

AgileX Robotics SCOUT MINI User Manual

AgileX Robotics Support Team

Version 1.0 Release

Description of Version Information

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1. Introduction to SCOUT MINI

SCOUT MINI intelligent mobile chassis, with 4WD, strong off-road performance and compact body shape, truly achieves "dexterous and flexible". SCOUTMINI inherits the advantages of SCOUT four-wheel differential chassis family, i.e. four-wheel drive, independent suspension, in-situ rotation and so on, and has made innovation in the design of hub motor. The minimum turning radius of the chassis is 0 m, and the climbing angle is close to 30 degrees. SCOUT MINI is still capable of excellent off-road performance although it is only half of SCOUT in size. In addition, it has a breakthrough high-speed, accurate, stable and controllable dynamic control system up to 20 km/h. SCOUTMINI development platform with its own control core, supports standard CAN bus communication, and can access to standard CAN bus communication, as well as all kinds of external equipment. On such basis, it supports secondary development such as ROS and more advanced access and the access of robot development system. Equipped with standard aeromodelling aircraft, 24V@15Ah lithium battery power system, its endurance mileage is up to 10 km. Additional components such as stereo camera, laser radar, GPS, IMUS, manipulator, etc. can be optionally installed on SCOUT MINI for expanded applications. SCOUT MINI is frequently used for unattended inspection, security, scientific research, prospecting, logistics, etc.

1.1 Product list

Name	Quantity
SCOUT MINI robot body	X 1
Battery charger (AC 220V)	X 1
Aviation male plug (4-Pin)	X 1
USB to CAN	X 1
RC transmitter	X 1

1.2 Performance parameters

Parameter Types	Items	Values
Mechanical specifications	L × W × H (mm)	627 × 550 × 252
	Wheelbase (mm)	452
	Front/rear wheel base (mm)	450
	Weight of vehicle body (kg)	20
	Battery type	Lithium battery 24V 15aH
	Motor	DC brushless 4 X 150W
	Drive type	Independent four-wheel drive
	Suspension	Independent suspension with rocker arm
	Steering	Four-wheel differential steering
	Safety equipment	Servo brake/anti-collision tube
Motion	No-load highest speed (km/h)	≤20
	Minimum turning radius	Be able to turn on a pivot
	Maximum climbing capacity	≥30°
	Minimum ground clearance (mm)	107

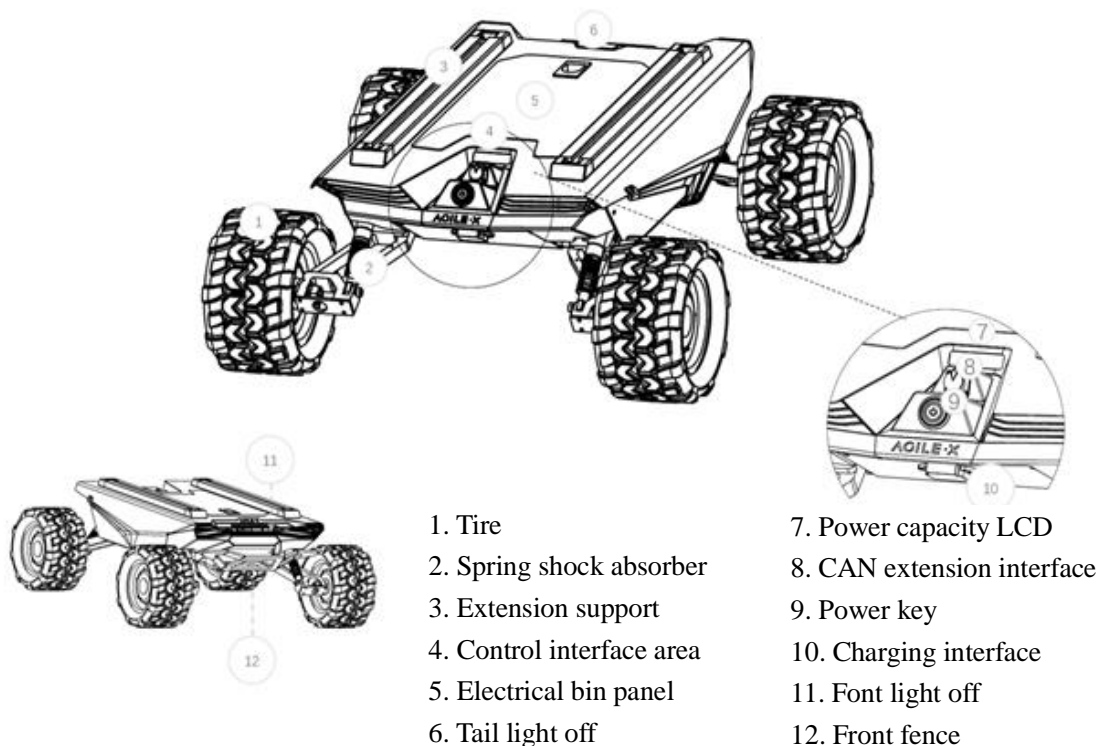
Control parameter	Control mode	Remote control Control command mode
	RC transmitter	2.4G/extreme distance 1km
	Communication interface	CAN

1.3 Requirement for development

FS RC transmitter is provided optionally in the factory settings of SCOUT MINI and it allows users to control the mobile chassis to move and turn; the CAN provided on SCOUT MINI can be used for secondary development via the CAN interface.

2. The Basics

This Section will basically introduce the basic knowledge about SCOUT MINI mobile robot chassis to users and developers. The overview of an entire mobile robot chassis is shown in Figure 2.1 and Figure 2.2 below.



Based on the concept of modular and intelligent design as a whole, SCOUT MINI combines filled solid tires with independent suspension as its power module, which, along with powerful hub motor, enables the development platform of SCOUT MINI robot chassis to flexibly move on different ground surfaces with high passing ability and ground adaptability. The hub motor saves the complex transmission structure design and makes it possible for the model to become more compact.

Anti-collision fence is mounted in the front of the vehicle to protect the front and reduce possible damages to the vehicle body during a collision. The front of the vehicle is equipped with white lights, which can be illuminated.

Electrical interfaces for DC power and communication interfaces are provided at the rear of the robot to facilitate secondary development. The electrical interfaces adopt waterproof plug-in components, not only allowing flexible connection between the robot and external components for customers but also allowing the use of the robot even under severe operating conditions.

A standard aluminum extension support is installed at the top of the vehicle to facilitate the use of external equipment extension.

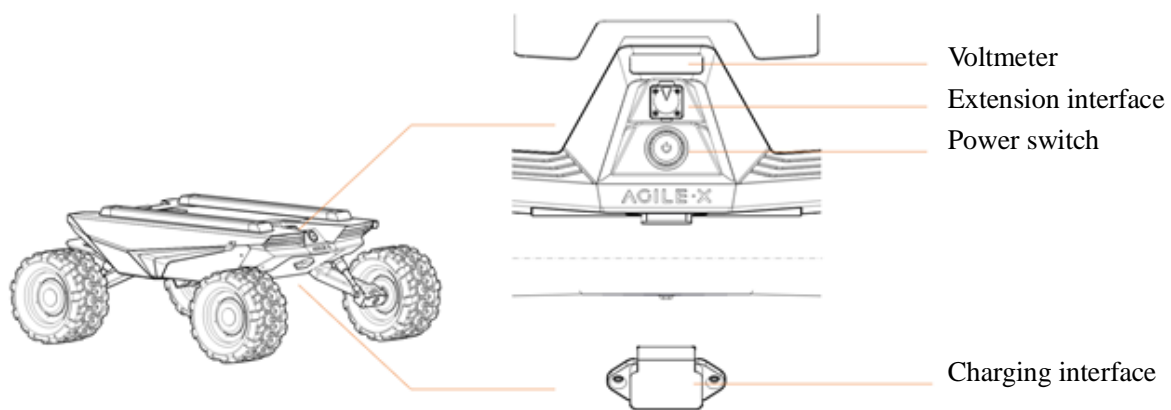
2.1 Status indication

Users can identify the status of vehicle body through the voltmeter, the power supply and lights mounted on SCOUT MINI.

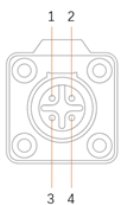
- Tail power switch: When the power switch is pressed, the ring indicator light will enter constant mode.
- Power indication: the tail power display module showing the information of the power capacity and voltage of the current battery.
- Front light: Front width light, can be switched by RC transmitter and command.

2.2 Instructions on electrical interfaces

In the SCOUT MINI tail minimalist design, all electrical interfaces are in the tail. The interfaces include voltage display interactive module, extension interface, power switch and charging interface. The position of each module at the tail is as shown in the figure.



SCOUT MINI aviation extension interface is configured with both a set of power supplies and a set of CAN communication interfaces. These interfaces can be used to supply power to extended devices and establish communication. The specific definitions of pins are shown in Figure 2.4.



Pin No.	Pin Type	Function and Definition	Remarks
1	Power	VCC	Power positive, voltage range 23 - 29.2V, MAX. current 5A
2		GND	Power negative
3	CAN	CAN_H	CAN bus high
4		CAN_L	CAN bus low

2.3 Remote control instructions

FS RC transmitter is an optional feature of SCOUT MINI for users to choose as actually required. With this RC transmitter designed on the left throttle in this product, users can easily control SCOUT MINI universal robot chassis. Its definitions and functions are shown in Figure 2.9 for

reference.

The RC transmitter is preset the mapping of keys at factory. Do not arbitrarily change the key mapping, otherwise normal control will be unavailable. The lever SWB switches control mode; the lever SWC is the manual control switch to control the light off; the lever SWD controls speed mode; the left rocker controls forward and backward movement; the right rocker controls the vehicle for left rotation and right rotation. It is worth noting that the mobile chassis on the internal control is mapped by percentage, so the speed will be constant when the lever is in the same position.



1. Lever SWA
2. Lever SWB
3. Lever SWC
4. Lever SWD
5. Left rocker
6. Right rocker
7. Power switch key 1
8. Power switch key 2
9. Mobile/Tablet fixing support interface
10. Ring interface
11. LCD panel

*When the customer gets the RC transmitter, the settings have been available without having to be set separately.

Figure 2.9 Schematic Diagram of Buttons on FS Remote Controller

2.4 Description of movement by remote control and control by command

A reference coordinate system shown in Figure 3.0 is established in accordance with ISO 8855 standard for moving vehicles on ground.

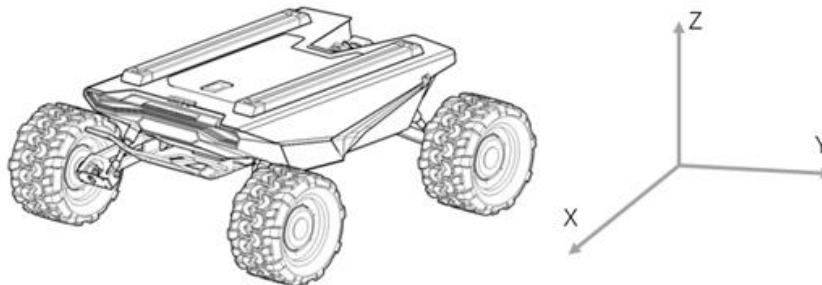
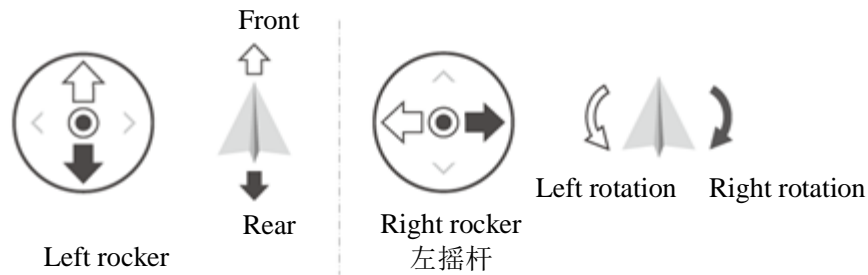


Figure 3.0 Schematic Diagram of Reference Coordinate System for Vehicle Body

As shown in Figure 3.0, the vehicle body of SCOUT MINI is in parallel with X axis of the established reference coordinate system.



In the controller mode with RC transmitter, pushing the left rocker of the RC transmitter forward and backward respectively refers to the movement on the positive and negative directions of axis X; when the left rocker of the RC transmitter is pushed to the maximum position, the speed of movement towards the position direction of axis X reaches the maximum; when the left rocker of the RC transmitter is pushed to the minimum position, the speed of movement towards the negative direction of axis X reaches the maximum; the right rocker of the RC transmitter controls the rotational movement of vehicle body to left and right; pushing the right rocker of the RC transmitter to left and right respectively refers to the rotational movement of vehicle body from the positive direction of axis X to the positive direction of axis Y and from the positive direction of axis X to the negative direction of axis Y; when the right rocker of the RC transmitter is pushed to the maximum position on the left, the rotational linear speed on anticlockwise direction reaches the maximum; when the right rocker of the RC transmitter is pushed to the maximum position on the right, the rotational linear speed on clockwise direction reaches the maximum.

In the control command mode, the positive value of linear speed refers to movement towards the positive direction of axis X, and the negative value of linear speed refers to movement towards the negative direction of axis X; the positive value of angular speed refers to the rotational movement of vehicle body from the positive direction of axis X to the positive direction of axis Y, and the negative value of angular speed refers to the rotational movement of vehicle body from the positive direction of axis X to the negative direction of axis Y.

2.5 Instructions on lighting control

Lights are mounted in front and at back of SCOUT MINI, and the lighting control interface of SCOUT MINI is open to the users for convenience. Meanwhile, another lighting control interface is reserved on the RC transmitter for energy saving.

There are 3 kinds of lighting modes controlled with RC transmitter, **which can be switched among each other by SWC lever toggling:**

- Normally closed mode: In normally closed mode, if the chassis is still, the light will be turned off; if the chassis is in the traveling state at certain normal speed, the light will be turned on;
- Normally open mode: In normally open mode, if the chassis is still, the light will be normally on; if in motion mode, the light will be turned on;
- Breathing light mode: The light is in breathing mode.

Note on mode control:

Toggling SWC lever respectively to bottom, middle and top positions refers to normally closed mode, normally open mode and breathing light mode.

3. Getting Started

This Section mainly introduces the basic operation and use of the SCOUT MINI platform and also introduces how to conduct secondary development of the vehicle body via the external CAN ports and CAN bus protocol.

3.1 Use and operation

The basic operating procedure of startup is shown as follows:

- **Check**
 - Check the condition of the vehicle body. Check whether there are significant anomalies; if so, please contact the after-sale service personnel for support;
- **Startup**
 - Press the SCOUT MINI power button and wait for a few seconds;
 - Move SWB to the middle and choose the position to be controlled;
 - You can try to manually switch the light mode and make sure that the mode selection is correct;
 - Try to gently push the left rocker a little forward, then you can see the vehicle moves forward slowly;
 - Try to gently push the left rocker a little backward, then you can see the vehicle moves backward slowly;
 - Release the left rocker, then the vehicle will stop;
 - Try to gently push the right rocker a little leftward, then you can see the vehicle rotates leftward slowly;
 - Try to gently push the right rocker a little rightward, then you can see the vehicle rotates rightward slowly;
 - Release the right rocker, then the vehicle will stop;
 - Try to control freely in the relatively open area, and get familiarized with the vehicle moving speed.
- **Shutdown**
 - Press the SCOUT MINI power button to release;

Basic operating procedure of remote control:

After SCOUT MINI mobile chassis is started correctly, turn on the RC transmitter and select the remote-control mode. Then, the SCOUT MINI platform motion can be controlled by the RC transmitter.

3.2 Charging

SCOUT MINI is equipped with a 10 A charger by default to meet customers' charging demand.

The detailed operating procedure of charging is shown as follows:

- Make sure SCOUT MINI chassis is in power-off state.
- Insert the charger plug into the charging interface on the rear of the vehicle;
- Connect the charger to power supply and turn on the switch in the charger. Then, the robot enters the charging state.

Note: For now, the battery needs about 1.5 hours to be fully recharged from 22 V, and the voltage of fully-recharged battery is about 29.2 V; the recharging duration is calculated as $15 \text{ aH} \div 10\text{A} = 1.5\text{h}$.

3.3 Development

SCOUT MINI provides CAN interface for user development. Users can select CAN command to conduct command control over the vehicle body.

3.3.1 CAN interface protocol

SCOUT MINI adopts CAN2.0B communication standard which has a communication baud rate of **500K** and Motorola message format. Via external CAN bus interface, the moving linear speed and the rotational angular speed of chassis can be controlled; SCOUT MINI will feedback the current motion status information, SCOUT MINI chassis status information, etc. in real time.

The protocol includes system status feedback frame, movement control feedback frame and control frame, the contents of which are shown as follows:

The system status feedback command includes the feedback information about current status of vehicle body, control mode status, battery voltage and system failure. The description is given in Table 3.1.

Table 3.1 Feedback Frame of SCOUT MINI Chassis System Status

Command Name	System Status Feedback Command			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x151	20ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	Current status of vehicle body	unsigned int8	0x00 System in normal condition 0x01 Emergency stop mode (not enabled) 0x02 System exception	
byte [1]	Mode control	unsigned int8	0x00 Remote control mode 0x01 CAN command control mode ^[1] 0x02 Serial port control mode	
byte [2]	Battery voltage higher 8 bits	unsigned int16	Actual voltage X 10 (with an accuracy of 0.1V)	
byte [3]	Battery voltage			

	lower 8 bits		
byte [4]	Failure information higher 8 bits	unsigned int16	See notes for details 【**】
byte [5]	Failure information lower 8 bits		
byte [6]	Count parity bit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit

Table 3.2 Description of Failure Information

Description of Failure Information		
Byte	Bit	Meaning
byte [4]	bit [0]	Check error of CAN communication control command (0: No failure 1: Failure)
	bit [1]	Motor drive over-temperature alarm ^[1] (0: No alarm 1: Alarm) Temperature limited to 55°C
	bit [2]	Motor over-current alarm ^[1] (0: No alarm 1: Alarm) Current effective value 15A
	bit [3]	Battery under-voltage alarm (0: No alarm 1: Alarm) Alarm voltage 22.5V
	bit [4]	RC transmitter disconnection protection (0: Normal 1: RC transmitter disconnected)
	bit [5]	Reserved, default 0
	bit [6]	Reserved, default 0
	bit [7]	Reserved, default 0
byte [5]	bit [0]	Battery under-voltage failure (0: No failure 1: Failure) Protective voltage 22V
	bit [1]	Battery over-voltage failure (0: No failure 1: Failure)
	bit [2]	No. 1 motor communication failure (0: No failure 1: Failure)
	bit [3]	No. 2 motor communication failure (0: No failure 1: Failure)
	bit [4]	No. 3 motor communication failure (0: No failure 1: Failure)
	bit [5]	No. 4 motor communication failure (0: No failure 1: Failure)
	bit [6]	Motor drive over-temperature protection ^[2] (0: No protection 1: Protection) Temperature limited to 65°C
	bit [7]	Motor over-current protection ^[2] (0: No protection 1: Protection) Current effective value 20A

[1]: The subsequent versions of robot chassis firmware version after V1.2.8 are supported, but previous versions need to be updated before supported.

[2]: The over-temperature alarm of motor drive and the motor over-current alarm will not be internally processed but just set in order to provide for the upper computer to complete certain pre-processing. If drive over-current occurs, it is suggested to reduce the vehicle speed; if over-temperature occurs, it is suggested to reduce the speed first and wait the temperature

to decrease. This flag bit will be restored to normal condition as the temperature decreases, and the over-current alarm will be actively cleared once the current value is restored to normal condition;

[3]: The over-temperature protection of motor drive and the motor over-current protection will be internally processed. When the temperature of motor drive is higher than the protective temperature, the drive output will be limited, the vehicle will slowly stop, and the control value of movement control command will become invalid. This flag bit will not be actively cleared, which needs the upper computer to send the command of clearing failure protection. Once the command is cleared, the movement control command can only be executed normally.

The command of movement control feedback frame includes the feedback of current linear speed and angular speed of moving vehicle body. For the detailed content of protocol, please refer to Table 3.3.

Table 3.3 Movement Control Feedback Frame

Command Name	Movement Control Feedback Command			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x131	20ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	Moving speed higher 8 bits	signed int16	Actual speed X 1000 (with an accuracy of 0.001m/s)	
byte [1]	Moving speed lower 8 bits			
byte [2]	Rotational speed higher 8 bits	signed int16	Actual speed X 1000 (with an accuracy of 0.001rad/s)	
byte [3]	Rotational speed lower 8 bits			
byte [4]	Reserved	-	0x00	
byte [5]	Reserved	-	0x00	
byte [6]	Count parity bit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent	
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit	

The control frame includes mode control, failure clearing command, control openness of linear speed, control openness of angular speed and checksum. For its detailed content of protocol, please refer to Table 3.4.

Table 3.4 Control Frame of Movement Control Command

Command Name	Control Command
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Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Decision-making control unit	Chassis node	0x130	20ms	500ms
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	Control mode	unsigned int8	0x00 Remote control mode 0x01 CAN command control mode ^[1] 0x02 Serial port control mode	
byte [1]	Failure clearing command	unsigned int8	See Note 2 for details*	
byte [2]	Linear speed percentage	signed int8	Maximum speed 5.0 m/s, value range (-100, 100)	
byte [3]	Angular speed percentage	signed int8	Maximum speed 0.5235rad/s, value range (-100, 100)	
byte [4]	Reserved	-	0x00	
byte [5]	Reserved	-	0x00	
byte [6]	Count parity bit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent	
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit	

Note 1 - Control mode instructions

In case the RC transmitter is powered off, the control mode of SCOUT MINI is defaulted to command control mode, which means the chassis can be directly controlled via command. However, even though the chassis is in command control mode, the control mode in the command needs to be set to 0 x 01 for successfully executing the speed command. Once the RC transmitter is switched on again, it has the highest authority to shield the command control and switch over the control mode.

Note 2 - Information about failure clearing command:

- 0x00 No failure clearing command
- 0x01 Clear battery under-voltage failure
- 0x02 Clear battery over-voltage failure
- 0x03 Clear No. 1 motor communication failure
- 0x04 Clear No. 2 motor communication failure
- 0x05 Clear No. 3 motor communication failure
- 0x06 Clear No. 4 motor communication failure
- 0x07 Clear motor drive over-temperature failure

- **0x08 Clear motor over-current failure**

Note 3 - Example data: The following data is only used for testing

1. The vehicle moves forward at 0.5m/s.

byte [0]	byte [1]	byte [2]	byte [3]	byte [4]	byte [5]	byte [6]	byte [7]
0x01	0x00	0x0a	0x00	0x00	0x00	0x00	0x44

2. The vehicle rotates at 0.07853rad/s.

byte [0]	byte [1]	byte [2]	byte [3]	byte [4]	byte [5]	byte [6]	byte [7]
0x01	0x00	0x00	0x0a	0x00	0x00	0x00	0x44

3. When the vehicle stays still, switch the control mode to command mode (test without the RC switched on)

byte [0]	byte [1]	byte [2]	byte [3]	byte [4]	byte [5]	byte [6]	byte [7]
0x01	0x00	0x00	0x00	0x00	0x00	0x00	0x3a

The chassis status information will be fed back; what's more, the information about motor current, encoder and temperature are also included. The following feedback frame contains the information about motor current, encoder and motor temperature:

The serial numbers of four motors in the chassis are as shown in the figure below:

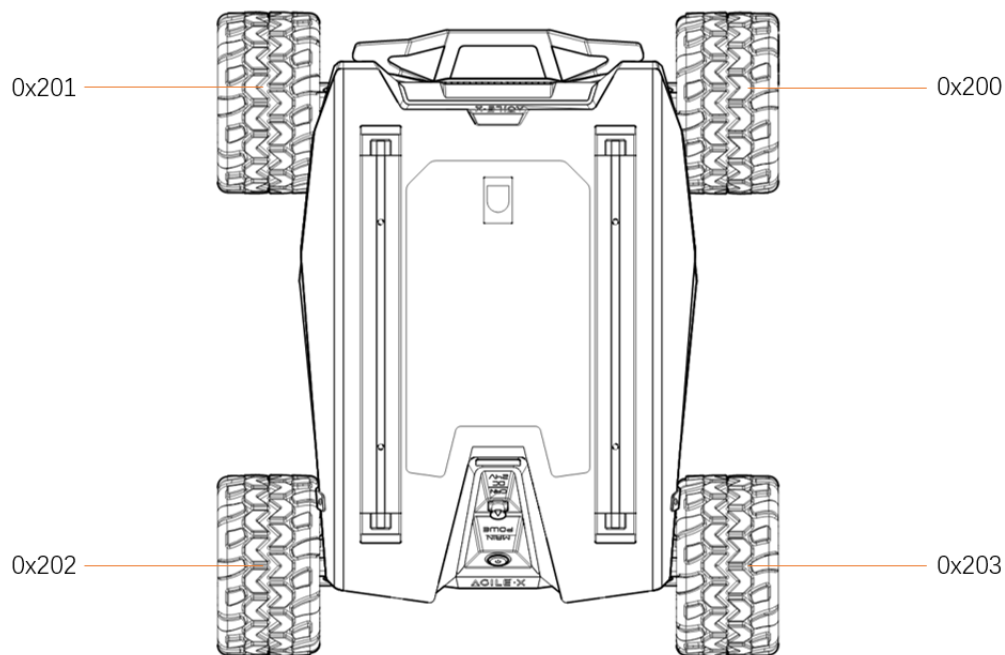


Figure 3.0 Schematic Diagram of Motor Feedback IDs

Table 3.5 No. 1 Motor Information Feedback

Command Name	No. 1 Motor Drive Information Feedback Frame			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x200	20ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	No. 1 drive current higher 8 bits	unsigned int16	Actual current X 10 (with an accuracy of 0.1A)	
byte [1]	No. 1 drive current lower 8 bits			
byte [2]	No. 1 drive rotational speed higher 8 bits	signed int16	Actual motor shaft velocity (RPM)	
byte [3]	No. 1 drive rotational speed lower 8 bits			
byte [4]	No. 1 drive temperature	signed int8	Actual temperature (with an accuracy of 1°C)	
byte [5]	No. 1 motor temperature	signed int8	Actual temperature (with an accuracy of 1°C)	
byte [6]	Count parity bit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent	
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit	

Table 3.6 No. 2 Motor Information Feedback

Command Name	No. 2 Motor Drive Information Feedback Frame			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x201	20ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	No. 2 drive current higher 8 bits	unsigned int16	Actual current X 10 (with an accuracy of 0.1A)	
byte [1]	No. 2 drive current lower 8 bits			
byte [2]	No. 2 drive rotational speed higher 8 bits	signed int16	Actual motor shaft velocity (RPM)	
byte [3]	No. 2 drive rotational speed lower 8 bits			

byte [4]	No.2 drive temperature	signed int8	Actual temperature (with an accuracy of 1°C)
byte [5]	No. 2 motor temperature	signed int8	Actual temperature (with an accuracy of 1°C)
byte [6]	Count parity bit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit

Table 3.7 No. 3 Motor Information Feedback

Command Name	No. 3 Motor Drive Information Feedback Frame			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x202	20ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	No. 3 drive current higher 8 bits	unsigned int16	Actual current X 10 (with an accuracy of 0.1A)	
byte [1]	No. 3 drive current lower 8 bits			
byte [2]	No. 3 drive rotational speed higher 8 bits	signed int16	Actual motor shaft velocity (RPM)	
byte [3]	No. 3 drive rotational speed lower 8 bits			
byte [4]	No. 3 drive temperature	signed int8	Actual temperature (with an accuracy of 1°C)	
byte [5]	No. 3 motor temperature	signed int8	Actual temperature (with an accuracy of 1°C)	
byte [6]	Count parity bit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent	
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit	

Table 3.8 No. 4 Motor Information Feedback

Command Name	No. 4 Motor Drive Information Feedback Frame			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x203	20ms	None
Data length	0x08			
Position	Function	Data type	Description	

byte [0]	No. 4 drive current higher 8 bits	unsigned int16	Actual current X 10 (with an accuracy of 0.1A)
byte [1]	No. 4 drive current lower 8 bits		
byte [2]	No. 4 drive rotational speed higher 8 bits	signed int16	Actual motor shaft velocity (RPM)
byte [3]	No. 4 drive rotational speed lower 8 bits		
byte [4]	No. 4 drive temperature	signed int8	Actual temperature (with an accuracy of 1°C)
byte [5]	No. 4 motor temperature	signed int8	Actual temperature (with an accuracy of 1°C)
byte [6]	Count parity bit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit

Table 3.9 Lighting Control Frame

Command Name	Lighting Control Frame			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Decision-making control unit	Steer-by-wire chassis	0x140	25ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	Lighting control enable flag	unsigned int8	0x00 Control command invalid 0x01 Lighting control enable	
byte [1]	Front light mode	unsigned int8	0x00 NC 0x02 BL mode 0x03 User-defined brightness	
byte [2]	Custom brightness of front light	unsigned int8	[0, 100], where 0 refers to no brightness, 100 refers to maximum brightness ^[5]	
byte [3]	Reserved	--	0x00	
byte [4]	Reserved	--	0x00	
byte [5]	Reserved	--	0x00	
byte [6]	Count parity bit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent	
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit	

Note [5]: This value is valid in custom mode

Table 3.10 **Lighting Control Feedback Frame**

Command Name	Lighting Control Feedback Frame			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x141	20ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	Current lighting control enable flag	unsigned int8	0x00 Control command invalid 0x01 Lighting control enable	
byte [1]	Current front light mode	unsigned int8	0x00 NC 0x01 NO 0x02 BL mode 0x03 User-defined brightness	
byte [2]	Current custom brightness of front light	unsigned int8	[0, 100], where 0 refers to no brightness, 100 refers to maximum brightness	
byte [3]	Reserved	--	0x00	
byte [4]	Reserved	--	0x00	
byte [5]	Reserved	--	0x00	
byte [6]	Count parity bit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent	
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit	

The data check bit is the last valid byte in the data segment of each frame of CAN message. Its check sum is calculated as follows: $\text{checksum} = (\text{ID_H} + \text{ID_L} + \text{data_length} + \text{can_msg.data}[0] + \text{can_msg.data}[1] + \text{can_msg.data}[2] + \text{can_msg.data}[3] + \text{can_msg.data}[4] + \dots + \text{can_msg.data}[n]) \& 0xFF$:

- ID_H and ID_L are respectively higher 8 bits and lower 8 bits of a frame ID. For example, if ID is 0x540, the corresponding ID_H is 0x05 and ID_L is 0x40;
- Data_length refers to the valid data length of a data segment in one frame of CAN message, which includes the checksum byte;
- can_msg.data[n] is the specific content of each byte in the valid data segment; the count parity bit needs to participate in the calculation of checksum, but the checksum itself does not participate in the calculation.

```
/**
 * @brief CAN message checksum example code
 * @param[in] id : can id
 * @param[in] *data : can message data struct pointer
 * @param[in] len : can message data length
```

```

* @return the checksum result
*/
static uint8 Agilex_CANMsgChecksum(uint16 id, uint8 *data, uint8 len)
{
    uint8 checksum = 0x00;
    checksum = (uint8)(id & 0x00ff) + (uint8)(id >> 8) + len;
    for(uint8 i = 0 ; i < (len-1); i++)
    {
        checksum += data[i];
    }
    return checksum;
}

```

Figure 3.1 CAN Message Check Algorithm

3.3.2 CAN cable connection

Two aviation male plugs are supplied along with SCOUT MINI as shown in Figure 3.2. Users need to lead wires out by welding on their own. For wire definitions, please refer to Table 2.2.



Figure 3.2 Schematic Diagram of Aviation Male Plug

Note: In the current SCOUT MINI version, only the top interface is open to external extension. The maximum current that can be provided in this version is 5A.

3.3.3 Implementation of CAN command control

Correctly start the chassis of SCOUT MINI mobile robot, and turn on DJI RC transmitter. Then, switch to the command control mode, i.e. toggling S1 mode of DJI RC transmitter to the top. At this point, SCOUT MINI chassis will accept the command from CAN interface, and the host can also parse the current state of the chassis with the real-time data fed back from CAN bus. For the detailed content of protocol, please refer to CAN communication protocol.

3.4 Firmware upgrade

To facilitate the customer's upgrading of the firmware version used by SCOUT MINI and bring the customer a better experience, SCOUT MINI provides a hardware interface for the firmware upgrading, and the corresponding client software as well. A screenshot of this application is shown

in Figure 3.3.

Upgrade preparation:

- Serial cable X 1
- USB-to-serial port X 1
- SCOUT chassis X 1
- Computer (Windows operating system) X 1

Upgrade procedure:

- Before connection, ensure the robot chassis is powered off;
- Connect the serial cable onto the serial port at tail end of SCOUT MINI chassis;
- Connect the serial cable to the computer;
- Open the client software;
- Select the port number;
- Power on SCOUT MINI chassis, and immediately click to start connection (SCOUT MINI chassis will wait for 6 s before power-on; if the waiting time is more than 6 s, it will enter the application); if the connection succeeds, "connected successfully" will be prompted in the text box;
- Load Bin file;
- Click the Upgrade button, and wait for the prompt of upgrade completion;
- Disconnect the serial cable, power off the chassis, and then turn the power off and on again.

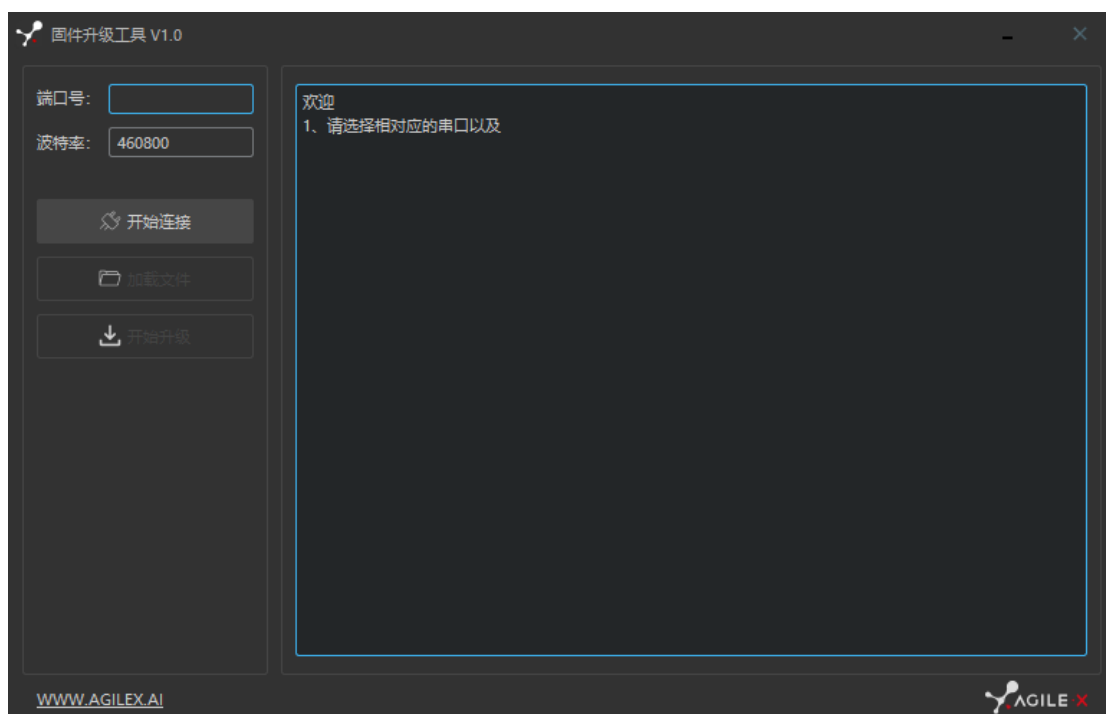


Figure 3.3 Client Interface of Firmware Upgrade

4. Attention

This Section includes some precautions that should be paid attention to for SCOUT MINI use and development.

4.1 Battery precautions

- The battery supplied with SCOUT MINI is not always fully charged in the factory setting, but its specific power capacity can be displayed on the voltmeter at tail end of SCOUT MINI chassis or read via CAN bus communication interface. Once the green indicator light of charger is switched on, it means the battery recharging is completed, but after this indicator light is on, the battery will still be charged slowly with 0.1A current for possibility about 30 minutes;
- Please do not charge the battery after its power has been depleted, and please charge the battery in time when low battery level alarm on SCOUT MINI is on;
- Static storage conditions: The best temperature for battery storage is -20°C to 60°C ; in case of storage for no use, the battery must be recharged and discharged once about every 2 months, and then stored in full voltage state. Please do not put the battery in fire or heat up the battery, and please do not store the battery in high-temperature environment;
- Charging: The battery must be charged with a dedicated lithium battery charger; please do not charge the battery below 0°C and do not use non-originally standard batteries, power supplies and chargers.

4.2 Application environment precautions

- The operating temperature of SCOUT MINI outdoors is -10°C to 45°C ; please do not use it below -10°C and above 45°C outdoors;
- The operating temperature of SCOUT MINI indoors is 0°C to 42°C ; please do not use it below 0°C and above 42°C indoors;
- The requirements for relative humidity in the use environment of SCOUT MINI are: maximum 80%, minimum 30%;
- Please do not use it in the environment with corrosive and flammable gases or closed to combustible substances;
- Do not place it near heaters or heating elements such as large coiled resistors, etc.;
- Except for specially customized version (IP protection class customized), SCOUT MINI is not water-proof, thus please do not use it in rainy, snowy or water-accumulated environment;
- The elevation of recommended use environment should not exceed 1,000m;
- The temperature difference between day and night of recommended use environment should not exceed 25°C ;

4.3 Precautions for electrical external extension

- For the extended power supply, the current should not exceed 5 A and the total power should not exceed 120 W;
- When the system detects that the battery voltage is lower than the safe voltage class, external power supply extensions will be actively switched to. Therefore, users are suggested to notice if external extensions involve the storage of important data and have no power-off protection.

4.4 Precautions for mechanical load

4.5 Other notes

- SCOUT MINI has plastic parts in front and rear, please do not directly hit those parts with excessive force to avoid possible damages;
- When handling and setting up, please do not fall off or place the vehicle upside down;
- For non-professionals, please do not disassemble the vehicle without permission.

4.6 Safety precautions

- In case of any doubts during use, please follow related instruction manual or consult related technical personnel;
- Before use, pay attention to field condition, and avoid mis-operation that will cause personnel
- Without technical support and permission, please do not personally modify the internal equipment structure.

5. Q&A

Q: SCOUT MINI is started up correctly, but why cannot the RC transmitter control the vehicle body to move?

A: First, check whether the drive power supply is in normal condition, whether the drive power switch is pressed down and whether E-stop switches are released; then, check whether the control mode selected with the top left mode selection switch on the RC transmitter is correct.

Q: SCOUT MINI RC transmitter is in normal condition, and the information about chassis status and movement is all fed back correctly, but when the control frame protocol is issued, why cannot the vehicle body control mode be switched and the chassis respond to the control frame protocol?

A: Normally, if SCOUT MINI can be controlled by a RC transmitter, it means the chassis movement is under proper control; if the chassis feedback frame can be accepted, it means CAN extension link is in normal condition. Please check the CAN control frame sent to see whether the data check is correct and whether the control mode is command control mode. You can check the status of error flag from the error bit in the chassis status feedback frame.

Q: SCOUT MINI gives "beep-beep-beep..." sound when running, how to deal with this problem?

A: If SCOUT MINI give this "beep-beep-beep" sound continuously, it means the battery is in the alarm voltage state. Please charge the battery in time. Once other related sound occurs, there may be internal errors. You can check related error codes via the CAN bus or communicate with related technical personnel.

Q: Is the tire wear of SCOUT MINI is normally seen when it is running?

A: The tire wear of SCOUT MINI is normally seen when it is running. As SCOUT MINI is based on the four-wheel differential steering design, sliding friction and rolling friction both occur when the vehicle body rotates. If the floor is not smooth but rough, tire surfaces will be worn out. In order to reduce or slow down the wear, small-angle turning can be conducted for less turning on a pivot.

Q: When communication is implemented via CAN bus, the chassis feedback command is issued correctly, but why does not the vehicle respond to the control command?

A: There is a communication protection mechanism inside SCOUT MINI, which means the chassis is provided with timeout protection when processing external CAN control commands. Suppose the vehicle receives one frame of communication protocol, but it does not receive the next frame of control command after 500 ms. In this case, it will enter communication protection mode and set the speed to 0. Therefore, commands from upper computer must be issued periodically.

6. Product Dimensions

6.1 Illustration diagram of product external dimensions

