YUHESEN

FR-mid Ackermann Steering Drive-by-wire Chassis

User manual V2.2.0

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CONTENTS

1. Foreword

(1) Thank you for purchasing our product, this user manual is applicable to FR-mid Ackerman Drive-by-wire Chassis (hereby referred to as "FR-mid").

(2) Before use, please carefully read this user manual and attentions, and correctly use strictly in accordance with this manual.

(3) For the loses caused by serious violation of this user manual, we undertake no responsibilities.

(4) Please well keep this manual for user reference during your operation.

(5) Professionals are required for commissioning, connection and installation of the chassis equipment to avoid irretrievable loses.

(6) DO NOT install, remove or replace equipment lines with electricity. If it is necessary to commission this product with electricity, please select the special commissioning tools with good insulation.

(7) Please use this product under the conditions allowed by laws and regulations, so that the public property or life safety will not be affected.

(8) We will irregularly update this product, the contents of update will be added into the new manual without notification.

(9) This manual may contain the contents which are not correct in technology or which do not comply with the operation. In case of problems which cannot be solved during use of this manual, please contact with the customer service or technical department of us.

(10) As for the contents of this manual, we will try our best to ensure that they are correct and accurate. In case of any improper or incorrect contents, please contact us for confirmation, thank you!

Safety Information

The information herein does not include how to design, install or operate a complete robot, nor the peripheral equipment which may affect the safety of this complete system. The design and use of the complete system comply with the safety requirements formulated in the national standards and specifications. The integrators and end customers of FR-mid are responsible for being sure to comply with practical laws and regulations of relevant countries to ensure that the application of the complete robot will not cause any major danger. These include but are not limited to the following:

■ Effectiveness and responsibilities:

- A risk evaluation shall be conducted to the complete robot system. All the additional safety equipment of other machineries defined by risk evaluation shall be connected. It shall be ensured that, the design and installation of the peripheral equipment of the whole robot system, including software and hardware system, are correct.
- This robot is not equipped with relevant safety functions that a complete autonomously moveable robot shall have, including but not limited to automatic collision avoidance, fall prevention and alarm for creature approaching, etc. For relevant functions, the integrators and end customers are required to conduct safety evaluation in accordance with relevant regulations and feasible laws and regulations to ensure that the developed robot has no any major danger or potential safety hazard during actual application.
- Collecting all the documents of technical files: Including risk evaluation and this manual. Before operation and use of equipment, the existing safety risks may be known.

■ Environments:

- For first use, please carefully read this manual to understand the basic contents and operation specifications.
- For remote operation, please select the areas which are relevantly open. This chassis

is not equipped with any sensor for automatic obstacle avoidance.

- This chassis shall be used under the temperature of -20°C~50°C.
- The chassis is not customized for IP protection grade, the IP protection grade of this chassis is IP44.

■ Inspection:

- Inspecting to ensure that the batteries of the equipment are full. Ensuring that the chassis has no abnormality. Inspecting whether the battery of the remote controller is full.

■ Operation:

- Please make sure that the remote control is on when you use it for commissioning, and make sure that the vehicle can receive the remote control commands.
- Ensuring that operation is conducted in a relatively open place. And remote control shall be conducted with sight distance.
- FR-mid The maximum load is 100KG, during use, it shall be ensured that the effective load does not exceed 100KG.
- In case of alarm of low battery of the equipment, please charge timely. In case of equipment abnormality, please stop use immediately to avoid secondary damage.
- In case of equipment abnormality, please contact relevant technicians, DO NOT process without permission.
- Please use the equipment in the environment which meets the IP protection grade requirements of the equipment.
- DO NOT directly push the chassis.
- During charging, please ensure that the environment temperature is higher than 0°C.

■ Maintenance:

- In case of serious tire wearing, please replace timely.
- If the battery will not be used for a long time, when the battery is fully charged, please charge the battery regularly in each month.
- The battery shall be charged once a month at least.

2. Introduction

FR-mid is a versatile drive-by-wire robotics mobile platform, it adopts Ackerman front steering, and rear drive form. Compared with the chassis of differential drive form on the ordinary pavement, FR-mid has a faster traveling ability and relatively strong load capacity. At the same time, the wearing of tire is lighter, matching with whole bridge suspension, the chassis can pass through the common obstacles, such as speed bump, etc. Therefore, it is more applicable for long-term outdoor traveling; And this chassis is a underlayer control system structure based on VCU vehicles control, it uses CAN bus management, having the features of high precision and modularization, etc. By the modules and navigation systems of LiDAR, GPS and manipulator, etc., this chassis is widely used in autonomous driving, unmanned patrol, logistics, transportation distribution, scientific research and various new applications and explorations requiring for mobile chassis.

2.1. Product list

After delivery, please carefully confirm the product list:

Chassis *1

Remote controller *1

Charger (48V) *1

Product manual *1

2.2. Performance parameters

Table 2 - 1 FR-mid Performance Parameter Table

Parameter type	Performance	Parameter
Structural size and weight	Dimensions(W*D*L)	1320*785*490mm
	Weight	125kg
	Drive	Ackermann front steering and rear wheel drive
	Suspension	Whole bridge suspension
	Material	Q235
	Ground clearance	115mm
	Wheelbase	660mm
	Wheel track	665mm
	Tire type/diameter	120/70-10, 420mm
Basic configuration	Driving motor	1000W, DC brushless motor
	Steering motor	400W, servo motor
	Battery type	48V/20AH lithium battery/BMS management system
	Charging time	≤4h
	Charging method	48V/5A, manual charging by charger
	External power supply	48V/10A-24V/15A-12V/15A
	Braking mode	Motor brake
	Parking method	Electromagnetic powe-off parking
	Turn signal light	√
	Brake lamp/deceleration indicator/fault indicator	√
	Wheel speed sensor	√
Safety measures	Emergency stop button	√
	Front and rear bumper strip	√
	Command check	√
Safety measures	Heartbeat protection	√
	Fault handling for steering system	√
	Fault handling for driving system	√
	Emergency power down parking protection	√
	Battery fault monitoring and protection	√
	Online detection for whole vehicle CAN node	√
	Whole vehicle fault level division and processing	√
	Vehicle fault warning	√
	Prompt of fast vehicle deceleration	√
	Processing of remote controller disconnection	√
	Charging safety monitoring and protection	√
VCU configuration	Dominant frequency	168MHz
	Kinematic analysis	√
	Hardware floating point acceleration	√
	Movement control	√

	Communication interface	CAN interface
	Communication protocol	CAN 2.0B
Performance parameters	Remote control distance	100m
	Vertical load (level road)	100kg
	Speed	8km/h
	Mileage	20km (no load)
	Minimum turning radius	2m
	Wading depth	80mm
	Maximum climbing angle	10° (full load)
	Crossing width	200mm (full load)
	Obstacle surmounting height	60mm (full load)
Performance parameters	Steering accuracy	≤0.5°
	Protection level	IP44
	Operating temperature	-20°C~50°C
	Storage temperature	0°C~40°C

3. Product presentation

The contents in this part are only the basic introductions for FR-mid Ackerman Drive-by-wire Chassis, facilitating the users and developers to know FR-mid chassis basically. As shown in Figure 3-1 and Figure 3-2, there are the front and rear overall figure of the whole Ackerman drive-by-wire chassis.

Figure 3 - 1 Front Overall Figure

Figure 3 - 2 Tail Overall Figure

Note: ①Emergency stop switch; ②Starting switch;Charging port; Top electrical connector; ⑤Profile light and turn signal light; ⑥Front bumper; ⑦Left battery compartment panel; ⑧Standard profile bracket; ⑨Brake light/malfunction indicator;⑩ Rear bumper; ⑪Right battery compartment panel.

Overall, FR-mid uses the thought of modular design, resulting in high safety and reliability. In structure, front Ackerman steering structure, rear whole bridge suspension and non-bearing vehicle body design make high vehicle body strength and high rigidity, so that the safety of the whole vehicle can be improved, bringing relatively strong impact resistance and performance of resistance to bump, so that the trafficability characteristics are excellent, and the vehicle can pass the pavement environments which are relatively complex.

Emergency stop switch is installed at the tail of the vehicle body. In case emergency, the traveling of the vehicle can be stopped by beating, so as to control the whole vehicle. At the same time, the emergency stop switch supports functional inspection. If the emergency stop switch is damaged or in case of disconnection, VCU will control the vehicle driver to power off; Multi-protection, guaranteeing safe driving of vehicles.

The chassis is also equipped with integrated control. VCU analyzes and judges the vehicle signals uniformly, and forms closed-loop control, therefore, the faults can be diagnosed, and corresponding safety protection and processing can be conducted to reliably achieve unmanned vehicle status monitoring remotely. At the top of the vehicle body, there are electrical interfaces and communication interfaces of 48V, 24V and 12V. At the same time, the top is equipped with standard profile fixing support, so that the users can conduct secondary development quickly.

3.1. State indicator

Via voltage display on the remote controller and the starting sound, users can determine the status of the vehicle body. Refer to Figure 3-1 for details.

Table 3 - 1 Description of Vehicle Body Status

Status	Description
Battery voltage	The current battery voltage can be viewed by sliding left on the remote control display screen, via Value in Ext. (Figure 3-3), the percentage of the remaining battery can be known by checking Table 3-2
Fault indicator	The fault status of the of the whole vehicle can be determined in accordance with the flashing frequency of the brake lamp under non-braking status and braking status. Once 1S: level I fault alarm;

Note:

Fault level division and processing method:

Level 1 fault: CAN signal and indicator alarm;

Level 2 fault: CAN signal and indicator alarm, and the power of the whole vehicle drops;

Level 3 fault: CAN signal and indicator alarm, the driver powers off.

R

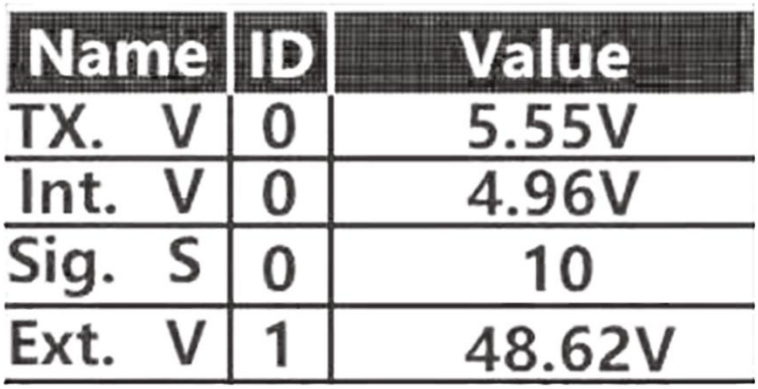


Figure 3-3 Interface of Vehicle Voltage on the Remote Controller

Note: The current interface appears by sliding the remote control screen left; where TX.V is the current battery voltage of the remote control; Int.V is the receiver power supply voltage; Sig.S is the receiver signal strength; Ext.V is the external battery voltage, i.e., the vehicle battery voltage; ID 0 is the transmitter or receiver signal of the remote control; ID 1 is the first sensor connected to the receiver and so on.

Comparison table for vehicle battery voltage and remaining percentage										
Voltage (V)	51.03	49.8	49.75	49.74	49.68	49.63	49.52	49.29	49.17	48.97
SOC (%)	100	95	90	85	80	75	70	65	60	55
Voltage (V)	48.96	48.95	48.91	48.82	48.65	48.45	48.19	47.83	47.53	42.65
SOC (%)	50	45	40	35	30	25	20	15	10	7 (Stop output)

Table 3-2 Comparison Table for Vehicle Battery Voltage and SOC

3.2. Instructions of electrical interface

3.2.1. Instructions of top electrical interface

FR-mid is is equipped with a WS32-11 electrical interface on the top.. This electrical interface is set with three sets of different power supplies and a set of CAN communication interface, and the wires have been led out, so that, the users can provide

power supplies and communication to different extension equipment. Refer to the schematic diagram of the top electrical position in Figure 3-4 for details

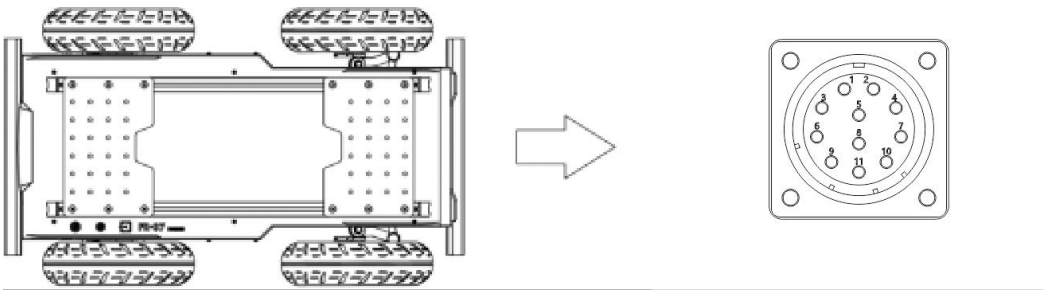


Figure 3 -4 Schematic Diagram of Top Electrical Position

The specific pin definitions of top electrical interfaces are shown in Table 3-3 below

Pin	Type	Definition	Remark
1	Reserve	RS232-GND	Serial port
2	Power supply	48V-	Negative pole of 48V power supply
3		48V+	Positive pole of 48V/10A power supply
4		24V-	Negative pole of 24V power supply
5	Reserve	RS232-TX	Serial port
6	Power supply	24V+	Positive pole of 24V/15A power supply
7		12V-	Negative pole of 12V power supply
8	Reserve	RS232-RX	Serial port
9	Power supply	12V+	Positive pole of 12V/15A power supply
10	CAN	CAN_L	CAN bus - high
11		CAN_H	CAN - low

Table 3 -3 Pin Definitions of Top Electrical Interface

It shall be noted that, the power supply for expansion is controlled internally. When the battery voltage is under-voltage, BMS will protect, and the battery stops discharging. During use, users are required to charge.

3.2.2. Instructions of electrical panel at the tail

The electrical panel at the tail is shown as Figure 3-5. Wherein, B1 is the interface for charging; B2 is starting switch; B3 is emergency stop switch.

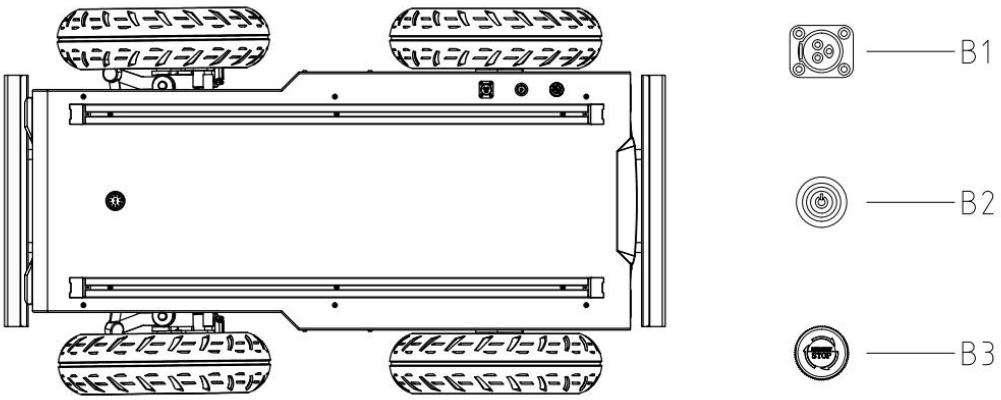


Figure 3 -5 Tail View and Electrical Panel

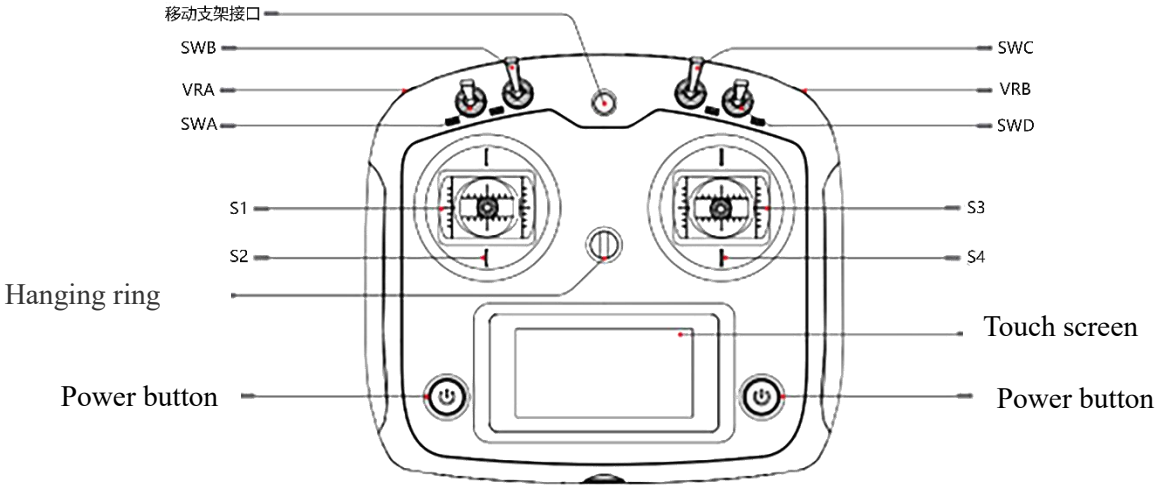
3.3. FS-i6S Remote control instructions

The remote controllers have been paired and set up before delivery, there is no need to modify the setups. Modification of remote controller setups without permission may lead to the problems of chaos in control and being out of control, etc. DO NOT modify the remote controller setups at will; In case of parameter faults, please contact our customer service or technical support. In case of modification, professional technicians are required for setting of remote controller.

3.3.1. Instructions of FS-i6S remote control

Each FR-mid is equipped with a FS-i6S remote controller. With this remote controller, users can easily control FR-mid. For FS-i6S remote controller of this product, we use the design of brake by the left hand, forward-backward acceleration, left-right rotation by the right hand. At the same time, the knob is used to adjust the maximum speed of the accelerator by the right hand. Refer to Figure 3-6 for the definitions and functions

Figure 3 -7Schematic diagram of FS-i6S remote control operating panel



The parameters of the remote controller have been configured before delivery. DO NOT modify the system configuration of the remote controller without permission, or, the robot may be out of control and in controlling chaos, etc. In case of any question, please contact the customer services or after-sales personnel for answering;

(1) SWA is the driving lever to switch the control mode. There are two control modes. For example, when the observe side of the remote controller is upward, and the driving lever of the SA driving lever is upward, the control mode is remote controller control mode; when the SA driving lever is downward, the control mode is command control mode;

(2) SWB is the driving lever to switch the gear. There are three gears. When the driving lever is in the center, and the vehicle is under N gear, forward-backward movement control signals will not be received; When the driving lever is pulled upwards to switch to Gear D, can the chassis receive the front movement signal transmitted by S4 rocker and move forwards; When the driving lever is pulled downwards to switch to Gear R, can the chassis receive the reverse movement signal transmitted by S4 rocker and move backwards;

(3) VRA is the horn control knob, which automatically returns to its position and enables the horn when the knob is swung down;

(4) VRB is the drive plate for parking request. When the drive plate is turned up, a parking request is sent to activate the parking brake; when the drive plate is turned down, a release request is sent to release the parking brake.

(5) The S4 rocker is the throttle control, which controls the forward and reverse speed of the FR-07; the S3 rocker controls the steering of the front wheels

(6) SWC for S4 rocker high school low-speed control mode, to forward gear, for

example: SWC is at the top of the S4 rocker control the vehicle's highest speed for the low-speed mode driving; SWC is in the middle of the position when the S4 rocker control the vehicle for the medium-speed mode driving; SWC is in the bottom of the position of the S4 rocker control the vehicle for the high-speed mode driving.

(7) The power switch is the power control switch of the remote control, when the remote control is in the off state and long press the power switch on both sides of the monitor to control the remote control to turn on; the remote control is in the on state and long press the power switch on both sides of the monitor to turn off; if the remote control receiver is in the power-on state and long press the power switch on both sides of the monitor to turn off the remote control, you need to uninstall the batteries to turn off the remote control.

3.3.2. Instructions of remote controller buzzer alarm

Switch position alarm	If the SWA/SWB/SWC/SWD toggle switches are not in the default position when powering on, an alarm interface will appear, prompting you to toggle all switches to up, and enter the main interface normally when all switches are in the default position.
Position switch alarm	When the voltage falls below the alarm voltage, the system will sound an alarm and the remote control screen will start flashing. The TX icon flashes if the remote control voltage is too low, and the RX icon flashes if the chassis voltage is too low.
Communication Abnormality Alarm	When the control distance between the remote control and the chassis is too far or the environment is covered with interference, it will cause the remote control signal strength to decrease, and if the signal strength is lower than 5, it will carry out the communication abnormality alarm to remind the user that the remote control signal strength is weak.
Remote control not used alarm	When the remote control is left unused for a long period of time, the remote control buzzer carries out an intermittent alarm.
Shutdown Alarm	The remote control will detect whether the chassis is turned off when shutting down, if the chassis is not turned off then a warning screen will pop up, and you need to turn off the chassis power to turn off the remote control. (If you need to force the remote control to turn off when the chassis is not turned off, you can use the method of removing the batteries.)

Table 3 -4 Instructions of Remote Controller Alarm Condition

3.3.3. Instructions of control commands and movement

In accordance with ISO 8855, we establish coordinate system as shown in Figure 3-7 for ground movement of the vehicle.

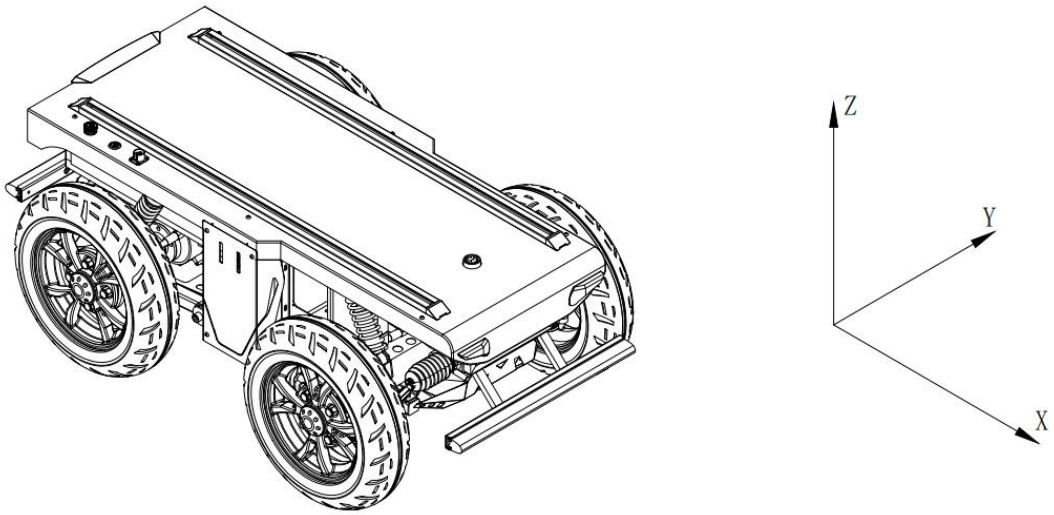


Figure 3 -7 The Vehicle Coordinate System

As shown in Figure 3-7, the vehicle body of FR-mid is parallel to axis-X of the established coordinate system.

Under remote controller control mode, pull down the VRB knob to release the parking gear, SWB toggle switches to D, remote control S4 rocker pushes forward to move in X positive direction, SWB toggle switches to R, S4 rocker pushes backward to move in X negative direction; S4 rocker pushes forward to the maximum value, the movement in the direction of X carries out the high school and low school control according to high school and low school set by the SWC; S4 rocker pushes backward to When S4 rocker is pushed backward to the maximum value, the movement in X negative direction is controlled according to the high and low speed set by SWC; S3 rocker of the remote control controls the steering movement of the front wheels of the vehicle body left and right; S3 rocker pushes to the left, the vehicle turns to the left and pushes it to the maximum, at this time the left steering angle is the maximum; S3 rocker pushes to the right, the vehicle turns to the right and pushes it to the maximum, at this time the right steering angle is the maximum.

Under the control command mode, at the target gear, the value of 04 indicates that the target gear moves along the positive direction of axis-X, and the value of 02 indicates that it moves along the negative direction of axis-X.

4. Getting started

This part mainly introduces the basic operation and use of FR-mid platform, and how to conduct secondary development to the vehicle body through CAN bus protocol.

4.1. Use and operation

The basic operations flow of remote operation are as follows:

Inspection

(1) Check the status of the vehicle body. Check that whether the vehicle body has obvious abnormality; If any, please contact after-sales support;

(2) Check the status of the emergency stop button, and confirm that the emergency stop button at the tail is under the released state;

(3) Check that all gears of the remote controller are in neutral position;

Start-up

(1) Press and hold the power switch on both sides of the monitor to turn on the remote control.

(2) Press B2 (starting switch)

(3) Check the vehicle battery voltage of the remote controller to see that whether the battery voltage is normal. If the voltage is lower than 47.5V, please charge first.

(4) Release the brake of the vehicle, switch to remote driving mode to observe that whether the brake lamp flashes and whether the vehicle is faulty. If there is any fault, connect to the CAN card to read the vehicle fault status and signal, and then, contact the after-sales personnel for solving.

Close operation

Press B2 (starting switch) again and release the switch to turn off the power supply;

Emergency stop

Beat the emergency stop switch on the electrical panel at the tail of FR-mid vehicle body;

4.2. Charge

The chassis of the FR-mid mobile robot is equipped with a 48V/5A charger in default, meeting the demands of charging of the users.

The specific operation processes of charging are as follows:

1) Before charging, please make sure that FR-mid is shut down and powered off, and confirm that B2 (starting switch) on the electrical board at the tail is closed;

2) First, insert the output plug of the charger into the B1 charging interface on the electrical board at the tail; Then, plug the AC plug of the charger into the 220V AC socket.

3) After charging, operate in accordance with the reserve orders, unplug the AC plug first, and then, unplug the output plug.

4) The working status indicator of the charger is shown in Table 4-1.

Table 4 -1 Instructions of LED Indicator for Charger Status

LED indicator light status	Charger status
LED1 is in bright red	The input line plug of the charger has been powered on
LED2 is in bright red	Indicating that the charger is charging
LED2 is in bright green	Indicating that the battery has been fully charged

5) If the temperature of the charging environment is too high, the charger may enable temperature protection. Please move the charger to a cool or ventilated place for use, and resume normal charging when the internal temperature of the charger is lowered to 60°C. Refer to Table 4-2 for the instructions of charger protection status:

Table 4 -2 Instruction of Charger Protection Status

Protection function	**Function description**
Over-heating protection	When the internal temperature of the charger reaches the over-temperature protection point, the charger stops charging automatically.
Output short-circuit protection	When the charger output is short-circuited unexpectedly, the charger turns off output automatically.
Output reverse connection protection	When the battery is connected in reverse, the charger will cut off the connection between the internal circuit and the battery.
Output over-voltage protection	When the output of the charger is over-voltage, the charger automatically turns off the output.

Note:

When the vehicle is being charged, VCU will protect the charging state of the whole vehicle. If the vehicle is being charged when it is powered on, to ensure the charging safety, the vehicle will enable hydraulic braking and electromagnetic band-type parking brake. At the same time, the driver will be controlled to power off under high voltage. After

charging, the driver will recover automatically. At the same time, the CAN signal will send the corresponding charging flag bit, and when necessary, if release is required, corresponding commands can be sent for release.

4.3. Development

FR-mid product provides CAN interface to users for development, and users can conduct command control to the vehicle body with CAN interface.

4.3.1. CAN interface protocol

The communication of FR-mid product is conducted by CAN2.0B extended frame, and the message format is Intel format with a baud rate of 500K. Through the external CAN bus interface, the vehicle speed, steering angle, brake pedal openness and parking request of the chassis can be controlled. The FR-mid will feed back the current movement state information and the system state information of the FR-mid chassis in real time.

The specific protocol contents are shown as below:

The motion command control frame includes gear control, vehicle speed control, steering angle control, brake pedal opening, parking request and inspection, etc. The specific protocol contents are shown in Table 4-3. Refer to 4.3.2 for wiring instructions, and 4.3.3 for CAN communication transmission requirements and test examples.

Note: The CAN interface is a non-isolated interface. During use, please prevent the CAN line from being wrongly connected or prevent the CAN bus from being connected with the power line of the given type. In case of connection, VCU may be burned out.

CAN protocol is shown as below:

Baud rate: 500K

Table 4-3 Command Control Frame and System Feedback Frame

Chassis control command									
Message name			ID				Cycle (ms)		(Byte) Message length
ctrl_cmd			0x18C4D2D0				10		8
Signal description	Arrangement format	Starting byte	Start bit	Signal duration	Data type	Precision	Offset	Unit	Signal value description

Target gear	Intel	0	0	4	Unsigned	1	0		00: disable 01: Gear P 02: Gear R 03: Gear N 04: Gear D
Target vehicle speed	Intel	0	4	16	Unsigned	0	0	m/s	0.001m/s/bit;
Targeted vehicle steering angle	Intel	2	20	16	signed	0.01	0	°	0.01°/bit;
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	4	Unsigned	1	0		For each sent frame, the value will increase by 1, after the maximum value is reached, the value will be reset to 0 to check packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	8	Unsigned	1	0		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Chassis I/O control command									
Message name			**ID**				**Cycle (ms)**		**(Byte) Message length**
io_cmd			0x18C4D7D0				50		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal duration**	**Data type**	**Precision**	**Offset**	**Unit**	**Signal value description**
I/O control enabling	Intel	0	0	1	Unsigned	1	0		0 = off 1 = on
Steering lamp switch	Intel	1	10	2	Unsigned	1	0		0 = off 1 = left turn signal lamp on 2 = right turn signal lamp on

Position lamp switch	Intel	1	13	1	Unsigned	1	0		0 = off 1 = on
Loudspeaker switch	Intel	2	16	1	Unsigned	1	0		0 = off 1 = on
Enforced power-on flag bit for charging	Intel	5	40	1	Unsigned	1	0		When the flag bit is forced to be enabled under the charging state, the vehicle can be controlled to be powered on under 48V, and the vehicle can resume control. When the flag bit is enabled, the vehicle cannot reverse under the charging state.
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	4	Unsigned	1	0		For each sent frame, the value will increase by 1, after the maximum value is reached, the value will be reset to 0 to check packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	8	Unsigned	1	0		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6
Chassis control feedback command									

Message name			ID				Cycle (ms)		(Byte) Message length
ctrl_fb			0x18C4D2EF				10		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal duration**	**Data type**	**Precision**	**Offset**	**Unit**	**Signal value description**
Target gear	Intel	0	0	4	Unsigned	1	0		00: disable 01: Gear P 02: Gear R 03: Gear N 04: Gear D
Current vehicle speed feedback	Intel	0	4	16	Unsigned	0	0	m/s	0.001m/s/bit;
Current vehicle steering angle feedback	Intel	2	20	16	signed	0.01	0	°	0.01°/bit;
Current vehicle operation mode feedback	Intel	5	44	2	Unsigned	1	0		0x0: auto 0x1: remote 0x2: stop
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	4	Unsigned	1	0		For each sent frame, the value will increase by 1, after the maximum value is reached, the value will be reset to 0 to check packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	8	Unsigned	1	0		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Left rear wheel information feedback

Message name	ID	Cycle (ms)	(Byte) Message length
lr_wheel_fb	0x18C4D7EF	10	8

Signal description	Arrangement format	Starting byte	Start bit	Signal Length	Data type	Precision	Offset	Unit	Signal value description
Current left rear wheel speed feedback	Intel	0	0	16	signed	0	0	m/s	0.001m/s/bit;
Current left rear wheel pulse feedback	Intel	2	16	32	signed	1	0	1	400 pluses for single wheel turn
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	4	Unsigned	1	0		For each sent frame, the value will increase by 1, after the maximum value is reached, the value will be reset to 0 to check packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	8	Unsigned	1	0		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Right rear wheel information feedback

Message name	ID	Cycle (ms)	(Byte) Message length
rr_wheel_fb	**0x18C4D8EF**	10	8

Signal description	Arrangement format	Starting byte	Start bit	Signal duration	Data type	Precision	Offset	Unit	Signal value description
Current right rear wheel speed feedback	Intel	0	0	16	signed	0	0	m/s	0.001m/s/bit;
Current right rear wheel pulse feedback	Intel	2	16	32	signed	1	0	1	400 pluses for single wheel turn
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	4	Unsigned	1	0		For each sent frame, the value will increase by 1, after the maximum value is reached, the value will be reset to 0 to check packet loss and disconnection

Check BCC XOR checkout for message	Intel	7	56	8	Unsigned	1	0		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Chassis I/O status feedback									
Message name			**ID**				**Cycle (ms)**		**(Byte) Message length**
io_fb			**0x18C4DAEF**				50		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal duration**	**Data type**	**Precision**	**Offset**	**Unit**	**Signal value description**
I/O control enabling status feedback	Intel	0	0	1	Unsigned	1	0		0 = off 1 = on
Steering lamp switch status feedback	Intel	1	10	2	Unsigned	1	0		0 = off 1 = left turn signal lamp on 2 = right turn signal lamp on
Brake lamp switch status feedback	Intel	1	12	1	Unsigned	1	0		0 = off 1 = on
Clearance lamp switch status feedback	Intel	1	13	1	Unsigned	1	0		0 = off 1 = on
Loudspeaker switch status feedback	Intel	2	16	1	Unsigned	1	0		0 = off 1 = on
Center front bumper strip switch status feedback	Intel	3	25	1	Unsigned	1	0		0 = off 1 = on
Center rear bumper strip switch status feedback	Intel	3	28	1	Unsigned	1	0		0 = off 1 = on
Enforced power-on flag bit for charging	Intel	5	40	1	Unsigned	1	0		When the flag bit is forced to be enabled under the charging state, the vehicle can be controlled to be powered on under 48V, and the vehicle can resume control. When the flag

									bit is enabled, the vehicle cannot reverse under the charging state.
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	4	Unsigned	1	0		For each sent frame, the value will increase by 1, after the maximum value is reached, the value will be reset to 0 to check packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	8	Unsigned	1	0		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Chassis speedometer feedback

Message name			ID				Cycle (ms)		(Byte) Message length
odo_fb			0x18C4DEEF				10		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal Length**	**Data type**	**Precision**	**Offset**	**Unit**	**Signal value description**
Accumulated mileage	Intel	0	0	32	signed	0	0	m	0.001m/bit
Accumulated angle(reserve)	Intel	4	32	32	signed	0	0	rad	0.001m/bit

Battery BMS information feedback

Message name			ID				Cycle (ms)		(Byte) Message length
bms_Infor			0x18C4E1EF				100		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal duration**	**Data type**	**Precision**	**Offset**	**Unit**	**Signal value description**
Current battery voltage	Intel	0	0	16	Unsigned	0.01	0	V	0.01V/bit;
Current battery current	Intel	2	16	16	signed	0.01	0	A	0.01A/bit;
Current remaining battery	Intel	4	32	16	Unsigned	0.01	0	Ah	0.01Ah/bit;

Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	4	Unsigned	1	0		For each sent frame, the value will increase by 1, after the maximum value is reached, the value will be reset to 0 to check packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	8	Unsigned	1	0		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Battery BMS mark status feedback									
Message name			**ID**				**Cycle (ms)**		**(Byte) Message length**
bms_flag_Infor			0x18C4E2EF				100		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal duration**	**Data type**	**Precision**	**Offset**	**Unit**	**Signal value description**
Percentage of current remaining battery	Intel	0	0	8	Unsigned	1	0	%	1%/bit;
Monomer over-voltage protection	Intel	1	8	1	Unsigned	1	0		0 = off 1 = on
Monomer under-voltage protection	Intel	1	9	1	Unsigned	1	0		0 = off 1 = on
Over-voltage protection of the whole group	Intel	1	10	1	Unsigned	1	0		0 = off 1 = on
Under-voltage protection of the whole group	Intel	1	11	1	Unsigned	1	0		0 = off 1 = on
Charging over-temperature protection	Intel	1	12	1	Unsigned	1	0		0 = off 1 = on
Charging low-temperature protection	Intel	1	13	1	Unsigned	1	0		0 = off 1 = on
Discharging over-temperature protection	Intel	1	14	1	Unsigned	1	0		0 = off 1 = on
Discharging low-temperature protection	Intel	1	15	1	Unsigned	1	0		0 = off 1 = on

Charging over-current protection	Intel	2	16	1	Unsigned	1	0		0 = off 1 = on
Discharge over-current protection	Intel	2	17	1	Unsigned	1	0		0 = off 1 = on
Protection against short circuit	Intel	2	18	1	Unsigned	1	0		0 = off 1 = on
Front-end detection IC error	Intel	2	19	1	Unsigned	1	0		0 = off 1 = on
Software locks up MOS	Intel	2	20	1	Unsigned	1	0		0 = off 1 = on
Charging flag bit	Intel	2	21	1	Unsigned	1	0		0 = discharge 1 = charge
Current highest temperature of the battery	Intel	3	28	12	signed	0.1	0	°C	0.1°C/bit;
Current lowest temperature of the battery	Intel	4	40	12	signed	0.1	0	°C	0.1°C/bit;
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	4	Unsigned	1	0		For each sent frame, the value will increase by 1, after the maximum value is reached, the value will be reset to 0 to check packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	8	Unsigned	1	0		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Vehicle fault status feedback									
Message name			**ID**				**Cycle (ms)**		**(Byte) Message length**
Veh_fb_Diag			0x18C4EAEF				10		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal duration**	**Data Type**	**Precision**	**Offset**	**Unit**	**Signal value description**

Whole vehicle fault level	Intel	0	0	4	Unsigned	1	0		0: No fault 1: Level 1 fault 2: Level 2 fault 3: Level 3 fault Others are invalid
Auto control CAN communication error	Intel	0	4	1	Unsigned	1	0		0 = normal 1 = fault
Auto IO control CAN communication error	Intel	0	5	1	Unsigned	1	0		0 = normal 1 = fault
EPS disconnection fault	Intel	1	8	1	Unsigned	1	0		0 = normal 1 = fault
EPS fault	Intel	1	9	1	Unsigned	1	0		0 = normal 1 = fault
EPS MOSFET over-temperature	Intel	1	10	1	Unsigned	1	0		0 = normal 1 = fault
EPS alarm fault	Intel	1	11	1	Unsigned	1	0		0 = normal 1 = fault
EPS work fault	Intel	1	12	1	Unsigned	1	0		0 = normal 1 = fault
EPS over-current fault	Intel	1	13	1	Unsigned	1	0		0 = normal 1 = fault
Driving motor controller disconnection fault	Intel	4	32	1	Unsigned	1	0		0 = normal 1 = fault
Driving motor controller over-heating fault	Intel	4	33	1	Unsigned	1	0		0 = normal 1 = fault
Driving motor controller over-voltage fault	Intel	4	34	1	Unsigned	1	0		0 = normal 1 = fault
Driving motor controller under-voltage fault	Intel	4	35	1	Unsigned	1	0		0 = normal 1 = fault
Driving motor controller short circuit fault	Intel	4	36	1	Unsigned	1	0		0 = normal 1 = fault
Driving motor controller emergency stop fault	Intel	4	37	1	Unsigned	1	0		0 = normal 1 = fault
Driving motor Hall sensor fault	Intel	4	38	1	Unsigned	1	0		0 = normal 1 = fault
Driving motor controller MOSFEF fault	Intel	4	39	1	Unsigned	1	0		0 = normal 1 = fault

Drive fault of being out of control	Intel	4	40	1	Unsigned	1	0		0 = normal 1 = fault
BMS CAN communication disconnection fault	Intel	5	44	1	Unsigned	1	0		0 = normal 1 = fault
Emergency stop fault	Intel	5	45	1	Unsigned	1	0		0 = on I = switch on
Remote controller close alarm	Intel	5	46	1	Unsigned	1	0		0 = normal 1 = fault
Remote controller receiver disconnection fault	Intel	5	47	1	Unsigned	1	0		0 = normal 1 = fault
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	4	Unsigned	1	0		For each sent frame, the value will increase by 1, after the maximum value is reached, the value will be reset to 0 to check packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	8	Unsigned	1	0		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

4.3.2. CAN wire connection

CAN wires of FR-mid have been welded out and marked, and users can directly connect them in accordance with the marks, as shown in Figure 4-1 below

Figure 4-1 Schematic Diagram of CAN Wire Position

Red is CAN_H; Black is CAN_L

4.3.3. Instructions of use of common VCU protocol

1. Attentions during test:

1.1 During transmission, it shall be noted that, AliveCounter requires for continuous change and cycled transmission.

1.2 During transmission of AliveCounter, it shall be specially noted that, AliveCounter occupies four bits from No. 52 to No. 55.

1.3 BYTE[7] parity bit is the first 7 Byte XOR gates: Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

1.4 The following routine is a simple control command when USB CAN is used. Please control the vehicle in accordance with the communication protocol.

1.5 During the test, the remote controller is switched to automatic driving mode or turned off.

1.6 As the vehicle movement and other conditions may be tested during test by connecting to computer via CAN analyzer, please set up the vehicle during test, and after the vehicle is stably tested, put the vehicle down.

1.7 During the landing test, as the remote controller has the highest priority, it is best to turn on the remote controller for testing, facilitating to switch to the remote control mode at any time during the test.

2. Instructions of vehicle control command ctrl_cmd

For vehicle body control command, it is required to transmit corresponding commands, heartbeat signals and parity bits.

(1) Targeted gear request ctrl_cmd_gear

The command of ctrl_cmd_gear is targeted gear signal, with a physical value range of 01-04. The default gear position is 01 Gear P; When the target gear is given as 03, it is the Gear N; When the target gear is given as 02, it is the Gear R; When the target gear is given as 04, it is the Gear D; When the target gear is given as 01, it is the Gear P.

For example: When target gear requests for drive gear, -04 0x04

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D2D0	0x04	0x00	0x00	0x00	0x00	0x00	0x10	0x14
0x18C4D2D0	0x04	0x00	0x00	0x00	0x00	0x00	0x20	0x24
0x18C4D2D0	0x04	0x00	0x00	0x00	0x00	0x00	0x30	0x34

Note: The above three frames of signals are circulated at an interval of 10ms, and the gear can be controlled to be switched to the Gear D.

Feedback:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D2EF	0x04	0x00	0x00	0x00	0x00	0x00	0x00	0x04

Note: Checksum and cyclic change of Alivecounter

(2) Target vehicle speed request ctrl_cmd_velocity

The command of ctrl_cmd_velocity is the target value of vehicle speed, and the physical value range of CAN communication is 0-65.535m/s (13 speed ratio, and the maximum vehicle speed of the vehicle with a wheel diameter of 420mm is 5m/s). The target vehicle speed is determined by vehicle speed precision (0.001m/s/bit). Target vehicle speed driving vehicle = 0.001* bus signal Forward and backward movement of vehicle shall be conducted in accordance with the gears.

Vehicle speed feedback is divided into three methods, they are:

1) Current vehicle speed feedback: vehicle speed feedback is always positive.
2) Speed feedback of left and right wheels: the speed corresponding to the current left and right wheels. The speed is positive when moving forward and negative when moving backward.
3) Pulse feedback of left and right wheels: pulse accumulation when moving forward, and pulse inverse accumulation when moving backward.

For example: When the given forward movement vehicle speed is 5m/s, the bus signal is 5000 0x1388

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D2D0	0x84	0x38	0x01	0x00	0x00	0x00	0x00	0xBD
0x18C4D2D0	0x84	0x38	0x01	0x00	0x00	0x00	0x10	0xAD
0x18C4D2D0	0x84	0x38	0x01	0x00	0x00	0x00	0x20	0x9D

Note: The above three frames of signals are circulated at 10ms intervals to control the vehicle to move forward at a speed of 5m/s.

Feedback:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D2EF	0x84	0x38	0x01	0x00	0x00	0x00	0x00	0xBD

Note: The checksum and Alivecounter cycle change, because the automatic adjustment of running speed may not feedback an absolute 5m/s, there is a certain deviation.

Left rear wheel speed and left rear wheel pulse feedback ID: 0x18C4D7EF

Right front wheel speed and right front wheel pulse feedback ID: 0x18C4D8EF

(3) Target steering angle ctrl_cmd_steering

The command of ctrl_cmd_steering is the target steering angle request. The physical range of CAN communication is (-40.96)° to (40.95)°. The internal soft limit angle of the vehicle is (- 25) degrees to (+25) degrees. The left steering is positive and the right steering is negative. Target steering angle is determined by precision 0.01 °/bit. Target steering angle = CANbus signal *0.01

For example: Given a target steering angle of - 25°, the bus signal = -2500 0XF63C

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D2D0	0x00	0x00	0XC0	0x63	0x0F	0x00	0x00	0xAC
0x18C4D2D0	0x00	0x00	0XC0	0x63	0x0F	0x00	0x10	0xBC
0x18C4D2D0	0x00	0x00	0XC0	0x63	0x0F	0x00	0x20	0x8C

Note: The above three frames of signals are sent in cycles every 10ms, and the steering angle can be requested to be -25°

Feedback:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D2EF	0x00	0x00	0XC0	0x63	0x0F	0x00	0x00	0xAC

Note: Checksum and cyclic change of Alivecounter.

3. Instructions of auxiliary control commands

Taking the enabling of the position lamp as an example, the control of other accessories is the same as the enabling control of the position lamp. IO port enabling control needs to send the enabling flag bit, heartbeat signal and parity bit at the same time. (If IO control is not enabled, all lighting controls will be conducted by VCU)

For example: io_cmd_clearance_lamp position lamp enabling control 0x01

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D7D0	0x01	0x20	0X00	0x00	0x00	0x00	0x00	0x21
0x18C4D7D0	0x01	0x20	0X00	0x00	0x00	0x00	0x10	0x31
0x18C4D7D0	0x01	0x20	0X00	0x00	0x00	0x00	0x20	0x01

Note: The above three frames of signals are circulated at an interval of 50ms, high beam lighting can be requested remotely.

Feedback:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4DAEF	0x01	0x20	0X00	0x00	0x00	0x00	0x00	0x21

Note: Checkout and cyclic change of Alivecounter.

Auxiliary enabling control supports position light control and left and right turn signal lamp control; Horn control can be controlled when the IO port enable signal is set to 1 or 0; The brake lamp is not controlled by the CAN signal, but is completely controlled by the VCU to feedback whether the enable signal is enabled.

5. Attention

This section contains some matters to be noted during use, storage and development of FR-mid.

5.1. Attentions for battery

▲ The battery of FR-mid products may not be fully charged when they are delivered. The specific situations CAN be read through FR-mid remote controller vehicle chassis voltage display or CAN bus communication interface. As for charging time, when the green indicator is on, indicating that the product has been fully charged;

▲ DO NOT charge the battery after it is exhausted, and please charge in time when the battery voltage is too low;

▲ The working temperature of the battery under discharging is -20°C~60°C, the battery can work normally within the specified temperature range, and the capacity loss is within the error range:

▲ Excessive discharge of the battery is prohibited during use to avoid damage to the battery;

▲ Avoid excessive impact on the battery; the impact beyond the specification may damage the battery, which may lead to battery leakage, heat, smoke, fire or explosion;

▲ In case of obvious battery abnormalities, please stop using the battery immediately!

5.2. Attentions for charging

▲ Charging can only be conducted by the charger matching with the battery. DO NOT use the non-original battery, power supply or charger;

▲ Charging can only be conducted under 10°C~45°C. Charging out of this temperature range will lead to battery leakage, heating or serious damage, which may lead to deterioration of battery performance and life;

▲ During charging, if the charger or battery is abnormal or damaged, please remove the charger input line and output line immediately;

▲ If charging cannot be completed within the specified time, please stop charging immediately. Or, the battery may heat, have smoke or get on fire (or explode);

▲ It is not allowed charge the battery of the vehicle body in thunderstorm weather;

▲ It not allowed to charge the battery of the vehicle body in the place which is wet

or with rain;

▲ It is not allowed to charge the battery of the vehicle body with high temperature, such as heat source or direct sunlight, etc.;

▲ Charging shall be conducted in the place which is ventilated and without dust;

▲ During charging, it is not allowed to block the air inlet and outlet of the charger, there shall be a space of 10cm at least;

5.3. Attentions for usage environment

▲ The working temperature of FR-mid is -20℃~50℃, DO NOT use in the environment with the temperature of lower than -20℃ or higher than 50℃;

▲ The best storage temperature for FR-mid is 0℃~25℃;

▲ DO NOT store or user in the environment with corrosive, inflammable and explosive gas;

▲ During use and storage, please keep away from heat resources and fire resources;

▲ Excepting for special edition (with customized IP protection level), the water-proof function of FR-mid is limited. DO NOT use FR-mid in the environment with deep ponding;

5.4. Attentions for remote operation

▲ Please make sure that the remote control is on when you use it for commissioning, and make sure that the vehicle can receive the remote control commands.

▲ Before starting the machine, make sure that all the dip switches are placed on the top; the emergency stop switch is released; and the throttle remote lever is returned to the zero position, i.e.: the chassis speed is in the 0 state;

▲ Please prioritize the use of low-speed gears to control the remote control, and then carry out medium or high-speed control after familiarizing yourself with the vehicle.

5.5. Attentions for external electrical extension

▲ The top power supply current shall be the battery voltage and current strictly selected. Over-current is not allowed;

▲ When the system detects that the battery voltage is lower than the safe voltage, protection procedure will be started automatically. If the external extension equipment

involves storage of important data, and there is not automatic storage function for powering off, please charge timely.

5.6. Other attentions

▲ During handling or setting, DO NOT fall or invert;

▲ In case of no professionals, DO NOT disassemble without permission;

▲ If the remote controller end will not be used for a long time, the battery shall be removed;

▲ The tires shall be replaced timely in accordance with the wearing conditions of the patterns on the wheel tread.

6. Common Q&A

Q: FR-mid starts normally, however, the vehicle body does not move under the control of the remote controller?

A: Firstly, confirm that whether the emergency stop switch at the tail has been released; And then, check that whether the SWA toggle is remote controller control mode, and check that whether the rocker of remote controller S1 brakes. After that, check that Whether to control the VRB knob for unlocking; Finally, check that whether the SWB knob is the minimum value.

Q: FR-mid What should I do that the battery of the remote controller is low, and the vehicle body stops running?

A: Replace the batteries in the remote control immediately, after that, normal communication will recover soon.

Q: Both of charger led1 and led2 are off

A: Please firstly check that whether the connection of the charger input interface is correct and firm; And then, check that whether there is AC input.

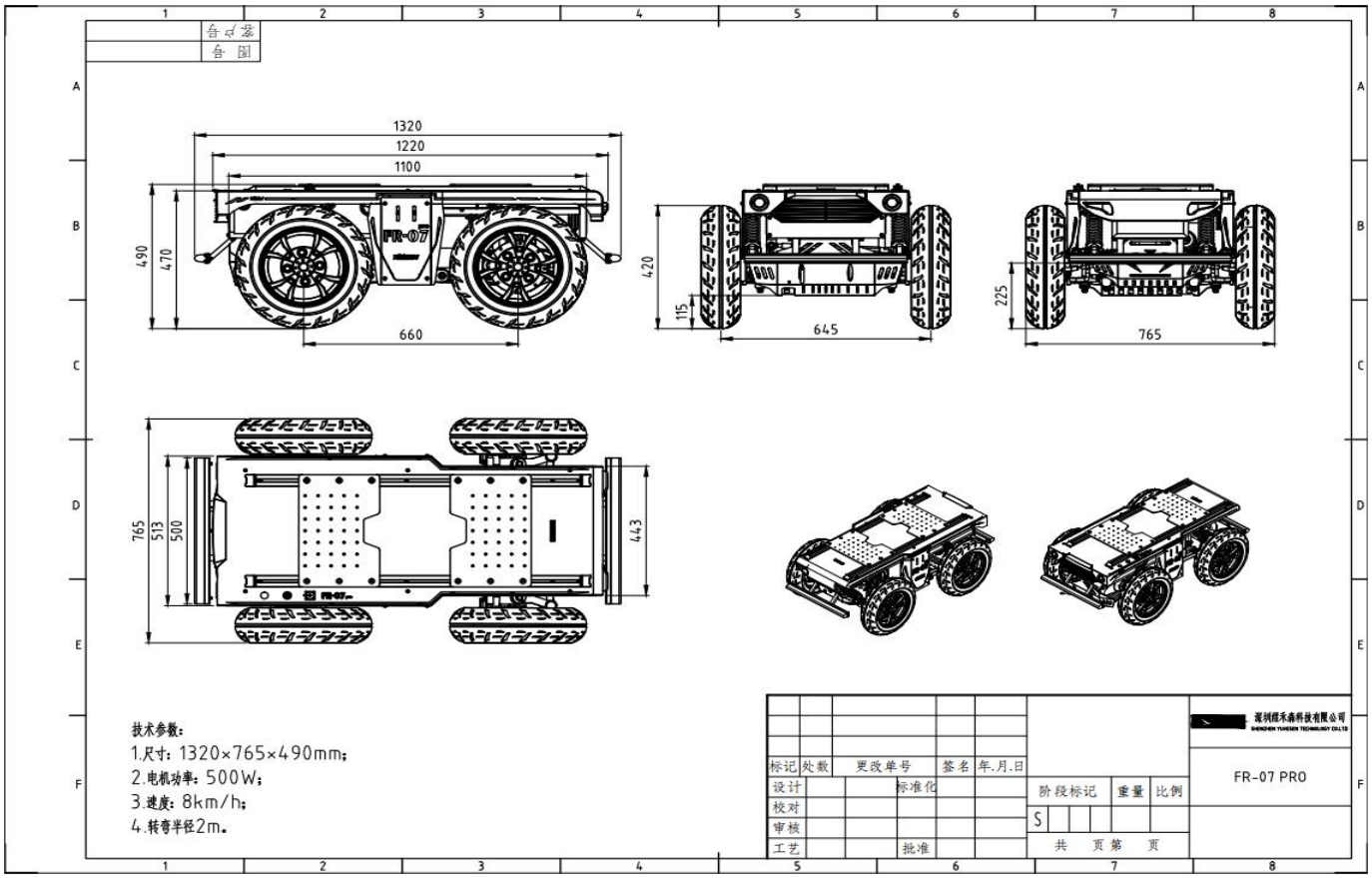
Whether the battery has not been used for a long time, and whether the battery over-discharges or is damaged;

Re-plug the plugger of input and output line with a time interval of larger than 10s to judge that whether the charger is being protected.

Q: How to turn off the remote control without powering down the remote control receiver.

A: Please disassemble the remote control solenoid and then reassemble it to complete the remote control receiver without powering off the remote control.

7. Specification



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