SCOUT 2.0

AgileX Robotics Team

User Manual V.2.0.0 2020.08

This chapter contains important safety information, before the robot is powered on for the first time, any individual or organization must read and understand this information before using the device. If you have any questions about use, please contact us at support@agilex.ai. Please follow and implement all assembly instructions and guidelines in the chapters of this manual, which is very important. Particular attention should be paid to the text related to the warning signs.

⚠ Safety Information

The information in this manual does not include the design, installation and operation of a complete robot application, nor does it include all peripheral equipment that may affect the safety of the complete system. The design and use of the complete system need to comply with the safety requirements established in the standards and regulations of the country where the robot is installed.

SCOUT integrators and end customers have the responsibility to ensure compliance with the applicable laws and regulations of relevant countries, and to ensure that there are no major dangers in the complete robot application. This includes but is not limited to the following:

1.Effectiveness and responsibility

- Make a risk assessment of the complete robot system.
- Connect the additional safety equipment of other machinery defined by the risk assessment together.
- Confirm that the design and installation of the entire robot system's peripheral equipment, including software and hardware systems, are correct.
- This robot does not have a complete autonomous mobile robot, including but not limited to automatic anti-collision, anti-falling, biological approach warning and other related safety functions. Related functions require integrators and end customers to follow relevant regulations and feasible laws and regulations for safety assessment , To ensure that the developed robot does not have any major hazards and safety hazards in actual applications.
- Collect all the documents in the technical file: including risk assessment and this manual.
- Know the possible safety risks before operating and using the equipment.

2.Environmental Considerations

- For the first use,please read this manual carefully to understand the basic operating content and operating specification.
- For remote control operation, select a relatively open area to use SCOUT2.0, because SCOUT2.0 is not equipped with any automatic obstacle avoidance sensor.
- Use SCOUT2.0 always under -20°C~45°C ambient temperature.
- If SCOUT 2.0 is not configured with separate custom IP protection, its water and dust protection will be IP22 ONLY.

3.Pre-work Checklist

- Make sure each device has sufficient power.
- Make sure Bunker does not have any obvious defects.
- Check if the remote controller battery has sufficient power.
- When using, make sure the emergency stop switch has been released.

4.Operation

- In remote control operation, make sure the area around is relatively spacious.
- Carry out remote control within the range of visibility.
- The maximum load of SCOUT2.0 is 50KG. When in use, ensure that the payload does not exceed 50KG.
- When installing an external extension on SCOUT2.0, confirm the position of the center of mass of the extension and make sure it is at the center of rotation.
- Please charge in tine when the device is low battery alarm.
- When SCOUT2..0 has a defect, please immediately stop using it to avoid secondary damage.
- When SCOUT2.0 has had a defect, please contact the relevant technical to deal with it, do not handle the defect by yourself.
- Always use SCOUT2.0 in the environment with the protection level requires for the equipment.
- Do not push SCOUT2.0 directly.
- When charging, make sure the ambient temperature is above 0 °C.
- If the vehicle shakes during its rotation, adjust the suspension.

5.Maintenance

- Regularly check the pressure of the tire, and keep the tire pressure between 1.8bar~2.0bar.
- If the tire is severely worn or burst, please replace it in time.
- If the battery do not use for a long time, it need to charge the battery periodically in 2 to 3 months.

CONTENTS

1. Introduction 1
1.1 Component list 1
1.2 Tech specifications 1

2. The Basics 2
2.1 Status indication 3
2.2 Instructions on electrical interfaces 3
2.2.1 Top electrical interface 3
2.2.2 Rear electrical interface 4
2.3 Instructions on remote control 5
FS_i6_S remote control instructions 5
2.4 Instructions on control demands and movements 5
2.5 Instructions on lighting control 6
6

3. Getting Started 6
3.1 Use and operation 6
3.2 Charging 6
3.3 Communication using CAN 13
3.3.1 CAN message protocol 13
3.3.2 CAN cable connection 13
3.3.3 Implementation of CAN command control 13
13
3.4 Communication using RS232 20
3.4.1 Introduction to serial protocol
3.4.2 Serial message protocol
3.4.3 Serial connection
3.5 Firmware upgrades 20
3.6 Use example of SCOUT 2.0 SDK 20
3.7 Use example of SCOUT 2.0 ROS Package 21
22

4. Precautions 22
4.1 Battery 22
4.2 Operational environment 22
4.3 Electrical/extension cords 22
4.4 Additional safety advices 22
4.5 Other notes 22

5. Q&A **23**

6. Product Dimensions **24**
6.1 Illustration diagram of product external dimensions 24
6.2 Illustration diagram of top extended support dimensions 25

1 Introduction

SCOUT 2.0 is designed as a multi-purpose UGV with different application scenarios considered: modular design; flexible connectivity; powerful motor system capable of high payload. Additional components such as stereo camera, laser radar, GPS, IMU and robotic manipulator can be optionally installed on SCOUT 2.0 for advanced navigation and computer vision applications. SCOUT 2.0 is frequently used for autonomous driving education and research, indoor and outdoor security patrolling, environment sensing, general logistics and transportation, to name a few only.

1.1 Component list

Name	Quantity
SCOUT 2.0 Robot body	X 1
Battery charger (AC 220V)	X 1
Aviation plug (male, 4-pin)	X 2
USB to RS232 cable	X 1
Remote control transmitter (optional)	X 1
USB to CAN communication module	X1

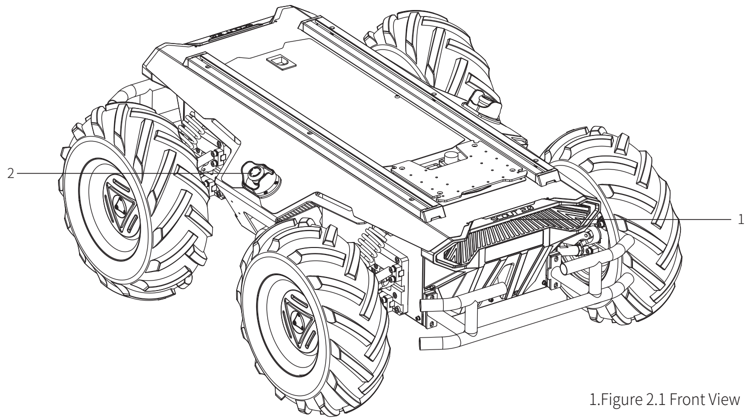
1.2 Tech specifications

Parameter Types	Items	Values
Mechanical specifications	L × W × H (mm)	9930 X 699 X 348
	Wheelbase (mm)	498
	Front/rear wheel base (mm)	582 / 582
	Weight of vehicle body (kg)	62
	Battery type	Lithium battery 24V 30AH
	Motor	DC brushless 4 X 200W
	Reduction gearbox	1:30
	Drive type	Independent four-wheel drive
	Suspension	Independent suspension with single rocker arm
	Steering	Four-wheel differential steering
	Safety equipment	Servo brake/anti-collision tube
Motion	No-load highest speed (m/s)	1.5
	Minimum turning radius	Be able to turn on a pivot
	Maximum climbing capacity	30°
	Minimum ground clearance (mm)	135
Control	Control mode	Remote control Control command mode
	RC transmitter	2.4G/extreme distance 1km
	Communication interface	CAN / RS232

DJI RC transmitter is provided (optional) in the factory setting of SCOUT 2.0, which allows users to control the chassis of robot to move and turn; CAN and RS232 interfaces on SCOUT 2.0 can be used for user’ s customization.
SCOUT 2.0 is eguibed with CAN and RS232 interfaces,users can secondary development thrangh CAN and RS232 interfaces.

2 The Basics

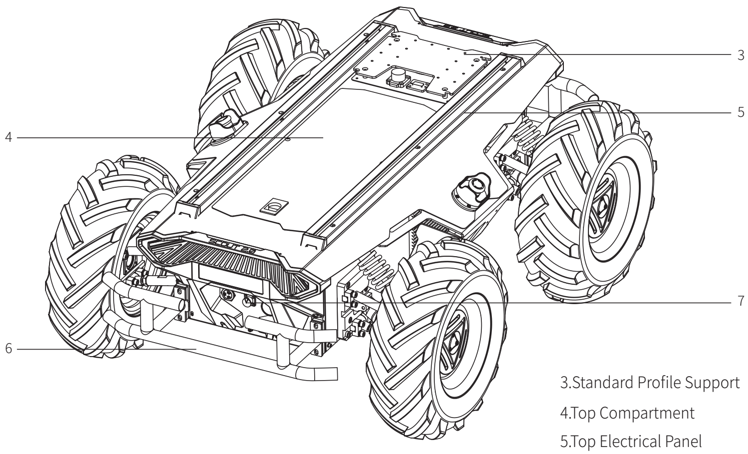
This section provides a brief introduction to the SCOUT 2.0 mobile robot platform, as shown in Figure 2.1 and Figure 2.2.



1.Figure 2.1 Front View

2.Stop Switch

Figure 2.1 Front View



3.Standard Profile Support

4.Top Compartment

5.Top Electrical Panel

6.Retardant-collision Tube

7.Rear Panel

Figure 2.2 Rear View

SCOUT2.0 adopts a modular and intelligent design concept. The composite design of inflate rubber tyre and independent suspension on the power module, coupled with the powerful DC brushless servo motor, makes the SCOUT2.0 robot chassis development platform has strong pass ability and ground adapt ability, and can move flexibly on different ground.Anti-collision beams are mounted around the vehicle to reduce possible damages to the vehicle body during a collision..
Lights are both mounted at front and at back of the vehicle, of which the white light is designed for illumination in front whereas the red light is designed at rear end for warning and indication.

Emergency stop buttons are installed on both sides of the robot to ensure easy access and pressing either one can shut down power of the robot immediately when the robot behaves abnormally.
Water-proof connectors for DC power and communication interfaces are provided both on top and at the rear of the robot, which not only allow flexible connection between the robot and external components but also ensures necessary protection to the internal of the robot even under severe operating conditions.
A bayonet open compartment is reserved on the top for users.

2.1 Status indication

Users can identify the status of vehicle body through the voltmeter, the beeper and lights mounted on SCOUT 2.0. For details, please refer to Table 2.1.

Status	Description
Voltage	The current battery voltage can be read from the voltmeter on the rear electrical interface and with an accuracy of 1V.
Replace battery	When the battery voltage is lower than 22.5V, the vehicle body will give a beep-beep-beep sound as a warning. When the battery voltage is detected as lower than 22V, SCOUT 2.0 will actively cut off the power supply to external extensions and drive to prevent the battery from being damaged. In this case, the chassis will not enable movement control and accept external command control.
Robot powered on	Front and rear lights are switched on.

Table 2.1 Descriptions of Vehicle Status

2.2 Instructions on electrical interfaces

2.2.1 Top electrical interface

SCOUT 2.0 provides three 4-pin aviation connectors and one DB9 (RS232) connector.
The position of the top aviation connector is shown in Figure 2.3.

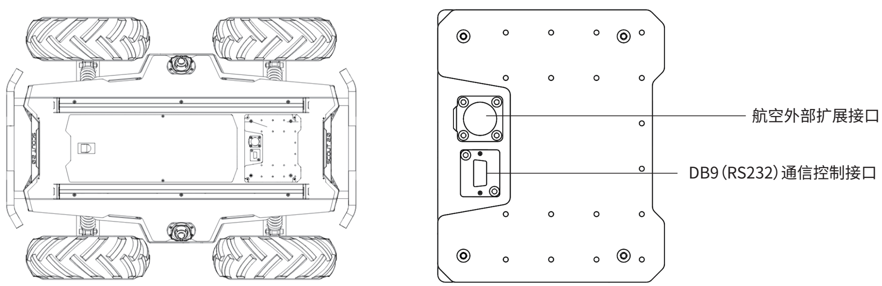
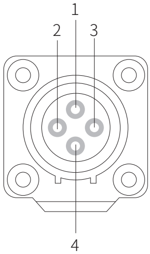


Figure 2.3 Schematic Diagram of SCOUT 2.0 Electrical Interface on Top

SCOUT 2.0 has an aviation extension interface both on top and at rear end, each of which is configured with a set of power supply and a set of CAN communication interface. 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.

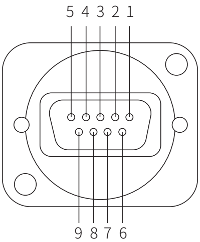
It should be noted that, the extended power supply here is internally controlled, which means the power supply will be actively cut off once the battery voltage drops below the pre-specified threshold voltage. Therefore, users need to notice that SCOUT 2.0 platform will send a low voltage alarm before the threshold voltage is reached and also pay attention to battery recharging during use.



Pin No.	Pin Type	Function and Definition	Remarks
1	Power	VCC	Power positive, voltage range 23 - 29.2V, MAX.current 10A
2	Power	GND	Power negative
3	CAN	CAN_H	CAN bus high
4	CAN	CAN_L	CAN bus low

Figure 2.4 Definitions for Pins of Top Aviation Extension Interface

Specific definitions for pins of Q4 are shown in Figure 2.5.



Pin No.	Definition
2	RS232-RX
3	RS232-TX
5	GND

Figure 2.5 Illustration Diagram of Q4 Pins

2.2.2 Rear electrical interface

The extension interface at rear end is shown in Figure 2.6, where Q1 is the key switch as the main electrical switch; Q2 is the recharging interface; Q3 is the power supply switch of drive system; Q4 is DB9 serial port; Q5 is the extension interface for CAN and 24V power supply; Q6 is the display of battery voltage.

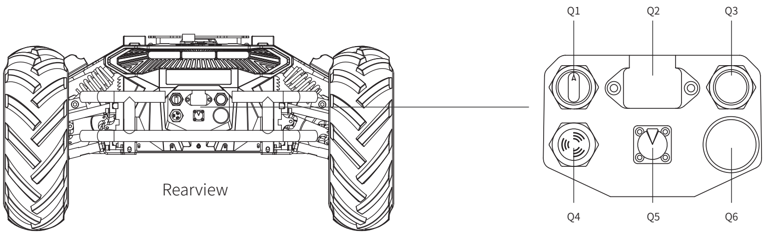
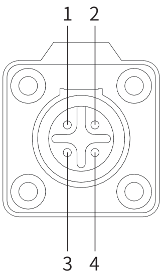


Figure 2.6 Rear View



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

Figure 2.7 Description of Front and Rear Aviation Interface Pins

2.3 Instructions on remote control

FS_i6_S remote control instructions

FS RC transmitter is an optional accessory of SCOUT2.0 for manually controlling the robot. The transmitter comes with a left-hand-throttle configuration. The definition and function shown in Figure 2.8. The function of the button is defined as: SWA and SWD are temporarily disabled, and SWB is the control mode select button, dial to the top is command control mode, dial to the middle is remote control mode; SWC is light control button; S1 is throttle button, control SCOUT2.0 forward and backward; S2 control is control the rotation, and POWER is the power button, press and hold at the same time to turn on.

Figure 2.8 Schematic Diagram of Buttons on FS RC transmitter

2.4 Instructions on control demands and movements

A reference coordinate system can be defined and fixed on the vehicle body as shown in Figure 2.9 in accordance with ISO 8855.

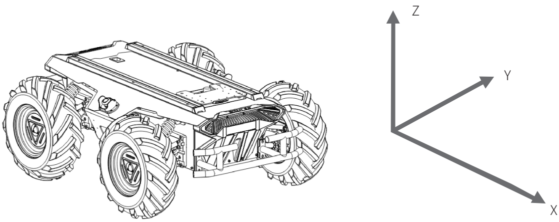


Figure 2.9 Schematic Diagram of Reference Coordinate System for Vehicle Body

As shown in Figure 2.9, the vehicle body of SCOUT 2.0 is in parallel with X axis of the established reference coordinate system.

In RC control mode, push the remote control stick S1 forward to move in the positive X direction, push stick S1 backward to move in the negative X direction. When S1 is pushed to the maximum value, the movement speed in the positive X direction is the maximum, when S1 is pushed to the minimum value, the movement speed is the maximum in the negative direction of the X direction.The remote control stick S2 controls the rotation of the car body left and right. The remote control joystick S2 controls the rotation of the car body left and right. When S2 pushes the car body to the left, it rotates from the positive direction of the X axis to the positive direction of the Y axis. When S2 pushes the car body to the right, it rotates from the positive direction of the X axis to the negative direction of the Y axis. S2 When pushing to the left to the maximum value, the counterclockwise rotation speed is the maximum. When S2 is pushed to the right to the maximum value, the clockwise rotation speed is the maximum.

Following this convention, a positive linear velocity corresponds to the forward movement of the vehicle along positive x-axis direction and a positive angular velocity corresponds to positive right-hand rotation about the z-axis.

2.5 Instructions on lighting control

Lights are mounted in front and at back of SCOUT 2.0, and the lighting control interface of SCOUT 2.0 is open to the users for convenience. Meanwhile, another lighting control interface is reserved on the RC transmitter for energy saving.

Currently the lighting control is only supported with the FS transmitter, and support for other transmitters is still under development. There are 3 kinds of lighting modes controlled with RC transmitter, which can be switched among each other by SWC toggling:

- NC MODE: IN NC MODE, IF THE CHASSIS IS STILL, THE FRONT LIGHT WILL BE TURNED OFF, AND THE REAR LIGHT WILL ENTER BL MODE TO INDICATE ITS CURRENT OPERATING STATUS; IF THE CHASSIS IS IN THE TRAVELING STATE AT CERTAIN NORMAL SPEED, THE REAR LIGHT WILL BE TURNED OFF BUT THE FRONT LIGHT WILL BE TURNED ON;
- NO MODE: IN NO MODE, IF THE CHASSIS IS STILL, THE FRONT LIGHT WILL BE NORMALLY ON, AND THE REAR LIGHT WILL ENTER THE BL MODE TO INDICATE THE STILL STATUS; IF IN MOVEMENT MODE, THE REAR LIGHT IS TURNED OFF BUT THE FRONT LIGHT IS TURNED ON;
- BL MODE: FRONT AND REAR LIGHTS ARE BOTH IN BREATHING MODE UNDER ALL CIRCUMSTANCES.

NOTE ON MODE CONTROL:TOGGLING SWC LEVER RESPECTIVELY REFERS TO NC MODE, NO MODE AND BL MODE IN BOTTOM, MIDDLE AND TOP POSITIONS.

3 Getting Started

This section introduces the basic operation and development of the SCOUT 2.0 platform using the CAN bus interface.

3.1 Use and operation

The basic operating procedure of startup is shown as follows:

Check

- Check the condition of vehicle body. Check whether there are significant anomalies; if so, please contact the after-sale service personnel for support;
- Check the state of emergency stop switches. Make sure both emergency stop buttons are released;
- Take off the cover of rear panel and you will see it;
- For first-time use, check whether Q3 (drive power supply switch) on the rear panel has been pressed down; if so, please release it, and then the drive will be powered off.

Startup

- Rotate the key switch (Q1 on the electrical panel), and normally, the voltmeter will display correct battery voltage and front and rear lights will be both switched on;
- Check the battery voltage. If there is no continuous "beep-beep-beep..." sound from beeper, it means the battery voltage is correct; if the battery power level is low, please charge the battery;
- Press Q3 (drive power switch button).

Shutdown

- Rotate the key switch to cut off the power supply;

Emergency stop

- Press down emergency push button both on the left and the right of SCOUT 2.0 vehicle body;

Basic operating procedure of remote control:

After the chassis of SCOUT 2.0 mobile robot is started correctly, turn on the RC transmitter and select the remote-control mode. Then, SCOUT 2.0 platform movement can be controlled by the RC transmitter.

3.2 Charging

SCOUT 2.0 IS EQUIPPED WITH A 10A CHARGER BY DEFAULT TO MEET CUSTOMERS' RECHARGING DEMAND.

The detailed operating procedure of charging is shown as follows:

- Make sure the electricity of SCOUT 2.0 chassis is powered off. Before charging, please make sure Q1 (key switch) in the rear control console is turned off;
- Insert the charger plug into Q2 charging interface on the rear control panel;
- 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 3 to 5 hours to be fully recharged from 22V, and the voltage of a fully recharged battery is about 29.2V; the recharging duration is calculated as 30AH ÷ 10A = 3h.

3.3 Communication using CAN

SCOUT 2.0 provides CAN and RS232 interfaces for user customization. Users can select one of these interfaces to conduct command control over the vehicle body.

3.3.1 CAN message protocol

SCOUT 2.0 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 2.0 will feedback on the current movement status information and its chassis status information 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 2.0 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 0x02 Serial port control mode	
byte [2] byte [3]	Battery voltage higher 8 bits Battery voltage lower 8 bits	unsigned int16	Actual voltage X 10 (with an accuracy of 0.1V)	
byte [4] byte [5]	Failure information higher 8 bits Failure information lower 8 bits	unsigned int16	See notes for detail[Description of Failure Information]	
byte [6]	Count paritybit(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 paritybit (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			
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 1.5m/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 paritybit (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 2.0 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 0x01 for successfully executing the speed command. Once the RC transmitter is switched on again, it has the highest authority level 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 0.15m/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 0.05235rad/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 RC transmitter 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 4 motors in the chassis are shown in the figure below:

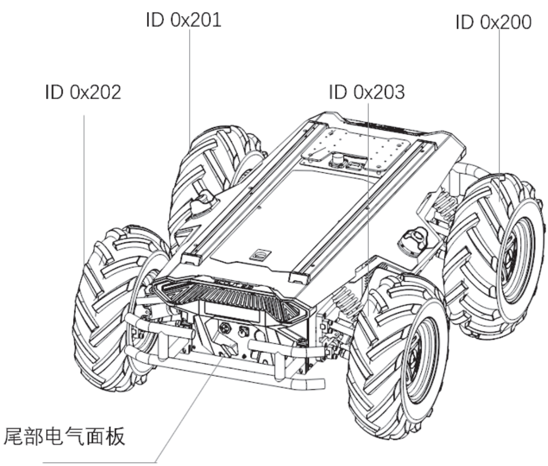


Figure 3.0 Schematic Diagram of Motor Feedback IDs

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 hard disk drive (HDD) 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 (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 hard disk drive (HDD) 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 (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.2 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 hard disk drive (HDD) 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 (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.2 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 hard disk drive (HDD) 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 (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 0x01 NO 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]	Rear light mode	unsigned int8	0x00 NC 0x01 NO 0x02BL mode 0x03 User-defined brightness	
byte [4]	Customize brightness for rear light	unsigned int8	[0, 100], where 0 refers to no brightness, 100 refers to maximum brightness	
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]: The values are valid for 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	25ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	Current lighting control enable flag	unsigned int8	0x00Control command invalid 0x01Lighting 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]	Current rear light mode	unsigned int8	0x00 NC 0x01 NO 0x02 BL mode 0x03 User-defined brightness	
byte [4]	Current custom brightness of rear light	unsigned int8	[0, 100], where 0 refers to no brightness, 100 refers to maximum brightness	
byte [5]	Reserved	--	0x00	
byte [6]	Count parity bit (count)	unsigned int8	[0, 100], where 0 refers to no brightness, 100 refers to maximum brightness	
byte [7]	Parity bit (checksum)	unsigned int8	Parity bit	

The data Parity bit is the last valid byte in the data segment of each frame of CAN message. Its checksum is calculated as follows: checksum =(ID_H + ID_L + data_length+ can_msg.data[0] + can_msg.data[1] + can_msg.data[2] + can_msg.data[3] +can_msg.data[4]+ …+ 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

2 aviation male plugs are supplied along with SCOUT 2.0 as shown in Figure 3.2. For wire definitions, please refer to Table 2.2.

RED :VCC(positive pole)

BLACK :GND(negative pole)

BLUE :CAN_L

YELLOW :CAN_H

Figure 3.2 Schematic Diagram of Aviation Male Plug

3.3.3 Implementation of CAN command control

Correctly start the chassis of SCOUT 2.0 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 2.0 chassis will accept the command from CAN interface, and the host can also parse the current state of 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 Communication using RS232

3.4.1 Introduction to serial protocol

This is a serial communication standard which was formulated collectively by Electronic Industries Association (EIA) together with Bell System, modem manufacturers and computer terminal manufacturers in 1970. Its full name is called "the technical standard for serial binary data exchange interface between data terminal equipment (DTE) and data communication equipment (DCE). This standard requires to use a 25-pin DB-25 connector of which each pin is specified with corresponding signal content and various signal levels. Afterwards, RS232 is simplified as DB-9 connector in IBM PCs, which has become a de facto standard since then. Generally, RS-232 ports for industrial control only use 3 kinds of cables - RXD, TXD and GND.

3.4.2 Serial message protocol

Basic parameters of communication

Item	Parameter
Baud rate	115200
Check	No check
Data bit length	8 bits
Stop bit	1 bit

Protocol specification

Start bit		Frame length	Command type	Command ID	Data field			Frame ID	Checksum composition
SOF		frame_L	CMD_TYPE	CMD_ID	data [0]	...	data[n]	frame_id	check_sum
byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	...	byte 6+n	byte 7+n	byte 8+n
5A	A5								

The protocol includes start bit, frame length, frame command type, command ID, data field, frame ID, and checksum composition. Where, the frame length refers to the length excluding start bit and checksum composition; the checksum refers to the sum from start bit to all data of frame ID; the frame ID is a loop count between 0 to 255, which will be added once every command sent.

```
/**
 * @brief  serial message checksum example code
  * @param[in]  *data : serial message data struct pointer
  * @param[in]  len :serial message data length
  * @return  the checksum result
  */
  static uint8 Agilex_SerialMsgChecksum(uint8 *data, uint8 len)
  {
     uint8 checksum = 0x00;
     for(uint8 i = 0 ; i < (len-1); i++)
     {
         checksum += data[i];
     }
     return checksum;
  }
```

System status feedback command

Command Name	System status feedback command		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	20ms	None
Frame length	0x0a		
Command type	Feedback command (0xAA)		
Command ID	0x01		
Data field length	6		
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) 0x01 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		

Description of Failure Information		
Byte	Bit	含义
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]	Reserved, default 0
	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.

Movement control feedback command

Command Name	Movement Control Feedback Command		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	20ms	None
Frame length	0x0A		
Command type	Feedback command (0xAA)		
Command ID	0x02		
Data field length	6		
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

Movement control command

Command Name	Control Command		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Decision-making control unit	Chassis node	20ms	None
Frame length	0x0A		
Command type	Control command (0x55)		
Command ID	0x01		
Data field length	6		
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 1.5m/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

No.1 motor drive information feedback frame

Command Name	No.1 Motor Drive Information Feedback Frame		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	20ms	None
Frame length	0x0A		
Command type	Feedback command (0xAA)		
Command ID	0x03		
Data field length	6		
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 hard disk drive (HDD) temperature	signed int8	Actual temperature (with an accuracy of 1°C)
byte [5]	Reserved	-	0x00

No.2 motor drive information feedback frame

Command Name	No.2 Motor Drive Information Feedback Frame		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	20ms	None
Frame length	0x0A		
Command type	Feedback command (0xAA)		
Command ID	0x04		
Data field length	6		
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 hard disk drive (HDD) temperature	signed int8	Actual temperature (with an accuracy of 1°C)
byte [5]	Reserved	-	0x00

No.3 motor drive information feedback frame

Command Name	No.3 Motor Drive Information Feedback Frame		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	20ms	None
Frame length	0x0A		
Command type	Feedback command (0xAA)		
Command ID	0x05		
Data field length	6		
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 hard disk drive (HDD) temperature	signed int8	Actual temperature (with an accuracy of 1°C)
byte [5]	Reserved	-	0x00

No.4 motor drive information feedback frame

Command Name	No.3 Motor Drive Information Feedback Frame		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	20ms	None
Frame length	0x0A		
Command type	Feedback command (0xAA)		
Command ID	0x06		
Data field length	6		
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 hard disk drive (HDD) temperature	signed int8	Actual temperature (with an accuracy of 1°C)
byte [5]	Reserved	-	0x00

Lighting control frame

Command Name	Lighting Control Frame		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Decision-making control unit	Chassis node	20ms	无
Frame length	0x0A		
Command type	Control command (0x55)		
Command ID	0x02		
Data field length	6		
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 0x01 NO 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]	Rear light mode	unsigned int8	0x00 NC 0x01 NO 0x02 BL mode 0x03 User-defined brightness
byte [4]	Custom brightness of rear light	unsigned int8	[0, 100], where 0 refers to no brightness, 100 refers to maximum brightness
byte [5]	Reserved	--	0x00

Lighting control feedback frame

Command Name	Lighting Control Feedback Frame		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	20ms	None
Frame length	0x0A		
Command type	Feedback command (0xAA)		
Command ID	0x07		
Data field length	6		
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]	Current rear light mode	unsigned int8	0x00 NC 0x01 NO 0x02 BL mode 0x03 User-defined brightness
byte [4]	Current custom brightness of rear light	unsigned int8	[0, 100], where 0 refers to no brightness, 100 refers to maximum brightness
byte [5]	Reserved	-	0x00

Example data

Start bit		Frame length	Command type	Command ID	Data field			Frame ID	Checksum composition
byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	…	byte 6+n	byte 7+n	byte 8+n
0x5A	0xA5	0x0A	0x55	0x01	…	…	…	0x00	0x6B

The data field content is shown as follows:

Position	Function	Value
byte [0]	Control mode	0x02
byte [1]	Failure clearing command	0x00
byte [2]	Linear speed percentage	0x0A
byte [3]	Angular speed percentage	0x00
byte [4]	Reserved	0x00
byte [5]	Reserved	0x00

The entire data string is : 5A A5 0A 55 01 02 00 0A 00 00 00 00 6B

- Additional notes:**This protocol requires a firmware version above V1.3.3.**

3.4.3 Serial connection

Take out the USB-to-RS232 serial cable from our communication tool kit to connect it onto the serial port at the rear end. Then, use the serial port tool to set corresponding baud rate, and conduct the test with the example date provided above. If the RC transmitter is on, it needs to be switched to command control mode; if the RC transmitter is off, directly send the control command. It should be noted that, the command must be sent periodically, because if the chassis has not received the serial port command after 500ms, it will enter the disconnected protection status.

3.5 Firmware upgrades

The RS232 port on SCOUT 2.0 can be used by users to upgrade the firmware for the main controller in order to get bugfixes and feature enhancements. A PC client application with graphical user interface is provided to help make the upgrading process fast and smooth. A screenshot of this application is shown in Figure 3.3.

Upgrade preparation

- Serial cable X 1
- USB-to-serial port X 1
- SCOUT 2.0 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 rear end of SCOUT 2.0 chassis;
- Connect the serial cable to the computer;
- Open the client software;
  Select the port number;
- Power on SCOUT 2.0 chassis, and immediately click to start
- connection (SCOUT 2.0 chassis will wait for 6s before power-on; if the waiting time is more than 6s, 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.

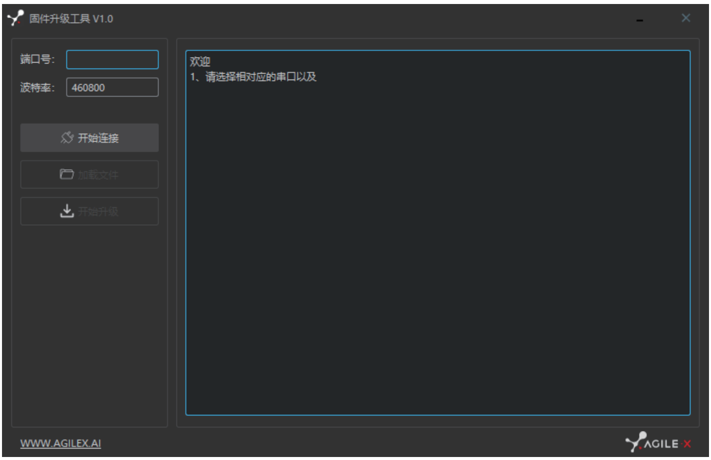


Figure 3.3 Client Interface of Firmware Upgrade

3.6 Use example of SCOUT 2.0 SDK

In order to help users implement robot-related development more conveniently, a cross-platform supported SDK is developed for SCOUT 2.0 mobile robot.SDK software package provides a C++ based interface, which is used to communicate with the chassis of SCOUT 2.0 mobile robot and can obtain the latest status of the robot and control basic actions of the robot. For now, CAN adaptation to communication is available, but RS232-based adaptation is still under way.Based on this, related tests have been completed in Nvidia Jetson TX2.

3.7 Use example of SCOUT 2.0 ROS Package

ROS provides some standard operating system services, such as hardware abstraction, control of underlying devices, implementation of common functions, and management of inter-process messages and data packets. ROS is based on a kind of graphic structure, so that processes of different nodes can accept, post and aggregate various kinds of information (such as sensing, control, status, planning, etc.). At present, ROS is best supported in UBUNTU.

Preparation for development

Hardware preparation

- CANable can communication module X 1
- Thinkpad E470 laptop computer X 1
- AGILEX SCOUT 2.0 mobile robot chassis X 1
- AGILEX SCOUT 2.0 supported RC transmitter FS-i6s X 1
- AGILEX SCOUT 2.0 top aviation socket X 1

Instructions on use example environments

- Ubuntu 16.04 LTS (beta version, which has been tested in Ubuntu 18.04 LTS)
- ROS Kinetic(subsequent versions also have been tested)
- Git

ROS installation and environment setup

For installation details, please refer to http: //wiki.ros.org/kinetic/Installation/Ubuntu.

CANable hardware testing and CAN communication

Set CAN-TO-USB adapter.

- Enabe gs_usb kernel module.
  $ sudo modprobe gs_usb
- Set the baud rate to 500k and enable can-to-usb adapter.
  $ sudo ip link set can0 up type can bitrate 500000
- If no error occurs in previous steps, you should be able to use the command to immediately view can equipment.
  $ ifconfig -a
- Install and use can-utils to test hardware.
  $ sudo apt install can-utils
- If can-to-usb has already been connected to SCOUT 2.0 this time and the vehicle has been turned on, following command can be used to monitor the data from SCOUT 2.0 chassis.
  $ candump can0
- Reference sources:
  [1] https: //github.com/westonrobot/SCOUT 2.0_sdk
  [2] https://wiki.rdu.im/_pages/Notes/Embedded-System/Linux/can-bus-in-linux.html

Download and compilation of AGILEX SCOUT 2.0 ROS Package

- Download ROS dependent packages.
  $ sudo apt install ros-melodic-controller-manager
  $ sudo apt install ros-melodic-teleop-twist-keyboard
- Clone and compile SCOUT 2.0_ros source codes.
  $ cd ~/catkin_ws/src
  $ git clone https://github.com/agilexrobotics/SCOUT _ros.git
  $ cd ..
  $ catkin_make
- Reference source: https: //github.com/agilexrobotics/SCOUT _ros

Hardware connection and preparation

- Lead out CAN cable from SCOUT 2.0 top or rear aviation socket, and connect the CAN_H and CAN_L wires to the corresponding CAN_TO_USB adapter terminals;
- Turn on the rotary switch of SCOUT 2.0 mobile robot chassis, and press down the control switch of drive power supply. Normally, you can hear the beeper to give a "beep" sound, which means the drive has been properly powered on; if there is no sound, check whether the E-stop switches on both sides have been released;
- Connect CAN_TO_USB to the usb port of laptop, and you can test again whether CAN is in normal condition.

Launching of ROS nodes

- Launch basic nodes.
  $ roslaunch SCOUT_bringup SCOUT_minimal.launch
  Launch remote operation nodes for keyboard.
- $ roslaunch SCOUT_bringup SCOUT_teleop_keyboard.launch

4 Precautions

This section includes some precautions that should be paid attention to for SCOUT 2.0 use and development.

4.1Battery

- The battery supplied with SCOUT 2.0 is not fully charged in the factory setting, but its specific power capacity can be displayed on the voltmeter at rear end of SCOUT 2.0 chassis or read via CAN bus communication interface. The battery recharging can be stopped when the green LED on the charger turns green. Note that if you keep the charger connected after the green LED gets on, the charger will continue to charge the battery with about 0.1A current for about 30 minutes more to get the battery fully charged.
- Please do not charge the battery after its power has been depleted, and please charge the battery in time when low battery level alarm 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; lithium-ion batteries cannot be charged below 0°C (32°F) and modifying or replacing the original batteries are strictly prohibited.

4.2 Operational environment

- The operating temperature of SCOUT 2.0 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 2.0 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 2.0 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 2.0 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;
- Regularly check the tire pressure, and make sure it is within 1.8 bar to 2.0bar。
- If any tire is seriously worn out or has blown out, please replace it in time.

4.3 Electrical/extension cords

- For the extended power supply on top, the current should not exceed 6.25A and the total power should not exceed 150W;
- For the extended power supply at rear end, the current should not exceed 5A and the total power should not exceed 120W;
- 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.

4.5 Other notes

- SCOUT 2.0 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.

4.4 Additional safety advices

- 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 safety problem;
- In case of emergencies, press down the emergency stop button and power off the equipment;
- Without technical support and permission, please do not personally modify the internal equipment structure.

5 Q&A

Q: SCOUT 2.0 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 2.0 remote control is in normal condition, and the information about chassis status and movement can be received 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 2.0 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 in command control mode. You can check the status of error flag from the error bit in the chassis status feedback frame.

Q: SCOUT 2.0 gives a "beep-beep-beep..." sound in operation, how to deal with this problem?

A: If SCOUT 2.0 gives 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 occur, there may be internal errors. You can check related error codes via CAN bus or communicate with related technical personnel.

Q:Is the tire wear of SCOUT 2.0 is normally seen in operation?

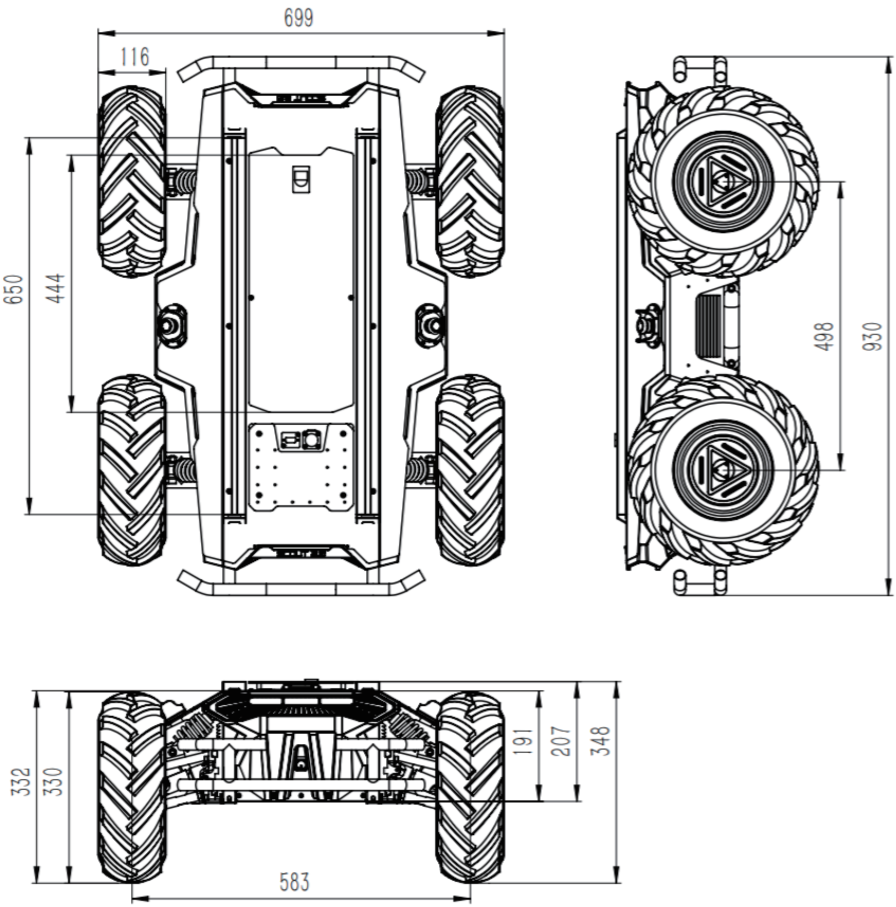
A: The tire wear of SCOUT 2.0 is normally seen when it is running. As SCOUT 2.0 is based on the four-wheel differential steering design, sliding friction and rolling friction both occur when the vehicle body rotates. If the floor is not smooth but rough, tire surfaces will be worn out. In order to reduce 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?

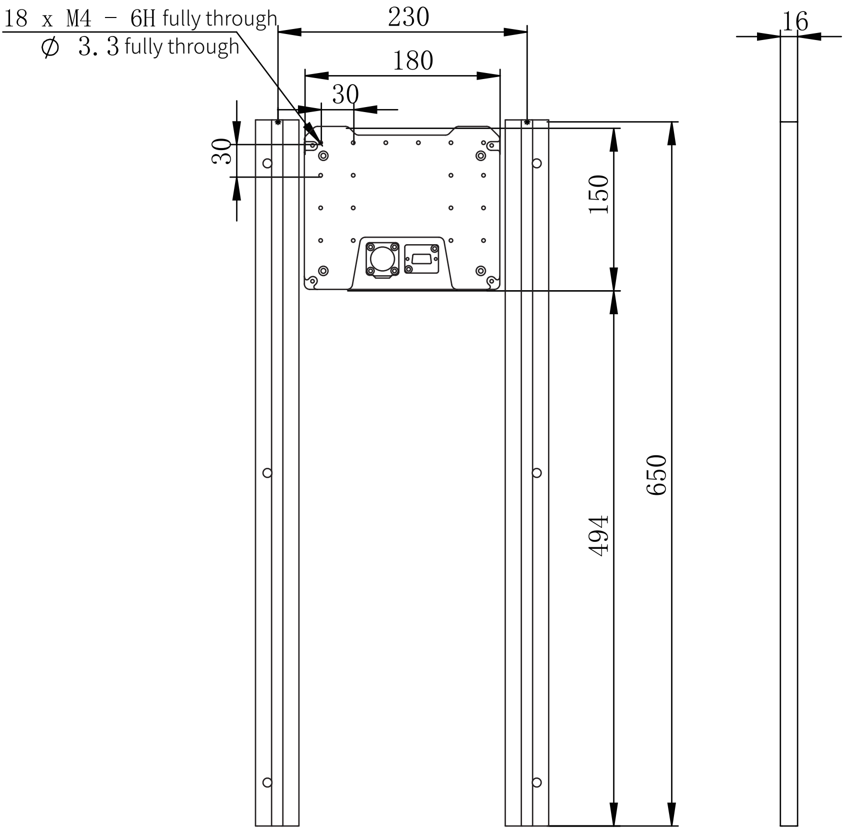
A: There is a communication protection mechanism inside SCOUT 2.0, which means the chassis is provided with timeout protection when processing external CAN control commands. Suppose the vehicle receives one frame of communication protocol, but it does no receive the next frame of control command after 500ms. 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



6.2 Illustration diagram of top extended support dimensions



AGILE·X
AgileX Robotics (Dongguan) CO., Ltd

WWW.AGILEX.AI
Email：sales@agilex.ai
TEL:+86-0769-22892150