ESP32 PROJECTS IOT PROJECTS

Getting Started with ESP32 DW1000 UWB (Ultra Wideband) Module

By **Mamtaz Alam** — Updated: January 4, 2024 7 Comments 10 Mins Read

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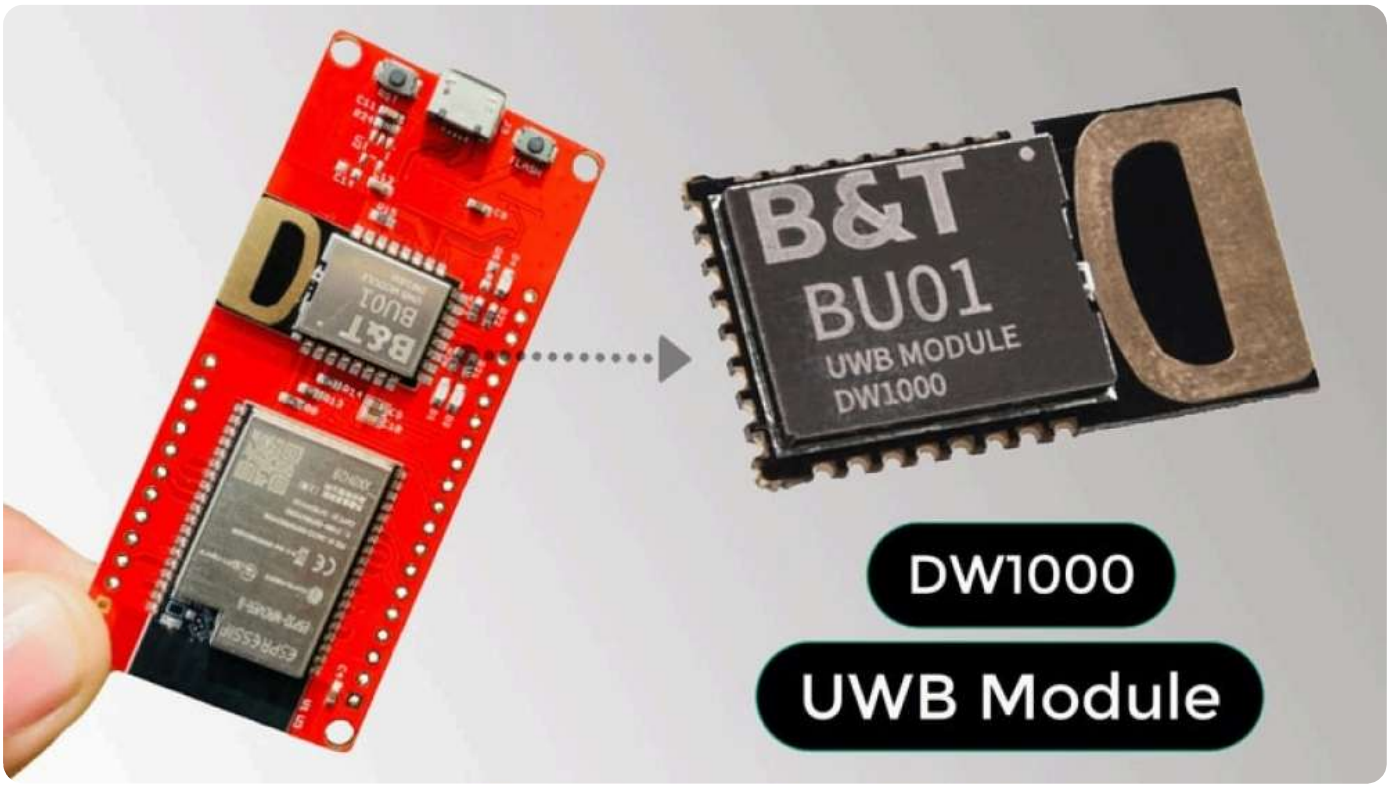


Overview

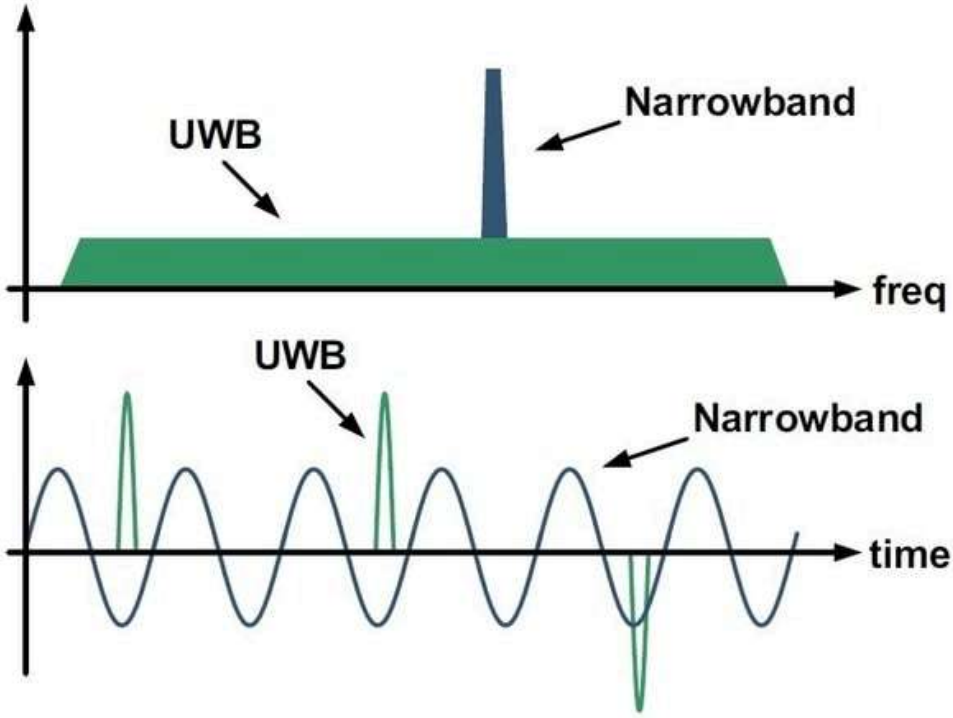
In this getting started tutorial, we will learn about the **Ultra Wideband Technology** using **ESP32 DW1000 UWB Module**. The UWB technology is a **wireless carrier communication technology** that uses a frequency bandwidth above 1 GHz. It does not use a sinusoidal carrier, but uses nanosecond-level non-sinusoidal narrow pulses to transmit data.

The **BU01** is developed by **Ai-Thinker** based on **DecaWave's DW1000 chip**, which integrates an antenna, all RF circuits, power management, and clock modules. **ESP32 UWB module** based on DW1000 and ESP32 is like a continuously scanning radar that can precisely lock onto another device, discover its **location**, and communicate with it.

In this tutorial, we will go through the board design, specifications, and applications. Then we will learn how to use the **ESP32 DW1000** embedded board for **object detection** and **ranging**. During range detection, there might be antenna delay issues leading to measuring incorrect distance. Therefore we will learn the method to fix the distance issue with the **Antenna delay calibrating** method.

What is Ultra Wideband?

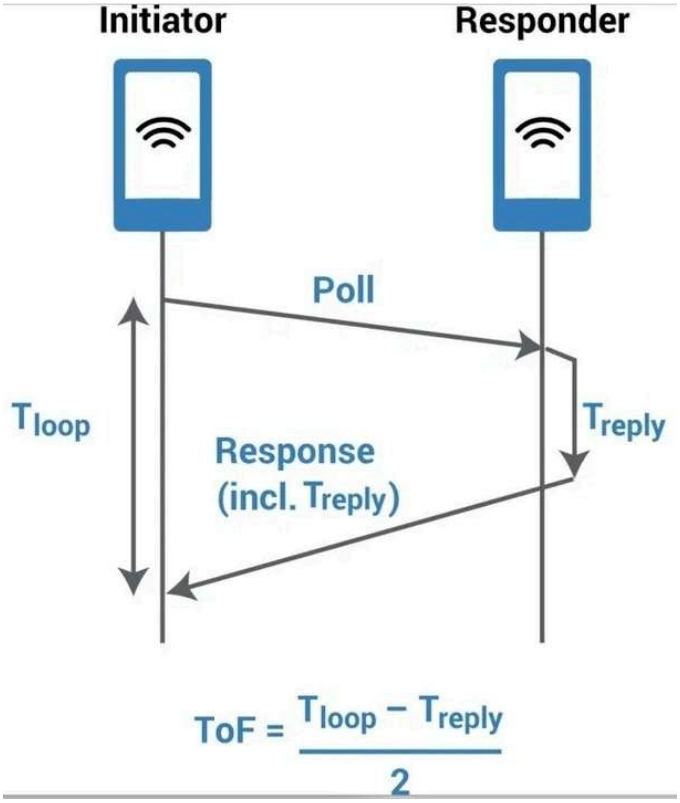
UWB is a short-range, wireless communication protocol similar to Bluetooth or Wi-Fi. It also uses radio waves for communication & operates at a very high frequency. As its name denotes, it also uses a wide spectrum of several GHz. One way to think of it is as a radar that can continuously scan an entire room and precisely lock onto an object like a laser beam to discover its location and communicate data.



The primary purpose of Ultra Wideband is location discovery and device ranging. While both Wi-Fi and Bluetooth have been modified to allow greater accuracy in locating other devices and connecting to them, UWB is natively more precise & uses less power.

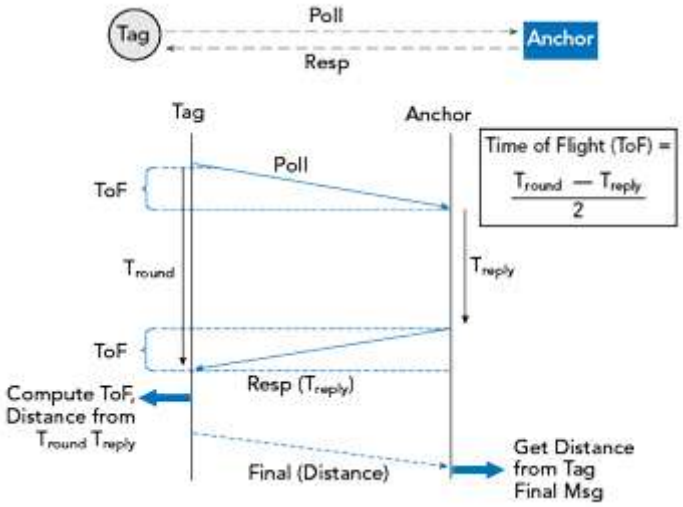
How does UWB work?

A UWB transmitter works by sending billions of pulses across the wide spectrum frequency. A corresponding receiver receives the signal, which translates the pulses into data by listening for a familiar pulse sequence sent by the transmitter. Pulses are sent about one every two nanoseconds, which helps UWB achieve its real-time accuracy.



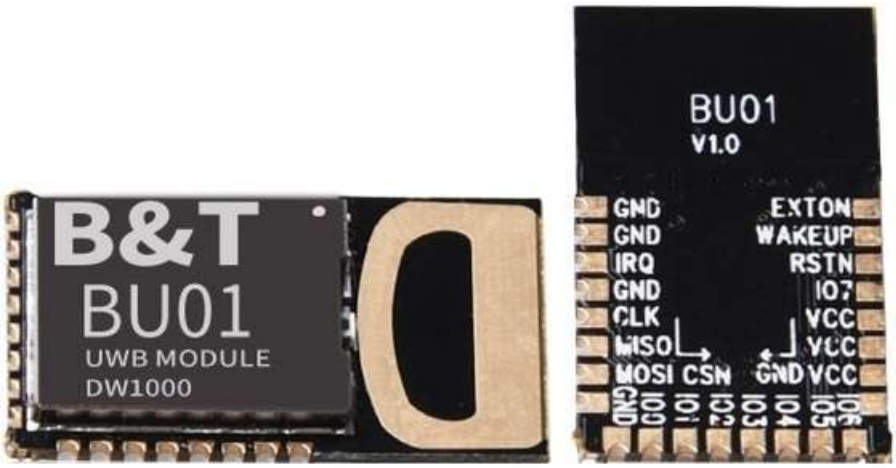
UWB is extremely low power. Its high bandwidth (500MHz) is ideal for relaying a lot of data from a host device to other devices up to about 30 feet away. Unlike Wi-Fi, it is not particularly good at transmitting through walls.

When a smartphone with a UWB chip comes close to another UWB device, the two starts ranging or measuring, their exact distance. The ranging is accomplished through “Time of Flight” (ToF) measurements between the devices. These are used to calculate the roundtrip time of challenge/response packets.



The concepts “anchor” and “tag” are important to understand distance and location measurement with UWB. An anchor is generally a fixed UWB device with a known location. A tag generally refers to a mobile UWB device. An anchor and tag exchange information to establish the distance between them. The exact location of a tag can be determined by communicating with multiple anchors. Some devices can act as either an anchor or tag.

DW1000 Based UWB Module BU01



The **BU01** module is developed by Ai-Thinker which is based on **DecaWave’s DW1000** chip. It integrates an antenna, all RF circuits, power management, and clock modules. The module can use two-way ranging or TDOA positioning system with a positioning accuracy of 10cm. The data transmission rate of up to 6.8Mbps.

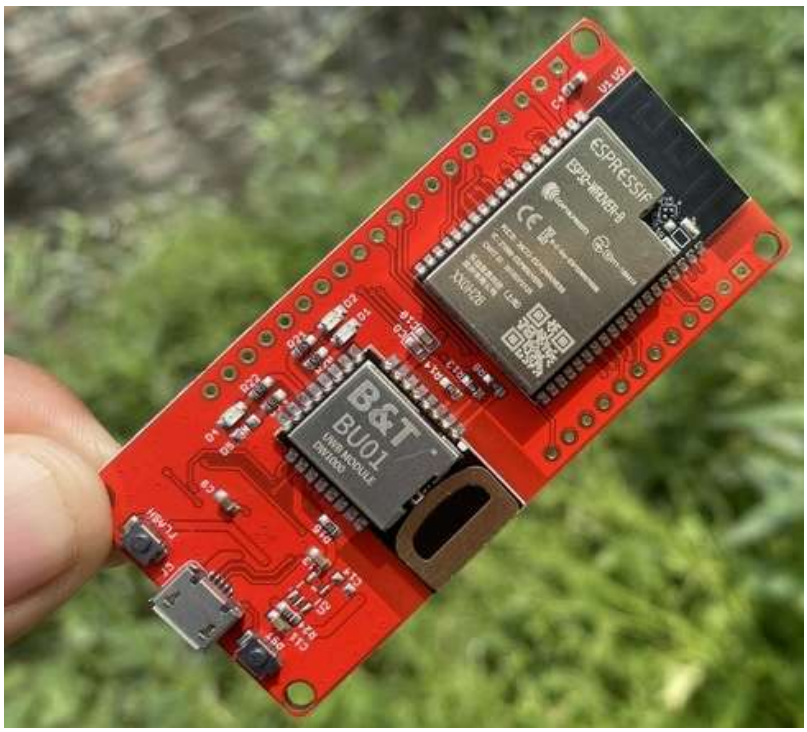
Features

- Simple integration, no RF design required
- Using RTLS infrastructure to expand the communication range
- Support high label density
- Comply with IEEE 802.15.4-2011 UWB standard

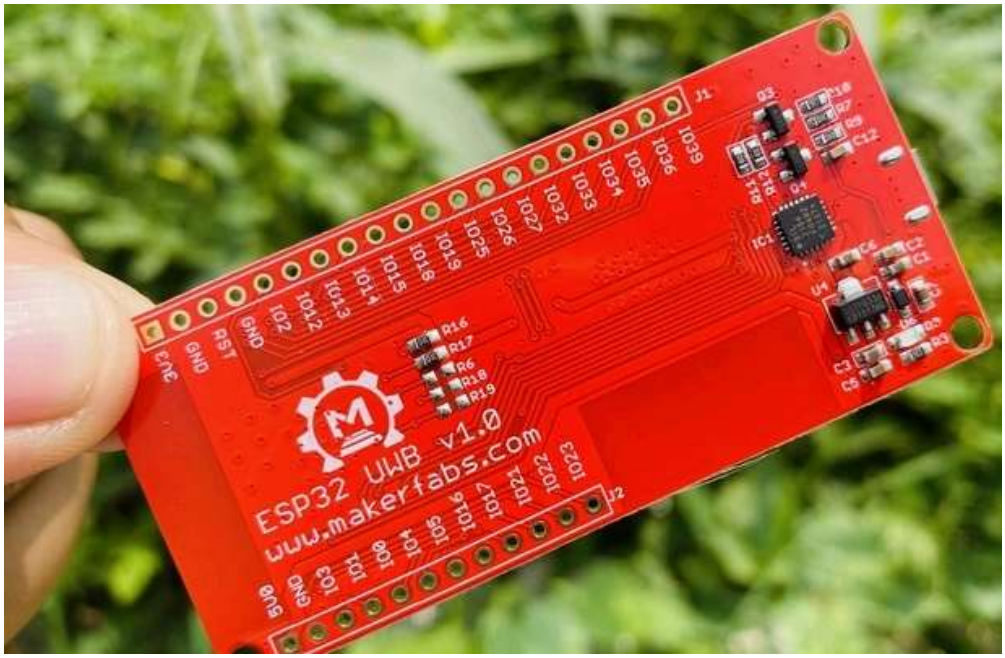
- Support 4 channels from 3.5 GHz to 6.5 GHz
- Programmable transmit power
- Power supply 2.8 V to 3.6 V
- Power consumption in sleep mode<1mA
- Support two-way ranging and TDOA
- Support SPI interface
- Data rate 110 kbps, 850 kbps, 6.8 Mbps

ESP32 UWB(Ultra Wideband) Board

The ESP32 UWB Ultra Wideband module is based on DW1000 and ESP32. This board is manufactured by **Makerfabs**. The BU01 Module based on DW1000 Chip is interfaced with ESP32 WiFi Module with I/O expansion. The board acts like a continuously scanning radar, that precisely locks onto another device (called Anchor) and communicates with it, thus calculating its own location.



The top side of the board has ESP32 WROOM/Wrover Module embedded with BU01 Module with other passive electronic components. There are two push buttons, one for flash and the other for rest. The board has a micro-USB port for uploading the firmware and Serial Communication.



On the backside of the board, there is CP2102 Chip for UART communication. The name of the input/output ports is also assigned on the board. The male or female headers can be soldered on both sides of the board. The board is breadboard friendly. Hence you can place it on a breadboard with other components during practical applications.

Features

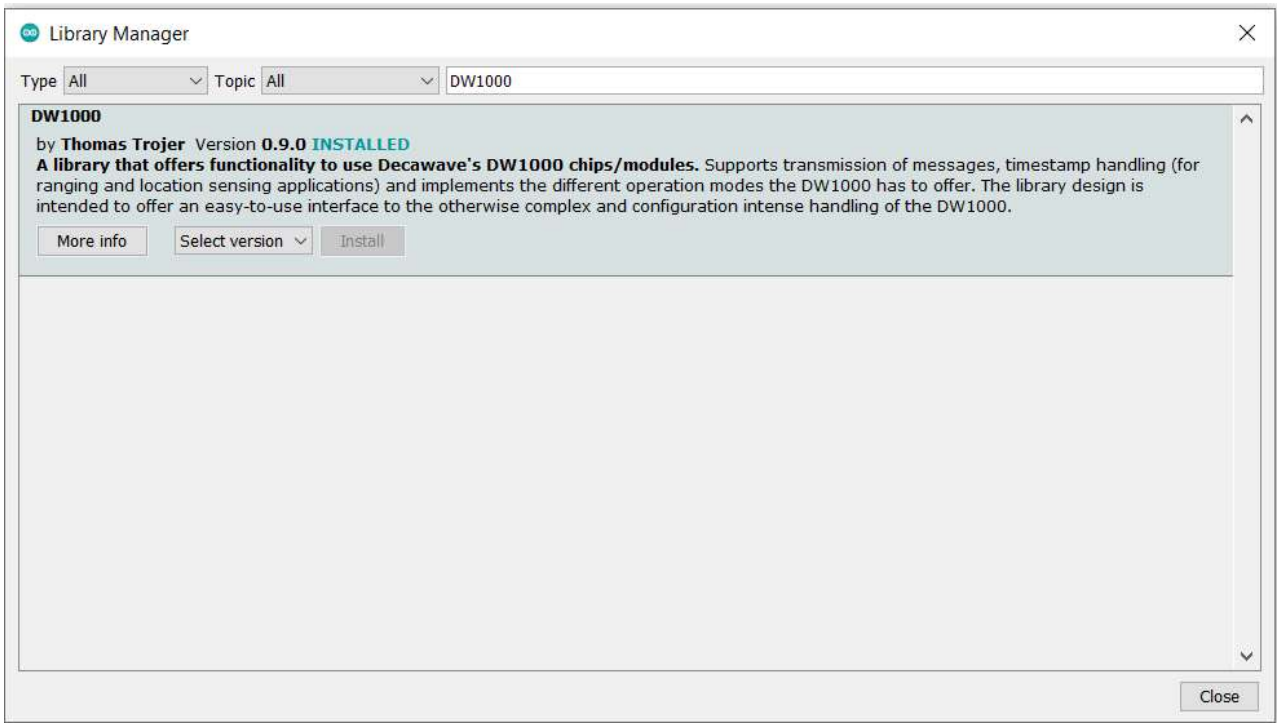
- Decawave DWM1000 for precision tracking
- ESP32 for fast & powerful applications
- Support Wifi, Bluetooth
- Arduino compatible
- Micro-USB connector
- Board USB supply voltage range: 4.8~5.5V, 5.0V Typical

Getting Started with ESP32 DW1000 UWB (Ultra Wideband) Module

Let's learn how we can use the ESP32 DW1000 UWB (Ultra Wideband) Board with Arduino IDE and measure the distance between the boards. For this project, you will need pair of boards. Then we need to go through a series of steps to use this Module.

Installing DW1000 Library

First we need to install **Arduino-DW1000 Library** from thotro. This library offers functionality to use Decawave's DW1000 chips/modules with Arduino.

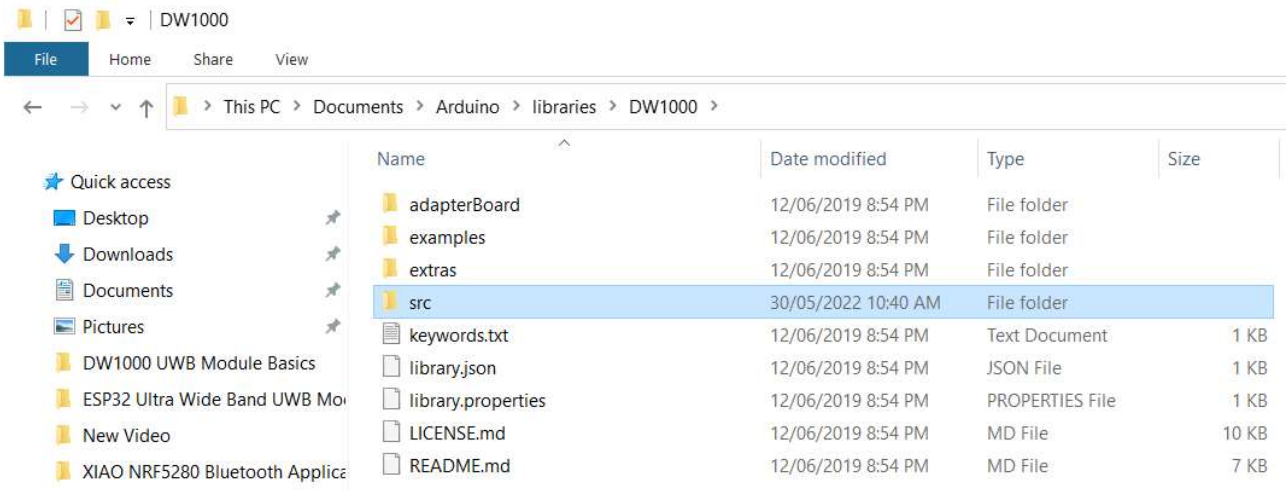


You can also install this library through the library manager. Just search for DW1000 and click on install to install the library.

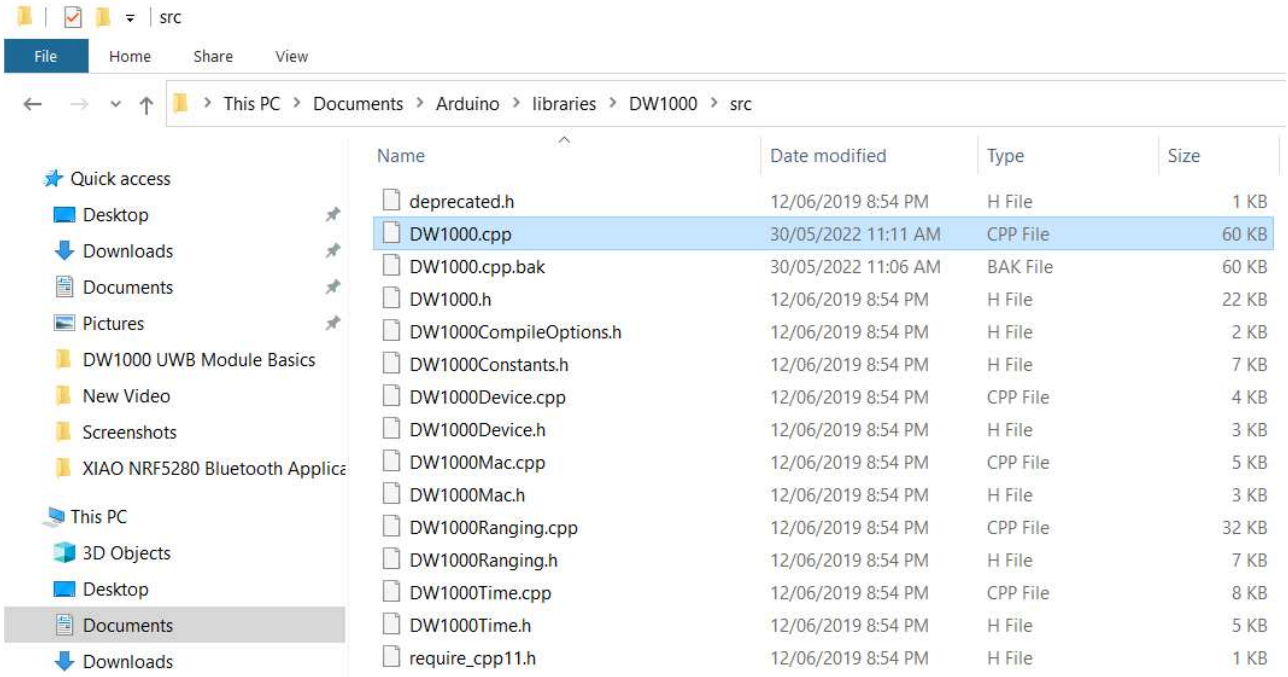
Modifying the Library

The **DW1000 UWB library** doesn't compile for ESP32 Boards directly. Therefore we need to make some modifications in the library part.

Go to the Arduino Library folder and look for **DW1000**. Then open the Library folder and look for the **source folder** (src).



Open the src folder and look for **DW1000.cpp** file. Open the file with some text editor like **Notepad++**.



Now look for the following lines (*Line No. 172*) and comment on all these 3 lines.

```
1 //#ifndef ESP8266
2     //  SPI.usingInterrupt(digitalPinToInterrupt(irq)); // not every board supp
3     //#endif
```

C:\Users\mamta\Documents\Arduino\libraries\DW1000\src\DW1000.cpp - Notepad++

File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?

pet_seed_final-1.ino | DW1000.cpp

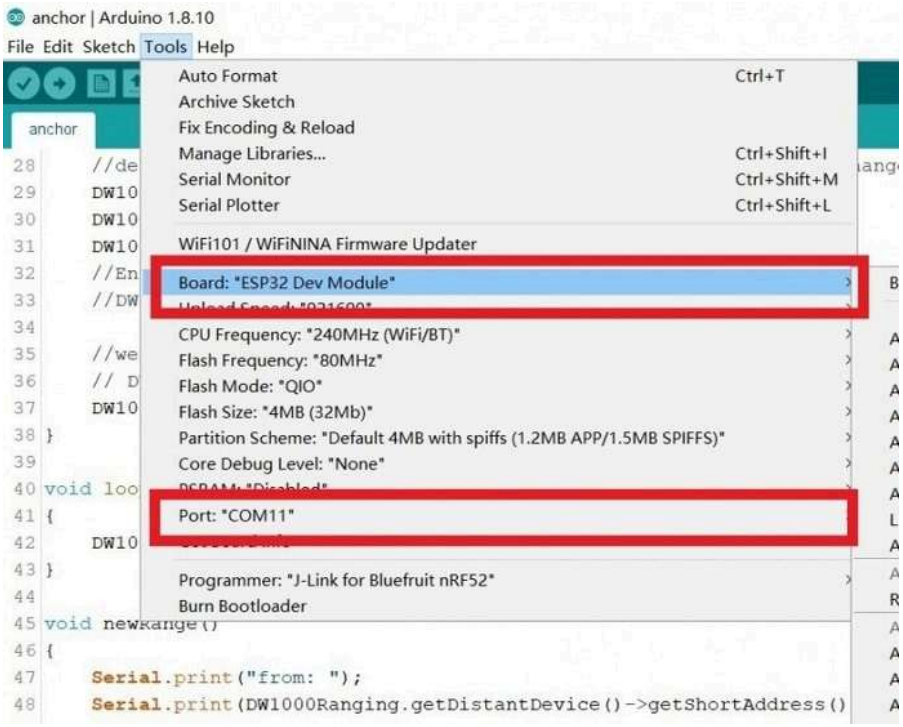
```
167     delay(5);
168     // Configure the IRQ pin as INPUT. Required for correct interrupt setting for ESP8266
169         pinMode(irq, INPUT);
170     // start SPI
171     SPI.begin();
172 //#ifndef ESP8266
173     //SPI.usingInterrupt(digitalPinToInterrupt(irq)); // not every board support this, e.g. ESP8266
174 //#endif
175     // pin and basic member setup
176     _rst        = rst;
177     _irq        = irq;
178     _deviceMode = IDLE_MODE;
179     // attach interrupt
180     //attachInterrupt(_irq, DW1000Class::handleInterrupt, CHANGE); // todo interrupt for ESP8266
181     // TODO throw error if pin is not a interrupt pin
182     attachInterrupt(digitalPinToInterrupt(_irq), DW1000Class::handleInterrupt, RISING); // todo inte
183 }
```

Once these lines are commented, the library code will successfully **compile**.

Board Selection

Connect the pair of **ESP32 Wrover Board** to the two different USB port of your computer with the help of micro-USB Cable.

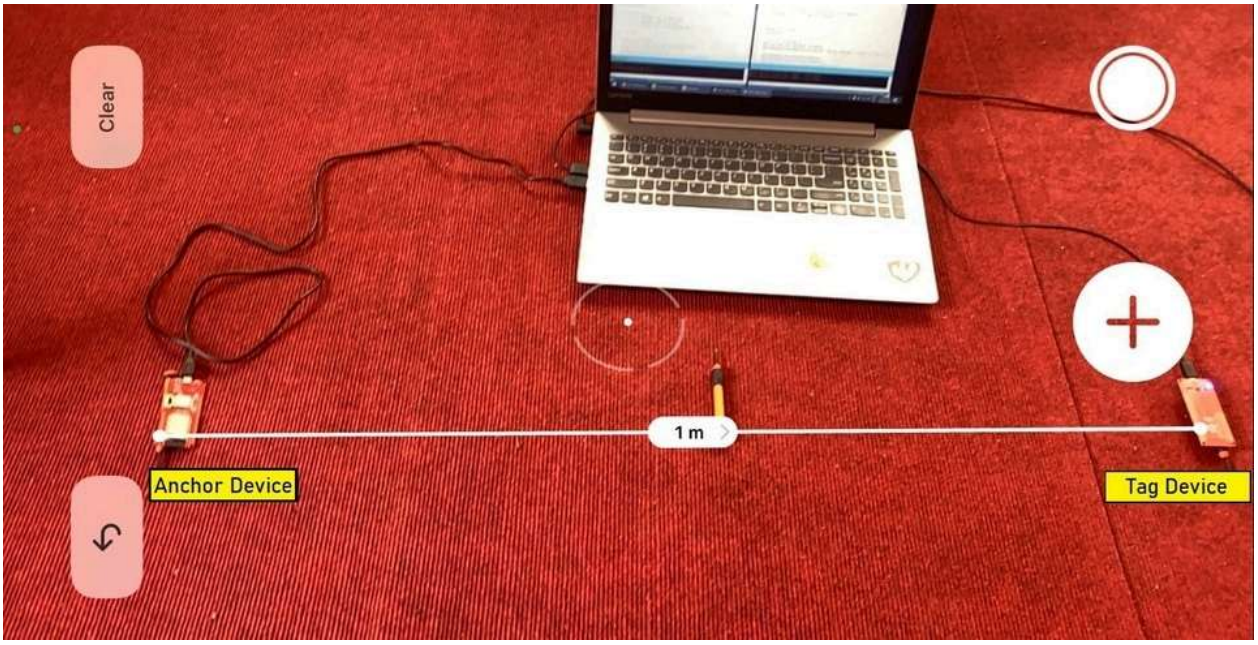
On your **Arduino IDE**, select the development board "**ESP32 Dev Module**" if you are using the ESP32 UWB Board with ESP32 WROOM Chip. Else select the "**ESP32 WROVER Module**", if you are using ESP32 UWB Board with ESP32 WROVER Chip.



Also select the **COM Port**. You can find the COM port from the device manager. Now the ESP32 Ultra Wideband Board is ready for Serial Communication.

How to use ESP32 UWB Module to measure the distance?

To measure the **distance** between the boards, we need to upload an "**Anchor**" code to one ESP32 Board and the "**Tag**" code to other ESP32 Board.



One of the board will act as an **Anchor (Sender)** and the other board will act as a **Tag (Receiver)**. According to UWB Standards, the Anchor should be **stationary** and the tag should be **movable**. For the test purpose, we are keeping the boards at a distance of **1 meter** from each other.

Anchor Code

Copy the following code and upload it to the first UWB(Ultra Wideband) Board.

```
#include <SPI.h>
#include "DW1000Ranging.h"     //https://github.com/thotro/arduino-dw1000

#define ANCHOR_ADD "83:17:5B:D5:A9:9A:E2:9C"

#define SPI_SCK 18
#define SPI_MISO 19
#define SPI_MOSI 23
#define DW_CS 4

// connection pins
const uint8_t PIN_RST = 27; // reset pin
const uint8_t PIN_IRQ = 34; // irq pin
const uint8_t PIN_SS = 4;   // spi select pin
```

```
15
16 void setup()
17 {
18     Serial.begin(115200);
19     delay(1000);
20     //init the configuration
21     SPI.begin(SPI_SCK, SPI_MISO, SPI_MOSI);
22     DW1000Ranging.initCommunication(PIN_RST, PIN_SS, PIN_IRQ); //Reset, CS, IR
23     //define the sketch as anchor. It will be great to dynamically change the
24     DW1000Ranging.attachNewRange(newRange);
25     DW1000Ranging.attachBlinkDevice(newBlink);
26     DW1000Ranging.attachInactiveDevice(inactiveDevice);
27     //Enable the filter to smooth the distance
28     //DW1000Ranging.useRangeFilter(true);
29
30     //we start the module as an anchor
31     // DW1000Ranging.startAsAnchor("82:17:5B:D5:A9:9A:E2:9C", DW1000.MODE_LONG
32
33     DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_LONGDATA_RANGE_LOWPOWE
34     // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_SHORTDATA_FAST_LOWP
35     // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_LONGDATA_FAST_LOWPO
36     // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_SHORTDATA_FAST_ACCU
37     // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_LONGDATA_FAST_ACCUR
38     // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_LONGDATA_RANGE_ACCU
39 }
40
41 void loop()
42 {
43     DW1000Ranging.loop();
44 }
45
46 void newRange()
47 {
48     Serial.print("from: ");
49     Serial.print(DW1000Ranging.getDistantDevice()->getShortAddress(), HEX);
50     Serial.print("\t Range: ");
51     Serial.print(DW1000Ranging.getDistantDevice()->getRange());
52     Serial.print(" m");
53     Serial.print("\t RX power: ");
54     Serial.print(DW1000Ranging.getDistantDevice()->getRXPower());
55     Serial.println(" dBm");
56 }
57
58 void newBlink(DW1000Device *device)
```

```
{
    Serial.print("blink; 1 device added ! -> ");
    Serial.print(" short:");
    Serial.println(device->getShortAddress(), HEX);
}

void inactiveDevice(DW1000Device *device)
{
    Serial.print("delete inactive device: ");
    Serial.println(device->getShortAddress(), HEX);
}
```

Tag Code

Copy the following code and upload it to the second UWB(Ultra Wideband) Board.

```
#include <SPI.h>
#include "DW1000Ranging.h"

#define SPI_SCK 18
#define SPI_MISO 19
#define SPI_MOSI 23
#define DW_CS 4

// connection pins
const uint8_t PIN_RST = 27; // reset pin
const uint8_t PIN_IRQ = 34; // irq pin
const uint8_t PIN_SS = 4;   // spi select pin

void setup()
{
    Serial.begin(115200);
    delay(1000);
    //init the configuration
    SPI.begin(SPI_SCK, SPI_MISO, SPI_MOSI);
    DW1000Ranging.initCommunication(PIN_RST, PIN_SS, PIN_IRQ); //Reset, CS, IR
    //define the sketch as anchor. It will be great to dynamically change the
    DW1000Ranging.attachNewRange(newRange);
    DW1000Ranging.attachNewDevice(newDevice);
    DW1000Ranging.attachInactiveDevice(inactiveDevice);
    //Enable the filter to smooth the distance
```

```
    //DW1000Ranging.useRangeFilter(true);

    //we start the module as a tag
    DW1000Ranging.startAsTag("7D:00:22:EA:82:60:3B:9C", DW1000.MODE_LONGDATA_R
}

void loop()
{
    DW1000Ranging.loop();
}

void newRange()
{
    Serial.print("from: ");
    Serial.print(DW1000Ranging.getDistantDevice()->getShortAddress(), HEX);
    Serial.print("\t Range: ");
    Serial.print(DW1000Ranging.getDistantDevice()->getRange());
    Serial.print(" m");
    Serial.print("\t RX power: ");
    Serial.print(DW1000Ranging.getDistantDevice()->getRXPower());
    Serial.println(" dBm");
}

void newDevice(DW1000Device *device)
{
    Serial.print("ranging init; 1 device added ! -> ");
    Serial.print(" short:");
    Serial.println(device->getShortAddress(), HEX);
}

void inactiveDevice(DW1000Device *device)
{
    Serial.print("delete inactive device: ");
    Serial.println(device->getShortAddress(), HEX);
}
```

Testing Range Between the Boards

Once, the code is uploaded on **Anchor** and **tag** boards, you can open both the Serial Monitor. The **Serial Monitor** will show the anchor and tag **ID**. It will also show the **range** in meters and

Receiver power in dBm.

According to our setup, we have placed the anchor and tag at a distance of **1 meter** from each other but the Serial Monitor shows a distance above 2 meters.

From here we can say, the measured distance is incorrect. This is because of the **Antenna Delay problem**. The DW1000 Antenna delay is internal to the chip and not included in the **Time of Flight (TOF) calculation**. Thus we need to **calibrate** this Antenna Delay issue.

What is Antenna Delay of DW1000?

DecaWave's DW1000, a multi-channel transceiver based on Ultra Wideband (UWB) radio communications, allows very accurate time-stamping of messages as they leave from and arrive at the transceiver.

The delays which are measured in these timestamps include the propagation delay through the DW1000 devices from the points at which the transmitter timestamps are applied to the points at which the receiver timestamps are captured. These delays are referred to as the transmit/receive antenna delays.

These antenna delays are internal to the chip and not included in the Time of Flight (ToF) but are included in the propagation delay from transmission timestamp to receive message timestamp.

$$tMeasured = tADTX + ToF + tADRX$$

where:

ToF = *Time of Flight*

tMeasured = *The measured time from the transmit timestamp to the receive timestamp*

tADTX = *Transmit antenna delay*

tADRX = *Receive antenna delay*

The internal propagation delays in DW1000 devices vary slightly from chip to chip. There can also be variations due to components between DW1000 and the antenna. Since we are measuring RF signals moving at the speed of light these variations can make differences to ranging measurements in the tens of centimeters. Antenna delay calibration is used to remove these variations.

Antenna Delay Calibration of DW1000

To fix the Antenna Delay issue the above **Thomas Trojer's DW1000** library is modified by Jim Remington.

The updated DW1000 library from Jim can be downloaded from **jremington Github** repository. With the antenna calibration, the distance measuring seems more accurate.

Delete the old DW1000 library from the Arduino Library folder and add the latest downloaded jremington DW1000 library file to the Arduino library folder.

ESP32 Anchor Autocalibrate Code

Copy the following code and upload it to the first ESP32 UWB Board.

In the following code, make changes to the following line:

```
float this_anchor_target_distance = 1; //measured distance to anchor in m
```

Replace the distance at which you are calibrating.

```
#include <SPI.h>
#include "DW1000Ranging.h"
#include "DW1000.h"

// ESP32_UWB pin definitions

#define SPI_SCK 18
#define SPI_MISO 19
#define SPI_MOSI 23
#define DW_CS 4

// connection pins
const uint8_t PIN_RST = 27; // reset pin
const uint8_t PIN_IRQ = 34; // irq pin
const uint8_t PIN_SS = 4;   // spi select pin


```

```
18 char this_anchor_addr[] = "84:00:22:EA:82:60:3B:9C";
19 float this_anchor_target_distance = 1; //measured distance to anchor in m
20
21 uint16_t this_anchor_Adelay = 16600; //starting value
22 uint16_t Adelay_delta = 100; //initial binary search step size
23
24
25 void setup()
26 {
27   Serial.begin(115200);
28   while (!Serial);
29   //init the configuration
30   SPI.begin(SPI_SCK, SPI_MISO, SPI_MOSI);
31   DW1000Ranging.initCommunication(PIN_RST, PIN_SS, PIN_IRQ); //Reset, CS, IRQ
32
33
34   Serial.print("Starting Adelay "); Serial.println(this_anchor_Adelay);
35   Serial.print("Measured distance "); Serial.println(this_anchor_target_dista
36
37   DW1000.setAntennaDelay(this_anchor_Adelay);
38
39   DW1000Ranging.attachNewRange(newRange);
40   DW1000Ranging.attachNewDevice(newDevice);
41   DW1000Ranging.attachInactiveDevice(inactiveDevice);
42   //Enable the filter to smooth the distance
43   //DW1000Ranging.useRangeFilter(true);
44
45   //start the module as anchor, don't assign random short address
46   DW1000Ranging.startAsAnchor(this_anchor_addr, DW1000.MODE_LONGDATA_RANGE_LO
47
48 }
49
50 void loop()
51 {
52   DW1000Ranging.loop();
53 }
54
55 void newRange()
56 {
57   static float last_delta = 0.0;
58   Serial.print(DW1000Ranging.getDistantDevice()->getShortAddress(), DEC);
59
60   float dist = 0;
61   for (int i = 0; i < 100; i++) {
```

```
    // get and average 100 measurements
    dist += DW1000Ranging.getDistantDevice()->getRange();
  }
  dist /= 100.0;
  Serial.print(",");
  Serial.print(dist);
  if (Adelay_delta < 3) {
    Serial.print(", final Adelay ");
    Serial.println(this_anchor_Adelay);
//    Serial.print("Check: stored Adelay = ");
//    Serial.println(DW1000.getAntennaDelay());
    while(1);  //done calibrating
  }

  float this_delta = dist - this_anchor_target_distance;  //error in measured

  if ( this_delta * last_delta < 0.0) Adelay_delta = Adelay_delta / 2; //sign
    last_delta = this_delta;

  if (this_delta > 0.0 ) this_anchor_Adelay += Adelay_delta; //new trial Adel
  else this_anchor_Adelay -= Adelay_delta;

  Serial.print(", Adelay = ");
  Serial.println (this_anchor_Adelay);
//  DW1000Ranging.initCommunication(PIN_RST, PIN_SS, PIN_IRQ); //Reset, CS, I
  DW1000.setAntennaDelay(this_anchor_Adelay);
}

void newDevice(DW1000Device *device)
{
  Serial.print("Device added: ");
  Serial.println(device->getShortAddress(), HEX);
}

void inactiveDevice(DW1000Device *device)
{
  Serial.print("delete inactive device: ");
  Serial.println(device->getShortAddress(), HEX);
}
```

ESP32 UWB Setup Tag Code

Copy the following code and upload it to the second ESP32 UWB Board.

```
#include <SPI.h>
#include "DW1000Ranging.h"
#include "DW1000.h"

#define SPI_SCK 18
#define SPI_MISO 19
#define SPI_MOSI 23
#define DW_CS 4

// connection pins
const uint8_t PIN_RST = 27; // reset pin
const uint8_t PIN_IRQ = 34; // irq pin
const uint8_t PIN_SS = 4;   // spi select pin

// TAG antenna delay defaults to 16384
// leftmost two bytes below will become the "short address"
char tag_addr[] = "7D:00:22:EA:82:60:3B:9C";

void setup()
{
  Serial.begin(115200);
  delay(1000);

  //init the configuration
  SPI.begin(SPI_SCK, SPI_MISO, SPI_MOSI);
  DW1000Ranging.initCommunication(PIN_RST, PIN_SS, PIN_IRQ); //Reset, CS, IRQ p

  DW1000Ranging.attachNewRange(newRange);
  DW1000Ranging.attachNewDevice(newDevice);
  DW1000Ranging.attachInactiveDevice(inactiveDevice);

// start as tag, do not assign random short address

  DW1000Ranging.startAsTag(tag_addr, DW1000.MODE_LONGDATA_RANGE_LOWPOWER, fals
}

void loop()
{
  DW1000Ranging.loop();
}

void newRange()
```

```
{
  Serial.print(DW1000Ranging.getDistantDevice()->getShortAddress(), HEX);
  Serial.print(",");
  Serial.println(DW1000Ranging.getDistantDevice()->getRange());
}

void newDevice(DW1000Device *device)
{
  Serial.print("Device added: ");
  Serial.println(device->getShortAddress(), HEX);
}

void inactiveDevice(DW1000Device *device)
{
  Serial.print("delete inactive device: ");
  Serial.println(device->getShortAddress(), HEX);
}
```

Calculating the Adelay Parameter

After uploading the code, open the both Serial Monitor. Place the module at a fix distance of **1 meter**. Then press the reset button.

The **DW1000 Antenna Delay Calibration** factor called **Adelay** can be determined from the code. In the Serial Monitor, the **Adelay factor** is something like **16586**. Copy this number as it is required in the final Code.

Measuring the distance Accurately with Adelay inclusion

Now the **DW1000 Antenna Delay Calibration factor** called **Adelay** is determined. Therefore, we need to upload the **final code** to the Anchor board. The code for tag remains the same.

ESP32 UWB Setup Anchor Code

The code needs modification in these two lines.

```
uint16_t Adelay = 16611;
float dist_m = 1; //meters
```

Replace the **Adelay** factor in the code and also mention the **distance** at which you found the factor.

```
#include <SPI.h>
#include "DW1000Ranging.h"
#include "DW1000.h"

// leftmost two bytes below will become the "short address"
char anchor_addr[] = "84:00:5B:D5:A9:9A:E2:9C"; //#4

//calibrated Antenna Delay setting for this anchor
uint16_t Adelay = 16611;

// previously determined calibration results for antenna delay
// #1 16630
// #2 16610
// #3 16607
// #4 16580

// calibration distance
```

```
18 float dist_m = 1; //meters
19
20 #define SPI_SCK 18
21 #define SPI_MISO 19
22 #define SPI_MOSI 23
23 #define DW_CS 4
24
25 // connection pins
26 const uint8_t PIN_RST = 27; // reset pin
27 const uint8_t PIN_IRQ = 34; // irq pin
28 const uint8_t PIN_SS = 4;   // spi select pin
29
30 void setup()
31 {
32   Serial.begin(115200);
33   delay(1000); //wait for serial monitor to connect
34   Serial.println("Anchor config and start");
35   Serial.print("Antenna delay ");
36   Serial.println(Adelay);
37   Serial.print("Calibration distance ");
38   Serial.println(dist_m);
39
40   //init the configuration
41   SPI.begin(SPI_SCK, SPI_MISO, SPI_MOSI);
42   DW1000Ranging.initCommunication(PIN_RST, PIN_SS, PIN_IRQ); //Reset, CS, IRQ
43
44   // set antenna delay for anchors only. Tag is default (16384)
45   DW1000.setAntennaDelay(Adelay);
46
47   DW1000Ranging.attachNewRange(newRange);
48   DW1000Ranging.attachNewDevice(newDevice);
49   DW1000Ranging.attachInactiveDevice(inactiveDevice);
50
51   //start the module as an anchor, do not assign random short address
52   DW1000Ranging.startAsAnchor(anchor_addr, DW1000.MODE_LONGDATA_RANGE_LOWPOWER
53   // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_SHORTDATA_FAST_LOWPOW
54   // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_LONGDATA_FAST_LOWPOWE
55   // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_SHORTDATA_FAST_ACCURA
56   // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_LONGDATA_FAST_ACCURAC
57   // DW1000Ranging.startAsAnchor(ANCHOR_ADD, DW1000.MODE_LONGDATA_RANGE_ACCURA
58 }
59
60 void loop()
61 {
```

```
  DW1000Ranging.loop();
}

void newRange()
{
  //    Serial.print("from: ");
  Serial.print(DW1000Ranging.getDistantDevice()->getShortAddress(), HEX);
  Serial.print(", ");

#define NUMBER_OF_DISTANCES 1
  float dist = 0.0;
  for (int i = 0; i < NUMBER_OF_DISTANCES; i++) {
    dist += DW1000Ranging.getDistantDevice()->getRange();
  }
  dist = dist/NUMBER_OF_DISTANCES;
  Serial.println(dist);
}

void newDevice(DW1000Device *device)
{
  Serial.print("Device added: ");
  Serial.println(device->getShortAddress(), HEX);
}

void inactiveDevice(DW1000Device *device)
{
  Serial.print("Delete inactive device: ");
  Serial.println(device->getShortAddress(), HEX);
}
```

Testing the Final Code

After uploading the new code in the Anchor part, open the Serial Monitor. As the anchor and tag both are placed at a distance of **1 meters** from each other, the Serial Monitor should show 1 meter distance.

Now let us do some other testing by moving the tag to half a meter distance from the anchor.

At this instance the Serial Monitor will show a distance of around **0.5 meters** which seems nearly accurate.

With a proper **Adelay set**, the measurement accuracy could be improved greatly. So, this is how you can Get Started with **ESP32 UWB (Ultra Wideband) Board** and measure the **distance**.

Video Tutorial & Guide

Getting Started with ESP32 DW1000 UWB (Ultra Wideband) Module | Short Range Detection

Watch this video on YouTube.

You may also refer to some of our articles related to **UWB Technology** using **DW1000/300 Chip** to have a more clear understanding:

- **ESP32 DW1000 UWB Indoor Location Positioning System**
- **Ranging & Localization with ESP32 UWB DW3000 Module**
- **ESP32 UWB Pro – Ultra Wideband Module with Amplifier**
- **ESP32 DW3000 UWB Module Achieving 500m Range**

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