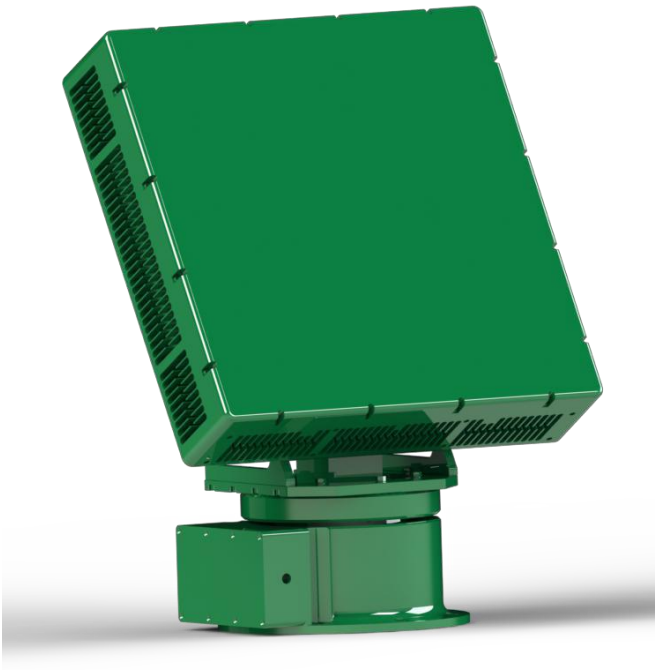
ADS2202A (Ku-band) Radar Detection Device

User Manual



Saluki Technology Inc.

Content

Chapter 1 Overview

1.1 Background

In recent years, with the gradual opening of low-altitude airspace control and the rapid spread of drone products, there have been more and more incidents such as drones and other "low-slow" targets that violate normal aviation order, spy investigations and terrorist attacks. Serious security risks have affected the national security and the normal development of the national economy. The “low and slow” target refers to flying objects with low flying height, slow flying speed and small radar reflection area. Typical types are drones and flying birds.

The low-slow and small targets have low flying heights, while the low-altitude areas have many occlusions and complex environmental clutter. The flying speed is slow and the Doppler frequency is not obvious. The RCS is small, the reflected echo intensity is small, and it is easy to be submerged in noise and environmental clutter. in. Therefore, the low-slow and small-sized targets can flexibly realize low-altitude and ultra-low-altitude raids, and have the characteristics of “detection is difficult, management is difficult, and disposal is difficult”. The detection and tracking of non-cooperative low-slow targets has always been a problem in the radar field. In addition, with the opening of low-altitude airspace, human low-altitude activities are increasing, traffic conditions in low-altitude airspace are becoming increasingly complex, and effective low-altitude regional monitoring and control measures are urgently needed.

1.2 Main Functions

Saluki ADS2202A (Ku-band) Radar Detection Device is short-range low-altitude surveillance radars, which can accurately detect and track low-low and small targets such as drones and birds, and display and output the distance, azimuth, pitch, speed and altitude of the target. Multidimensional information such as intensity forms a three-dimensional motion situation of low-altitude targets.

ADS2202A adopts advanced one-dimensional active phased array system, and has the ability to detect various aircraft such as quadrotor UAV and fixed-wing UAV. This product features flexible data rates, configurable probing capabilities and probing range, and multi-function probing capabilities for multiple targets and complex environments. At the same time, the product can output the radar track through the predetermined interface protocol to other devices such as optoelectronics, accusation, etc., to achieve the guidance of these devices. In addition, the product has an input interface reserved for remote control and networking.

Compared with the same type of products, ADS2202A has the advantages of good portability, long detection power and high detection accuracy.

1.3 Technical Specifications

The main indicators are as below:

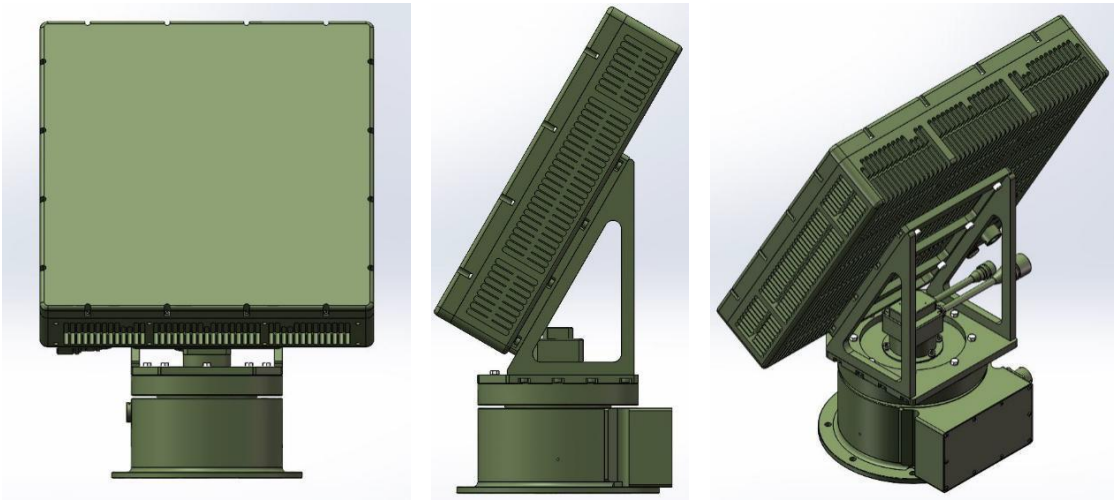
Table 1.1 Technical specifications

No.	Parameters	ADS2202A
1	Frequency Band	Ku
2	Frequency	16GHz
3	Frequency Point	Adjustable
4	Transmit Signal Bandwidth	≤ 40MHz
5	System	One-dimensional active phased array
6	Scan Mode	Pitch electronic scanning, Azimuth mechanical scanning
7	Turntable Horizontal Speed	Adjustable
8	Antenna Emission Peak Power	< 130W
9	Average Power	< 100W
10	Detection Range (@RCS = 0.01m^2)	≥ 5km
11	Distance Dead Zone	≤ 200m
12	Azimuth Range	360°
13	Pitch Range	> 40°
14	Speed Range	3 - 80 m/s
15	Distance Resolution	7.5m
16	Azimuth Accuracy	0.5°
17	Pitch Accuracy	0.5°
18	Speed Accuracy	1 m/s
19	Probability of Detection	85%
20	Probability of False Alarm	10^{-6}
21	Data Rate	≤ 7s/r
22	Multi-target Detection Capability	Yes
23	Number of Targets Detected Simultaneously	≥100
24	Networking Capability	Yes
25	Trace Output Protocol	UDP
26	Weight	Radar host: 19kg, Turntable: 11kg, Total: 30kg
27	Host Dimension	420mm*420mm*100mm

28	Turntable Dimension	320mm*310mm*250mm
29	Waterproof and Moistureproof	IP56

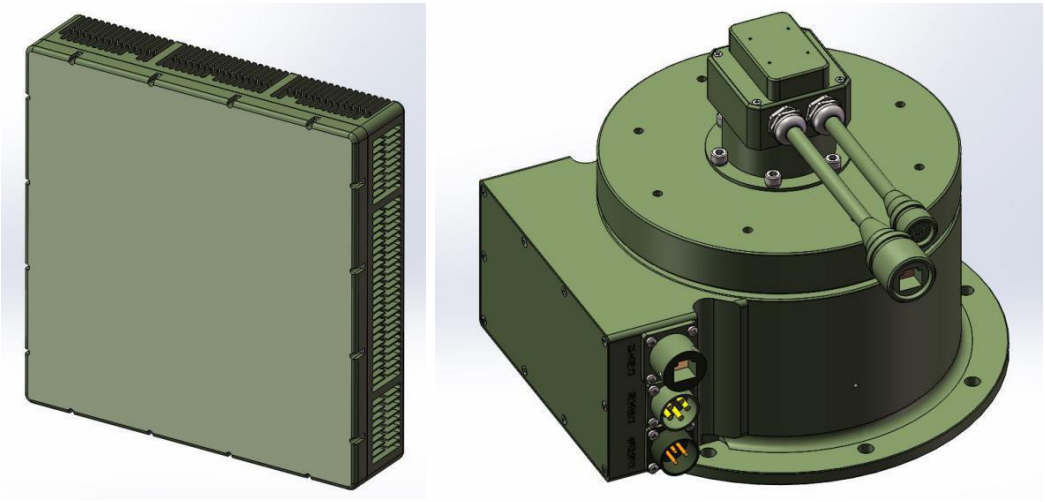
Chapter 2 Installation

2.1 Product Structure



(a) Front view (b) Side view (c) Oblique view

Figure 2.1 Radar machine diagram



(a) Host (b) Turntable

Figure 2.2 Radar host and turntable diagram

ADS2202A radar is mainly composed of radar host, radar bracket, turntable and PC software. The radar machine diagram is shown in Figure 2.1. The radar host and turntable diagram is shown in Figure 2.2. The packing list is shown in the table below.

Table 2.1 Packing list

No.	Item	Qty.
1	Radar host	1 unit
2	Radar bracket	1 pcs

3	Turntable	1 unit
4	Mounting screws	1 set
5	PC software	1 set
6	User manual	1 pcs
7	Test report	1 pcs
8	Certificate	1 pcs
9	Power aviation connector	1 pcs
10	Network port aviation connector	1 pcs
11	Power adapter	1 pcs
12	Machine bracket	Option

2.2 Installation Method

2.2.1 Interface and connection

The main interface is shown in Figure 2.3 and Table 2.2. In the actual installation, please follow the steps below:

1) Connect interface 4 to 1;

2) Connect interface 3 to2;

3) Connect interface to computer via cable;

4) Tighten the waterproof cover of interface 6;

5) Connect interface 7 to the power supply.

Note: Please tighten the power plug of interface 7 first, then turn on the power!

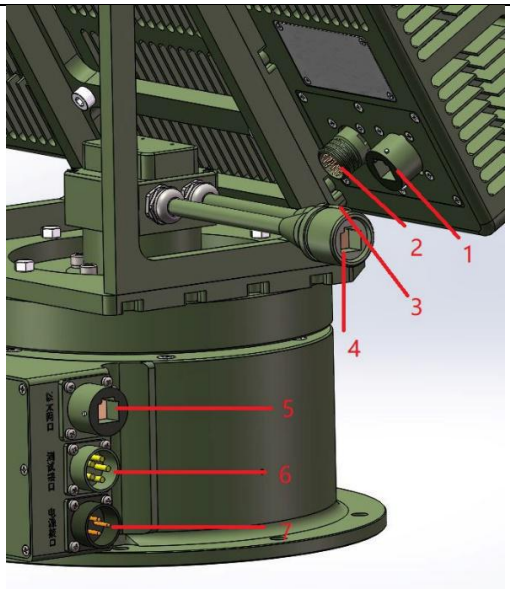


Figure 2.3 Radar interface diagram

Table 2.2 Radar interface

No.	Name	Note
1	Radar host Ethernet port	/
2	Radar host power interface	/
3	Turntable output Ethernet port	/
4	Turntable output power interface	/
5	Turntable input Ethernet port	/
6	Turntable test port	Please put on a waterproof cap.
7	Turntable input power interface	DC 24V, Current >5A

2.2.2 Installation Instructions

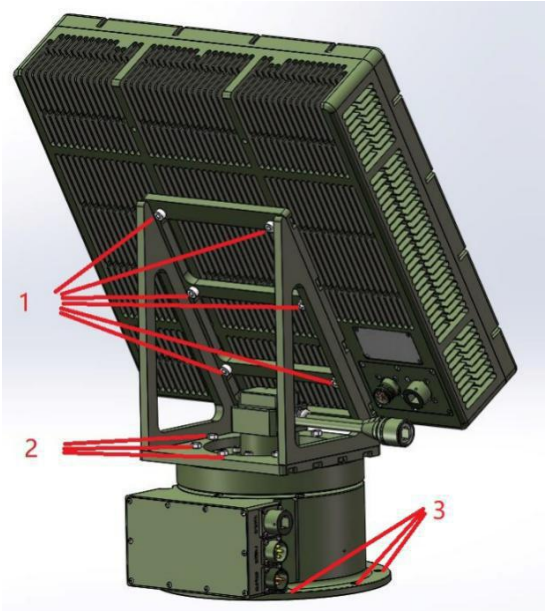


Figure 2.4 Screw mounting position diagram

As shown in Figure 2.4, the 6 screws at "2" are used to fix the turret bracket on the turret; the 6 screws at "1" are used to fix the radar main unit to the turret bracket; the screws at "3" are used for The turntable is fixed to the whole machine bracket.

Note:

1) Please prepare a set of hex driver (see Fig.5);
2) It is recommended to install more than two people;
3) In order to improve the angle measurement accuracy, please adjust the bottom level of the turntable before installation.

Figure 2.5 Hex wrench

2.3 Precautions

1) Please keep a certain distance from the radar to prevent personal injury caused by sudden rotation of the radar;
2) Be sure to ensure the level of radar installation;

3) Do not have metal coverings near the radar;
4) When the radar works in the “receive and receive power-on” mode, there can be no people around;
5) The use of the radar site must be guaranteed to be unobstructed;
6) The radar will rotate when working, and the radar stand must be fixed reliably;
7) Ensure that the radar power supply output is stable and the grounding is reliable;
8) The radar should be used within the protection range of the lightning rod;
9) Do not place any objects on the device to avoid affecting the normal operation of the device;
10) When plugging and unplugging the equipment cable, disconnect the power supply first;
11) Do not disassemble the equipment by yourself. If the equipment fails, please contact the manufacturer for repair;
12) Unauthorized, no unit or individual may make structural, safety and performance design changes to the equipment to avoid affecting the equipment warranty.

Chapter 3 Introduction of PC Software

3.1 Precautions

1) When the radar is working ("transmission and power-on" mode), please ensure that there are no other people around the radar;
2) The interface parameters are all values that meet the performance after factory debugging. Please contact the manufacturer before modifying the parameters. If the radar parameters are degraded after modifying the interface parameters without communication, please restore the default settings or contact the factory as soon as possible;
3) Please do not arbitrarily change the files in the working directory of the PC software, otherwise the host computer may not work properly;
4) The PC software has the function of automatic admission, which may cause the memory occupied by the working directory to increase. Please reserve enough memory for the PC software.

3.2 Recommended Environment

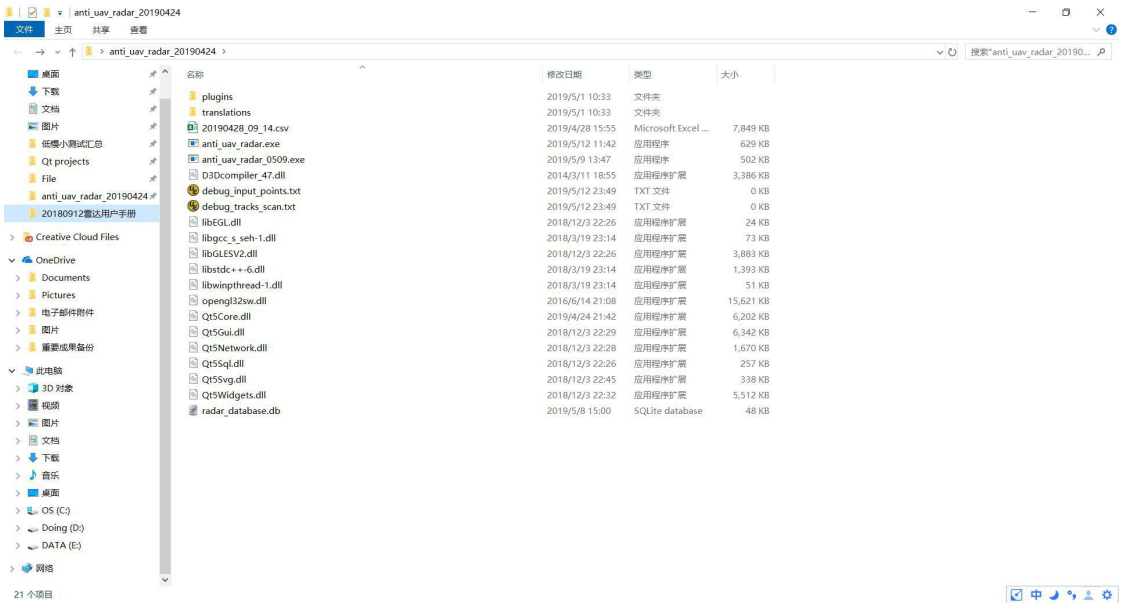
The recommended environment for running the PC software is as follows:

Table 3.1 Operating environment

Hardware	CPU	2.0GHz or more
	Hard disk	500GB or more
	RAM	4GB or more
	Display resolution	1920*1080
Software	OS	Windows 7 and above
	Network software	WinPcap 4.1.3 (must)

3.3 Installation Method

1) Copy and paste the host computer running software to the working directory, see as below;



2) Install “WinPcap_4_1_3.exe”;

3) Run “anti_uav_radar.exe”;

3.4 Operating Steps

1) Open “anti_uav_radar.exe”, and the “Network Port Selection” window will pop up, select the network port (usually Ethernet port) connected to the radar;

2) If the radar is working properly, select “System Control / Antenna Power-on Mode” on the main interface as “Transceiver and Power-on”. Click the “Work” button and the radar will start working normally.

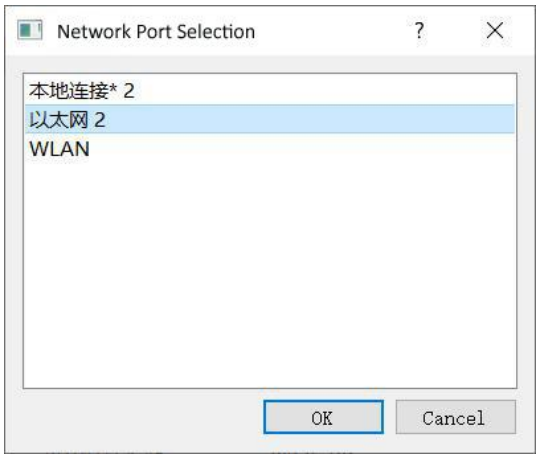


Figure 3.1 Network port selection interface

3.5 Introduction of Interface Parameters

3.5.1 Main interface（Control and track display interface）

Main interface is shown in Figure 3.2.

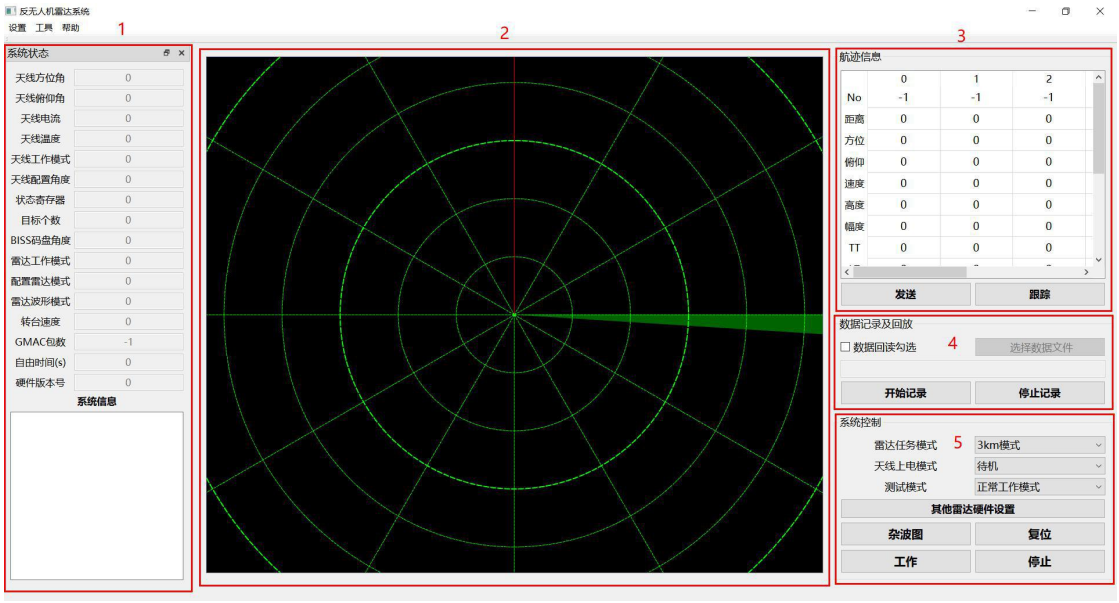


Figure 3.2 Main interface

- **"1"** is the system status, and the system information such as the current azimuth and elevation angle of the radar is displayed in real time. The "System Information" box will display the error of the radar system. For the common error handling method, refer to Section 4.1.
- **"2"** is the track display frame. The track map is shown in Fig.8. The green fan shape is the current beam direction of the radar. The original track is displayed as a white partial transparent point. The incomplete batch track is displayed in gray. Displayed in yellow, the selected track is displayed in red, and the corresponding information of the selected track is displayed at the sequence number 0 of the track information box at "3";
- **"3"** is the track information, where the sequence number 0 shows the selected track. The track information includes: No (track number), distance, azimuth (degree), pitch (degree), speed (near the radar is positive, Far away from negative), height (m), amplitude, longitude, latitude, altitude, etc.;
- **"4"** is the data recording and playback function area;
- **"5"** is the system control function area, "Radar task mode" is used to select the radar mission mode, there are "3km mode", "5km mode", etc. (Note: some old models may need to upgrade hardware or programs to have "5km" "Mode" and other functions; the "Clutter Map" button is used to generate the clutter map. During the generation of the clutter map, please do not stop the radar or click other buttons on the interface; the "Reset" function is used to control the radar reset; "Work" and The Stop button is used to control the start and stop of the radar.

Note: After clicking the "Stop" button, "Antenna Power-on Mode" will be automatically set to "Standby". If you need to start normally, please select "Power-on and Send-up" again and click the "Work" button.

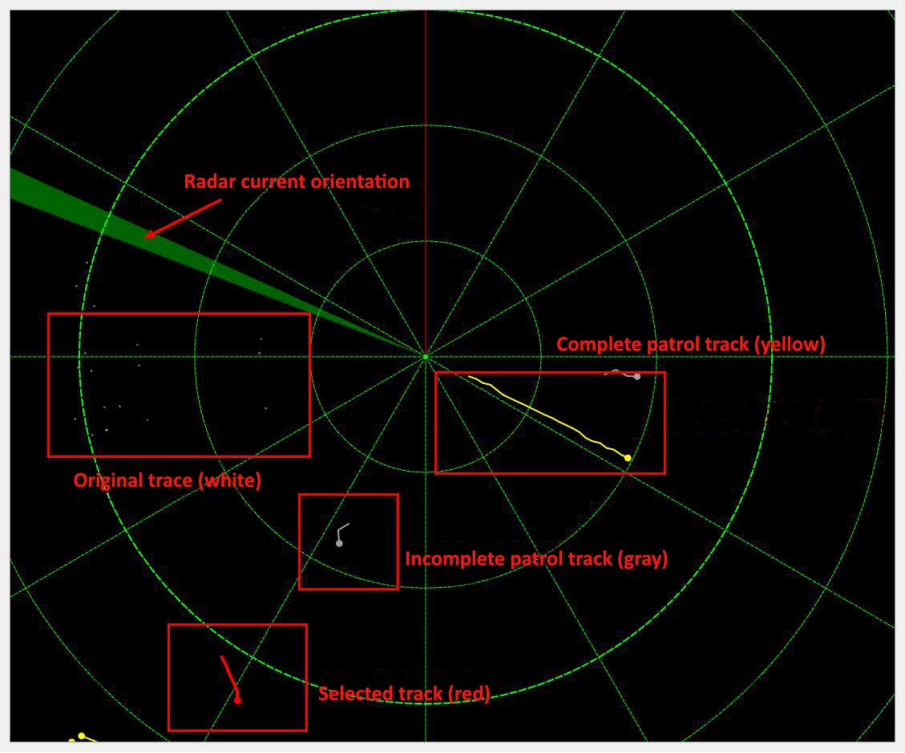


Figure 3.3 Track map

3.5.2 Other hardware settings

Figure 3.4 Other settings interface

When you click the “Other Radar Settings” button on the main interface, the “Other Radar Settings” interface will pop up. See Figure 3.4. The main function is to configure the working parameters of the antenna, turntable and signal processing. These parameters are adjusted to an appropriate value at the factory and are generally not changed. The role of “Apply” is to apply the settings. The function of “Cancel” is to close other radar setting interfaces. The function of “OK” is to apply settings and close the interface.

Note: If you have modified some parameters, be sure to click "Apply" or "OK" to make it work.

3.5.3 Radar software settings

Figure 3.5 Software settings

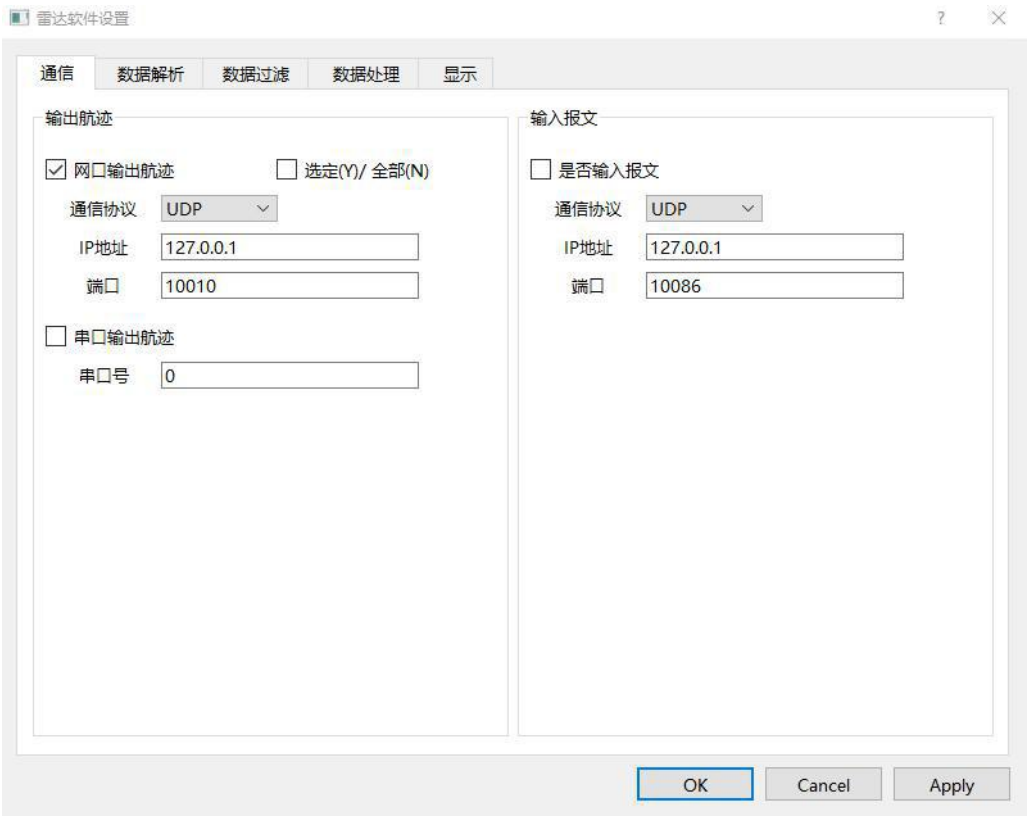


Figure 3.6 Software settings interface

As shown in Figure 3.5, after clicking “Settings - Software Settings” in the menu bar at the top left of the main interface, the “Radar Software Settings” screen shown in Figure 3.6 will pop up. The software setting interface includes 5 sub-directories such as “communication”, “data parsing”, “data filtering”, “data processing” and “display”. These parameters are adjusted to an appropriate value at the factory and are generally not changed. The function of “Apply” is the application setting. The function of “Cancel” is to close other radar setting interfaces. The function of “OK” is to apply the settings and close the interface.

Note: If you have modified some parameters, be sure to click "Apply" or "OK" to make it work.

3.6 Main Functions

3.6.1 Conversion between radar coordinate system and northbound coordinate system

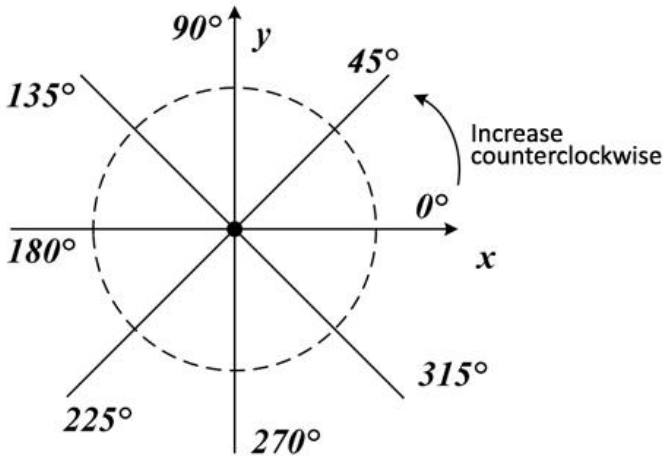


Figure 3.7 Radar coordinate system

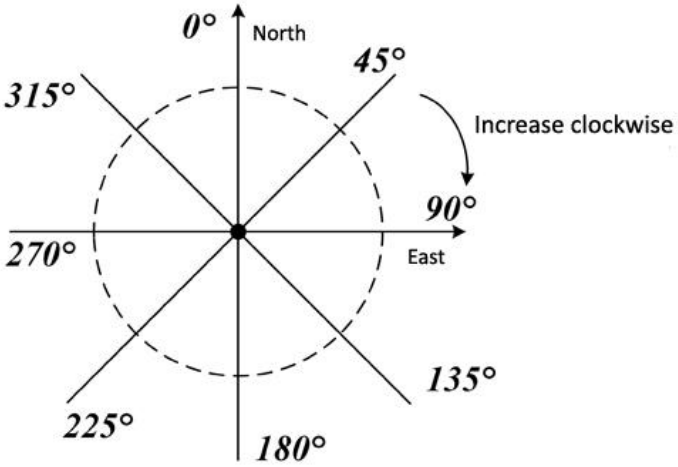


Figure 3.8 Northbound coordinate system

The radar coordinate system is a standard Cartesian coordinate system (Cartesian coordinate system), as shown in Figure 3.7 The target azimuth obtained by radar detection is the angle from the x-axis counterclockwise rotation to the radar target connection, so the azimuth increases counterclockwise, the positive x-axis represents 0 degrees, and the positive y-axis represents 90 degrees. The northbound coordinate system is shown in Figure 3.8. The azimuth in the northbound coordinate system refers to the angle at which the northwest clockwise rotates to the radar target line, so the azimuth increases clockwise, with the northward representing 0 degrees and the eastward representing 90 degrees. The conversion formula between the azimuth angle φ_r of the radar coordinate system and the azimuth angle φ_n of the north coordinate system is

$$\varphi_n = \mathrm{mod}(450 - \varphi_r, 360)$$

That is, the azimuth angle φ_n of the north coordinate system is equal to 450 degrees minus the azimuth angle φ_r of the radar coordinate system, and the modulo is taken for 360 degrees (note: floating point number modulo).

3.6.2 Azimuth pitch correction function

The software can correct the azimuth and elevation angles analyzed in the message. The specific setting position is “software setting/data analysis/angle correction”, as shown in Figure 3.9. This function is mainly used for the school, the east, the school level, etc.

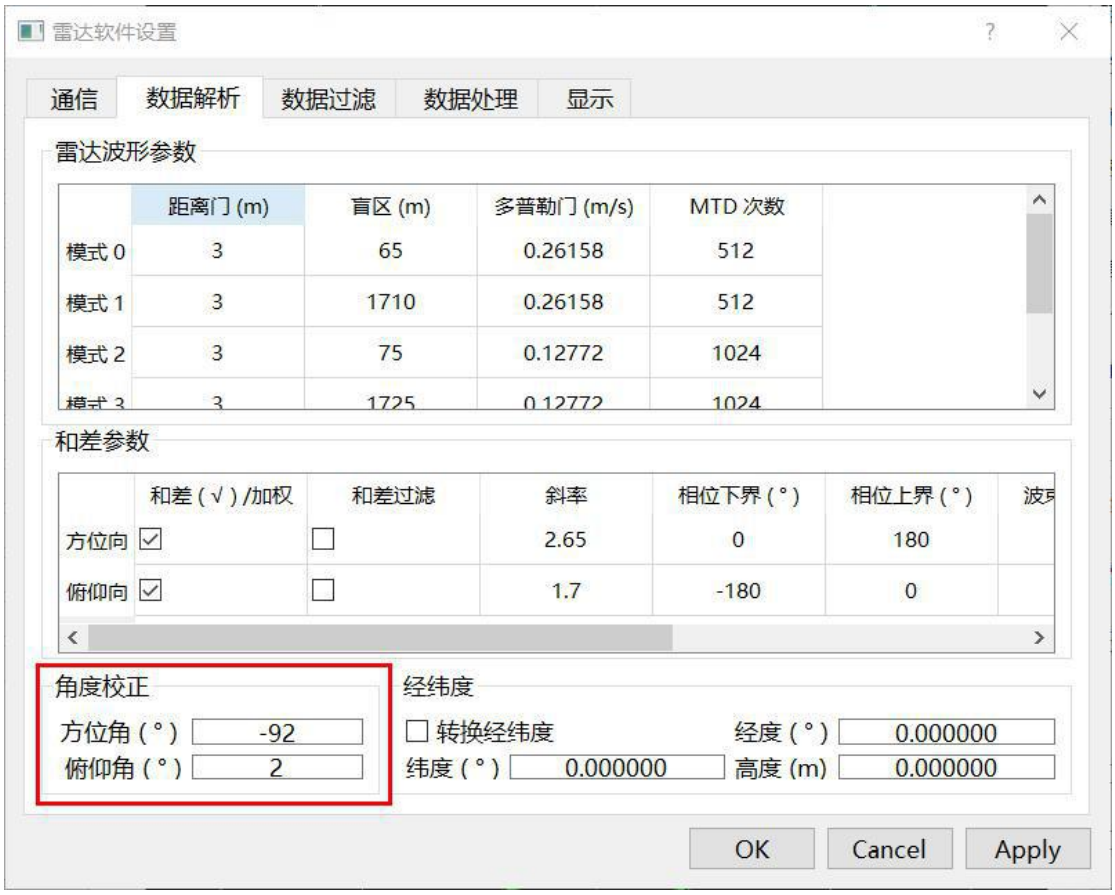


Figure 3.9 Azimuth pitch correction

3.6.3 Track transmission function

The software can output all the tracks or select a certain track to output to the target device (photoelectric, accusation software, etc.), and the IP address and port of the target device can be set. In "Software Settings / Communication", after selecting "Select (Y) / All (N)" (Figure 3.10), you can click on the track interface to select the track, and then click on the "Track Information" box. The "send" button will send the track. Taking Fig.16 as an example, after clicking the track in the red frame, the “Track Information” area displays the information of the track, such as the number 59688, the current distance is 4470, the current orientation is 151.834 degrees, etc., and then click “ Send” button to send this track.

If “Select (Y)/All (N)” in “Software Settings/Communication” is not checked, all tracks will be sent to the target device. “Min_TT” is used to control the minimum number of tracking times for sending tracks. The default setting is 3 and the

minimum can be set to 2. If you want to upload a relatively small number of tracks, you can increase the “Min_TT”, but correspondingly, the time from the start of the track to the time the target device receives the track will increase.

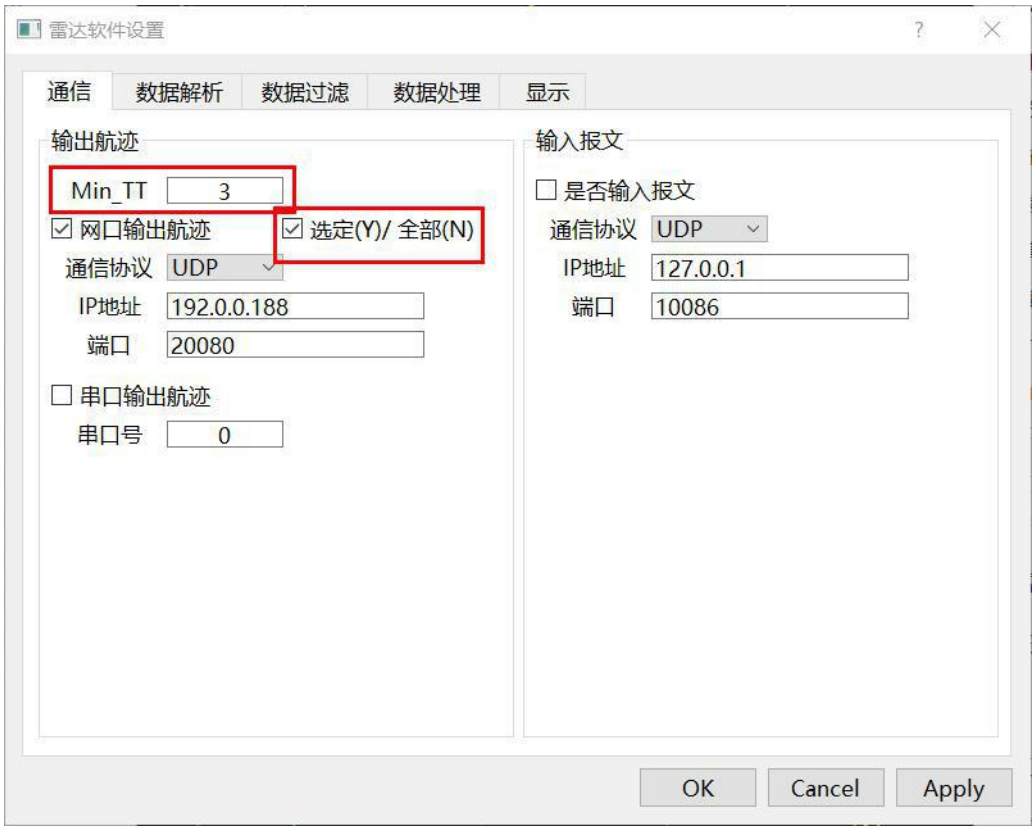


Figure 3.10 Select track or all output diagram

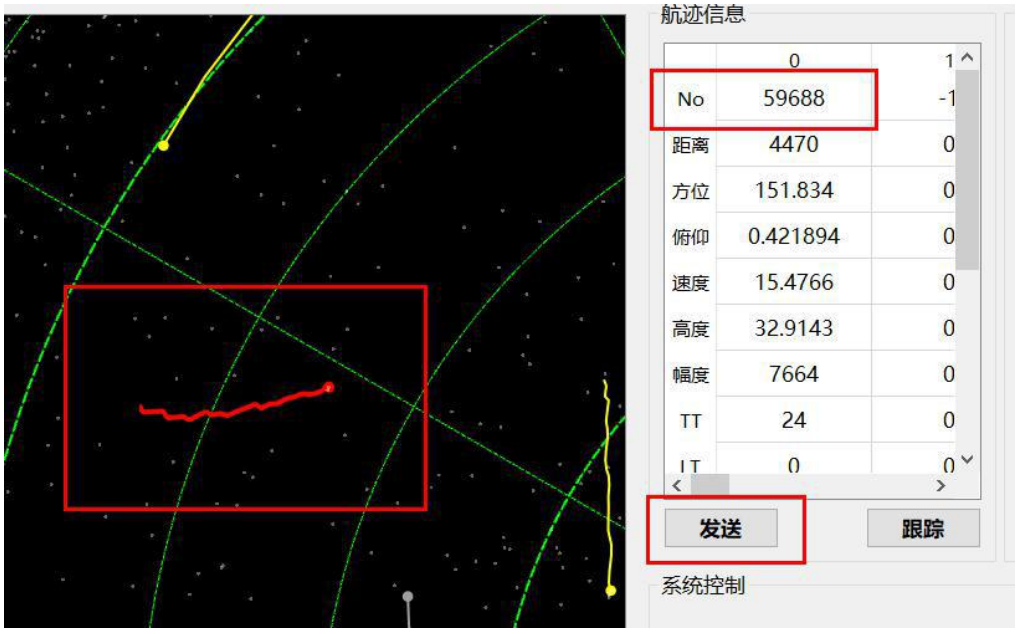


Figure 3.11 Select the track and send

3.6.4 Data collection function

The software can collect raw data messages received by the host computer software, which is convenient for data playback and analysis. In the “Data Recording and Playback” area of the main interface, cancel the “Data Readback Check” and click “Start Recording” to start recording the original data message. The location of the log file is in the "... / fpga_packet" folder. The file naming format is: "fpga_packet_year_month_day_hour_minute_second.txt"; click "stop recording" to stop recording the message and save. When the recorded radar message reaches 120,000 packets, the previous file will be closed and a new file will be restarted.

Figure 3.12 Data record

In addition to the recording features that come with the software, you can also use the Wireshark software for acquisition. Open the Wireshark software and select the network card for the radar data input, which is usually the Ethernet port. The radar raw data message is broadcasted at the data link layer, and the source address and destination address are "5a:5a:00:08:06:06" and "ff:ff:ff:ff:ff:ff", respectively. Right-click on the eligible message "5a:5a:00:08:06:06", select "Apply as Filter/Select" in the pop-up menu; right on the "Broadcast" of the eligible message Click , in the pop-up menu, select "Apply as Filter / ... and Selected", and then click the "Use Filter String for Display" application setting. At this time, the message display area will only display the messages that meet the filter criteria. When the test needs to stop data collection, click the “Stop Capture Group” button in the upper left corner, then select “File/Export Group Parsing Result/Or Plain Text”. In the pop-up window, select the directory and enter the file name. (For example, "1.txt", be sure to add txt), then follow the settings in Figure 3.15(c) and click "Save" to save the data.

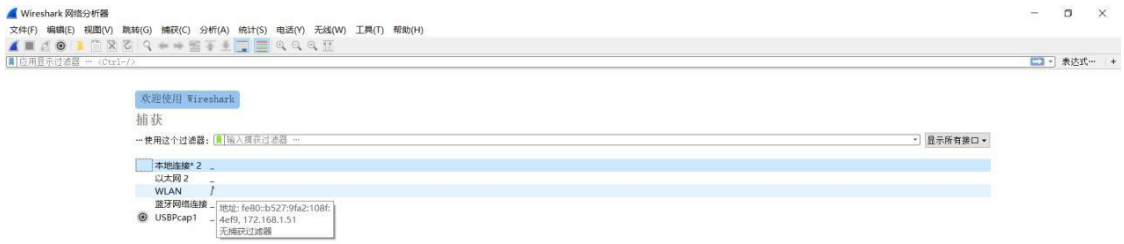
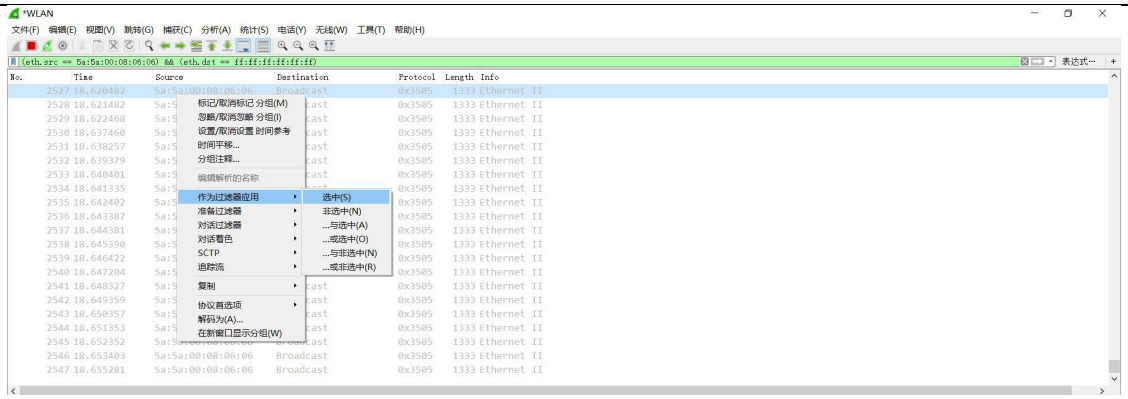
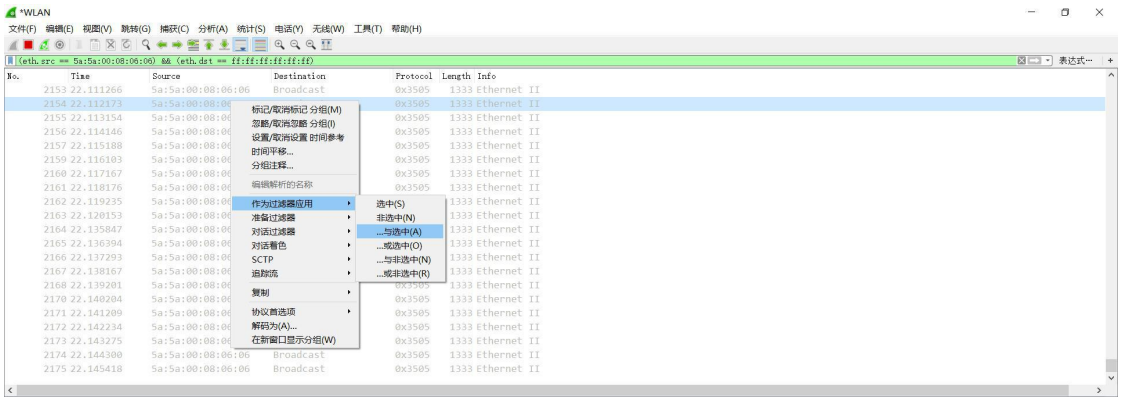


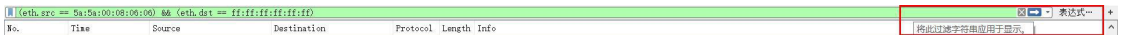
Figure 3.13 Wireshark select network port diagram



(a) Select source address



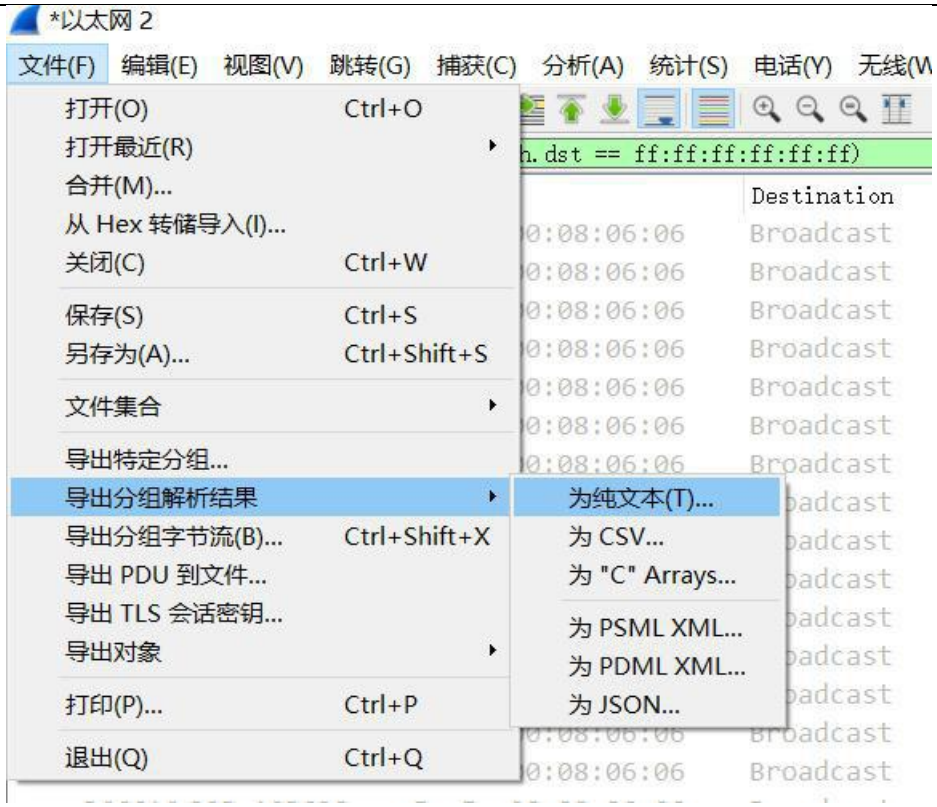
(b) Select destination address



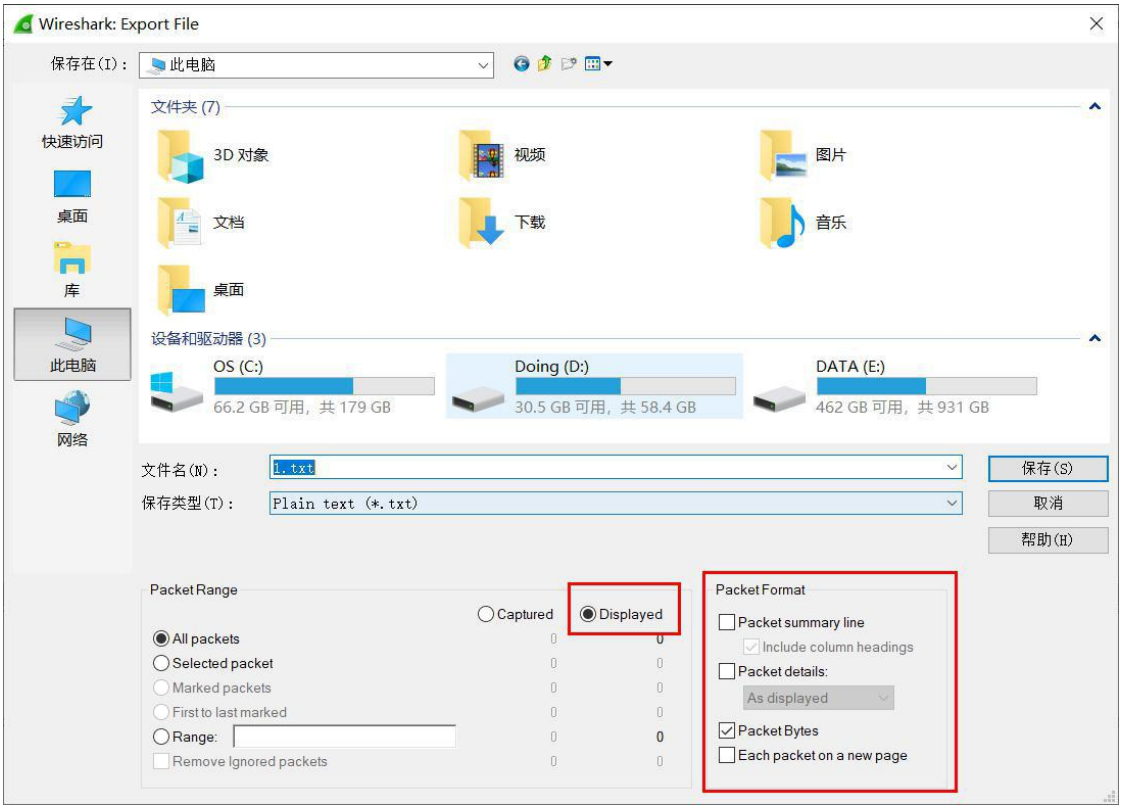
(c) Apply filter

Figure 3.14 Wireshark set filter criteria and apply filter criteria

(a) Stop data collection



(b) Export file



(c) Set the export file format

Figure 3.15 Wireshark stop collection and export file

3.6.5 Data readback function

After the data acquisition is completed, the software can read back the saved radar message files. First, check "Data Recording and Playback / Data Readback Check"; then, click "Select Data File", select the message file in the pop-up window; finally, click the "Work" button on the main interface and " The Stop button controls the start or pause of the readback.

Figure 3.16 Select the file to read back

3.6.6 Silent function

This product can be set to the silent area, that is, the antenna does not open in the setting area, which is used to protect the personnel in the silent area. The place to modify the silent settings is: "Software Settings / Data Filtering / Silent (Counterclockwise)". To turn on silence, you need to check "Enable Silence". The silence angle is the area that rotates counterclockwise from the lower boundary of the silent direction to the upper boundary of the azimuth. For the setting of the silence angle, refer to Figure 3.18. In Figure 3.18 (a), the lower bound is set to 315° and the upper bound is set to 45°. The corresponding silent region is the shaded area rotated from 315° counterclockwise to 45°; in Figure 3.18 (b), the lower bound is set to 45°, the upper bound is set to 315°, and the corresponding silent region is the shaded area rotated from 45° counterclockwise to 315°.

Note: If the azimuth offset angle is set in the software settings, the corresponding silence area should also be added with the corresponding offset angle.

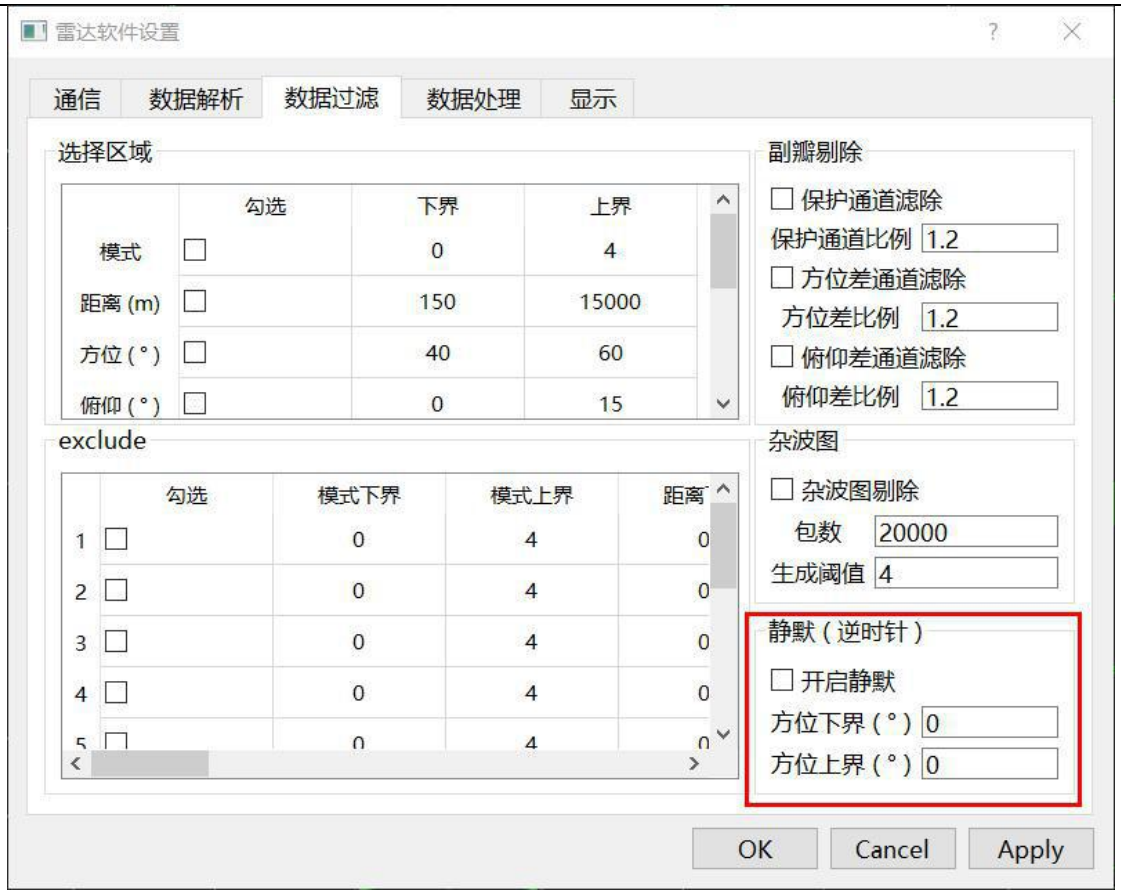
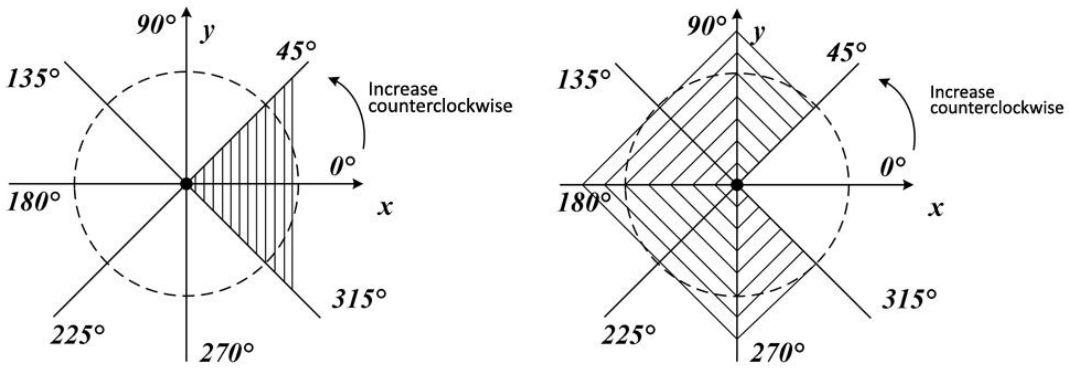


Figure 3.17 Silent setting



(a) Lower bound 315°, upper bound 45° (b) Lower bound 45°, upper bound 315°

Figure 3.18 Setting silent area

3.6.7 Data filter function

The software can filter the input target original points, such as the target within the preset speed range or within the preset height range. The software provides two methods of data filtering, one is to select the range of target parameters to be processed; the other is to filter out the parameters to meet the target range.

The first type, select the range of target parameters to be processed, the corresponding setting position is: "software settings / data filtering / selection area". If a parameter is checked, only the upper boundary of ≥ upper bound and ≤ lower

bound is processed during data processing. Taking the distance as an example, if the distance selection is checked, the lower bound is set to 500 and the upper bound is set to 1000, only the original trace with the slant range in the range [500, 1000] is actually processed.

The second type, the filter parameter meets the target of the setting range, and the corresponding setting is "software setting / data filtering / exclude". If an option is checked, the original point of each parameter ≥ corresponding upper bound and ≤ corresponding lower bound is ignored during data processing. For example, if the first item is checked, and the lower bound of the mode is 0, the upper bound is 1; the lower bound is 500, the upper bound is 1000; the lower bound is 30, the upper bound is 60; the lower bound is 0, upper bound It is 10; the lower bound is -3, the upper bound is 3; the lower bound is 0, the upper bound is 1000; the lower bound is 0, and the upper bound is 50. At this time, during subsequent data processing, the relevant original trace below will be filtered out .

$$\text{Mode} \in \{0,1\}$$

$$\text{Distance} \in [500,1000]$$

$$\text{Orientation} \in [30,60]$$

$$\text{Pitch} \in [0,10]$$

$$\text{Velocity} \in [-3,3]$$

$$\text{Amplitude} \in [0,1000]$$

$$\text{Height} \in [0,50]$$

3.6.8 Conversion function between longitude and latitude and distance azimuth

The software can calculate the latitude and longitude of the known target 1 and the horizontal distance and the northward azimuth angle of the target 2 relative to the target 1, calculate the latitude and longitude of the target 2; or the known latitude and longitude of the target 1 and the latitude and longitude of the target 2, and calculate the target 2 relative to The horizontal distance of target 1 and the function of the northward azimuth. To achieve distance and azimuth conversion latitude and longitude, you need to enter the latitude and longitude of target 1 (example: longitude 105.851535, latitude 38.512354, unit: degree), and the horizontal distance and north azimuth of target 2 relative to target 1, then click "calculate The latitude and longitude button can get the latitude and longitude of the target 2; if you need to realize the latitude and longitude conversion distance, you need to input the latitude and longitude (unit: degree) of the target 1 and the target 2, and then click the “calculate the distance orientation” button to get the target. 2 Horizontal distance and north azimuth relative to target 1.

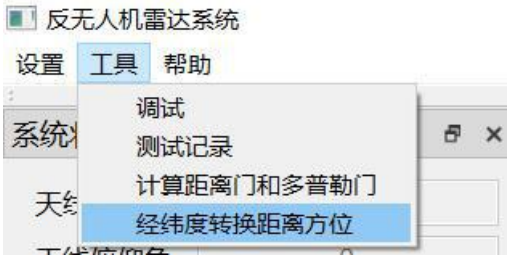


Figure 3.19 Open the latitude and longitude conversion distance bearing window

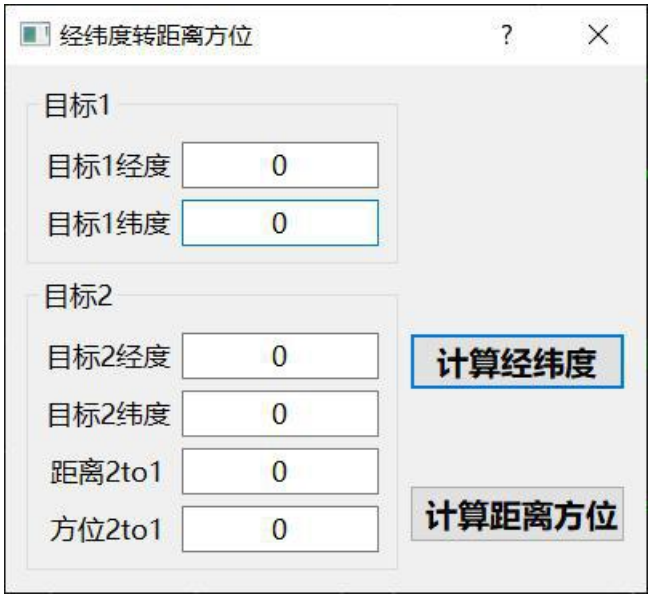


Figure 3.20 Longitude and latitude conversion distance azimuth window

3.7 Interface Protocol

The protocol for the track output is shown in Table 3.1. The latest points of each track are as follows:

Table3.1 Track output interface protocol

Based on UDP transmission, Adjustable port and IP address			
Length	**Byte subscript**	**Meaning and number of bytes**	**Content**
12BYTE	1 - 6	Destination address (6 BYTE)	0x77FFFFFFFFFF
	7 - 12	Source address (6 BYTE)	0x77CCCCCCCCCC
4BYTE	13 - 16	Azimuth sector number (4BYTE)	
	17 - 20	Number of tracks in this package (4BYTE)	0 - 10
880BYTE	21 - 900	10 track information, each track only sends the latest track	See table 3

Table 3.2 Track information of the latest track

No.	Parameters	Type	Occupied Bytes (Byte)	Note
1	Trace number	int32	4	1 - 999,999
2	Timestamp (ms)	int64	8	Epoch time
3	Distance (m)	float	4	Slant distance
4	Azimuth (°)	float	4	Radar coordinate system
5	Pitch angle (°)	float	4	Above the water level
6	Radial speed (m/s)	float	4	Stay away from being negative, close to being positive
7	Target strength	int32	4	Dimensionless
8	Longitude (°)	float	4	/
9	Latitude (°)	float	4	/
10	Altitude (m)	float	4	/
11	Eastward speed ve (m/s)	float	4	Speed in X direction, increase to positive
12	Northward speed vn (m/s)	float	4	Speed in Y direction, increase to positive
13	Vertical speed vz (m/s)	float	4	Speed in Z direction, increase to positive
14	x (m)	float	4	$x = r\cos(\theta)\cos(\varphi)$
15	y (m)	float	4	$y = r\cos(\theta)\sin(\varphi)$
16	z (m)	float	4	$z = r\sin(\theta)$
17	Whether this time is relevant	int32	4	Determine if it is an extrapolation point.
18	Number of tracked times	int32	4	/
19	Lost numbers	int32	4	When the number of losses is 4, the track is terminated.
20	Reserved text	/	8	/

Chapter 4 Common Problems and Solutions

4.1 Common Errors

(1) “The status of the turntable is abnormal”:

Possible reason: the power supply is not grounded or the output voltage is unstable.

Solution: Replace the grounded power supply. If there is no better power supply, you can ignore this error.

(2) “Missing package: xxx, cumulative yyyyy package”:

Possible reason: the network port is unstable or the network is blocked.

Solution: Check whether the network cable connection is loose. Try to prevent multiple devices from connecting to the same switch.

(3) “Missign sector: xxx, cumulative yyyyy ”:

Possible reason: the predetermined speed is too fast, or the instability of the radar installation center causes the turret to be unstable.

Solution: Check if the radar is level or increase "Other Radar Hardware Settings / SPR" (ie reduce the speed).

(4) “Antenna lost lock / Array lost lock”:

Possible reason: the power supply is not grounded, or the current is unstable..

Solution: Replace the grounded power supply. If there is no better power supply, you can choose to reset or power off and restart.

4.2 Other Problems

(1) Adding or removing a computer's network card (such as a USB network port) will cause a change in the list of network cards, which may result in a change in the serial number of the working network card;

Solution: In the main interface, set/switch network port and re-select the correct network port, as shown in Figure 4.1.

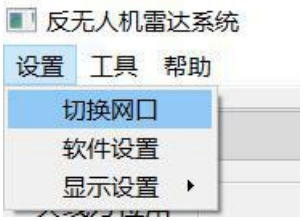


Figure 4.1 Switch network port

(2) During the running of the software, the computer sleeps. After restarting, it prompts “The currently selected network port stops working, please re-select the network port!”, as shown in Figure 4.2.

Solution: In the main interface, set/switch network port and re-select the correct network port, as shown in Figure 4.1.

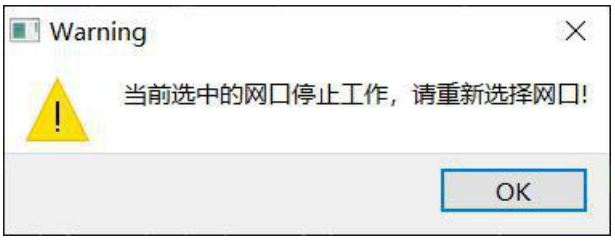


Figure 4.2 The currently selected NIC is stopped working

(3) Take up the problem of increased storage space. During the running of the software, the original traces and track information of the target will be stored in the database in real time, and some debugging status information will be output at the same time. In addition, the user may also choose to record the original message, so the working directory of the software. Will continue to increase.

Solution: Regularly clean up unwanted files, and important files define backups.

(4) Gigabit network port. The computer running on the PC software of this product must be equipped with a Gigabit Ethernet port, and the Gigabit Ethernet port is connected to the radar through the network cable to connect directly or jointly to the same switch.

Solution: Equipped with USB port accessories.

Figure 4.3 USB transfer network port

-END OF DOCUMENT-