Research on Synchronization Between Two UWB Beacons

1. Introduction

Synchronization between two Ultra-Wideband (UWB) beacons is crucial for accurate position tracking, ranging, and real-time sensor detection. Unlike single-anchor setups, multiple beacons require precise time synchronization to ensure that the distance and angle calculations are correct. We explore synchronization methods, challenges, and best practices for achieving high accuracy in UWB-based systems.

2. Key Synchronization Techniques

Time-Difference-of-Arrival (TDoA):

In TDoA-based systems, beacons synchronize their timestamps and compare signal arrival times to estimate position.

Requires a networked system where at least one beacon acts as a master clock for synchronization.

Commonly used in indoor positioning systems where multiple anchors track a moving device.

Two-Way Ranging (TWR) Synchronization:

Uses a back-and-forth communication method between the two beacons to calculate relative clock offsets.

Ensures that devices agree on a common time reference for distance measurements.

Used when TDoA isn’t feasible due to infrastructure limitations.

3. Challenges in Synchronizing Two Beacons

Clock Drift & Accuracy Issues: UWB beacons use independent crystal oscillators, which can lead to small timing inconsistencies over time.

BLE Latency for Initial Sync: Many UWB devices use Bluetooth Low Energy (BLE) for discovery, which introduces small delays that can impact ranging accuracy.

Environmental Interference: Walls, obstacles, and reflections can affect UWB signal propagation, leading to timing error.

4. Best Practices for Synchronization

Use a master/slave beacon configuration to maintain a consistent clock reference.

Calibrate beacons in a controlled environment before deployment to minimize initial sync errors.

Implement firmware adjustments to compensate for clock drift over time.

Use multiple synchronization techniques (TDoA + TWR) to improve accuracy.