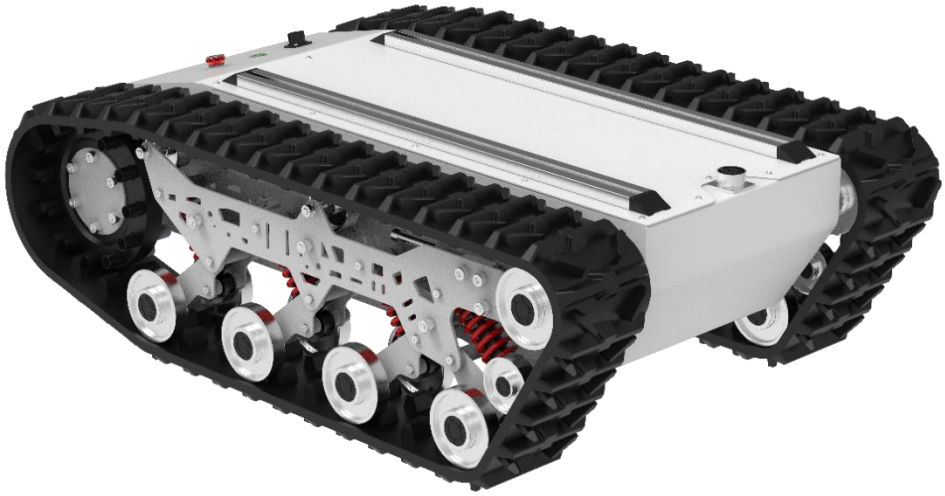
YUHESEN

TK-mid Track Differential Steering Drive-by-wire Chassis

User Manual

User manual V2.2.0



Shenzhen Yuhesen Technology Co., Ltd.

CONTENT

1. Foreword

(1) Thank you for purchasing our product, this user manual is applicable to TK-mid tracked differential steering drive-by-wire chassis (hereby referred to as "TK-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 non-metallic special screwdriver or special debugging tool 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 TK-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 IP64.

■ 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:

- Ensuring that operation is conducted in a relatively open place. And remote control shall be conducted with sight distance.
- The maximum load of TK-mid is 80KG, during use, it shall be ensured that the effective load does not exceed 80KG.
- 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:

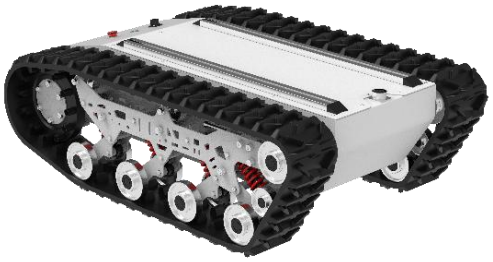
- In case of serious track wearing, please replace timely.
- If the battery will not be used for a long time, when the battery is fully charged, please charge the battery regularly in each month.
- The battery shall be charged once a month at least.

2. Introduction

TK-mid is a versatile drive-by-wire robotics mobile platform, it adopts differential steering and motor drive form. TK-mid has a relatively strong load capacity. 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 equipping with the modules of navigation systems, GPS and IMU, cameras etc., this chassis is widely used in unmanned patrol, logistics, transportation, 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*1	User Manual*1
	

2.2. Performance Parameters

Table 2 - 1 TK-mid Performance Parameter Table

Parameter type	Performance	Parameter
Structural size and weight	Dimensions(W*D*L)	1070*700*345mm
	Weight	140kg
	Drive	Differential Steering Motor Drive
	Suspension	Christie Independent suspension
	Material	Q235
	Ground clearance	103mm
	Wheelbase	570mm
	Wheel track	224mm
Basic configuration	Driving motor	1000W*2 DC brushless motor
	Battery type	48V/40AH lithium battery
	Charging time	≤4h
	Charging method	48V/10A, manual charging by charger
	External power supply	24V/15A-12V/15A
	Braking mode	Motor brake
	Parking method	Motor parking
Safety measures	Emergency stop button	√
	Command check	√
	Heartbeat protection	√
	Current protection	√
	Temperature protection	√
VCU configuration	Dominant frequency	168MHz
	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)	80kg
	Speed	0-4km/h (adjustable)
	Mileage	20km (without load)
	Minimum turning radius	0m
	Wading depth	100mm
	Maximum climbing angle	20° (full load)
	Crossing width	250mm (full load)
	Obstacle surmounting height	150mm (full load)
	Protection level	IP64
	Operating temperature	-20°C~50°C

3. Product presentation

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

Figure 3 - 1 Front Overall Figure

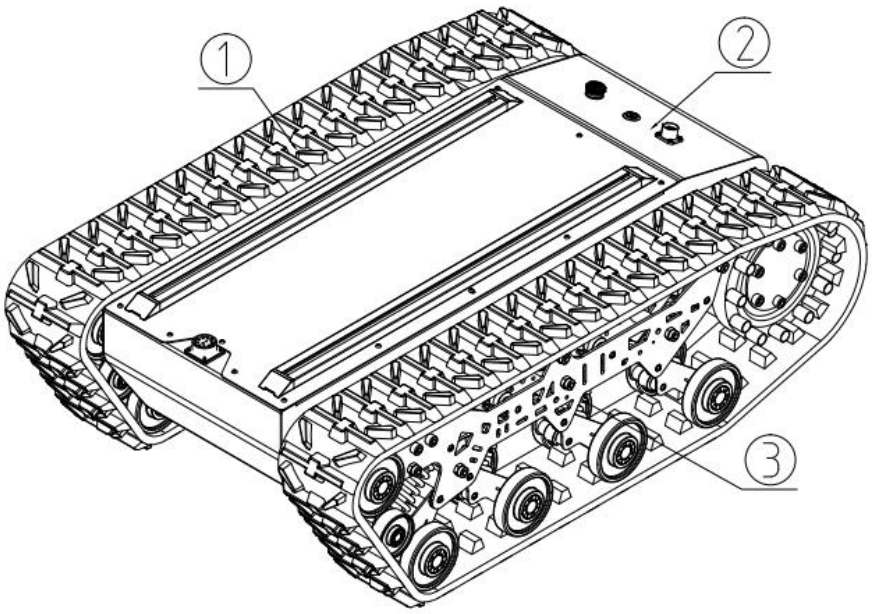
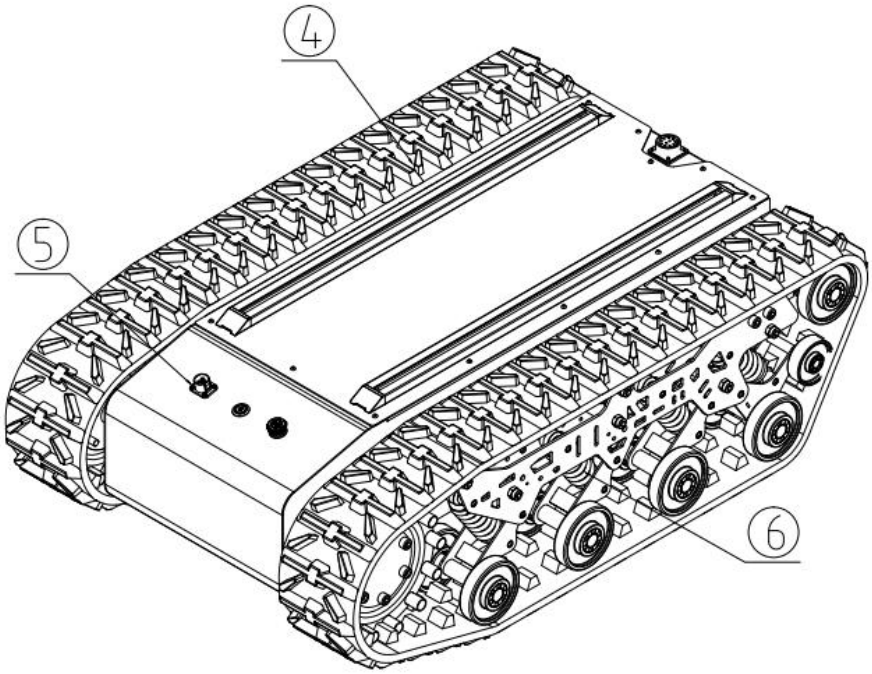


Figure 3 - 2 Tail Overall Figure



Note：①rubber track; ②tail electrical components; ③suspension system; ④rubber track; ⑤tail electrical components; ⑥suspension system;

TK-mid adopts modular design concept, with high safety and reliability. In terms of structure, it adopts a Christie suspension, which has good strength and high rigidity, and can improve the safety of the entire vehicle. It has strong impact resistance and anti bumping performance, and has strong off road capability, which can pass through various ground surfaces.

There's an emergency stop switch at the rear of the vehicle body, which can stop the vehicle from moving in a timely manner when taken in an emergency, achieving the effect of controlling the entire vehicle. At the same time, the emergency stop switch supports functional detection. If the emergency stop switch is damaged or not connected, the VCU controls the vehicle driver to not power on; Multiple protections ensure safe driving of vehicles.

Chassis integrated control, VCU conducts unified analysis and judgment of vehicle signals, forming closed-loop control, capable of fault diagnosis and timely safety protection processing, and reliably achieving remote unmanned vehicle status monitoring. 24V and 12V electrical and communication interfaces are configured on the top of the vehicle body, and standard profile fixed brackets are installed, allowing users to quickly carry out secondary development.

3.1. Function Description of Electrical Board

3.1.1. Description of top electrical board

There is an electrical panel on the top of TK-mid, and the electrical panel on the top is shown in Figure 3-3, where B1 is the emergency stop switch; B2 is the main power switch; B3 is the charging interfacce.

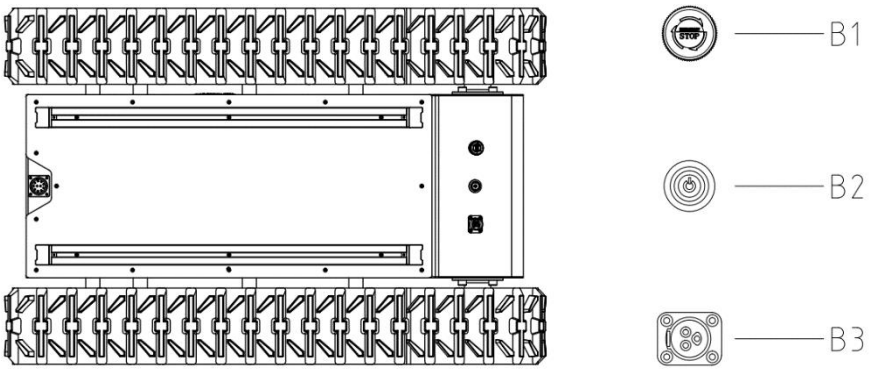


Figure 3-3 Top electrical location diagram

TK-mid is equipped with a WS32-11 core aviation plug at the top, and the electrical interface is configured with two different sets of power supplies and a set of CAN communication interfaces. The wires have been led out, making it easy for users to provide power and communication to different expansion devices. The specific location is shown in the electrical schematic diagram at the top of Figure 3-4.

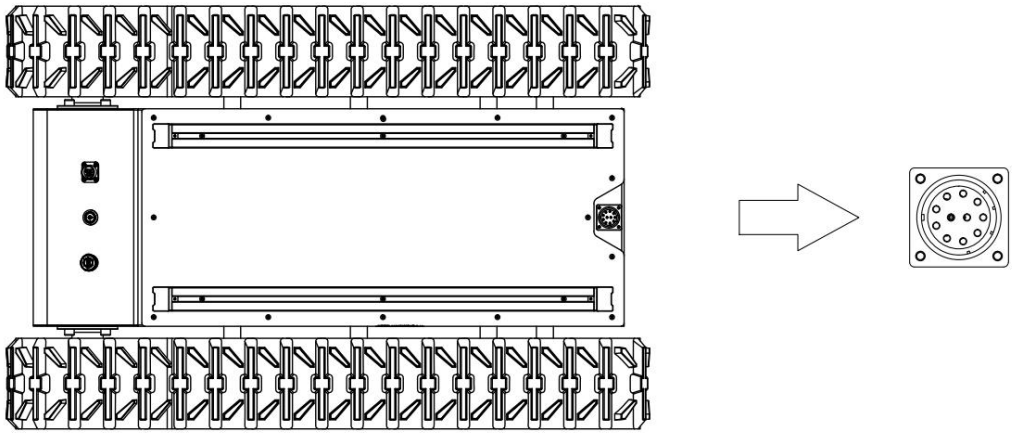


Figure 3-4 Schematic diagram of top electrical location

The specific pin definitions for the top electrical interface are shown in Table 3-1.

Table 3-1 Top Electrical Interface Pin Definition

Pin	Type	Definition	Remark
1	reserve	RS232-GND	serial port
2	power supply	48V-	48V negative pole of power supply
3		48V+	48V/10A positive pole of power supply
4		24V-	24V negative pole of power supply
5	reserve	RS232-TX	serial port
6	power supply	24V+	24V/15A positive pole of power supply
7		12V-	12V negative pole of power supply
8	reserve	RS232-RX	serial port
9	power supply	12V+	12V/15A positive pole of power supply
10	CAN	CAN_L	CANbus low
11		CAN_H	CANbus high

It should be noted that the extended power supply here is controlled internally. When the battery voltage is too low, the BMS will protect and stop the battery discharge. Users should pay attention to charging during use.

3.2. Instructions of TK-mid Remote Control

3.2.1. Instructions of TK-mid Remote Control

Each TK-mid is equipped with a FS-i6S remote control, which allows users to easily control TK-mid. In this product, the FS-i6S remote control is designed with left hand left/right direction control and right hand front/rear throttle control. Its definition and function can be referred to Figures3-5:

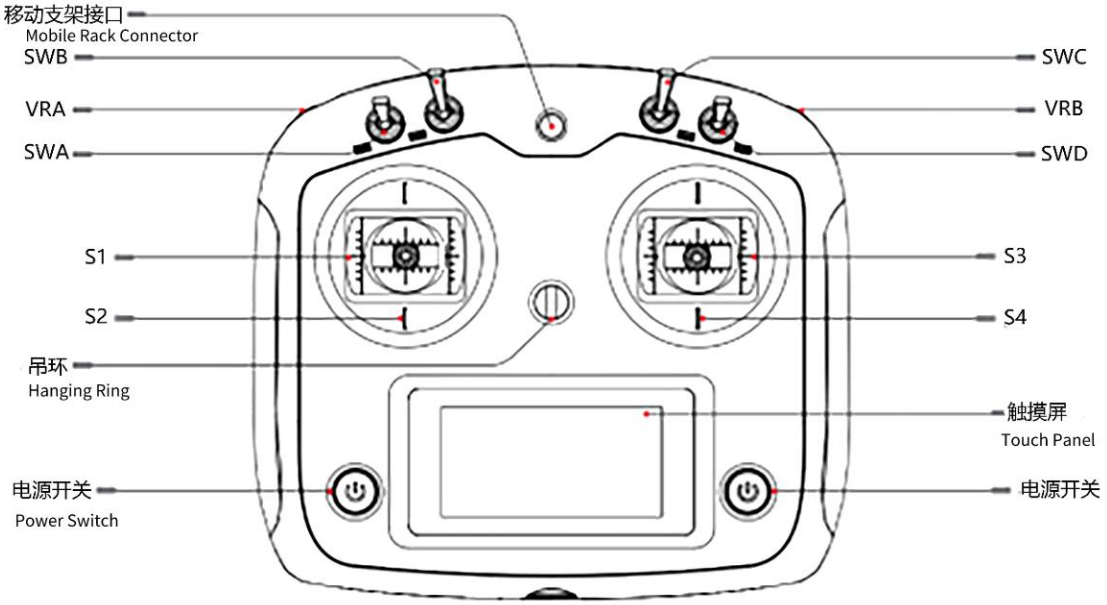


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Figure 3 -5 Schematic Diagram of WFLY ET07 Remote Controller Keys

The parameter settings of the remote control have been set before leaving the factory. Please do not modify the system settings without authorization, otherwise it may cause problems such as robot loss of control and chaos. If there are any problems, it is recommended to return to the factory for repair; The detailed operating instructions for the remote control are as follows:

(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 SWA driving lever is upward, the control mode is remote controller control mode; when the SWA driving lever is downward, the control mode is command control mode.

(2) SWC is the gear shift lever, with three gears, low speed gear when the lever is up; high speed gear when the lever is down; medium speed gear when the lever is in the center.

(3) VRA is the safety parking unlock dial, which is used to release the safety parking, the

anti-collision bar will trigger the safety parking after sensing the collision. After triggering the safety parking, toggle the VRA dial once (or pull the right rocker S4 once in the opposite direction of the collision) to release the safety parking and continue the operation.

(4) VRB is dial for operation protection. **When operating the rocker, press and hold VRB at the same time**. Otherwise, the chassis will not receive the motion command issued by the rocker.

(5) The left rocker is the direction control rocker, rocker S1 moves left-right to control the left-right steering of the chassis, rocker S2 up-down control is not enabled, and up-down toggling has no effect on the chassis movement.

(6) The right rocker is the throttle control rocker, rocker S4 moves forward and backward to control chassis forward and backward, rocker S3 left and right control is not enabled, left and right toggle has no effect on chassis motion.

(7) There is a power button on the left and right side, press and hold both power buttons at the same time, you can switch on and off the machine.

(8) The instructions of the displayed home screen are shown as below:

The start page is divided into four sections, with two timers T1 and T2 on the upper left, flight mode on the lower left, power display on the upper right, where TX is the remote control power and RX is the robot power, and the unlock button and fine-tuning button on the lower right.

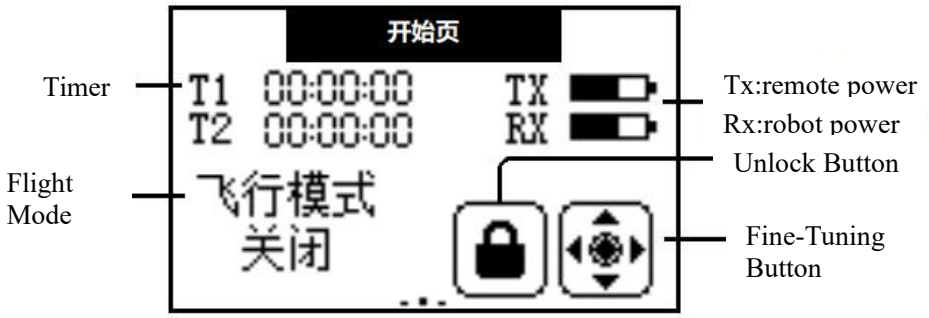


Figure 3-6 Remote Control Start Page

The left page of the remote control start page is the channel screen, as shown:

Figure 3-7 Remote Control Channel Page

Each of these channels corresponds to the operating parts of the remote control as follows:

Table 3-2 Remote Control Channel Correspondence

Channel No.	1	2	3	4	5	6	7	8	9	10
Remote controller parts	S3	S2	S4	S1	VRA	VRB	SWA	SWB	SWC	SWD

The right page of the remote control start page is the sensor list page, where the TX.V item is the remote control battery voltage, the Int.V item is the receiver voltage, the Sig.S item is the signal strength, with a normal signal strength of 10, and the Ext.V item is the robot chassis voltage, noting that the unit is V there.

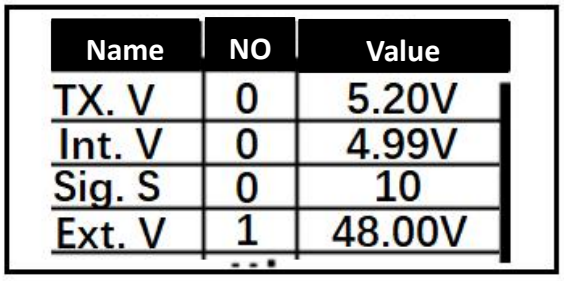


Figure 3-8 Remote Control Sensor List Page

Refer to Table 3-3 for specific SOC:

Table 3-3 Vehicle Battery Voltage vs. SOC

Vehicle Battery Voltage vs. Remaining Capacity 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）

◆ **Control of remote control and communication instructions:**

(1) When there is no remote control: after starting up, receive the communication command and operate according to the command.

(2) When the remote control and the command exist at the same time: the remote control has priority control. The equipment is controlled according to the SWA paddle mode of the remote control. The control right can be obtained by pressing the SWA paddle.

(3) When remote control only: remote control gear, controlled by remote control.

3.2.2. Remote control buzzer warning instructions

Table 3-3 Remote control alarm status description

Switch position alarm	If the SWA/SWB/SWC/SWD lever is not in the default gear during startup, an alarm interface will appear. Tips that you need to toggle all switches to up and enter the main interface normally when all switches are in the default position.
Low voltage 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.
Shutdown alarm interface	The remote control will detect if the chassis is turned off when shutting down, if the chassis is not turned off, a warning screen will pop up, and you need to turn off the chassis power in order to shut down the remote control. Also, a warning screen will pop up when the remote control is about to shut down due to low batteries.
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 unused alarm	When the remote control is left unused for a long period of time, the remote control buzzer will carry out an intermittent alarm.

3.2.3. Control instructions and motion instructions

We will establish a coordinate reference system for ground moving vehicles according to the ISO 8855 standard, as shown in Figure 3-9.

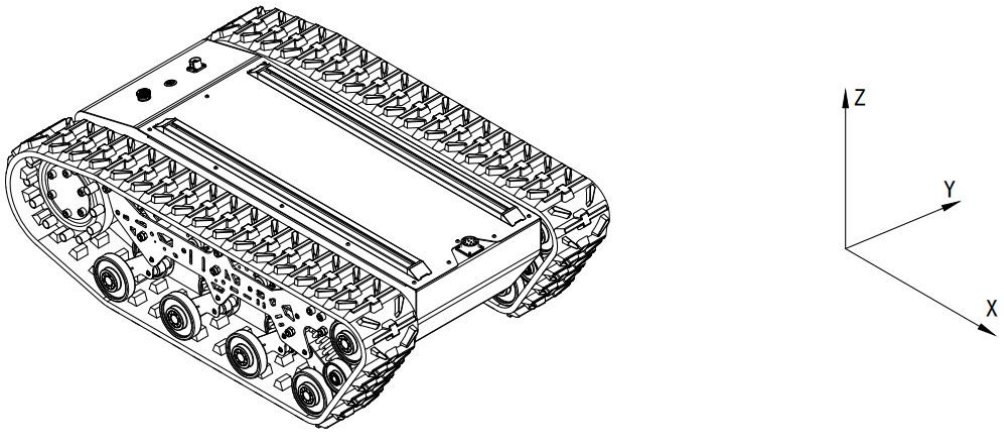


Figure 3-9 Body Coordinate System

As shown in Figures 3-6, the TK-mid vehicle body is parallel to the established reference coordinate system X-axis.

Under the remote control mode, press and hold VRB operation protection dial. When the remote control right throttle rocker S4 is pushed forward, it moves in the X positive direction. When S4 is pushed back, it moves in the X negative direction. When S4 is pushed to its maximum value, it moves in the X direction at the maximum speed. When S4 is pushed to its minimum value, it moves in the X negative direction at its maximum speed;

The remote control left directional rocker S1 controls the steering movement of the vehicle body from left to right. S1 pushes to the left, and the car turns to the left, pushing to the maximum. At this time, the left steering angular velocity is maximum. S1 pushes to the right, and the car turns to the right, pushing to the maximum. At this time, the right steering angular velocity is maximum.

4. Getting Started

This section mainly introduces the basic operation and use of the TK-mid platform, how to operate through a remote control, and how to conduct secondary development of the vehicle body through the CAN protocol.

4.1. Use and Operation

4.1.1 Remote control operation control instructions:

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 default position;

Starting

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

(2) Check the battery voltage, see if the battery voltage is normal, if the voltage is too low, please charge it first;

Shutdown operation

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

Emergency stop

Beat the emergency stop switch on the rear of the TK-mid body; turn it clockwise again to release the emergency stop knob.

4.2. Charge

The chassis of the TK-mid mobile robot is equipped with a 48V/10A 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 TK-mid is shut down and powered off, and confirm that the main power switch is off;

2) First, insert the output plug of the charger into the charging port; Then, plug the

AC plug of the charger into the 220V AC socket.

3) After charging, operate in accordance with the reserve way, 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 Description of Charger Status LED Indicators

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: The charging process must be carried out in sequence to prevent the charging port of the charger from being charged and the battery charging port from being short circuited, causing damage to the robot battery and charger, or unnecessary personal injury.

4.3. Development

4.3.1. Connection of CAN cable

The CAN wires of TK-mid have been soldered out and labeled, and users can directly connect according to the labeling, as shown in Figure 4-1 below.

Figure 4-1 Schematic diagram of CAN cable

4.3.2. CAN interface protocol

The communication in TK-mid product adopts the CAN2.0B standard, with a baud rate of 500K, and the message format adopts Intel format. The linear speed, angular speed, etc. of chassis movement can be controlled through an external CAN interface; At the same time, it will provide real-time feedback on the current motion status information and the system status information of the TK-mid chassis.

There are two control modes of motion command control: kinematics control and free control. Users can select the corresponding command control mode according to their needs, and only one mode can be used for control. The protocol content includes control frames and feedback frames, and the specific protocol content is shown in the table:

Motion Control Command - Control Frame									
Message Name			**ID**			**Type**	**Cycle (ms)**		**Length (Byte)**
ctrl_cmd			0x18C4D1D0			Cycle	10		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Target gear	Intel	0	0	Cycle	4	Unsigned	1		00: disable 01: Gear P 02: Gear N 03: Kinematics control gear
Target speed	Intel	0	4	Cycle	16	signed	0.001	m/s	0.001m/s/bit;
Target angular speed	Intel	2	20	Cycle	16	signed	0.01	°/s	(0.01°/s)/bit;
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	Cycle	4	Unsigned	1		For each frame sent, the value is incremented by 1. After reaching the maximum value, it is counted again from 0 to detect packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR

									Byte4 XOR Byte5 XOR Byte6

Free Control Instruction - Control Frame									
Message Name			**ID**			**Type**	**Cycle (ms)**		**Length (Byte)**
free_ctrl_cmd			0x18C4D2D0			Cycle	10		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Target gear	Intel	0	0	Cycle	4	Unsigned	1		00: disable 01: Gear P 02: Gear N 04: Free control gear
Left wheel target speed	Intel	0	4	Cycle	16	signed	0.001	m/s	0.001m/s/bit;
Right wheel target speed	Intel	2	20	Cycle	16	signed	0.001	m/s	0.001m/s/bit;
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	Cycle	4	Unsigned	1		For each frame sent, the value is incremented by 1. After reaching the maximum value, it is counted again from 0 to detect packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5

									XOR Byte6

I/O Control Instructions - Control Frame									
Message Name			**ID**			**Type**	**Cycle (ms)**		**Length (Byte)**
io_cmd			0x18C4D7D0			IfActive	10		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Safe parking unlock switch	Intel	0	1	IfActive	1	Unsigned	1		0 = Invalid 1 = Unlock Enable
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	Cycle	4	Unsigned	1		For each frame sent, the value is incremented by 1. After reaching the maximum value, it is counted again from 0 to detect packet loss and disconnection
Check BCC XOR checkout for message	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**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Current gear feedback	Intel	0	0	Cycle	4	Unsigned	1		00: disable 01: Gear P 02: Gear N 03: Kinematics control gear 04: Free control gear
Current vehicle linear speed feedback	Intel	0	4	Cycle	16	signed	0.001	m/s	0.001m/s/bit;
Current vehicle angular speed feedback	Intel	2	20	Cycle	16	signed	0.01	°/s	(0.01°/s)/bit;
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	Cycle	4	Unsigned	1		For each frame sent, the value is incremented by 1. After reaching the maximum value, it is counted again from 0 to detect packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Wheel Train Control Status - Feedback Frame									
Message Name			**ID**			**Type**	**Cycle (ms)**		**Length (Byte)**
l_wheel_fb			0x18C4D7EF			Cycle	10		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Current left wheel speed feedback	Intel	0	0	Cycle	16	signed	0.001	m/s	0.001m/s/bit;
Current left wheel pulse feedback	Intel	2	16	Cycle	32	signed	1	1	N pulses per wheel turn, N=encoder lines * reduction ratio
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	Cycle	4	Unsigned	1		For each frame sent, the value is incremented by 1. After reaching the maximum value, it is counted again from 0 to detect packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Wheel Train Control Status - Feedback Frame									
Message Name			**ID**			**Type**	**Cycle (ms)**		**Length (Byte)**
r_wheel_fb			0x18C4D8EF			Cycle	10		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Current right wheel speed feedback	Intel	0	0	Cycle	16	signed	0.001	m/s	0.001m/s/bit;
Current right wheel pulse feedback	Intel	2	16	Cycle	32	signed	1	1	N pulses per wheel turn, N=encoder lines * reduction ratio
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	Cycle	4	Unsigned	1		For each frame sent, the value is incremented by 1. After reaching the maximum value, it is counted again from 0 to detect packet loss and disconnection
Check BCC XOR checkout for message	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**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Safe parking unlock switch	Intel	0	1	IfActive	1	Unsigned	1		0 = invalid 1 = unlock enable
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 status 1 = Remote control status
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	Cycle	4	Unsigned	1		For each frame sent, the value is incremented by 1. After reaching the maximum value, it is counted again from 0 to detect packet loss and disconnection
Check BCC XOR checkout for message	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**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Current battery voltage	Intel	0	0	Cycle	16	Unsigned	0.01	V	0.01V/bit;
Battery current	Intel	2	16	Cycle	16	signed	0.01	A	0.01A/bit;
Current battery capacity	Intel	4	32	Cycle	16	Unsigned	0.01	Ah	0.01Ah/bit;
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	Cycle	4	Unsigned	1		For each frame sent, the value is incremented by 1. After reaching the maximum value, it is counted again from 0 to detect packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

Battery Flag Status - Feedback Frame									
Message Name			**ID**			**Type**	**Cycle (ms)**		**Length (Byte)**
bms_flag_fb			0x18C4E2EF			Cycle	100		8
Signal description	**Arrangement format**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Current remaining battery percentage	Intel	0	0	Cycle	8	Unsigned	1	%	1%/bit;
Individual overvoltage protection	Intel	1	8	Cycle	1	Unsigned	1		0 = off 1 = on
Individual undervoltage protection	Intel	1	9	Cycle	1	Unsigned	1		0 = off 1 = on
Whole group overvoltage protection	Intel	1	10	Cycle	1	Unsigned	1		0 = off 1 = on
Whole group undervoltage protection	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**	**Starting byte**	**Start bit**	**Signal transmission type**	**Signal Length**	**Data type**	**Accuracy**	**Unit**	**Signal value description**
Fore-end IC error detection	Intel	2	19	Cycle	1	Unsigned	1		0 = off 1 = on
Software locked MOS	Intel	2	20	Cycle	1	Unsigned	1		0 = off 1 = on
Charging flag position	Intel	2	21	Cycle	1	Unsigned	1		0 = discharge 1 = charge
The highest temperature of battery	Intel	3	28	Cycle	12	signed	0.1	℃	0.1℃/bit;
The highest temperature of battery	Intel	5	40	Cycle	12	signed	0.1	℃	0.1℃/bit;
Alive Rolling Counter Heartbeat signal (loop counter)	Intel	6	52	Cycle	4	Unsigned	1		For each frame sent, the value is incremented by 1. After reaching the maximum value, it is counted again from 0 to detect packet loss and disconnection
Check BCC XOR checkout for message	Intel	7	56	Cycle	8	Unsigned	1		Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

4.3.3. Instructions for using CAN communication protocol

1.Precautions during the testing process:

1.1 During the sending process, note that AliveCounter needs to continuously change and send in a cyclic manner.

1.2 During the process of sending AliveCounter, pay special attention to the four bits occupied by AliveCounter ranging from 52 to 55.

1.3 The check bits of BYTE [7] are XOR checks of the first 7 Bytes: Checksum = Byte0 XOR Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6

1.4 The following routine is a simple control command for issuing commands using USB CAN. Please control and issue commands according to the communication protocol when controlling the vehicle.

1.5 During the testing process, switch the remote control to command control mode or turn off the remote control.

1.6 During the testing process of using a computer to connect the CAN analyzer, due to the possibility of testing vehicle movement and other situations, please set up the vehicle during the testing process and let it down when using the program to test after the vehicle has stabilized.

1.7 During the road test, as the remote control has the highest priority, it is best to turn on the remote control for testing to facilitate switching to remote control mode at any time during the testing process.

2.Vehicle control command description ctrl_cmd

The vehicle control command needs to send corresponding commands, heartbeat signals, and check bits simultaneously.

(1) Target gear request ctrl_cmd_gear

ctrl_cmd_gear command is the target gear signal, with a physical value range of 00 to 03. The default gear position is 00, which is the disable gear; When the target gear is set to 01, it is in parking gear; When the target gear is given 02, it is in neutral; When the target gear is set as 03, it is the kinematics control gear.

Example: when the target gear request is kinematics control gear - 03 0x03

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

0x18C4D1D0	0x03	0x00	0x00	0x00	0x00	0x00	0x10	0x13
0x18C4D1D0	0x03	0x00	0x00	0x00	0x00	0x00	0x20	0x23
0x18C4D1D0	0x03	0x00	0x00	0x00	0x00	0x00	0x30	0x33

Note: The above three frames of signals are sent circularly every 10ms, and the control gear can be switched to the kinematics control gear.

Feedback:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1EF	0x03	0x00	0x00	0x00	0x00	0x00	0x00	0x03

Note: Checksum and Alivecounter cyclic change.

(2) Target speed request ctrl_cmd_liner

ctrl_cmd_liner command is the target value for driving the vehicle's liner speed. The physical value range of CAN communication is -32.767 to 32.767 m/s (with a maximum speed of 4.5 m/s for a 50 speed ratio and a 400mm wheel diameter). The target line speed is determined by the vehicle speed accuracy (0.001 m/s/bit). The target line speed of the driving vehicle is 0.001 * bus signal. The vehicle is used in combination with gears for forward and backward movement.

There are three types of vehicle speed feedback methods, namely:

1) Current vehicle speed feedback: This vehicle speed feedback is always positive.

2) Left and right wheel speed feedback: The vehicle speed corresponding to the current left and right wheels is positive when moving forward and negative when moving backward.

3) Feedback of left and right wheel pulse number: Forward is the accumulation of pulses, and backward is the accumulative decrease of pulses.

Example: Given a forward speed request of 1m/s, the bus signal is equal to 1000 0x03E8

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1D0	0x83	0x3E	0x00	0x00	0x00	0x00	0x00	0XBD
0x18C4D1D0	0x83	0x3E	0x00	0x00	0x00	0x00	0x10	0XAD
0x18C4D1D0	0x83	0x3E	0x00	0x00	0x00	0x00	0x20	0x9D

Note: The above three frames of signals are issued in cycles with an interval of 10ms, which can control the vehicle to move forward at a speed of 1m/s.

Feedback:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D2EF	0x83	0x3E	0x00	0x00	0x00	0x00	0x00	0xBD

Note: Checksum and Alivecounter cyclic change. Due to the automatic adjustment of the operating speed, the feedback may not be absolute 1m/s.

The left front wheel speed and left front wheel pulse feedback ID: 0x18C4D6EF

The left front wheel speed and left front wheel pulse feedback ID: 0x18C4D7EF

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

The right rear wheel speed and pulse feedback ID: 0x18C4D9EF

(3) Target angular speed ctrl_cmd_angular

ctrl_cmd_angular command is the target angular velocity request, with a physical range of (-327.68) degrees to (327.67) degrees for CAN communication. The left turn is positive, and the right turn is negative. The target angular velocity is determined by the accuracy (0.01 °/s)/bit. Target angular velocity=bus signal * 0.01

Example: Given a target angular velocity of -25 °/s, the bus signal is equal to -2500 0XF63C

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1D0	0x03	0x00	0XC0	0x63	0x0F	0x00	0x00	0xAF
0x18C4D1D0	0x03	0x00	0XC0	0x63	0x0F	0x00	0x10	0xBF
0x18C4D1D0	0x03	0x00	0XC0	0x63	0x0F	0x00	0x20	0x8F

Note: The above three frames of signals are sent in cycles with an interval of 10ms, and the angular velocity can be requested to be -25 °/s.

Feedback:

ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x18C4D1EF	0x03	0x00	0XC0	0x63	0x0F	0x00	0x00	0xAF

Note: Checksum and Alivecounter cyclic change.

3.Description of auxiliary component control instructions

Taking the safe parking unlock switch as an example, the IO port enabling control needs to send the enabling flag bit, heartbeat signal, and check bit simultaneously.

Example: io_cmd_unlock safe parking 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: If the above signals (falling edge) are issued at an interval of 20ms, it can be requested to unlock the safety stop switch.

Feedback:

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

Note: Checksum and Alivecounter cyclic change.

5. Attention

This section contains some precautions to be taken when using and developing TK-mid.

5.1. Attentions for Battery

▲ When the TK-mid product leaves the factory, the battery may not be fully charged. The specific battery level can be read through the remote control voltage display or the CAN bus communication interface. The charging time is indicated by the green indicator light on the charger indicating that the charging is complete;

▲ Please do not charge the battery after it has been completely used up. When the battery voltage is too low, please charge it in a timely manner;

▲ The operating temperature of the battery under discharge condition is for -20℃~50℃. The battery can work normally within the specified temperature range and the capacity loss is within the error range;

▲ During use, excessive discharge of the battery is prohibited to avoid damage to the battery.

▲ Avoid excessive shock to the battery, out of gauge shocks may damage the battery which may result in leakage, heat, smoke, fire or explosion;

▲ If you notice an obvious abnormality in the battery, stop using the battery immediately!

5.2. Attentions for Charging

▲ It is necessary to use a dedicated battery charger for charging. Do not use batteries, power supplies, or chargers that are not standard from the original factory at will;

▲ Charge only at 0°C~45°C. Charging outside of this temperature range may cause the battery to leak, heat up, or cause serious damage. It may also cause deterioration in the performance and life of the battery;

▲ When charging, if the charger or battery is abnormal or damaged, please immediately unplug the input power cord and output power cord of the charger;

▲ If the charging process cannot be completed within the specified time, the charging process should be stopped. The battery may generate heat, smoke, and catch fire (or explode);

▲ It is strictly prohibited to charge the vehicle battery in thunderstorm weather;

▲ It is strictly prohibited to charge the vehicle battery in damp or rainy areas;

▲ It is strictly prohibited to charge the vehicle battery in areas with high temperatures such as heat sources and direct sunlight;

▲ Charging should be carried out in a ventilated and dust-free area;

▲ During charging, it is strictly prohibited to block the air inlet and outlet of the charger, leaving at least 10cm of space;

5.3. Attentions for Usage Environment

▲ The working temperature of TK-mid is -20 ℃~50 ℃. Do not use it in environments with temperatures below -20 ℃ or above 50 ℃;

▲ Do not store or use in environments with corrosive, flammable, and explosive gases;

▲ Do not store or use near heat or ignition resources;

▲ Except for the specially customized version (IP protection level customization), MID-001 has limited waterproof function. Please do not use it in waterlogged environments at will;

5.4. Attentions for Remote Control Operation

▲ Under the remote control mode, all chassis motion control requires holding down the VRB operation protection dial. When the VRB is released, the chassis will automatically stop and no longer respond to left hand direction and right hand throttle rocker control.

▲ Emergency stop knob is released; the throttle remote lever is returned to the zero position, i.e.: the chassis speed is in the 0 state;

▲ When the S4 remote lever at the remote control end is pushed forward to control the vehicle's forward movement, if it is necessary to perform a reverse operation on the vehicle body, the S4 remote lever should be reset to zero before proceeding with the reverse operation. It is prohibited to quickly shift to the reverse gear when pushing forward; The operation of left and right turn control is the same, and both sides need to return to center and return to zero before changing direction.

▲ Do not turn off the power supply of the remote control terminal during normal driving of the vehicle. When the remote control terminal runs out of battery and

communication is interrupted, the protection program will be activated, and the chassis will stop walking after 3 seconds; After the remote control is powered on again, communication will automatically resume and it can be used normally.

5.5. Attentions for External Electrical Extension

▲ The current of the top expansion power supply should be strictly used according to the selected battery voltage and current, and should not be overloaded;

▲ When the system detects that the battery voltage is lower than the safe voltage, it will start the protection program. If the external expansion device involves the storage of important data and there is no automatic power down storage function, please charge it in a timely manner.

5.6. Other Attentions

▲ Do not fall or invert during handling and setting up operations;

▲ Non professional personnel, please do not disassemble without permission;

▲ If the remote control terminal is not used for a long time, the dry battery should be removed;

▲ The track should be replaced in a timely manner based on the wear of the tread pattern.

6. Q&A

Q: TK-mid starts normally, use the remote control to control the vehicle body not to move?

A: Firstly, confirm whether the rear emergency stop switch has been released;

Check if the remote control SWA is in the remote control mode again;

Then check if the V2 operation protection dial is simultaneously pressed during operation.

Q: Using the remote control to control the TK-mid, what should I do when the remote control runs out of power and the car stops running?

A: Please replace the remote control batteries immediately. Normal communication can be resumed after replacing the batteries.

Q: Charger LED 1 and LED 2 indicator lights are not on

A: Please first check if the input line interface of the charger is connected correctly and securely;

Check again for AC input.

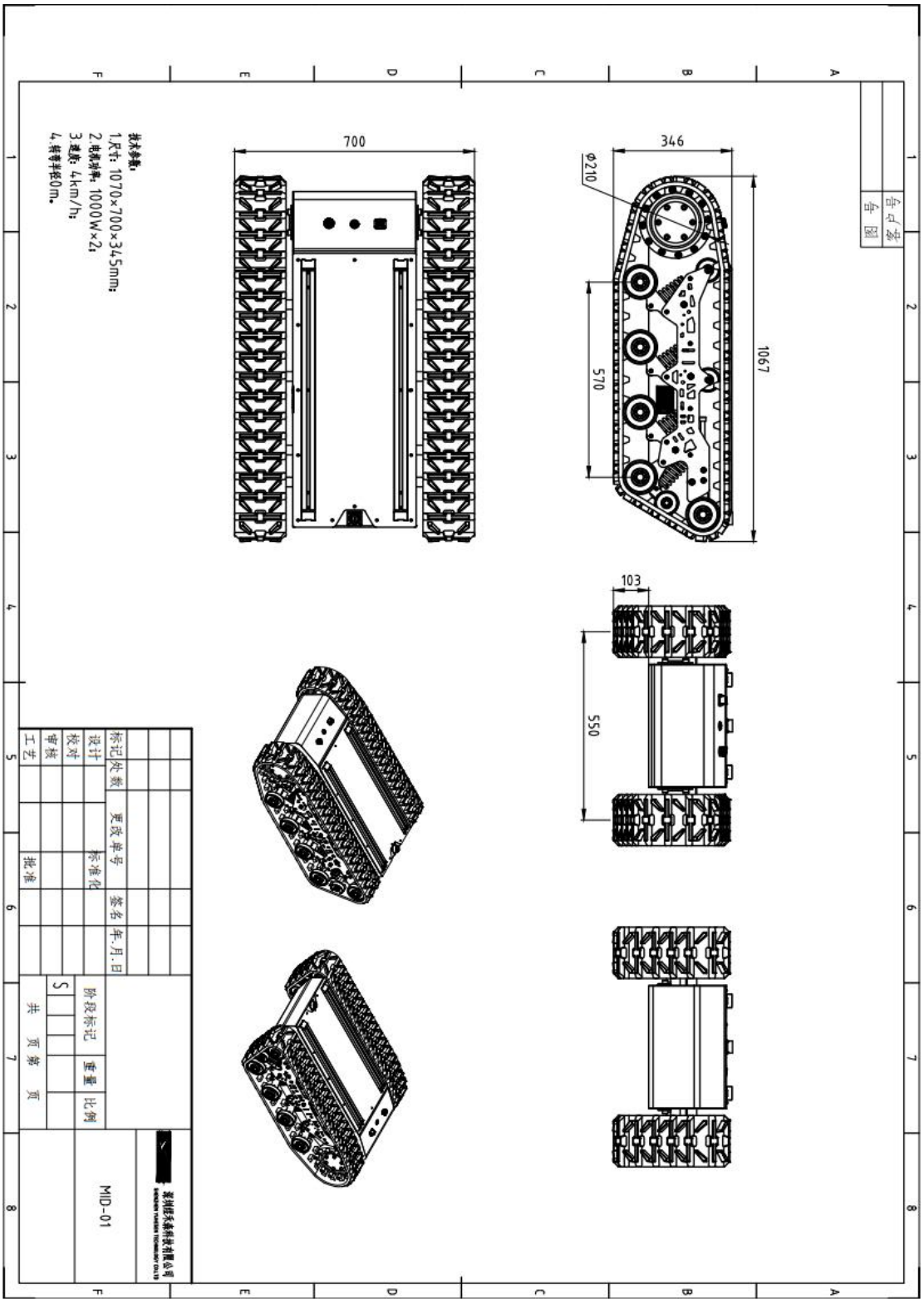
Q: Charger LED 2 indicator light (red light) does not light up

A: Please first check whether the output line interface of the charger is connected correctly and firmly;

Whether the battery has not been used for a long time, discharged excessively, or damaged;

Reinsert and unplug the input and output cable plugs, with an interval of more than 10 seconds, to determine whether the charger is in a protected state.

7. TK-mid Drawing



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