Version	EFF. Date	Author	Description
A1	03/07/2025	Xin Genghui;	Created
A2	04/23/2025	Xin Genghui, LiuCheng	1: Modify the interface line sequence and swap the positions of Rx and Tx 2: Add Snuber RC to solve EMC issues 3: Add shielding cover to solve EMC problems 4: Modify the antenna gain graph from normalized gain to actual gain

Catalogue

1. UWB Dongle module Hardware introduction

As the base station in the UWB module, UWB_TR1_2RF-V80-3.4 integrates RF, analog, modem, and CPU subsystems. The main features of the module are as follows:

Dimensions:

80.00mm x 30.00 mm

RF/Analog：

Support frequency band channel 9 (7987.2 MHz)
Ultra wideband transceiver using 1T2R structure
Integrate all RF switches & Balun into the device
Integrated DCDC, ultra-high efficiency
Few external BoM components, ultra-low power consumption

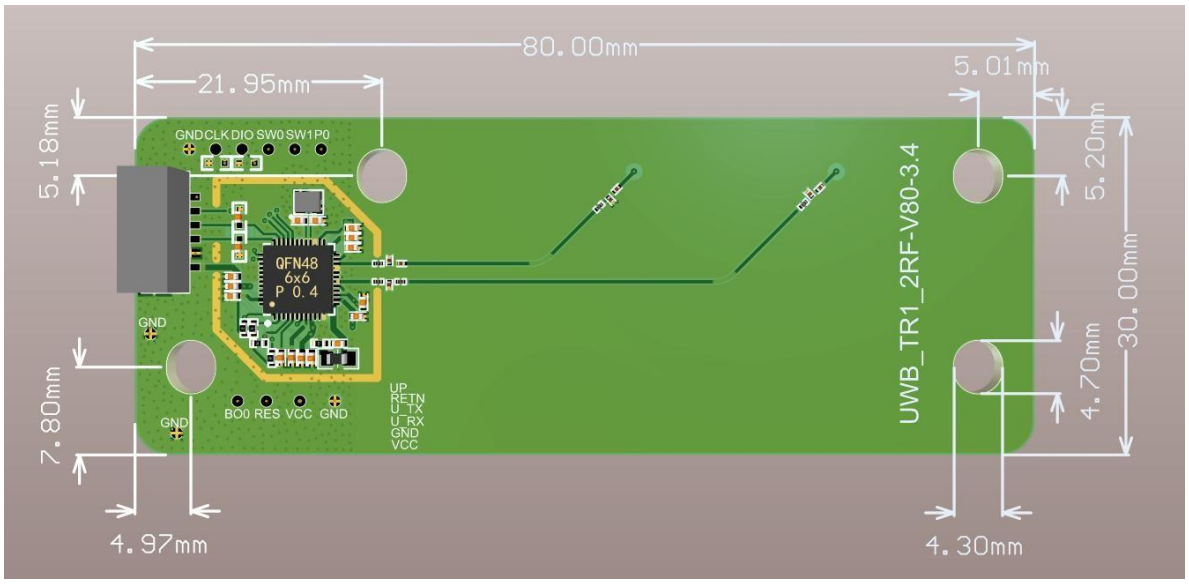
Modem：

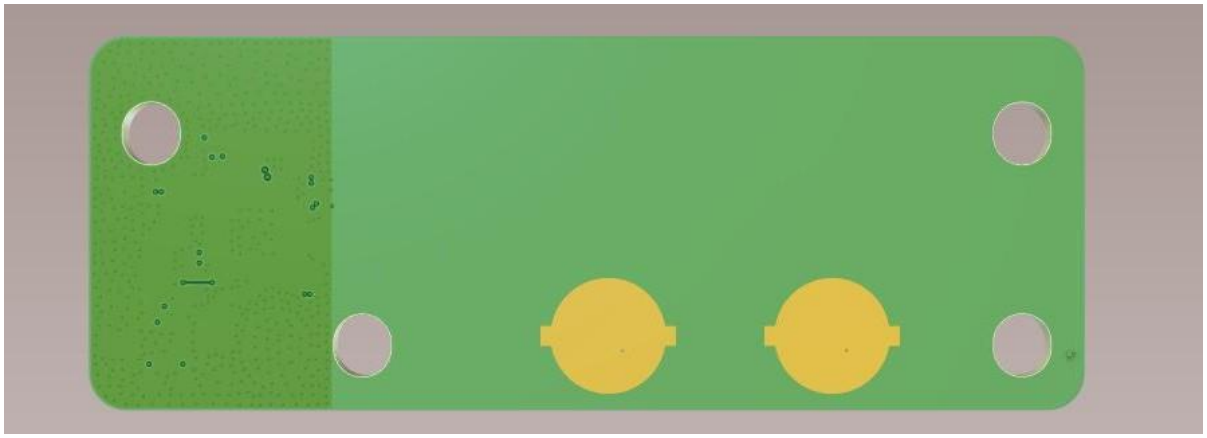
IEEE802.15.4z compatible
BRRF: 62.4MHz PRF
HPRF: 124.8MHz and 249.6MHz
Supports message lengths ranging from 0 to 1023 bytes
Support bidirectional ranging SS-TWR, DS-TWR;
Support bidirectional angle measurement PDoA, 3D AoA
Support static and dynamic STS
Integrated hardware encryption module, supporting AES 128/256
Data rate: 850Kbps, 6.8Mbps, and 54.4Mbps.

CPU System:

Support DMA
8K D-Cache + 8K I-Cache 64KB ROM
256KB RAM
Built in 512KB FLASH
2K bits EFUSE
Peripherals include SPI, I2C, SWD, UART, WDT, TIMER
Supports internal 13KHz OSC or external 32KHz Crystals in sleep mode, with a maximum frequency of 124.8MHz in working mode

2. UWB module size and pin definition





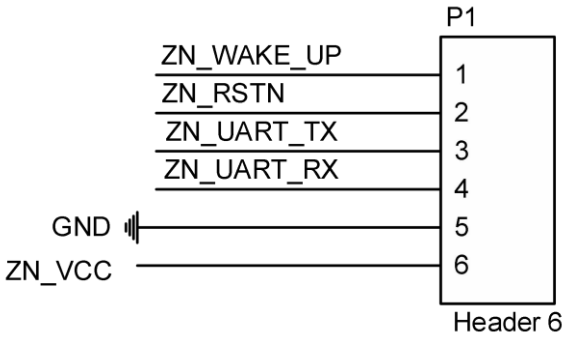


Table 2.1 Module Pin Definitions

Pin	Definition	Type	Description
1	ZN_WAKE_UP	I/O	Wake-up pin
2	ZN_RSTN	I/O	Reset, low effectiveness
3	ZN_UART_TX	I/O	UART TX or regular IO use
4	ZN_UART_RX	I/O	UART RX or regular IO use
5	GND	GND	Ground
6	ZN_VCC	Power	Power supply，3.3V

3. Electrical parameters of UWB module

3.1 Working conditions

Table 3.1 Recommended working conditions

Rating	Min	Type	Max	Unit
Supply Voltage VBAT	-0.3	3.3	3.6	V
Temperature – Storage temperature	-55	-	+150	℃
ESD (Human Body Model)			2000	V
ESD (Charge Device Model)			500	V

3.2 Positioning Function

Table 3 2. Positioning accuracy

Parameter	Test Conditions	Min	Max	Unit
Ranging accuracy	In line of sight conditions	-5	+5	cm
Ranging standard deviation	In line of sight conditions	-3	+3	cm
Angle accuracy	In line of sight conditions	-5	+5	°
Angle standard deviation	In line of sight conditions	-3	+3	°

4. Passive testing of UWB module onboard antenna

4.1 Testing Environment and Method

Testing site and testing instruments used：

1. Antenna test site

Using far-field measurement method in a microwave anechoic chamber, the antenna is installed at a height of 2 meters and the testing distance is about 5 meters. It is installed on the anechoic chamber test turntable and leveled by laser aiming. The tested antenna is the transmitting antenna, and the probe receives the transmitted signal.

After the antenna setup adjustment is completed, start the far-field measurement and testing software, set the required parameters, conduct testing, and automatically record and save the far-field data of the

tested antenna. The test system configuration diagram is shown in Figure A1.

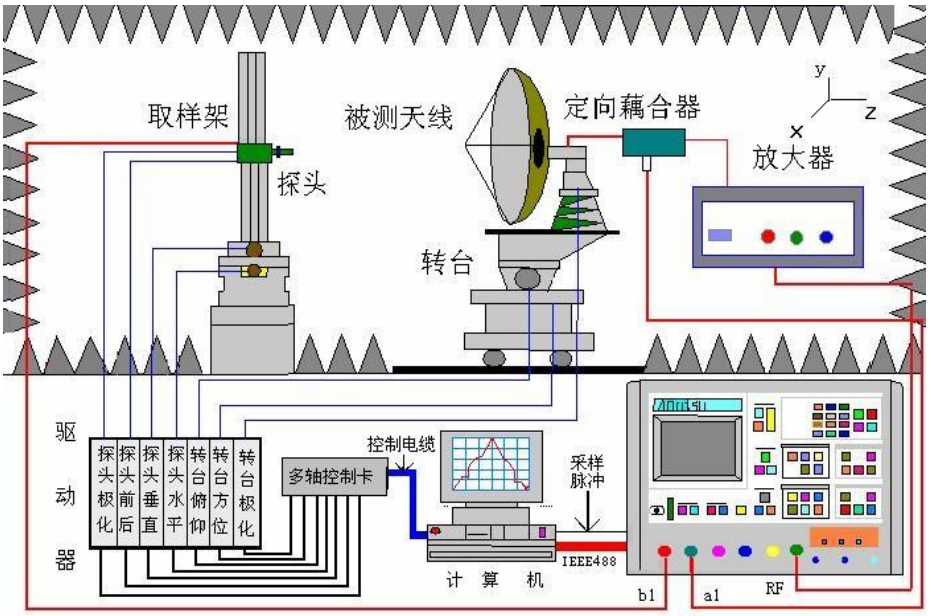


Figure A1 Test system configuration diagram

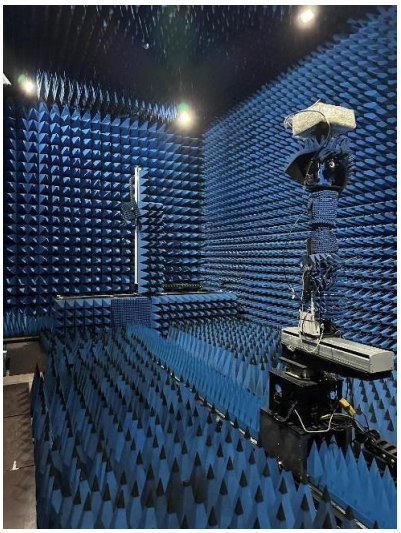
2. Test instruments and equipment

Microwave receiver：HP 8530A；

Signal source：Agilent 83630B；

Test frequency range：10MHz~26.5GHz；

Test using antennas: standard probe, standard horn antenna; All equipment used is within the valid measurement period



Antenna test method

1. Test Procedure

First, measure the receiving level of the standard antenna. While keeping the standard probe and antenna at the same height, test the maximum receiving level of the standard antenna and record its value. The standard antennas are standard horn antennas and standard spiral antennas.

The state of the transmitting antenna remains unchanged, and the tested antenna is vertically placed at the same position as the testing standard antenna for measurement, while keeping the standard probe and the tested antenna at the same height. This is equivalent to testing the receiving level of the tested antenna in all directions in the horizontal plane, and recording the maximum receiving level of the tested antenna in each horizontal plane.

The transmitting antenna undergoes polarization transformation, and the tested antenna is placed horizontally at the same position as the standard antenna being tested, while maintaining the same height as the standard probe and the tested antenna. The receiving levels of the tested antenna in all directions are tested relative to each other.

2. Gain test: using comparative method

The standard antenna gain is read separately from the frequency division points of the standard horn and standard spiral gain curves. The measured antenna gain is the measured antenna gain. The calculation formula is as follows:

$$G_{被测}(dBi) = P_{最大}(dB) - P_{标准}(dB) + G_{标准}(dBi)$$

Where: $G_{被测}(dBi)$--- Tested antenna gain;

$P_{最大}(dB)$--- Receiving level of the tested antenna;

$P_{标准}(dB)$--- Standard antenna receives maximum voltage level;

$G_{标准}(dBi)$--- Standard antenna gain

3. Voltage standing wave ratio test

Before testing, calibrate according to the standard specifications for measuring voltage standing wave ratio using a vector network analyzer. Then, test the voltage standing wave ratio of the antenna when it is in operation and record the voltage standing wave ratio at each frequency point.

4.2 Test result

4.2.1 Standing Wave Ratio

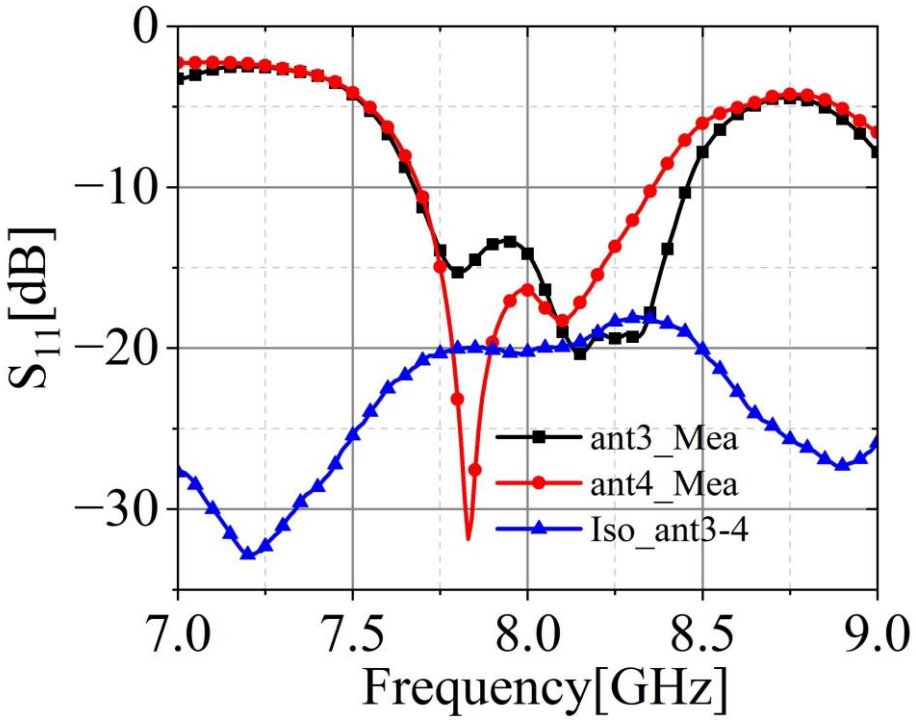
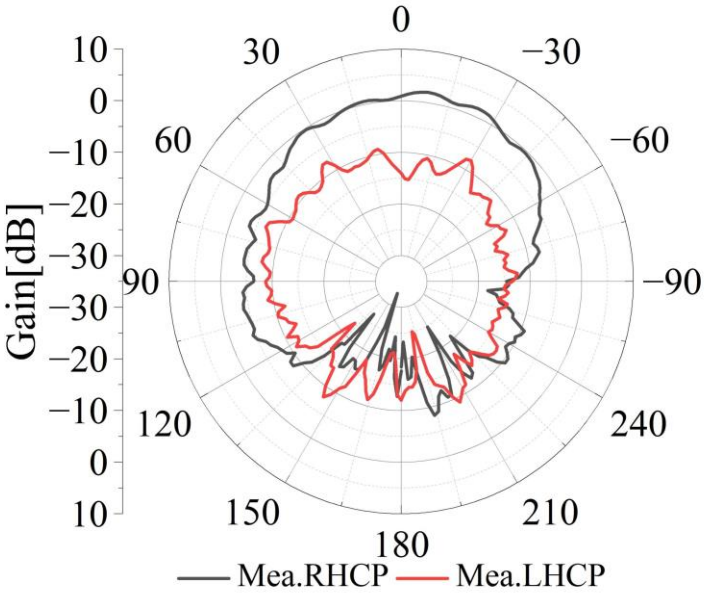


Figure 1 S parameter test results

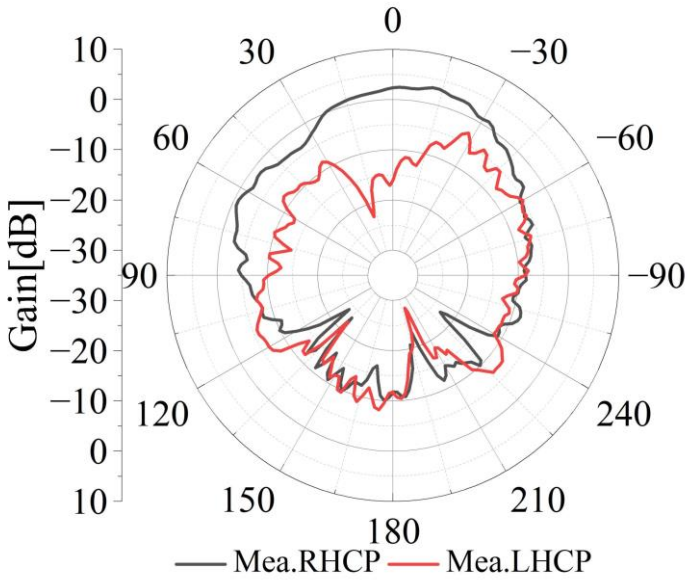
4.2.2 Direction diagram

The radiation pattern of the antenna was tested, and the main polarization and cross polarization of XOZ and YOZ planes were tested for each port. The pattern of each port was the same as that at 8GHz.



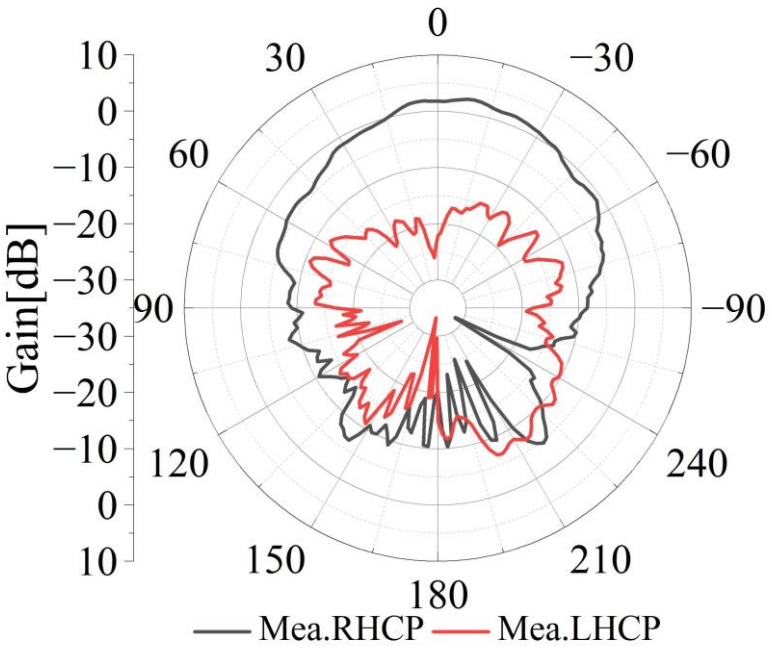
Ant3_8GHz_xoz
Max gain is
2.0dB

Figure 2. Ant3_8GHz_xoz directional diagram



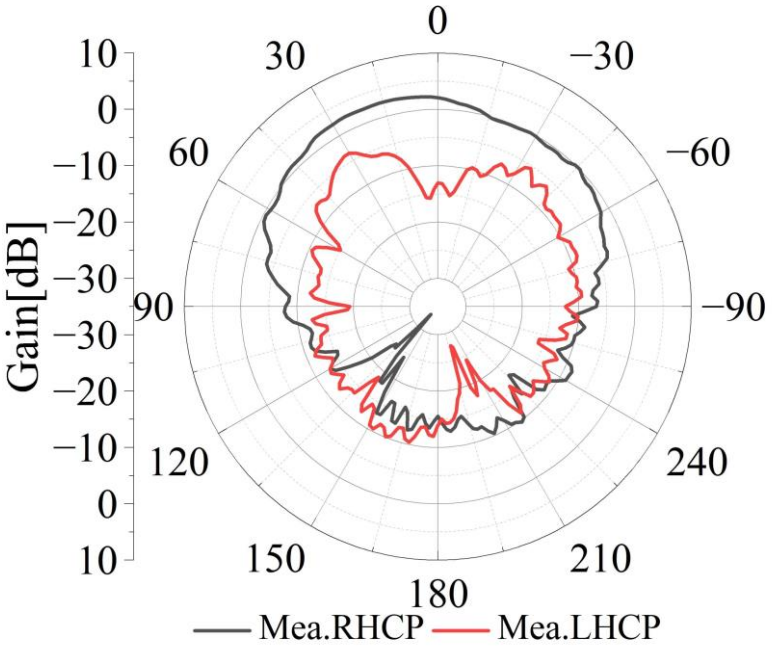
Ant3_8GHz_yoz
Max gain:
3.2 dB

Figure 3. Ant3_8GHz_yoz directional diagram



Ant4_8GHz_xoz
Max gain:
2.5dB

Figure 4. Ant4_8GHz_xoz directional diagram



Ant4_8GHz_yoz
Max gain:
2.6dB

Figure 5. Ant4_8GHz_yoz directional diagram

5. Active testing of UWB module onboard antenna

5.1 PDoA/AoA Calibration background

The theoretical relationship between the angle of arrival (AoA) and the angle difference between the two antennas calculated by the chip (PDoA) is shown in Figure 5.1.1:

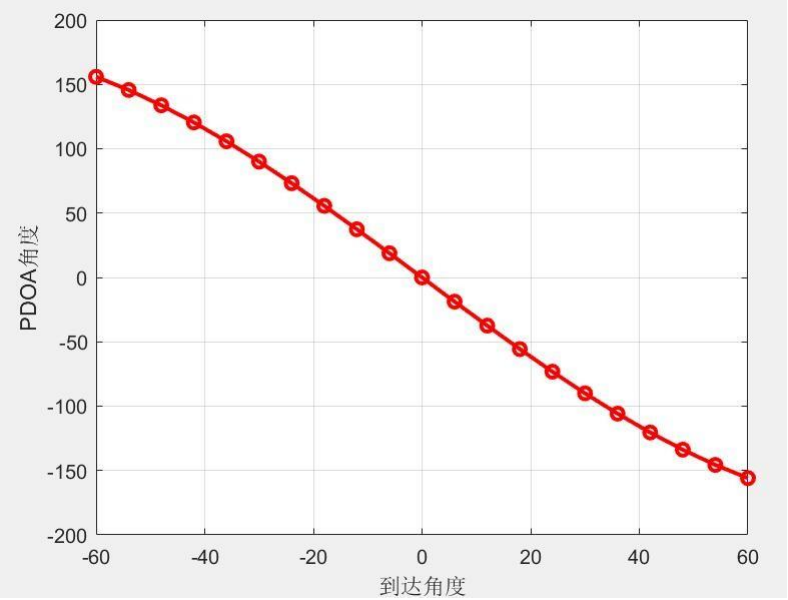


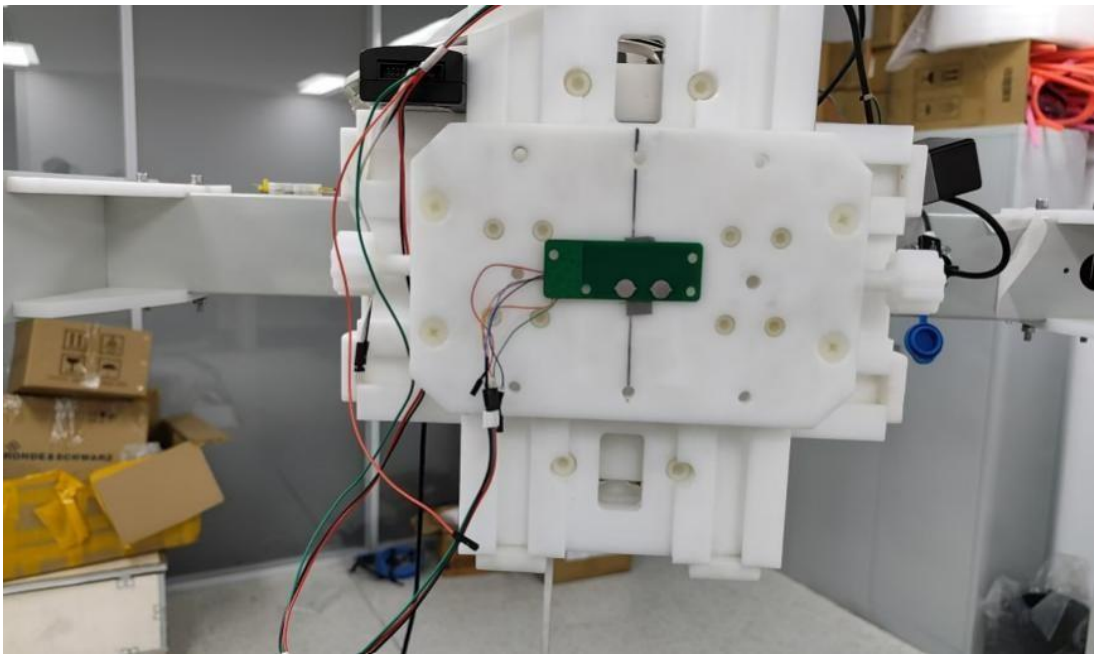
Figure 5.1.1 Relationship between the arrival angle and PDoA angle when the distance between two antennas is half a wavelength

However, due to size limitations during antenna design, it is difficult for the PDoA results corresponding to signals with different arrival angles to meet the above correspondence relationship. Therefore, it is necessary to calibrate each antenna in order to achieve the optimal final output arrival angle result.

This calibration process requires placing the antenna to be calibrated on the turntable, and then performing a fitting based on the PDoA results of each angle output by the turntable to achieve optimal angular performance.

5.2 Turntable Settings

Figure 5.2 shows the actual appearance of the turntable. The Dongle board to be tested is placed in the center of the turntable, and then PC software is used to control how the turntable rotates and obtain the rotation results. Fit the results within the PC, and then write the fitted coefficients back to the Dongle board for re rotation to determine if the fitting performs optimally.



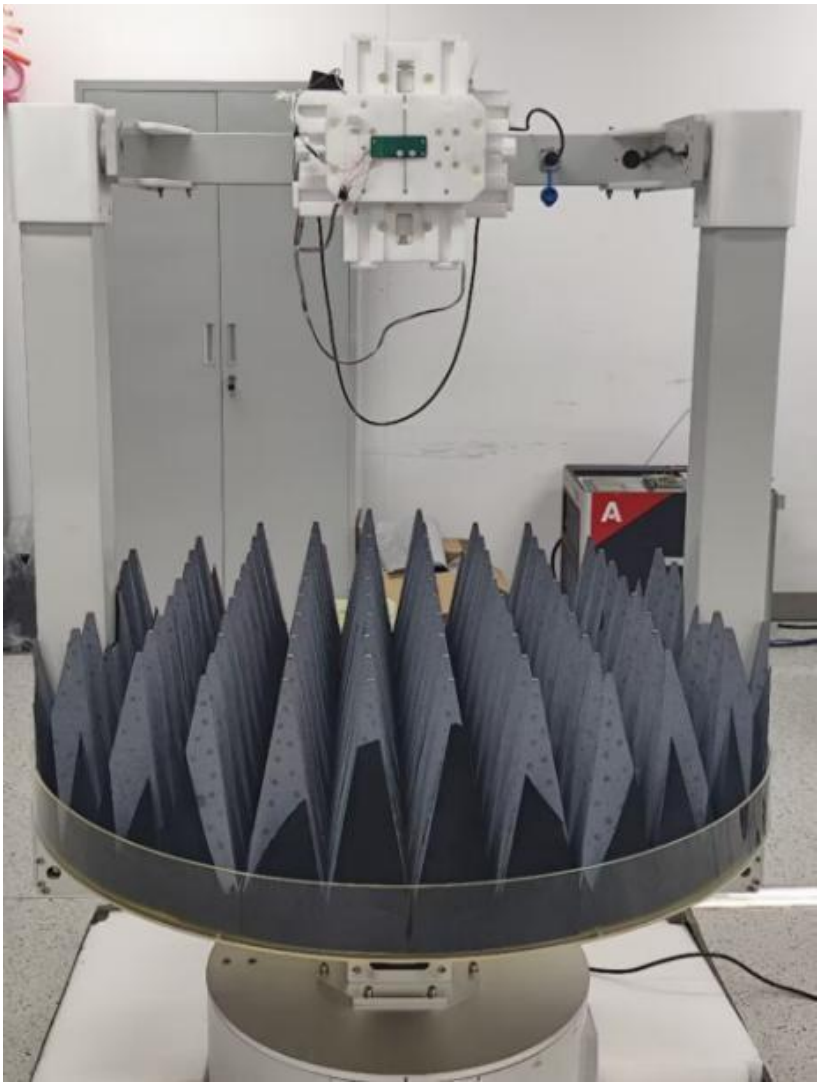


Figure 5.1.2 Turntable

5.2.1. Hardware Connection

First, use a USB cable to connect the turntable to the USB interface on the PC side. Then, use an Ethernet cable to establish network port communication between the turntable control system chassis and the PC upper computer. Finally, turn on the power button on the chassis.

Figure 5.2.1 USB, Ethernet and PC Connection Diagram

Note: The blue line in the figure represents the Ethernet cable, the black line intersecting with the blue line represents the USB cable, and the green display part of the chassis represents the power button

5.2.2. Computer Configuration

The Ethernet configuration on the computer side is shown in the following figure, and the specific steps are as follows:

Press and hold the shortcut key【win+x】-> click on【network connection】-> find advanced network settings, click on【change adapter options】-> select Ethernet, right-click on【properties】-> enter Ethernet properties, double-click on【Internet Protocol version 4】-> select【use the following IP address】， enter the IP address 192.168.10.xxx, where xxx cannot be filled in except for 100, select one from 0-255 to complete the configuration ->【confirm】complete Configuration。

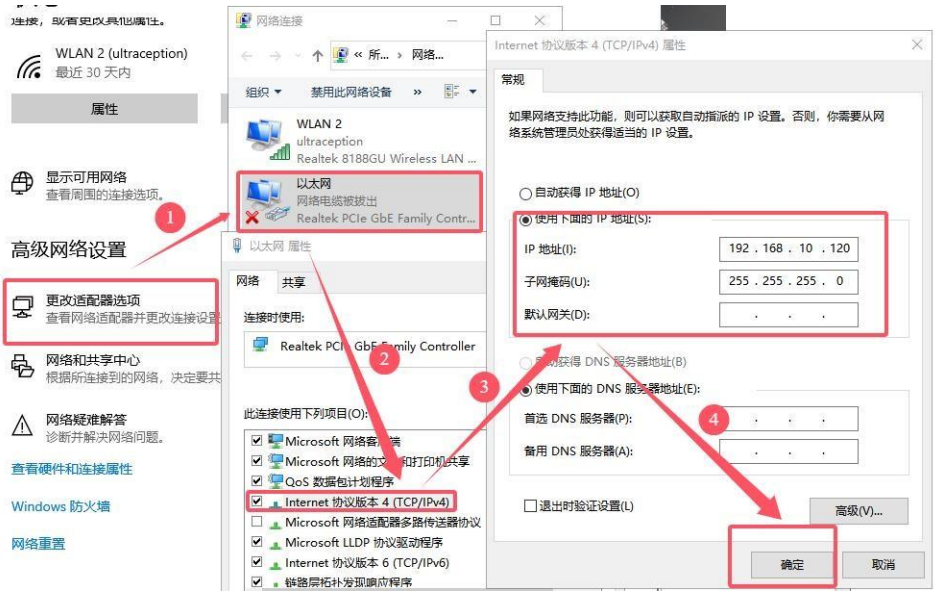


Figure 5.2.2 Computer Ethernet Configuration

5.3 Test Data

9 Dongle boards were randomly selected for testing on the turntable, and the PDoA results at various points of the PC software reported as shown in Figure 5.3.1.

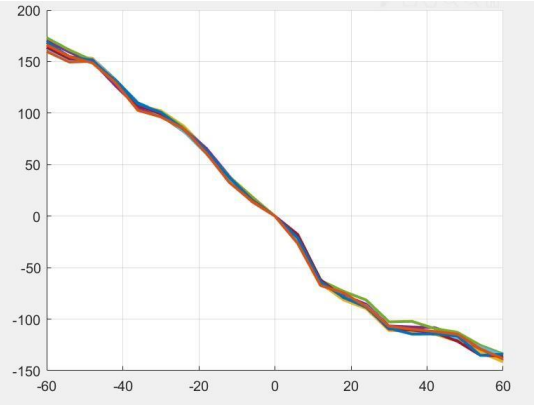


Figure 5.3.1 Results of measured arrival angles and PDoA for 9 Dongle boards

From Figure 5.3.1, it can be seen that the consistency of this Dongle board is very good, and the PDOA results of each board are basically overlapping at different arrival angles. It is same to the trend of the theoretical curve in Figure 5.1.1, but there is a significant difference between each point and the theoretical value. Therefore, if the theoretical formula is used without calibration, the calculated AOA result is shown in Figure 5.3.2.

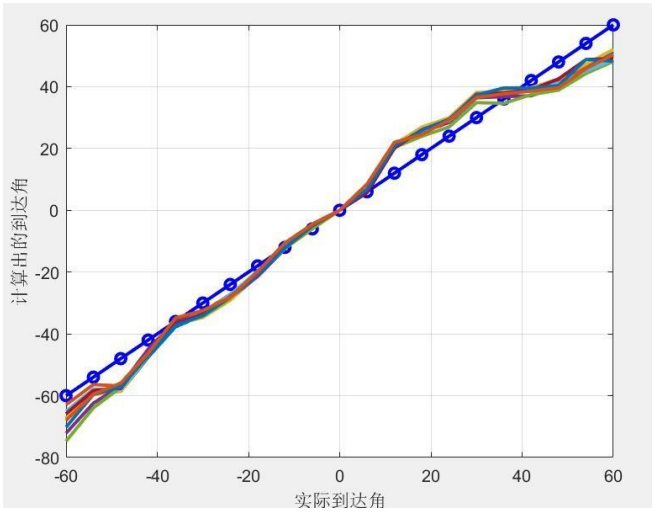


Figure 5.3.2 The relationship between the calculated arrival angle and the actual arrival angle without calibration

The PC obtained the PDoA results of 9 Dongle boards reaching the corner position at [-60:6:60] degrees from the turntable (10 frames were counted at each point and averaged to obtain the PDoA result for that point). In this way, each Dongle board obtains PDoA results at 21 points, and then the PDoA results of 9 Dongle boards are averaged at each point, resulting in one PDoA result for each positioning. The calibration algorithm performs a fitting operation on these results, and through the fitting operation, some calibration coefficients can be obtained, which are then distributed to each Dongle board,

Rotate the Dongle board from the new turntable and see if the angle of arrival is correct, as shown in Figure 5.3.3.

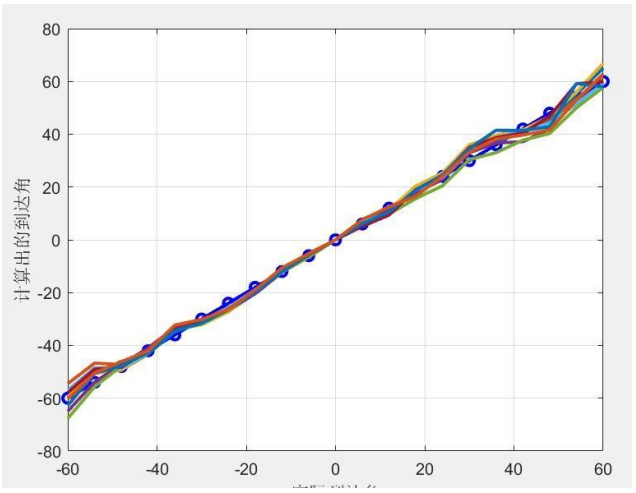


Figure 5.3.3 Relationship between the calculated arrival angle after fitting calibration and the actual arrival angle