



MR-F5-1600-HI(CE) Mobile Robot

User Manual

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About this Manual

The Manual includes instructions for using and managing the Product. Pictures, charts, images and all other information hereinafter are for description and explanation only. The information contained in the Manual is subject to change, without notice, due to firmware updates or other reasons. Please find the latest version of this Manual at the Hikrobot website (<https://en.hikrobotics.com>).

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Available Model

This manual is applicable to MR-F5-1600-HI(CE) mobile robot.

Symbol Conventions

The symbols that may be found in this document are defined as follows.

Symbol	Description
 Note	Provides additional information to emphasize or supplement important points of the main text.
 Caution	Indicates a potentially hazardous situation, which if not avoided, could result in equipment damage, data loss, performance degradation, or unexpected results.
 Danger	Indicates a hazard with a high level of risk, which if not avoided, will result in death or serious injury.

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Chapter 1 Safety Instructions

Our company has designed a multi-layer security protection mechanism for the mobile robot. But accidents can still be caused by operators ignoring safety guidelines or operating mobile robots not in accordance with safety instructions. The vast majority of accidents involved in the operation, maintenance, repair and other processes are caused by the failure to follow the safe operation specifications and precautions in the actual operation. In fact, if you can analyze the existing security risks and take corresponding security measures before each operation, most accidents that occur in practice can be completely avoided.

The content of this manual is intended to ensure that mobile robots do not put people and machines at risk. Please read this manual carefully for operators and anyone who may have access to the site. Improper operation, maintenance, repair, etc. are very dangerous and may cause casualties. Therefore, you can only operate, maintain, and repair the device after you have read the manual thoroughly and fully understand the relevant operations.

Note

- All losses caused by unreasonable use are the responsibility of the user, and our company is not responsible.
 - Even if all operations are carried out in accordance with safety instructions, it cannot be guaranteed that the device will not cause personal and property damage.
 - Our company is not responsible for the personal and property losses caused by the replacement parts or modified parts.
-

1.1 Fire Protection Requirement

- Design fire protection instructions (fire extinguisher, fire sandbox, emergency exit, firewall, etc.) according to the national standard *Code of Design on Building Fire Protection and Prevention*.
- It is recommended to equip with a dry power extinguisher or a fire sandbox in 5 m² for a single charging station, or to design a safety house.
- When the mobile robot is on fire, the firefighters must wear a filter type gas mask (full face mask) or isolation respirator, and wear full body fire-fighting and gas protective suits to put out the fire in the upwind direction. Water mist extinguishers, foam fire extinguishers, dry powder extinguishers, CO₂ fire extinguishers, and fire sandbox can be adopted.
- No open flame in the mobile robot operation field.

1.2 Environment Requirement

- The mobile robot is designed for indoor environment, so it can be only used for indoor carrying.
- Working temperature: 0 °C to 40 °C (32 °F to 104 °F); with heated battery: -10 °C to +40 °C (14 °F to 104 °F). Working humidity: 10% to 90% (no condensation).
- Do not use mobile robot in environment with potential explosion hazard.
- The operation field must meet the requirement of Hikrobot standard. (Please see the specific requirements in [Field Requirement](#).)
- Fence is required and the staff is forbidden to enter the mobile robot working area.
- The working area should be kept clean. There should be no water, oil and other substances that may cause the mobile robot to slip. When there are scattered materials on the ground, it must be cleaned immediately.
- Do not run the mobile robot in the damaged environment of the working area, so as to prevent the mobile robot from bumping and causing the goods to roll over.
- During the implementation of the project, ensure that the size and height of the roadway and ceiling in the area are appropriate, and the mobile robot can run and will not scratch the ceiling when lifting the fork in the roadway.
- Before transportation, it is necessary to check whether the packing wooden box is solid to prevent the mobile robot from being damaged due to loose box.
- During transportation, severe vibration and turbulence shall be strictly prevented to avoid severe mechanical impact on the mobile robot.
- In the process of loading and unloading, it is forbidden to throw, roll and heavily press.
- Do not put the packing wooden cases in the open air and expose them to the sun or rain.
- Use crane or forklift to carry the wooden box of mobile robot.
- It is strictly forbidden to place the packing wooden box in an inclined way.
- It is strictly forbidden to step on the packing wooden box.
- When unpacking, please wear labor protection gloves to avoid being scratched by tools or sharp parts of packing wooden box.
- After unpacking, first confirm whether the functions of emergency stop button, pneumatic bumper strip, and obstacle avoidance laser sensor are normal.
- Make sure to use the slope to transfer the mobile robot from the wooden box to the ground. It is forbidden to transfer mobile robot by manual handling.
- After unpacking, please keep the original packaging, paper instructions, etc. properly for the subsequent use of the transport mobile robot.

1.3 Operation Requirement

- Train operators on the use, safety and maintenance of mobile robot. Ensure that the operators comply with the operating regulations and safety requirements, and have the ability to assess the potential hazards of the work to be carried out.

- Only professional and technical personnel with proper training are allowed to operate mobile robots. If the mobile robot is used without permission, the operating company and the operator should take full responsibility, not the manufacturer.
- Unauthorized persons are not allowed to operate the mobile robot.
- In order to ensure safety, all personnel entering the working area are required to wear safety protection equipment such as safety helmet, labor protection shoes, reflective vest, and labor protection gloves.
- The operator shall strictly abide by this manual and the electrical safety regulations of the country and the region.
- The mobile robot operates automatically and has no direct operator on the product.
- The workers in the field should wear personal PPE to reduce the harm of the noise generated by the mobile robot in operation.
- Do not operate the mobile robot when the limbs are with water, oil and other substances that may cause slipping.
- When the mobile robot is working, no one is allowed to enter the working area of the mobile robot. Walking into the running route of the mobile robot and walking towards the moving mobile robot may be collided and crushed by the mobile robot.
- Before starting the mobile robot, make sure that there are no obstacles in the running area of the mobile robot.
- The patients with heart failure who need pacemaker and defibrillator cannot enter this area. The electromagnetic field in this area will cause pacemaker and defibrillator failure.
- Indicators will flash when the mobile robot is working. Do not stare at the flashing indicator long time.
- If the mobile robot is in contact with any liquid: turn off the power supply of the mobile robot firstly, remove the liquid as much as possible, and do not restore the power supply before the mobile robot body is dried.
- Do not put hands under the turntable of the latent mobile robot or in the middle of the roller of the roller mobile robot.
- When manual cart is used to transfer latent and mobile robot, both hands should be placed on the back panel. Please do not put them on the turntable or in the gap between the turntable and the mobile robot to prevent pinch.
- Do not walk, stand or sit on the fork of the forklift mobile robot.
- When the mobile robot stops working, do not assume that it has finished work. It is probably waiting for the next task.
- Do not lean on the mobile robot.
- Do not press the operation button at will.

1.4 Checking Requirement

- Check the mobile robot before using to make sure each part can work normally.
- Follow the requirements to maintain the mobile robot. Do not use a failure mobile robot.

- Make sure there are no people in the working area and operation route before you start the mobile robot.
- The mobile robot is equipped with safety components. If safety components have any exception, you need to power off the mobile robot immediately and stop using it.
 - Emergency stop button: Press it to stop the mobile robot before manual intervention when there is an exception occurs.
 - Pneumatic bumper strip: The mobile robot will stop and send alarms when an obstacle crashes into the pneumatic bumper strips.
 - Obstacle avoidance sensor: The mobile robot will decelerate or stop when the sensor detects there is an obstacle.
- Set the speed, acceleration speed, deceleration speed, and rotation speed of the mobile robot according to recommended values.

1.5 Loading Requirement

- Do not use the mobile robot to carry people or animals.
- Do not use the mobile robot to carry, drag, and fork another mobile robot.
- Make sure the goods carried by the mobile robot are in a stable structure, and the load must be evenly and symmetrically placed on the mobile robot.
- Do not load eccentric goods.
- Make sure the goods carried by the mobile robot meet the load bearing standards and size standards of mobile robot.
- Do not transport goods that exceed the rated load of the mobile robot (see the mobile robot body nameplate for rated load information and [Loading Curve](#) for goods requirement). Overload will affect the braking distance and stability of the mobile robot.
- Make sure the total weight of goods and mobile robot meets the load capability of the ground.
- Make sure the elevator can withstand the total weight of the mobile robot, goods, and the operator before the mobile robot entering.

1.6 Parking Requirement

- Design a storage area for free mobile robot in advance.
- Do not put the mobile robot on a slope unattended.
- Do not park the mobile robot at exits or near extinguishers.
- Make warning marks if you need to park the mobile robot in somewhere temporarily.

1.7 Battery Requirement

- Only use the original charging station to charge the mobile robot.
- Keep good ventilation and no fireworks when charging.
- The operator needs to wear glasses and gloves during the battery checking.

- If any liquid splashes on your skin or into your eyes, you should rinse it immediately and see doctor in time.
- Do not press and disassemble the battery. Any battery damage may cause battery burning or explosion.
- Do not wet the battery.
- Do not use water to extinguish fire, instead, use a foam fire extinguisher, dry powder extinguishers, and fire sand to extinguish fire.
- Move or store batteries when they are in 50% power.
- If the mobile robot needs to be stored for a long time, fully charge the robot every 3 months and discharge to 50% to 70% battery level.
- The maximal charging circulation ranges from 1000 to 1500 times. Replace the battery before it is used up.
- Dispose the battery according to local rules and regulations.
- Divide a special area for charging to prevent crashes in advance.
- After the mobile robot is automatically shut down (including power-loss shutdown and other shutdowns), it needs to be charged within 24 hours. Failure to charge for more than 24 hours may cause irreversible damage to the battery.

1.8 Maintenance Requirement

- Arrange professional maintenance personnel to regularly maintain the mobile robot in accordance with the mobile robot maintenance manual and maintenance checklist.
- During project planning, maintenance areas must be divided. Mobile robot maintenance can only be carried out in the maintenance area, and it is strictly forbidden to maintain in the working area.
- The power supply of the mobile robot must be turned off before maintenance, and live maintenance is strictly prohibited.
- The mobile robot must be placed on the truck to replace the caster wheel, battery, location code camera (code reading device, camera) and other operations that need to be suspended.
- The mobile robot belongs to large and heavy equipment. It is strictly forbidden to carry and roll the mobile robot manually.
- When you maintain the rotating parts of the mobile robot, such as drive assembly, electric lifting structure, and slewing structure, it is strictly forbidden to wear gloves to prevent the gloves from being stuck by the parts.
- When you maintain other parts except the rotating parts, the maintenance personnel must wear work gloves to prevent some sharp parts or the sharp edge of the mobile robot itself from being stabbed.
- Without the consent of the manufacturer, the product manual, signboard, mechanical structure, electronic system, and software shall not be modified, and the third-party installation parts shall not be used, otherwise the warranty qualification will be canceled.
- The manufacturer shall not be responsible for the personal and property losses caused by the replacement parts or modified parts.

1.9 Elevator Requirement

- After the landing door and the elevator door are closed, the gap between the door and the door post shall not be larger than 6 mm for the passenger elevator, and the size of the freight elevator shall not be larger than 8 mm.
- The horizontal distance between the elevator door and the closed landing door, or the passage distance between the doors during the entire normal operation period shall not be greater than 0.12 m.
- The horizontal distance between the elevator sill and the landing door sill shall not be greater than 35 mm.
- Arrange professional maintenance personnel to repair and maintain the elevator regularly according to the maintenance requirements of the elevator.
- According to the site environment, plan a safe area for duty personnel. The safe area cannot be on the running route of the device.
- Do not use the elevator for device to transport people.
- Matters needing attention when the elevator is abnormal:
 - Pause the device first via the robot control system, monitor platform, or pressing the emergency stop button.
 - Disable roads to enter and exit from elevators via the remote control platform.
 - Warning signs shall be placed at the door of elevator to prohibit non-professional maintenance personnel from entering.
 - Inform the monitoring center to monitor the elevator status.
 - Arrange operators to enable the elevator manual mode in the machine room, and place warning signs at the door of the machine room to prohibit non-professional maintenance personnel from entering.
- The operators manually adjust the elevator to the flat floor. If the device is in the elevator, manually push out the device or use the forklift to push out the device and empty all the equipment in the elevator, and then carry out the next step of maintenance.

1.10 Safety Component

Danger

- If safety components have any exception, you need to power off the device immediately and stop using it.
-

The mobile robot is equipped with the following safety components to ensure its safe operation.

- Emergency stop button: Press it to stop the mobile robot before manual intervention when there is an exception occurs. (See [Emergency Stop Button](#) for details.)
- Pneumatic bumper strip: The mobile robot will stop and send alarms when an obstacle crashes into the bumper strips. (See [Pneumatic Bumper Strip](#) for details.)

- Obstacle avoidance sensor: The mobile robot will decelerate or stop when the sensor detects there is an obstacle. (See [*Obstacle Avoidance Laser Sensor*](#), [*Fork Non-Contact Detection Optoelectronics*](#), and [*Binocular Camera*](#) for details.)

Chapter 2 Overview

2.1 Introduction

The forklift mobile robot (FMR) is an important part of the smart factories, and it solves the issues of high labor costs, low working efficiency, and error prone material management in traditional forklift operations by realizing automatic carrying of pallets, racks and other materials that are suitable for forklifting. The mobile robot can also connect with the upper-level management systems, such as MES, ERP, WMS, to realize the automatic delivery of tasks and the management of material information.

The mobile robot adopts a navigation method based on the combination of reflective materials and natural contours, and completes map construction and positioning navigation via the SLAM algorithm. With the feature of high reflectivity, reflective materials are easy to separate from the surroundings. While natural contours can characterize the on-site environment, and its features are easy to interpret. Thus, reflective materials and natural contours complement each other, which can improve the robustness and adaptability of the algorithm.

The mobile robot is applicable to automobile, 3C, manufacturing, logistics, food and pharmaceutical industries.

2.2 Key Feature

- Transports in forklift mode, and supports mast customization and fork size customization.
- Adopts SLAM navigation to achieve accurate positioning.
- Supports smooth motion with max. running speed of 1.5 m/s.
- Adopts smart/independent power management, and supports auto-charge and self-returning after charging completed, and environmental friendly.
- Supports multiple safety protections, such as laser/infrared obstacle avoidance, load detection, emergency stop button, and audible alarm.
- Supports moving forward and moving backward with goods, and carrying, lifting, and lowering goods up to 600 kg (1322.77 lb.) via standard pallets.
- Supports indicating device status via LCD screen and status indicator.
- Supports Wi-Fi communication and seamless roaming in a network-covered area.

Chapter 3 Get Started

3.1 Appearance

 Note

- The figures below are for reference only.

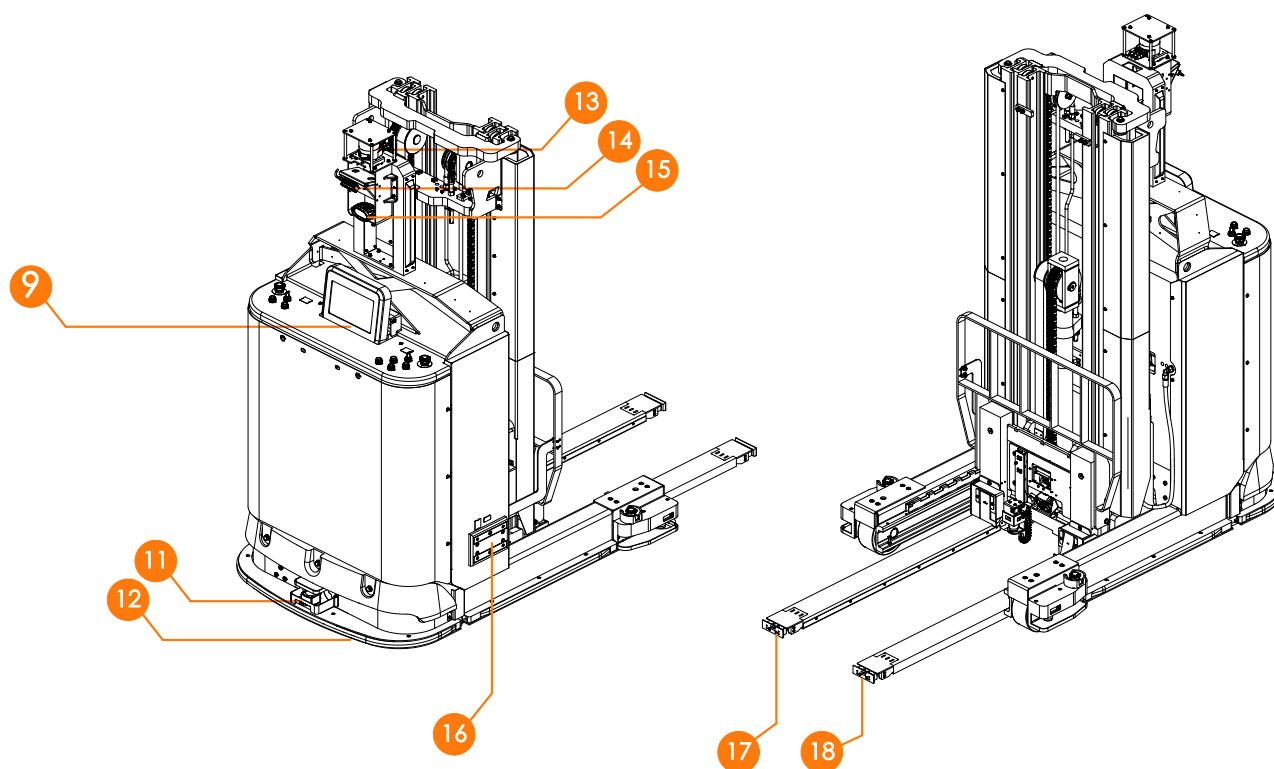


Figure 3-1 Front View

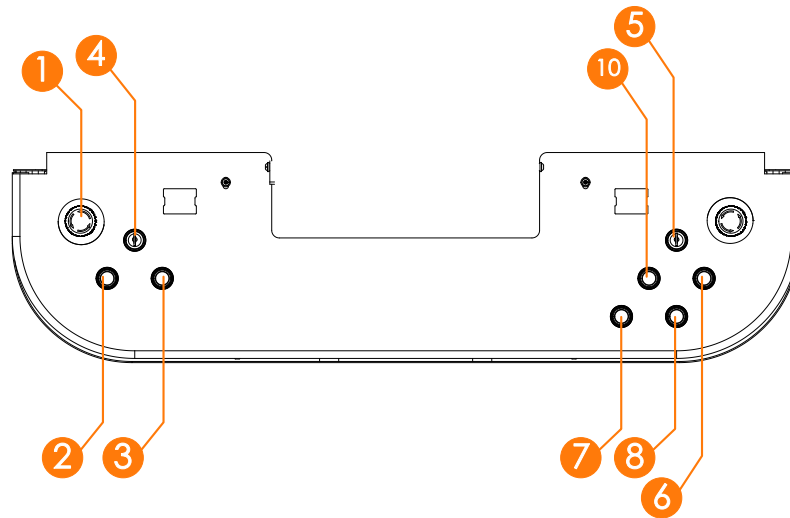


Figure 3-2 Control Panel

Table 3-1 Main Components

No.	Name	No.	Name
1	Emergency Stop Button (Total: 4)	10	Forward Button
2	Pause/Resume Button	11	Obstacle Avoidance Laser Sensor
3	Reset Button	12	Pneumatic Bumper Strip
4	Auto/Manual Button	13	Laser Navigation Sensor
5	Power Switch	14	Binocular Camera
6	Backward Button	15	Blue Light
7	Lifting Button	16	Charging Brush Block
8	Lowering Button	17	Fork Non-Contact Detection Sensor
9	LCD Screen	18	Fork Anti-Collision Structure

3.2 Replace Oil Tank Plug

Note

- In order to prevent the hydraulic oil from leaking out during transportation, the oil tank plug has been replaced with a steel plug before shipping. After the arrival of the mobile robot, you should replace the steel plug with the oil tank plug to ensure normal use of the hydraulic station.

Step 1 Use hex wrench to rotate the steel plug counterclockwise, and remove it.



Figure 3-3 Remove Steel Plug

Step 2 Install the oil tank plug.

 **Note**

- The oil tank plug is packed in a self-sealing package and attached to the hydraulic valve connector.
-



Figure 3-4 Install Oil Tank Plug

3.3 Power On and Start Mobile Robot

Danger

- After the mobile robot is powered on, the operator should leave the working area of the mobile robot to avoid interferences that may cause the mobile robot to be abnormal.
 - Clear the obstacles on the operating site to ensure that the working area of the mobile robot is unobstructed.
-

Step 1 Make sure all emergency stop buttons are unlocked. If not, rotate the emergency stop button clockwise and let it release automatically.

Step 2 Switch the power switch to ON.

Step 3 The display screen displays task exception, and press the reset button to continue.

3.4 Pause Mobile Robot

Note

- The mobile robot will not receive any task if it is paused.
-

You can pause the mobile robot via pressing the emergency stop button or log in to the monitoring client to pause the mobile robot.

3.5 Power Off and Stop Mobile Robot

Prerequisites: There are no ongoing tasks.

You can switch the power switch to Off to power off and stop the mobile robot.

3.6 Move Mobile Robot via App

Note

- The app is only available for Android system.
-

The mobile robot has a built-in wireless transceiver module. After the robot's soft AP function is enabled, the mobile terminal app of mobile robot (hereinafter referred to app) can directly connect to the robot via wireless network to control the robot.



Figure 3-5 App

Step 1 Enable the robot’s soft AP function via LCD screen.

Step 2 Use the app to connect to the robot via wireless network.

Note

- Get the IP address from the robot’s screen.
- The wireless network name of the mobile robot is the robot’s No.

Step 3 Run the app and select the connection way as **Link AMR Directly**.

Step 4 Tap  and select **Link IP Directly**.

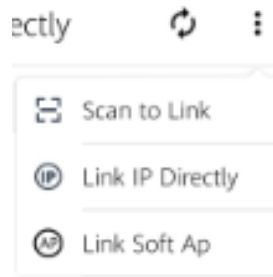




Figure 3-6 Link IP Directly










Step 5 Control the mobile robot via the panel.




Figure 3-7 Control Panel

Table 3-2 Control Panel Description

Button	Description	Button	Description
	Tap to make the mobile robot move forward.		Tap to make the mobile robot move backward.

	<p>Tap to make the mobile robot turn left.</p> <p>Tap it and the  together to make the mobile robot move in arc path (left).</p>		<p>Tap to make the mobile robot turn right.</p> <p>Tap it and the  together to make the mobile robot move in arc path (right).</p>
<p>100.0</p> 	<p>Tap to adjust speed of the mobile robot.</p>		<p>Tap to pause the mobile robot.</p>
	<p>Tap to enable obstacle avoidance function. The obstacle avoidance function is not enabled by default in the direct connection control page. After the function is enabled, the mobile robot will automatically stop if there are obstacles in the front during moving. In this case, the robot cannot move forward, but can move in other directions. After obstacles are removed or obstacle avoidance function is disabled (not recommended), the robot can move on. Currently, only laser sensor supports obstacle avoidance function.</p>		<p>Tap to disable obstacle avoidance function.</p>
	<p>The operation control panel will be automatically locked if there is no operation in</p>		

	30 seconds. You can tap  to lock.		
--	--------------------------------------------------------------------------------------------------------------------	--	--

3.7 Charge Mobile Robot

Charge the mobile robot with the charging station.

Note

- For specific graphical user interfaces, refer to the actual one.

Caution

- Only use the original charging station to charge the mobile robot.
- Deploy the charging station according to the mobile robot's specifications. The manufacturer is not responsible for any error caused by incorrect deployment.

3.7.1 Charge Automatically

The charging station is in the auto charging mode by default when it is powered on. The mobile robot will go to charging station automatically if its battery is lower than the charging threshold. After charging is completed, the mobile robot will continue to work.

Note

- Set the charging threshold in robot control system.

If RCS software cannot be provided on site, the robot cannot be charged via the platform, and the manual charging current is too small, you can charge via screen. The charging task will be applied via the screen, and the charging process is the same as the auto charging task.

- Step 1 Make sure the mobile robot and the charging station are on the same LAN, and IP address can be pinged.
- Step 2 Move the robot to the charging station, enter IP address of the charging station on the screen, and click OK. The charging station will be automatically connected.
- Step 3 The robot starts charging and ends automatically when the battery is full, or ends the charging task on the screen.



Figure 3-8 Switch

3.7.2 Charge Manually

Step 1 Switch to manual mode and remote control the robot to the charging station.

Step 2 Tap charger connector button, and make sure the charging head connects to the charging brush plate.

Step 3 Enable the mobile robot's charging switch relay.

1. Go to the LCD screen, and enable relay. Perform the next step if there is no relay.
2. Enter **castor_cli -R "202 50"** via the SecureCRT tool. Use the multimeter to measure the mobile robot's voltage if the relay is enabled (voltage range: 30 V to 60 V). Perform the next step if the operation fails.
3. Enter **castor_charge_relay_set back/left/right/down 1** via the SecureCRT tool. Use the multimeter to measure the mobile robot's voltage if the relay is enabled (voltage range: 30 V to 60 V).



Figure 3-9 Switch

Note

- You can enter the command (**back/left/right/down**) according to charging station location.

Step 4 Tap **User Log In** in the home page to enter user login interface.

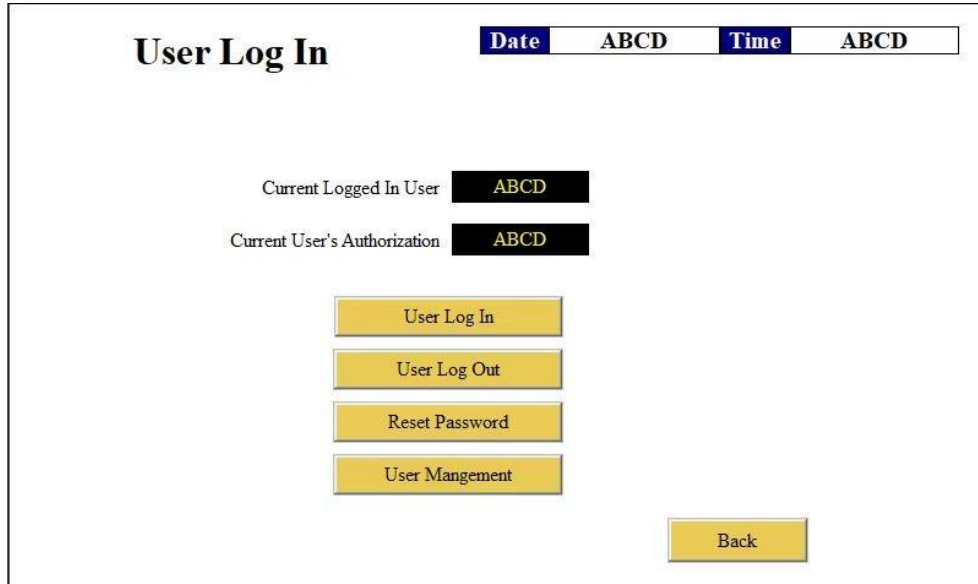
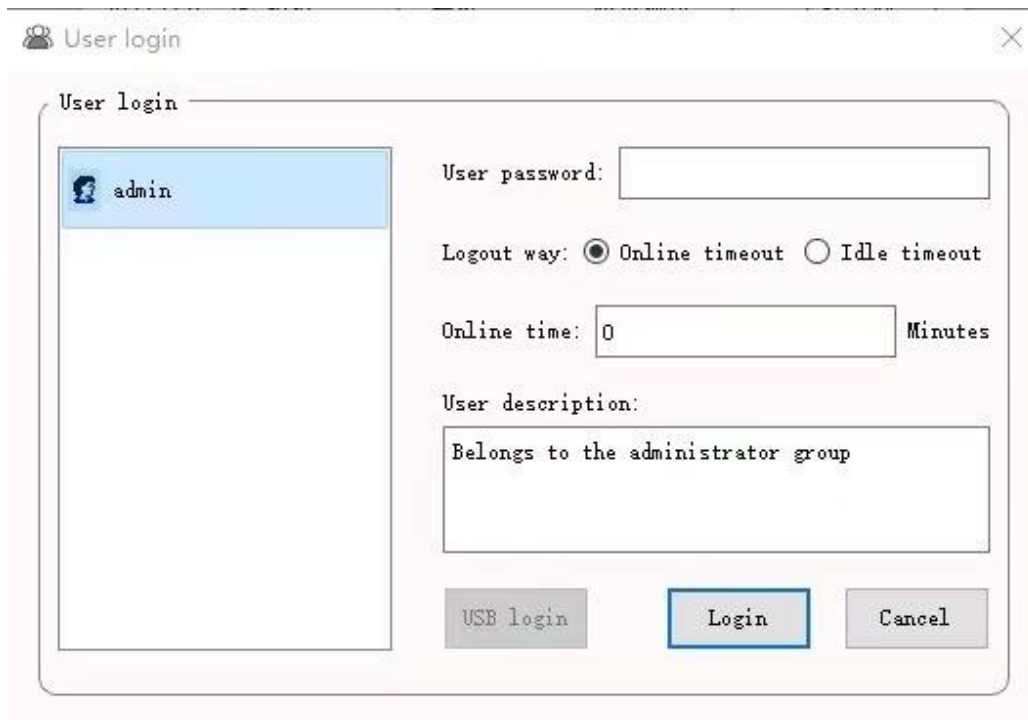


Figure 3-10 User Login

Step 5 Select the user name and enter the password (111119). After entering the password, you will have the permission to charge manually.



User login

User login

admin

User password:

Logout way: Online timeout Idle timeout

Online time: Minutes

User description:
Belongs to the administrator group

USB login Login Cancel

Figure 3-11 User Login

Step 6 After login, tap **Return** to go to the home page.

Step 7 Tap **Manual Charging**.

Step 8 Select **60 AH Manual Charging**. Select the charging mode according to actual demands.

Note

- The selected current should be smaller than the mobile robot's battery level $\times 0.5$.
- For separated-type charging station, disconnect DB9 communication port of the charging station before manual charging. For integrated-type charging station, this operation is not required.

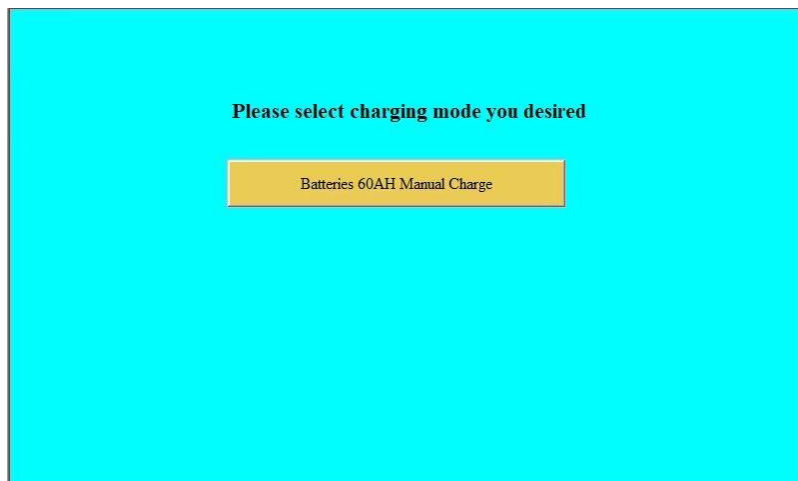


Figure 3-12 Charging Mode

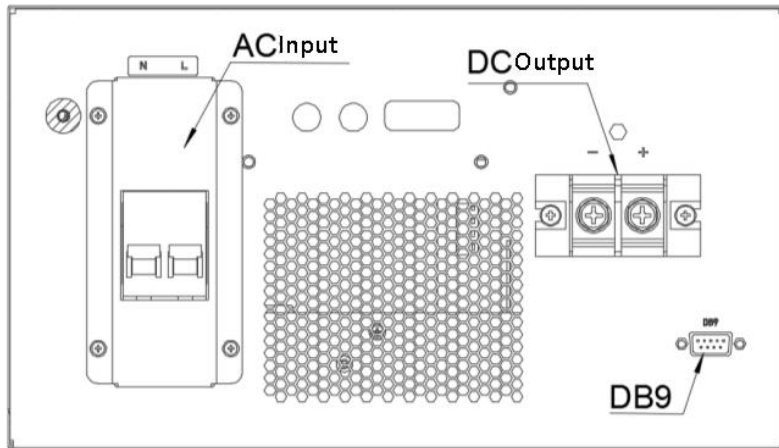


Figure 3-13 Port

Step 9 After charging is completed, end manual charging and follow the steps below to disable the robot's charging switch relay.

1. Go to the LCD screen, and disable relay. Perform the next step if there is no relay.
2. Enter `castor_charge_relay_set` back/left/right/down 0 via the SecureCRT tool.

Step 10 Exit the manual charging page, go to home page, and tap **Automatic Charge**. Tap charger connector button to disconnect.

Step 11 Reconnect DB9 port.

 **Note**

- Stop charging first before disconnecting the charging station from the robot.
 - Power off when disconnecting or connecting DB cable.
-

Chapter 4 Component Introduction

4.1 Indicator and Blue Light

Table 4-1 Indicator/Light Description

Indicator/Light	Status	Description
Blue Light	Solid	The mobile robot is powered on.
Steering Light	Left Steering Light Flashing	The mobile robot is turning left.
	Right Steering Light Flashing	The mobile robot is turning right.
	Left and Right Steering Lights Flashing	The mobile robot is backing up.
	Left and Right Steering Lights Off	The mobile robot is moving forward.
Status Indicator	Flashing Green for 2 s	The mobile robot is free.
	Flashing Yellow for 800 ms	The mobile robot is moving backward.
	Solid Green	The mobile robot is charging or is moving straightly, or is lifting or pausing on site.
	Solid Red	Emergency stop button is triggered or initialization fails.
	Flashing Red for 200 ms	The mobile robot decelerates or stops when it meets obstacles.
	Flashing Yellow for 3 s	The platform is disconnected.
	Flashing Yellow for 800 ms on One Side	The mobile robot is moving forward in arc or rotating in place.

	Flashing Yellow for 800 ms on Both Sides	The mobile robot is moving backward in arc.
	Flashing Red for 800 ms	The mobile robot is in manual mode.
	Flashing Yellow for 200 ms	All obstacle avoidance functions are disabled when mobile robot is in motion.
	Solid Yellow	Mobile robot second-level alarm is triggered.

4.2 LCD Screen

The LCD screen is designed for displaying mobile robot's real-time status information, task information, alarm information, obstacle avoidance data, and also map configuration information.

Note

- Interface images in the manual are for reference only.

4.2.1 Home Page

Real-time task information of the home page includes 3 parts:

- Upper status bar: indicates current mode, time, signal strength, and battery level.
- Left bar: indicates real-time status of the mobile robot, including running status, fork height, real-time speed, steering wheel angle, and number of reflective plates.
- Right bar: indicates the schematic of mobile robot's status.

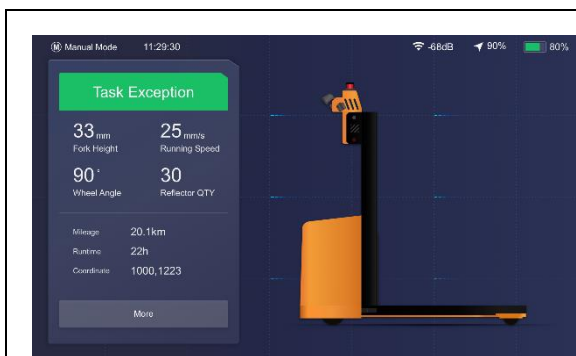


Figure 4-1 Home Page

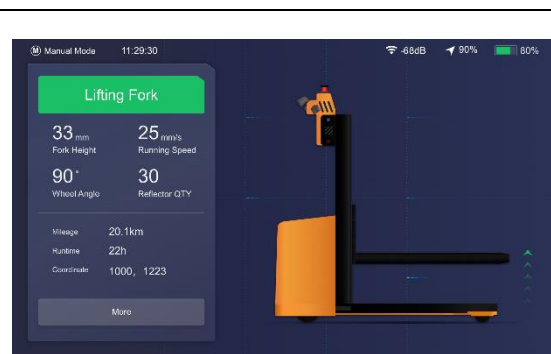


Figure 4-2 Lifting Fork

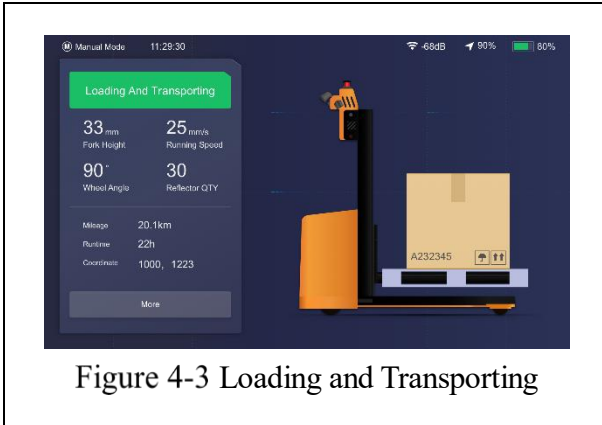


Figure 4-3 Loading and Transporting

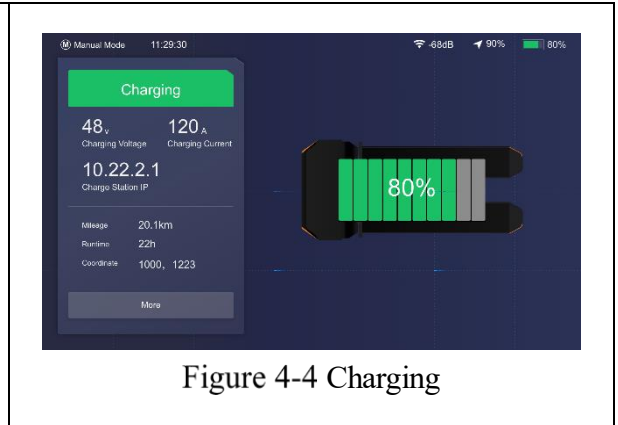


Figure 4-4 Charging

4.2.2 Safety Status

When any safety obstacle avoidance sensor of the mobile robot is triggered, the screen will display the type and location of the obstacle.



Figure 4-5 Obstacle Detected



Figure 4-6 Emergency Stop Triggered

4.2.3 Maintenance Information

Enter maintenance information interface to search the operation information and maintenance information.

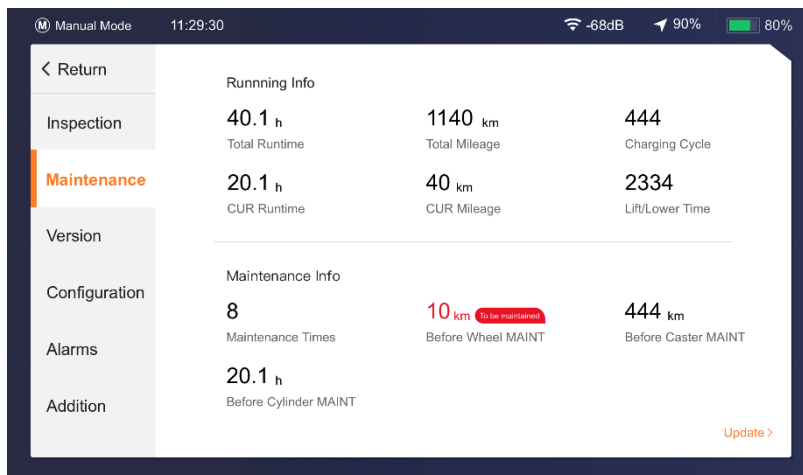


Figure 4-7 Maintenance Information

4.2.4 Version Information

Enter version information interface to search the version information of software.

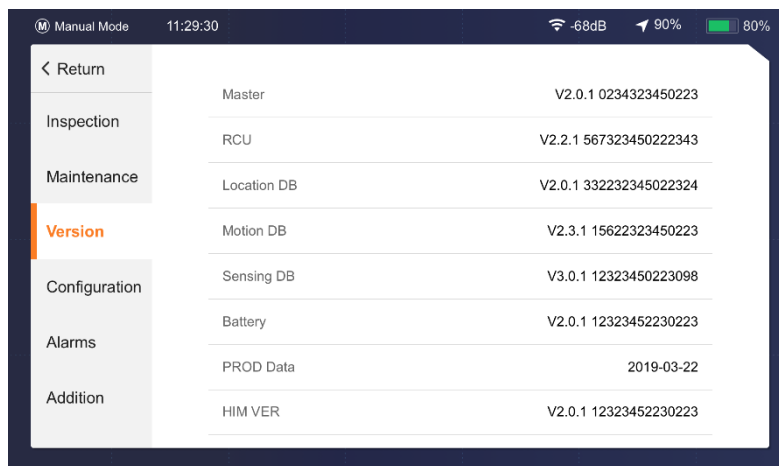


Figure 4-8 Version Information

4.2.5 Configuration Information

Enter configuration information interface to search related configuration information.

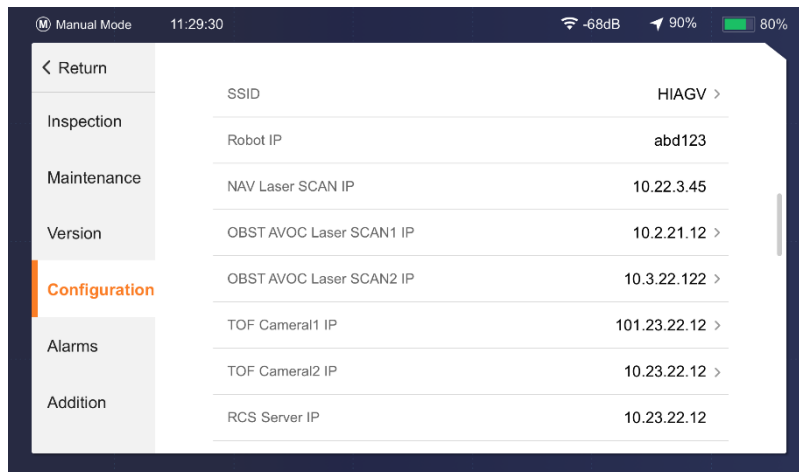


Figure 4-9 Configuration Information

4.2.6 Alarm

Enter alarm log interface to view the alarm records.

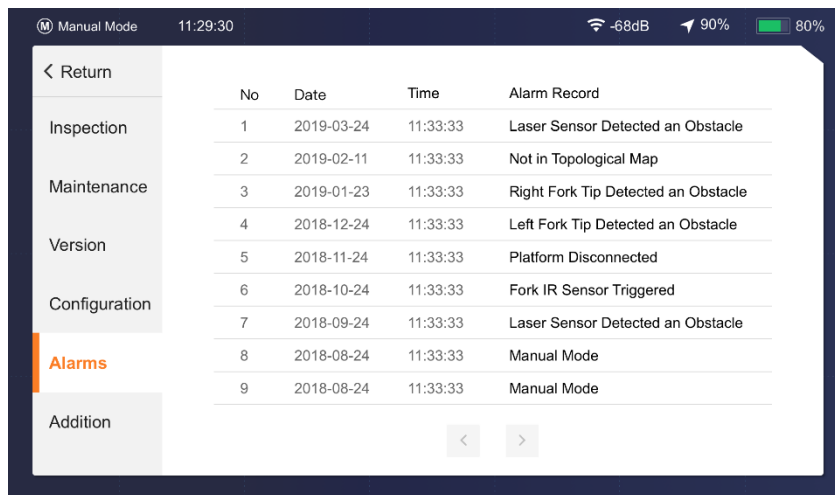


Figure 4-10 Alarm

4.2.7 Switch Configuration

Enter switch configuration interface to enable relay, soft AP, manual mounting, and charging.



Figure 4-11 Switch Configuration



Figure 4-12 Switch Configuration

4.3 Power Switch

Power switch is used to power on or off the mobile robot. Switch the power switch to **On** to power on the mobile robot, and press the reset button to run the mobile robot.

Switch the power switch to **Off** to power off the mobile robot.

Note

- Do not power off the mobile robot during working.

4.4 Emergency Stop Button

Emergency stop button plays a key role in stopping the mobile robot manually when an emergent situation occurs.

Press this button when an exception occurs, and then the mobile robot stops with an audible alarm and the solid red indicator.

Release this button and press the reset button, and then the mobile robot recovers to the working mode. At this time, the audible alarm stops, and the solid red indicator is unlit.

4.5 Pause/Resume Button

Only when the pause/resume button is pressed, the mobile robot can be operated.

4.6 Fork Lifting & Lowering Button

Switch the mobile robot to manual mode and press the lifting/lowering button to adjust fork height according to actual demands.

4.7 Forward & Backward Button

Switch the mobile robot to manual mode and press the forward/backward button to adjust mast according to actual demands.

4.8 Auto/Manual Button

The mobile robot supports two operating modes: auto mode and manual mode.

- Auto mode (A): In this mode, the mobile robot is controlled by the robot control system.
- Manual mode (M): In this mode, the mobile robot can lift/lower forks, but it no longer receives tasks from the robot control system.

4.9 Reset Button

The reset button is used to help the mobile robot continue to work normally after the robot recovers from malfunctions. Here are some common scenarios where you need to press the reset button.

When the mobile robot moves out of topological points and the display screen displays task exception, you should press reset button to continue.

When the display screen displays task exception with an audible alarm after the mobile robot is powered on, you should press reset button to continue.

4.10 Navigation Laser Sensor

The navigation laser sensor is used to scan the environment and collect data for creating the map. It is also used to determine the location of the mobile robot on the map according to scanned environment.

When an obstacle is detected in the plane of the mounting height, the robot will decelerate or stop to avoid collision.

4.11 Obstacle Avoidance Laser Sensor

The mobile robot will decelerate or stop when the sensor detects there is an obstacle.

The obstacle avoidance laser sensors are installed on the front, left, and right sides of the mobile robot.

- Sensor on the front: A plane with a radius of 8 m, a 180° horizontal field of view, and 178 mm above the ground can be detected. The obstacles below or above this plane cannot be detected.
- Sensors on the left and right: A plane with a radius of 8 m, a 199° horizontal field of view, and 118 mm above the ground can be detected. The obstacles below or above this plane cannot be detected.

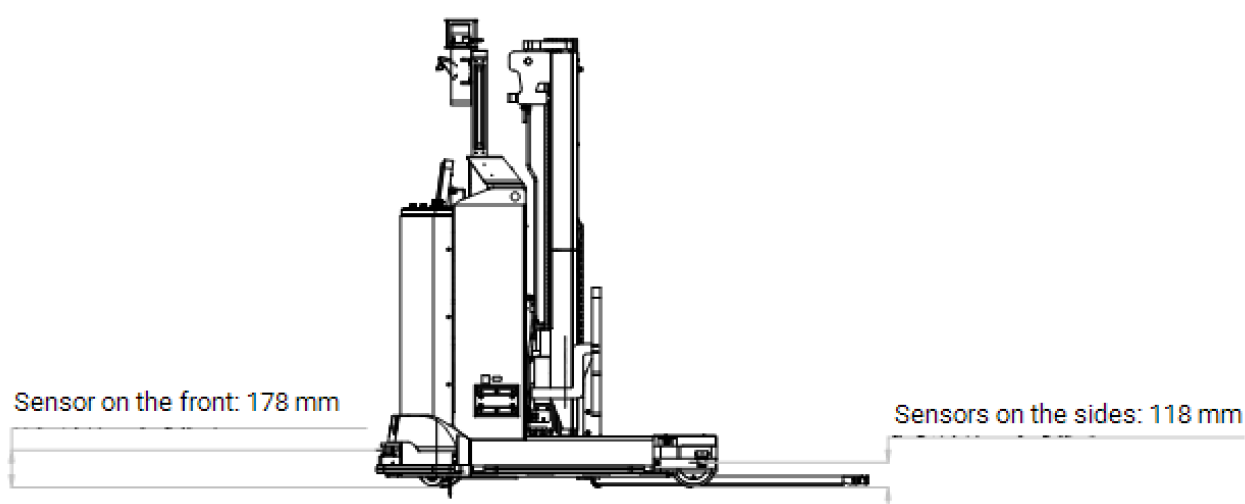


Figure 4-13 Installation Height

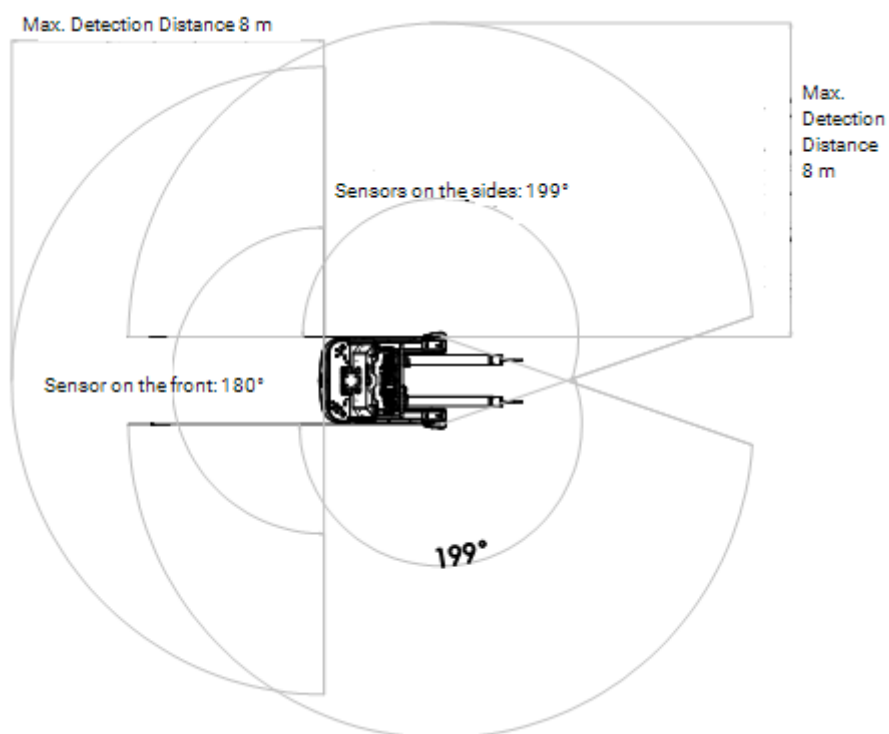


Figure 4-14 Protection Area

 **Note**

- The protection area can be configured according to the capability of the sensor in the robot control system.
-

4.12 Fork Non-Contact Detection Optoelectronics

The fork non-contact detection optoelectronics is mainly used to detect obstacles in front of the mobile robot by transmitting pulsed infrared light and receiving it from objects. After an object is detected, the mobile robot will stop immediately.

Each fork has 2 non-contact detection optoelectronics.

The detection range is a 285 mm line segment emitted from the photoelectric sensor at a height of 39 mm above the ground. Objects within the range can be detected.

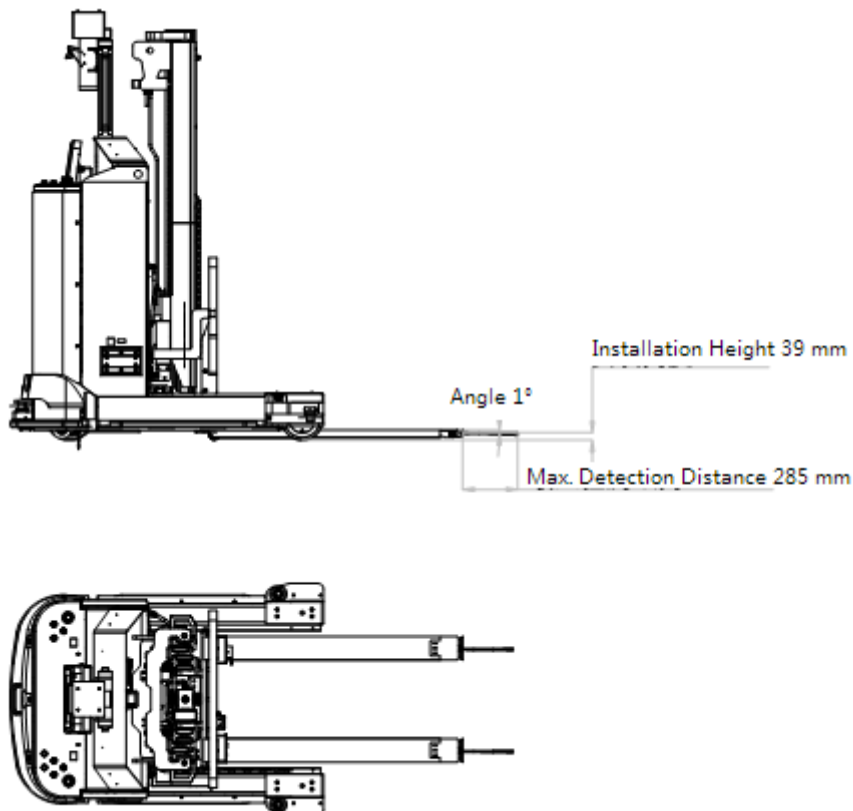


Figure 4-15 Installation Height and Protection Area

4.13 Pneumatic Bumper Strip

The mobile robot is equipped with pneumatic bumper strips that are used to protect the mobile robot. When the mobile robot collides with an obstacle, the air pressure in bumper strips will change, and the mobile robot will stop and send alarms.

After bumper strips are triggered, you need to press the emergency stop button and remove obstacles. After that, release the emergency stop button, press the reset button, and then the mobile robot will continue to work.

4.14 Fork Anti-Collision Structure

The fork anti-collision structure is used to protect the mobile robot when the fork collides with an obstacle.

After fork anti-collision structure is triggered, you need to press the emergency stop button and remove obstacles. After that, release the emergency stop button, press the reset button, and then the mobile robot will continue to work.

4.15 Binocular Camera

Note

- The data collected by binocular camera is only used for obstacle detection. No videos of object or people are recorded.

The binocular camera is installed on the front panel of the mobile robot. It can detect pothole and small-sized obstacles on the ground, and send the size and distance of the obstacle to the robot control system which makes the mobile robot decelerate or stop to avoid collision.

The binocular camera can detect area between 200 mm and 1 m from 90° horizontal field of view and 65.5° vertical field of view.

Setting the range of the protection area is not allowed.

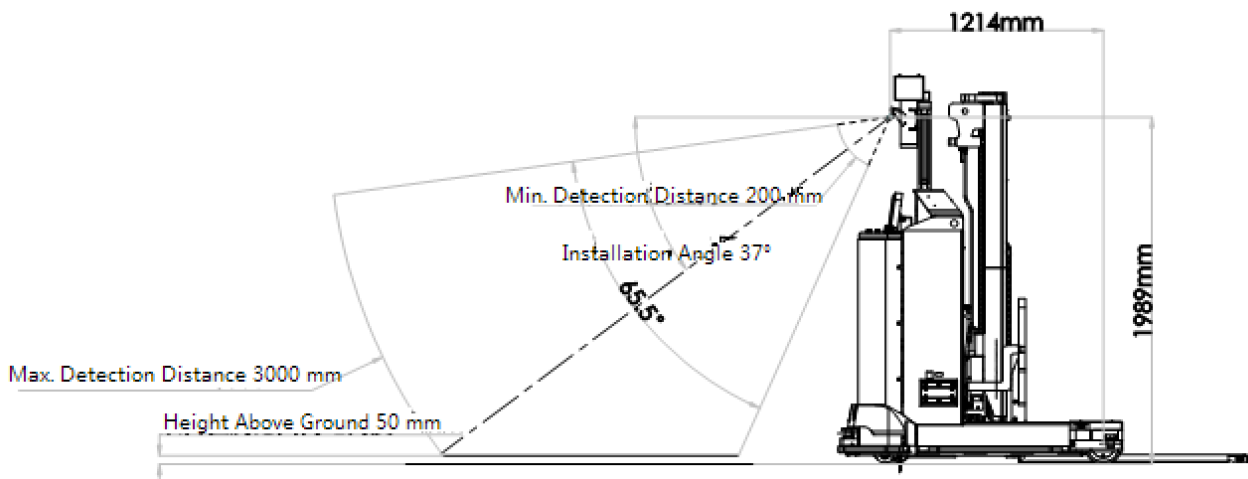


Figure 4-16 Installation Height and Protection Area

Chapter 5 Lift Mobile Robot

Danger

- Before lifting, check the ground condition, and make sure that the ground can support the weight of the mobile robot and the crane.
 - During lifting, no one is allowed to enter the lifting area.
-

Note

- Before lifting, check the lifting device to ensure normal operation.
 - Use the lifting sling that can support 1 ton and above.
 - During lifting, the angle between the lifting sling and the vertical plane should be less than 45°.
 - During lifting, avoid collision between the mobile robot and lifting device.
-

Step 1 Power off the mobile robot.

Step 2 Connect hoist ring, hook, and lifting sling.

Step 3 Lift the mobile robot.

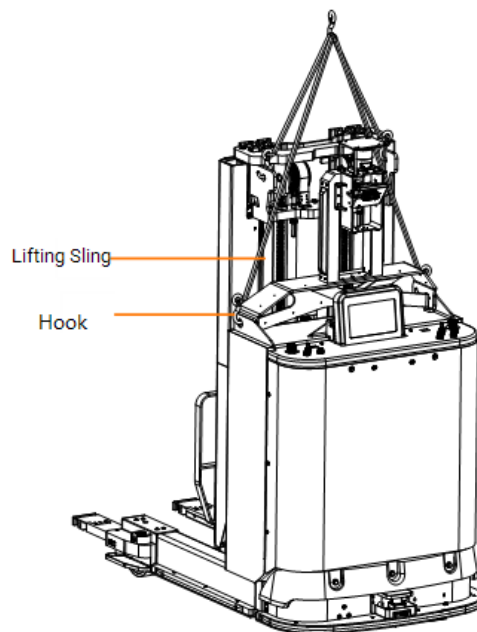


Figure 5-1 Lifting

Chapter 6 Alarm Handling

6.1 Alarm Recovery

When the mobile robot has an exception, it will show alarms via the status indicator (see [Indicator and Blue Light](#)) and LCD screen.

When alarms are triggered, the mobile robot can be recovered to the normal status via the following methods:

Automatic Recovery

The mobile robot automatically handles alarms and continues to execute the current tasks.

Manual Recovery

If the alarm persists, the mobile robot needs manual recovery. Press the emergency stop button, check the alarm types on the screen, and troubleshoot based on the table below. When the alarm handles, pull up the emergency stop button and press the reset button, and then the mobile robot will continue to work.



Caution

- Any troubleshooting must follow the related safety information in the [Safety Instructions](#).
-

6.2 Alarm Description and Solution

Table 6-1 Alarm Description and Solution

Alarm Type	Description	Solution
MCU Disconnected	The mobile robot does not detect the heartbeat signal from the MCU for more than 10 seconds.	<ol style="list-style-type: none"> Restart MCU program. Power off and restart the mobile robot.
Network Failed	When robot control system is disconnected and the main network card is not started, an IP address cannot be obtained or the main network card cannot ping through the gateway.	<ol style="list-style-type: none"> If only one mobile robot is disconnected, power off and restart the mobile robot. If the robot is frequently disconnected from the robot control system, check the antenna connection. Check network.
Robot Control System Disconnected	The mobile robot does not detect the recovery heartbeat signal from the robot control system.	<ol style="list-style-type: none"> If all mobile robots are offline, check the network, server, and robot control system status.

		<ol style="list-style-type: none"> 2. If only one mobile robot is disconnected, power off and restart the mobile robot. 3. If the robot is frequently disconnected from the robot control system, check the antenna connection.
Navigation Blocked	The navigation module data processing is blocked.	<ol style="list-style-type: none"> 1. Stop the mobile robot and wait for automatic recovery. 2. Disable PLC serial port printing if the mobile robot does not automatically recover for a long time.
Storage Exception	Loading storage intermedia failed.	<ol style="list-style-type: none"> 1. Power off and restart the mobile robot. 2. Check the connection of storage intermedia.
Robot Powered Off	The main battery is powered off.	Check the battery.
Platform Command Error	The mobile robot cannot execute platform tasks.	<ol style="list-style-type: none"> 1. Check tasks from robot control system and status of mobile robot. 2. Press the emergency stop button and adjust the mobile robot.
IP Conflict	The IP address of the mobile robot conflicts with that of other devices.	Wait for self-recovery of the mobile robot.
Incorrect Initialization Parameters	Initialization parameters are incorrect.	Upgrade with the correct upgrade package.
Incorrect Configuration Parameters	Configuration parameters are incorrect.	Edit the linear acceleration value to a normal value.
Task Application Exception	Exception occurred when applying task.	Check the route speed set on the map.
Battery Communication Failure	The mobile robot fails to communicate with BMS.	Check communication between the mobile robot and the battery.
Battery Overvoltage I	First-level overvoltage alarm of the battery cell is triggered. Charging maintenance is required.	<ol style="list-style-type: none"> 1. Charging task is applied by the robot control system. 2. Use manual charging to finish the maintenance.
Battery Undervoltage I	First-level undervoltage alarm of the battery cell is triggered. Charging maintenance is required.	<ol style="list-style-type: none"> 1. Charging task is applied by the robot control system. 2. Use manual charging to finish the maintenance.

Battery Voltage Deviation I	First-level voltage deviation alarm of the battery cell is triggered. Charging maintenance is required.	<ol style="list-style-type: none"> 1. Charging task is applied by the robot control system. 2. Use manual charging to finish the maintenance.
Battery Overtemperature I	BMS alarm.	Check the environment and the battery.
Battery Low Temperature I	BMS alarm.	Check the environment and the battery.
Battery Returning Maintenance	At the end of full charging of BMS battery pack, the voltage deviation is greater than 300 mV and a single voltage exceeds 3.65 V.	Return to factory for maintenance.
Charging Station Overvoltage Output Failure	The output voltage exceeds 60 V.	<ol style="list-style-type: none"> 1. Check the charging station. 2. Restart the charging station.
Charging Station Overcurrent Output Alarm	The output current exceeds 33 ± 1 A.	<ol style="list-style-type: none"> 1. Check the charging station. 2. Restart the charging station.
Charging Station Overvoltage Output Alarm	The output voltage exceeds 59 V.	<ol style="list-style-type: none"> 1. Check the charging station. 2. Restart the charging station.
Charging Station Over-Temperature Failure	The charging station reports exceptional status. Charging is not available.	<ol style="list-style-type: none"> 1. Restart the charging station. 2. Check if the charging station works normally.
Charging Station Communication Failure	Communication error occurs during charging.	<ol style="list-style-type: none"> 1. Check the location of charging station. 2. Check communication cables between the charging station and the mobile robot. 3. Check power supply of the charging station.
Battery Unchanged	Battery stays unchanged after charging for 5 minutes, or charging current is 0 after charging for more than 30 seconds.	<ol style="list-style-type: none"> 1. Check the charging station. 2. Check power connection between the charging station and the mobile robot.
Charging Station Unconnected	Data interaction failure lasts for more than 30 seconds during charging.	<ol style="list-style-type: none"> 1. Check the location of charging station. 2. Check communication cables between the charging station and the mobile robot. 3. Check power supply of the charging station.

Battery Overvoltage II	Second-level overvoltage alarm of the battery cell is triggered. Charging maintenance is required.	Use manual charging to finish the maintenance.
Battery Undervoltage II	Second-level undervoltage alarm of the battery cell is triggered. Charging maintenance is required.	Use manual charging to finish the maintenance.
Battery Overtemperature II	BMS alarm.	Check the environment and the battery.
Main Battery Low	The battery is lower than 10%.	Use manual charging to finish the maintenance.
Battery Low Temperature II	BMS alarm.	Check the environment and the battery.
Discharging Overcurrent I	BMS alarm.	Check battery connection and condition.
Discharging Overcurrent II (Short Circuit)	BMS alarm.	Check battery connection and condition.
Battery Voltage Deviation II	Second-level voltage deviation alarm of the battery cell is triggered. Charging maintenance is required.	<ol style="list-style-type: none"> 1. Charging task is applied by the robot control system. 2. Use manual charging to finish the maintenance.
Charging Overcurrent I	BMS alarm.	Check battery connection and condition.
Charging Overcurrent II	BMS alarm.	Check battery connection and condition.
Charger Connector Exception	The charger connector is exceptional.	Check the charger connector of charging station.
Rely Switch Exception	The status of rely switch is exceptional.	Check the relay switch.
Blank IP Address	Robot control system does not send the IP address of charging station while sending the commands.	Check whether the wireless charging station is configured on the map.
Rotational Motor Error	The rotational motor is exceptional.	Check rotational motor, driver connection, and power supply.
Walking Motor Error	The walking motor is exceptional.	Check connection between walking motor and driver, and power supply status.
Gyroscope Data Exception	The gyroscope source data delivered by the sensor is not true.	Calibrate the gyroscope.

No Data from SLAM Laser	The mobile robot does not receive data from SLAM laser.	<ol style="list-style-type: none"> 1. Check SLAM laser connection. 2. Check the navigation laser settings.
SLAM Data Unreliable	The location confidence that outputted by the positioning library is relatively low. Valid reflective plate information is insufficient and contours are similar.	<ol style="list-style-type: none"> 1. Check if the fork of the mobile robot is lowered in lifting status. 2. Move the mobile robot to somewhere that has more reflective plates and features under manual mode.
SLAM Map Unconfigured	Reading from SLAM map data failed.	Check whether the map is configured in robot control system.
Front Bumper Strip Triggered	The front bumper strip is triggered.	Press the emergency stop button, and press Reset to recover.
Laser CAN/IO Board Communication Exception	Laser sensor communication exception exists and no heartbeat can be detected.	Check the laser communication cable.
Laser Sensor Error	The laser sensor reports internal error.	<ol style="list-style-type: none"> 1. Check if the laser is working normally. 2. Power off and restart the mobile robot.
Lifting Motor CAN Cable Disconnected	The driving heartbeat of the lifting motor cannot be detected, and CAN cable is disconnected.	Check the CAN cable connection.
Ultrasonic Sensor Communication Failure	The communication of ultrasonic sensor is exceptional.	Check the ultrasonic sensor.
Display Screen Communication Failure	The communication of display screen is exceptional.	Check the connection between the display screen and the main control.
Load Cell Exception	The communication of load cell is exceptional.	Check connection of the load cell.
Load Cell Overweight	The weight exceeds the rated weight of the mobile robot.	Check whether the goods weight exceeds the load capacity of the mobile robot.
Laser Powered Off	The laser is powered off.	Check the laser connection.
Front Bumper Strip Offline	The front bumper strip is offline.	Check the front bumper strip.
Safety Circuit Disconnected	The safety laser is triggered, the emergency stop button is pressed, and forks collide.	Check whether the emergency stop button is pressed. If yes, pull up the button and press Reset.
RCU Working Mode Error	RCU working mode is exceptional.	Switch the Auto/Manual and press Reset.

Initialization Protection	Initialization protection alarm is triggered.	Press Reset.
Left Fork Tip Meets Obstacles	The left fork tip meets obstacles.	<ol style="list-style-type: none"> 1. Check the actual situation. 2. Manually operate the forklift or remove obstacles.
Right Fork Tip Meets Obstacles	The right fork tip meets obstacles.	<ol style="list-style-type: none"> 1. Check the actual situation. 2. Manually operate the forklift or remove obstacles.
Contour Laser Receiving Timeout	Contour laser is set but no data is received.	Check the contour laser connection.
Incorrect Contour Laser Data	Contour laser data is incorrect, such as incorrect length or incorrect content.	Check the contour laser settings.
No Data in ToF Camera	The ToF is set but no data is received.	Check the connection of ToF camera.
Goods Detector Exception	The status of goods detector does not match with that of the current task.	<ol style="list-style-type: none"> 1. Check if the status of loading matches with that of the current task. 2. Press Reset.
Rotational Motor Communication Exception	The driving heartbeat of the left motor cannot be detected, and CAN cable is disconnected.	Check the CAN cable connection.
Walking Motor Communication Exception	The driving heartbeat of the right motor cannot be detected, and CAN cable is disconnected.	Check the CAN cable connection.
Rotational Motor Speed Follow-Up Exception	The actual speed of the left motor is 30% slower than the target speed and lasts for 4 seconds.	<ol style="list-style-type: none"> 1. Check if it is overloaded. 2. Check wheels.
Walking Motor Speed Following Exception	The actual speed of the right motor is 30% slower than the target speed and lasts for 4 seconds.	<ol style="list-style-type: none"> 1. Check if it is overloaded. 2. Check wheels.
Current Overload of Rotational Motor	The current of the left motor reaches the rated current (98% to 103%) and lasts for 1 second.	<ol style="list-style-type: none"> 1. Check if it is overloaded. 2. Check wheels.
Current Overload of Walking Motor	The current of the right motor reaches the rated current (98% to 103%) and lasts for 1 second.	<ol style="list-style-type: none"> 1. Check if it is overloaded. 2. Check wheels.
Left Rear Caster Wheel Maintenance	The running mileage exceeds 3000 km.	Replace components and clear maintenance data.

Right Rear Caster Wheel Maintenance	The running mileage exceeds 3000 km.	Replace components and clear maintenance data.
Main Battery Maintenance	Times of charging and discharging exceed 10000.	Replace components and clear maintenance data.
Lifting Structure Maintenance	The lifting times exceed 110000.	Replace components and clear maintenance data.
Main Steering Wheel Maintenance	The running mileage exceeds 3000 km.	Replace components and clear maintenance data.
Rotational Motor Maintenance	The number of running rotations exceeds 5000000.	Replace components and clear maintenance data.
Walking Motor Maintenance	The number of running rotations exceeds 5000000.	Replace components and clear maintenance data.
Robot Not on Topological Map	The mobile robot is not on the topological map.	<ol style="list-style-type: none"> 1. Adjust the mobile robot manually. 2. Press Reset and wait for the mobile robot to automatically return to the topological map.
Robot Not on Route	The robot rushes past the destination, but is still on the topological route.	<ol style="list-style-type: none"> 1. Adjust the mobile robot manually. 2. Press Reset and wait for the mobile robot to automatically return to the topological map.
Lifting Algorithm Error	Draw wire or pulley of draw wire is exceptional.	<ol style="list-style-type: none"> 1. Check draw wire or pulley of draw wire. If the wire removes from the pulley, or pulley is deformed and cannot be operated, please change in time. 2. Press Reset.
	The lifting motor is exceptional.	<ol style="list-style-type: none"> 1. Check lifting motor by switching to manual mode and performing lowering and lifting actions. 2. Press Reset.
	Other exceptions.	Add running self-calibration, and recalibrate lifting parameters.

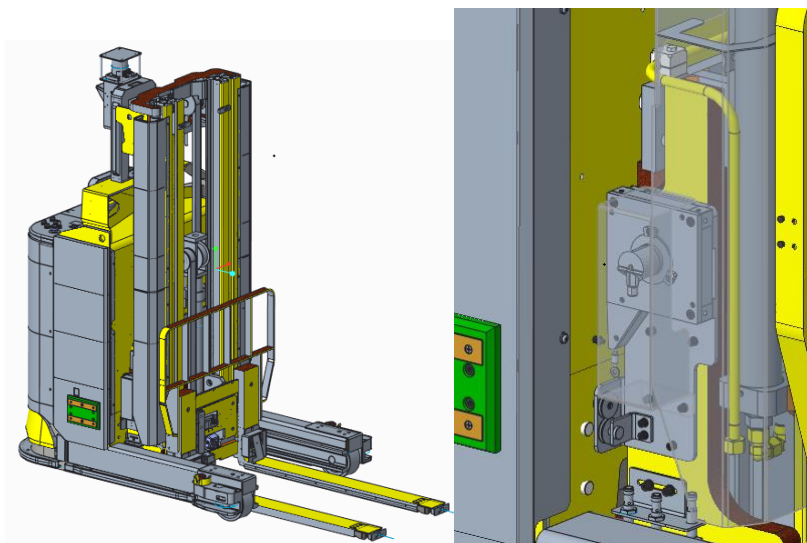


Figure 6-1 Draw Wire or Pulley

Appendix A Open Source Software License

This product's software uses third-party open source software, source code or components in strict accordance with the relevant requirements of the open source license agreement. The open source compliance statement of the corresponding software can be queried by scanning the QR code below.



Figure A-1 QR Code

Appendix B Field Requirement

Road Fluctuation

Road fluctuation refers to the difference between max. height and min. height in the reference range. When the road fluctuation is smaller than the max. value, the mobile robot can move in the nominal speed. The max. fluctuation value should be less than 3 mm (including 3 mm) within 1 m².

Road Gradient

Road gradient refers to the max. ratio of horizontal difference to path length in a path over 100 mm. When the road gradient is less than the max. value, the mobile robot can move in the nominal speed. The max. road gradient should be less than 0.05 (including 0.05). For the stop where precise positioning of mobile robot is required, the road gradient should be less than 0.01 (including 0.01).

Step Height

Step height refers to the max. height difference in a path within 100 mm. When the step height is less than the max. value, the mobile robot can move in the nominal speed. The mobile robot cannot stop at steps, and the max. step height should be less than 5 mm (including 5 mm).

Width Range

When the width range is less than the max. value, the mobile robot can move in the nominal speed. The mobile robot cannot stop at grooves, and the max. width range should be less than 8 mm (including 8 mm). When the width range exceeds the max. value, the requirement should be made according to the step height.

Ground Friction Coefficient

The mobile robot wheel adopts PU material, and the ground sliding friction coefficient is greater than 0.5. Ground friction coefficient is important for brake safety distance and location accuracy. Dirty ground, water logging, cleaning agent can also affect mobile robot running.

Ground Load Bearing

Load per unit of ground should be higher than that of mobile robot horizontally-projected area to keep ground from being damaged. Composite ground is recommended, which can conduct the pressure of mobile robot to the cement bearing layer. The small-area pressure from wheels should be taken into consideration as well.

There should be no hidden hollow in ground, which will significantly affect mobile robot operation. Constructor needs crack detection in operational area. Unqualified ground must be rebuilt until qualified.

Ground Electrical Characteristics

Ground conductive resistance should maintain in 10^6 to 10^9 to avoid mobile robot accumulated electrostatic (referred to Germany DIN51953 Standard).

Appendix C Loading Curve

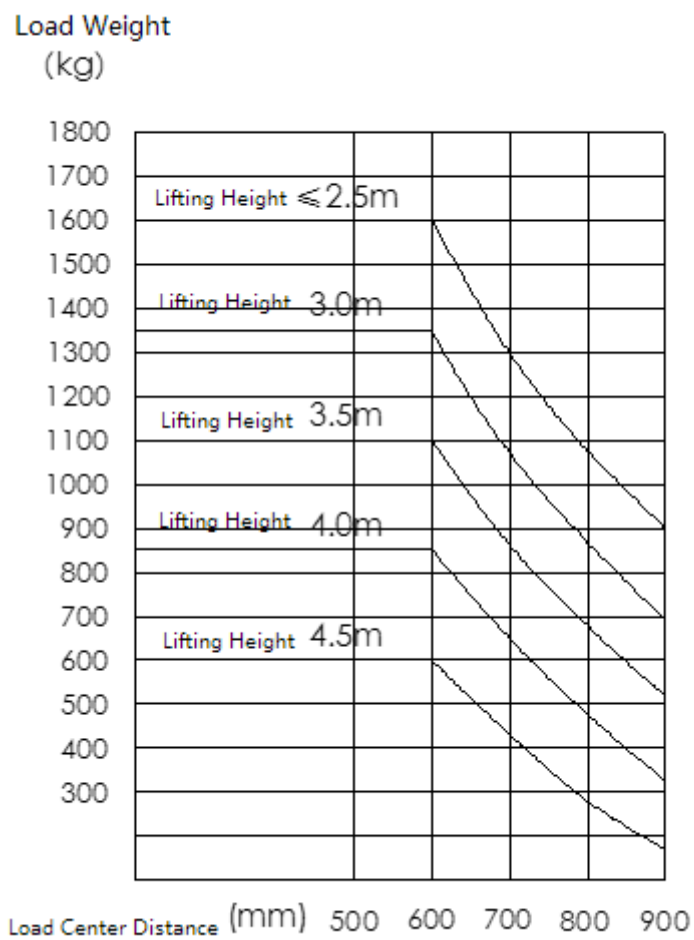


Figure C-1 Loading Curve

Appendix D Wireless Network Requirement

D.1 Wireless AP (Access Point) Deployment Requirement

Location and Quantity Requirement

The AP model (especially omnidirectional and directional) decides its coverage and installation method.

APs can adopt ceiling mounting or wall mounting. For wall mounting, the recommended slope is 7° to 9°, and the height is 3 m to 5 m.

Specify the AP quantity according to the AP coverage and your space size. Too many APs may easily cause signal interference. Here we give an example for reference. When the AP transmitting power is 20 dBm and the mobile robot carries metal rack, the AP covered radius is 15 m. If the mobile robot does not carry any rack, the AP covered radius could be 20 m.

Due to poor penetration of wireless signal, the physical isolation should be considered during AP deployment and AP quantity should be increased if needed. Firewall (construction) is commonly used in warehouse, which weakens the signal sharply. In this case, deploying an AP near the firewall may be recommended.

Channel Configuration Requirement

AP supports 2 kinds of frequency: 2.4 G and 5.8 G. For 2.4 G, channel 1, channel 6, and channel 11 are available; and for 5.8 G, channel 149, channel 153, channel 157, channel 161, and channel 165 are available.

Adjacent AP channels should be staggered and fixed.

Here we take 2.4 G frequency band channel and its deployment diagram as an example.

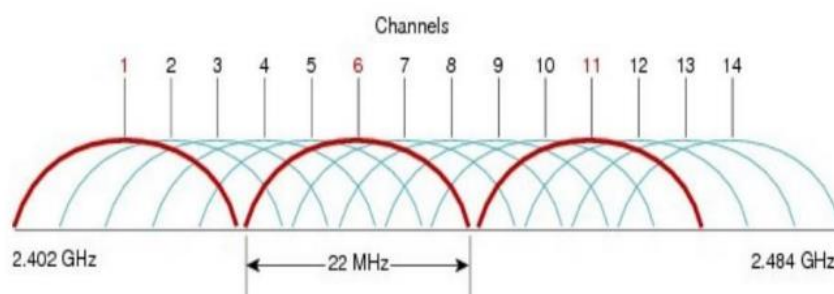


Figure D-1 2.4 G Channels

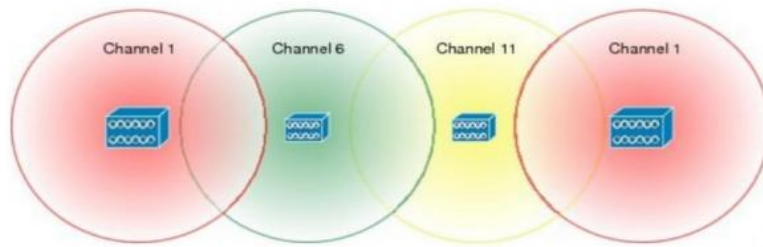


Figure D-2 2.4 G Channels Deployment 1

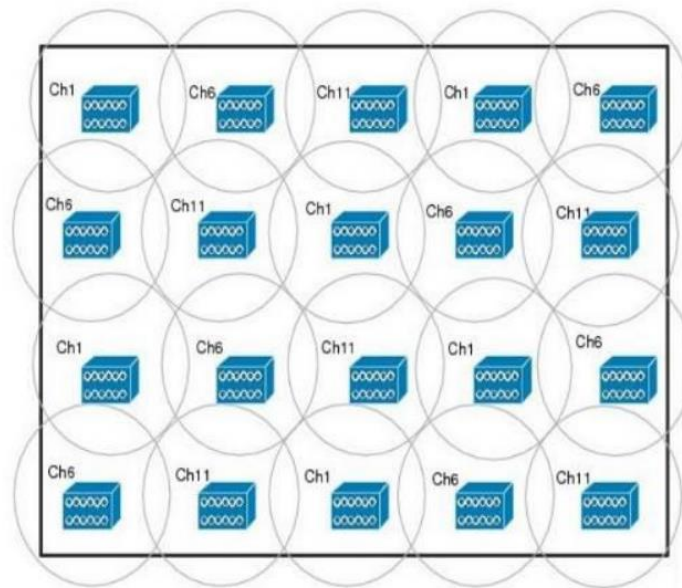


Figure D-3 2.4 G Channels Deployment 2

Signal Overlapping Range Requirement

The signal overlapping range of adjacent APs is the key point to the AP deployment.

Four elements determine the signal overlapping range: STA roaming switch scheme, matching threshold of AP and STA, max. STA moving speed, and switching time of AP/AC. It is recommended to ensure each AP has -65 dB strength overlapping.

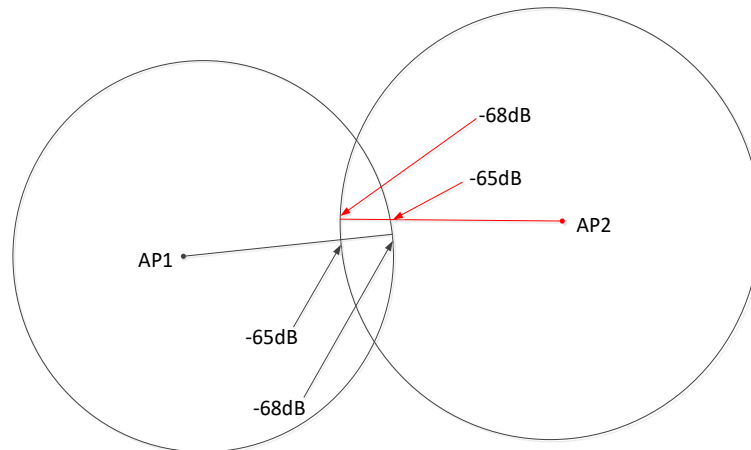


Figure D-4 Strength Overlapping Diagram

D.2 Wireless Network Settings Requirement

- Make sure the mobile robot uses 2.4 G or 5.8 G network frequency band independently.
- It is recommended to bind the mac address to manage the mobile robot in order to ensure the IP address of the mobile robot is unique and unregistered users cannot use this wireless network.
- Disable the AP intelligent antenna to fix the AP transmitting power and transmitting channel.
- Do not enable Distinguish Auto Channel or Power Auto Adjustment function.
- Set 2.4 G and 5.8 G bandwidth to 20 M to ensure communication stability.

D.3 Wireless Network Signal Strength Requirement

Signal Strength Requirement

There are different signal strength requirements for different areas.

- High-frequency activity area: usually refers to the inbound/outbound area, the queuing area, etc. The mobile robot signal strength should be larger than -55 dB, and the time delay of ping 1500 Byte packet should be less than 100 ms.
- Low-frequency activity area and non-gathering area: usually refers to warehouse edge and non-main route. The mobile robot signal strength should be between -68 dB and -65 dB.
- Remote area: usually refers to the place where the mobile robot seldom comes. When the signal strength is under -65 dB, the time delay of ping 1500 Byte packet should be less than 200 ms.

Note

- The strength refers to the actual testing of the mobile robot self-carried Wi-Fi.

Signal Strength Testing Scheme

There are two quick schemes to rate the wireless environment on site.

- Test mobile robot auto roaming in the testing area shown in the figure below. Connect to the specific AP1, and move at the speed of 800 mm/s near the AP signal strength with around -65

dB. The time delay of ping 1500 Byte packet should be less than 200 ms, and upstream and downstream rate should be no less than 2 Mbit.

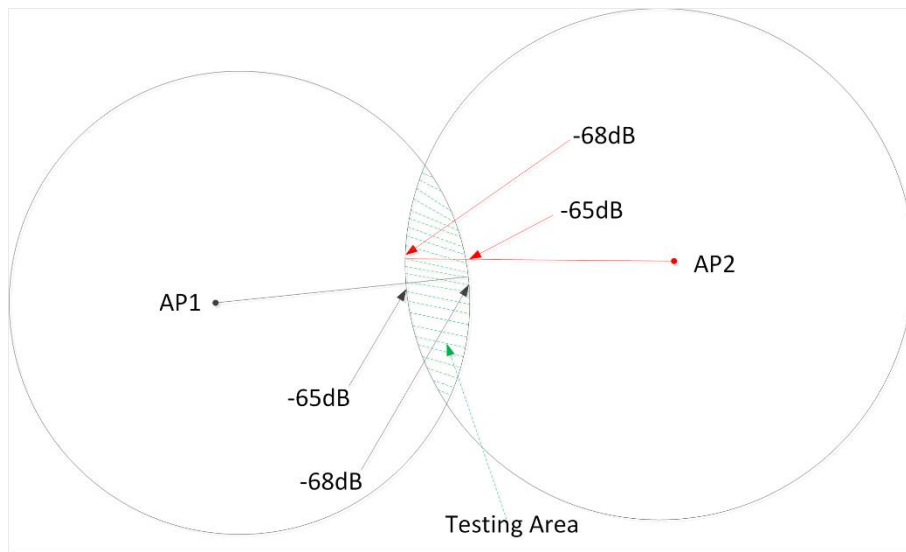


Figure D-5 Scheme Diagram

- When the mobile robot is roaming between APs, ensure the number of lost roaming ping packets is less than 2 at each time and the switching time should be within 100 ms. In order to keep a stable wireless environment, double AC back-up deployment method is recommended.

Appendix E Reflective Stripe Deployment

A sufficient quantity and reasonable deployment of reflective stripes should be arranged within a range of 25 m for positioning.

Due to the angle limitation of the reflective plate, the reflective stripes cannot be observed at all angles. So the incident angle of the laser should be considered during the deployment of the reflective plates.

For example, as shown in figure below, the black square with an arrow at the bottom represents a reflective plate, the arrow represents the normal vector of the reflective plate; and the red area is the area where the reflective plate can be observed.

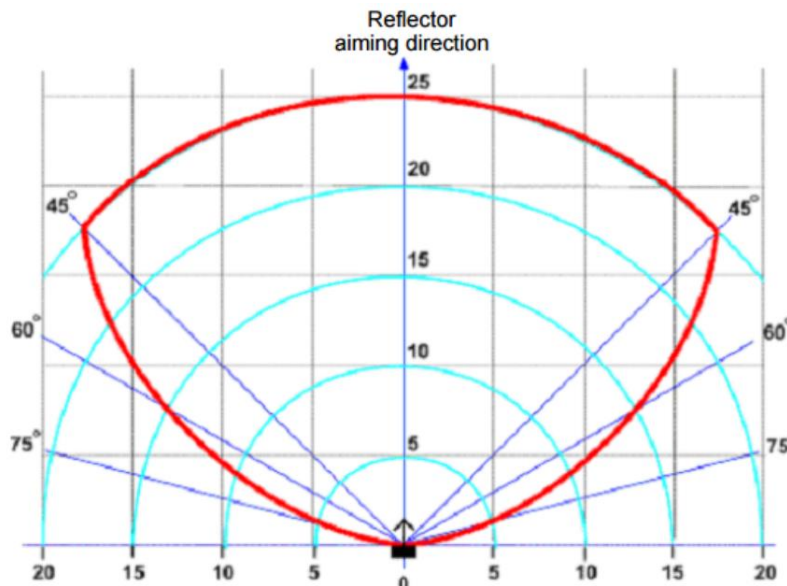


Figure E-1 Detection Area

The deployment of the reflective plates should be reasonable. Establish a coordinate system with the laser head as the center, and ensure that each quadrant has a reflective plate.

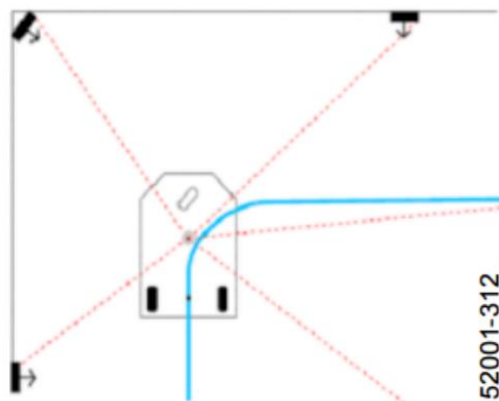


Figure E-2 Sample of Reasonable Reflective Stripe Deployment

The figure above is an example of reasonable deployment of reflective stripes, which are evenly deployed in the environment.

The figure below is an example of unreasonable deployment of reflective stripes. The reflective strips are unevenly deployed in the environment, and there is a large area where the reflective strips cannot be observed, which will easily cause deviations in the positioning of the mobile robot.

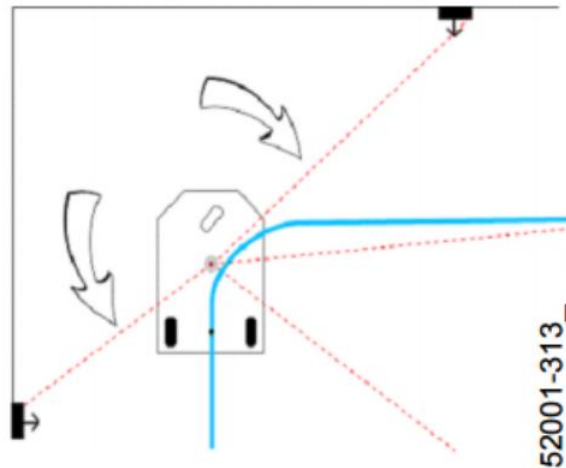


Figure E-3 Sample of Unreasonable Reflective Stripe Deployment

The figure below is an example of unreasonable deployment that the distance between the reflective pillars and the reflective stripes is too close.

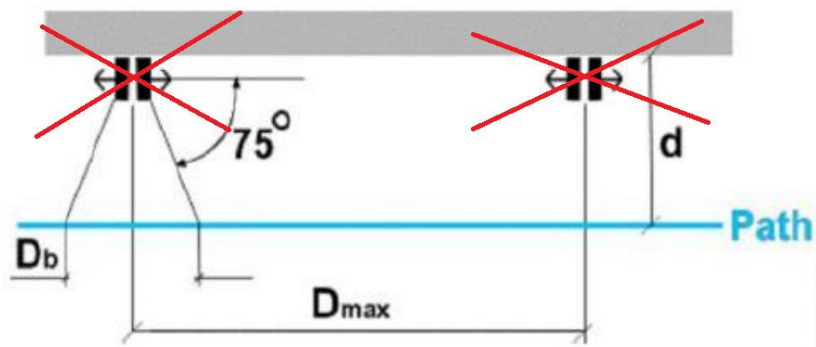


Figure E-4 Sample of Unreasonable Reflective Stripe Deployment

The figure below is an example of reasonable deployment of reflective pillars.

The figure below is an example of unreasonable deployment of reflective pillars.

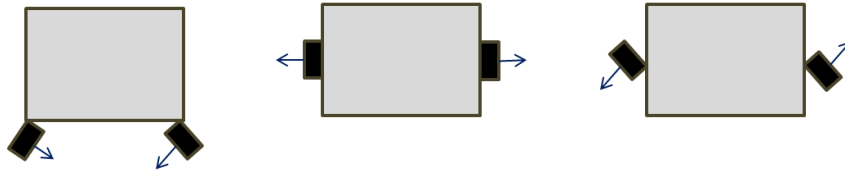


Figure E-5 Sample of Reasonable Reflective Pillar Deployment

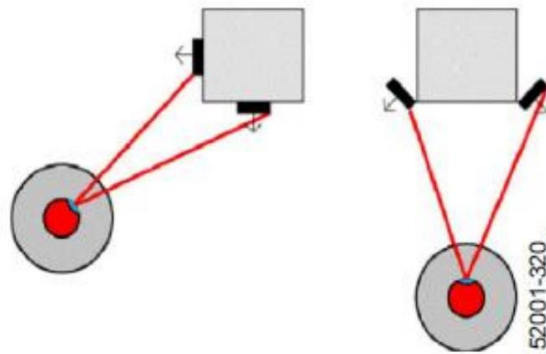


Figure E-6 Sample of Unreasonable Reflective Pillar Deployment

Multi-angle mixed installation is recommended, as shown in figure below.

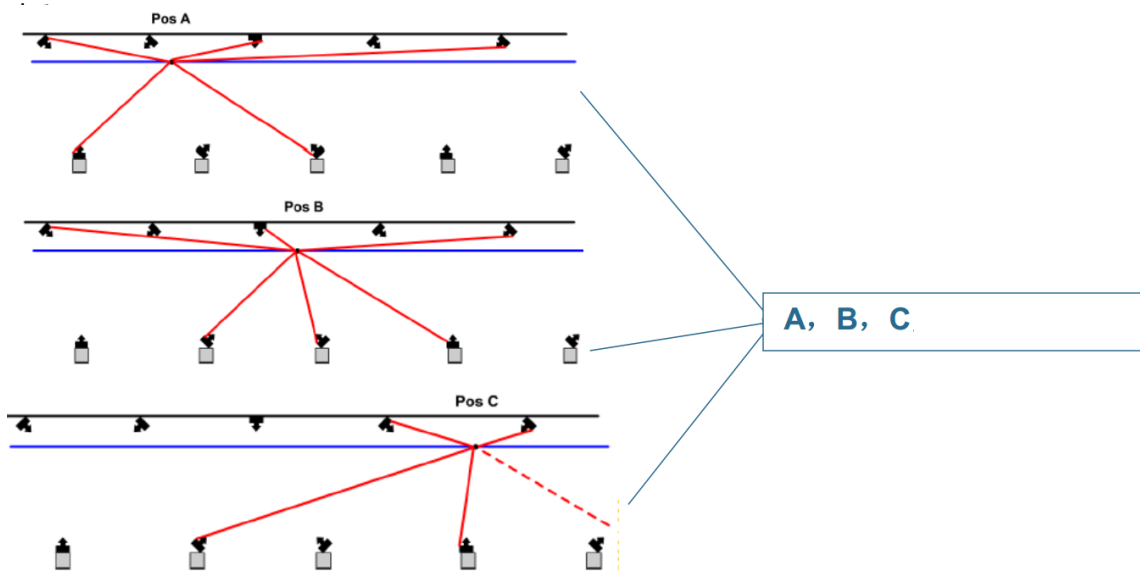


Figure E-7 Overall Deployment

When high location accuracy is required, it is recommended to deploy more reflective plates, as shown in figure below.

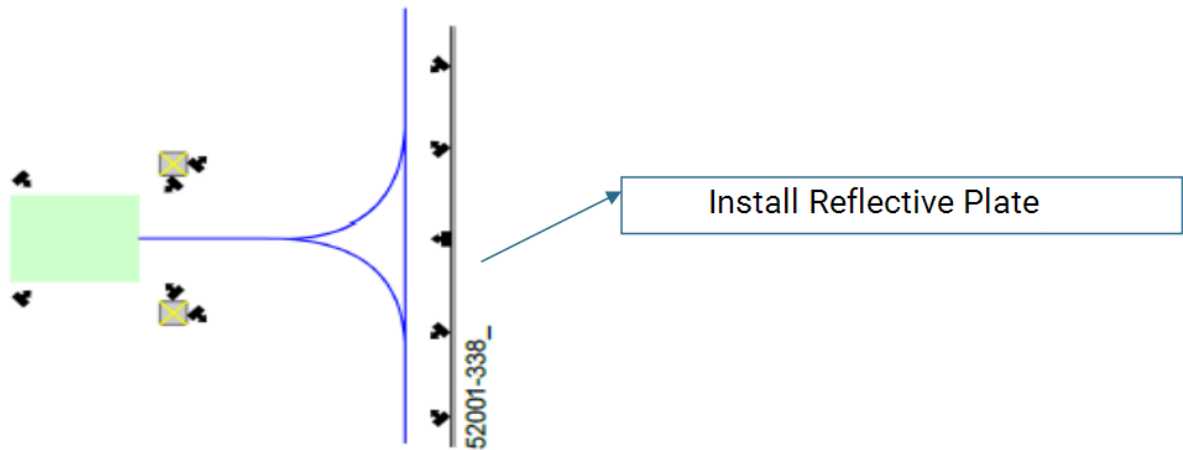


Figure E-8 Sample

If the reflective pillars are deployed symmetrically, it is easy to cause confusion for the mobile robot and fail to hop online. Therefore, the reflective pillar should not be deployed in a symmetrical structure, such as a rectangle and an equilateral triangle.

Do not place the reflective strips near high-reflectivity materials, such as windows and steel plates, which may cause interference.

Appendix F Abbreviation

Table F-1 Abbreviation

Abbreviation	Full Name
MR	Mobile Robot
RCU	Real-Time Control Unit
FMR	Forklift Mobile Robot
AMR	Automated Mobile Robot
AP	Access Point
AC	Access Controller
MCU	Microcontroller Unit
HMI	Human Machine Interface

