4WS-4WD Robot Chassis

Xspirebot-FW-max

User manual V2.0.2

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1. Foreword

(1) Thank you for purchasing our products. This user manual is applicable to Xspirebot FW-max robot chassis (hereinafter referred to as " FW-max ").

(2) Please be sure to read this manual and precautions carefully before use, and strictly follow these instructions.

(3) Our company will not be held responsible for any losses caused by the use of this product in violation of these instructions.

(4) Please keep this manual in a safe place so that you can refer to it at any time during operation.

(5) Professionals should be invited to debug, connect and install the robot chassis to avoid irreparable losses.

(6) Do not install, remove, replace equipment lines or replace corresponding modules while the power is on. If you need to debug this product while the power is on, please use a special debugging tool with good insulation performance and perform the corresponding operation under the guidance of professionals.

(7) Please use this product under the conditions permitted by laws and regulations, and will not affect public property and life safety.

(8) Our company will update this product from time to time, and the updated content will be added to the new version of the manual without further notice.

(9) This manual may contain technical inaccuracies or inconsistencies with product operations. If you encounter problems that cannot be solved when using this manual, please contact our customer service or technical support department.

(10) We strive to ensure that the contents of this manual are correct. If you find any inappropriateness or errors, please contact us for confirmation. Thank you!

2. Safety Information

This manual does not cover the design, installation, and operation of a complete robot, nor does it cover all peripheral equipment that may affect the safety of this complete system. The design and use of this complete system must comply with the standards and regulations of the location where the robot is installed. Integrators and end customers of FW-max are responsible for complying with the laws and regulations of the relevant countries to ensure that there are no significant hazards in the application of the robot. This includes, but is not limited to, the following:

Validity and responsibility:

- Make a risk assessment of the complete robot system. Connect the additional safety equipment of other machines defined in the risk assessment. Confirm that the design and installation of the peripheral equipment of the entire robot system, including software and hardware systems, are accurate.
- This robot does not have the relevant safety functions of a complete autonomous mobile robot, such as automatic collision avoidance, fall prevention, and biological proximity warning, but it is not limited to the above description. The relevant functions require integrators and customers to follow laws and regulations for safety assessment to ensure that the developed robot does not pose any major dangers or safety hazards in actual application.
- Collect all documents in the technical files, including risk assessment and this manual. Be aware of possible safety risks before operating and using the equipment.

Environment:

- First, please read this manual carefully to understand the basic operation content and specifications.
- For remote control operation, choose a relatively open area or suspend the driving wheel for the corresponding operation test. The chassis itself does not have any automatic obstacle avoidance sensors.
- Use in an ambient temperature of -20℃~50℃.
- In the case of a robot chassis with a non-customized IP protection level, the chassis's dust and waterproof level is IP44.

Examine:

- Make sure all devices are fully charged.
- Make sure there are no obvious abnormalities on the robot chassis.

Check if the remote control batteries are sufficiently charged.

Operate:

- Make sure the surrounding area is relatively open during operation and control the remote control within the line of sight.
- The maximum load capacity of FW-max is 150KG. When in use, please ensure the payload does not exceed 150KG.
- Please charge in time when the device alarms for low battery.
- When the device is abnormal, please stop using it immediately to avoid secondary equipment damage.
- When the device is abnormal, please contact the relevant technicians and do not handle it without authorization.
- Please use it in an environment that meets the protection level requirements according to the IP protection level.
- When charging, ensure that the ambient temperature is greater than 0℃.

Maintainance:

- If the tire is severely worn, please replace it in time.
- If the battery is not used for a long period of time, it should be periodically charged every 2 to 3 months when fully charged.
- The battery must be charged and discharged once a month; otherwise, the battery will be damaged due to low battery power.

3. Introduction

The FW-max is a versatile wheeled robotic mobile chassis, embodying exceptional flexibility. It adopts a four-wheel rear-wheel drive structure, two-wheel independent drive, and four-wheel independent steering, which can achieve precise control of chassis steering. The independent drive provides a strong driving force, superior maneuverability, and off-road performance. Its flexible control enables it to move laterally and on-site steering, and its excellent terrain adaptability makes it suitable for a variety of applications both indoors and outdoors. Its smooth, low-noise ride and tire-resistant design combine the advantages of both front-steering and differential systems, overcoming the steering shortcomings of four-wheel differentials. This mobile platform can carry a variety of specialized equipment and perform a variety of specialized tasks. It is widely used in inspection, patrol, reconnaissance, testing, transportation, firefighting, bomb disposal, and other applications requiring a mobile chassis.

3.1 Product List

After the goods arrive, please carefully confirm the product list:

Robot Chassis ×1

Remote Control x 1

Charger（48V） ×1

User Manual×1

3.2 Performance Parameters

Parameter Type	Performance	Parameter
Structural	Design Size	960*558*395mm
	Chassis Weight	115kg
	Structural Form	Four-wheel steering, Rear-wheel drive
	Chassis Material	Aluminum Alloy
	Ground Clearance	Suspension 53mm/Chassis 120mm
	Wheelbase	600 mm
	Front/Rear Track	450 mm
	Tire Model/Diameter	250mm
Basic Configuration	Drive Motor	600W*2
	Battery	48V/27AH LiFePO4 Battery
	Charging Time	3h
	Charging Type	48 V/10A manual charging plug
	External Power Supply	12V-15A/24V- 15A /48V-10A
	Braking Type	Motor brake
	Parking Type	Electromagnetic brake
Safety Measures	Emergency Stop Switch	√
	Instruction Checksum	√
	Alive Counter Protection	√
	Current Protection	√
	Temperature Protection	√
VCU Configuration	Frequency	168MHz
	Hardware Floating Point Acceleration	√
	Communication Interface	CAN interface
	Communication Protocol	CAN standard communication protocol
	Kinematic Analysis	√
	Remote Control Distance	100m
Performance Parameters	Vertical Load (Horizontal Road Surface)	150kg
	Running Speed	0-5.4 km/ h
	Range	25km

	Minimum Turning Radius	0
	Wading Depth	50mm
	Maximum Climbing Angle	10°(Full loaded)
	Span Width	120mm(Full loaded)
	Obstacle Clearance Height	40mm(Full loaded)
	Protection Level	IP44
	Operating Temperature	-20 ℃ ~ 50 ℃

4. Product Presentation

This section provides a basic introduction to the FW-max mobile robot chassis to help users and developers gain a basic understanding of the FW-max chassis. The FW-max utilizes a modular, automotive-grade design approach, featuring independent omnidirectional steering. Each of its four wheels can rotate 360° on the spot, enabling lateral movement, Ackerman steering, tilting, and pivoting. Its flexible handling and durable tires allow users to precisely control the chassis steering. Its four-wheel drive provides powerful traction, excellent climbing performance, resistance to slipping, and excellent adaptability to road conditions. It utilizes the standard CAN communication protocol and features a variety of application modules and universal standard interfaces, allowing users to quickly install camera cradles, robotic arms, infrared modules, and other components, enabling rapid secondary development.

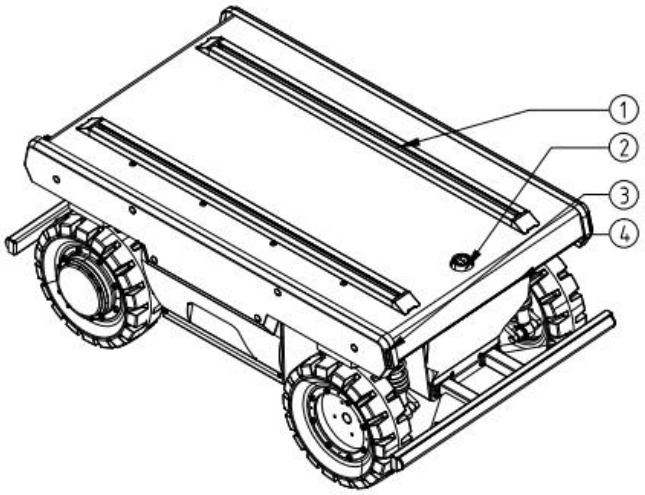


Figure 4-1 Front Overview

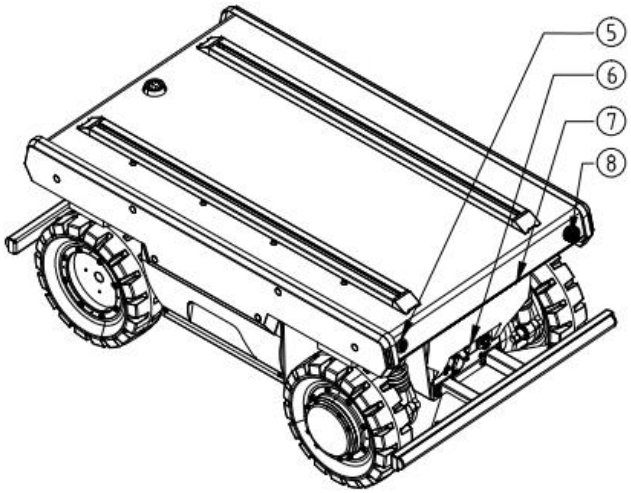


Figure 4-2 Tail Overview

Note: ① 1640Q profile; ② Power supply and communication port; ③ Turn signal; ④ Headlight; ⑤ Start switch; ⑥ Charging and debugging board; ⑦ Brake light; ⑧ Emergency stop switch

4.1 Electrical Interface Description

4.1.1 Top Electrical Panel Description

The FW-max has a WS32-11 core aviation electrical interface at the top. The electrical interface is configured with three different power supplies and two CAN communication interfaces, with wires leading out, making it convenient for users to provide power and communication for different expansion devices. The specific location of the top electrical interface is shown in Figure 4-3, and the specific pin definitions are shown in Table 4-1.

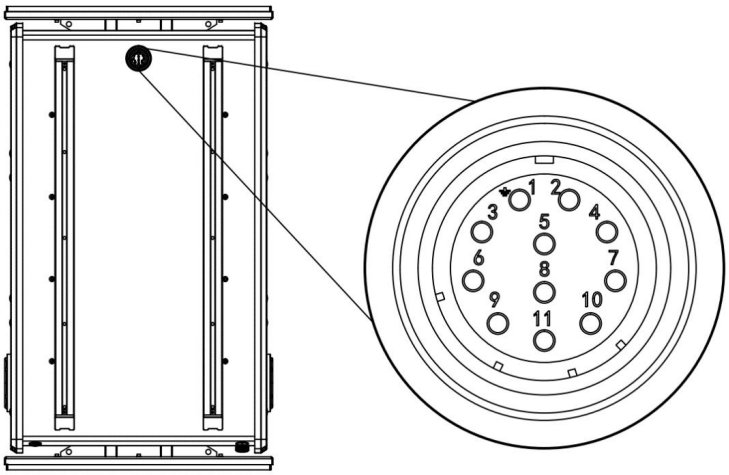


Figure 4-3 Top Electrical Location Diagram

Pinout	Type	Definition	Remark
1	Reserve	Reserve	Reserve
2	power supply	48V-	48V power supply negative pole
3		48V+	48V/10A power supply positive pole
4		24V-	24V power supply negative pole
5	ultrasound	CAN1_L	CAN1 bus low
6	power supply	24V+	24V/15A power supply positive pole
7		12V-	12V power supply negative pole
8	ultrasound	CAN1_H	CAN1 bus high
9	power supply	12V+	12V/15A power supply positive pole
10	Customer-supplied CAN	CAN 2 _L	CAN 2 bus low
11		CAN 2 _H	CAN 2 bus high

Table 4-1 Top Electrical Interface Pin Definitions

4.1.2 Rear Electrical Panel Description

The rear section is equipped with an electrical panel. You need to open the cover of the electrical panel when operating. As shown in Figure 4-4, where B1 is the internal CAN debugging port of the chassis; B2 is the external unlocking interface of the electromagnetic brake (reserved); and B3 is the manual charging interface.

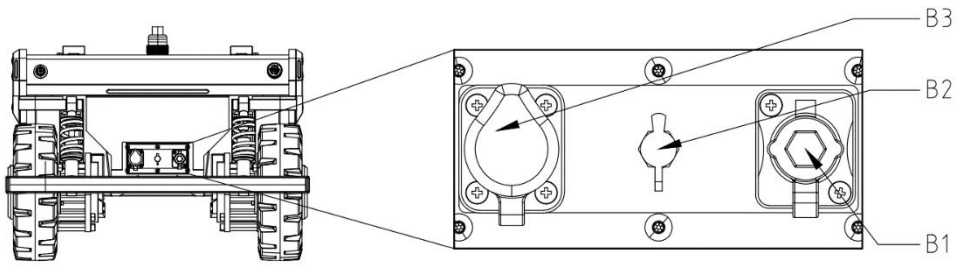


Figure 4 -4 Rear View And Electrical Location Diagram

4.2 Remote Control

4.2.1 Remote Control Instructions

Each FW-max is equipped with an FS-i6S remote control, which helps users easily control the FW-max. The remote control for this product is designed with the left hand controlling left and right directions and the right hand controlling forward and backward throttle. Its definition and functions can be found in Figures 4-5.

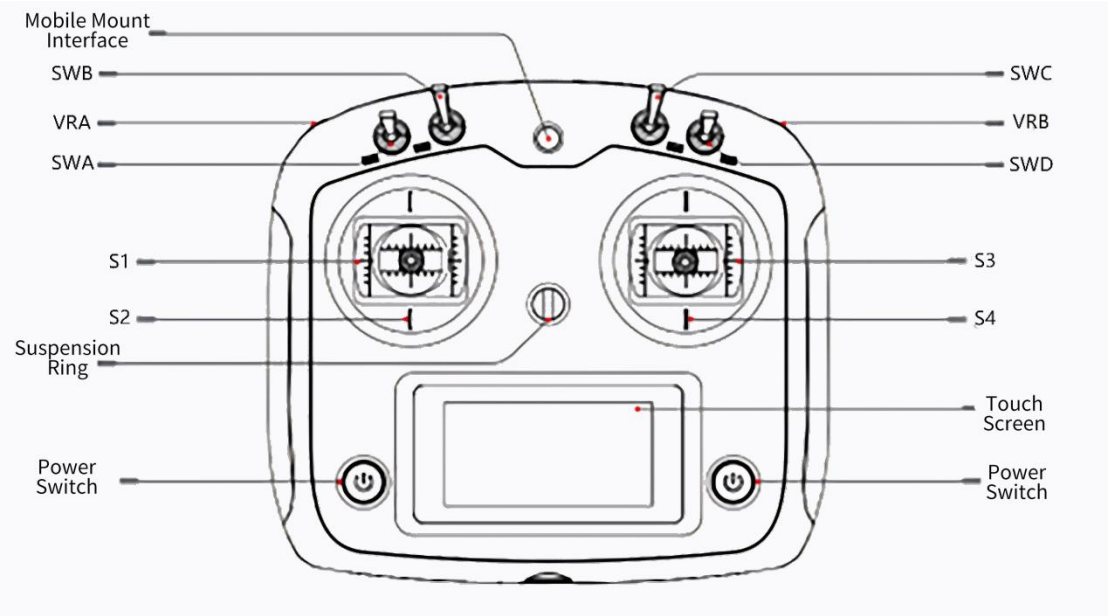


Figure 4-5 FS - i 6S Remote Control Button Diagram

The remote control parameters are pre-set at the factory. Please do not modify the system settings on your own; otherwise, it may cause the robot to lose control or become chaotic. If there is any problem, we recommend returning the unit to the factory for repair. The detailed operating instructions for the remote control are as follows:

(1) SWA is the control mode switch lever, with two gears. When the lever is up, it is in the remote control mode, and when the lever is down, it switches to the command control mode.

(2) SWB is the gear switch lever, with three gears. When the lever is up, it switches to the parking gear, and the chassis wheels switch to the parking state, making the chassis unable to move; when the lever is in the middle position, it switches to the four-wheel drive (4T4D) gear, which operates in the double Ackerman mode; when the lever is down, it switches to the lateral gear, and the chassis steering mode is lateral.

(3) SWC is the speed switch lever, with three gears. When the lever is up, it is in low speed mode; when the lever is down, it is in high speed mode; when the lever is in the middle, it is in medium speed mode.

(4) VRA is the safety parking unlock dial, which is used to release the safety parking. When the anti-collision bar senses a collision, it will trigger a safety stop. After the safety stop is triggered, toggle the VRA dial once (or toggle the right joystick S4 once in the opposite direction of the collision) to release the safety stop and continue operation.

(5) VRB is the operation protection dial. When operating the joystick, you must press and hold the VRB dial at the same time. Otherwise, the chassis will not receive the movement instructions sent by the joystick.

(6) The left joystick is the direction control joystick. The left and right movements of the joystick S1 control the left and right steering of the chassis. The up and down movement control of the joystick S2 is not enabled. Toggling it up and down has no effect on the movement of the chassis.

(7) The right joystick is the throttle control joystick. The forward and backward movements of the joystick S4 control the forward and backward movement of the chassis. The left and right movement control of the joystick S3 is not enabled. Toggling it left and right has no effect on the movement of the chassis.

(8) There is a power button on each side. Press and hold both power buttons at the same time to turn the machine on and off.

(9) The standby interface is described as follows:

The start page is divided into four parts. The upper left is the two timers T1 and T2, the lower left is the flight mode, the upper right is the battery display, where TX is the remote controller battery level and RX is the robot battery level, and the lower right is the unlock button and fine-tuning button.

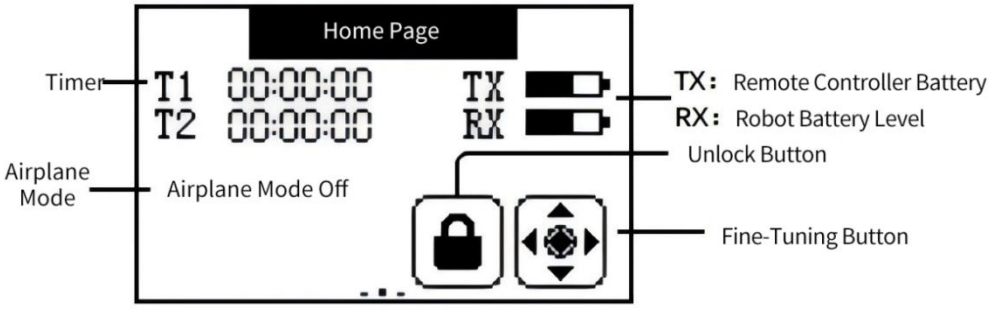


Figure 4-6 Remote Control Start Display Page

The left side of the remote control's home page is the channel interface, as shown in the figure:

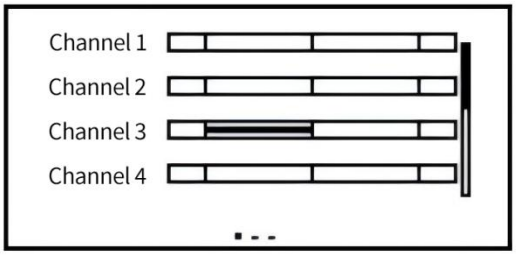


Figure 4-7 Remote Control Channel Display Page

The corresponding relationship between each channel and the remote control operating components is as follows:

Table 4-2 Remote Control Channel Correspondence

Channel Number	1	2	3	4	5	6	7	8	9	10
Operating Parts	S3	S2	S4	S1	VRA	VRB	SWA	SWB	SWC	SWD

The page to the right of the remote control's home page is the sensor list page, where the TX.V item indicates the remote control battery voltage, the Int. V item indicates the receiver voltage, the Sig.S item indicates the signal strength (normal signal strength is 10), and the Ext. V item indicates the robot chassis battery level (SOC). Note that the unit displayed here is V, but it represents a percentage. For example, the remaining battery level is 66% in the figure.

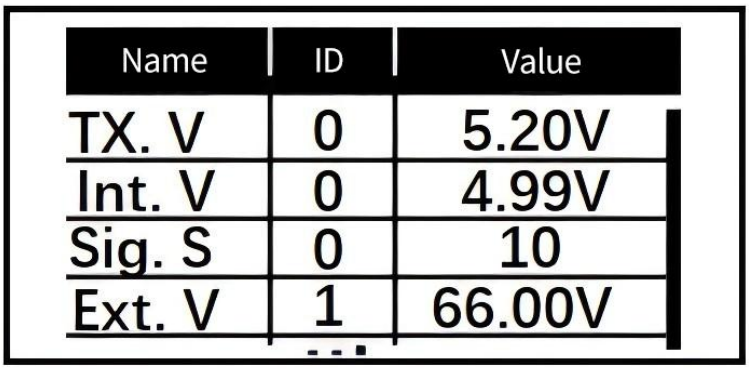


Figure 4-8 Remote Control Sensor List Page

Regarding the control rights of the remote control and communication commands:

(1) When there is no remote control: After powering on, the device receives the communication command and operates according to the command.

(2) When both the remote control and the command are present, the remote control has priority control and controls the device according to the remote control's SWA lever mode. The SWA lever can be used to obtain control with one click.

(3) When there is only a remote control, the remote control position is controlled by the remote control.

4.2.2 Remote Control Buzzer Warning Instructions

Table 4 - 3 Remote Control Alarm Status Description

Switch position alarm	If the SWA /SWB / SWC / SWD lever switch is not in the default position when the device is turned on, an alarm interface will appear, prompting you to move all switches upward. When all switches are in the default position, the device will enter the main interface normally.
Low voltage alarm	When the voltage is lower than the alarm voltage, the system will sound an alarm and the remote control screen will start flashing. If the remote control voltage is too low, the TX icon will flash, and if the chassis voltage is too low, the RX icon will flash.
Shutdown alarm	When the remote control is turned off, it will detect whether the chassis is turned off. If the chassis is not turned off, a warning interface will pop up and you need to turn off the chassis power to turn off the remote control. In addition, when the remote control battery is too low and is about to shut down, the remote control will also pop up a warning interface.
Communication abnormality alarm	When the control distance between the remote control and the chassis is too far or there is interference from the environment, the remote control signal strength will be reduced. If the signal strength is lower than 5, a communication abnormality alarm will be issued to remind the user that the remote control signal strength is weak.
Remote control not in use alarm	When the remote control is not used for a long time, the remote control buzzer will sound an intermittent alarm.

4.2.3 Control Instructions And Motion Instructions

We establish a coordinate reference system for the ground mobile platform according to the ISO 8855 standard as shown in Figure 4-9.

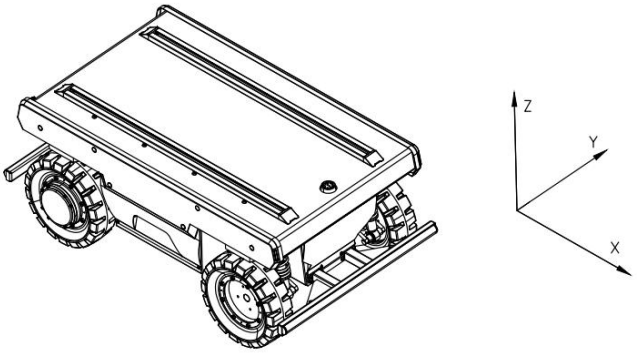


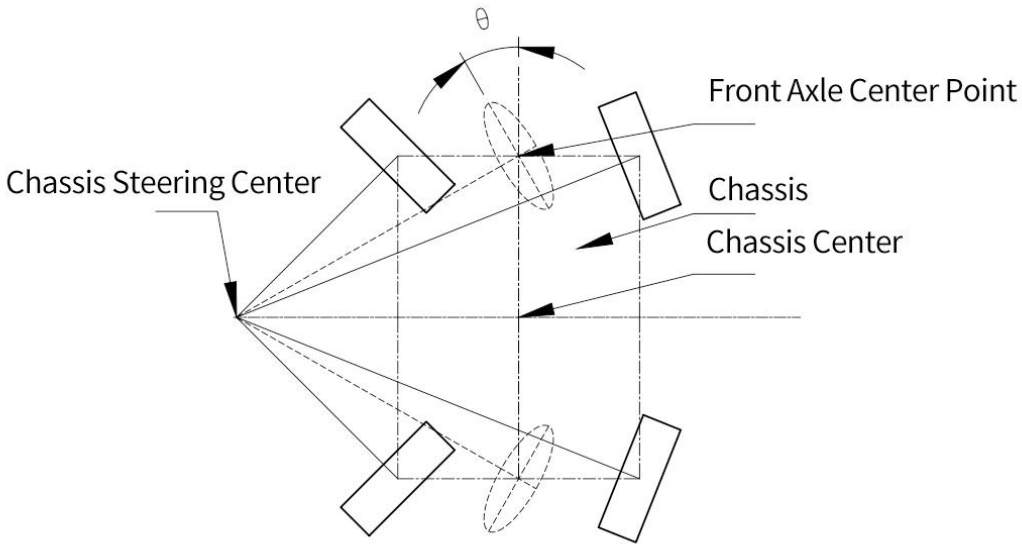
Figure 4-9

As shown in Figure 4-9, the FW-max chassis is parallel to the X-axis of the established reference coordinate system.

In remote control mode, hold down the VRB operation protection dial. Pushing the right-hand throttle joystick S4 forward on the remote control causes movement in the positive X direction, while pushing it backward causes movement in the negative X direction. When the joystick S4 is pushed to its maximum value, the movement speed in the X direction is maximum; when pushed to its minimum value, the movement speed in the negative X direction is maximum.

The left-hand direction joystick S1 on the remote control controls the chassis's steering movement when pushed left or right. When the SWB switch is in 4WD mode (4T4D), pushing the direction joystick S1 to the left causes the chassis to turn left. When pushed to the maximum left position, the left steering angle speed is maximum. Pushing the direction joystick S1 to the right causes the chassis to turn right. When pushed to the maximum right position, the right steering angle speed is maximum.

The schematic diagram illustrating the virtual steering wheel is as follows:



Among them, the chassis X-axis speed, chassis Z-axis angular velocity, and chassis Y-axis speed are based on the chassis center point as a reference; the virtual steering wheel speed and virtual steering wheel angle are based on a virtual steering wheel at the midpoint of the front axle as a reference; special note: the steering wheel corresponds to the front wheel of the bicycle after the four-wheel drive chassis is virtualized into a bicycle model. The virtual steering wheel speed refers to the speed of the wheel, and the virtual steering wheel angle refers to the angle between the centerline of the wheel and the centerline of the chassis, which is the angle θ marked in the figure.

5. Getting Started

This section mainly introduces the basic operation and use of the FW-max platform, how to operate it through the remote control, and how to perform secondary development of the chassis through the CAN protocol.

5.1 Usage and Operation

The basic remote control operation process is as follows:

Inspection

(1) Check whether there are obvious abnormalities in the chassis; if so, please contact after-sales support.

(2) Check the status of the emergency stop switch and confirm that the emergency stop buttons at the rear are in the released state.

(3) Check that all gears of the remote control are in the default position.

Start Operation

(1) Press the start button (main power switch button).

(2) Check whether the battery voltage is normal. If the voltage is too low, please charge it first.

Shutdown Operation

(1) Press the start button (main power switch button) again and release the switch to turn off the power.

Emergency Stop

(1) Press the emergency stop knob on the top of the FW-max chassis; turn it clockwise again to release the emergency stop knob.

5.2 Charging

FW-max is equipped with a 48V/10A manual charger to meet the user's charging needs. The specific charging operation process is as follows:

(1) Before charging, please ensure that the FW-max is in the shutdown state and the main power switch is in the off state.

(2) First, insert the output plug of the charger into the rear charging port; then insert the AC plug of the charger into a 220V AC socket. When the indicator light turns red, it enters the charging state, and when the indicator light turns green, charging is completed.

(3) After charging is completed, unplug the AC plug first, then unplug the output plug.

(4) The charger protection status is described in Table 5-1.

Table 5-1 Charger Protection Status Description

Protection Function	Functional Description
Overheat protection	When the internal temperature of the charger reaches the over-temperature protection point, the charger automatically stops charging.
Output short circuit protection	When the charger output is accidentally short-circuited, the charger automatically shuts down the output.
Output reverse polarity protection	When the battery is connected reversely, the charger will cut off the connection between the internal circuit and the battery.
Output overvoltage protection	When the charger output is over-voltage, the charger automatically shuts down the output.

Note:

The charging process must be performed in the specified order to prevent electrical shorts between the charger connector and the battery charging port, which could damage the robot battery, charger, or cause unnecessary personal injury.

5.3 CAN Line Connection

The FW-max provides a standard CAN communication protocol for user development. Users can control the chassis via the USB interface on the rear electrical board.

5.4 CAN Communication Protocol

The FW-max uses the CAN 2.0B standard for communication, with a baud rate of 500K and Intel format message structure. Through the external CAN interface, users can control the chassis' linear speed, steering angle, and steering angle velocity; simultaneously, real-time feedback is provided on the current motion status information and the system status information of the FW-max chassis. The motion command control frame includes gear control, linear speed control, steering angle control, steering angle velocity control, lighting control, parking request, and verification. The protocol content includes control frames and feedback frames, with the specific protocol details shown in the table below:

Motion Control Instructions-Control Frames				
Message Name	ID	Type	Cycle (ms)	Length (Byte)

ctrl_cmd			0x18c4d1d0			Cycle	10~50		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Target Gear	Intel	0	0	Cycle	4	Unsigned	1		00 : disable 01 : parking position 02 : empty File 06 : 4T4D- File 08 : Horizontal shift - File
Target Chassis X-Axis Speed	Intel	0	4	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ; Only valid when the target gear is 4T4D- gear or lateral - gear
Target Chassis Z-Axis Angular Velocity	Intel	2	20	Cycle	16	Signed	0.01	°/s	(0.01°/s)/bit ; Only valid when the target gear is 4T4D-
Target Chassis Y Axis Speed	Intel	4	36	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ; Only valid when the target gear is the horizontal shift gear .
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Motion Control Instructions-Control Frames									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
steering_ctrl_cmd			0x18C4D2D0			Cycle	10~50		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Target Gear	Intel	0	0	Cycle	4	Unsigned	1		00 : disable 01 : parking position 02 : empty File 05 : 4T4D- File 07 : Horizontal shift - File
Target Virtual Steering Wheel Speed	Intel	0	4	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ; only valid when the target gear is 4T4D- gear or lateral gear
Target Virtual Steering Wheel Angle	Intel	2	20	Cycle	16	Signed	0.01	°	0.01°/bit ; only valid when the target gear is 4T4D- gear or traverse - gear
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Note: In a four-wheel drive chassis, “virtual steering wheels” do not refer to physically existing additional steering wheels. For details, please refer to Section 4.2.3.

I /O control instructions - control frames									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
io_cmd			0x18C4D7D0			IfActive	10		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Light Control Mode	Intel	0	0	IfActive	1	Unsigned	1		0 = Automatic control by status 1 = Free control
Safety Parking Unlock Switch	Intel	0	1	IfActive	1	Unsigned	1		0 = Invalid 1 = Unlock enabled (falling edge valid)
Low Power Mode Enable Switch	Intel	0	1	IfActive	1	Unsigned	1		0 = Disable 1 = Enabled (default)
Low Beam Switch	Intel	1	8	IfActive	1	Unsigned	1		0 = Off 1 = On
Turn Signal Switch	Intel	1	10	IfActive	2	Unsigned	1		0 = All off 1 = Turn on the left turn signal 2 = Turn on the right turn signal
Brake Light Switch	Intel	1	12	IfActive	1	Unsigned	1		0 = Off 1 = On
Low Power Mode Trigger Ratio	Intel	2	1 6	IfActive	8	Unsigned	1		1%/bit; invalid when less than 0 or greater than 100; The larger the ratio, the harder it is to trigger.
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR

									Byte4 XOR Byte5 XOR Byte6

Motion Control Status-Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
ctrl_fb			0x18C4D1EF			Cycle	10		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Current Gear Feedback	Intel	0	0	Cycle	4	Unsigned	1		00 : disable 01 : parking 02 : neutral 06 : 4T4D-shift 08 : horizontal shift
Current Body X-Axis Speed Feedback	Intel	0	4	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ;
Current Body Z-Axis Angular Velocity Feedback	Intel	2	20	Cycle	16	Signed	0.01	°/s	(0.01°/s)/bit ;
Current Body Y Axis Speed Feedback	Intel	4	36	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ;
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.

Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Motion Control Status-Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
steering_ctrl_fb			0x18C4D2EF			Cycle	10		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Current Gear Feedback	Intel	0	0	Cycle	4	Unsigned	1		00 : disable 01 : parking 02 : neutral 06 : 4T4D- shift 07 : shift - shift
Current Virtual Steering Wheel Speed Feedback	Intel	0	4	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ;
Current Virtual Steering Wheel Angle Feedback	Intel	2	20	Cycle	16	Signed	0.01	°	0.01°/bit ;
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.

Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Wheel Control Status - Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
lf_wheel_fb			0x18C4D6EF			Cycle	10		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Current Left Front Wheel Speed Feedback	Intel	0	0	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ;
Current Left Front Wheel Pulse Number Feedback	Intel	2	16	Cycle	32	Signed	1	1	Wheel single turn N pulses, N = encoder harness 32768 * reduction ratio 16
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Wheel Control Status - Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
lr_wheel_fb			0x18C4D7EF			Cycle	10		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Current Left Rear Wheel Speed Feedback	Intel	0	0	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ;
Current Left Rear Wheel Pulse Number Feedback	Intel	2	16	Cycle	32	Signed	1	1	Wheel single turn N pulses, N = encoder harness 32768 * reduction ratio 16
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Wheel Control Status - Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
rr_wheel_fb			0x18C4D8EF			Cycle	10		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Current Right Rear Wheel Speed Feedback	Intel	0	0	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ;
Current Right Rear Wheel Pulse Number Feedback	Intel	2	16	Cycle	32	Signed	1	1	Wheel single turn N pulses, N = encoder harness 32768 * reduction ratio 16
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Wheel Control Status - Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
rf_wheel_fb			0x18C4D9EF			Cycle	10		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Current Right Front Wheel Speed Feedback	Intel	0	0	Cycle	16	Signed	0.001	m/s	0.001m/s/bit ;
Current Right Front Wheel Pulse Number Feedback	Intel	2	16	Cycle	32	Signed	1	1	Wheel single turn N pulses, N = encoder harness 32768 * reduction ratio 16
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Wheel Control Status - Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
front_angle_fb			0x18C4DCEF			Cycle	10		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Left Front Servo Joint Angle Feedback	Intel	0	0	Cycle	16	Signed	0.01	°	0.01°/bit ;
Right Front Servo Joint Angle Feedback	Intel	2	16	Cycle	16	Signed	0.01	°	0.01°/bit ;
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Wheel Control Status - Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
rear_angle_fb			0x18C4DDEF			Cycle	10		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Left Rear Servo Joint Angle Feedback	Intel	0	0	Cycle	16	Signed	0.01	°	0.01°/bit ;
Right Rear Servo Joint Angle Feedback	Intel	2	16	Cycle	16	Signed	0.01	°	0.01°/bit ;
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

I/O Control Status-Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
io_fb			0x18C4DAEF			Cycle	50		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Light Control Status Feedback	Intel	0	0	Cycle	1	Unsigned	1		0 = Automatic control by status 1 = Free control
Safety Parking Unlock Status Feedback	Intel	0	1	IfActive	1	Unsigned	1		0 = Invalid 1 = Unlock successful
Low Power Enabled Status Feedback	Intel	0	2	Cycle	1	Unsigned	1		0 = Not enabled 1 = Enabled
Low Power Trigger Status Feedback	Intel	0	3	Cycle	1	Unsigned	1		0 = Not triggered 1 = Triggered
Low Beam Switch Status Feedback	Intel	1	8	Cycle	1	Unsigned	1		0 = Off 1 = On
Turn Signal Switch Status Feedback	Intel	1	10	Cycle	2	Unsigned	1		0 = All off 1 = Turn on the left turn signal 2 = Turn on the right turn signal 3 = Turn on both turn signals
Brake Light Switch Status Feedback	Intel	1	12	Cycle	1	Unsigned	1		0 = Off 1 = On
Low Power Trigger Proportiona l Feedback	Intel	2	16	Cycle	8	Unsigned	1		1%/bit
Emergency Stop Switch Status Feedback	Intel	5	40	Cycle	1	Unsigned	1		0 = Off 1 = On
Remote Control Status Feedback	Intel	5	41	Cycle	1	Unsigned	1		0 = Command control state 1 = Remote control state

Charging Pile Status Feedback	Intel	5	42	Cycle	1	Unsigned	1		0 = No charging station 1 = Connected to charging station
Manual Charger Signal Feedback	Intel	5	43	Cycle	1	Unsigned	1		0 = No manual charging 1 = Manual charging
Remote Control First Power-On Feedback	Intel	5	44	Cycle	1	Unsigned	1		0 = Not powered on for the first time 1 = Powered on for the first time
Remote Control Signal Online Feedback	Intel	5	45	Cycle	1	Unsigned	1		0 = Not powered up for the first time or Signal is offline 1 = Signal is online
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Battery Status-Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
bms_fb			0x18C4E1EF			Cycle	100		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Current Battery Voltage	Intel	0	0	Cycle	16	Unsigned	0.01	V	0.01V/bit ;
Current Battery Current	Intel	2	16	Cycle	16	Signed	0.01	A	0.01A/bit ;
Current Remaining Battery Capacity	Intel	4	32	Cycle	16	Unsigned	0.01	Ah	0.01Ah/bit ;
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Battery Status Indicator - Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
bms_flag_fb			0x18C4E2EF			Cycle	100		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Current Remaining Battery Percentage	Intel	0	0	Cycle	8	Unsigned	1	%	1%/bit ;
Single Overvoltage Protection	Intel	1	8	Cycle	1	Unsigned	1		0 = Off 1 = On
Single Cell Undervoltage Protection	Intel	1	9	Cycle	1	Unsigned	1		0 = Off 1 = On
Overvoltage Protection For The Whole Group	Intel	1	10	Cycle	1	Unsigned	1		0 = Off 1 = On
Undervoltage Protection For The Whole Group	Intel	1	11	Cycle	1	Unsigned	1		0 = Off 1 = On
Charging Over-Temperature Protection	Intel	1	12	Cycle	1	Unsigned	1		0 = Off 1 = On
Charging Low Temperature Protection	Intel	1	13	Cycle	1	Unsigned	1		0 = Off 1 = On
Discharge Over Temperature Protection	Intel	1	14	Cycle	1	Unsigned	1		0 = Off 1 = On
Discharge Low Temperature Protection	Intel	1	15	Cycle	1	Unsigned	1		0 = Off 1 = On
Charging Overcurrent Protection	Intel	2	16	Cycle	1	Unsigned	1		0 = Off 1 = On
Discharge Overcurrent Protection	Intel	2	17	Cycle	1	Unsigned	1		0 = Off 1 = On
Short Circuit Protection	Intel	2	18	Cycle	1	Unsigned	1		0 = Off 1 = On

Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Front-End Detection IC Error	Intel	2	19	Cycle	1	Unsigned	1		0 = Off 1 = On
Software Lock MOS	Intel	2	20	Cycle	1	Unsigned	1		0 = Off 1 = On
Charging Flag	Intel	2	21	Cycle	1	Unsigned	1		0 = Not charging 1 = Charging
Heating Flag	Intel	2	22	Cycle	1	Unsigned	1		0 = Not heating 1 = Heating
Current Maximum Battery Temperature	Intel	3	28	Cycle	12	Signed	0.1	℃	0.1 ℃ /bit ;
Current Minimum Battery Temperature	Intel	5	40	Cycle	12	Signed	0.1	℃	0.1 ℃ /bit ;
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Drive Motor Current-Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
drive_motor_current_fb			0x18C4E3EF			Cycle	100		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Left Front Drive Motor Current Value	Intel	0	0	Cycle	12	Signed	0.1	A	0.1A / bit
Left Rear Drive Motor Current Value	Intel	1	12	Cycle	12	Signed	0.1	A	0.1A / bit
Right Front Drive Motor Current Value	Intel	3	24	Cycle	12	Signed	0.1	A	0.1A / bit
Right Rear Drive Motor Current Value	Intel	4	36	Cycle	12	Signed	0.1	A	0.1A / bit
Left Front Drive Motor Stall Sign	Intel	6	48	Cycle	1	Unsigned	1		0 = No 1 = Yes
Left Rear Drive Motor Stall Sign	Intel	6	49	Cycle	1	Unsigned	1		0 = No 1 = Yes
Right Front Drive Motor Stall Sign	Intel	6	50	Cycle	1	Unsigned	1		0 = No 1 = Yes
Right Rear Drive Motor Stall Sign	Intel	6	51	Cycle	1	Unsigned	1		0 = No 1 = Yes
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect

									packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Steering Motor Current-Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
steering_motor_current_fb			0x18C4E4EF			Cycle	100		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Left Front Steering Motor Current Value	Intel	0	0	Cycle	12	Signed	0.1	A	0.1A / bit
Left Rear Steering Motor Current Value	Intel	1	12	Cycle	12	Signed	0.1	A	0.1A / bit
Right Front Steering Motor Current Value	Intel	3	24	Cycle	12	Signed	0.1	A	0.1A / bit
Right Rear Steering Motor Current Value	Intel	4	36	Cycle	12	Signed	0.1	A	0.1A / bit
Left Front Steering	Intel	6	48	Cycle	1	Unsigned	1		0 = No 1 = Yes

Motor Stall Sign									
Left Rear Steering Motor Stall Sign	Intel	6	49	Cycle	1	Unsigned	1		0 = No 1 = Yes
Right Front Steering Motor Stall Sign	Intel	6	50	Cycle	1	Unsigned	1		0 = No 1 = Yes
Right Rear Steering Motor Stall Sign	Intel	6	51	Cycle	1	Unsigned	1		0 = No 1 = Yes
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Front Ultrasonic-Feedback Frame				
Message Name	ID	Type	Cycle (ms)	Length (Byte)
front_ultrasonic_fb	0x18C4E8EF	Cycle	50	8

Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
No. 1 Ultrasonic Distance	Intel	0	0	Cycle	12	Unsigned	1	mm	/ bit within the measuring range ; 200mm = In the blind spot 2540mm = Over range 2560mm = without probe
No.2 Ultrasonic Distance	Intel	1	12	Cycle	12	Unsigned	1	mm	/ bit within the measuring range ; 200mm = In the blind spot 2540mm = Over range 2560mm = without probe
No.3 Ultrasonic Distance	Intel	3	24	Cycle	12	Unsigned	1	mm	/ bit within the measuring range ; 200mm = In the blind spot 2540mm = Over range 2560mm = without probe
No.4 Ultrasonic Distance	Intel	4	36	Cycle	12	Unsigned	1	mm	/ bit within the measuring range ; 200mm = In the blind spot 2540mm = Over range 2560mm = without probe

Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Rear Ultrasonic-Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
rear_ultrasonic_fb			0x18C4E9EF			Cycle	50		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
No.5 Ultrasonic Distance	Intel	0	0	Cycle	12	Unsigned	1	mm	/ bit within the measuring range ; 200mm = In the blind spot 2540mm = Over range 2560mm = without probe

No.6 Ultrasonic Distance	Intel	1	12	Cycle	12	Unsigned	1	mm	/ bit within the measuring range ; 200mm = In the blind spot 2540mm = Over range 2560mm = without probe
No.7 Ultrasonic Distance	Intel	3	24	Cycle	12	Unsigned	1	mm	/ bit within the measuring range ; 200mm = In the blind spot 2540mm = Over range 2560mm = without probe
No.8 Ultrasonic Distance	Intel	4	36	Cycle	12	Unsigned	1	mm	/ bit within the measuring range ; 200mm = In the blind spot 2540mm = Over range 2560mm = without probe
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.

Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Fault Information-Feedback Frame									
Message Name			ID			Type	Cycle (ms)		Length (Byte)
error_fb			0x18C4EAEF			Cycle	100		8
Signal Description	Arrangement Format	Start Byte	Start Bit	Signal Sending Type	Signal Length	Data Types	Accuracy	Unit	Signal Value Description
Failure Level	Intel	0	0	Cycle	8	Unsigned	1		00: No fault E1: General failure E2: Serious failure E3: Fatal Failure
Faulty Component Type	Intel	1	8	Cycle	8	Unsigned	1		00: None A 0 ： Remote control B0: Battery C0: VCU D1: Drive system D2: Steering system D3: Braking system F0 : Sensor 80: Other parts
Faulty Component ID	Intel	2	16	Cycle	8	Unsigned	1		00: Default/None 06: Front left 07: Left rear 08: Front right 09: Right rear

Fault Code	Intel	3	24	Cycle	8	Unsigned	1		0x00: Reset/No abnormality 0x1X: General exception 0x2X: Abnormal current 0x3X: Abnormal voltage 0x4X: Abnormal temperature 0x5X: Hardware abnormality 0x6X: Software abnormality 0x7X: Accessory abnormality 0x8X: Communication abnormality 0xF0: Device specific exception X represents 0, 1, 2...E, F, etc. Please see the table below for details.
Error Register	Intel	4	32	Cycle	16	Unsigned	1		Please consult after-sales for details
Alive Rolling Counter	Intel	6	52	Cycle	4	Unsigned	1		The value increases by 1 for each frame sent. When the maximum value is reached, it starts counting again from 0. It is used to detect packet loss and disconnection.
Check BCC	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Remark: Detailed explanation of fault codes

Fault Coding	Fault Explanation	Fault Coding	Fault Explanation	Fault Coding	Fault Explanation	Fault Coding	Fault Explanation
10	General Abnormalities	20	Abnormal Current	30	Abnormal Voltage	40	Abnormal Temperature
11	Stall	21	Overload	31	Overpressure	41	Driver Over Temperature
12	Stall	22	Overcurrent	32	Undervoltage	42	Motor Overheating
13	Speed Exceeds	23	Short Circuit	33	Voltage Out Of Limit	43	Power Module Overtemperatur e
14	Speed Limit Exceeded	24	Current Out Of Tolerance	34	Charging Overvoltage	44	Battery Overheating
15	Location Out Of Tolerance	25	Current Limit Exceeded	35	Abnormal Power Supply Voltage	45	Battery Low Temperature
16	Position Out Of Limit	26	I2T Failure	36		46	Device Overheating
17	Power Limit Exceeded	27	Charging Overcurrent	37		47	
Fault Coding	Fault Explanation	Fault Coding	Fault Explanation	Fault Coding	Fault Explanation	Fault Coding	Fault Explanation
50	Hardware Abnormality	60	Software Anomaly	70	Accessory Abnormality	80	Communication Abnormality
51	Encoder Failure	61	Initialization Exception			81	Communication Hardware Error
52	Hall Fault	62				82	Can Communication Overload
53	EEPROM Failure	63				83	Node daemon error
54	IGBT Failure	64				84	Protocol Error
55	Braking Resistor Failure	65				85	Communication Timeout
56	FLASH Failure	66				86	Alive Counter Failure
57	FRAM failure	67				87	CRC Failure
58	ADC Failure	68				88	Disconnection Failure

59	Motor Phase Failure					89	Disconnection Prompt
5A	Power Device Failure						

5.5 CAN Communication Protocol Instructions

5.5.1 Testing Notes

1) During transmission, note that the Alive counter must be continuously changing and cyclically transmitted.
2) During transmission, pay special attention to the fact that the Alive counter occupies bits 52 to 55, a total of four bits.
3) The BCC message checksum is the XOR checksum of the first seven bytes: Checksum = Byte 0 XOR Byte 1 XOR Byte 2 XOR Byte 3 XOR Byte 4 XOR Byte 5 XOR Byte 6
4) The following example uses USB CAN to issue simple control commands. Please follow the communication protocol when controlling the chassis.
5) During testing, switch the remote control to command control mode or turn it off.
6) When connecting a computer to the CAN card, set up the chassis during testing, as it may be testing chassis movement. Wait until the chassis is stable before lowering it for testing with the program.
7) During testing, since the remote control has the highest priority, it is best to enable remote control testing so that you can switch to remote control mode at any time.

5.5.2 Chassis Motion Control Command Description

Chassis motion control commands are divided into two types: the ctrl_cmd message and the steering_ctrl_cmd message. Both messages need to send the corresponding command, Alive counter, and XOR check at the same time to pass the protection and verification.

The ctrl_cmd message uses "target chassis X-axis speed + target chassis Z-axis angular velocity + target chassis Y-axis speed" to control the target chassis movement. When the target gear is a

4T4D (06), only "X-axis speed + Z-axis angular velocity" is valid, and "Y-axis speed" is invalid. When the target gear is the lateral (08), only "X-axis speed + Y-axis speed" is valid, and "Z-axis angular velocity" is invalid. When the target gear is disable, parking, or neutral, all three signals are invalid.

The steering_ctrl_cmd message uses "target virtual steering wheel speed + target virtual steering wheel angle" to control the target chassis movement. When the target gear is a 4T4D (05) or lateral gear (7), "virtual steering wheel speed + angle" is valid. When the target gear is disable, parking, or neutral, both signals are invalid.

Control Requests and Feedback in the ctrl_cmd Message

The target gear signal value is 0-3 bits, with a physical value range of 00 to 08. The default target gear is 00, which is the disable gear. A target gear setting of 01 is the parking gear; a target gear setting of 02 is the neutral gear; a target gear setting of 06 is the 4T4D gear; and a target gear setting of 08 is the shift gear. Target gear settings of 05 or 07 are invalid in the ctrl_cmd message.

Example 1:

When the target gear position is 4T4D (06), the chassis is in four-speed four-wheel drive mode;

The target X-axis speed is 0.001m/s/bit*bus signal. If you want to request a target X-axis speed of 0.5m/s, the bus signal is 500 (0x01F4). The X-axis speed value is positive in the forward direction and negative in the backward direction.

The target Z-axis angular velocity is 0.01°/s/bit*bus signal. If you want to request a target Z-axis angular velocity of -25°/s, the bus signal is -2500 (0xF63C). Looking down at the chassis from above, the Z-axis angular velocity is positive in the counterclockwise direction and negative in the clockwise direction;

The target Y-axis speed is invalid in this gear position. The default value is 0 (0x0000).

The example command is as follows:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1D0	0x46	0x1F	0xC0	0x63	0x0F	0x00	0x10	0xE5
0x18C4D1D0	0x46	0x1F	0xC0	0x63	0x0F	0x00	0x20	0xD5
0x18C4D1D0	0x46	0x1F	0xC0	0x63	0x0F	0x00	0x30	0xC5

Note: The three signal frames above are sent cyclically at 10ms intervals, controlling the chassis to

operate in a four-speed, four-wheel drive mode with an X-axis speed of 0.5m/s and a Z-axis angular velocity of -25°/s.

The feedback message is as follows:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1EF	0x46	0x1F	0xC0	0x63	0x0F	0x00	0xA0	0x55
0x18C4D1EF	0x46	0x1F	0xC0	0x63	0x0F	0x00	0xB0	0x45
0x18C4D1EF	0x46	0x1F	0xC0	0x63	0x0F	0x00	0xC0	0x35

Note: XOR checksum and Alive counter change cyclically. Due to the automatic speed adjustment during operation, the feedback value may not be absolute.

Example 2:

When the target gear request is the lateral gear (08), the chassis is in lateral mode;

The target X-axis speed is 0.001m/s/bit*bus signal. If you want to request a target X-axis speed of 0.3m/s, the bus signal is 300 (0x012C). The X-axis speed value is positive when it is forward and negative when it is backward.

The target Z-axis angular velocity is invalid in this gear, and the default value is 0 (0x0000).

The target Y-axis speed is 0.001m/s/bit*bus signal. If you want to request a target Y-axis speed of -0.3m/s, the bus signal is -300 (0xFED4). The Y-axis speed value is positive when it is to the left and negative when it is to the right.

The example command is as follows:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1D0	0xC8	0x12	0x00	0x00	0x40	0xED	0x4F	0x38
0x18C4D1D0	0xC8	0x12	0x00	0x00	0x40	0xED	0x5F	0x28
0x18C4D1D0	0xC8	0x12	0x00	0x00	0x40	0xED	0x6F	0x18

Note: The three signal frames above are sent cyclically at 10ms intervals, controlling the chassis to operate in a traverse mode with an X-axis speed of 0.3m/s and a Y-axis speed of -0.3m/s.

The feedback message is as follows:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1EF	0xC8	0x12	0x00	0x00	0x40	0xED	0xDF	0xA8
0x18C4D1EF	0xC8	0x12	0x00	0x00	0x40	0xED	0xEF	0x98
0x18C4D1EF	0xC8	0x12	0x00	0x00	0x40	0xED	0xFF	0x88

Note: XOR checksum and Alive counter change cyclically. Due to the automatic speed adjustment during operation, the feedback value may not be absolute.

Control Requests and Feedback in the steering_ctrl_cmd Message

The target gear position signal value is 0-3 bits, with a physical value range of 00 to 08. The default target gear position is 00 (disable); a target gear position of 01 is park; a target gear position of 02 is neutral; a target gear position of 05 is 4T4D; and a target gear position of 07 is shift. Target gear positions of 06 or 08 are invalid in the steering_ctrl_cmd message.

Example 1:

When the target gear position is 4T4D (05), the chassis is in four-wheel drive mode;

The target virtual steering wheel speed is 0.001m/s/bit*bus signal. If you want to request a target virtual steering wheel speed of 0.3m/s, the bus signal is 300 (0x012C). The steering wheel speed is positive when it is forward and negative when it is backward.

The target virtual steering wheel angle is 0.01°/bit*bus signal. If you want to request a target virtual steering wheel angle of 45°, the bus signal is -4500 (0xEE6C). The steering wheel angle is positive when it is to the left and negative when it is to the right.

The example command is as follows:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1D0	0xC5	0x12	0xC0	0xE6	0x0E	0x00	0x10	0xEF
0x18C4D1D0	0xC5	0x12	0xC0	0xE6	0x0E	0x00	0x20	0xDF
0x18C4D1D0	0xC5	0x12	0xC0	0xE6	0x0E	0x00	0x30	0xCF

Note: The three signal frames above are sent cyclically at 10ms intervals, controlling the chassis to

operate in a four-wheel drive mode with a steering wheel speed of 0.3m/s and a steering wheel angle of 45°.

The feedback message is as follows:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1EF	0xC5	0x12	0xC0	0xE6	0x0E	0x00	0xA0	0x5F
0x18C4D1EF	0x45	0x06	0xC0	0xE6	0x0E	0x00	0xB0	0x4F
0x18C4D1EF	0x45	0x06	0xC0	0xE6	0x0E	0x00	0xC0	0x3F

Example 2:

When the target gear request is lateral gear (07), the chassis is in lateral mode;

The target virtual steering wheel speed is 0.001m/s/bit*bus signal. If you want to request a target virtual steering wheel speed of -0.5m/s, the bus signal is -500 (0xFE0C). The steering wheel speed is positive when it is forward and negative when it is backward.

The target virtual steering wheel angle is 0.01°/bit*bus signal. If you want to request a target virtual steering wheel angle of 30°, the bus signal is 3000 (0x0BB8). The steering wheel angle is positive when it is to the left and negative when it is to the right.

The example command is as follows:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1D0	0xC7	0xE0	0x8F	0xBB	0x00	0x00	0x40	0x53
0x18C4D1D0	0xC7	0xE0	0x8F	0xBB	0x00	0x00	0x50	0x43
0x18C4D1D0	0xC7	0xE0	0x8F	0xBB	0x00	0x00	0x60	0x73

Note: The three signal frames above are sent cyclically at 10ms intervals, controlling the chassis to operate in lateral mode with a steering wheel speed of -0.5m/s and a steering wheel angle of 30°.

The feedback message is as follows:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1EF	0xC7	0xE0	0x8F	0xBB	0x00	0x00	0xD0	0xC3
0x18C4D1EF	0xC7	0xE0	0x8F	0xBB	0x00	0x00	0xE0	0xF3
0x18C4D1EF	0xC7	0xE0	0x8F	0xBB	0x00	0x00	0xF0	0xE3

5.5.3 Auxiliary Control Command Description

Using the safety stop unlock switch as an example, the IO port enable control requires sending the enable flag, Alive counter, and check bit simultaneously. Please note the impact of issuing IO control messages on other IO flags.

Example: io_cmd_unlock safety stop unlock switch 0x02

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D7D0	0x02	0x00	0X00	0x00	0x00	0x00	0x00	0x02
0x18C4D7D0	0x02	0x00	0X00	0x00	0x00	0x00	0x10	0x12
0x18C4D7D0	0x00	0x00	0X00	0x00	0x00	0x00	0x20	0x20
0x18C4D7D0	0x00	0x00	0X00	0x00	0x00	0x00	0x30	0x30

Note: The above signal (falling edge) is sent every 20ms to request unlocking the safety stop switch.

The feedback message is as follows:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4DAEF	0x00	0x00	0X00	0x00	0x00	0x00	0x00	0x02
0x18C4DAEF	0x02	0x00	0X00	0x00	0x00	0x00	0x00	0x02
0x18C4DAEF	0x00	0x00	0X00	0x00	0x00	0x00	0x00	0x02

Note: The XOR checksum and Alive counters change cyclically.

6. Attention

This section contains some precautions when using, storing, and developing the FW-max.

6.1 Battery Usage Precautions

- The FW-max battery may not be fully charged when shipped from the factory. The exact charge level can be read from the remote control voltage display or the CAN bus communication interface. Charging completion is indicated by the green indicator on the charger.
- Do not charge the battery until it is completely depleted. If the battery voltage is too low, recharge it immediately.
- The battery's operating temperature under discharge conditions is -20°C~50°C. The battery will operate normally within the specified temperature range, and capacity loss is within tolerance.
- Do not over-discharge the battery during use to avoid damage.
- Avoid excessive shock to the battery. Shocks exceeding the specified range may damage the battery, potentially causing leakage, overheating, smoke, fire, or explosion.
- If any obvious battery abnormality is observed, stop using it immediately!

6.2 Charging Precautions

- Only use the battery-specific charger provided with the battery. Do not use non-original batteries, power supplies, or chargers.
- Charge only in an environment between 0°C~45°C. Charging outside this temperature range may cause battery leakage, overheating, or serious damage, and may also impair battery performance and lifespan.
- If the charger or battery exhibits abnormal behavior or damage during charging, immediately disconnect the charger's input and output power cables.
- If the charging process cannot be completed within the specified time, stop immediately. The battery may generate heat, smoke, fire, or explosion.

- Do not charge the chassis battery during thunderstorms.
- Do not charge the chassis battery in damp, rainy, or waterlogged areas.
- Do not charge the chassis battery in areas with high temperatures, such as near heat sources or under direct sunlight.
- Charging should be performed in a well-ventilated, dust-free area.
- Do not block the air intake and exhaust ports of the charger during charging; ensure at least 10 cm of space around them.
- The charging process must be performed in the correct sequence to prevent electrical contact between the charger's connectors and the battery's charging ports, which could damage the robot battery, charger, or cause unnecessary personal injury.

6.3 Environmental Precautions

- The FW-max has an operating temperature range of -20°C~60°C. Do not use in environments below -20°C or above 60°C.
- The optimal storage temperature for the FW-max is 0°C~40°C.
- Do not store or use in environments with corrosive, flammable, or explosive gases.
- Keep away from heat and ignition sources during use and storage.
- Except for specially customized versions (with customized IP ratings), the FW-max has limited waterproofing capabilities. Do not use in environments with excessive water.

6.4 Remote Control Operation Precautions

- When operating the chassis in remote control mode, press and hold the VRB to protect the dial. Releasing VRB will automatically stop the chassis and will no longer respond to left-hand steering or right-hand throttle control.
- When the remote control's S4 stick is used to control the chassis forward, if you need to reverse the chassis, first return the S4 stick to the center position and return it to zero before attempting to reverse. Do not push it directly into reverse. The procedures for left and right turns are the same; both must be returned to the center position and returned to zero before changing direction.

- Do not turn off the remote control during normal operation. If the remote control battery is depleted and communication is lost, a protection program will be activated, and the chassis will stop after 3 seconds. Restarting the remote control will automatically restore communication and allow normal operation.

6.5 Electrical External Expansion Precautions

- The top expansion power supply current must strictly comply with the selected battery voltage and current. Do not overload.
- When the system detects that the battery voltage is below the safe level, a low-battery alarm will be activated. If the external expansion device stores important data and does not have automatic power-off recovery, please recharge it immediately.

6.6 Other

- Do not drop or invert the device during transportation or setup.
- Unauthorized disassembly is prohibited.
- Remove the battery from the remote control if it is not in use for an extended period.
- Replace tires promptly based on tread wear.
- When shipping through customs, use a thin tool to press the button inside the left hole to turn off the main battery switch.

7. Q&A

Q: The FW-max starts normally, but the chassis won't move when controlled using the remote control.

A: First, make sure the rear emergency stop switch is released. Second, make sure the SWA joystick is in remote control mode, the SWB gear is not in Park, and that VRB is pressed during operation. Finally, make sure the chassis is not charging.

Q: When controlling the FW-max using the remote control, the remote control runs out of battery, causing the chassis to stop. What should I do?

A: Please replace the remote control batteries immediately. Normal communication should be restored after replacing the batteries.

Q: The charger's green LED indicator light is off.

A: First, check that the charger's input cable is properly and securely connected, and then check for AC power.

Q: The charger's red LED indicator light is off.

A: First, check that the charger's output cable is properly and securely connected.

Check that the battery has not been used for a long time, is overly discharged, or is damaged.

Reconnect the input and output cables, leaving them at least 10 seconds apart, to determine if the charger is in a protection state.

Q: The FW-max automatically switches to parking mode after a period of no remote control or command control.

A: If the remote control and command control are normal, the FW-max automatically switches to parking mode due to a low-power mode trigger. This function is used to reduce motor current or prevent motor overload during long periods of parking on flat or sloped surfaces, thereby conserving power.

8. Specifications