WOOZOOM

THEONE-A

Flight Controller of Agricultural Unmanned Aircraft

User's Manual V1.0

Thank you very much for your use of THEONE-A flight controller product. Before using this product, please read this User's Manual carefully and follow the instructions on installation, commissioning, operation and maintenance of the product strictly as detailed in the manual. This product requires to be used cooperatively with the software of a PC terminal ground station, which shall be installed according the hints in the manual by yourself.

Contents

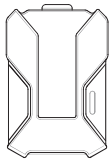
This company will not take any responsibilities for any personal injuries or property losses due to the following causes. Please read the following provisions carefully: The product is not operated by a minor under 18 years old.

1. The product is imitation. Or it is acquired or used through abnormal (illegal) channels.
2. The product is not installed, set up or used correctly according to this User' s Manual.
3. The product is reformed or replaced voluntarily with parts or accessories that are not produced by Woozoom, resulting in poor operation of the aircraft and further injuries or damages.
4. The operator operates this product in poor physical or mental conditions.
5. The operator causes property damages or personal injuries due to subjective intention or improper operation.
6. The operation of the product is proper due to natural aging or wearing of the aircraft parts and components.
7. The product is used in a harsh environment that exceeds the applicable environment specified for the product.
8. The product is damaged due to misuse.

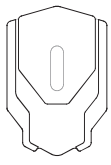
2.1 Product Description

THEONE-A flight controller of agricultural unmanned aircraft is a type of flight control system that is orientated to agricultural multi-rotor unmanned aircraft, which has the following characteristics:
1) High precision sensor attitude detection unit, GPS receiver with high stability and CPU with high speed processing capability are adopted, which are designed with real time online dual redundancy.
2) Having passed rigorous reliability testing, it can work in all kinds of complicated and harsh environments. The waterproof grade is IPV4.
3) It supports multilateral irregular terrain route planning. The unique breakpoint continuous spraying technology can guarantee that there is no missed spraying.
4) It provides CAN, RS232, I2C communication interfaces and 18 input-output interfaces, so it has a strong expandability and can support differential GPS.
5) It is easy for use, installation, operation, maintenance and repair.

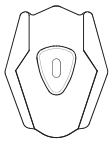
2.2 Packing List



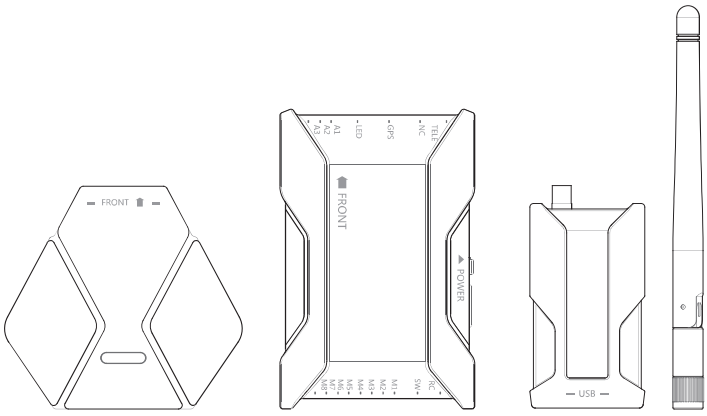
Power management Unit



LED



Safety Switch



Compass　　Controller Unit　　Telemetry

Other Accessories

Micro-USB wire (1), compass unit holder (1), 3M adhesive tape (1)and receiver connecting wire (1)

> **Attention** Please download the corresponding latest versions of ground station software from WooZoom official website.

2.3 List of Self-Furnished Devices

Aircraft Take quad-rotors as an example only

Remote Control Model: T14SG　Producer: Futaba

Others

1. Receiver Model:R7008SB　Producer:Futaba

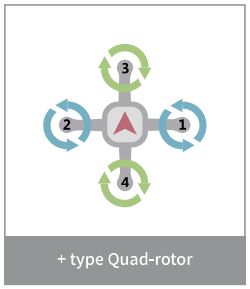
2. Battery

Aircraft

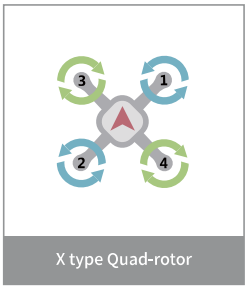
Remote Control

3.1 Types of Supported Aircraft

The product supports the following 6 types of multi-rotor aircraft. The arrow indicates the default rotating direction of the motor. In case the rotating direction of the motor is to be changed to the counterclockwise direction, it may be realized by setting the motor rotating direction parameter to 1 in “Attitude Parameter Setting”. See “Attitude Parameter Setting” for details.



+ type Quad-rotor



X type Quad-rotor

+type Hex-rotor

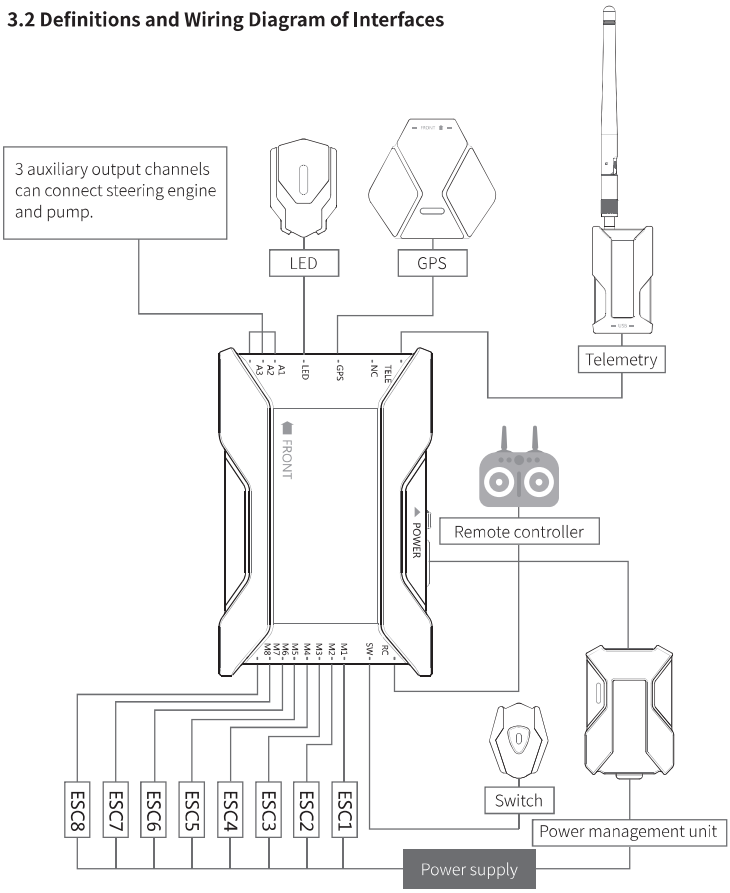
X type Hex-rotor

+ type Oct-rotor

X type Oct-rotor

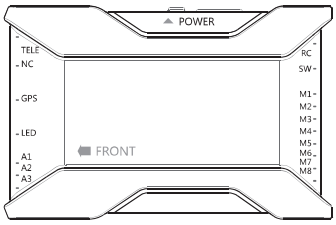
As in the related pages of the ground station, click the above icons to select the type of aircraft, then by clicking “OK” button, the equipment will be restarted to update the type parameters. The ground station requires reconnecting before it completes the subsequent settings.

3.2 Definitions and Wiring Diagram of Interfaces

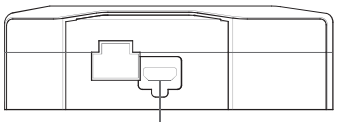


Attention Before flight, please confirm the connecting wires on the main controller is not loose. It is recommended that the joints should be reinforced with suitable quantity of hot melt adhesive. Also, check the blades, which should be installed correctly and firmly.

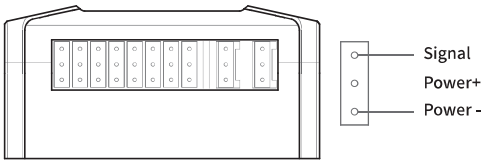
3.3 Methods for Installation of Components



M1~M8	Connect aircraft ESC
TELE	Connect telemetry
SW	Connect safetyConnect GPS and compass
GPS	Connect GPS and compass
RC	Connect receiver
LED	Connect LED
Power supply	Connect power unit
A1~A3	Output for auxiliary PWM, connect steering engine, etc.



USB interface on the side of master controller to be used for firmware updating

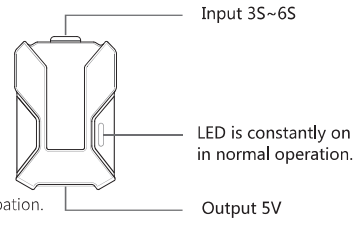


Installation requirements

The master controller is aligned with the nose in the arrow direction on the shell and placed in the horizontal center of the airframe as much as possible. Do not cover the connecting interface. The master controller may be fixed directly on the airframe of the aircraft with screws of corresponding size.

3.3.2 Power Unit

Introduction to the interface



Installation requirements

There is no requirement for installation direction,

but it must be installed in a position with good heat dissipation.

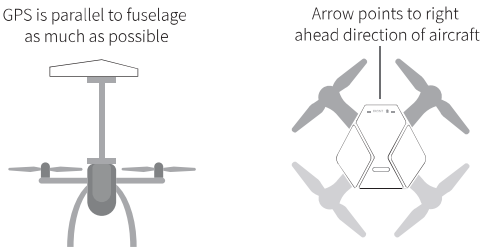
3.3.3 Compass

The compass is composed of GPS and a box compass. The box compass is used to measure geomagnetic field and to realize aircraft horizontal orientation and set the points.

Installation procedure

1. Assemble the holder Assemble the GPS holder with AB adhesive and then fix the holder on the center plate of the airframe with screws (Please select and use long supporting rods so as to guarantee signal quality).

2. Assemble GPS Fix the GPS on the tray with 3M double-faced adhesive tapes. When assembling GPS, make sure that it should be parallel to the fuselage as much as possible. Use long supports to assemble the GPS so that it is away from other electronic devices as much as possible. Point GPS arrow toward the right ahead direction of the aircraft.



Operating requirements

The inner compass is a magnet-sensitive device, so it must be away from all other electronic devices and magnetic substances. Otherwise abnormal flight may happen. During its operation, there must be no tall buildings or trees around, which may cover the device, affect receiving of GPS signal and result in slowing down the searching speed of GPS satellite and bad satellite signal quality. When the aircraft takes off in the position control mode, there must be at least 7 satellites. Otherwise, the takeoff cannot be executed.

3.3.4 SW

After the aircraft is powered on and before the SW is unlocked, the aircraft is in the “Waiting for flight” state, the SW indicator flicker slowly. After the SW is unlocked, the aircraft shall come into “Ready for takeoff” state and the SW indicator shall flicker quickly. If the aircraft is manually controlled for takeoff, it must be unlocked for takeoff via the remote control, i.e., toggling the (xx stick) rightward by 1S or more.

3.3.5 LED

Working mode	LED color	Flight regime indication
Conventional operation	Blue LED flickers	System stand by mode
	Red LED flickers quickly	System sensor or electric quantity detection is abnormal
	Green LED flickers	GPS signal is good
	Green LED lights constantly	System is unlocked for normal flight
	White LED flickers	It is a prompt of success of the current operation
Agricultural operation	Yellow LED flickers	The flight controller is controlling the aircraft automatically to reduce the speed, over ridges or continue cruising at breaking points.
	Red LED lights constantly	It is a prompt of error in the operating flight direction
	Violet LED flickers	It is a prompt that the user may control the operating flight
	Violet LED lights constantly	The flight is normal
	Green LED flickers	The agricultural operation is finished

3.4 Calibration of Remote Control

This product can support three input modes：PPM，SBUS and XBUS. It has 18 input channels. It can calibrate the remote control input rockers and the switch strokes automatically. By clicking the “Calibration” option in the interface, push the pitching, rolling, heading and throttle rockers according to the graphic prompts, and toggle all the switches between the maximum and the minimum strokes according to the prompt messages in the interface.

The first page of remote control calibration 1

By using the remote control to calibrate the pull-down menu under the view, you can fill in the messages such as PWM range, dead zone, forward/ reverse direction and neutral point of each input channel. You can also set the mapping relations between all the auxiliary channels.

Remote control calibration example 2

You can set the control switch mapping of two auxiliary channels: AUX1 (water pump) and AUX2 (collection place gage point). As for AUX3 (clear away the mission), you need to select the designated channel mapping in the pull-down list of the channel under the interface. Refer to "Agricultural flight operation" for details. AUX 4 is flight mode selection function. It has three control modes: ECO, COMFORT and SPORT. In each of the modes, the throttle response as well as the pitching and rolling accelerations have obvious changes. AUX5 is agricultural advanced function start. See "Agricultural Flight Operation" for details. By using the remote control to calibrate the pull-down menu under the view, you may fill in the messages such as PWM range, dead zone, forward/ reverse direction and neutral point of each input channel. You may also set the mapping relations between all the auxiliary channels.

3.5 Calibration of Sensors

Circumstances that require re-calibration

1) When the first initialization is made and aircraft model is changed.

2) During flight, the flight mission interface shows red letters to prompt calibration messages or to display a larger variance between the aircraft attitude angle/heading angle and the actual angle.

By clicking the corresponding buttons in the interface below and following the dynamic prompts in the graphics, you may complete automatic calibrations of two gyroscopes, double-set accelerometers and double-set magnetic compasses. The items to be calibrated include

1) Calibration of magnetic compass: Rotate the product from 6 azimuths as shown in the graph in order to calibrate the 6 axial data of the magnetic compass.

2) Calibration of accelerometer: Place the product in 6 azimuths still as shown in the graph in order to calibrate the 6 axes deviations automatically.
3) Calibration of gyroscope: Place the product horizontally still in order to calibrate the zero offset of the gyroscope.
4) Calibration of attitude angle zero offset: Calibration of attitude angle zero offset is required when the production installation angle is misaligned with horizontal plane of the aircraft. Place the aircraft horizontally for a moment and the product will calculate the deviation value automatically.

Sensor calibration page 1

Sensor calibration page 2

3.6 Installation and Configuration of GCS Software

Please refer to "THEONE-A Ground Station System Installation Manual" for installation and configuration of GCS software.
Related documents can be downloaded from https://www.woozoom.net/.

4.1 Requirements for Operating Environment

1) Before use, the user must have related flight training and exercise experience, or have professional guidance in the process.
2) Do not use the product in severe weathers such as wind force above 5, heavy rain or heavy fog.
3) Select an open takeoff site where there are no tall and big coverings around as that they may affect normal work of GPS and compass.
4) Fly the aircraft far away from any obstacle, crowd, HV power line, water surface and so on.
5) Keep the remote control unit from mutual influence or interference with other wireless devices (make sure that there is no base station or launching tower around).

4.2 Pre-Flight Inspection

Please check the following items carefully before the aircraft takes off
1) The battery and the remote control unit must have sufficient power level.
2) The installation direction of blades must be correct.
3) The installation direction of the motor must be correct.
4) The type of aircraft must be matched.
5) GPS, compass and other components must be installed correctly.
6) The sensors and the remote control unit must have been calibrated.
7) ESC must be connected correctly and firmly.
8) The navigation module must be bonded firmly.
9) The aircraft must take off with the safety takeoff weight.
10) All the components must work normally without any aging or damage.

4.3 Setting Flight Mode

The product has 5 flight modes: attitude stabilization mode, GPS fixed-altitude mode, GPS positioning mode, agricultural mission flight mode and automatic homing mode, each of which shall be realized through the coordination of the remote control switch with the set threshold. The remote control switch is selected in the pull-down list under each stabilization mode in the flight mode interface while the switching threshold of each mode may be set by dragging it directly in the dragging bar under each mode. In this interface, the user may also examine the selected flight mode in real time so as to select the switch number and adjust the threshold.

Example of setting flight mode

Attitude stabilization The attitude of aircraft is controlled automatically. The expected attitude value is the rocker amount. The magnitude of expected attitude value can be set in “Attitude control parameter” page; the heading angle is controlled automatically. The heading operation given by the rocker is heading angular rate. The expected magnitude of angular rate can be regulated in “Attitude control parameter” page; the product does not control the altitude channel. The throttle amount given by the remote control shall be given to the output.

GPS fixed-altitude mode The altitude channel shall be controlled by the product automatically; the remote control throttle gives climbing speed. The maximum climbing speed can be regulated in “Position control parameter” setting. When the throttle rocker is set within ±10% of the neutral point of the remote control, the product shall maintain the current flight altitude by itself; The operating modes of the other channels shall be the same as the attitude stabilization flight mode.

GPS positioning mode The horizontal position is controlled by the product itself. The remote control pitching and rolling joysticks gives expected forward and lateral speeds. The maximum expected speed can be regulated in “Position control setting”. When the joystick is in the neutral position, the product maintains the horizontal position by itself. The operations of the other channels shall be the same as GPS positioning mode.

Automatic homing mode The product operates the aircraft automatically to climb from the current position then return to the takeoff position, and regulates the heading angle to the heading angle at the time of takeoff, and hovers at a certain altitude from the takeoff position. Climbing altitude, hovering altitude, landing waiting time, descending speed and other parameters shall be regulated in “Safety parameter setting”.

Agricultural mission mode The product shall operate the aircraft to perform agricultural missions automatically. See “Agricultural flight operation” for details.

4.4 Setting Safety Parameters

The product is provided with automatic auxiliary function such as homing landing protection when the remote control and remote signal are failed, battery electric quantity monitoring and low voltage reminding, airframe structure vibration early warning and navigation system vibration protection, landing automatic locking and takeoff position control. The parameters of all the functions shall be set in “Safety setting” page.

Setting remote control and remote signal failure protection Whether or not to start the remote signal failure protection can be set (the aircraft shall return the base when telemetry link is off), default means it is forbidden to use. The remote signal failure protection is enabled forcibly in the flight controller.
Setting automatic homing parameters The user may set safe climbing altitude for homing, overhead hovering altitude after returning to the takeoff point, hovering time, automatic descending speed and automatic landing locking time. When the homing mode is motivated, the aircraft climbs to the safety altitude automatically, align with the heading automatically after returning to the takeoff point and perform landing automatically.
Automatic locking time The product supports setting of landing locking time. The parameter set at **-**1 means it is invalid. Before the aircraft takes off, if the throttle is pushed by more than 10% and there is no operation within the set time, the aircraft shall be locked automatically. After the aircraft is landed and the throttle is retarded to the minimum value, the aircraft shall wait until the set time is over and shall be locked automatically. After the aircraft performs landing in fixed-altitude and fixed-point mode, the waiting time may be longer because the descending speed of the throttle is limited in this mode.

Setting safety parameters (Example 1)

Vibration early-warning and navigation protection When the flight controller has any abnormality due to airframe vibration in GPS fixed-altitude and fixed-point flight modes, the product is provided with graded early warning function. In specific early warning grade, it switches over the covariance matrix of the accelerometer automatically to guarantee correct speed estimation at the most extent. Meanwhile, the ground station prompts the user with red letters that the vibration is abnormal. After receiving the early warning message, please change over to attitude mode, return to the base and examine the cause of the airframe vibration as soon as possible.

Voltage detection and early warning Type of battery and maximum and minimum electric quantities may be set to enable the flight controller for early warning at low voltage. When the voltage is below the set value, a prompt in red letters shall be given to the user in the command window.

Electric regulator calibration Electric regulator calibration may be completed automatically. First start the electric regulator setting function in USB link mode. Then supply electricity to the master flight controller and the electric regulator from lithium battery. The electric regulation shall be performed for calibration automatically.

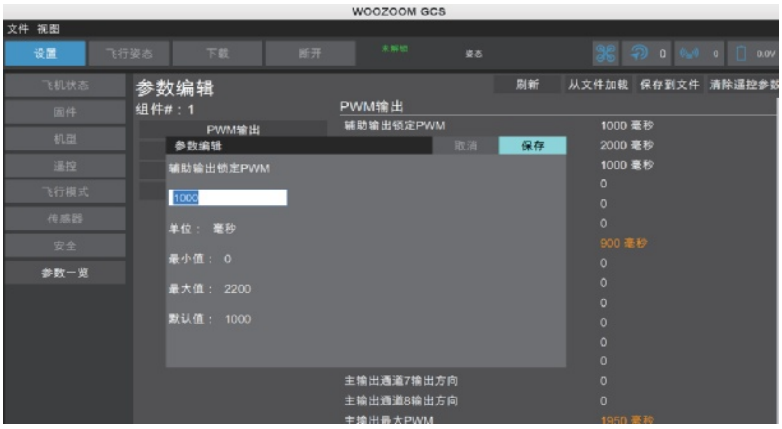
Setting safety parameters (Example 2)

Setting safety parameters (Example 3)

4.5 Setting PWM Parameters

The user can set PWM waveform parameters of 8 main channels and 3 auxiliary channels, a total of 11 output channels. The default PWM output frequency of main channels is 400HZ, which is used to drive the main motor of multi-axis aircraft. The refresh rate of auxiliary channels shall be 50HZ as a default, which is used to drive water pump, sprayer and other agricultural loads. Please contact the manufacturer to refresh the firmware in case the default PWM refresh rate needs to be regulated (for instance, main channel rather than motor electric regulation is used to drive the steering engine of a model airplane). For all the main channels and the auxiliary channels, the user may regulate and lock the mode in the following interfaces to output PWM high level time, the maximum value of high level time in PWM unlocking condition and the minimum value of high level time in PWM unlocking condition. Furthermore, the user may regulate both the positive and negative directions of PWM output in each channel and use them for different settings of the electric regulator, the system default is to increase the high level time and the electric regulator shall increase RPM of the motor.

Setting PWM parameters 1



Setting PWM parameters 2

4.6 Setting Attitude Parameters

Regulation of attitude control parameters of the product is the premise of stable flight. The product can support many items of control parameter regulation such as pitching parameter, rolling parameter and heading parameter. Moreover, every direction is provided with independent regulation of angle loop and angular rate loop. The user must regulate the angular rate channel parameters first, and then regulate the angle channel parameters. Each angular rate channel is composed of 4 parameters, namely, feed-forward coefficient, sensitivity coefficient, inertia coefficient and oscillation suppression coefficient. Each angle channel is composed of two coefficients: sensitivity coefficient and oscillation suppression coefficient.

1) Feed-forward coefficient It is used to regulate the mobility of given quantity and output quantity; meanwhile, it reduces the angular rate oscillation caused by input mutation. However, if the parameter is larger, input mutation oscillation will occur. It is recommended that default value should be used for flight regulation.
2) Sensitivity coefficient (important) When this parameter excessively large, the airframe shall have 3-5HZ oscillation, and the input quantity shall decline correspondingly if this parameter is smaller. The magnitude of this parameter is closely related to aircraft model, motor and electric regulator types and the angular oscillation value of airframe, so it must be regulated appropriately according to the conditions of the matched aircraft model. It is recommended that, this parameter should be reduced to 70% of the default value before the flight parameters are regulated in the first test flight.
3) Inertia coefficient (important) This coefficient is closely related to the dynamics of the carrying aircraft, so it is an important reflection of control robustness of the product. When this coefficient is too large, the angular adjustment of the airframe shall be too slow. That is, after the stick is released, the attitude still changed continuously toward the previous direction of attitude change. When this parameter is regulated to a smaller value, it shall result in no operation in many axes, the attitude response shall be too slow after the stick is applied. Moreover, it shall be affected greatly by the flight speed. For the sake of safety, in the first flight, 70% of the default value should be used to start the flight regulation.
4) Oscillation suppression coefficient To increase this coefficient may reduce the oscillation on the basis that the sensitivity is not reduced, but oscillation shall reoccur if it is increased too much. It is recommended that the default value should be used for flight regulation. This parameter shall be increased properly when the sensitive value is regulated to a comfortable hand feeling but oscillation occurs occasionally.
5) Maximum angular speed It is used to adjust the maximum angular speed of the aircraft. It may be configured according to the selected motor model and the airframe structure. An overlarge parameter may result in large transient current and high energy consumption; too small a parameter may cause failure of fast tracking of the attitude and slow response. Please regulate the parameter according to the situation.
6) Maximum angular acceleration To adjust this parameter may efficiently reduce the transient motor output current due to attitude change, which shall smoothen the attitude leveling process. This parameter should not be overlarge. Otherwise, the attitude loop execution shall be extremely slow, in which case, oscillated rolling might occur. It is recommended that the default value should be adopted for the first flight and a fine adjustment within 10% should be made for each regulation.
7) Sensitivity coefficient The regulating method is the same as the regulation of angular rate loop. An overlarge parameter may cause 2HZ oscillation approximately. At this moment, oscillation suppression parameter may be increased for reduction of vibration. It is recommended that 80% of the default angular loop sensitivity value should be used for the first test flight regulation.
8) Attitude softening filtering parameter It is used to adjust the hand feeling of attitude manipulation. It can have a first lowpass filtering for the expected input corresponding to the angular rate so as to reduce the angular acceleration during release the stick and level off. This parameter should not be overlarge, otherwise the attitude loop operation shall be extremely slow and oscillated rolling might occur. It is recommended that the default value should be adopted for the first flight and a fine adjustment within 10% should be made for each regulation.

Setting of attitude parameters 1

Setting attitude parameters 2

Setting attitude parameters 3

4.7 Setting Position Parameters

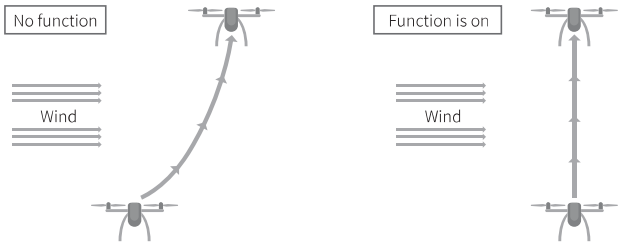
Regulation of position control parameters is a necessary condition for stabilized flight of the aircraft in fixed-point and fixed-altitude mode. Position parameters include two levels: position loop and speed loop, it may also configure the acceleration hand feeling.

Regulation of position parameters 1

1) Position loop sensitivity It determines positioning correction sensitivity and consists of two parts: level and altitude. When this parameter is overlarge, low frequency oscillation shall occur, the horizontal movement or altitude direction oscillation shall be about 1HZ; When this parameter is smaller, low frequency circling movement shall occur, together with altitude low frequency movement, the cycle shall be about 0.3~0.5HZ. Using default value is recommended.
2) Speed loop sensitivity It determines speed tracking sensitivity. When the parameter is too large, large attitude repeated fluctuation shall occur, so it cannot maintain a fixed attitude to track the given speed of the remote control push rod. When this parameter is too small, there will be a phenomenon that speed tracking and acceleration are tardy, or a small attitude hovering near the fixed point. Using default value is recommended.
3) Speed loop inertia coefficient It determines the ability of the product to use attitude angle change for tracking the speed. When this parameter is larger, the attitude changes greatly in fixed-point mode and oscillation phenomenon shall occur. When this parameter is smaller, the phenomenon shall appear that the given speed is not reached from beginning to end. Using default value is recommended.
4) Speed loop oscillation suppression coefficient When the speed sensitivity is higher, the oscillation may be eliminated by increasing this parameter. However, when the coefficient is too high, oscillation shall reappear. Using default value is recommended.
5) Maximum aerial attitude angle The permissible maximum attitude angle of the aircraft in fixed-point mode.
6) Maximum landing attitude angle The permissible maximum attitude angle of the aircraft in landing mode (for example, homing after out-of-control).
7) Maximum throttle quantity Automatic control of maximum throttle quantity.
8) Minimum throttle quantity Automatic control of minimum throttle quantity.
9) Maximum manual throttle quantity Maximum throttle quantity in manual mode.
10) Minimum manual throttle quantity Minimum throttle quantity in manual mode.
11) Maximum pitch angle in manual operation Maximum pitch angle in manual mode.
12) Maximum roll angle in manual operation Maximum roll angle in manual mode.
13) Maximum yaw angle rate in manual operation Maximum yaw angle rate in manual mode.
14) Fixed-point identification horizontal speed Enter into fixed-point mode when the horizontal speed is below this value,
15) Fixed-point identification vertical speed Enter into fixed-altitude mode when the vertical speed is below this value.
16) Fixed-point identification horizontal dead zone ratio Enter into fixed-point mode when the rocker horizontal given speed is below this value.
17) Fixed-point identification vertical dead zone ratio Enter into fixed-altitude mode when the rocker vertical given speed is below this value.
18) Maximum horizontal speed maximum horizontal speed allowed in fixed-point mode.
19) Maximum climbing rate maximum climbing/descending speed allowed in fixed-altitude mode.
20) Lateral auxiliary enabling In fixed-point mode, maintain maximum reduction of air route deviation under sidewind condition by applying positioning control that is vertical to the push rod direction.

Regulation of position parameters 2

Regulation of position parameters 3



Schematic diagram of lateral auxiliary function

4.8 Setting Agricultural Operation Parameters

The product supports spraying in fully automatic and semi-automatic modes. The user may set the opening of water pump and its proportional relation with the speed, it also supports dynamic plot rotating operation. This parameter setting is very important to smooth implementation of fully automatic and semi-automatic agricultural spraying and collection of plot information.

1)Maximum number of ridges to be eluded from agricultural course Maximum spraying number of ridges that may be shifted out laterally in semi-automatic operating mode.
2)Width of agricultural deceleration strip Setting safe distance beyond the set point.
3)Flight speed for agricultural spraying Rated flight speed in the spraying process.
4)Agricultural spraying modes There are 6 modes to be selected: Fully automatic + collection of point information with aircraft, fully automatic + setting of points on electronic map, fully automatic + plot with preset length and width, semi-automatic + collection of point information with aircraft, semi-automatic + setting of points on electronic map, semi-automatic + plot with preset length and width.
5)Sensitivity coefficient to be maintained for agricultural channel It is the tracking accuracy of agricultural ridges, vibration may occur when the coefficient is larger. Therefore, use of the default value is recommended.
6)Sensitivity coefficient to be maintained for agricultural spraying altitude It is the altitude accuracy in agricultural flight course. Vibration may occur when the coefficient is larger. Therefore, use of the default value is recommended.
7)Proportionality coefficient of agricultural spraying flow rate to speed The product of flight speed times this coefficient is the aperture of the water pump.
8)Aperture of centrifugal motor For centrifugal nozzles, it is the centrifugal electronic rotating regulator' s input throttle aperture. Configuration of -1 means an ordinary pressure sprayer.
9)Amplitude of agricultural spraying The covering area of sprayers in multi-axis single ridge flight.
10)Rated length of plot The length of a preset plot.

11) Rated width of plot The width of a preset plot.
12) Aperture of ridge-crossing pump The aperture of water pump in lateral movement.
13) Compulsory rotating speed of agricultural plot The rotating speed to rotate the plot angle compulsorily after the mode in which the length and the width are preset.
14) Enabling altitude aiding In collection of point information mode, the agricultural aircraft can automatically fly the preset course to climb the elevation of the plot according to the elevations of the first and the second points that have been collected.
15) Enabling terrain tracking function It may be used cooperatively with altitude aiding enabling function. In this mode, the product automatically integrates laser radar, sonar, acceleration and velocity information to obtain topographical changes and track the altitude changes automatically. The mode is used for sudden topographical changes on the course that is preset in the altitude aiding mode, such as sudden ground upheavals. This mode may be turned on or off by means of the remote control switch that is configured for AUX 5. This mode can be realized only when it is matched with THEONE ground radar.
16) Early warning for front and rear barriers The radar probes the barriers in front of and behind the aircraft by using the radar that can change its angles on the basis of the driving direction. It sends early warning and no longer gets close to the barrier when the distance to the barrier is less than 3m. This mode can be realized only when it is matched with THEONE variable-direction early warning radar.

Example for regulation of agricultural operation parameters

Schematic diagram of altitude aiding

Schematic diagram of terrain tracking

Schematic diagram of early warning for anterior and posterior barriers

Agricultural flight may be performed in many modes such as attitude mode, fixed-altitude mode, fixed-point mode, semi-automatic mode and fully automatic mode. In attitude, fixed-altitude and fixed-point modes, all the operations shall be performed by the remote controller, the operation of the water pump shall be given by AUX 1 channel. The first half stroke of the channel is equal ratio output while the other half of the stroke is speed scale output (the scale factor can be set in agricultural parameters). The operations in semi-automatic and fully automatic modes are emphasized below.

5.1 Methods for Point Information Collection

The product can support three modes for collection of point information: collection of point information in flight, collection of point information with preset length and width of plot, and setting point on electronic map. The product supports loading of arbitrary convex polygon plot and automatic planning. Beforehand collection of farm boundary points can assist the product in automatic identification of operating routes, which is very important for smooth performance of operation.

Collection of point information in flight Pull AUX2 remote control input switch to collect the current position coordinates of the aircraft, the collected number of points shall be presented on the message page of the ground station. When the interval between two collection points is too close, it shall be reminded automatically, and the second point shall be abandoned. With the first point as the starting point of operation, the collection points shall be sequenced clockwise automatically, and the nose direction shall be initialized along the line from the first point and the second point.

Presetting length and width of plot The user may preset length and width of the plot in agricultural parameters. First adjust the aircraft to the operation starting point, pull AUX2 switch to load spraying mission, and the ground station shall present the loading information automatically. The system shall initialize the farm course automatically. The nose direction when pulling AUX2 shall be the direction of flight operation(Fine adjustment can be made if there is any course deviation, refer to "Operating Method in Semi-automatic Mode")

Setting points on electronic map Set the boundary points on the ground station map by double clicking the mouse, it must be a convex polygon, the first point shall be the starting point of operation, and the second point in the clockwise direction shall be the nose direction. Plot dynamic rotation fine adjustment shall not be supported in this mode. After the setting is finished, click "Load" button to synchronize the set points. After they are synchronized, the ground station shall present the boundary points information that has been synchronized in the flight controller.

5.2 Starting of Agricultural Mission

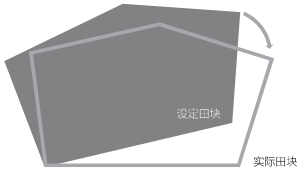
The user may start operation of agricultural mission with the mode change-over switch (refer to "Remote Control Calibration"), with toggling AUX3 switch to eliminate existing coordinate point information and to load missions. Both collection of point information in flight and presetting length and width missions can be started directly, but setting points on electric map shall be loaded automatically only after restarting the flight controller after the mode is set.

> **Attention** Setting points on electronic map has the lowest limit of authority, so the electronic map can be activated to set the operation mission only by loading the coordinate points through the ground station after eliminating all the operation missions with AUX3. After the mission is activated, the product shall automatically rearrange the set coordinate in clockwise direction, and judge whether it is a reasonable convex polygon. In case it is abnormal, the ground station shall automatically prompt a coordinate point error message, and the aircraft shall maintain hovering in the current position.

5.3 Operating Method for Semi-Automatic Mode

In this mode, the product shall aid the user to maintain the flight direction, altitude and lateral course of the aircraft, and control the discharging volume of the water pump according to the speed ration parameter. The user may set forward or reverse speed by using pitching push rod of the remote controller, adjust aircraft altitude at any time by using the throttle push rod that has a dead zone, make fine adjustment spraying direction by using the heading push rod that has a dead zone (when adjusting the spraying direction, because the course shall automatically rotate around the operation starting point, the aircraft position shall also be changes with it. Therefore, the farther the aircraft is away from the lateral position, the greater the lateral position shall be changed). Adjust the lateral position by using the lateral push rod in order to elude the barriers encountered in the operation course (the maximum lateral movement distance is the set number of ridges of agricultural parameters, the aircraft also comes back to the central position of the course automatically when the lateral push rod is neutralized).

When the aircraft reaches the boundary of the plot, it shall decelerate and move laterally by a ridge distance of a spraying width. At the same time, it shall send out an agricultural flight direction prompt to the ground station. If the pitching push rod is pushed to a direction that is not identical to the operation direction, the system shall shut the water pump automatically, and give the user a prompt of direction error via the ground station. In case the user runs in the wrong spraying direction all the time, the system shall only permit the aircraft to reach the set boundary of the plot. Barrier early warning and terrain tracking functions may be started in this mode.



Schematic diagram of plot rotation with fine adjustment

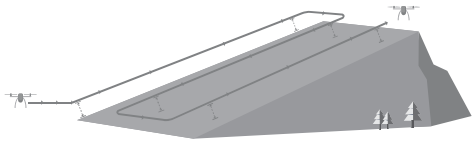
5.4 Operating Method for Fully-Automatic Mode

In this mode, the aircraft shall fly back and forth in the set plot at the set operating speed, and change ridges automatically. The whole process shall be completed by the flight controller automatically; the user shall only control the aircraft altitude by using the throttle control stick that has a dead zone so as to avoid the altitude from drifting in the operation. The whole process is similar to the semi-automatic mode, but the barrier early warning cannot be started while the terrain tracking function may be started.

5.5 Altitude Aiding and Terrain Tracking

After "Altitude aiding" function is started, according to "collection of point information mode", the product can collect elevation difference between the first point and the second point, set the altitude change automatically and aid the user to control it in slope agricultural operating environment. After turning on the agricultural mission switch, push the push rod forward (aircraft collection of point information + semi-automatic mode), and the aircraft shall move forward and climb along the slope. This function is applicable to fast operation over a slope plot.

After "Terrain tracking" switch is turn on, the product shall, on its own initiative, estimate the real time ground height above sea level via laser radar, sonar, acceleration and speed information. If there is any abnormal circumstance (such as sudden upheaval of ground surface exceeding the preset elevation, sudden rise of vegetation), it shall control the aircraft to rise a corresponding distance automatically. Refer to "Setting of Agricultural Operation Parameters" for related graphical representations.



Schematic diagram of slope operation aiding function

5.6 Automatic Processing of Abnormalities

The product can make automatic processing of abnormal conditions to guarantee flight safety and operating convenience.

Abnormal condition	Description	Explanation of processing mode
Manual cutoff of mission	By using the mode selection switch, the user may interrupt the mission during	The system shall automatically record the cutoff point and the flight mission, and automatically continue the flight when resuming the agricultural mission. It shall remain valid after power-off and repower-on without the need to reloading the mission.
Automatic termination of mission	After the mission is finished.	When the remaining plot is not enough for the set value of spraying magnitude, the mission shall be terminated automatically, and the aircraft maintains hovering. At the same time, the recorded missions shall be cleared off automatically, and give a prompt via the ground station to the user that the mission is finished.
Interruption of remote control signal	Remote control signal is interrupted during agricultural operation.	The system shall automatically record the information of mission and interruption point, and start the automatic homing mode. After the remote control signal is restored, it can still resume the operation mission.
Interruption of telemetering signal	Telemetering signal is interrupted.	The system shall automatically record the information of mission and interruption point, and start the automatic homing mode. After the remote control signal is restored, it can still resume the operation mission.

The ground station can automatically display the aircraft position on the electronic map, flight path, the loaded plot graph and the completed operation volume. Meanwhile, the flight speed, compass direction, attitude, climbing speed and height above sea level can be displayed on the digital instrument. The ground station is provided with an information indication box to show real time information of the aircraft to the user, such as flight mode, vibration early warning and takeoff point.

Example of flight information in ground station

FCC Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

-- Reorient or relocate the receiving antenna.

-- Increase the separation between the equipment and receiver.

-- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

-- Consult the dealer or an experienced radio/TV technician for help.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:(1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.