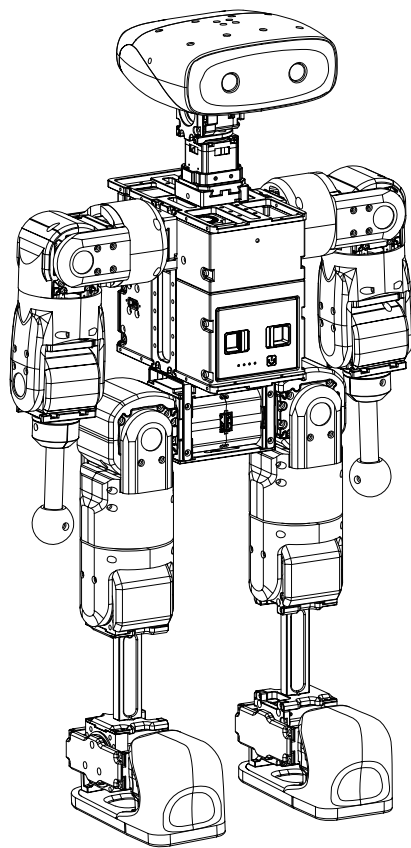


Mini Pi+ Robot

User Manual



HIGH TORQUE
高擎机电

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I. Disclaimer

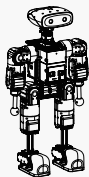
- ◎ This manual is compiled by Guangzhou High Torque Electromechanical Technology Co., Ltd. (hereinafter referred to as High Torque) With the aim of helping users use this product correctly and safely Please read this manual carefully before using the product for the first time and operate it strictly in accordance with the instructions.
- ◎ Once this product is used, the user shall be deemed to have read, understood, and accepted all the terms and conditions set forth in this manual, including but not limited to the safety instructions for use, usage restrictions, and disclaimers.
- ◎ If the user violates the operating specifications in this manual, or modifies the system configuration,intended use, or other aspects of the product without authorization, High Torque shall not bear any legal liability for personal injury, property damage, or other adverse consequences arising therefrom.
- ◎ The user undertakes to be responsible for their own actions and independently bear all legal consequences arising from the use of this product.
- ◎ The user shall use this product solely for legal and compliant purposes, and shall not use it for any acts that violate laws and regulations, infringe upon the legitimate rights and interests of third parties, or endanger public safety. Otherwise, High Torque shall have the right to terminate its after-sales support and services, and pursue legal liability in accordance with the law.
- ◎ To the maximum extent permitted by law, High Torque makes no express or implied warranties regarding this product, including but not limited to warranties of merchantability, fitness for a particular purpose, or non-infringement of third-party rights.
- ◎ To the maximum extent permitted by law, High Torque shall not be liable for any direct, indirect, incidental, or consequential damages arising from the use, inability to use, or improper use of the product. It shall also not be liable for any claims arising from product performance issues, service delays, interruptions, or errors, including but not limited to loss of profits, business interruption, or loss of information, even if High Torque has been notified of the possibility of such damages.
- ◎ The total amount of any compensation liability that High Torque may bear to the user in respect of this product (whether based on contract, tort, or other legal grounds) shall be capped at the actual purchase price paid by the user for the product.
- ◎ Given that the product may undergo continuous optimization and upgrades, there may be discrepancies between the functions, appearance, parameters, etc., listed in this manual and the actual product. The physical product shall prevail. This manual does not constitute a legally binding commitment regarding product performance.
- ◎ When using this product, the user shall strictly comply with the laws and regulations of the place where the product is used, including but not limited to provisions on safe use, transportation, import, and export restrictions. The user shall not use this product for any dangerous purposes, including but not limited to harming humans or animals, or modifying it into a weapon.
- ◎ If the user violates applicable laws and regulations or these terms, the warranty rights for the purchased product shall automatically become invalid, and High Torque Robotics shall have the right to refuse to provide any subsequent technical support, maintenance, or replacement services.
- ◎ High Torque reserves the right to update, modify, or terminate these terms as needed, without prior notice. The updated terms shall take effect from the date of publication.
- ◎ The right to interpret the content involved in this manual shall belong to High Torque, and the manual shall be implemented in accordance with the relevant laws and regulations of the People's Republic of China.

II. Safety Instructions

- ⊙ Please place the robot on a flat and stable surface to avoid falling and damage.
- ⊙ Do not insert fingers or other objects into the robot's joints to prevent pinching injuries.
- ⊙ Avoid placing robots in damp or dusty environments to prevent damage to electronic components.
- ⊙ To extend the product's service life, do not use this product in high-temperature or high-pressure environments for a long time.
- ⊙ When using the robot (especially when it is not protected by a protective frame or safety rope), ensure the robot remains within your line of sight. The robot must maintain a safe distance from crowds (especially the elderly, weak, disabled, pregnant women, and children), obstacles, complex ground surfaces, water bodies, and other objects!
- ⊙ The robot is not waterproof. Do not use it on wet ground or in rainy, snowy weather.
- ⊙ The robot is not dustproof. Do not use it in gravel or dusty environments.
- ⊙ Do not use the robot in severe weather conditions, such as fog, snow, rain, lightning, sandstorms, storms, tornadoes, etc.
- ⊙ Do not use the robot in environments with electromagnetic interference, including but not limited to high-voltage transmission lines, high-voltage substations, mobile phone base stations, and TV broadcasting towers.
- ⊙ Do not use the robot in scenarios where multiple wireless communication devices are in operation.
- ⊙ Controllers vary in their operating proficiency. To ensure stability, use the robot in a flat and open environment.
- ⊙ Do not suddenly push or kick the robot with force, as this may cause it to fall and be damaged; such damage will not be covered by the warranty.
- ⊙ If the robot needs to be on standby for a long time, hoist it on a protective frame.
- ⊙ When the battery level is too low or the battery overheats, stop and turn off the robot in a timely manner.
- ⊙ The robot is only for use by persons aged 14 and above.
- ⊙ The robot must not be used by persons with physical, sensory, or intellectual disabilities, nor by persons without relevant experience, skills, or knowledge.
- ⊙ All parts and accessories of the robot must be correctly installed and used in accordance with the User Manual. Improper installation or use may pose risks during operation.
- ⊙ Before use, check whether the lithium battery and power adapter are damaged. Do not use the product if the lithium battery or power adapter is damaged.
- ⊙ The interior of the product and the power adapter contain live components. Do not immerse them in water or other liquids for cleaning. Wipe the robot body, cameras, and other sensors with a dry cloth, and wait until they are completely dry before use.
- ⊙ Charge the product in accordance with the instructions in the manual. Incorrect charging may damage the battery.
- ⊙ During charging, if there is an unusual odor, smoke, overheating, discoloration, or deformation, immediately unplug the charger from the robot and stop using the robot.
- ⊙ If the battery leaks and the electrolyte gets into the eyes, do not rub the eyes; rinse the eyes with clean water and seek medical treatment immediately

III. Package List

Essentials



1 Complete Robot



1 Battery



1 Charging Chamber



1 Zero-Position
Bracket



1 Control Handle



1 USB-to-CANFD
Debugging Board



2 XT 30 (2+2)
Wires



1 Charging Head



1 Type-C Charging
Cable



1 Screwdriver



4 Hexagon Allen
Wrenches



1 Rolling Luggage



1 Copy of Shipping
Confirmation Form

PART 01

Product Introduction

IV. Product Overview

1. Product Information

© **Product Name:**Low-Cost Modular Open-Source Mini Pi+

© **Product Introduction:**The Mini Pi+ is a low-cost, modular, open-source humanoid platform independently developed and manufactured by High Torque Electromechanical. It features 22 degrees of freedom (for the gripper- free version), with a self-weight of approximately 10kg and a height of around 65cm. As a secondary development platform that combines high cost-effectiveness, high performance, and high expandability, it is widely applicable to scenarios such as scientific research and development, educational practice, and individual maker projects. It assists users in algorithm verification and system integration development in fields including motion control, reinforcement learning, perceptual cognition, and behavior planning.

© **ROS Version:** ros-noetic-desktop

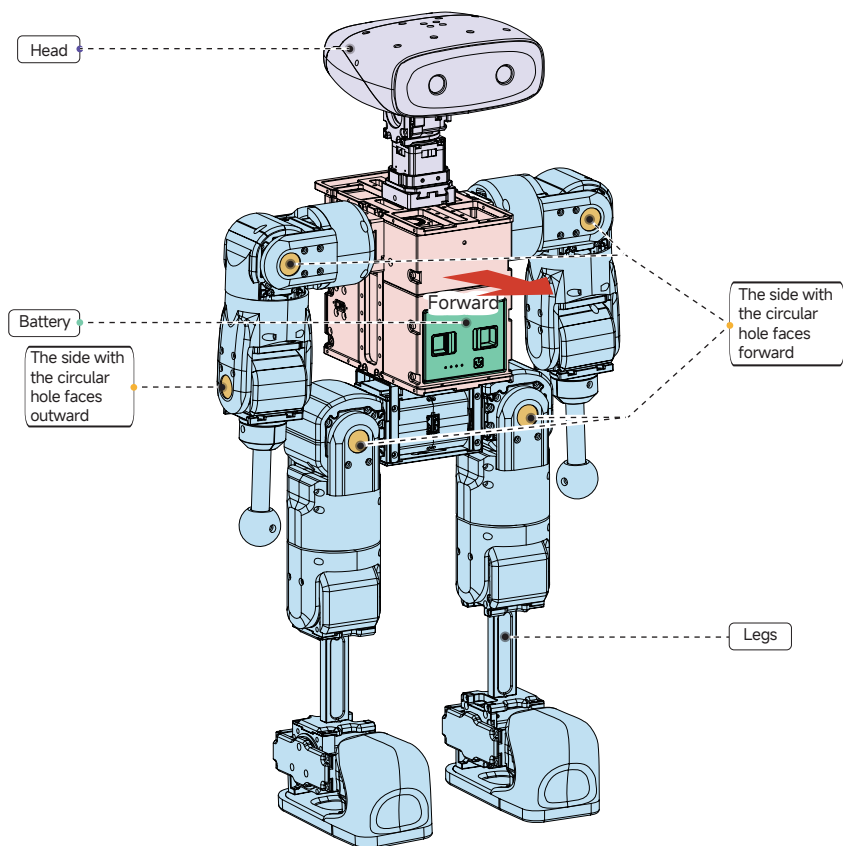
© **Operating System:** Ubuntu_20.04_desktop_arm

© **User name and Password**

Version	Pi+	Pi+ Pro
user name	hightorque	nvidia
operation password	ht	nvidia

2. Product Composition

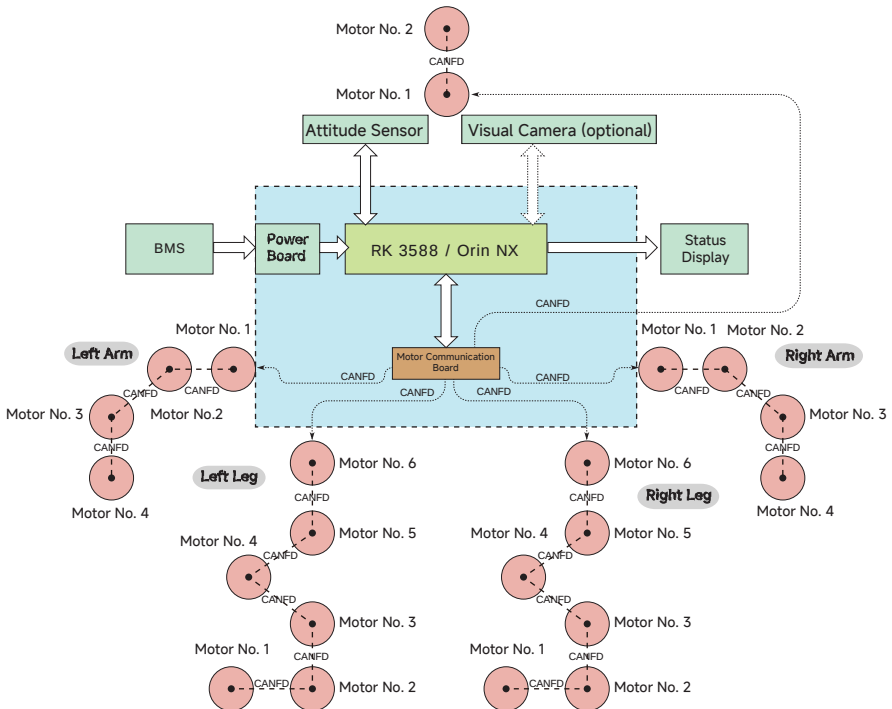
2.1 External Structure



Note: The identification method for the gripper version is the same.

2.2 Main Control Hardware System

The core of the basic version system is RK3588, which communicates with multiple motors through the motor communication board and transmits data using the CAN FD protocol.



2.2.1 Main Control

The main controller of Mini Pi+ consists of four parts: the RK3588 core board, RK3588 base board, power board, and IMU. It provides a variety of interfaces and supports the expansion of interfaces for microphones, fans, WiFi network cards, displays, speakers, and more.

Main Controller Parameters of Mini Pi+:

- CPU:	8-core 64-bit (4-core A76 + 4-core A55), with a maximum frequency of 2.4GHz
- GPU:	ARM Mali-G610
- Memory:	16+128G
- NPU:	6T

The main controller of Mini Pi+ Pro consists of the Jetson Orin NX and the HYAI-311UAV_O_V10 artificial intelligence development board. It provides a variety of interfaces and supports the expansion of interfaces for microphones, fans, WiFi network cards, displays, audio, and more.

Main Controller Parameters of Mini Pi+ Pro:

- CPU:	8-core Cortex-A78AE (64-bit) Armv8.2 heterogeneous multiprocessor architecture, with a maximum frequency of 3.2GHz
- GPU:	NVIDIA CUDA
- Memory:	16+128G
- NPU:	256T

IMU Attitude Angle Indicators

Parameters		Typical Value	Remarks
Roll Angle	Accuracy	0.15°	1σ RMS,25°C
	Range	±180°	
Pitch Angle	Accuracy	0.15°	1σ RMS,25°C
	Range	±90°	
Unreferenced Heading Angle	Accuracy	0.2°	1σ RMS,25°C
	Range	±180°	
Angular Resolution		0.001°	

IMU Gyroscope Indicators

Parameters	Typical Value	Remarks
Range	$\pm 2000^{\circ}/s$	
Non-Linearity	$\pm 0.05\%FS$	
Noise Density	$0.005^{\circ}/s/\sqrt{Hz}$	
Bias Instability	$6^{\circ}/h$	Allan variance @ 25°C (1 σ)
Bandwidth (-3dB)	50Hz	
Zero Offset	$\pm 1^{\circ}/s$	1 σ RMS, 25°C
Zero Drift with Temperature	$\pm 1^{\circ}/s$	1 σ RMS, -40~85°C

2.2.2 Joint Module

The humanoid robot Mini Pi+ is equipped with self-developed planetary series servo motors by High Torque throughout its body, featuring strong torque and load capacity. It has a total of 22 degrees of freedom (the gripper version has a total of 26 degrees of freedom for the whole body).

There are 2 units of HTDW-3536-32-NE in the head.

The detailed parameter introduction of HTDW-3536-32-NE is as follows:

- Reduction ratio: 32	- Rated Current: 0.35A
- Voltage Range: 12-48V	- Peak Current: 2.6A
- Peak Torque: 3.7Nm	- Rated Torque: 0.6Nm
- Rated Rotational Speed: 60RPM	- No-Load Speed: 110RPM
- Communication Baud Rate: 5Mbps	- Control Frequency: 3KHz
- Speed Control Accuracy: ±15%	- Response Time: ≤200μs

The 4-degree-of-freedom (DOF) ball-hand version hand is equipped with a total of 8 units of HTDW-4438-30-NE (the gripper version is equipped with a total of 12 units).

The detailed parameter introduction of HTDW-4438-30-NE is as follows:

- Reduction ratio: 30	- Rated Current: 1A
- Voltage Range: 12-48V	- Peak Current: 5A
- Peak Torque: 10Nm	- Rated Torque: 2Nm
- Rated Rotational Speed: 45RPM	- No-Load Speed: 75RPM
- Communication Baud Rate: 5Mbps	- Control Frequency: 3KHz
- Speed Control Accuracy: ±15%	- Response Time: ≤200μs

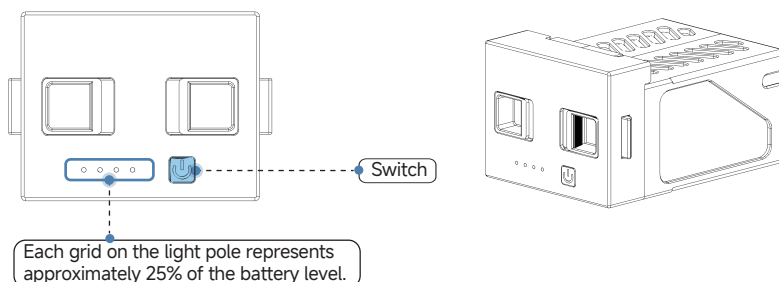
The legs are equipped with a total of 12 units of HTDW-5047-36-NE, among which the No. 4 motor of a single leg is the crossed roller version.

The detailed parameter introduction of HTDW-5047-36-NE is as follows:

- Reduction ratio: 36	- Rated Current: 2A
- Voltage Range: 12-48V	- Peak Current: 10A
- Peak Torque: 16Nm	- Rated Torque: 4Nm
- Rated Rotational Speed: 40RPM	- No-Load Speed: 60RPM
- Communication Baud Rate: 5Mbps	- Control Frequency: 3KHz
- Speed Control Accuracy: ±15%	- Response Time: ≤200μs

2.2.3 Battery

The battery equipped on the humanoid robot Mini Pi+ is the self-developed HTB-24 lithium battery by High Torque.



Parameter Information:

- Battery Capacity: **5000mAh**
- Output Voltage: **24V**
- Output Current: **It can continuously output a current of 20A, and can output an instantaneous peak current of over 60A.**

- ⦿ **Charge and Discharge Protection:** Equipped with overvoltage, overcurrent, and reverse connection protection mechanisms to ensure safe and stable charging. It also supports over-discharge, overcurrent, and short-circuit protection to prevent battery damage.
- ⦿ **Automatic Discharge:** When the battery remains fully charged for more than 1 day, it will automatically discharge to approximately 97%; if fully charged for more than 7 days, it will automatically discharge to around 60% for storage.
- ⦿ **Thermal Balance:** It can evenly regulate the heat generated during operation, effectively preventing the battery cells from performance degradation caused by excessively rapid temperature rise.

2.2.4 ZED mini/D435i Camera (Optional)

D435i Camera Parameters:

- Field of View Distance: **0.3-3m** - Output Resolution: **Up to 1280x720 at 30fps**
- Field of View Angle: **85.2°x58°x94°(+/-3°)** - Output Frame Rate: **90fps**
- Dimensions: **90mmx25mmx25mm**

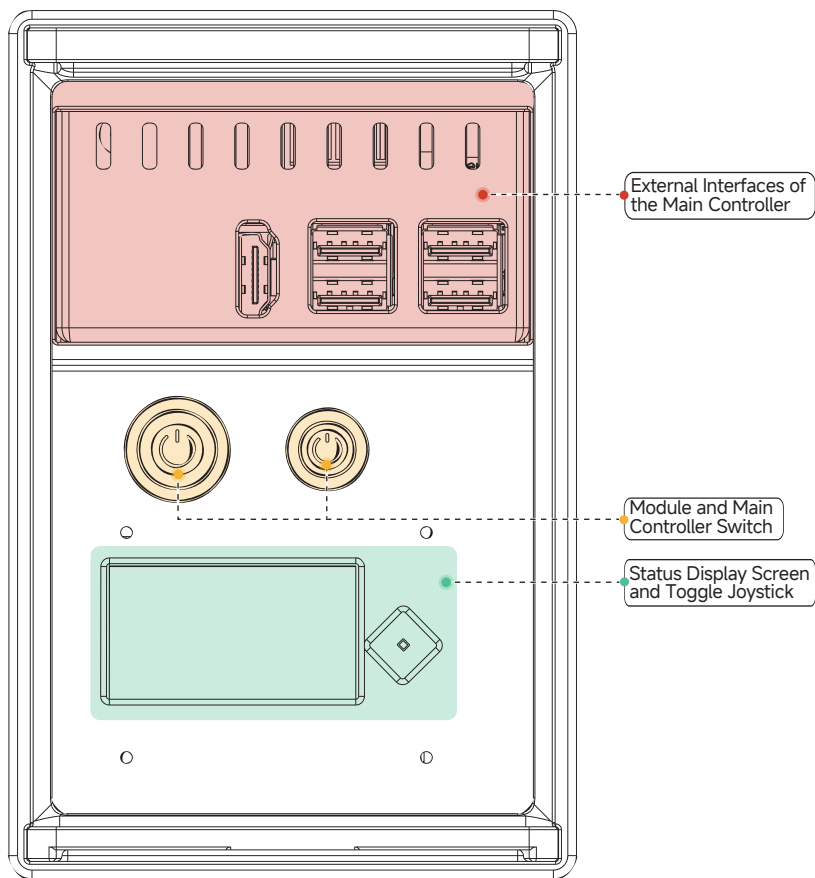
ZED mini Camera Parameters:

- Field of View Distance: **0.1-15m** - Output Resolution: **Up to 4416x1242 (2K) at 15fps**
- Field of View Angle: **90°x60°x100°** - Output Frame Rate: **100fps**
- Dimensions: **124.5 mmx30.5 mmx26.5mm**

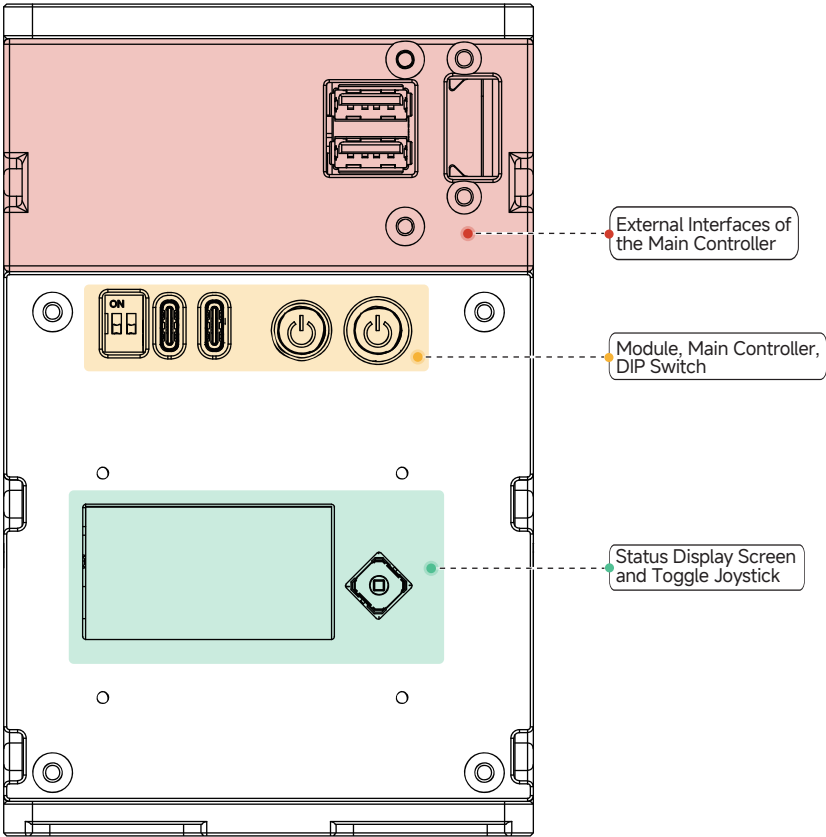
3. Backplane Description

3.1 Overview of Mini Pi+ Backplane

Mini Pi+ RK3588 Version:

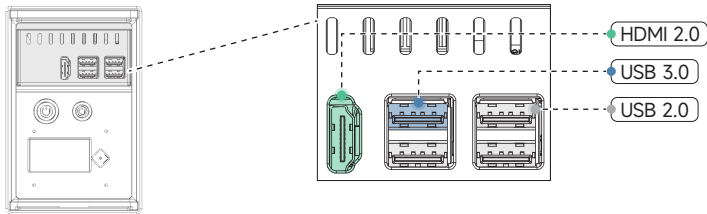


Mini Pi+ Pro Orin Version:

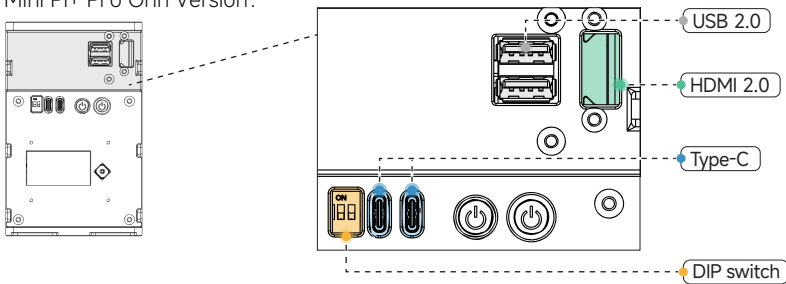


3.2 External Interfaces of Mini Pi+ Main Control

Mini Pi+ RK3588 Version:



Mini Pi+ Pro Orin Version:



Parameter Information:

- CAN Baud Rate: **1Mbps**
- CANFD Baud Rate: **5Mbps**
- Serial communication speed: **4Mbps**

◎ Feature Introduction:

- Output up to 4 channels of CANFD information through SDK, with each channel capable of controlling up to 20 motor modules.
- Use software algorithms to control the overall hardware system and achieve robot attitude control.

◎ IMU external interface:

The Type-C interface on the left is the external interface of the IMU.

◎ External interface of communication board:

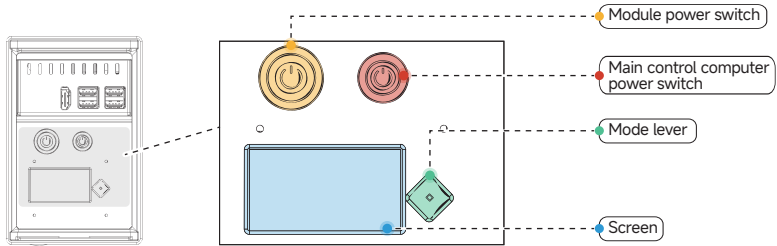
The Type-C interface on the right is the external interface of the communication board.

◎ DIP switch:

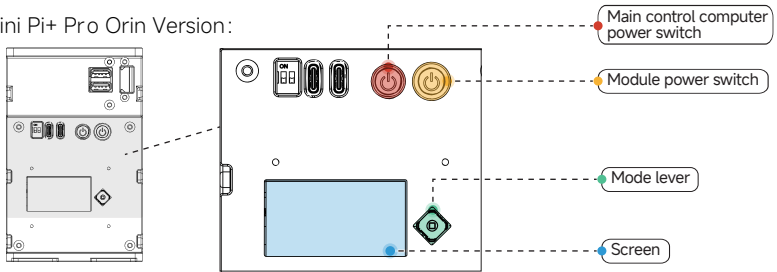
- The switch corresponds to the Type-C interface on the right; the switch 2 corresponds to the Type-C interface on the left.
- When both Switch 1 and Switch 2 are toggled down to the "Off" position, it serves as the internal system computing power input.
- When both Switch 1 and Switch 2 are toggled up to the "On" position, it serves as the external main controller computing power input.

3.3 Buttons on Mini Pi+ Backplane

Mini Pi+ RK3588 Version:



Mini Pi+ Pro Orin Version:



⦿ Module power switch:

- Power on: Short press the switch button to turn on the power of the joint module, and then turn on the lights
- Power off: Short press the switch button to turn off the power of the joint module, and the switch light will turn off after turning off

⦿ Main control computer power switch:

- Power on: Press the power button for more than 2 seconds and then release it. When turned on, the switch light will turn on
- Power off: Press and hold the power button for more than 2 seconds, then release it. After turning it off, the switch light will turn off

⦿ Mode lever:

- By continuously moving the lever, the robot's IP address, battery level, and other different statuses can be viewed on the screen (see 3.4 for details)

3.4 Backplane Display Screen

Status Display

Joint Status Display

After connecting the status display screen, the joint status can be detected in real time. When a joint module signal is lost, the light at the corresponding position on the status display screen will turn off; Generally, if individual joint status signal lights go out, it indicates that the corresponding module may have a power abnormality. If there are joint status signal lights, they will turn off sequentially until the end. It indicates that the CAN signal of the joint module in this channel is lost.

Motor State



IMU Data Printing

The status display screen can achieve IMU data printing, making it easier for developers to operate without an external display.

IMU State

R:0.0.0
P:0.0.0
Y:0.0.0



IP Address Display

Print the loopback address (lo), wired network address (eth0), and wireless network address (wan0) on the same page respectively.

Robot IP

Lo: 127.0.0.1
eth0: 127.0.0.1
wlan0: 127.0.0.1

Battery Level Display

This page allows real-time viewing of battery level information.

Battery



Robot Mode Management

This page allows you to select the corresponding robot control mode.

Robot State

INITIAL

Joystick Switch

Toggling the rocker switch left or right allows sequential switching between functions such as IMU information display, joint status display, IP address display, robot mode management, and battery level display.



User Manual for Mini Pi+ Robot15

PART 02

Preparation

V. Unboxing and Startup Preparation

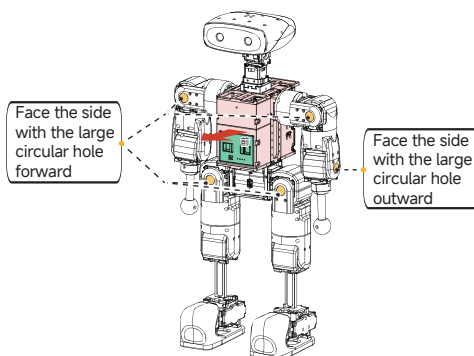
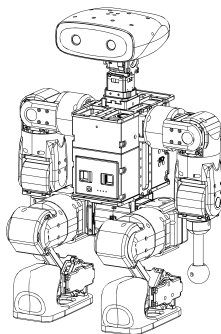
① Unboxing

After receiving the robot package, please carefully remove the outer packaging materials. Open the included custom luggage and verify that all internal accessories are complete, including: the robot body, battery, control handle, power adapter, spare screws and tool kit, user manual, etc. (see Chapter 3: Packaging List for details).

Grasp the handle on the robot's head, pull it out of the case with a slight force, and then take out the other accessories one by one.

② Pose Calibration

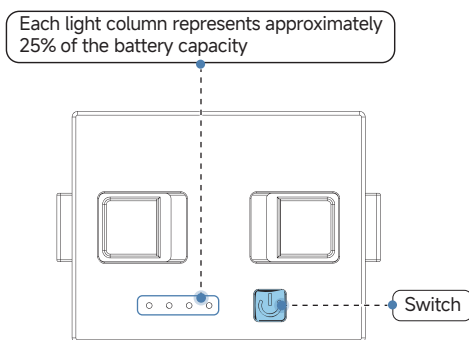
After taking them out, ensure the motors are oriented correctly and the wires are not tangled. If issues such as abnormal gait occur later and require zero calibration, please refer to (Section 9-1-Step 2) for detailed operation guidelines.



Before powering on the robot, please place it in a squatting posture.

③ Battery Level Check

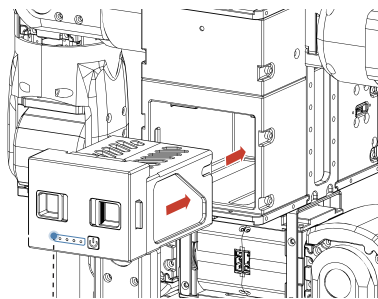
Press the power button on the battery briefly to check the battery level. The number of illuminated light columns indicates the current battery status (see Chapter 4, Section 2.2.3 for details). Please recharge the battery in a timely manner if the level is below 25%.



(Note: The battery needs to be fully charged for the first use.)

④ Battery Installation

There are two buckle structures at the front end of the battery. Clamp the two buckles firmly and insert them into the front battery compartment of the robot in the direction shown in the diagram. Push them to the deepest point to release the two buckles and lock them in place. Press and hold the battery power button briefly, then press and hold for 2-3 seconds again. The battery light column will display a flowing scrolling light, indicating that the battery has been successfully turned on.



When the battery is successfully turned on, it shows a flowing running marquee status

⦿ Battery charging:

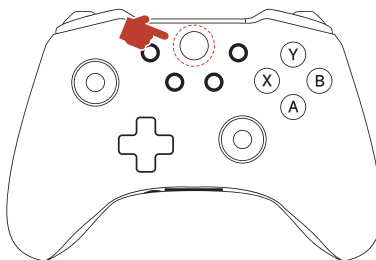
There are two buckle structures at the front end of the battery. Clamp the two buckles firmly and insert them into the charging compartment in the direction shown in the diagram. Push them to the deepest point to release the two buckles and lock them in the charging compartment, then the battery can be installed in the charging compartment. Remove in the same way, but in the direction of extraction. Use a Type-C charging cable and a 45W or higher power adapter to charge, and the battery needs to be turned on during charging.

⦿ Battery level display:

There are 4 light columns on the battery, each corresponding to a battery percentage level. During the charging process, the light columns will be lit up one by one. When the battery is fully charged, it will automatically cut off power, and all light columns will turn off completely.

⑤ Handle Power-On and Battery Level Check

Observe the BeiTong button light ring on the controller. If the light ring is off, the controller is in a shutdown state (Note: The controller is usually in a shutdown state when first used, and it needs to be fully charged before first use). Press the BeiTong button, and the RGB light ring starts flashing, indicating that the controller is turned on.



When the device is turned on, the RGB light ring on the controller will flash slowly. When the RGB light ring on the controller flashes rapidly, it indicates that the controller is in a low battery state and needs to be charged in time to ensure subsequent use.

Insert the receiver of the wireless controller into any external USB port of the robot. If the handle vibrates and the RGB light ring displays a constant white light, it indicates that the handle has been successfully paired.

Comparison table of handle RGB light ring status:

Handle RGB Light Ring Status	Meaning Represented
Slowly flashing in alternating colors	Waiting for pairing in normal state
Rapid alternating flashing of multiple colors	Battery level is below 30%, please charge
Slowly flashing white	Charging in shutdown state
The white light stays on for 10 seconds and then goes off	Fully charged when turned off
White steady on	The receiver has been successfully paired

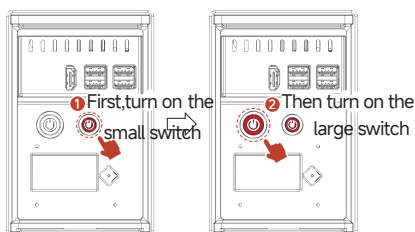
⑥ Robot Power-On and Power-Off

Attention:

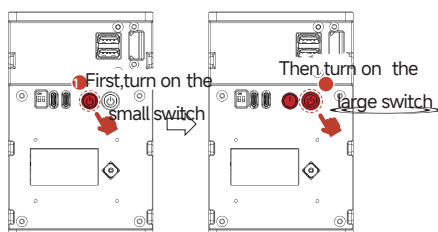
Please ensure to check the initial position of the robot motor and the state of the wiring harness before powering on (see this chapter ② for details);

Please pay attention to the sequence of turning on and turning off the backplane buttons, and monitor the product status during this process.

Mini Pi+ RK3588 Version:



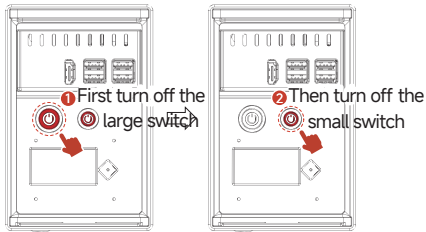
Mini Pi+ Pro Orin Version:



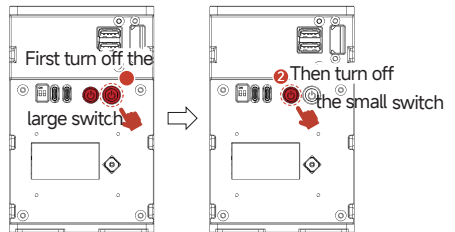
Power on

- ① After the battery is installed, turn on the battery by pressing it briefly and then pressing and holding it (see details in this chapter ④).
- ② First, turn on the main control system. Face the robot's back panel, press and hold the small button on the right for 2-3 seconds until the red indicator light illuminates and the screen displays "loading" — this indicates the main control system has been successfully activated.
- ③ Activate the joint modules. Face the robot's back panel, press the large left button briefly, and the red indicator light will illuminate — indicating the joint modules have been successfully activated.
- ④ Remove the sliding cover on the back of the handle, take out the USB receiver, and insert it into the USB interface area on the back panel. If the handle vibrates and the RGB light ring stays steadily white, the handle has been successfully connected.

Mini Pi+ RK3588 Version:



Mini Pi+ Pro Orin Version:



Power off

1 Ending robot control:

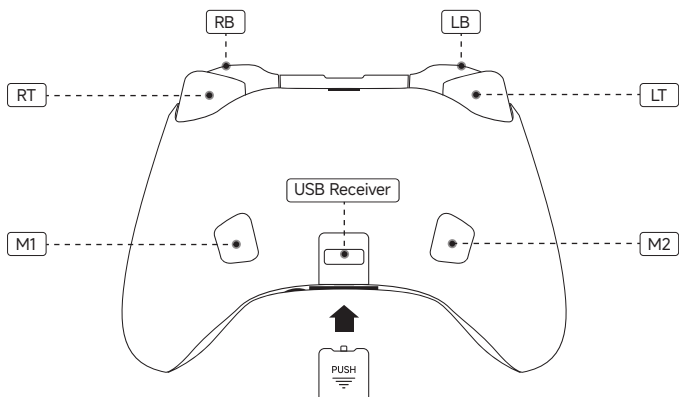
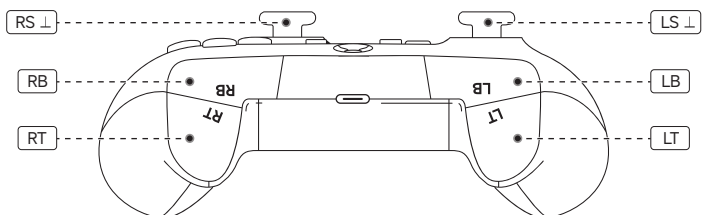
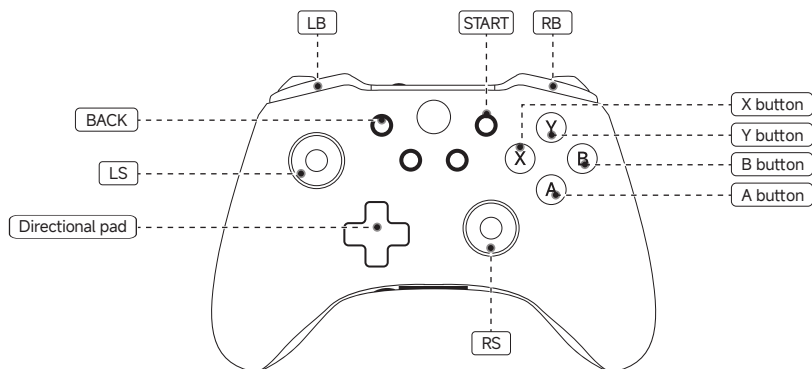
- 1) Ensure the robot is in a flat and unobstructed environment, and that all control operations on the robot have been completed. Press the RT + LT + B buttons; the robot will disconnect from the remote controller's control. During this process, monitor the robot's status and promptly stabilize it to prevent tipping.
- 2) Check the OLED status display and confirm that the node management shows "INITIAL" (initial state).
- 2 Face the robot's back panel. First, press and release the large left button to turn off the joint modules, then press and hold the small right button to turn off the main control system.
- 3 Press and release the battery's power button first, then press and hold it to turn off the power.
- 4 Remove the USB receiver and insert it back into the back of the handle.

PART 03

Operation Guide

VI. Operation Guide

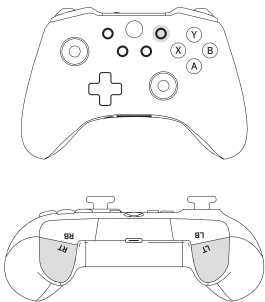
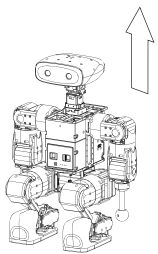
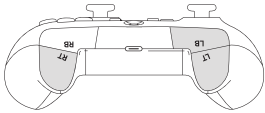
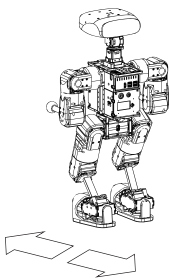
1. Wireless Controller Buttons and Operation Instructions

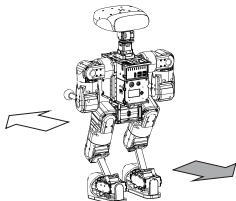
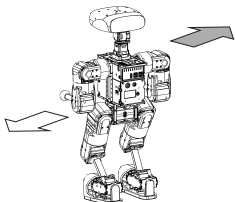
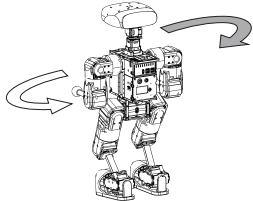
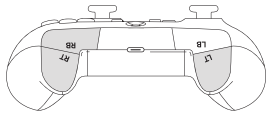
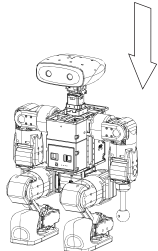


2. Running Basic Movements of the Robot

Observe the display screen on the robot's back panel. After a brief loading screen, the robot will enter Default mode.

Command	Operation and Status
Start the Robot	Press LT+RT+START simultaneously, and the robot will stand up
Walking and Stopping	When LT+RT+LB are pressed simultaneously, the robot will activate; pressing them again will lock it (Note: Only by pressing LT+RT+LB in advance can the robot be unlocked, and subsequent commands such as forward, translate, and backward will take effect)
Moving forward and backward	Left joystick (LS.L): When the joystick is pushed up, the robot moves forward; when it is pushed down, the robot moves backward
Moving left and right	Left joystick (LS.L): When the joystick is pushed left, the robot moves left; when it is pushed right, the robot moves right
Steering and Yaw	Right joystick (RS.R): When the joystick is pushed to the left, the robot yaw to the left; when it is pushed to the right, the robot yaw to the right
Ending Control	When the RT + LT + RB buttons are pressed simultaneously, the robot will stop accepting control from the remote controller and squat down. (When the control is turned off, please keep your fingers and other body parts away from the robot to ensure safety and be careful not to get your fingers pinched)

Remote Control Handle	Status Display	Control Methods
		RT+LT+START, press to make the robot slowly stand up
		Activation and Locking: When LT+RT+LB are pressed simultaneously, the robot can execute subsequent commands. Pressing them again will lock the commands

Remote Control Handle	Status Display	Control Methods
		Left joystick (LS): When pushing up the joystick, the robot moves forward Left joystick (LS): When pushing down the joystick, the robot moves backward
		Left joystick (LS): When the joystick is pushed to the left, the robot translates to the left Left joystick (LS): When pushing the right joystick, the robot translates to the right
		Right joystick (RS): When the left joystick is pushed, the robot yaw to the left Right joystick (RS): When the joystick is pushed to the right, the robot yaw to the right
		Ending Control: When the RT + LT + RB buttons are pressed simultaneously, the robot will squat down and return to the INITIAL mode. Please perform this operation when the robot is stationary, and monitor the robot's status.

Adjust the walking state of the robot:

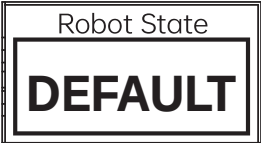
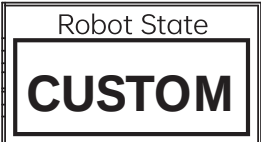
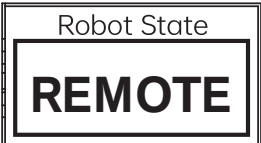
Command	Operation and Status
Step Frequency (Increase)	Press (A) to increase the robot's step frequency
Step Frequency (Decrease)	Press (Y) to decrease the robot's step frequency
Step Length (Increase)	Press (X) to increase the robot's stride frequency
Stride Length (Decrease)	Press (B) to decrease the robot's stride frequency

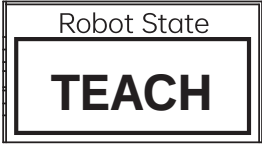
Note: Try to avoid excessively adjusting parameters during the robot's walking process

Reinforcement Algorithm Switching:

1)	When the robot is in the activated state, press the RT + LT + LB buttons simultaneously to put the robot in the locked state.
2)	When the robot is in the locked state, press the RT + LT + Directional pad (D-pad) Left/Right (either left or right works) simultaneously, and the robot will vibrate.
3)	After the robot vibrates, press the RT + LT + LB buttons. The robot will march in place, indicating that the mode has been switched successfully.
4)	When you need to switch back to the default algorithm, you can repeat steps 1) - 2) above. The robot will switch back to the default algorithm; press RT + LT + LB again, and the robot can be activated.

3. Instructions for Different Modes of the Robot (for detailed application scenarios, please refer to the official website's advanced development tutorial)

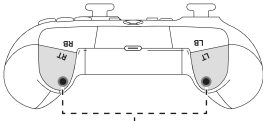
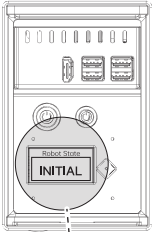
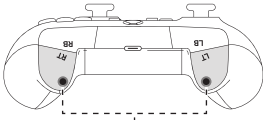
Control mode Node management	Backplane screen status display	Node description
Initial State		The robot management node starts, but there will be no triggering action.
Default State		If the shutdown is triggered by pressing a button inside sim2real or by a limit switch, it is regarded as a normal shutdown, and the system will jump to the INIT state. If an issue is detected with the IMU or the motor, the system will enter the protection mode. If the mode is actively shut down externally, the system will also enter the damping mode.
Custom State		It is completely consistent with the Default mode, but provides a config file interface that allows you to modify the policy and other parameters by yourself. However, the replaced policy should be trained using our open-source training algorithm as much as possible. (If our algorithm is not used, at the very least, you must ensure that the input and output lengths of your policy are consistent with those of ours.)
Remote State		On the robot side, it continuously subscribes to the jointstate topic published by the host and executes commands accordingly. On the host side, it visualizes the robot's joint states and IMU (Inertial Measurement Unit) states, and continuously publishes the jointstate topic to the robot.

Control mode Node management	Backplane screen status display	Node description
Calibration State	 The image shows a rectangular screen with a black border. At the top, the text "Robot State" is displayed in a standard font. Below it, the word "RSTZERO" is shown in a large, bold, black sans-serif font.	Place the robot on the calibration support as described in (9-1- Step 2). After entering this mode, it will automatically calibrate and feed back the calibration results on the OLED screen.
Teach State	 The image shows a rectangular screen with a black border. At the top, the text "Robot State" is displayed in a standard font. Below it, the word "TEACH" is shown in a large, bold, black sans-serif font.	Manually control the robot to multiple fixed actions and use the handle to record. The robot will generate its own motion path and execute it. The path file will be saved locally for later repeated calls.
Protect State	 The image shows a rectangular screen with a black border. At the top, the text "Robot State" is displayed in a standard font. Below it, the word "PROTECT" is shown in a large, bold, black sans-serif font.	This mode is entered when there is an issue with the IMU or joints, or when a motion mode is actively interrupted during other motion mode phases. In this mode, the motors will not receive any control commands.
Error State	 The image shows a rectangular screen with a black border. At the top, the text "Robot State" is displayed in a standard font. Below it, the word "ERROR" is shown in a large, bold, black sans-serif font.	When the robot detects that a motor is not connected, the error status will be displayed. It is necessary to check the joint communication, and it will automatically recover after a while.

4. Methods for Switching Control Modes

If you need to switch between different modes, please follow the steps below:

First, check whether the robot is in a certain mode. If you need to switch modes, press and hold LT+RT first, and press B briefly to exit the current mode.

Remote Control Handle	Status Display	Control Method
 Press and hold (LT & RT) simultaneously 	 Robot State INITIAL ↓ Robot State DEFAULT	Mode Switching: Keep (LT+RT) pressed, and then press [Cross Direction Key (Left or Right)] to switch between different control modes
 Press and hold (LT & RT) simultaneously 	Robot State DEFAULT ↓ Robot State DEFAULT	Selecting State: Keep (LT + RT) pressed, then press the (A) button to select the current control mode. Exiting the Mode: Keep (LT + RT) pressed, then press the (B) button to exit the current control mode.

PART 04

Maintenance

VII. Transportation, Handling and Storage

1. Public Transportation Such as Aviation and High-Speed Rail

- ◎ The outer luggage case of the Mini Pi+ meets the size requirements for carry-on luggage, allowing you to take it with you on public transportation such as airplanes and high-speed trains.
- ◎ If the product contains batteries (such as lithium batteries like HTB24/HTB48), the relevant national and carrier-specific laws, regulations, and security inspection rules regarding lithium battery transportation must be complied with during shipment. If you need to carry the product with you on high-speed trains or flights, please learn about the security inspection policies of your destination in advance. We can provide battery compliance certification materials; however, we shall not be liable for transportation delays, return shipments, or safety incidents caused by regional policy differences or carrier refusal to accept the shipment.

2. International Transportation

- ◎ For exported products, please provide battery compliance certification documents (such as CE, UN38.3, RoHS, etc.) in accordance with the relevant requirements of the destination country. It is recommended to use international logistics services with dangerous goods transportation qualifications to ensure smooth customs clearance.
- ◎ A clear warning label shall be affixed to the packaging.

3. Notes for Express Transportation

- ◎ The logistics services we use for product delivery or repair returns are all compliant and formal logistics companies with hazardous goods transportation qualifications. Their packaging, labeling, and transportation processes all comply with national and relevant industry standards, ensuring the safety and compliance of robots and battery-containing products during transportation.
- ◎ If you (the user) need to send the product for repair on your own initiative, please confirm the transportation method and packaging requirements with us in advance to ensure that the product and its battery do not suffer damage or get detained due to improper packaging, non-compliant logistics, or other such reasons.
- ◎ If a third-party courier service is used to ship the product, it is recommended to select a logistics company with the qualification to transport lithium batteries.
- ◎ When packing, be sure to use the original protective foam and pressure-resistant box to prevent severe vibration, extrusion, dropping, and other situations during transportation, thus avoiding damage to the product and its battery or the risk of fire.

4. Handling Instructions

- ⦿ Do not shake or tip the product violently, and avoid dropping it or striking the robot structure.
- ⦿ When moving the mobile robot equipment, it is recommended that two people cooperate to avoid structural deviation or joint damage caused by single-person handling.

5. Storage Requirements

- ⦿ The product should be stored in an environment that is dry, well-ventilated, free of strong magnetic fields and corrosive gases. Avoid direct sunlight as well as high-temperature and high-humidity environments.
- ⦿ When not in use for an extended period, please disconnect the main power supply. The battery should be maintained at a charge level of 30% to 60%, and the storage temperature is recommended to be between 10°C and 35°C to prevent over-discharge or deterioration of cell performance.

VIII. Maintenance and Servicing

1. Mainframe maintenance

- ⊙ Please regularly check whether the appearance of each part is in good condition and whether it has been damaged by external impact.
- ⊙ Before maintenance and cleaning, please ensure that the product has been turned off.
- ⊙ Use a mild detergent to clean the outside of the robot. Do not use strong solvents.
- ⊙ When using, make sure that the head surface is clean. Avoid scratching the camera lens.
- ⊙ During handling, please handle with care to avoid falling. Mechanical impact will cause damage to
- ⊙ parts. When placing the robot, ensure that the legs are in a natural state to avoid joint force.

2. Battery maintenance

- ⊙ Please check the battery power and health condition regularly. When the battery is recycled for more than 1000 times or the battery life is significantly shortened, please contact the customer service to replace the battery.
- ⊙ Do not use the charger to charge in the environment with too high or too low temperature. The charging temperature is 15 °C~35 °C.
- ⊙ The charging time should not exceed 24 hours. Overcharging will shorten the battery life.
- ⊙ If the battery is not used for a long time, check the remaining battery power regularly. If the battery power is lower than 30%, please charge the battery to 70% and save it to avoid excessive discharge and damage to the battery.
- ⊙ When in use, the robot may not have enough power to move and perform actions when the battery shows 10% power. Please stop using and charge as soon as possible.
- ⊙ Do not charge immediately after use, and wait for cooling to room temperature before charging. Forced charging may seriously damage battery life.
- ⊙ Never clean the charger with alcohol or other flammable agents.

IX. Troubleshooting

This chapter is intended to help users quickly locate and resolve problems that may arise during the robot's operation. If you encounter any of the following situations, please first refer to the content of this section. If the problem still cannot be resolved, please contact the after-sales support team in a timely manner.

1. Common Problems and Solutions

It is recommended that you confirm the correct orientation of the robot's joints and the proper routing of the wiring harness before each use. Failure to check the wiring harness routing and motor orientation may result in issues such as wire tangling of the robot, motor disconnection, command failure, and leg curling.

1.1 Zero Calibration

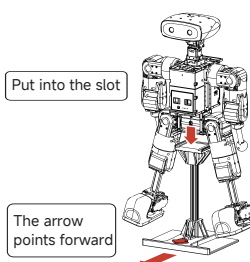
When the robot exhibits symptoms such as abnormal gait or partial joint curling, it may indicate that the zero position needs to be recalibrated. Please follow the steps below to perform the calibration.

Method 1: Built-in Mode Calibration

Step 1: Perform pose calibration using the zero-position bracket

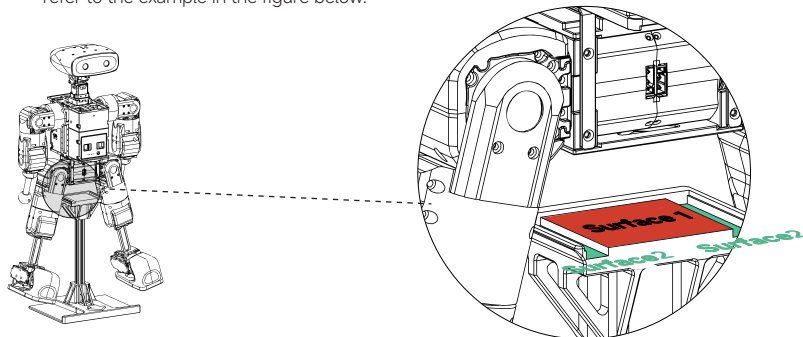
Step 1

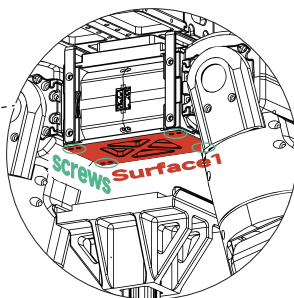
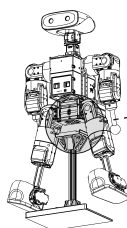
- 1 Prepare the zero-position bracket: Take out the zero-position bracket (marked with an identification arrow) from the package.
- 2 Position the robot: Spread the robot's legs at an appropriate angle and place it firmly on the zero position bracket.



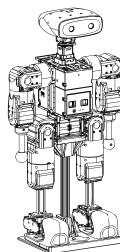
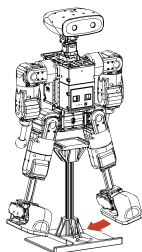
Step 2

Position the two motors of the robot's hip on the upper end of the zero-position bracket, align them, and then place them into the slot. Surface 1 should correspond to Surface 1, and the groove belonging to Surface 2 is used to place the screws. Please refer to the example in the figure below.

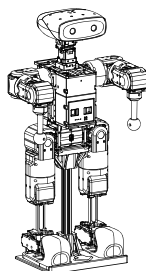
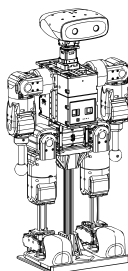




Step 3 Gather the robot's legs toward the center, keeping the legs in a vertical position with the footplates flat against the base plate of the zero-position bracket.

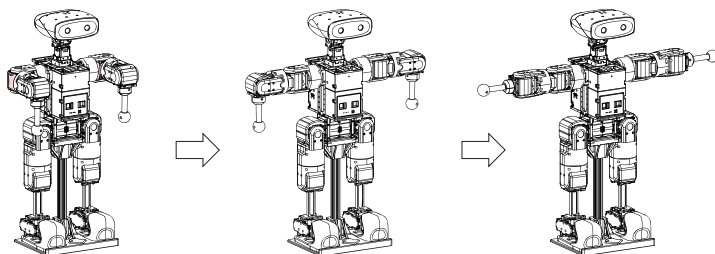


Step 4 Rotate the robot's shoulder motors upward until the surface with the three screws faces upward.

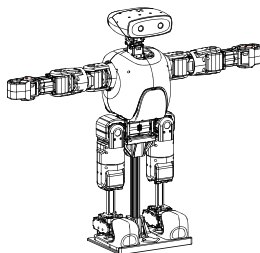


Step 5

Swing the upper arm section toward the rear of the body until it is at the same horizontal level as the shoulder motors, and similarly rotate the elbow motors upward until the surface with the three screws faces upward.

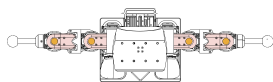


Place the gripper version with the surface having three screws facing upward, as shown in the figure on the right:

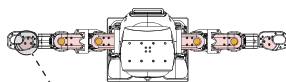


Step 6

After completing the adjustments, please check from a top-down view to ensure that all joints of both arms are aligned in a straight line. Once the above steps are finished, the robot will be in its initial pose and ready for calibration.



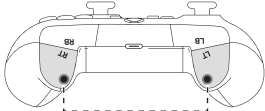
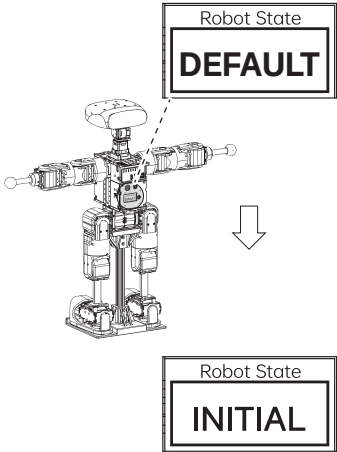
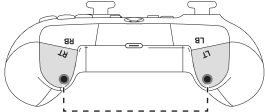
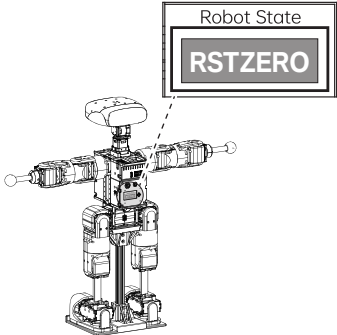
Ball-Player Version

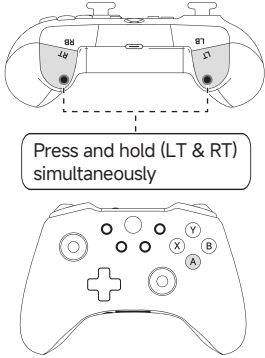
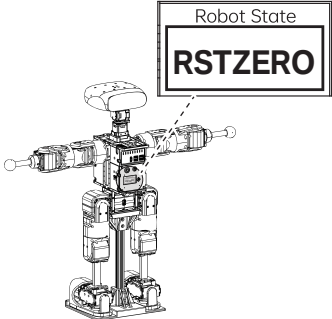
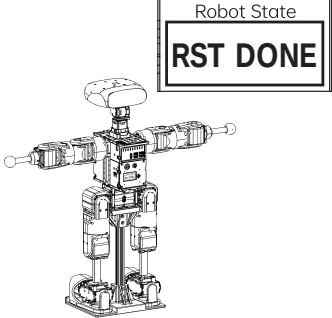
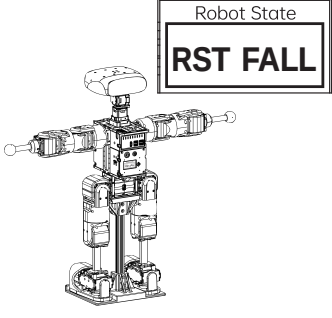


For the gripper version, place it with the surface having three screws facing upward.

Check from a top-down view to ensure that all joints of both arms are aligned in a straight line, and that the surface with the large circular hole faces upward.

Step 2: Zero Calibration in RSTZERO Mode

Remote Control Handle	Status Display	Control Method
 Press and hold (LT & RT) simultaneously 		In Default mode, press RT + LT + B on the controller to exit the current mode. At this point, the screen will display "INITIAL" mode.
 Press and hold (LT & RT) simultaneously 		Press and hold LT + RT + the right direction button simultaneously to switch modes, and switch to RSTZERO mode.

Remote Control Handle	Status Display	Control Method
 Press and hold (LT & RT) simultaneously		Press RT + LT + A to select RSTZERO mode. The robot will then automatically start zero calibration —please do not perform any other operations while waiting for the calibration to complete.
		The screen will display zero calibration feedback after a period of time. Please pay attention to the screen status when the screen shows "RST DONE", it indicates that the zero calibration has been successfully completed.
		When "RST FAIL" appears on the screen, it indicates that the zero calibration has failed this time. At this point, you need to check the robot's pose, repeat the above steps, and perform zero calibration again until "RST DONE" is displayed on the screen.

Method 2: Instruction Calibration

Step 1 Please repeat Step 1 from Method 1 to ensure the robot is placed with an accurate pose.

Step 2 1. When the robot is powered on, connect the robot host to an external display via the HTDM cable. Open the terminal, navigate to the robot workspace directory where the SDK is located, and execute the `test_reset_zero.sh` command.

```
1 cd sdk所在的机器人工作空间
2 source devel/setup.bash
3 roslaunch livelybot_bringup motor_set_zero.launch
```

2. Confirm that the zero position setting is successful

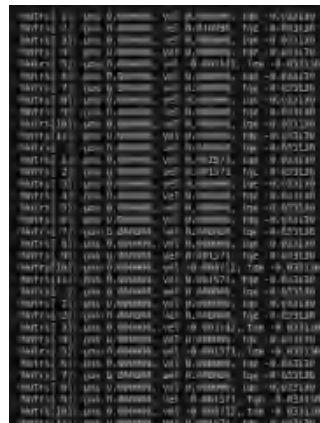
After executing the zero-adjustment command, the following two scenarios may occur:

If the two decimal places of the position (`pos`) data value shown in the diagram are 0, it indicates that the command has been executed successfully.

If individual joints have non-zero values, please follow the steps below:

- 1 Press "Ctrl+C" in the terminal to execute the exit command and terminate the node.
- 2 Restart the power supply of the joint modules.
- 3 Execute the `test_reset_zero.sh` command (Step 2)

After successfully executing the zero calibration command, press "Ctrl+C" in the terminal to exit the command, then restart the power supply of the joint modules.



Joint	pos	vel	acc	time
motor1	0.00	0.00	0.00	0.000000
motor2	0.00	0.00	0.00	0.000000
motor3	0.00	0.00	0.00	0.000000
motor4	0.00	0.00	0.00	0.000000
motor5	0.00	0.00	0.00	0.000000
motor6	0.00	0.00	0.00	0.000000
motor7	0.00	0.00	0.00	0.000000
motor8	0.00	0.00	0.00	0.000000
motor9	0.00	0.00	0.00	0.000000
motor10	0.00	0.00	0.00	0.000000
motor11	0.00	0.00	0.00	0.000000

Step 3 3. Check if the robot's zero position status is normal:

Fix the robot on a bracket of a certain height or lift it with your arms (when executing the command, ensure to maintain a safe distance from the robot); when the robot is powered on, open the terminal, navigate to the robot workspace directory where the SDK is located, and execute the `test_motor_run.sh` command.

```
1 cd sdk所在的机器人工作空间
2 source devel/setup.bash
3 roslaunch livelybot_bringup motor_move_zero.launch
```

After executing the command, check if the robot's zero position is normal. Press Ctrl+C in the terminal to exit the command state.

1.2 Handle Connection

? Problem 1: Failed to connect?

Under normal circumstances, an obvious vibration will occur upon successful connection of the controller. When you find that the controller fails to pair successfully with the robot, please consider the following scenarios:

- ⊙ The handle indicator flashes rapidly, which may be due to the insufficient power of the handle. It is recommended to charge it in time.
- ⊙ The handle indicator light is off, which may be that the handle is not powered on. Press the logo key to power on.
- ⊙ The wireless receiver is not plugged in correctly. Please take out the receiver from the card slot on the back of the handle and plug it into any HDMI interface on the robot backplane.
- ⊙ The handle is powered but cannot be connected. You can plug the receiver into another host (such as a laptop) and wait for the handle to vibrate again for pairing. Or use a USB to type C data cable to connect the handle with the robot host to realize wired operation.
- ⊙ Restart pairing. At the same time, press and hold the LT key, the back key and the right rocker (RS V) to start up and reset, and then press the B key and the back key to shut down. At this time, the logo key flashes for a few seconds and then goes out. After the receiver is plugged into the host backplane, long press the logo key on the handle to pair again. At this time, the logo key is in a white light state.

? Problem 2: Key mapping error

According to the official instructions and use experience of Beitong, the handle can switch modes by pressing the LOGO key for about 5 seconds. When you find that the key positions of the handle keys in the manual are disordered, please consider the following situations:

- ⊙ If there is an incorrect mode switching of the controller, you can press and hold the logo button + A button to switch the mode.
- ⊙ Restart and re-pair. Same as above.

? Problem 3: Indicator flashes

- ⊙ The handle is looking for pairing. After the receiver is removed and the operation is over, the handle indicator still flashes, indicating that the handle has not entered the standby mode or is still looking for a pair. You can wait a moment until it automatically turns off. If it flashes for a long time, you can press the logo key for 5-10s.
- ⊙ The handle is charging. It is normal for the indicator light to flash when the handle is charged.
- ⊙ Restart and re-pair. Same as above.

1.3 Battery Charging

? Problem: The battery cannot be charged or the charging speed is very slow?

If you find that the battery cannot be charged or the charging speed is very slow, please consider the following situations:

- ⊙ Not using a power adapter with a power of 45W or higher, or not using a fast-charging data cable;
- ⊙ When charging, ensure as much as possible that a single adapter supplies power to only one battery;
- ⊙ Not turning on the device before charging the battery;
- ⊙ Poor contact of the charging interface;
- ⊙ Internal damage caused by hot-swapping the battery.

1.4 Motor Disconnection

? Common problems of motor error reporting

The Mini Pi+ is equipped with 22 motors (26 motors for the gripper version). You can check the motor status by toggling the lever on the side of the backplane display. When an error code appears during development with an external display connected, please consider the following scenarios:

- ⊙ Loose or falling off wiring
 - *The power cable or communication cable is not properly connected, inserted in reverse, or has poor contact.*
 - *The connector is aging or the terminal is oxidized.*
- ⊙ Interface damage
 - *The CAN interface, CANFD module, or driver board is damaged.*
 - *The cable is broken or has internal breakage.*
- ⊙ Wrong interface
 - *Motors are connected to an incorrect communication port, or there is an address conflict among multiple motors.*
- ⊙ CAN ID conflict or configuration error
 - *Multiple motors using the same ID cause recognition failure.*
- ⊙ The terminal resistor is not connected or connected incorrectly
 - *120Ω terminating resistors are not connected to both ends of the CAN bus, or connected in the wrong position.*
- ⊙ Motor not initialized or calibrated
 - *If the self-test or initialization process is not completed, the motor cannot respond to control commands.*

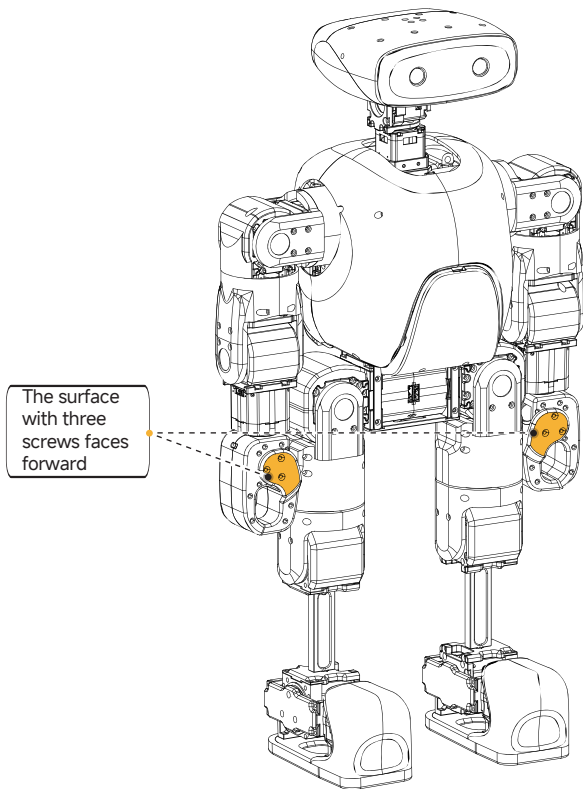
1.5 Other Instructions

- ⊗ In case of unrecoverable or repeated problems, do not disassemble the equipment by yourself to avoid affecting the warranty.
- ⊗ More development tutorials can be found on the official website.
- ⊗ For more technical support, please call: +86-18144897433 or add GQJD2022 on WeChat.

X. After-Sales Warranty

- ⊗ After you purchase the complete machine and other related products, the warranty period starts from the day you receive the goods.
- ⊗ The warranty period of the product is one year, which starts from the date when you pick up the product or the date when the express logistics information is displayed and signed.
- ⊗ During the warranty period, if you modify, disassemble or open the shell without permission, the warranty period will become invalid directly.
- ⊗ During the warranty period, if the product is in normal use and has a non artificial performance failure, we will provide corresponding free maintenance or replacement of parts for the product you purchased. You need to provide a valid purchase voucher (invoice/order/contract record).
- ⊗ If the product you purchased has exceeded the warranty period, you can also get our help by purchasing additional services.
- ⊗ You can use the official after-sales platform <https://www.hightorque.cn/support> Submit your after-sales demand and check the after-sales progress.

Note: The added claw/chest shell is a customized version, and the operation mode is the same as the above 4-DOF arm version.





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