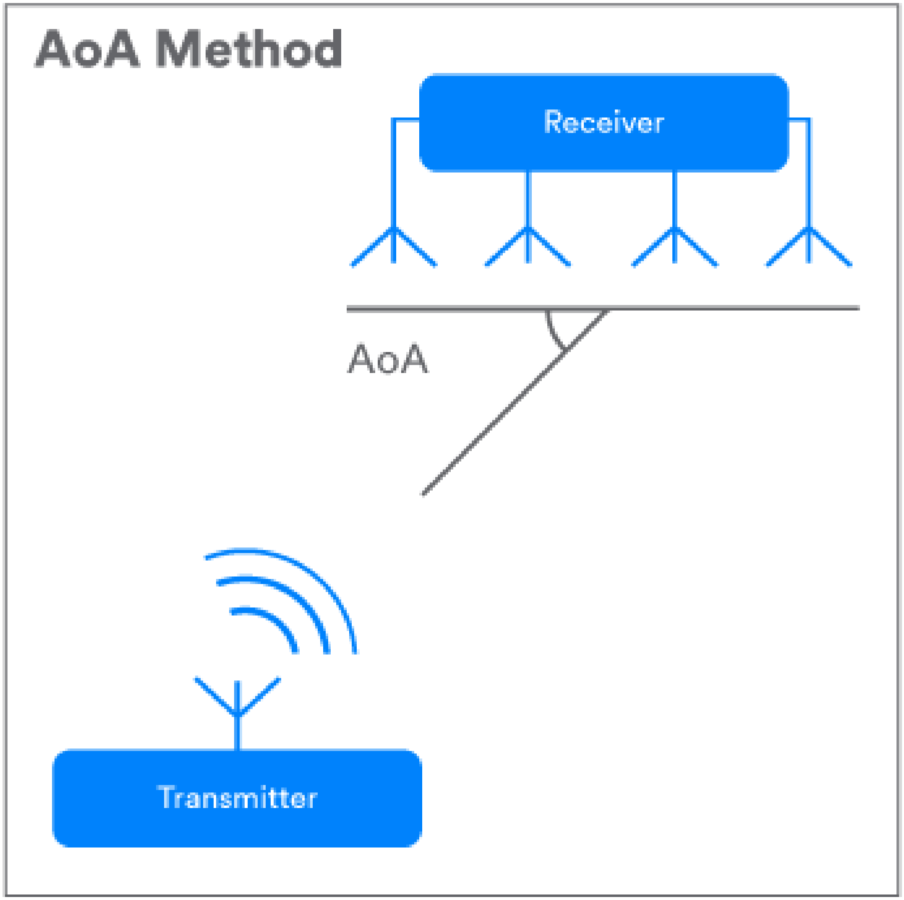
With **4 receivers**, I know my exact 3D location



4 receivers is the minimum, realistically we want more

Angle of Arrival (AoA)
An alternate method to determine location ….

- With AoA, receiver must have **multiple antennas**
- Based on the phase differences of a received signal, the angle of arrival can be determined
- “Trianglulation” can be used to determine location if multiple receivers have AoA information
- It is possible for a system to include both ToF (distance) and AoA (angle) measurements to determine location



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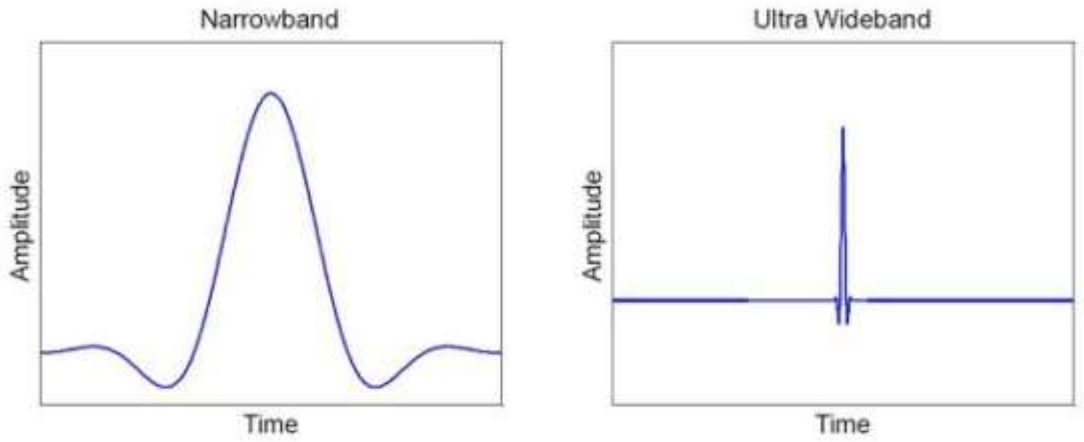
High Level UWB Specs (802.15.4z)

Parameter	Value
Center Frequency Range (LRP)	6489.6 – 9945.6 MHz
Channel Bandwidth	500 MHz (typical) up to >1 GHz
Transmit Output Power	< -41.3 dBm / MHz
Data Rates	110 kpbs, 425 kbps, 850 kpbs,1.7 Mbps, 6.81 Mbps, 27.24 Mbps
Ranging Support	Yes
Range	10 m – 100 m
Positional Accuracy	~10 cm

+/-10 cm is ~70ps accuracy



Channel number	Center frequency (MHz)
0	6489.6
1	6988.8
2	7987.2
3	8486.4
4	6681.6
5	7334.4
6	7987.2
7	8640.0
8	9292.8
9	9945.6

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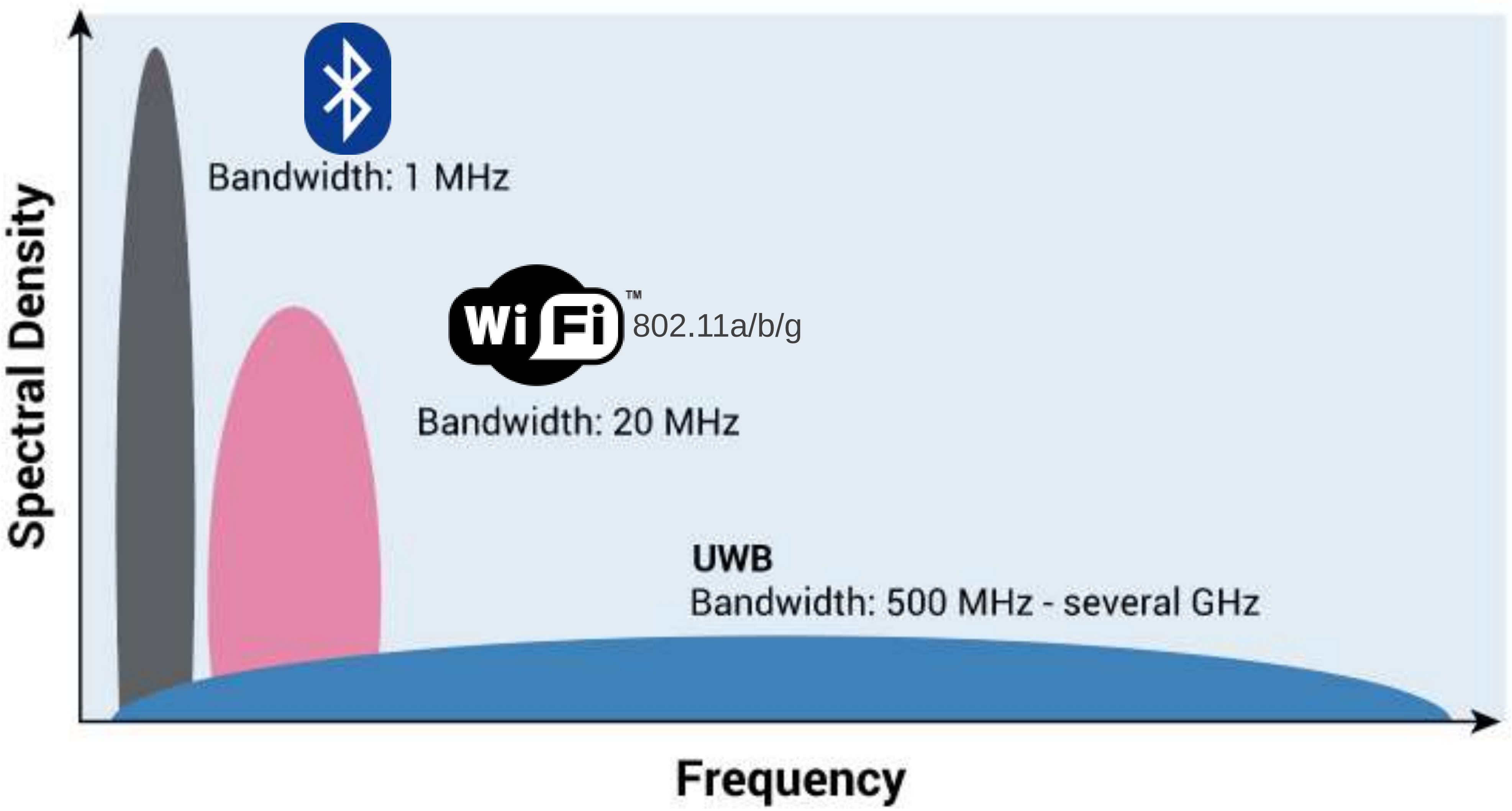
Bandwidth Comparison to other Technologies



Source: FiRa Consortium

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UWB Test Solution

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Integrated UWB Ranging Test Solution: IQgig-UWB

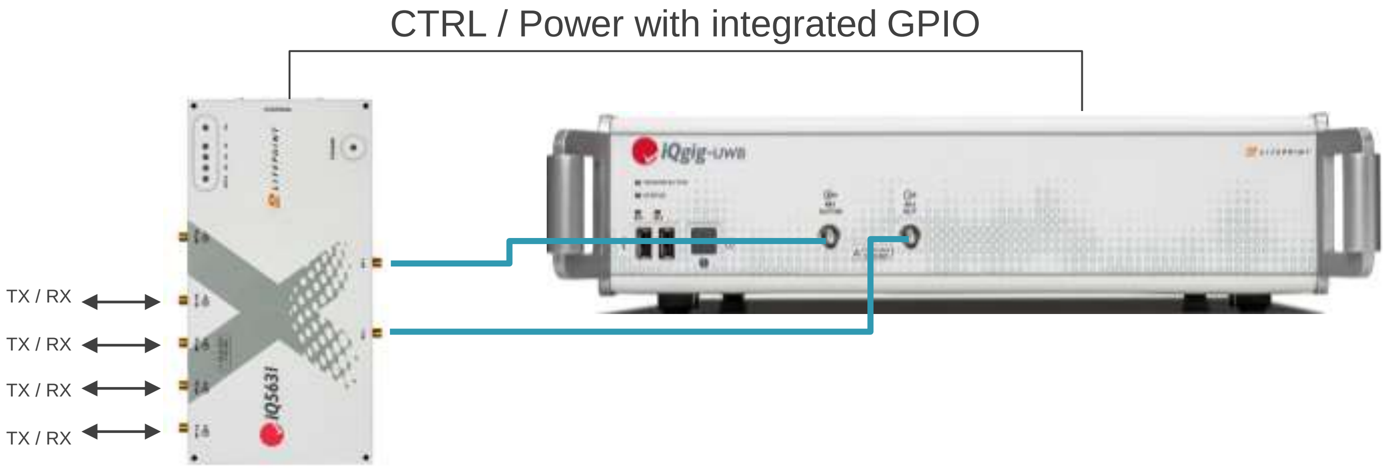
- First Integrated Test Solution for Complete UWB Testing
  - Integrated VSG and VSA for high-performance TX / RX testing of UWB devices
  - 5 to 19 GHz frequency range covers core UWB channels
  - 2 GHz single-shot VSA & VSG modulation bandwidth
  - Supports **802.15.4z** standard

- Time of Flight Calibration
  - Precision trigger / response mechanism to deliver ≤ 20 us response time with ps level jitter

- Wide Dynamic Range for Sensitivity Testing
  - Combined with the IQ5631 Power and Delay Control Module (PDCM), IQgig-UWB enables receiver sensitivity testing for below -100 dBm

Enhanced Measurements with IQ5631 Power and Delay Control Module (PDCM)

Optional accessory enabling RX sensitivity and multi-antenna devices



IQ5631 PDCM

- IQ5631 Power and Delay Control Module can be located **close to DUT** to minimize VSWR error & delay errors
- Enables RX sensitivity testing below -100 dBm
- Enables multi-DUT test for single antenna devices

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Integrated UWB PHY Layer Measurements

Standard UWB PHY Layer Measurements

UWB (802.15.4) Measurement Specification

Measurement	Description
Spectrum Mask	Transmit spectrum mask
Symbol Modulation Accuracy	Correlation to reference pulse (%)
Carrier Frequency Offset	Carrier frequency error (kHz)
Chip Clock Error	Error in ppm
Chip Frequency Error	Error in Hz
Pulse Main Lobe Width	Width of main lobe in time (ns)
Pulse Side Lobe Power	Power relative to main lobe (%)
Power (Preamble & Data)	Average power of complete data capture (dBm)
Peak Power (Preamble & Data)	Peak power over all symbols (dBm)
Pulse Jitter	Jitter in ps
Pulse NMSE	Normalized Mean Square Error (ppm)
RX PER	Receiver Packet Error Rate (requires DUT support)

Additionally, Time of Flight (ToF) & Angle of Arrival (AoA)

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Implementing the Time-of-Flight (ToF) Measurement

Measurement Procedure

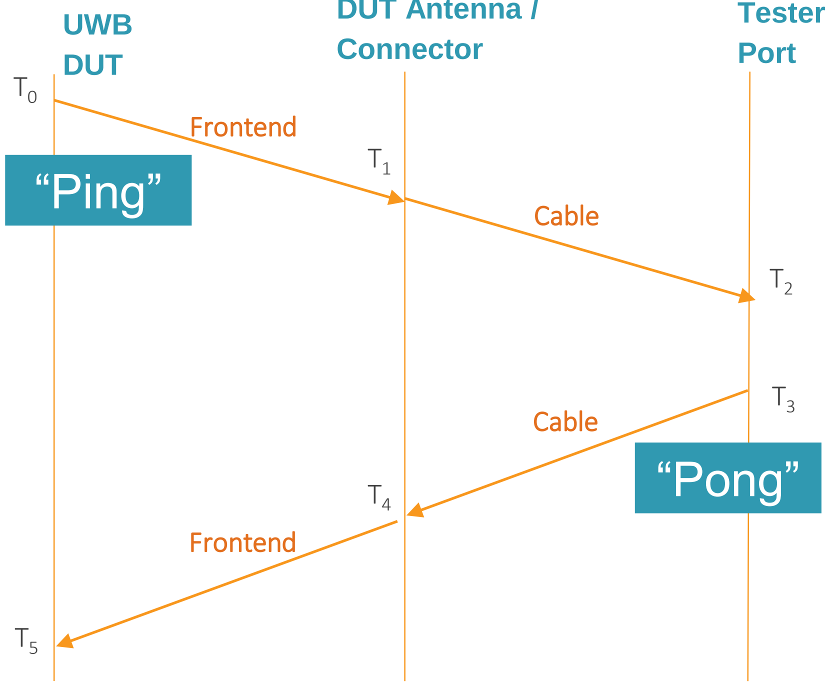
1. **[Tester]** Setup VSA & VSG
2. **[DUT]** Setup TWR system
3. **[Tester]** ARM ToF Sequence with known delay
4. **[DUT]** Transmit Ping
5. **[Tester]** Respond with Pong
6. **[DUT]** Receive Pong and calculate ToF

TWR = Two Way Ranging

DW1000

Applying ToF to DUT Calibration

- Goal is to measure the DUT front-end delay
- 1st step is to perform tester cable calibration to measure cable delay
- Once cable delay is known & tester delay is programmed, the ToF measurement measures the frontend delay
- Measured frontend delay then programmed into DUT for calibration



$$T_3 - T_2 = Tester\ Delay$$

$$T_4 - T_1 = (2\ x\ Cable) + Tester\ Delay$$

$$T_5 = DUT\ Measure\ Time$$

$$T_0 = DUT\ Transmit\ Time$$

$$Frontend = \frac{T_5 - T_0 - T_4 + T_1}{2}$$

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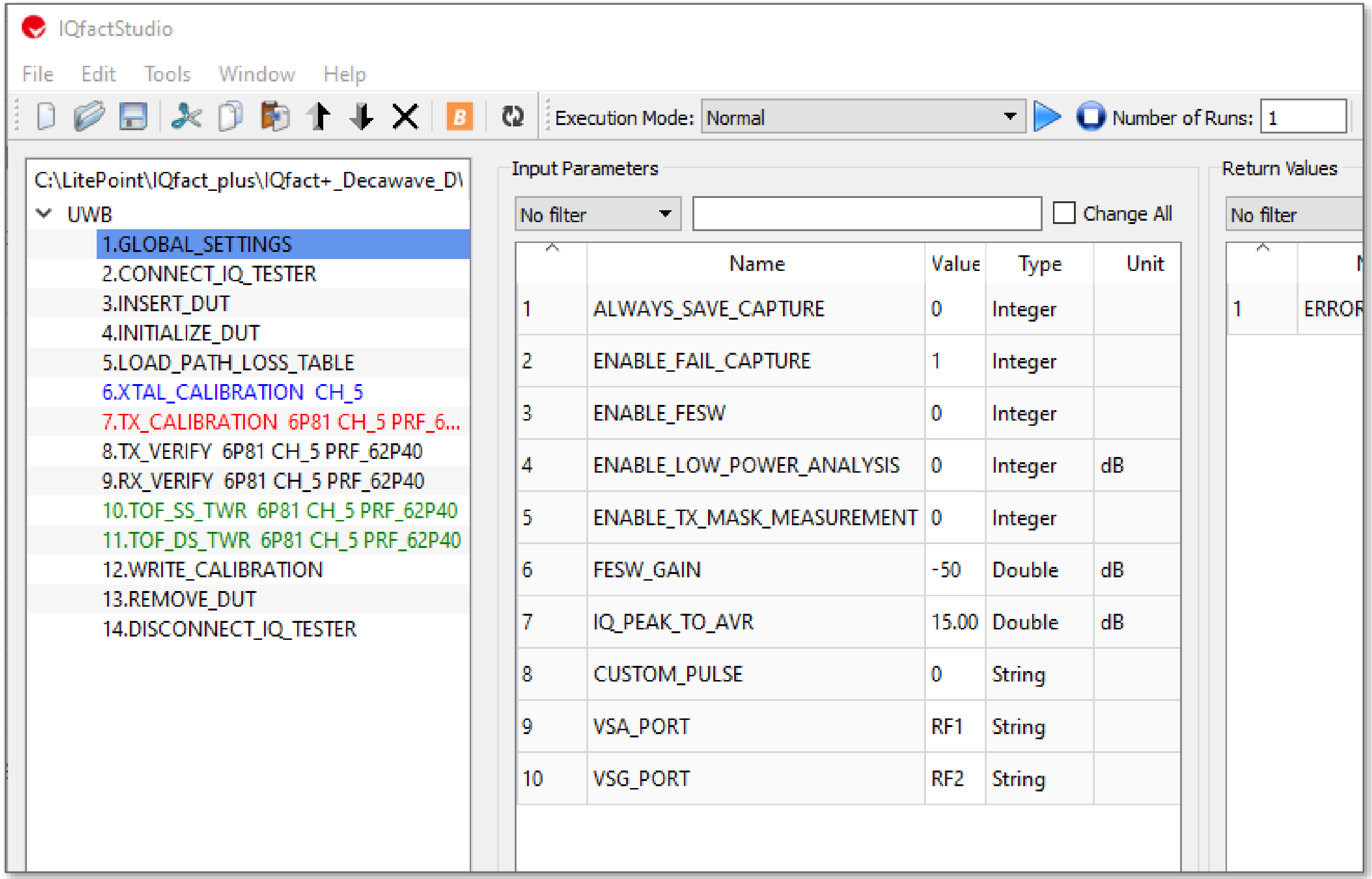
Turnkey IQfact+ Solutions for UWB Ranging Applications



Based on commercially-available UWB development kit

IQfact+ Turnkey Test Procedures

- **Automate test procedures for UWB devices**
- **Supported Tests:**
  - Crystal Calibration
  - TX Calibration
  - TX Verification
  - RX Verification
  - Time of Flight (single-sided & double-sided)

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UWB: Helping to Make the World More Secure

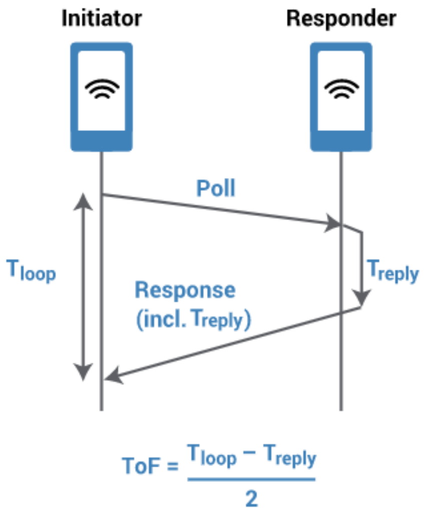
- UWB technology is back again, this time targeting accurate ranging and positioning

- A device can now understand its position, which improves security in a variety of applications:
  - Building / Automotive access, financial transactions, etc.

- Current consumer wireless technologies used for ranging (Bluetooth, NFC, etc) are susceptible to hacking
  - Power (RSSI) can be hacked
  - Encryption can be broken

- UWB uses Time of Flight to determine position, adding a new layer of security…
  - It is very difficult to “fake” time
  - UWB’s wide bandwidth is extremely immune to interference

Source: FiRa Consortium



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