Antenna Tracking System

Separated Designed Dual-speed Servo Control System For Satellite Antennas

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SatHarbor Technology (Since1999)

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1 Overview

The antenna control system (NS-D2000) is a full-featured dual speed antenna control system, which is composed of the antenna drive unit (ADU), ADU controller and antenna control unit (ACU). NS-D2000 is able to manually or automatically control the antenna position for satellite pointing and communication. This control system has the features as the following:

- Large, high-resolution industrial touch screen for ACU;
- In addition to receiving control command from ACU, the ADU controller has independent control function and perfect control & protection logic;
- User to remotely control the ACU through Ethernet;
- ACU is available for presetting and modifying the parameter information of 50 satellites, which is convenient for one-button guidance;
- The system is able to adjust the antenna speed as per requirements；
- Accurate scanning and high-precision auto tracking available;
- To provide comprehensive prompt and alarm information;
- Brand new and user-friendly system menu design and operation experience.

2 System Specifications

Table 2-1 Separated antenna control system specifications

Item		Description
Applicable on antenna		4.5m, 6.2m, 7.3m, 9.0m, 13m, 18m
Structure		Separated
Driving speed		Constant/dual speed (optional)
System consumption	indoor ACU	500W
	outdoor ADU controller	200W
	outdoor ADU	2500W
	outdoor thermal insulation cabinet heating unit	600W
Angle display range		0～360°
Angle display resolution		0.01°
Encoder accuracy		AZ 0.01° (0.001° optional)

	EL 0.01° (0.001° optional)
Tracking accuracy	1/10 receive beam width
Number of satellites for preset	ACU supports 50 satellites
	ADU controller supports 10 satellites
Communication interface	RJ-45 Ethernet port
Power supply	ACU: AC 220V±10%, 50/60Hz
	ADU: AC 380V±10%, 50/60Hz
Working temperature	Outdoor equipment: -40℃ ~ 50℃; Cables: -40℃ ~ 60℃;
Safety	1. Soft limit and hard limit for system normal and safe operation; 2. All cables are flame retardant; 3. ACU and ADU is equipped with an independent circuit breaker respectively to further improve system safety.

3 System Block Diagram and Module Composition

3.1 System Block Diagram

The dual speed separated antenna control system mainly consists of four parts: antenna control unit (ACU), antenna drive unit controller (ADU controller), antenna drive unit (ADU), and antenna. The system diagram is shown as below:

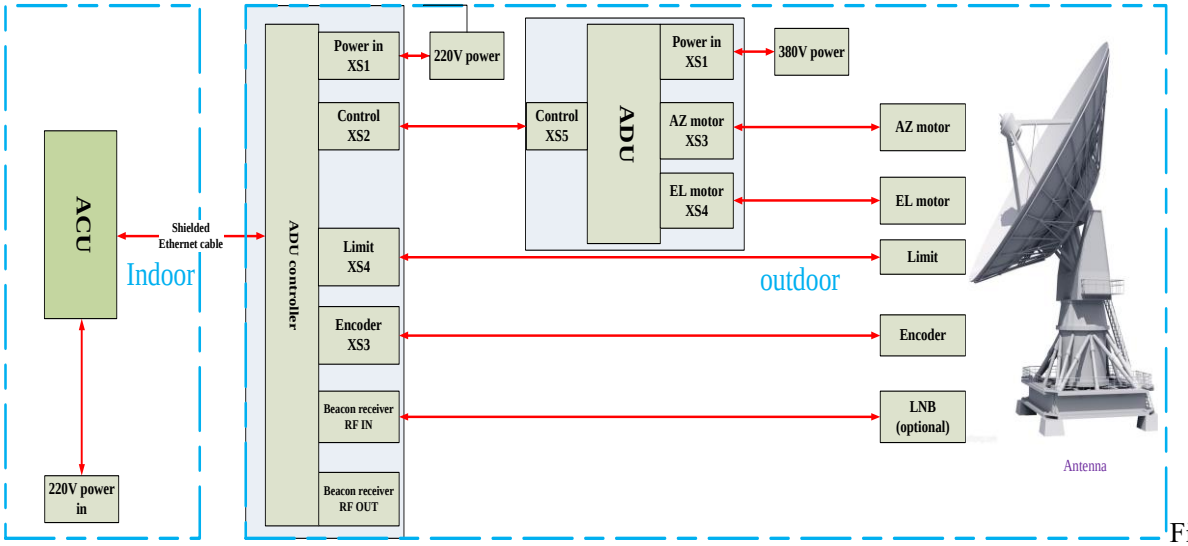


Figure 3-1 System Diagram

The system is designed to control the antenna as shown in the figure below.

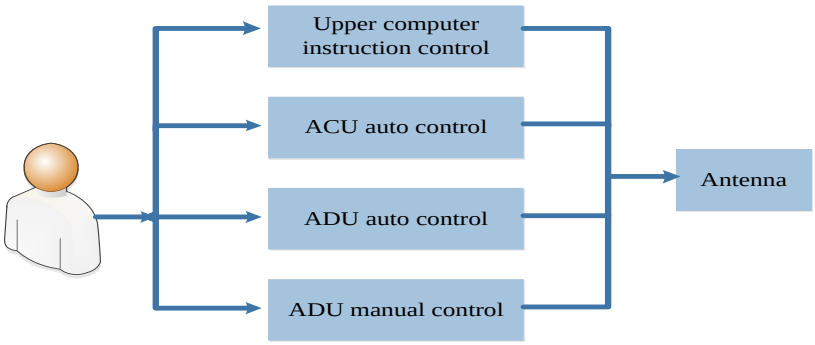


Figure 3-2 Control Mode

The 3 control modes are described in Table 3-1 as below

Table 3-1 Description of control mode

Mode	Description of control	Application
Manual control of ADU controller	1. Operate the antenna to move by directly press the physical keys on the controller. 2. The hardware limit for motor rotation is enabled. 3. Press the " MANUAL " key on the controller panel to enter the manual operation mode. **The interface displays with the control mode of**	Installation maintenance, and emergency control

	"Manual". The touch screen becomes read-only and cannot be operated under manual mode.	
Auto control of ADU controller	1. Press and release the "MANUAL" key on the controller panel to **enter the auto operation mode. The interface display with the control mode of "Auto".** 2. Use the touch screen to interact with the system control program to complete all antenna control and operation. 3. The motor rotation hardware and software limits are enabled. 4. Realize high-speed and low-speed control of the AZ and EL axis.	Routine operation
Auto control of ACU	1. Antenna operation can be controlled remotely. If ACU is connected to ADU, all antenna control operations can be completed through system data interaction. 2. The motor rotation hardware and software limits are enabled. 3. ADU panel is displayed with control mode of “Auto”, the controller panel is displayed with “Local”. 4. Realize high-speed and low-speed control of the AZ and EL axis.	Routine operation
Upper computer instruction control (remote control)	1. After the upper computer is connected to Ethernet port of the ACU, it remotely controls the ACU and the ADU. At this time, the ACU interface displays the control mode as "Remote", and the auto modes of both ACU and ADU are disabled. 2. It is possible to run various functions of the controller by sending instructions to the upper computer	Routine operation

Note: After the antenna controller software is turned on, ACU automatically connects to ADU controller once the ACU software is activated. If user to operate the ADU controller separately, please do close the ACU software before manual and automatic operation of the ADU controller

3.2 System Configuration

3.2.1 Antenna Control Unit（ACU）

The NS-D2000 antenna control system ACU chooses Intel i5-4440 processor, and the front panel is equipped with power switch and USB interface; 7.8-inch high-definition touch screen is selected for display screen, with simple and practical operation interface; the operating system is WIN10. See Figure 3-3 for photo of ACU.

Figure 3-3 Photo of ACU

3.2.2 ADU Controller

3.2.2.1 ADU controller

The antenna is designed to be controlled by the ADU controller. The case is made of 2.0mm thick steel plate, and the surface is sprayed with plastic, which can effectively prevent the case from corrosion due to long-term exposure outdoor environment. Refer to the photo below for the physical ADU controller case:

Figure 3-4 Photo of ADU controller

Hardware configuration of ADU controller:

- Small relay
- DC power module
- PCB
- Ethernet cable
- Beacon receiver

The satellite beacon receiver is built in the ADU controller and is mainly used to receive single beacon in L-band, accurately estimate the power, and nominal in digital or analog voltage.
See photo below for the beacon receiver.

Figure 3-5 Beacon receiver

It has the characteristics of high sensitivity, large dynamic range and short capture time. The product principle is shown in Figure 2-6

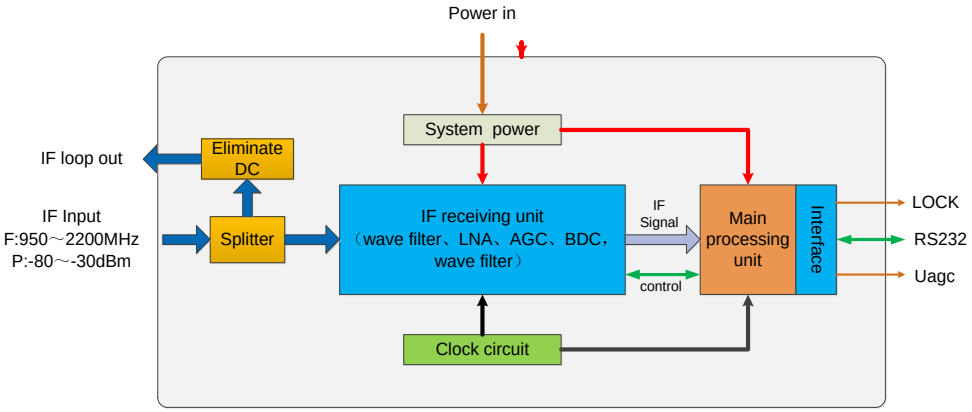


Figure 3-6 Schematic diagram of beacon receiver

3.2.2.2 Encoder

The encoder is used to collect the real-time angle of the antenna movement, and detects the displacement to determine the positive and negative directions and the position of the displacement.

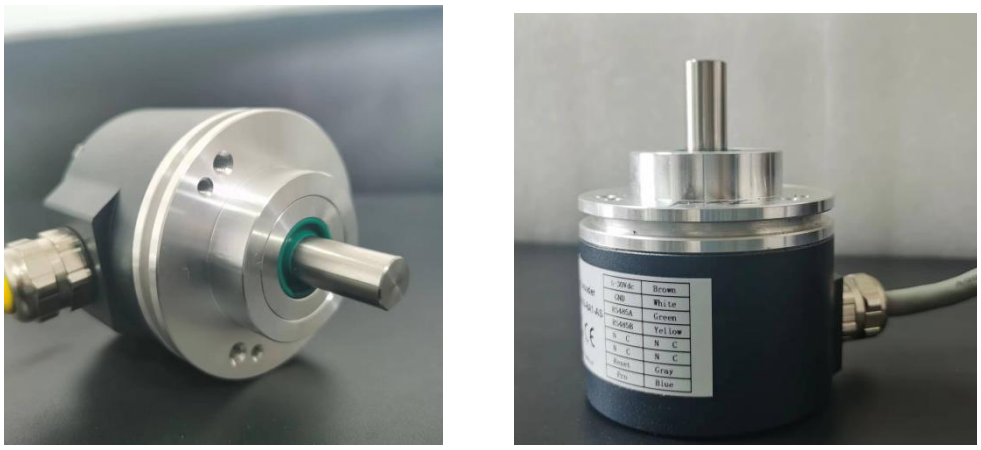


Figure 3-7 Encoder

3.2.2.3 Limit switch

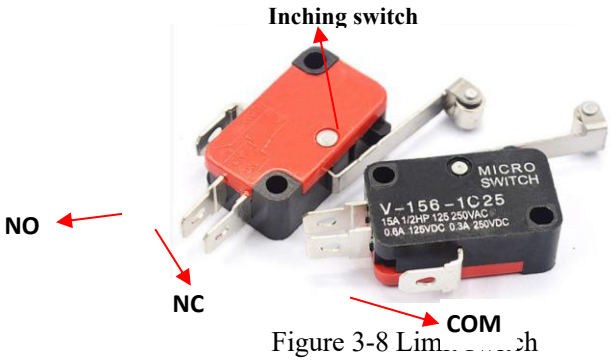


Figure 3-8 Lim... ...ch

3.2.3 Antenna Drive Unit

The antenna drive unit (ADU) mainly controls the actions of each module for drive control.

Figure 3-9 Antenna drive unit

3.2.4 Insulated Cabinet for Controllers

The insulated cabinet is to ensure that the antenna control system operates normally in harsh environmental conditions such as severe cold, and is less affected by external environmental factors.

Figure 3-10 Insulated cabinet

The insulated cabinet is mainly controlled by the system shown in Figure 3-10. The system heating mode is set as follows:

Figure 3-11 Heating temperature controller

Long press the up/down button, the starting temperature will flash, and set the starting temperature through the up/down buttons.

Long press the down button to stop the temperature flashing, and set the stop temperature value through the up/down button buttons.

Note: The starting temperature shall be lower than the stop temperature in setting process

4 System Installation and Operation

4.1 On-site Installation

Before installation on site, the equipment shall be unpacked and inspected for any damage and loosen parts

ACU installation: the indoor ACU is a standard rack mount chassis.

Note: The cable from the ACU to the ADU controller shall be within 80 meters. If the distance is more than 80 meters, SC-SC fiber optic interface shall be selected.

Installation of ADU and ADU controller: the ADU and ADU controller shall be interconnected and mounted in the thermal insulation cabinet. Pay attention to the following considerations:

- They shall be mounted away from the electric equipment with poor anti-electromagnetic interference;
- They must be well grounded;

Figure 4-1 Insulted Cabinet for ADU Controller

a) Front view b) Rear view

Figure 4-2 Internal Structure of Insulted Cabinet

Note: All exposed cables must be provided with protective sheaths. The heavy-current cables and weak-current cables shall be laid separately. All cable joints shall be connected securely, firmly, and free from rosin joint. Each multi-core or single-core cable shall be complete without splicing, and there must be no short circuit between any cables

The ADU and ADU controller shall be independently grounded, with a grounding resistance of ≤ 4 Ω.

4.2 Operation and Debugging

Attentions shall be paid to the debugging for personal and equipment safety:

- People in this work must read the User Manual carefully and get better understanding on the debugging method, operation and troubleshooting of the equipment;
- Confirm the driving motors, encoders, and mechanical transmission parts are in good condition, and the 3-phase power supply as well as grounding is up to the operation requirements;
- Do not remove the plugs and connectors with the equipment powered up to avoid any circuit or component damage;
- Inspection and measurement shall be done with great cares to avoid high voltage electric shock or short circuit hazards to people and equipment;
- The antenna control and operation shall be monitored in the debugging to void damage on the antenna structure;
- In case of any fault, it shall be eliminated as per the fault description in this manual;

- After debugging, all set parameters shall be well recorded for quick restore of the equipment in the future.

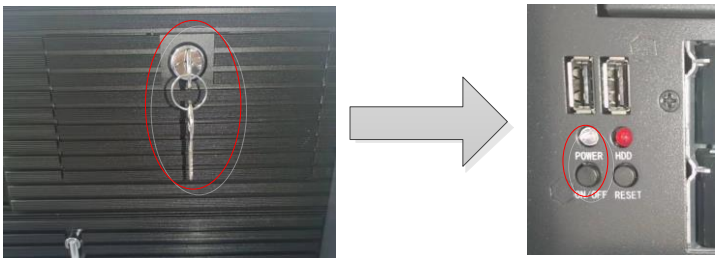
4.2.1 Power Supply Check

Check all cables are connected properly and reliably. All cables are laid at the designated positions. Keep the cables free from twisting in antenna movement.

Check the equipment startup and panel display are normal. Debugging is allowed only when there is no abnormal.

4.2.1.1 ACU power supply

Power up the ACU. Press the POWER key on the front panel. The system starts up with blue LED on (Figure 4-3).



① Open the front panel here

② Press POWER key

Figure 4-3 ACU power supply

4.2.1.2 ADU power supply

ADU connects XS1 connector ① - air switch ② - front panel switch ③ in turn as shown in the following figure, and the equipment starts to work.

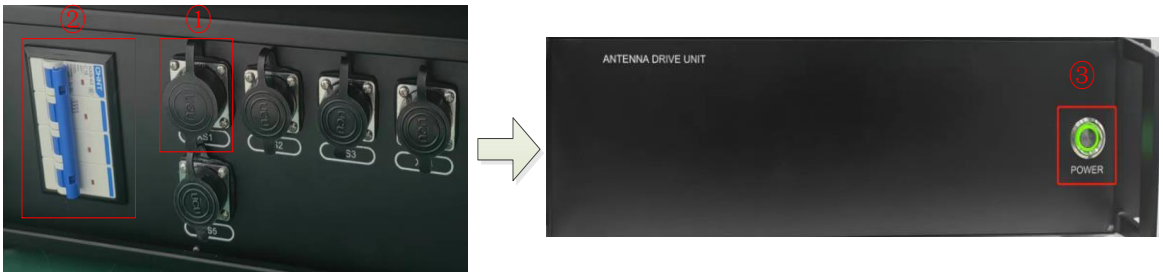


Figure 4-4 ADU power supply

4.2.1.3 ADU controller power supply

ADU controller connects XS1 connector ① - air switch ② - front panel switch ③ in turn as shown in the following figure, and the equipment starts to work

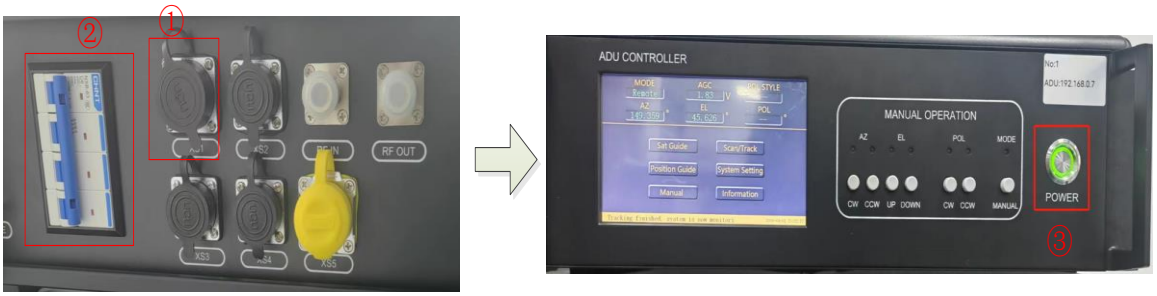


Figure 4-5 ADU controller power supply

Note: The antenna controller system needs to first open The ADU and ADU controller shall be started up first before activating the testing software "Debug" ACU.

4.2.2 System Connection

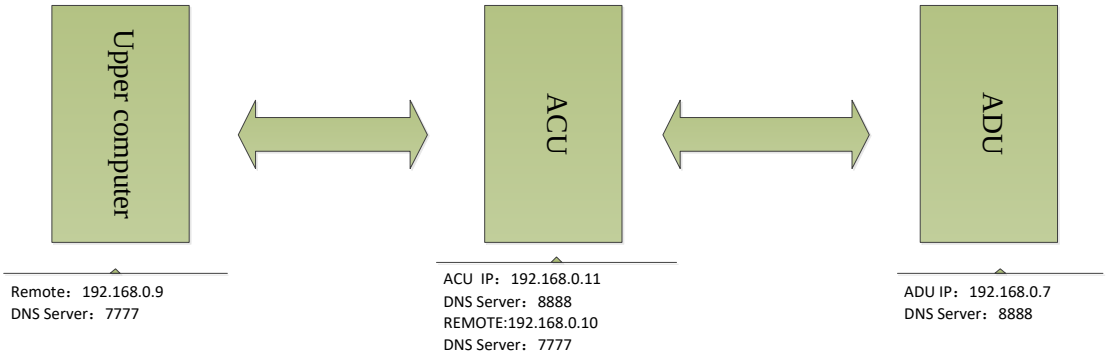


Figure 4-6 Diagram System Connection

The ADU will connected to ACU automatically if they are connected through an Ethernet cable. The ADU is controlled through the ACU automatically, and the automatic control of the ADU is inactive; the ACU is connected to the user's upper computer through TCP. After the connection is completed, the ACU can only be controlled through instructions from the upper computer, and then the ADU can be controlled. The automatic control for both ACU and ADU are inactive.

4.2.3 System Debugging

4.2.3.1 Preparations

Before the on-site debugging, the following antenna information shall be well known:

- Antenna aperture;
- Local site geographical longitude and latitude;
- Number of bits of the antenna encoders;
- Related information for polarization control, position detection, motor type, etc.

4.2.3.2 Debugging of ADU and ADU controller

Check and make sure the ADU, ADU controller and antenna are properly connected in good condition before any operation.

(1) Adjustment of antenna and polarization direction

Control the AZ movement in clockwise under manual mode, and observe if the AZ direction is consistent with the displayed control direction. If not, switch the wiring between any two phases of the azimuth drive motor after equipment shutdown, and restart the equipment to test check again. The same method is applicable for EL motor adjustment.

Figure 4-7 Manual Control Panel of ADU Controller

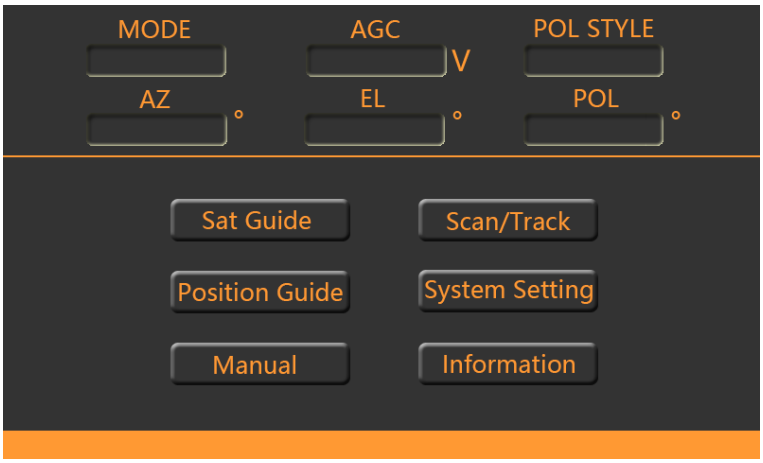


Figure 4-8 ADU Controller Display

(2) Adjustment for direction change of position display

Control the AZ movement in clockwise under manual mode, and observe if the AZ position display is consistent with the displayed azimuth moving direction (when turning clockwise, the displayed azimuth position shall increase). If not, the encoder direction shall be reversed and he equipment be restarted to test. Adjust the direction of change in EL and POL position display in the same way.

Figure 4-9 Encoder Reverse

(3) High and low speed (optional)

Click on the screen or manually adjust the antenna to high and low speed respectively, and observe the corresponding high and low speed display on the screen.

(4) Encoder calibration

After the angle encoder is installed, the displayed angle is a random value and cannot represent the true AZ, EL and POL angle of the antenna. It requires angle calibration. Before calibrating the encoder, point the antenna to the satellite, and set the AZ, EL and POL angle to the true values of the satellite.

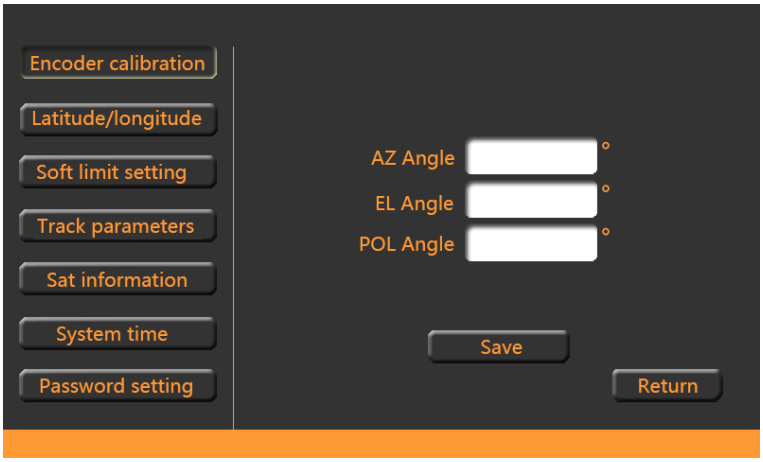


Figure 4-10 Encoder Calibration

(4) Hard limit debugging

According to the antenna moving range, control AZ to the clockwise and counterclockwise switch limit positions respectively, adjust the limit block, and rotate the antenna to repeatedly hit the limit switch several times to confirm that the switch limit is in active. Set EL up and down switch limits as well as POL switch limit in the same way.

Check EL up and down switch limit detection and POL switch limit detection in the same way.

(5) Soft limit setting

The clockwise and counterclockwise soft limit values shall be set before the corresponding hard limit, with a difference of no less than 2 degrees. In this way, the azimuth is protected by the soft limit before the switch limit. Adjust and set the elevation and polarization soft limits in the same method.

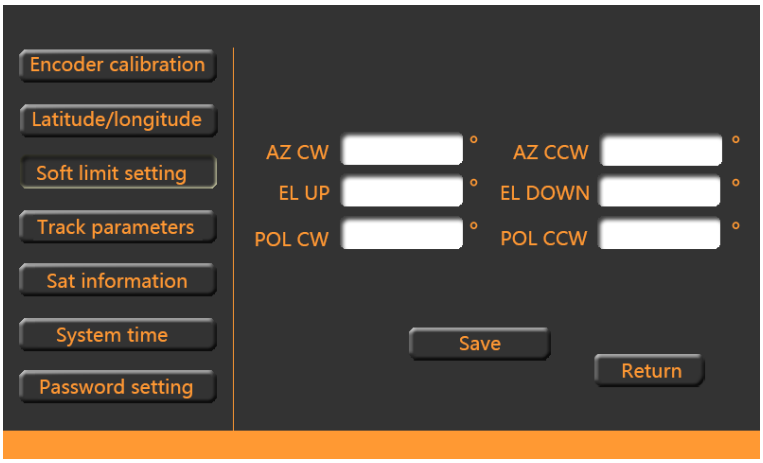


Figure 4-11 Soft limit setting

4.2.3.3 ACU Debugging

After the debugging of the ADU and controller, connect the ADU controller through the Ethernet cable (set the IP address of the Ethernet port in advance), start the ACU to enter the software interface, conduct remote connection, select manual operation, and click the movement buttons in each direction as follows:

- Press AZ CW button to observe if AZ angle increases and the limit is normal;
- Press AZ CCW button to observe if AZ angle decreases and the limit is normal;
- Press EL UP button to observe if EL angle increases and the limit is normal;
- Press EL DOWN button to observe if EL angle decreases and the limit is normal;
- Press POL CW button to observe if POL angle increases and the limit is normal;
- Press POL CCW button to observe if POL angle decreases and the limit is normal;

The ACU debugging is completed in case that the above functions are normal.

Note: No need to consider the polarization if the antenna is in two axis.

4.3 Description of Operation

The antenna control unit (ACU) will automatically enter the software interface once started. After remote connection, the control authority is to ACU by default, and subsequent operations are performed in ACU.

4.3.1 Home Display

Figure 4-12 Remote Control Interface

As shown in Figure 4-12, the remote control main interface consists of five parts. The top part is for system information display, the left side is for system status display, the middle part is for function menu, the right side is for system settings, and the bottom part is for operation information prompt.

4.3.2 Standby

Click the "Stop" button to stop the antenna movement in emergency during any operation.

4.3.3 Program Boot File Generation

Click "Satellite Orbit Cale" to enter the interface, as shown in Figure 4-13. The data format of Preset Parameters and Local Parameters must be consistent as shown in the figure.

"Start time" and " End time" are the start time and end time of the satellite to be calculated; "Time zone" is filled in according to the local time zone, for example: Beijing time zone is 8, and central standard time is -6; "Step length" is the time interval of each line of data in the generated file. This value can be appropriately selected according to the satellite's moving speed. It is recommended to use 1 second. If the satellite's moving speed is low, select the appropriate "Time Interval" in the "Program Tracking" function.

Enter the local longitude and latitude in degrees for the "Local Latitude" and "Local Longitude"; "Altitude" is the altitude of the station, in kilometers; "Min EL" is the minimum elevation angle that the antenna can move to.

In the "Select 2-line root file" area, click "Select" to choose the two-line root file to be calculated. The file must be in txt format. The file path and file name can only contain English letters and Arabic numerals. Refer to Figure 4-14 for file content.

Select existing folders in "Existing", and delete unnecessary folders by clicking "Delete"; Input the folder name of the satellite orbit file to be saved in the "Folder name", and click "Calculate" to generate the folder and the

included file.

The file is saved under the D://output/output folder.

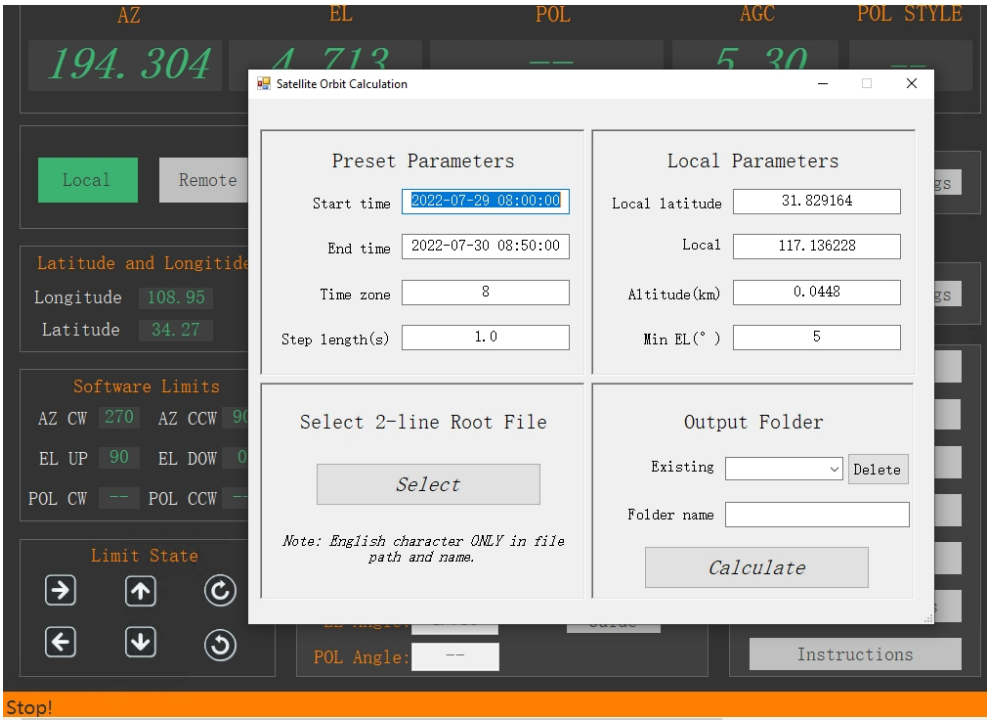


Figure 4-13 Main Interface of Program Boot File Generation

```
ATLAS CENTAUR 2
1 00694U 63047A   23053.58682173  .00003469  00000+0  44098-3 0  9991
2 00694  30.3532 249.5729 0578117  64.1631 301.7431 14.04442305974865
```

Figure 4-14 Template of Two-line Root File

4.3.4 Program Tracking

Click "Program Tracking" to enter Figure 4-15. In the main interface of program tracking, select the folder where the satellite orbit file needs to be tracked at "Select Folder". Select the tracking file at "Select File", and fill in the tracking time at "Time Interval". If the "Step length" is 1 second in the "Sat Orbit Calc", select a few seconds here, that is, it is considered to be guided once in a few seconds; If the "Step length" is 10 seconds in the "Sat Orbit Calc", and here is 1 second, it is 10 seconds to conduct a guidance.

After filling in the data, click "Import", and the system will load the satellite track of the file, as shown in Figure 4-16. Click "Start" and the system will wait for the time to start the program tracking.

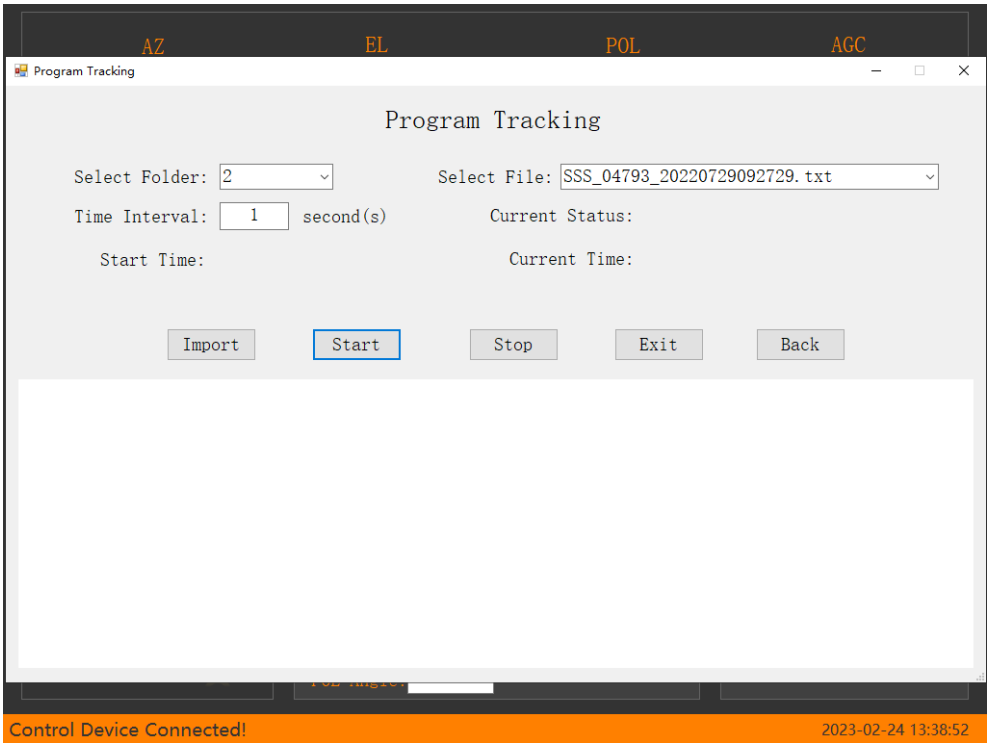


Figure 4-15 Main Interface of Program Tracking

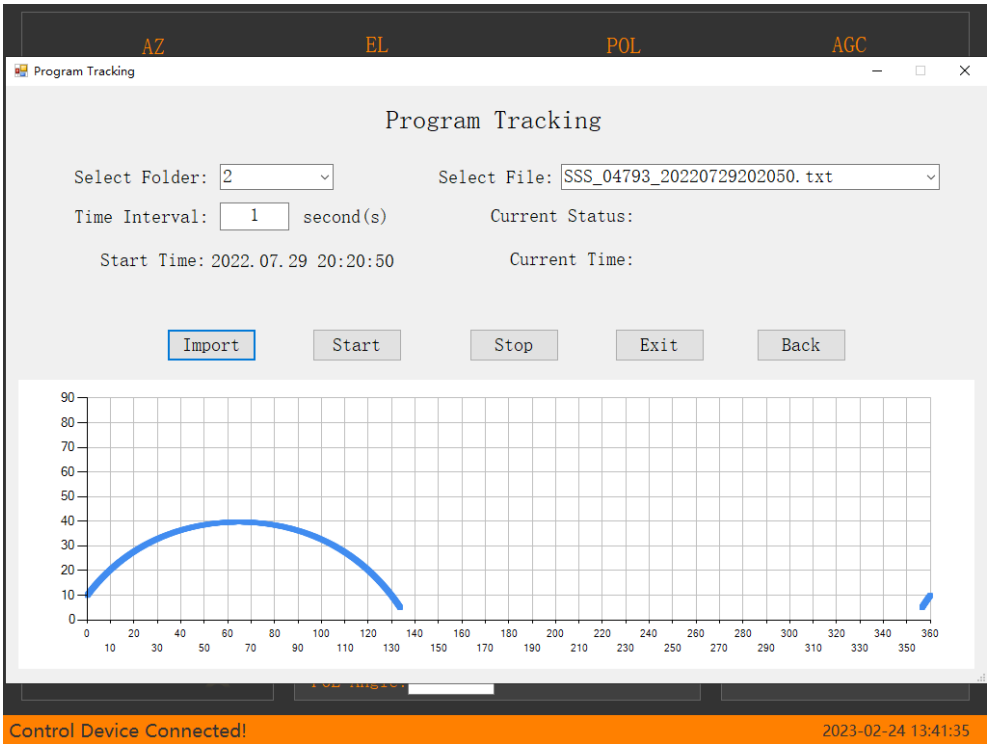


Figure 4-16 Interface of Program Tracking

4.3.5 Preset Satellite

Some satellite information is usually added in advance for direct call in a new system. If the required information does not exist, it can be added and deleted as appropriate.

How to add satellites:

- Click Preset Sat on the main interface to enter the preset satellite information, as shown in Figure 4-17;
- Click Add Sat on the preset satellite information to add new satellites;
- Press "Save" to keep the result.

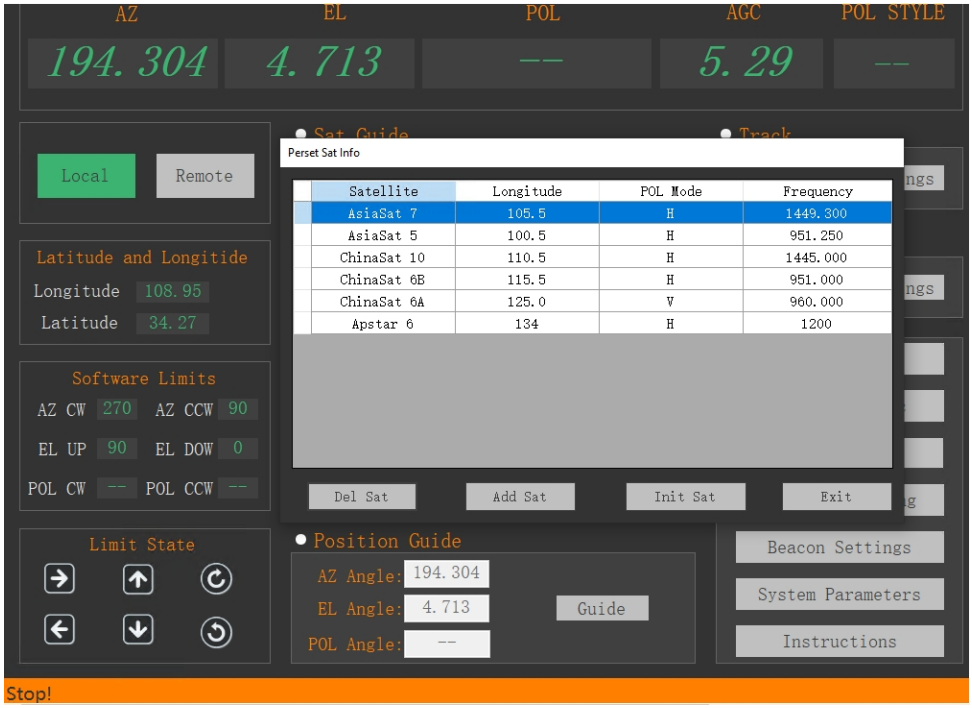


Figure 4-17 Preset Satellite

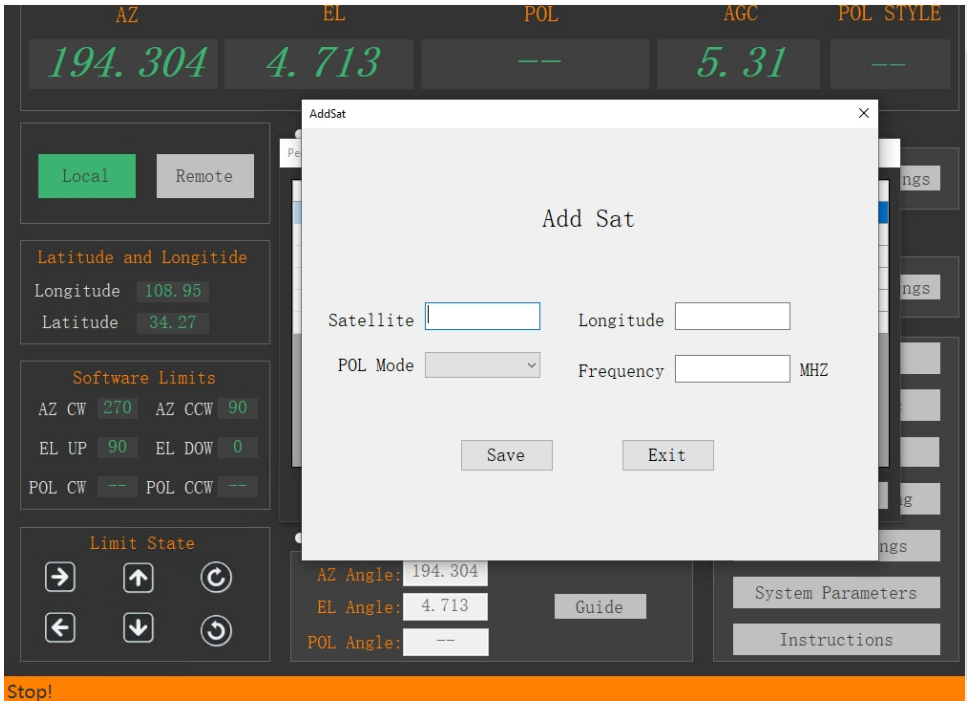


Figure 4-18 Add Satellite Information

4.3.6 Beacon Setting

Click “Beacon Setting” button to enter the interface as shown in Figure 4-19. The current beacon frequency and feed voltage for LNB are modifiable.

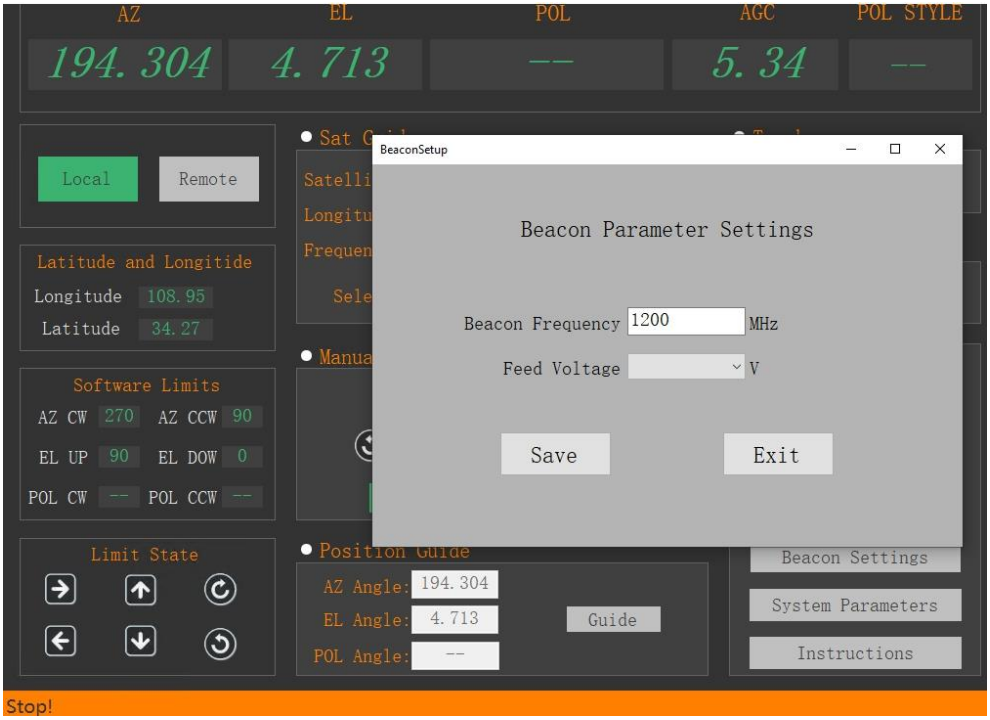


Figure 4-19 Beacon Setting

4.3.7 System Parameters Setting

4.3.7.1 Local latitude and longitude

Fill in the local latitude and longitude and “Save”, as shown in Figure 4-20.

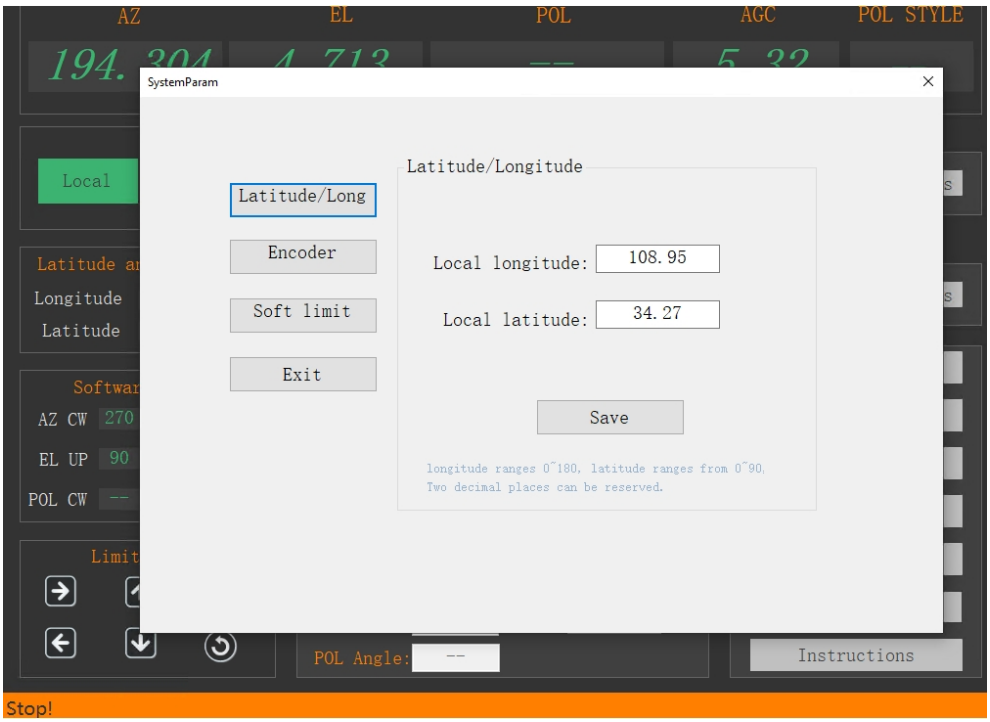


Figure 4-20 Longitude and Latitude Setting

4.3.7.2 Encoder calibration

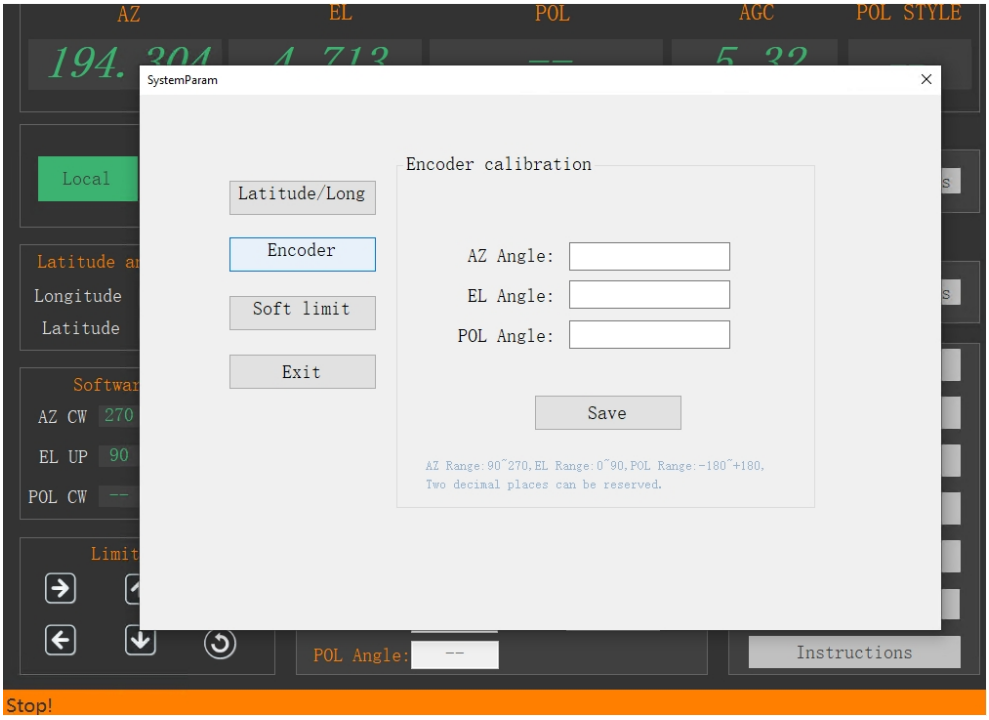


Figure 4-21 Encoder Calibration

After the angle encoder is installed, the displayed angle is a random value and cannot represent the true AZ, EL and POL angle of the antenna. It requires angle calibration, as shown in Figure 4-21. Point the antenna to the satellite, and set the AZ, EL and POL angle to the true values of the satellite to complete encoder calibration.

4.3.7.3 Soft limit setting

In order to protect the antenna from rotating out of the normal working range due to unexpected reasons, the soft limit shall be properly set, as shown in Figure 4-22. Generally the software limit position is slightly smaller than the hardware limit position of the system.

The system will control the antenna to stop immediately once the antenna activates the soft limit. At this point, the antenna shall be moved in manual in the opposite direction to release the limit.

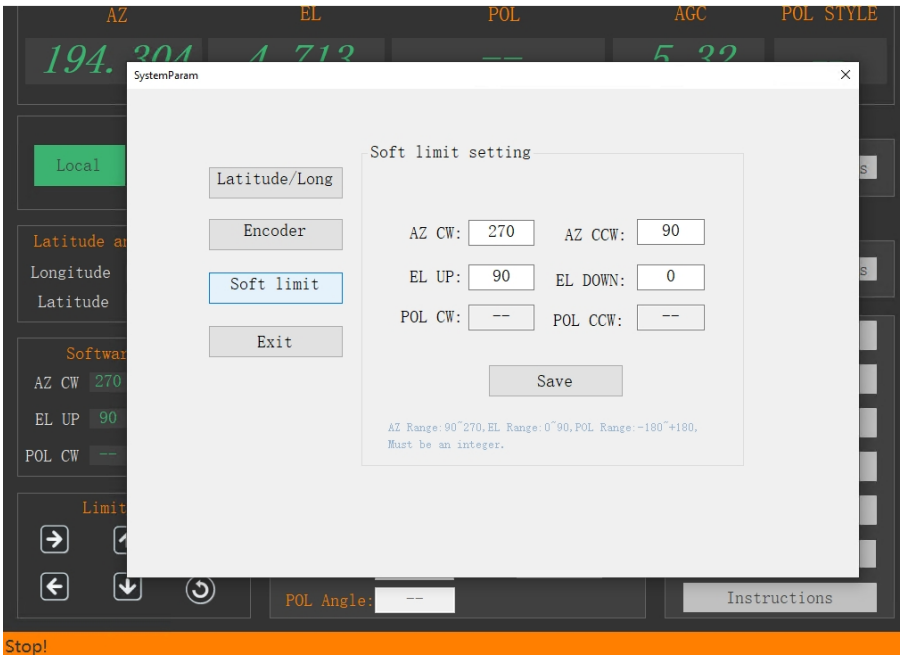


Figure 4-22 Soft Limit Setting

4.3.7.4 Instructions

Click “Instructions” and read the descriptions carefully before antenna operation. It describes limit status display, satellite position guide, direction guide, position guide, automatic tracking, scan and tracking, preset satellite, beacon setting, standby, etc. See Figure 4-23.

Figure 4-23 Instructions

4.3.8 Satellite Guide

①Click “Sat Guide”;

②Click “Select” to pick up the preset target satellite, as shown in Figure 4-24;

③The satellite information, beacon frequency and the target angle are to be calculated and displayed;

④Click “Guide” to move the antenna automatically towards the target satellite

Figure 4-24 Satellite Guide

Figure 4-25 Satellite Select

Note: Before selecting a satellite on the interface of Figure 4-25, the relevant parameters of the target satellite shall be preset in the setting menu of the main interface. This system supports preset of 50 satellites. The satellite presetting here is independent from that of the ADU controller.

4.3.9 Auto Track

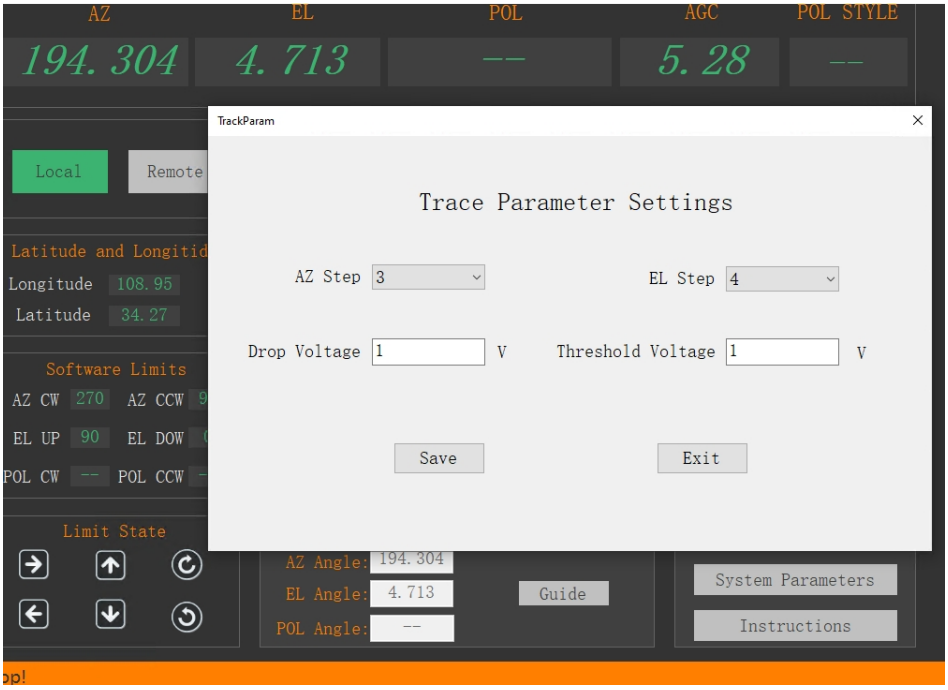


Figure 4-26 Auto Track

① Select “Track” (upper) firstly to activate the editable line (Track and Settings);

② Click “Settings”. Input the parameters and “Save”. as shown in Figure 4-26；

③ Click “Track” to start the tracking. The antenna starts to monitor the system AGC voltage. According to the current AGC value and the track parameters in the system settings, the antenna movement is to automatically start and stop;

The system defaults to low speed for AZ and EL motor in operation.

4.3.10 Scan

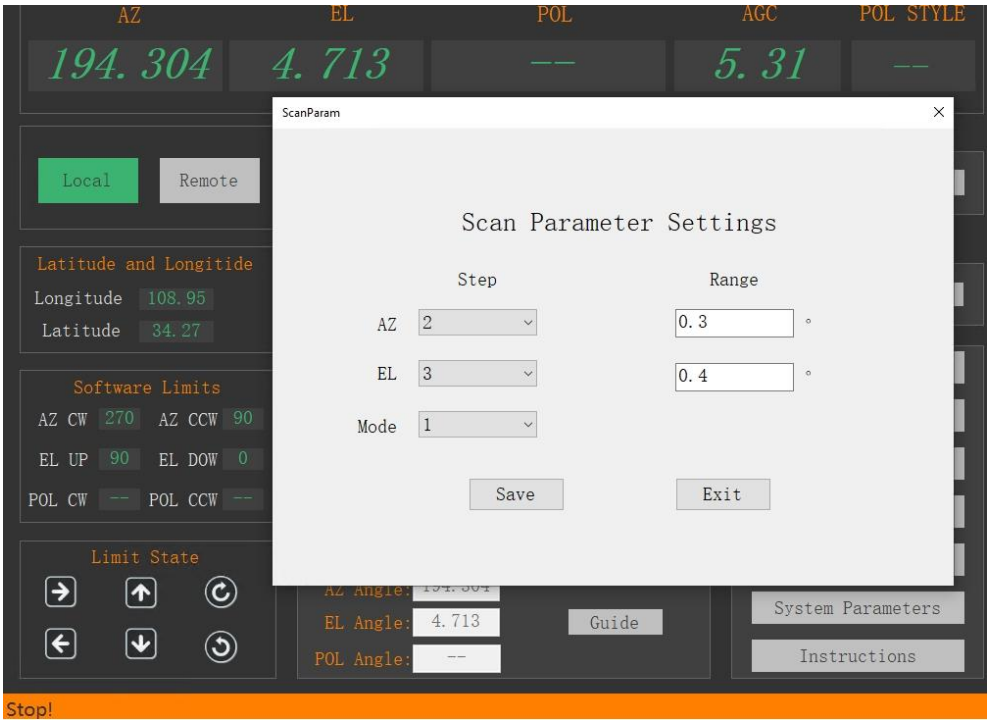


Figure 4-27 Scan

① Select “Scan” (upper) firstly to activate the editable line (Scan and Settings);

② Click “Settings”. Input the AZ, EL step, and scanning range, select “Mode” and “Save”, as shown in Figure 4-30；

③ Click “Scan” to start the scanning. During the scanning, please do not operate;

④ Scanning mode 1, the system defaults to scanning: high speed - track: low speed when the motor is running.

4.3.11 Direction Movement

Click the direction buttons to move antenna, and pause button to stop movement, as shown in Figure 4-28.

Figure 4-28 Manual Operation

4.3.12 Speed Setting

Figure 4-29 High and Low Speed Display

This is a dual-speed control system, high speed and low speed. The speed is adjustable at the same time during the direction movement process, but the system's default operating is in low speed during auto tracking; In scanning operation mode I (system scans first and then tracks), when the scanning process is executed, the system runs at high speed, but the tracking system after scanning is at low speed by default. Other items run at high speed by default.

4.3.13 Position Guide

As shown in Figure 4-30, fill in the target AZ, and EL respectively. Click “Guide” to move the antenna and automatically stop at the set target angle.

Figure 4-30 Position Guide

5 Troubleshooting and Repair

5.1 Troubleshooting

When the equipment is running normally, it will automatically diagnose the antenna soft and hard limit and encoder angle faults, and display and alarm the detected faults.

Table 5-1 Methods for troubleshooting

Fault Type	Methods for Troubleshooting
Soft limit	In case of any soft limit fault, the antenna shall be controlled under manual mode to remove the corresponding limit.
Hard limit	1. Check if there is a corresponding soft limit alarm before the hard limit, if not, the soft limit setting is not suitable and shall be reset. 2. In case of any hard limit fault, the antenna shall be controlled under manual mode to remove the corresponding limit. 3. The antenna system shall be checked for damage of limit switch and proper cable connection in case of any hard limit alarm and antenna not in limit position.
Angle display	1. Check the corresponding position encoder for proper cable connecting. 2. Adjust the encoder direction via ACU. 3. Check the number of bits of the encoder.
ACU connection	1. ADU and controller are not powered up. 2. The IP and port settings are not correct and shall be reconfigured.
Motor steering	1. Check the motor and corresponding connection are normal. 2. Swap any two wires of the U, V, W three-phase cable for the AZ and EL motors.
Abnormal power supply voltage	1. Check the three-phase input power supply for default phase. 2. Check the failure detection circuit of the relevant AC power.

5.2 Maintenance Interface

5.2.1 LNB Feed Setting

Click “System Setting” on the main interface and input the password, the factory default password is “5288”. Click “FEED” for LNB power supply, and select LNB feeding voltage.

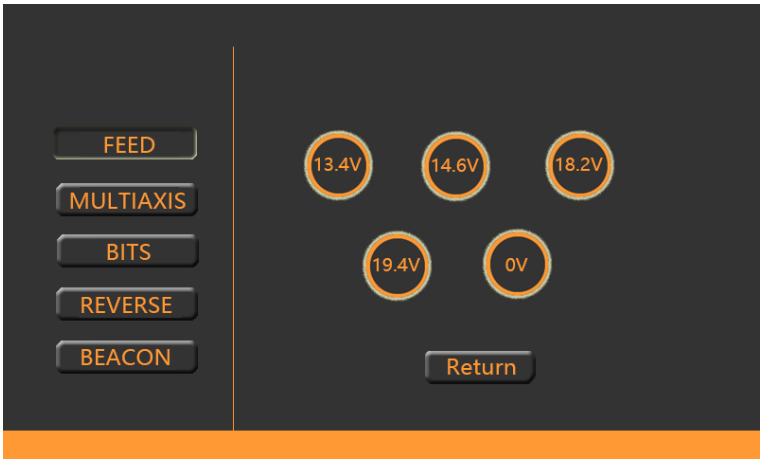


Figure 5-1 LNB Feed Setting

5.2.2 Motorized polarization

Click “MULTIAXIS” and select the number of antenna axis in the interface as shown in Figure 5-2。

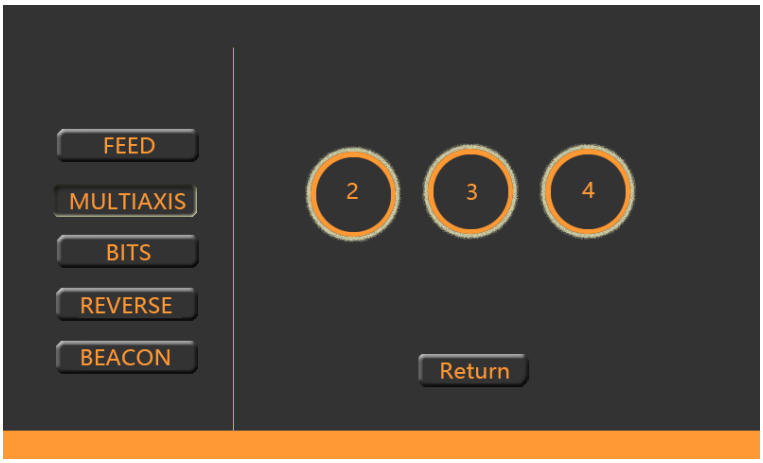


Figure 5-2 Motorized polarization setting

5.2.3 Encoder bits

After the antenna installation, click “BITS” and fill in the bits of the current antenna AZ, EL, and POL encoders. Click “Save” to finish, as shown in Figure 5-3.

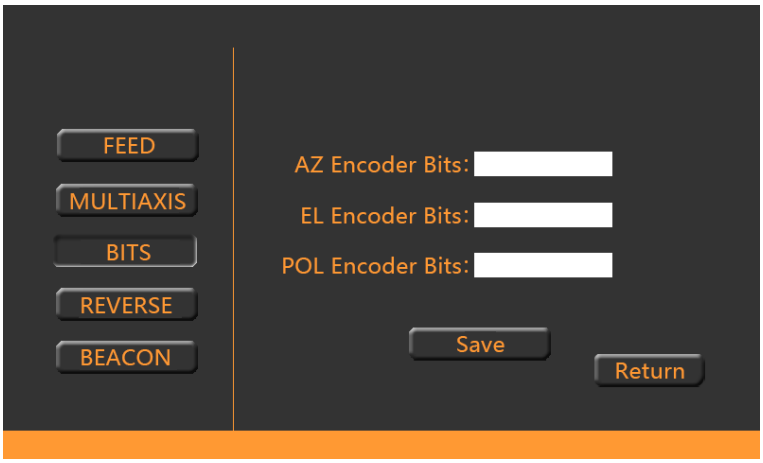


Figure 5-2 Motorized polarization setting

5.2.4 Encoder Reverse

When debugging the antenna, it may encounter EL upward movement and a decrease in EL angle display, which indicates that the encoder direction is opposite to the antenna moving direction. At this time, the encoder needs to be set in reverse, that is, to move upward in EL and increase the angle. Click on System Settings on the main interface, enter password 5288, click Verify, enter the interface shown in Figure 5-4, Click "REVERSE" and select the correct direction of the encoder for setting in the interface of Figure 5-4

Figure 5-4 Encoder reverse

6 System Maintenance

To ensure personal safety and normal operation of electrical equipment, generally, the following six methods are used for daily maintenance.

- Visual check: Check the appearance of the equipment structures. For example, loosen fasteners, carbonized and blackened insulating material, values from the instrument and status of the indicating device.
- Sound check: Check the electrical equipment in operation for any noise or abnormal sound.
- Sniff check: Smell the odors emitted by electrical equipment in operation such as pungent burnt smell caused by short circuit, overload and over temperature.
- Hand check: Touch the equipment enclosure for temperature evaluation and proper operation.

- Test: Test various operating parameters and insulation resistance of the electrical equipment through common measuring instruments.
- Measures: Regular cleaning, inspection and maintenance as per the requirements of electrical equipment maintenance.
- Regularly check the contactors, circuit breakers for normal operation.
- Regularly check all circuit connecting points for looseness, oxidation, etc.
- Dusts and greasy dirt on the equipment, lines and motors shall be removed in a timely manner.
- The grounding conductor shall be checked in good condition and the grounding resistance shall meet the requirements (no more than 4Ω).
- Each control operating system of the equipment shall be sensitive and reliable and free of any abnormal sound.
- The lead screw, rotating shaft and bearing of the equipment transmission system shall be lubricated at specified intervals.
- Safety devices of the equipment shall be complete and in no malfunction.