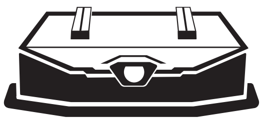


TRACER

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. TRACER 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.

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 TRACER, because TRACER is not equipped with any automatic obstacle avoidance sensor.
- Use TRACER always under -10°C~45°C ambient temperature.
- If TRACER 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 TRACER is 100KG. When in use, ensure that the payload does not exceed 100KG.
- When installing an external extension on TRACER, confirm the position of the center of mass of the extension and make sure it is at the center of rotation.
- Please charge in time when the device voltage is lower than 22.5V.
- When TRACER has a defect, please immediately stop using it to avoid secondary damage.
- When TRACER has had a defect, please contact the relevant technical to deal with it, do not handle the defect by yourself.
- Always use SCOUT MINI(OMNI) in the environment with the protection level requires for the equipment.
- Do not push SCOUT MINI(OMNI) directly.
- When charging, make sure the ambient temperature is above 0°C.

5.Maintenance

- In order to ensure the storage capacity of the battery, the battery should be stored under electricity, and it should be charged regularly when not used for a long time.

CONTENTS

1 MINIAGV（TRACER）Introduction

TRACER is designed as a multi-purpose UGV with different application scenarios considered: modular design; flexible connectivity; powerful motor system capable of high payload.The combination of two-wheel differential chassis and hub motor can make it move flexible indoor.Additional components such as stereo camera, laser radar, GPS, IMU and robotic manipulator can be optionally installed on TRACER for advanced navigation and computer vision applications. TRACER is frequently used for autonomous driving education and research, indoor and outdoor security patrolling and transportation, to name a few only.

1.1 Component list

Name	Quantity
TRACER Robot body	x1
Battery charger(AC 220V)	x1
Remote control transmitter(optional)	x1
USB to serial cable	x1
Aviation plug (male,4-Pin)	x1
USB to CAN communication module	x1

1.2 Tech specifications

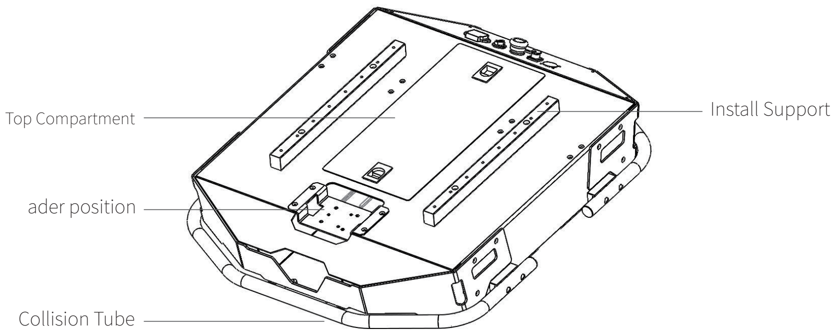
Parameter Types	Items	Values
Mechanical specifications	L × W × H (mm)	685 X 570X 155
	Wheelbase (mm)	360
	Weight of vehicle body (kg)	25~30
	Battery type	Lithium battery 24V 15AH
	Motor	DC brushless 2X150W
	Drive type	Independent drive
	Suspension	Independent suspension with rocker arm
	Steering	Differential steering
	Safety equipment	Servo brake/anti-collision tube
Motion	No-load highest speed (m/s)	2.3
	Minimum turning radius	Be able to turn on a pivot
	Minimum ground clearance (mm)	30
	Maximum climbing capacity	10°
Control	Control mode	Remote control
	RC transmitter	Control command mode 2.4G/extreme distance 1km
	Communication interface	CAN / RS232

1.3 Development requirements

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

2 The Basics

This section provides a brief introduction to the TRACER mobile robot platform, as shown in Figure 2.1 and Figure2.2.



igure 2.1 Front View

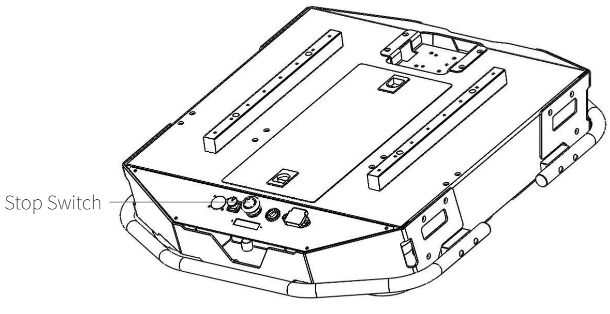


Figure 2.2 Rear View

TRACER is Designed as a complete intelligent module, which along with powerful DC hub motor, enables the chassis of TRACER robot to flexibly move on flat ground of indoor. Anti-collision beams are mounted around the vehicle to reduce possible damages to the vehicle body during a collision.

Lights is mounted at front of the vehicle, of which the white light is designed for illumination in front.

An emergency stop switch is mounted at the rear end of vehicle body, which can shut down power of the robot immediately when the robot behaves abnormally.

Water-proof connectors for DC power and communication interface is provided at the rear of TRACER, 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 and lights mounted on TRACER. 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 22V, the vehicle body will give abeep-beep-beep sound as a warning. When the battery voltage is detected as lower than 21.5V, TRACER 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 light is switched on.

Table 2.1 Descriptions of Vehicle Status

2.2 Instructions on electrical interfaces

2.2.1 Rear electrical interface

The extension interface at rear end is shown in Figure 2.3, where Q1 is D89 serial port; Q2 is the stop switch; Q3 is the power charging port; Q4 is the extension interface for CAN and 24V power supply; Q5 is the electricity meter; Q6 is the rotary switch as the main electrical switch.

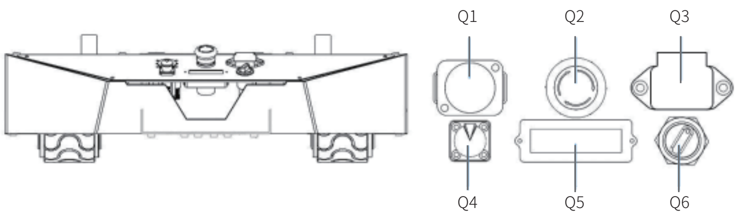
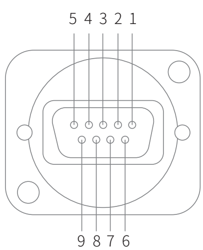


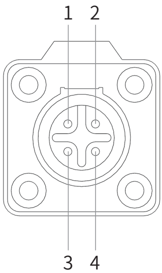
Figure 2.3 Illustration Diagram of Q1 Pins



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

Figure 2.4 Illustration Diagram of Q4 Pins

The rear panel provides the same CAN communication interface and 24V power interface with the top one (two of them are internally inter-connected). The pin definitions are given in Figure 2.5.



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 2.5 Description of Rear Aviation Interface Pins

2.3 Instructions on remote control

FS RC transmitter is an optional accessory of TRACER for manually controlling the robot. The transmitter comes with a left-hand-throttle configuration. The definition and function as shown in Figure 2.6.

Figure 2.6 Schematic Diagram of Buttons on FS RC transmitter

In addition to the two sticks S1 and S2 used for sending linear and angular velocity commands, two switches are enabled by default: SWB for control mode selection (top position for command control mode and the middle position for remote control mode), SWC for lighting control. The two POWER buttons need to be pressed and held together to turn on or turn off the 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 2.7 in accordance with ISO 8855.

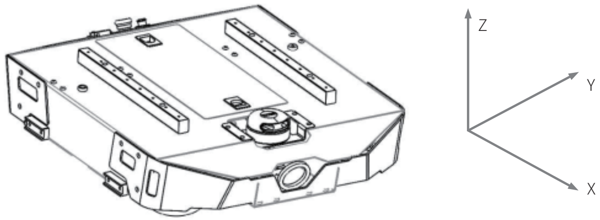


Figure 2.7 Schematic Diagram of Reference Coordinate System for Vehicle Body

As shown in Figure 2.7, the vehicle body of TRACER is in parallel with X axis of the established reference coordinate system. 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. In the manual control mode with a RC transmitter, pushing the C1 stick (DJI model) or the S1 stick (FS model) forward will generate a positive linear velocity command and pushing C2 (DJI model) and S2 (FS model) to the left will generate a positive angular velocity command.

3 Getting Started

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

3.1 Use and operation

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.

Start up

- Emergency stop switch status. Confirm that the emergency stop buttons are all released;
- Rotate the key switch (Q6 on the electrical panel), and normally, the voltmeter will display correct battery voltage and front and rear lights will be both switched on.

Shut down

- 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 rear vehicle body;

Basic operating procedure of remote control:

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

3.2 Charging

TRACER 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 TRACER chassis is powered off. Before charging, please make sure Q6 (key switch) in the rear control console is turned off;
- Insert the charger plug into Q3 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.

3.3 Communication using CAN

TRACER 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

TRACER 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; TRACER 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 TRACER 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 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] 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]	Failure information	unsigned int16	See notes for details【Table 3.2】	
byte [5]	Reserved	-	0x00	
byte [6]	Reserved	-	0x00	
byte [7]	Count paritybit (count)	unsigned int8	0 - 255 counting loops	

Table 3.2 Description of Failure Information

		Description of Failure Information
byte [4]	bit [0]	Battery under-voltage failure (0: No failure 1: Failure) Protective voltage 22V
	bit [1]	Battery under-voltage alarm (0: No alarm 1: Alarm) Alarm voltage 22.5V
	bit [2]	RC transmitter disconnection protection (0: Normal 1: RC transmitter disconnected)
	bit [3]	Reserved
	bit [6]	Reserved
	bit [7]	Reserved

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	0x221	20ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0] byte [1]	Moving speed higher 8 bits Moving speed lower 8 bits	signed int16	Vehicle speedUnit：mm/s	
byte [2] byte [3]	Rotational speed higher 8 bits Rotational speed lower 8 bits	signed int16	Vehicle angular speed Unit：0.001rad/s	
byte [4]	Reserved	-	0x00	
byte [5]	Reserved	-	0x00	
byte [6]	Reserved	-	0x00	
byte [7]	Reserved	-	0x00	

The control frame includes control openness of linear speed and control openness of angular speed. 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)
Steer-by-wire chassis	Chassis node	0x111	20ms	500ms
Data length	0x08			
Position	Function	Data type	Description	
byte [0] byte [1]	Moving speed higher 8 bits Moving speed lower 8 bits	signed int16	Vehicle speed Unit：mm/s	
byte [2] byte [3]	Rotational speed higher 8 bits Rotational speed lower 8 bits	signed int16	Vehicle angular speed Unit：0.001rad/s	
byte [4]	Reserved	—	0x00	
byte [5]	Reserved	—	0x00	
byte [6]	Reserved	—	0x00	
byte [7]	Reserved	—	0x00	

The light control frame includes current state of front light. For its detailed content of protocol, please refer to Table 3.5.

Table 3.5 Lighting Control Frame

Command Name	灯光控制帧			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Steer-by-wire chassis	0x121	20ms	500ms
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]	Reserved	--	0x00	
byte [4]	Reserved	--	0x00	
byte [5]	Reserved	--	0x00	
byte [6]	Reserved	-	0x00	
byte [7]	Count paritybit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent	

Note[5]: This date only valid in custom mode

The light control frame includes light control mode and control openness. For its detailed content , please refer to Table 3.6.

Table 3.6 Lighting Control Frame

Command Name	Lighting Control Frame			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x231	20ms	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	
byte [3]	Reserved	--	0x00	
byte [4]	Reserved	--	0x00	
byte [5]	Reserved	--	0x00	
byte [6]	Reserved	-	0x00	
byte [7]	Count paritybit (count)	unsigned int8	0 - 255 counting loops, which will be added once every command sent	

The control mode frame include set the control mode of chassis. For its detailed content , please refer to Table 3.7.

Table 3.7 Control Mode Frame Instruction

Command Name	控制模式设定帧			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x421	None	None
Data length	0x01			
Position	Function	Data type	Description	
byte [0]	Control mode	unsigned int8	0x00 Control mode 0x01 CAN command control mode[1] 0x02 Serial port control mode	

Note 1，Control mode instruction

In case the RC transmitter is powered off, the control mode of TRACER 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.

The status position frame includes clear error message. For its detailed content , please refer to Table 3.8.

Table 3.8 Status position Frame Instruction

Command Name	Status position Frame			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Decision-making control unit	0x441	None	None
Data length	0x01			
Position	Function	Data type	Description	
byte [0]	Control mode	unsigned int8	0x00 Clear all errors 0x01 Clear errors of motor 1 0x02 Clear errors of motor 2	

Table 3.9 Odometer Feedback Instruction

Command Name	运动控制回馈指令			
Sending node	Receiving node	ID	Cycle (ms)	接收超时(ms)
Steer-by-wire chassis	Decision-making control unit	0x311	20ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	Left tyre highest odometer	signed int32	Data of left tyre odometer Unit mm	
byte [1]	Left tyre second highest odometer			
byte [2]	Left tyre second lowest odometer			
byte [3]	Left tyre lowest odometer			
byte [4]	Right tyre highest odometer	signed int32-	Data of right tyre odometer Unit mm	
byte [5]	Right tyre second highest odometer			
byte [6]	Right tyre second lowest odometer			
byte [7]	Right tyre lowest odometer			

The chassis status information will be feed back; what' s more, the information about motor. The following feedback frame contains the information about motor :

The serial numbers of 2 motors in the chassis are shown in the figure below:

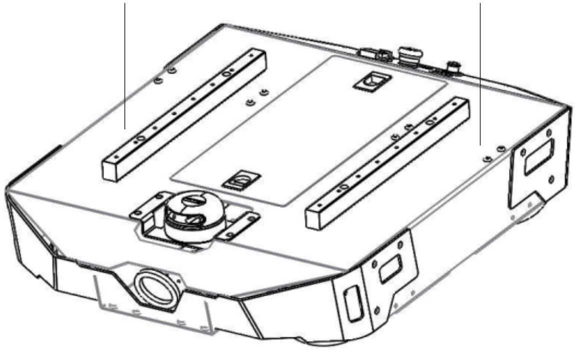


Table 3.0 Motor Feedback ID schematic diagram

Table 3.10 Motor High-speed Information Feedback Frame

Command Name	Motor High-speed Information Feedback Frame			
Sending node	Receiving node	ID	Cycle (ms)	Receive-timeout (ms)
Steer-by-wire chassis	Steer-by-wire chassis	0x251~0x252	20ms	None
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	Motor rotational speed higher 8 bits	signed int16	Motor rotational speed	
byte [1]	Motor rotational speed lower 8 bits		Unit：RPM	
byte [2]	Reserved	-	0x00	
byte [3]	Reserved	--	0x00	
byte [4]	Reserved	--	0x00	
byte [5]	Reserved	--	0x00	
byte [6]	Reserved	-	0x00	
byte [7]	Reserved	-	0	

Table 3.11 Motor Low-speed Information Feedback Frame

Command Name	Motor Low-speed Information Feedback Frame			
Sending node	Receiving node	ID	Cycle (ms)	
Steer-by-wire chassis	Steer-by-wire chassis	0x261~0x262	100ms	
Data length	0x08			
Position	Function	Data type	Description	
byte [0]	Reserved	-	0x00	
byte [1]	Reserved		0x00	
byte [2]	Reserved	-	0x00	
byte [3]	Reserved	--	0x00	
byte [4]	Reserved	--	0x00	
byte [5]	Driver status	--	Details are shown in Table 3.12	
byte [6]	Reserved	-	0x00	
byte [7]	Reserved	-	0	

Table 3.12 Description of Failure Information

Description of Failure Information		
byte [5]	bit [0]	Reserved
	bit [1]	Reserved
	bit [2]	Reserved
	bit [3]	Reserved
	bit [4]	Whether the CAN communication is disconnected(0: Normal 1：Disconnected)
	bit [6]	Reserved
	bit [7]	Reserved

3.3.2 CAN cable connection

FOR WIRE DEFINITIONS, PLEASE REFER TO TABLE 2.2.

Red:VCC(battery positive)

Black:GND(battery negative)

Blue:CAN_L

Yellow:CAN_H

Figure 3.2 Schematic Diagram of Aviation Male Plug

Note:The maximum achievable output current is typically around 5 A.

3.3.3 Implementation of CAN command control

Correctly start the chassis of TRACER mobile robot, and turn on FS RC transmitter. Then, switch to the command control mode, i.e. toggling SWB mode of FS RC transmitter to the top. At this point, TRACER 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

Basic parameters of communication

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.

Protocol content

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] 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 details [Description of Failure Information]

```
/**
 * @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];
  }
```

Figure 3.3 Example of serial check algorithm code

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]	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 See Note 2 for details*
byte [1]	Failure clearing command	unsigned int8	Maximum speed 1.5m/s, value range (-100, 100)
byte [2]	Linear speed percentage	signed int8	Maximum speed 0.7853rad/s, value range (-100, 100)
byte [3]	Angular speed percentage	signed int8	0x00 Remote control mode 0x01 CAN command control mode[1] 0x02 Serial port control mode See Note 2 for details*
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

Lighting control frame

Command Name	Lighting Control Frame		
Sending node	Receiving node	Cycle (ms)	Receive-timeout (ms)
Decision-making control unit	Chassis node	20ms	500ms
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
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

The chassis is controlled to move forward at a linear speed of 0.15m/s, from which specific data is shown as follows:

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

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 TRACER 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
- TRACER chassis X 1
- Computer (Windows operating system) X 1

Firmware update software

- https://github.com/agilexrobotics/agilex_firmware

Upgrade procedure

- Before connection, ensure the robot chassis is powered off;
- Connect the serial cable onto the serial port at rear end of TRACER chassis;
- Connect the serial cable to the computer;
- Open the client software;
- Select the port number;
- Power on TRACER chassis, and immediately click to start connection (TRACER 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.

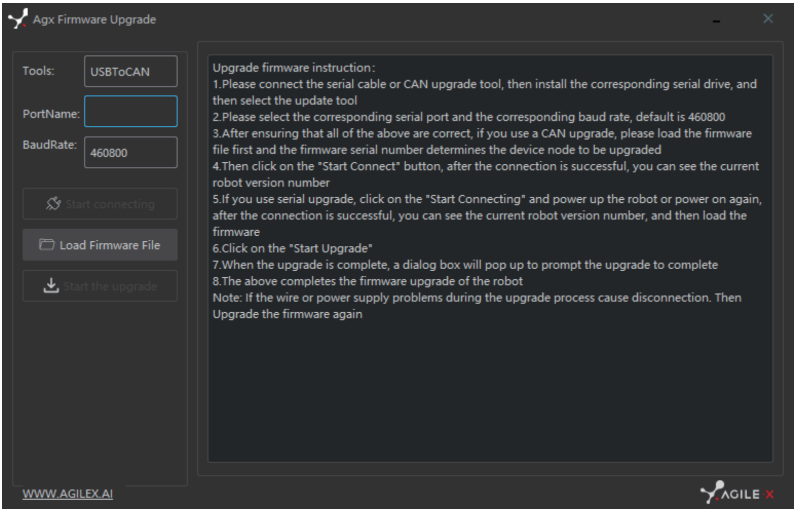


Figure 3.3 Client Interface of Firmware Upgrade

4 Precautions

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

4.1 Battery

- The battery supplied with TRACER is not fully charged in the factory setting, but its specific power capacity can be displayed on the voltmeter at rear end of TRACER 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 TRACER outdoors is -10°C to 45 °C;please do not use it below -10°C and above 45°C outdoors;
- The operating temperature of TRACER 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 TRACER 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), TRACER 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 Electrical/extension cords

- 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 advice

- 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.

4.5 Other notes

- 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.

5 Q&A

Q：TRACER 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:TRACER 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 TRACER 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.

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

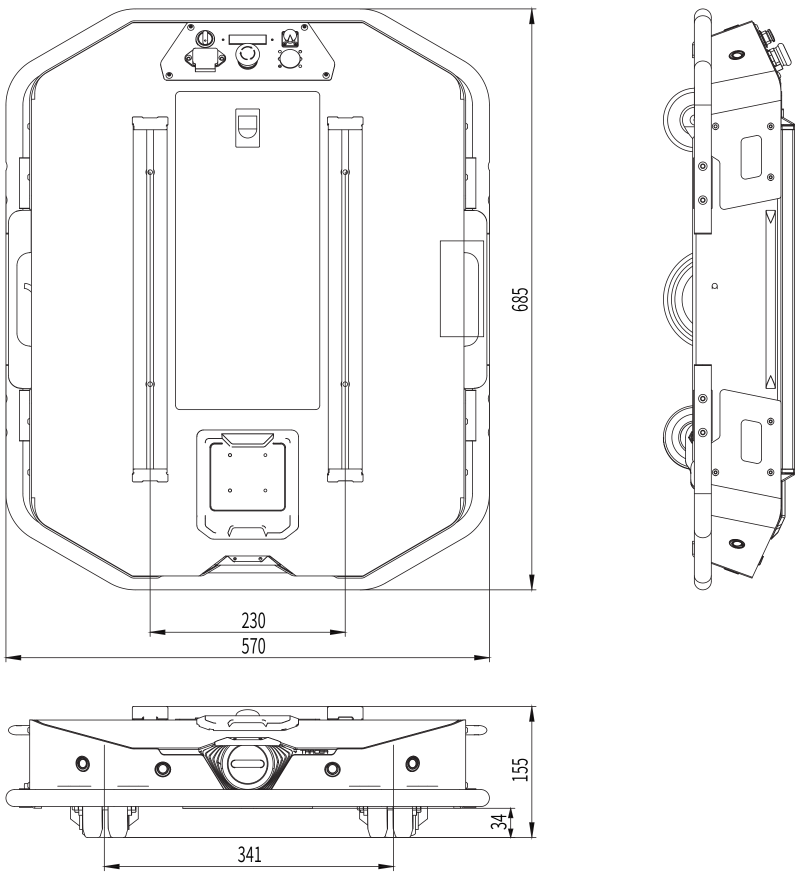
A:If TRACER gives this "beep-beep-beep" sound continuously,it means the battery is in the alarm voltage state. Please charge the battery in time. Once other related sound occur, there may be internal errors. You can check related error codes via CAN bus or communicate with related technical personnel.

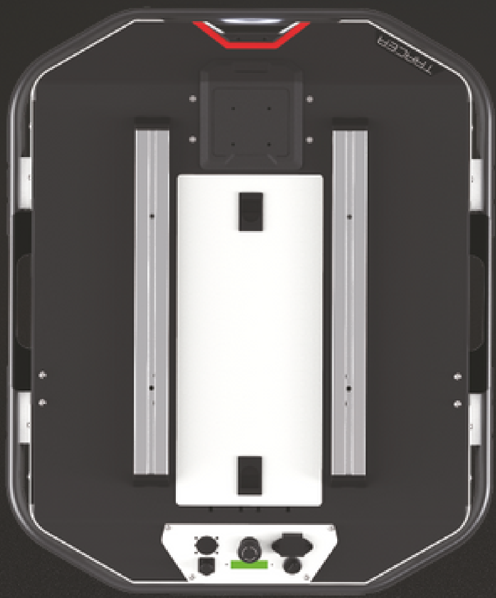
Q:When communication is implemented via CAN bus, the chassis feedback command is issued correctly, but why does not the vehicle respond to the control command?

A:There is a communication protection mechanism inside TRACER, 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





Génération ROBOTS

Official distributor

service@generationrobots.com

+49 30 30 01 14 533

www.generationrobots.com