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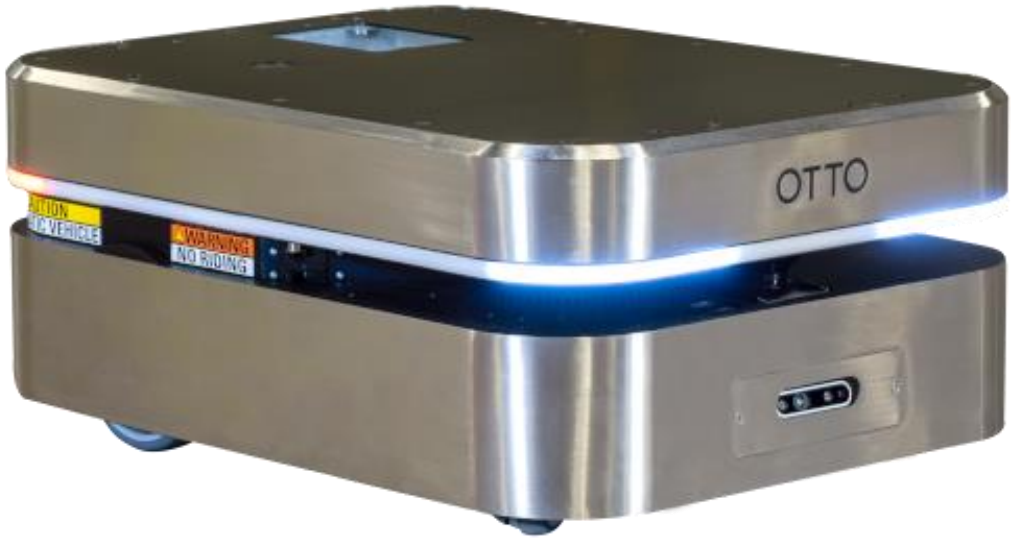

OPERATION AND MAINTENANCE MANUAL

OTTO 100 V2.4

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CONTACT INFORMATION

OTTO Motors is committed to your success and satisfaction. We are located in Kitchener, Ontario. If you have any questions or concerns, visit our support knowledge base for more information, or get in touch with our support team.

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DANGER

Failure to follow these instructions will result in SERIOUS INJURY, INCLUDING DEATH.

WARNING

Failure to follow these instructions may result in SERIOUS INJURY, INCLUDING DEATH.

CAUTION

Failure to follow these instructions may result in INJURY or DAMAGE to the system and or property.

The top priority of OTTO Motors is the safety of its users. OTTO Motors produces high power and fast-moving pieces of machinery that potentially could cause serious injury, including death, if improperly used or maintained. In order to inform our users of some of these risks, throughout OTTO Motors documentation you will see safety messages corresponding to either a DANGER, WARNING, or CAUTION level as shown above.

1 REVISION HISTORY

Table 1 Revision History

REVISION	DATE	CHANGES
A	November 2020	Initial release

2 HAZARDS AND AWARENESS

2.1 General Hazard Labels

Review the following to learn more about the labels that may be used on OTTO Motors products. Hazards can also apply to attachments and accessories used in conjunction with an OTTO Motors product.

Table 2 General Hazard Labels

LABEL	LABEL TITLE	LABEL DESCRIPTION	LABEL	LABEL TITLE	LABEL DESCRIPTION
	Grounding Electrical Hazard	Improper grounding of OTTO Motors chargers can result in a potential shock risk.		Pinching Risk	Keep hands and other objects clear of pinch points at all times. Keep clear of all docking OTTO AMRs.
	Harmful Battery Substance	Robot batteries contain harmful material. Always use proper handling procedures when handling robot batteries.		Crushing Risk	Objects or personnel can be crushed between OTTO AMRs and another object. Keep hands and other objects clear of crush points at all times. Keep clear of all docking OTTO AMRs.
	Hot Surfaces	Robot PC heat sinks and robot motors can become extremely hot during operation.		Impact Risk	OTTO AMRs travelling through a facility can potentially impact objects and personnel. Keep clear of all docking OTTO AMRs.

	Manual Load Handling	Always use ergonomic technique when manually lifting loads.		OTTO AMR Movement	OTTO AMRs may suddenly begin moving autonomously or when being driven manually. Always be aware of OTTO Motors products and their potential for movement.
	Tripping Hazard	OTTO Motors products may pose a tripping hazard.		Automated Mobile Robot Traffic	Be aware that OTTO AMRs can be anywhere in the operating area of the facility at any time.
	Lock-Out/Tag-Out	When performing maintenance on an electrically powered OTTO Motors product, always follow the applicable Lock-Out Tag-Out procedure.		Personal Protective Equipment (PPE) Requirement	Proper PPE must be worn, including safety footwear (ie. steel toe) around OTTO Motors products. Insulated gloves and/or tools are recommended when performing any maintenance on OTTO Motors products.
	Do Not Ride	OTTO AMRs are not designed for carrying personnel and should not be ridden at any time.			

2.2 Safety Awareness

Personnel present in an OTTO Motors facility need to be made aware or be accompanied by personnel who are familiar with the specific risks and hazards associated with automated mobile robots (AMR).

The following checklist identifies basic topics that should be addressed by site-specific worker and visitor safety orientation training.

Caution

Additional items may need to be addressed based on the site-specific risk assessment.

- [ ] Proper PPE must be worn, including safety footwear (ie. steel toe).
- [ ] Crossing into the path of a moving OTTO AMR should be avoided, as well as placing or throwing obstacles into the path of a moving OTTO AMR.

Impact

Never move quickly into the path of a moving robot. Robot LiDAR safeguards offer protection against static or slow moving objects within its detection range but will be unable to safeguard against personnel running or jumping into its path.

- [ ] Be aware that an OTTO AMR can be anywhere in the operating area of the facility at any time, and may pose a tripping hazard even when not in motion.
- [ ] Personnel need to be aware of operation limitations, such as floor grades, negative and overhanging obstacles, and the OTTO AMR LiDAR obstacle detection plane.
- [ ] The floor of the operating area should be kept free of dirt and debris.
- [ ] Personnel need to be aware of OTTO AMR docking and charging areas, where detection fields are reduced.

See the Product Safety section of the operations and maintenance manual for the applicable OTTO AMR.

- [ ] Personnel should be aware of facility areas where OTTO AMRs travel through narrow aisles/corridors resulting in reduced clearance between OTTO AMRs and personnel and aisles/corridors shared between OTTO AMRs, other robots, and personnel.

> See the Product Safety section of the operations and maintenance manual for the applicable OTTO AMR.

- Personnel should be aware that OTTO AMR LiDAR safety scanners use a class 1 laser and high intensity LED.
- Personnel should keep all loose clothing and body parts away from OTTO AMRs, accessories, attachments, and payloads, while they are in autonomous operation. Using an Emergency Stop button is the only acceptable manner of interacting with an OTTO AMR or attachment while it is being operated autonomously.

In addition to the preceding basic items for all workers and visitors, the following should be considered for facility personnel, including drivers of other robots:

- High traffic areas, tight clearance areas, emergency exits, areas around electrical panels or in front of shelves and racking, and obstacles that are outside the field of view of safety sensors (i.e. overhanging obstacles) should have bollards placed around them so that OTTO AMRs do not drive or stop in those areas
- When required to move a product manually, personnel must ensure it is in an Emergency Stop state (in the case of an OTTO AMR) or shut down completely and should not push manually for prolonged periods.

> See the Basic Usage section of the operations and maintenance manual for the applicable product.

- Operators of other industrial robots must not leave skids or other loads overhanging or unstable near the edges of racking as they may not be detected by an OTTO AMR.
- Alert personnel that while operating an OTTO AMR outside of the Autonomy State, they are solely responsible for obstacle and collision avoidance.
- Maintenance not outlined in the operations and maintenance manual can only be performed by OTTO Motors Authorized Personnel.

2.3 Facility Conditions

OTTO AMRs, attachments, and accessories are designed to work on flat and clean surfaces - facility conditions greatly affect their ability to operate safely and navigate properly.

Warning

Bypassing the drive wheels of an OTTO AMR while it is on a ramp is a dangerous situation where the OTTO AMR may move unexpectedly. Never bypass drive wheels unless the OTTO AMR is on a flat surface that is clear of objects.

- Facility floors must be dry and clean with a coefficient of friction greater than 0.4 to better assist OTTO AMRs in achieving safe stopping distances. Debris on the floors may become caught in casters and lead to premature failure of wheels, casters, or drive components. Areas with floors that can't meet these requirements should be isolated by bollards or physical LiDAR-height barriers. Exclusion Zones in Fleet Manager cannot be solely relied upon to prevent entry to areas with floors that don't meet OTTO AMR requirements.
- OTTO AMRs should never be driven onto curbs or across gaps in the floor that may result in damage to the robot drive systems, attachments, or accessories - for example, at the top of stairs, the top of dock doors, or mezzanines without a protective ledge. Areas matching these descriptions should be isolated by bollards or physical LiDAR-height barriers.

Crush

LiDAR safeguards offer protection from collision and crushing by OTTO AMRs to nearby pedestrians within the LiDAR detection plane. Objects such as forklift tines, or low-profile pallets outside of the detection plane are not safeguarded against by the LiDAR system and can be struck by an OTTO AMR. Secondary injuries such as collision or crushing resulting from an object being pushed by an OTTO AMR are possible.

- OTTO AMRs are designed to operate indoors free of direct sunlight. Infrared light sources (including sunlight, light curtains, welding) may interfere with the operation of OTTO AMRs when shone directly into the robot's optical sensors.
- OTTO AMRs rely on LiDAR to protect personnel from crushing or collision hazards. Although rare, very reflective or very light absorbent (eg. black) material can impede the LiDAR safety systems. Avoid the use of such materials in clothing or obstacles to assist their detection by OTTO AMR LiDAR safety systems.
- Areas in front of or behind chargers or other docking areas (eg. P&D stands) should be marked for personnel to avoid the space.

- OTTO AMR drive wheels and cart brakes should never be manually bypassed on a ramp condition as this may lead to robots or carts navigating erratically and losing control. If stopped on a slope greater than 1° (1.6 % grade), robots and carts will begin to roll and may present a hazard.

> **Warning**
>
> Ramps with a slope of greater than 3° (5 % grade) must be identified and blocked from all OTTO AMR traffic.

2.4 Payload Maximums

OTTO Motors products support a specific maximum payload. OTTO AMR maximum payloads change when an attachment or accessory is connected because of the weight of the attachment/accessory itself. In the case of an attachment/accessory-equipped OTTO AMR, payloads should not exceed the maximum payload documented on the Attachment Nameplate.

> **Caution**
>
> Loading an OTTO Motors product with more weight than specified by the attachment, accessory, or base OTTO AMR (when no attachment is present) will prevent OTTO AMRs from correctly determining stopping distances and may also damage the robot, attachment, or accessory. Never load an OTTO Motors product with more weight than is specified by the current signage on each OTTO AMR and accompanying attachment or accessory.

2.4.1 OTTO 100 AMR

For the default configuration for the OTTO 100 AMR, the payload must lie within the projected view of the OTTO 100 AMR body and not project over the front, rear, or sides of the robot. The payload must be smaller than 740 mm x 550 mm and no higher than 1700 mm. The Center of Mass of the payload must lie within the constraints dictated by ICD-000079 and not exceed a mass of 150 kg.

Where the payload is carried on a Staging Cart, the payload must lie within the projected view of the Staging Cart and be smaller than 912 mm x 803 mm and no higher than 1500 mm. It may not project beyond the boundaries of the cart footprint. The allowable position of the Center of Mass of the payload is dictated by ICD-000073 and must not exceed a mass of 130 kg.

The OTTO 100 AMR requires a custom robot configuration in order to accommodate payloads that project beyond the dimensions of the base OTTO 100 AMR platform or Staging Cart. Please contact OTTO Motors if a custom robot configuration is required.

2.5 Battery Handling

Like most applications using batteries with Lithium technology, special precautions should be taken to handle this type of material. Battery packs should only be handled by trained personnel to ensure proper handling. Be aware of the operating environments for OTTO AMRs and more specifically, the battery pack.

Warning

Whenever completing inspections or maintenance on or around the areas of an OTTO AMR battery pack, follow the proper Lock-Out Tag-Out Procedure for the applicable robot. Not properly following the Lock-Out Tag-Out procedure can result in live voltage locations on the OTTO AMR. Always be sure to lock-out the robot before proceeding with inspections and maintenance.

2.6 Overhang and Underhang Detection

Existing equipment in your facility could be rendered invisible to an OTTO AMR due to configuration of an "overhang" - for example, a robot with wheels offset from the body of the robot itself. OTTO AMRs use LiDAR to detect potential obstacles and obstacles located above an OTTO AMR's LiDAR detection plane may not be perceived by an OTTO AMR. In this example, the OTTO AMR would detect the existing equipment's wheels but not its body panels, increasing the possibility of a collision.

We encourage installation of perception-assist flaps (see the following) to assist OTTO AMRs without 3D perception capabilities in detecting obstacles - especially in cases of potential mobile obstacles.

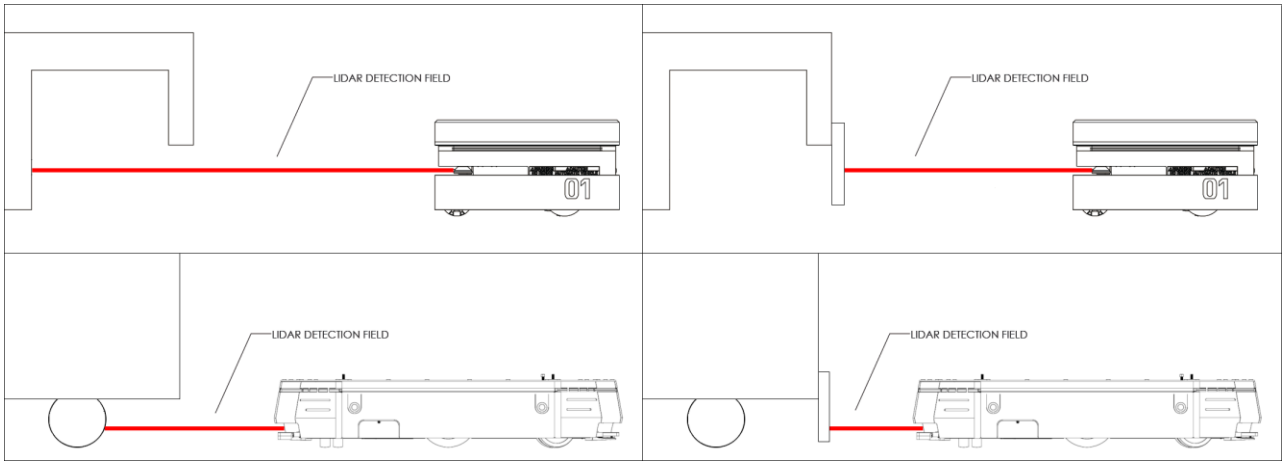


Figure 1 Perception-Assist Flap Installation

OTTO AMRs capable of 3D perception - either integrated or through use of an equipped 3D Perception Attachment - are better able to detect overhanging obstacles without the presence of perception-assist flaps.

- Ideally, installed flaps should touch the floor; however, in instances where the flap can't be installed that close to the floor, the distance between the flap's bottom edge and the floor should not exceed 75 mm.
- Opaque materials with a matte finish are best as reflective materials can scatter LiDAR pulses. Rubber works especially well due to its flexibility, color, and durability.
- Flaps can be bolted directly to exterior body panels or secured using high-strength magnets.

Caution

Failing to take LiDAR detection field dimensions into account will increase the possibility of a collision. See the operating manual for the applicable OTTO AMR.

2.7 Disclaimer

The information found within this documentation is subject to change without notice. This document may be periodically reviewed and revised in the future. OTTO Motors assumes no responsibility for any errors or omissions that may appear in this document. In no event shall OTTO Motors be liable for any costs or damages arising from the use of this document or the hardware and software described within. The reference documents listed in this manual shall be applicable at the latest revision in effect.

While OTTO Motors does its best to inform its users of potential risks, it is impossible to provide an exhaustive list of all possible hazards in your environment.

It is the responsibility of the user to be familiar with all applicable safety standards and ensure that the hardware, software, and/or services delivered by OTTO Motors (collectively referred to as the "Product") are maintained and operated in a safe manner, in a suitable environment, and in accordance with the recommended maintenance requirements prescribed by OTTO Motors.

Without limiting the foregoing, it is the user's responsibility to ensure that personnel operating the Product are adequately trained and comply with all laws, regulations, codes, and safe practices, including health and safety and workers' compensation laws, applicable to the user's activities and its ownership, possession, and use of the Product. Modification, removal or addition of components, or changes to the functionality or operation of the Product in any way, except as expressly authorized by OTTO Motors, may jeopardize the safety of the Product. If at any time you have any questions or concerns regarding the safe operation of your OTTO Motors product, contact OTTO Motors Support.

3 INTENDED USE

OTTO Motors robots are Autonomous Mobile Robots (AMR) intended for use in industrial facilities. OTTO AMRs are intended to transport materials indoors in industrial buildings, utilizing visual mapping and location and intelligent navigation to plan their motion. They can perform autonomous navigation and route planning to achieve their planned Jobs and will operate without direct user intervention. Users are intended to have suitable training or familiarization as needed for their interactions with the robots and systems. This intended use extends to the OTTO infrastructure including - but not limited to - Chargers, Docks, Carts, Attachments, Custom Components, and software.

4 INTRODUCTION

This document provides important information pertaining to the safe operation and use of the OTTO™ 100 V2.4 autonomous mobile robot. The OTTO™ 100 V2.4 is a autonomous mobile robot (AMR) designed to move boxes, carts, bins, and other human-scale payloads through dynamic environments.

Information in this document related to software functionality is up-to-date as of OTTO™ Software Version 2.18.

No field modifications of the OTTO 100 V2.4 AMR that influence the performance or safety of the robot shall be permitted. This includes, but is not exclusive to, modifications that affect the physical size, mass, or floor traction of the robot. No modifications may be carried out that affect the integrated sensors or internal electronics.

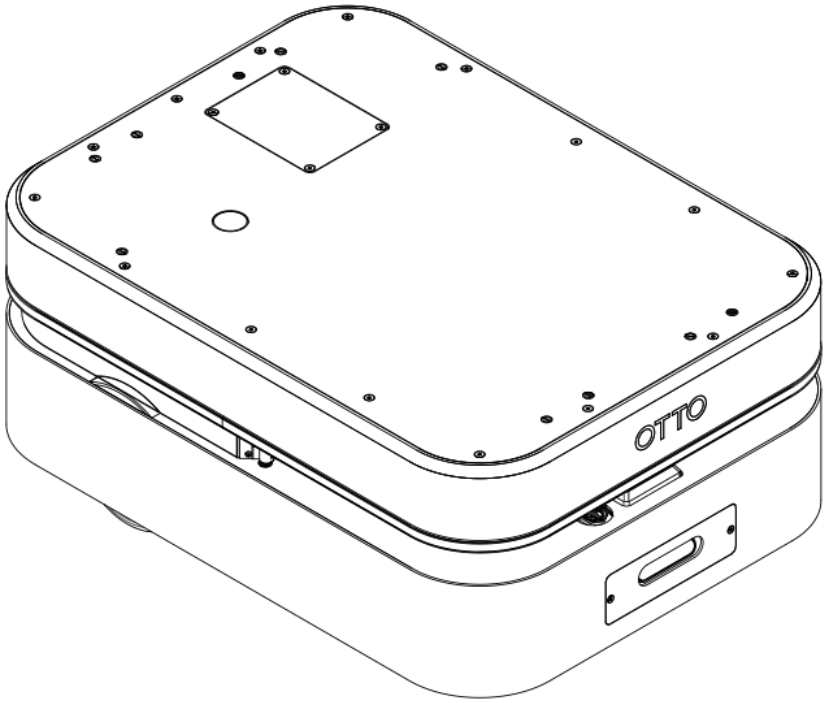


Figure 2 OTTO 100 V2.4 AMR Isometric View

5 APPLICABLE DOCUMENTS

For additional information refer to the following documents. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

Table 3 Applicable Documents

REFERENCE	NUMBER
OTTO 100 V2.4/2.5 AMR Payload Interface	ICD-000079
OTTO 100 V2.4/2.5 AMR Sensor Footprint	ICD-000078
OTTO 100 Fast Charger Operation and Maintenance Manual	OMM-000037
OTTO 100 Charger Operation and Maintenance Manual	OMM-000088
OTTO 100 Manual Charger Operation and Maintenance Manual	OMM-000039
Staging Cart Operation and Maintenance Manual	OMM-000074
Default OTTO 100 V2.4/2.5 Navigation Specification	SC-000056
Staging Cart Layout	ICD-000073

6 PRODUCT SAFETY

6.1 Important Notes

- Read all instructions before using this product.
- Familiarize yourself with the System Specifications in the **System Overview**.
- All stairwells or similarly open holes must be marked and surrounded by obstacles exceeding 20 cm in height with spacing no greater than 30 cm. These obstacles must be able to withstand 2000 N of force without failing or be at least 70 mm wide from all directions and visible to the LiDAR.

6.2 Risk Reduction

Despite the safety features OTTO Motors has put into place, the OTTO 100 V2.4 AMR is heavy and capable of moving quickly. The best way to ensure protection of life and equipment around the OTTO 100 V2.4 AMR is to keep a safe distance from it and pay attention to the light pipe and auditory warnings to anticipate the robot's intentions. If work is being performed on the charge system, follow local Lock-Out Tag-Out procedures for safety.

See Basic Usage for more detail.

6.3 Hazards

The OTTO 100 V2.4 AMR presents a number of risks to users even during the course of normal operation. All users should familiarize themselves with the potential hazards of the system so they can anticipate and avoid them.

The hazards currently identified are as follows:

Electrical Shock

The OTTO 100 Charger/Fast Charger V2.4 system is powered by a high voltage power system exceeding 200 V.

Never attempt to open the main electrical enclosure or adjust any cabling to or from the enclosures while the system is on.

Never touch the charge contacts of the robot or the charger without first ensuring an electrically-safe work condition, including performing the appropriate Lock-Out Tag-Out process. Prevent an OTTO AMR from entering the charger dock while working on the charger.

Crushing/Impact

The OTTO 100 V2.4 AMR assumes the environment meets the requirements set by OTTO Motors for autonomous driving. Stairwells, loading docks, and other unprotected vertical drops must not be accessible to the OTTO 100 V2.4 AMR. It is unable to detect these vertical drops with its sensors.

The OTTO 100 V2.4 AMR has the potential to fall from unprotected vertical drops and steps and could present a crush hazard.

Fire

The OTTO 100 V2.4 AMR contains a lithium iron-phosphate chemistry battery which can create a fire hazard if used improperly.

Never use the OTTO 100 V2.4 AMR in an environment outside the specified temperature and humidity constraints.

In the event of a damage to the battery or a battery fire, call local emergency services and vacate the area immediately.

Pinch/Crush

Objects can be pinched between the OTTO 100 V2.4 AMR and the OTTO 100 Charger/Fast Charger V2.4, carts and material buffer stands. All docking situations are considered a potential pinch/crush hazard area.

Keep hands and other objects clear of these pinch points at all times. Keep clear of all docking OTTO AMRs.

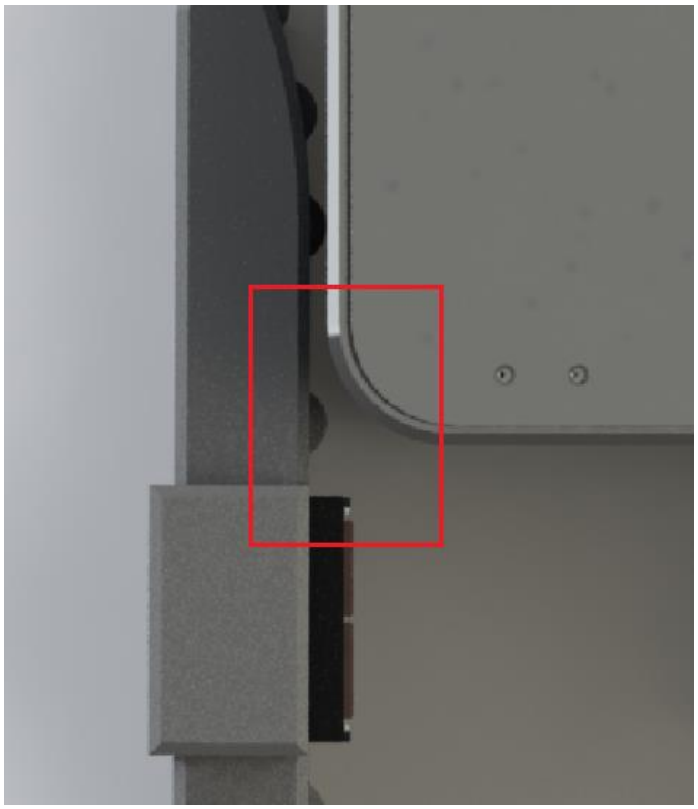


Figure 3 Pinch / Crush Zones as the OTTO 100 V2.4 AMR docks

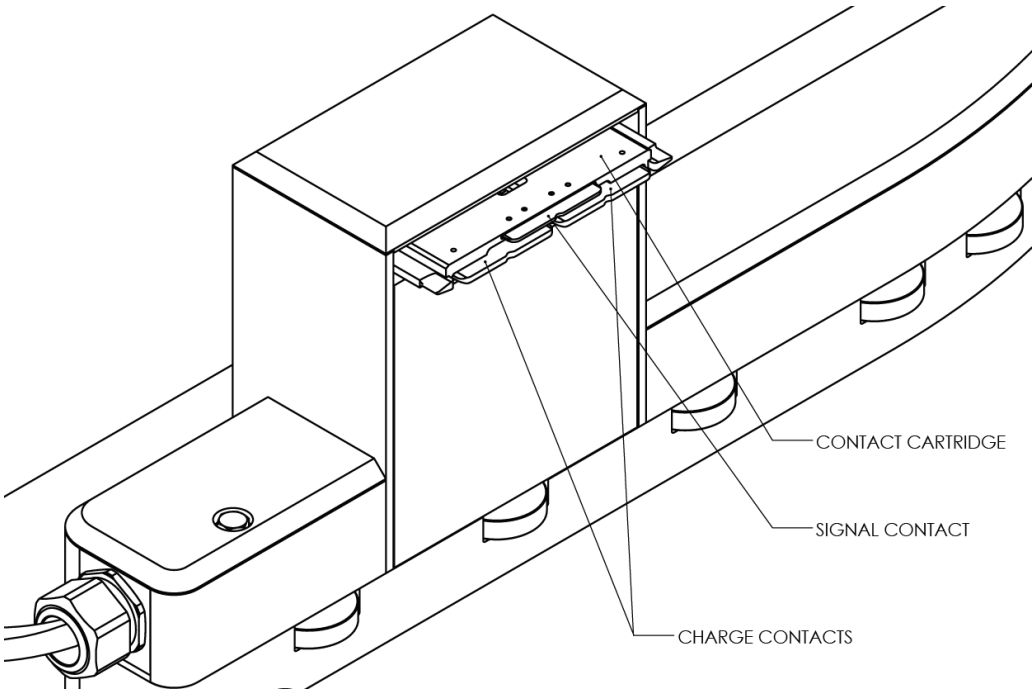


Figure 4 Charger Contacts Danger Area

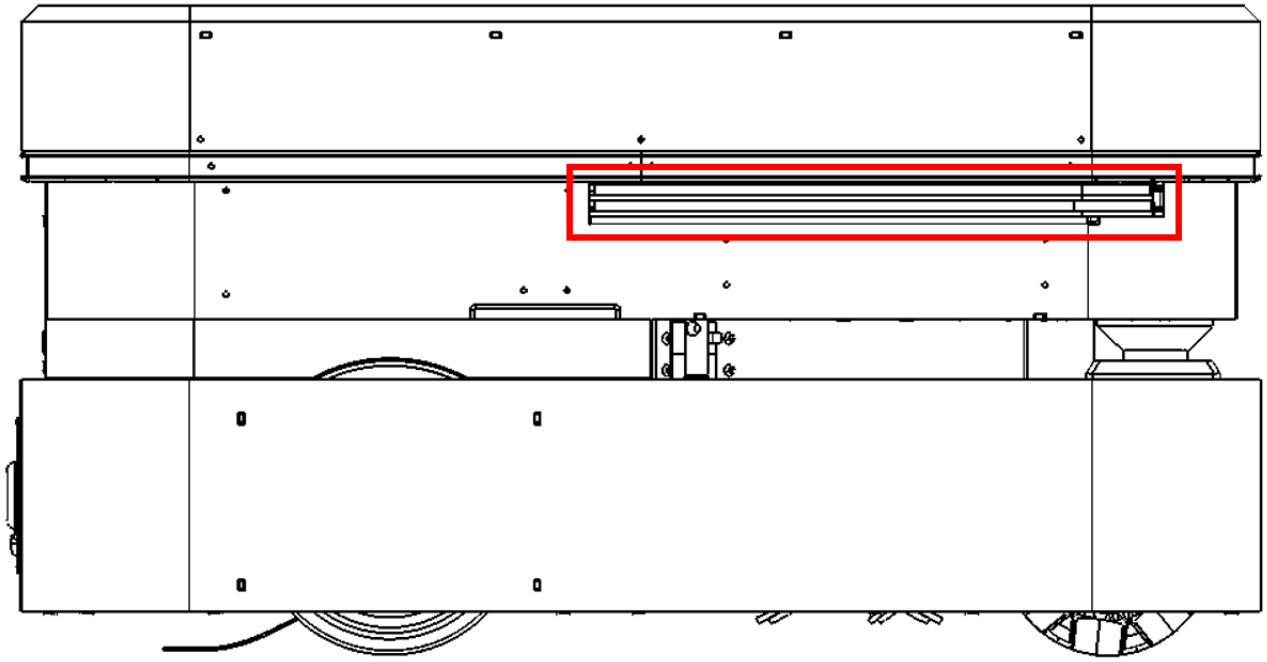


Figure 5 Robot Charge Contacts Danger Area

Pinch/Crush

Objects can be pinched by lift plate.

Never touch or place an object near the lift plate or near signal or charge contacts as this may result in pinching or crushing.

Figure 6 Pinch / Crush Zones for the Staging Cart

The shaded area represents an area with a pinch and crush hazard for the use of the staging cart with the OTTO 100 AMR. Do not grab or lift the cart from within here and do not insert hands or other body parts into here.

Falling Objects

Objects can fall from a loaded OTTO 100 V2.4 AMR or cart.

Follow ICD-000079 for loading objects on the OTTO 100 V2.4 AMR or cart. Never exceed the provided constraints. Environmental factors, such as uneven flooring and obstacles, may further increase these constraints. The user is responsible for adequately testing their loading scenario for safe usage.

Crushing/Impact

As shown below (refer to ICD-000078 for detailed view), the OTTO 100 V2.4 AMR obstacle detection plane is above the height of a human foot. While this distance has been taken into account for stopping distances and maneuvering, the risk still exists that the robot may impact an operator's foot in certain orientations. Proper PPE, including approved safety footwear with toe cap, should be worn when operating around the OTTO 100 V2.4 AMR. While operating in a hazard zone, such as narrow spaces and docking, the OTTO 100 AMR will reduce the buffer zone further and reduce speed. In these situations it may contact an extended foot below the LiDAR plane.

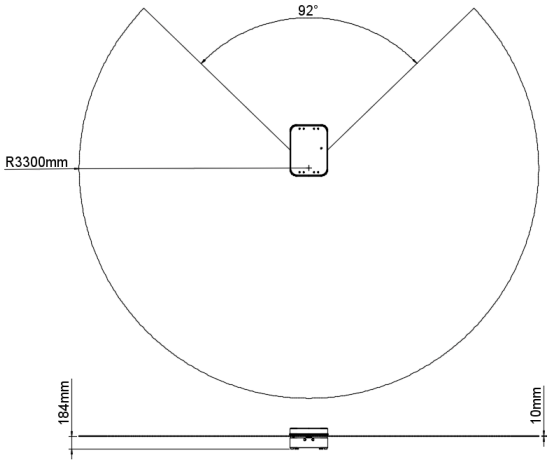


Figure 7 LiDAR Detection Field of View

6.4 Safety Distance

Please refer to ISO 3691-4 Annex A and Navigation Specification document (SC-000056 or the specific document for your facility provided by OTTO Motors or an authorized Partner) issued to you for your specific OTTO 100 V2.4 AMR installation for references regarding the human exclusion zone during charging and other distances required for operation. The customer shall use clear floor markings to define this zone as a special hazard zone. ISO 3691-4 Annex A establishes minimum requirements for the preparation of the zones so that the AMR can safely operate. Employee training is recommended for a safe working environment with the system.

Where the OTTO 100 AMR is travelling through a corridor with a width narrower than 500 mm more than the width of the robot it will enter a narrow hazard mode where the robot indicates a potential hazard with flashing lights, low speed and an audible tone. These areas should be considered restricted areas in accordance with local standards.

6.5 Safety System Functionality

The OTTO 100 V2.4 autonomous mobile robot (AMR) complies with ISO 3691-4 (2020) - *Industrial trucks - Safety requirements and verification - Part 4: Driverless industrial trucks and their systems.*

The primary method of navigation and controlling the safety of motion is through the use of a robot-mounted laser scanner (Hokuyo UAM-05LP Safety Area Scanner) to ensure safe velocity and separation control. The Hokoyu UAM-05LP SAS covers a 270° arc in front of the OTTO AMR (see below). Use of an OTTO Cart reduces the effective scanning arc - see ICD-000078 for details.

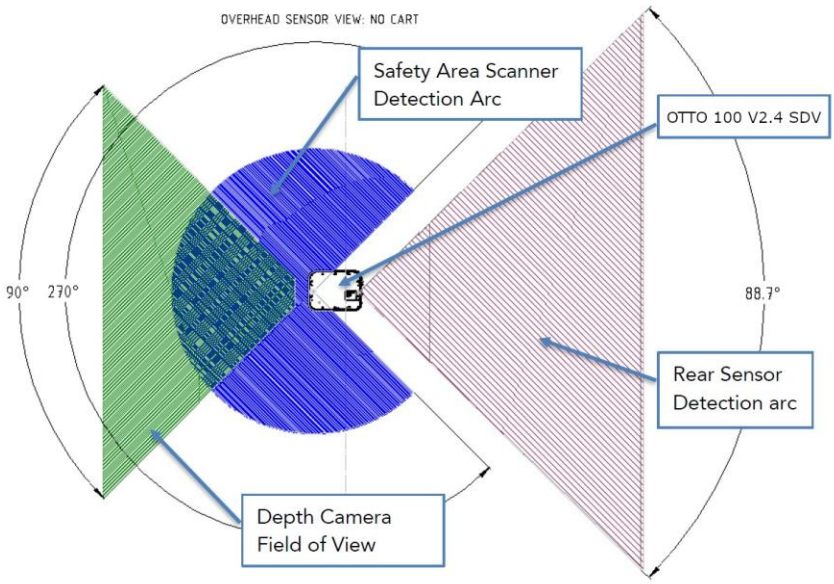


Figure 8 Effective sensor scanning areas for the OTTO 100 V2.4 AMR. For details see ICD-000078.

The OTTO 100 V2.4 AMR LiDAR uses a class 1 laser.

The Safety Area Scanner is programmed to stop the OTTO AMR by means of a direct hardware-controlled safety stop if an object is detected inside of the pre-defined LiDAR safety field in front of the robot or if the robot exceeds the allowable velocity for a LiDAR field set (LFS). The object is as defined by ANSI B56.5:2019 and ISO 3691-4:2020. The pre-defined LFS has been defined for each application of the OTTO AMR and verified by testing to work within the designed performance and environmental specifications.

Additionally, the SAS or the OTTO Motors Safety System will trigger a hardware Safety Stop if the robot speed or differential between wheel speeds exceeds preset limits. This safety system meets the requirements for a PLd CAT 3 rating according to ISO EN 13849-1:2015.

The LFS includes allowances for feet that may be beneath the detection plane of the SAS, degradation in OTTO AMR braking performance, and allowances for deviations in floor friction. Where overhanging payloads are used, the allowance for feet may be reduced as the overhanging payload reduces the distance needed to account for feet. The allowances for feet are reduced at low speeds (less than 0.3 m/s) in order to provide the best possible performance.

Safety Stops will clear approximately 2 seconds after wheel speeds re-enter an acceptable range. An Emergency Stop will be triggered if a failure of any of the components of the safety system is detected.

For motion into an area not covered by the scanning area of the SAS (such as to the rear of the OTTO AMR - see above), the speed of the outermost extremity of the OTTO AMR and its payload is limited by the OTTO Motors Hardware and Software to less than 0.3 m/s in order to adequately reduce the hazard. Additionally, three additional methods are used to further reduce risk:

- The robot is equipped with a rear Emergency Stop button within easy reach of the back of the OTTO AMR
- The OTTO AMR uses an auxiliary optical sensor to detect obstacles to the rear of the robot and reduce the probability of backing into any person or equipment
- The OTTO AMR uses visual and acoustic warnings to alert operators in the area of the OTTO AMR's intent to reverse

These measures ensure that personnel in the area are warned about the motion of the OTTO AMR. Should a person or object move into the area behind a reversing OTTO AMR, the OTTO AMR's limited speed also ensures low impact force is applied from the OTTO AMR itself. The static pushing force of an OTTO AMR on a level floor is less than 500 N. The exact amount of force applied will depend on the OTTO AMR's payload and floor traction. The slow application of this force and the warning of the OTTO AMR’s intent allows anyone impacted by the force sufficient time to avoid it or stop the OTTO AMR by use of the Emergency Stop button on the rear of the OTTO AMR.

The rear-facing optical sensor is not safety rated and is not part of the safety system but acts to reduce the probability of a rear collision to levels such that it will not impact normal operation of the OTTO AMR.

Impact

When the OTTO AMR is operated manually (while using OTTO App for mapping, for example) the rear-facing optical sensor is not active, and the user is responsible for obstacle avoidance and collision avoidance.

The safety of each OTTO AMR needs to be evaluated in the context of the installation where it is used. Environmental and process factors in each installation will ultimately govern the risk of injury resulting from the interaction of people or equipment in the facility with the OTTO AMR.

7 IN CASE OF A COLLISION

1. Stop the robot by pressing a red **Emergency Stop** button on the robot or an equipped attachment.

   See the Components Overview for Emergency Stop button locations.

2. Is anyone hurt? Administer first aid immediately. Seek medical attention if necessary. Follow workplace injury and accident reporting procedures.
3. Document the incident.
   a. Note the time and place.
   b. Note which robot was involved.
   c. Interview any witnesses.
   d. Take photos or make a drawing.
   e. If the robot is connected to Fleet Manager, create a Manual Snapshot to capture diagnostic information and robot sensor data to assist OTTO Motors in diagnosing the incident cause.
4. Assess the state of the robot.
   a. Visually inspect the robot for damage and take photos of any damage found.
   b. If there is no visible damage, observe the robot after it returns to service.
   c. If any irregularities or differences in its behavior are observed, remove the affected robot from service and contact OTTO Motors support. If the damage is extensive, wait for communication from OTTO Motors before returning the robot to service.

   Refer to Product Safety for more detail.

8 SYSTEM OVERVIEW

This section provides an overview of the important elements of the OTTO 100 V2.4 autonomous mobile robot (AMR) system.

Table 4 OTTO 100 V2.4 AMR System Specifications

8.1 System Specifications

COMPONENT	SPECIFICATION
Size and Weight	
Dimensions (L x W x H)	740 x 550 x 309 mm (29.1 x 21.7 x 12.2 in)
Net Mass (unloaded)	107 kg (236 lbs)
Speed and Performance	
Maximum Total Payload	150 kg (331 lbs) (1472 N) Refer to the payload supported by the specific Navigation Specification document supplied for your installation by OTTO Motors.
Maximum Speed	2.0 m/s (7.2 km/h) (4.5 mph)
Suspension	Fixed. Rigid suspension.
Positional Accuracy	X, Y + / - 10 mm (0.4 in) Yaw + / - 1° Docking accuracy is subject to the deployment. Please speak to your OTTO Motors representative for more information.
Turning Radius	0 mm Rotation in place around drive wheels.
Lift Stroke	**Cart Engagement Height** 62 mm **Charging Height** 83 mm

Battery and Power System	
Battery Run Time	~ 6 hrs for a typical use-case OTTO AMRs are designed for opportunity charging and will intelligently manage their own charging between Jobs.
Managed Battery Operation	24/7 continuous operation with 85 % individual robot uptime is achieved with automated and brief visits to the OTTO charger at opportune times without human intervention. Battery charge levels are intelligently managed by the OTTO Fleet Manager.
Battery Type	Lithium Ion Phosphate. 26.4 VDC Nominal / 32 V DC Max
Battery Capacity	35 Ah (924 Wh)
Interfacing and Communication	
Attachment Interface	1 x USB Type A Female (USB 3.0a - for future features) 1 x RJ45 (Gigabit Ethernet - for future features) 1 x RS232 Interface - for future feature 8 x Digital IO (See section of manual) 2 x Dry Contact Emergency Stop Loops (See section of manual) 2 x E-Stop Loops (See section of manual) 1 x Auxiliary Monitor Contact (See section of manual) Unregulated Battery Voltage 19 VDC to 32 VDC, Nominally 26.4 VDC - 12 A Maximum.
Communication	WiFi (802.11 a/b/g/n/ac, 2.4 Ghz. 5 Ghz)
Sensors	Laser Safety Scanner - 270° Field-of-View (Safety Rated) Rear ToF Sensor - 88° Field-of-View Front Depth Camera - 90° Field-of-View Inductive Cart-Detect-Sensor - 8mm range

Audio and Visual Indicators	**Audio Tones** 85 dB max. **Visual Indicator** 360° Light Pipe Indicator
Human-Robot Interaction	Emergency Stop Button Reset Button Power Button
Operating Environment	
Maximum Floor Slope	1° (1.6 %)
Floor Obstacle Maximums	**Obstacle Height - Step Obstacle** 6 mm (0.25 in) **Floor Gap** 13 mm (0.5 in) Operating speed may need to be limited to achieve safe traversal of these obstacles with a payload.
Operating Environment	Indoor
Operating Temperature Range	20°C - 40°C (68°F to 104°F) Please contact OTTO Motors if lower operating temperatures are needed.
Operating Relative Humidity	0 - 85 % non-condensing
Maximum Operating Altitude	2000 m N.N. (6500 ft above sea level)
Non-Operating Temperature Range	**Continuous Storage** -20°C - 35°C (-4°F to 95°F) **Transport (< 14 days)** -20°C - 80°C (-4°F to 176°F)
Non-Operating Relative Humidity	0 - 85 % non-condensing
Time-weighted Sound Pressure Emissions Level	> 70 dB(A)

9 COMPONENTS OVERVIEW

The components overview is intended to familiarize the user with some of the sensors and actuators in the OTTO 100 V2.4 autonomous mobile robot system (AMR).

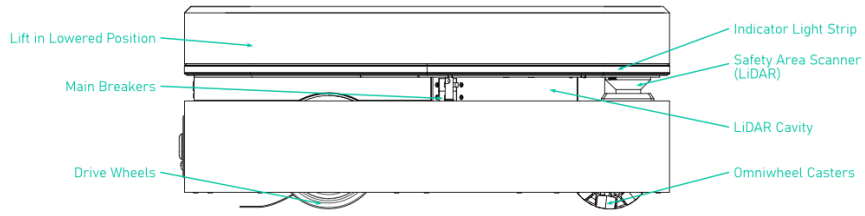


Figure 9 OTTO 100 V2.4 AMR with the lift in the lowered position

9.1 Lift Appliance

The OTTO 100 V2.4 AMR is equipped with an internal lift capable of lifting up to 150 kg. As seen below, the top half of the robot above the LiDAR cavity can be raised to pick up a payload or to expose the charge contacts.

The lift has three positions: lowered, cart engaged, and charging, where charging is the highest position.

When raised to charging position (see below), the lift will raise beyond the upper payload engagement position to expose the charge contacts required for autonomous robot charging.

Pinch/Crush

Objects can be pinched by lift plate.

Never touch or place an object near the lift plate or near signal or charge contacts as this may result in pinching or crushing.

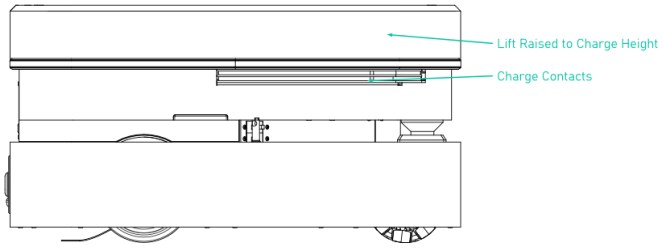


Figure 10 OTTO 100 V2.4 AMR with the lift in the charge position

9.2 Buttons and Ports

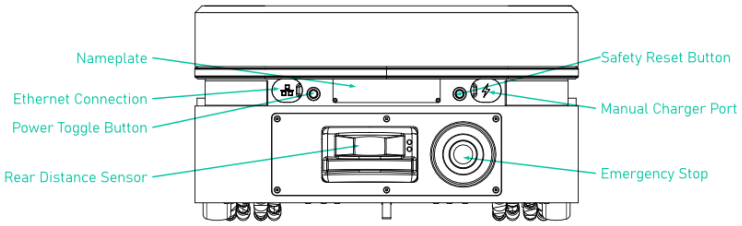


Figure 11 Rear view of the OTTO 100 V2.4 AMR with the lift in the lowered position

9.2.1 Emergency Stop Button

An Emergency Stop button is located at the rear of the OTTO 100 V2.4 AMR (see above) and is positioned so that it can be kicked easily in an emergency. Once pressed, the robot is unable to move and will remain in this state until the button is pulled out and the Safety Reset button is pressed.

9.2.2 Safety Reset Button

The Safety Reset button is located above the Emergency Stop button (see above) and is used by an operator to indicate that the OTTO 100 V2.4 AMR is cleared for autonomous use. This switch must be pressed following the OTTO 100 V2.4 AMR start-up process to indicate the area is safe for autonomous navigation.

9.2.3 Power Toggle Button

The Power Toggle button is located next to the Ethernet Connection (see above) and is used by an operator to recover the OTTO 100 V2.4 AMR from an unknown state. Momentarily pressing this button will boot up or shut down the OTTO 100 V2.4 AMR. This switch can be held for 10 seconds to reset all electronics within the OTTO 100 V2.4 AMR.

9.2.4 Manual Charge Port

The Manual Charge Port - located next to the Safety Reset button (see above) - is used in conjunction with a Manual Charger to charge the OTTO 100 V2.4 AMR when the robot is unable to use a OTTO 100 Charger/Fast Charger battery charger.

See OMM-000039 - OTTO 100 Manual Charger Operation and Maintenance Manual for more detail. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

9.2.5 Ethernet Connection

The Ethernet Connection is located next to the Power Toggle button (see above) and is used to perform diagnostics or configure the robot.

See Basic Usage for more detail on connecting to the OTTO 100 V2.4 AMR.

9.3 Robot State Indicators

9.3.1 Light Pipe and Visual Indications

OTTO autonomous mobile robots (AMR) are equipped with light panels and pipes designed to signal what a robot is doing at any given time by changing the light color and flashing frequency - the light pattern - to indicate a robot's state or motion. Coupled with audible indications, robots will always make it obvious what behavior you can expect.

Warning

OTTO AMRs rely on audiovisual indications to warn nearby personnel of their presence, intent, and mode of motion. Ensure that the robot audio volume is at least loud enough that nearby personnel can detect the presence of the OTTO AMR. See the Basic Usage section of the operations and maintenance manual for the applicable OTTO AMR for instructions on changing robot volume settings.

Table 5 OTTO 100 V2.4 AMR light pipe patterns and indicated state

NAME	DESCRIPTION	VISUAL INDICATION
Starting Up	The OTTO AMR is on but has not completed the boot cycle.	Full Solid Dull White
Normal Travel	The OTTO AMR is traveling normally.	Front Solid Dull White Rear Solid Red

Reversing	The OTTO AMR is reversing.	 Rear Solid Dull White in direction of travel Front Solid Red with Dull White
Turning	The OTTO AMR is turning.	 Side Blinking Yellow in turn direction
About to Move v2.18 and later	The OTTO AMR is about to start traveling.	 White Pulses Chasing from Center to Corners
Charging	The OTTO AMR is charging at a Charging Dock.	 Rear Corners Red Green Slowly Expanding indicating charge level Front Corners Orange
Charging v2.16 and later	The OTTO AMR is charging at a Charging Dock.	 Rear Corners Red Green Slowly Expanding indicating charge level in 20% increments Front Corners White
Parked	The OTTO AMR has entered a Parked state.	 Rear Corners Red Front Corners Dimmed
Docking	The OTTO AMR is docking.	 Front Solid Dull White Rear Solid Red Alternating Yellow Stripes

Narrow Corridor	The OTTO AMR is entering what it considers a narrow corridor.	 Front Dull White Rear Red Blinking Yellow Stripes
Manual Control v2.16 and later	The OTTO AMR is being manually controlled.	 Full Solid Blue Front Dull White
Manual Control v2.14 and earlier	The OTTO AMR is being manually controlled.	 Front Dull White Rear Red
Attachment Activated v2.16 and earlier	The OTTO AMR has activated its attachment.	 Front Solid Dull White Rear Solid Red with Dull White Lights Strobe Effect
Attachment Activated v2.18 and later	The OTTO AMR has activated its attachment. The OTTO 100 AMR has activated its integrated lift.	 Full Pulsing Yellow
Working In Place	The OTTO AMR's movement is locked as it waits for further input from a user or attachment.	 Full Green
Blocked v2.16 and later	The OTTO AMR is blocked from proceeding on its planned path.	 Front Flash Yellow Rear Solid Red
Blocked v2.14 and earlier	The OTTO AMR is blocked from proceeding on its planned path.	 Front Solid Dull White Rear Solid Red

Safety Stopped	The OTTO AMR has been placed in a Safety Stop state.	 Front and Rear Flashing Red Front Narrow Solid Dull White
Emergency Stopped	The OTTO AMR has been placed in an Emergency Stop state.	 Full Flashing Red
Failed Target Find	The OTTO AMR has failed find its target (Dock, Cart, etc.).	 Front Solid Dull White Rear Solid Red
Lost	The OTTO AMR can't determine its location relative to its loaded Map.	 White Light Chasing
Lost Connection to WiFi/Fleet Manager	The OTTO AMR is disconnected from the WiFi signal/Fleet Manager.	 Front Flashing Yellow/Orange Rear Flashing Yellow/Orange Flashing color is dependent on OTTO AMR model and software version
Operating System Failure	The operating system for the OTTO AMR has failed to run.	 Full Solid Red

9.3.2 Speaker

The speaker is located near the front of the OTTO 100 V2.4 AMR in the LiDAR cavity. The speaker is intended to warn users of an approaching robot and works with the light pipe to indicate various robot states.

9.4 Perception Sensors

9.4.1 Safety LiDAR and the LiDAR Cavity

Danger

Obstacles outside of the LiDAR detection plane will not be identified by the OTTO 100 V2.4 AMR's safety systems. While auxiliary sensors such as the 3D Perception Camera may detect the obstacles, it is a navigational aid only and should not be relied upon as a safety system.

The OTTO 100 V2.4 AMR uses a LiDAR (Light Detection and Ranging) safety system to detect obstacles, prevent collisions, and localize in the environment. The LiDAR is connected directly to the drive system to help avoid collisions, preventing the OTTO 100 V2.4 AMR from moving if there is an obstacle in the LiDAR field.

See Product Safety for more detail on safety system functionality.

The LiDAR scans in a horizontal plane located 185 mm above the floor, projected out in front and to the sides of the robot. Obstacles with a height below 180 mm may not be detected by the OTTO 100 V2.4 AMR and will create a collision risk. Overhanging obstacles above 190 mm but below 380 mm may also cause a risk of collision (see below).

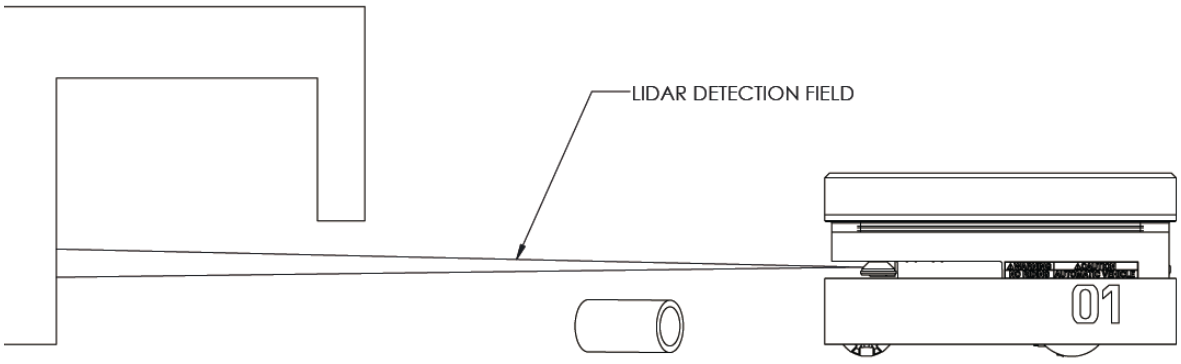


Figure 12 Obstacle demonstrating the limitations of the LiDAR system to detect obstacles above or below the scanning field

Caution

The LiDAR cavity houses and protects the LiDAR system and must be kept clean and clear of any debris.

9.4.2 3D Perception Camera

The OTTO 100 V2.4 AMR is equipped with a 3D Perception Camera so that the operation of the robot can be monitored for diagnostic purposes. The camera may be used in autonomous navigation to avoid overhanging obstacles in newer software versions.

Check with OTTO Motors Support to confirm if overhanging obstacle detection is enabled on your robot.

9.4.3 Optical Rear Sensors

An optical array sensor detects obstacles to the rear of the OTTO 100 V2.4 AMR during reversing motion. These sensors are auxiliary sensors and do not constitute part of the safety system. The OTTO 100 V2.4 AMR is therefore limited to a reversing speed of lower than 0.3 m/s in order to reduce the risk of injury.

9.5 Circuit Breakers and Lock-Out/Tag-Out

The two circuit breakers accessed within the LiDAR cavity (see below) allow operators to fully disconnect the battery from the OTTO 100 V2.4 AMR (see below).

> See Basic Usage for detail on performing the Lock-Out/Tag-Out procedure.

The Lock-Out Tag-Out pin drops into the LiDAR cavity to hold the breakers in the open position. The top breaker protects the drive and lift motors while the bottom breaker is the main battery power.

> The Lock-Out Tag-Out pin is not visible when the circuit breaker is switched closed.

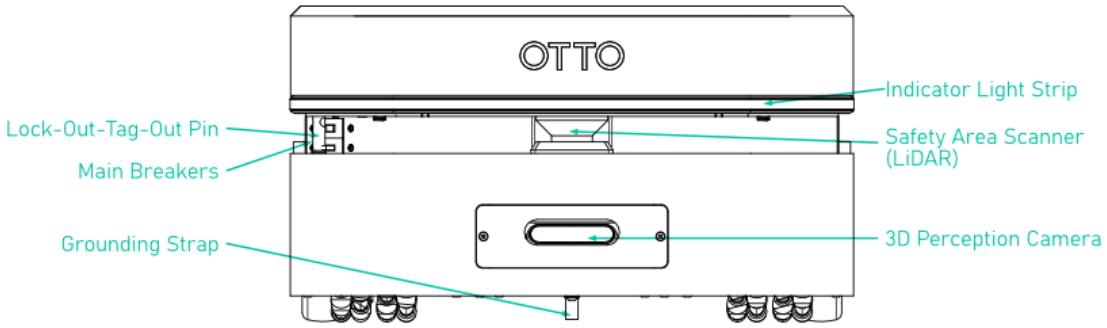


Figure 13 OTTO 100 V2.4 AMR as seen from the front with the lift in the lowered position

9.6 OTTO 100 Charger/Fast Charger

OTTO 100 V2.4 AMRs can charge at OTTO 100 Charger/Fast Charger docks fully autonomously. See below for a visual of the large keyhole-shaped navigation footprint which must be clear of obstacles for autonomous charging. The navigation footprint will be contained in the Navigation Specification document accompanying the installation.

Caution

Never manually push the robot into the charge dock as it can result in damage to the OTTO 100 V2.4 AMR's charge contacts.

See OMM-000037 - OTTO 100 Charger/Fast Charger Operation and Maintenance Manual for more detail. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

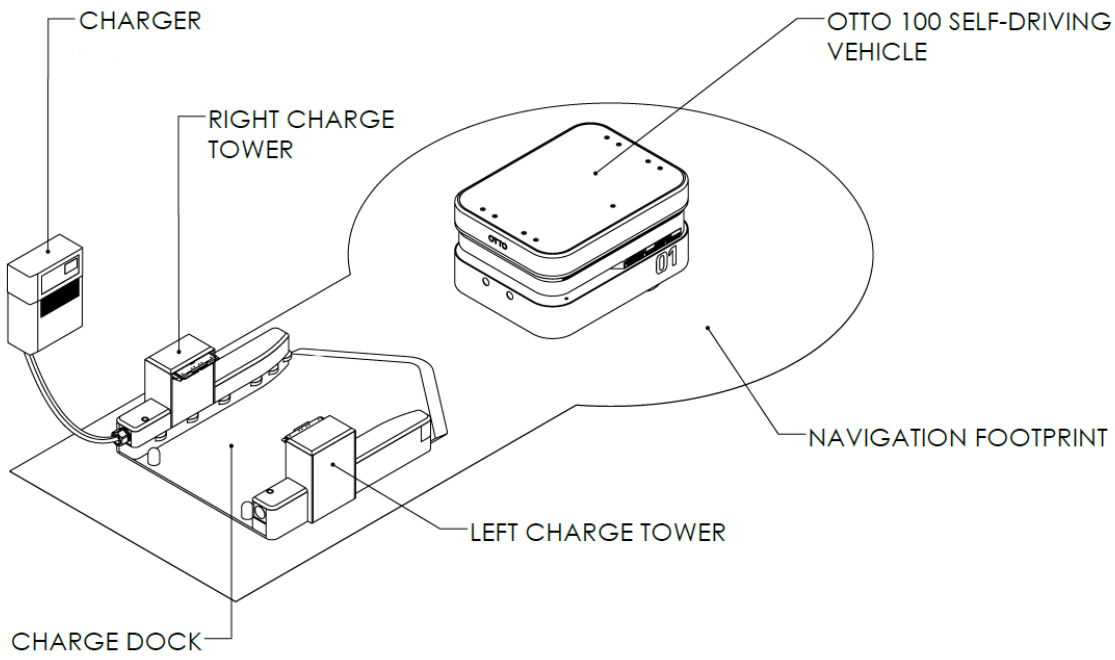


Figure 14 OTTO 100 V2.4 AMR and OTTO 100 Charger/Fast Charger Components (charger and charge Dock)

9.7 Staging Cart

Staging Carts may be included in your installation. The Staging Cart is designed to transport payloads not exceeding 130 kg and objects placed on the cart must conform to the requirements for stability. The Staging Cart uses a braking mechanism to prevent it from rolling when not engaged with an OTTO 100 V2.4 AMR.

See OMM-000074 - Staging Cart Operation and Maintenance Manual for more detail. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

10 ATTACHMENT INTERFACE

This section describes the connections available on OTTO 100 V2.4 autonomous mobile robots (AMR) configured with an Attachment Interface. The Attachment Interface provides the user with ports for communication with the on-board PC, power sourced from the robot battery, and interfacing with the robot Emergency Stop circuit.

See ICD-000079 - OTTO 100 V2.4 AMR Payload Interface for more detail. These documents are available on the OTTO Motors Support Center at help.ottomotors.com. For safe loading, ensure that the center of mass is within the loading pyramid as indicated in ICD-000079.

10.1 Attachment Interface Access

From the factory, the Attachment Interface is shielded with a sealed cover plate.

To access:

- Remove the 4 x M4 flat head screws, using a 2.5 mm Allen key (see below for screw locations).

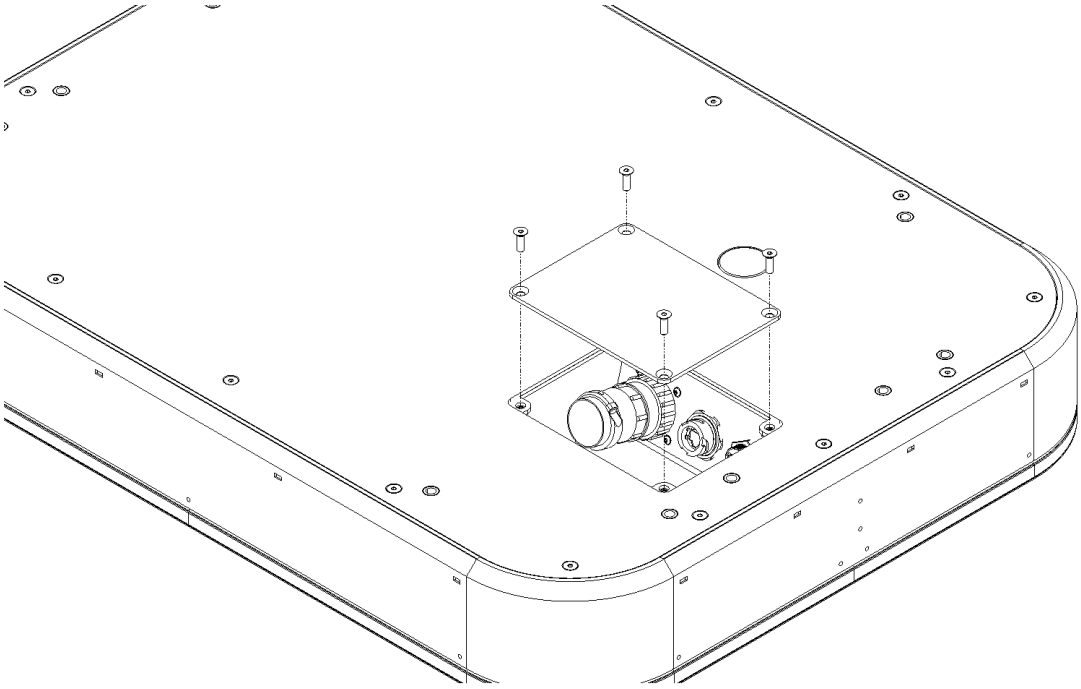


Figure 15 Attachment Interface Access

When reinstalling the Attachment Interface cover plate, apply a load to it to ensure it is flush with the payload plate prior to tightening the fasteners.

10.2 Attachment Interface Connections

The following circuits are presented at the payload connector access panel:

- 1 x Power over Ethernet (PoE+) RJ45 bulkhead connector
- 1 x USB 3.0 Type A bulkhead connector
- 1 x 37 Position CPC panel receptacle - this contains the following connections
    - 8 x Isolated digital inputs to the PC
    - 8 x Isolated digital outputs from the PC
    - 2 x External emergency stop channels
    - 2 x Dry contact circuits
    - 2 x Battery power breakouts, limited to 12A
    - 2 x Robot ground breakouts
    - 1 x Serial RS-232 (3-wire) connections to the PC

10.2.1 Ethernet (PoE+)

There is 1 x Power over Ethernet (PoE+) RJ45 port available in the Attachment Interface that supports the IEEE 802.3at (PoE+) standard and is capable of providing up to 25.5 W of power at 48 V. Additionally, this port supports 1000Base-T gigabit communication.

There is no special configuration required to enable the power output or set the communication speed of these ports. The Ethernet port allows for communication to the on-board PC operating system for the purposes of diagnostics.

Check the capabilities of your software version for the communications features supported by the OTTO Software for this port.

10.2.2 USB 3.0

There is 1 x USB 3.0 female type A connection available in the Attachment Interface compliant with the USB 3.0 Gen 1 standard, supporting SuperSpeed (SS) data transfer up to 5 Gbit/s with a supporting device.

The power available from this port meets the “Low Power” standard, providing up to 300 mA at 4.75 V. If additional current is required up to the “High Power” current draw of 900 mA, the supply voltage will drop to 4.27 ± 0.5 V. If this lower voltage is insufficient for the selected devices you can use an externally powered bus.

Check the capabilities of your software version for the communications features supported by the OTTO Software for this port.

10.2.3 CPC Connector

The mating connector for the 37-position CPC connector is TE Connectivity, CPC Plug Assembly Size 23-37, part number 206305-1. Access documentation for the TE Connectivity, CPC Plug Assembly here.

Warning

Do not connect or disconnect the 37 position CPC connector while the robot breakers are live. You must Lock-Out Tag-Out the robot first. See **Basic Usage** for detail on the Lock-Out/Tag-Out procedure.

Bulkhead connector pin numbers are shown from the wire insertion side.

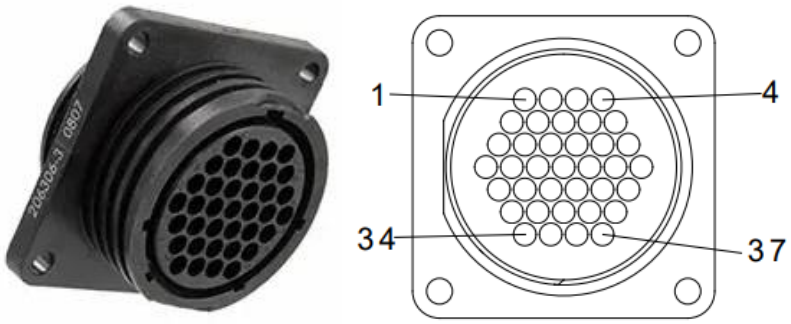


Figure 16 37 Position CPC Connector

Table 6 Attachment Interface Pinout

PIN	DESCRIPTION	WIRE GAUGE
1-8	Isolated Digital Inputs (GPIO Pin 0 - 7)	24 AWG
9	Digital Input Common	24 AWG
10	External DIO Ground	24 AWG

11-18	Isolated Digital Outputs (GPIO 8 - 15)	24 AWG
19	External DIO Power, 24 – 36 VDC	24 AWG
20	External E-Stop Channel A – Source	16 AWG
21	External E-Stop Channel B – Source	16 AWG
22	External E-Stop Channel A – Return	16 AWG
23	External E-Stop Channel B – Return	16 AWG
24	Dry Contact Channel A – INPUT	18 AWG
25	Dry Contact Channel A – OUTPUT	18 AWG
26	Dry Contact Channel B – INPUT	16 AWG
27	Dry Contact Channel B – OUTPUT	16 AWG
28-29	Attachment Power	16 AWG
30-31	Attachment Ground	16 AWG
32	Serial Receive Data (RXD)	24 AWG
33	Serial Transmit Data (TXD)	24 AWG
34	Serial Ground	24 AWG
35	Auxiliary Contact Loop - Source	16 AWG
36	Not Connected	-
37	Auxiliary Contact Loop - Return	16 AWG

10.2.3.1 Serial Communication

The 37-pin CPC connector supports serial communications with the onboard PC through use of a 3-wire, RS-232 implementation. This port provides access to the RXD, TXD, and GND pins of serial interface 2 (ttyS2) on the PC. Since only 3 wires are connected, hardware handshaking functions including, DCD, DTR, DSR, RTS, CTS, and RI, cannot be utilized.

10.2.3.2 Isolated Digital Input/Output

The onboard PC is equipped with 8 digital input (DI) and 8 digital output (DO) pins. Each of these pins is connected with a photo-coupler to provide electrical isolation between the interface and the rest of the PC. The DO circuit has an integrated power buffer device, TPD2007F. This device is intended to allow the DO to drive motors, solenoids, and lamp drivers, up to a maximum of 500 mA per channel (1-Vecow Co., Ltd., 2016).

The pins are mapped into Fleet Manager software sequentially:

- GPIO pins from 0 to 15
- DI pins are listed as GPIO pins 0 to 7
- DO pins are listed as GPIO pins 8 to 15

DIO specs:

- External power supply: 6 ~ 40 VDC
- Maximum input current on DIs: 10 mA
- Maximum output current on DOs: 300 mA

Note that the circuit will not work unless the regulated 24 VDC power is applied. The DI pins can be operated as either SINK (NPN) or SOURCE (PNP) mode, while the DO pins can only operate in SINK (NPN) mode. Both the DI and DO pins are setup with Fleet Manager to invert the SINK (NPN) logic so that a circuit will turn on when the pin is set HIGH and off when the pin is set LOW. That eight digital inputs / outputs can be set to work in only one mode at a time because they share the common pins. The, high- or low-level DIO can be configured as either '0' or '1' in Fleet Manager. The following diagram shows electrical connections for different applications.

For example, an LED connected to a DO pin (see Reference Design, DO SINK Mode (1-Vecow Co., Ltd., 2016)) will be turned ON when the pin is set to “HIGH” and turn OFF when the pin is set “LOW”. In order to close the DIO circuits, an external power supply between 24 VDC and 36 VDC must be applied. The battery output from the autonomous mobile robot will vary between 22V and 29.2V depending upon the robot’s electrical load and state of charge (SOC). As such, this voltage must be regulated to 24V or greater if it will be used to drive the external power supply required for the DIO circuit.

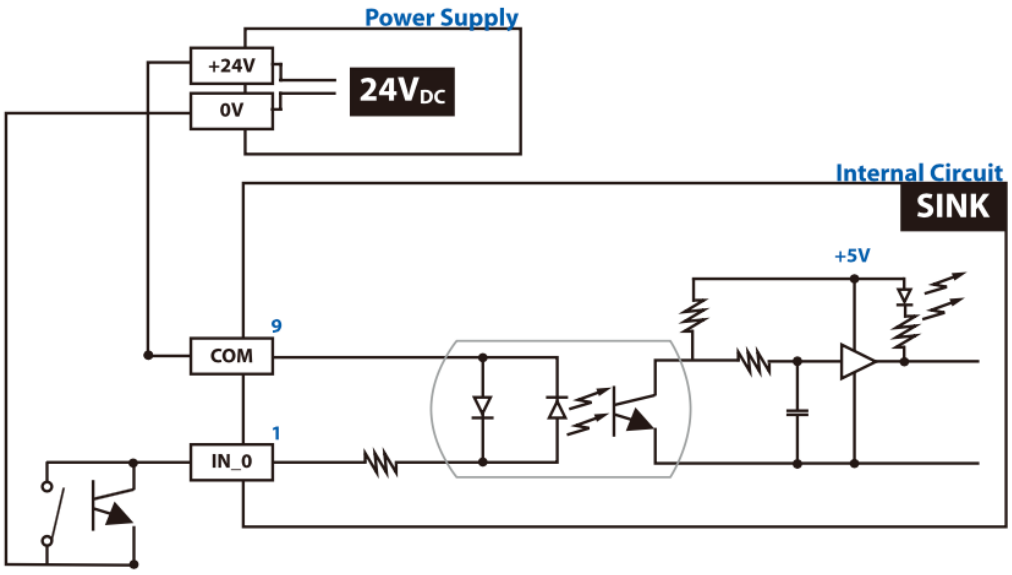


Figure 17 Reference Design, DI SINK Mode (1-Vecow Co., Ltd., 2016)

Digital GPIO input signal circuit in SINK mode (NPN) is illustrated above. When eight DIs are used for NPN signals 24 VDC should be applied to Pin 9 (Digital Input Common). The switch or FET should be connected to the corresponding input pin and 24 V GND. When the switch is open or the FET is off the internal signal is high; when the switch is closed or the FET is on the internal signal is low.

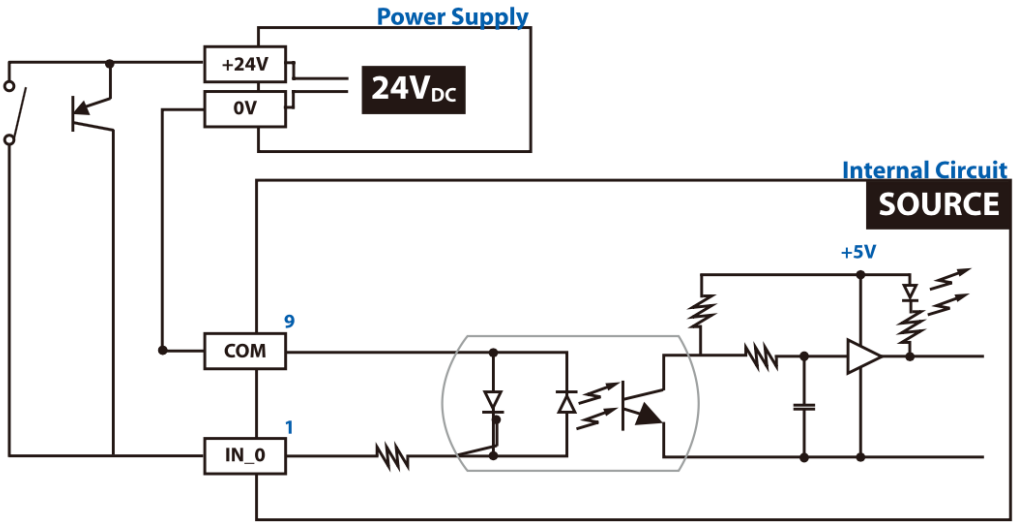


Figure 18 Reference Design, DI SOURCE Mode (1-Vecow Co., Ltd., 2016)

PNP digital input signal circuit (SOURCE) is illustrated above. When eight DIs are used for PNP signals 24 V GND should be applied to Pin 9 (Digital Input Common). The switch or FET should be connected to the corresponding input pin and 24 VDC. When the switch is open or the FET is off the internal signal is high; when the switch is closed or the FET is on the internal signal is low.

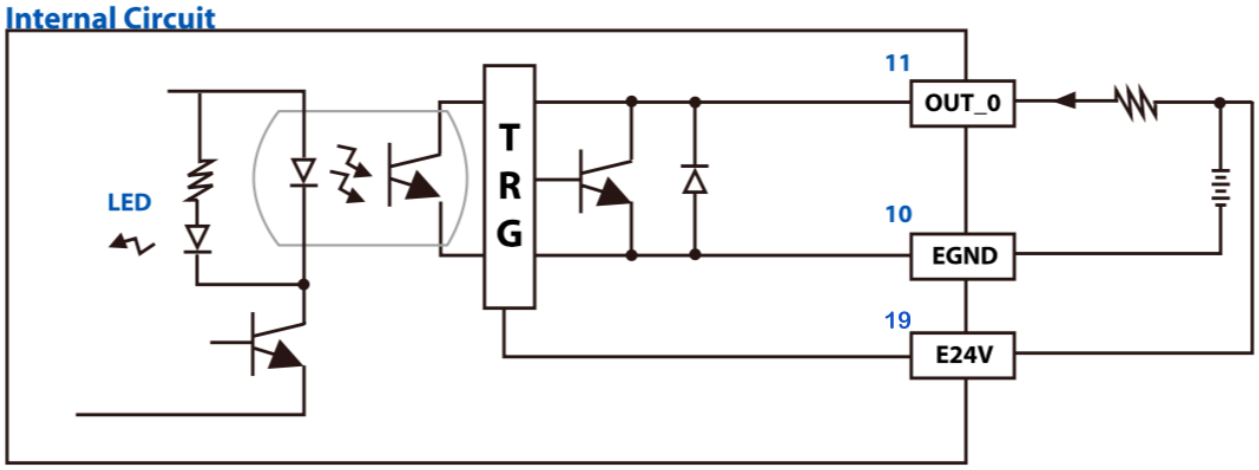


Figure 19 Reference Design, DO SINK Mode (1-Vecow Co., Ltd., 2016)

Digital output signal circuit (SINK) is illustrated above. 24 VDC should be applied to Pin 19 (External DIO Power) and 24 V GND should be connected to Pin 10 (External DIO ground). The load should be connected to 24 VDC and the corresponding output pin. When the internal output signal is high the load will be energized; when the internal output signal is low the load will be disengaged from the power.

10.2.3.3 External Emergency Stop

The OTTO 100 V2.4 AMR uses a two-channel, Emergency Stop system. The attachment interface provides a break-out of this two-channel circuit to allow for the incorporation of an attachment-mounted Emergency Stop trigger. This circuit operates by presenting a 24 V signal and monitoring the return lines. If the circuit is opened, the system will enter and remain in an Emergency Stop state. If the circuit is closed, the Safety Reset button can be pressed to transition the robot into normal operation mode.

If an external Emergency Stop is to be used, the external switch should be a DPST-NC switch intended for use as an Emergency Stop and confirming to EN 60947-5-5.

An Omron Emergency Stop Switch, part number A165E-S-02, is an example of an acceptable switch.

Ensure that all mounting, housing, and marking requirements have been satisfied when implementing an external emergency stop. See below for a simple example circuit.

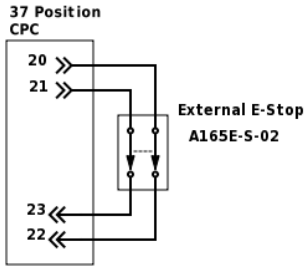


Figure 20 Reference External Emergency Stop Wiring

If an external Emergency Stop is not to be used, the provided loopback connector must be installed in order to close the circuit and allow the robot to leave the Emergency Stop state.

10.2.3.4 Dry Contact Circuits

The interface presents access to two "dry" contact circuits which are controlled by the main safety relays of the OTTO 100 V2.4 AMR. A "dry" contact is a circuit that passes through a relay and has not been provided voltage, or "wetted", by a voltage source.

The two channels on the system run parallel to each other and both pass through 2 safety relays before looping back to the interface port. The safety relays are a normally open (NO) configuration and are placed in series to provide redundancy in the event of a component failure. When the robot is in Emergency Stop, Safety Stop, or powered off, the relays will be open. Only when the robot is in a normal operating condition will the relays close.

The safety relays are force guided relays, RF1V-5A1BL-D24, manufactured by IDEC. Key characteristics for these components are as follows:

- Contact Resistance: 100mΩ
- Rated Load (resistive load): 6A 250V AC, 6A 30V DC
- Allowable Switching Power (resistive load): 1500 VA, 180W
- Minimum Applicable Load: 5V DC, 1mA

A full list of the relay specifications can be found in IDEC Corp. (3-IDEC Corp., 2009).

The contact ratings above represent the maximum values. Take the necessary precautions to ensure that these limits are not exceeded during inrush or operation. When an inductive load is attached to the "dry" contact, a surge absorbing circuit is required to ensure contact reliability, contact life, and noise suppression of the relay.

See following reference from IDEC Corp. (3-IDEC Corp., 2009), presenting 4 examples of circuit protection circuits.

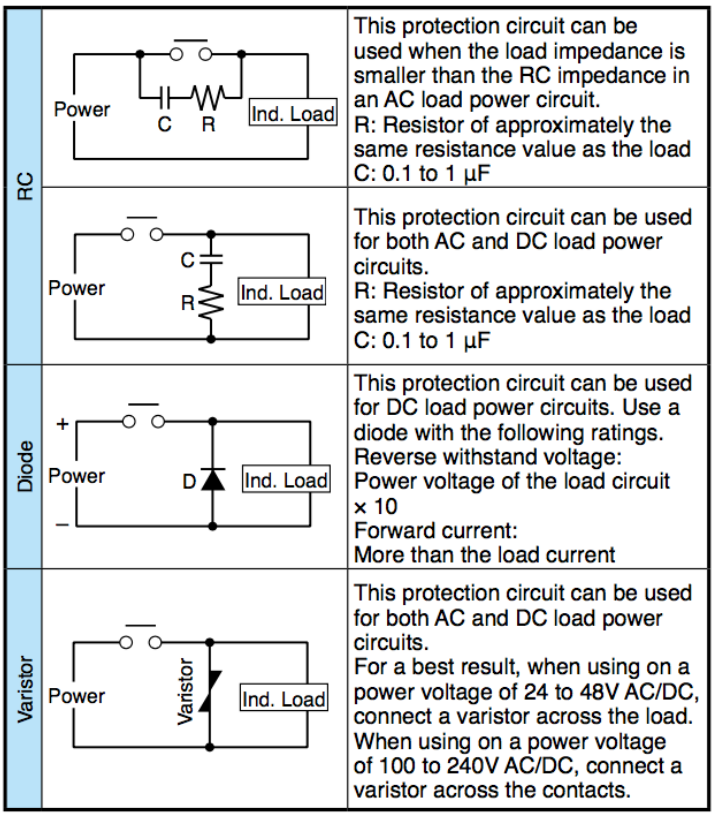


Figure 21 Contact Application Guide (3-IDEC Corp., 2009)

If a load is applied incorrectly to the "dry" contact circuit, the following behavior may be observed on the robot:

- Robot may unexpectedly enter an Emergency Stop state
- Robot may not be able to release from Emergency Stop state
- Audible "chattering" noise may be produced by the safety contacts when releasing the robot from Emergency Stop state
- Robot may enter an Emergency Stop state when a Safety Stop is triggered

10.2.3.5 Auxiliary Contact Loop Circuit

Pin 35 and Pin 37 are in the loop of the auxiliary contacts of the external contactors and force guided relays, which is in parallel with the reset button.

If the OTTO 100 V2.4 AMR is in normal operation, opening the Auxiliary Contact Loop will prevent a reset of the Emergency Stop and clearing of safety stops.

If the OTTO 100 V2.4 AMR is in an Emergency Stop state, opening this circuit is a way to prevent a reset of the Emergency Stop in a failure situation.

10.2.3.6 Attachment Power

Power from the OTTO 100 V2.4 AMR can be sourced through the 37-pin CPC connector. This port provides un-switched battery voltage intended to drive a resistive load up to a maximum of 12.5 A. The voltage is driven directly from the battery and as such will vary between 22V and 29.2V depending upon the robot's electrical load and state of charge. If an over current event occurs, the fuse needs to be replaced internal to the OTTO 100 V2.4 AMR. Please contact your OTTO Motors Service Representative for replacing this fuse.

Danger

The Emergency Stop circuit in the OTTO 100 V2.4 AMR will NOT disconnect power at the attachment interface port. Use the Dry Contacts if you need to disconnect power on a circuit during an Emergency Stop event.

Warning

Do not attempt to pull power from the Attachment Interface Port while using the Manual Charger. The Manual Charger circuit is only able to supply 8 A. Pulling excessive current by using the Attachment Interface Power while using the manual charger will damage the charger circuitry or blow the fuse.

The attachment power is designed to be used with resistive loads only. Capacitive and Inductive loads run the risk of introducing electrical noise into the robot which may cause component failure or inadvertently trip the safety or over-current protection circuits. If high frequency noise is generated at the attachment, it is recommended to install ferrite beads on the power lines connected to the interface port.

Warning

Improper electrical loading of the attachment power port, specifically highly inductive or capacitive loads may, may cause failure of the over-current protection circuit. If this component fails, the OTTO 100 V2.4 AMR will be unable to supply power at the attachment power port.

If an inductive or highly capacitive load is required, it is suggested that an external battery be installed as the main power source for the attachment devices. With the appropriate battery charging circuit, the attachment power port can be used to provide a continuous trickle charge for this second battery.

11 3D PERCEPTION FUNCTIONALITY

The OTTO 100 V2.4 autonomous mobile robot (AMR) is fitted with a depth perception camera capable of detecting 3D obstacles. OTTO Motors is continuously improving our capabilities in our software. Please ensure that you are running the latest software version in order to take full advantage of the benefits of this system.

The 3D perception is based upon a projected pattern in a near-infrared light spectrum, invisible to human eyes, but possibly visible to monitoring cameras such as security systems. This is normal. The projected light is diffuse and low-power and does not present a risk to personnel.

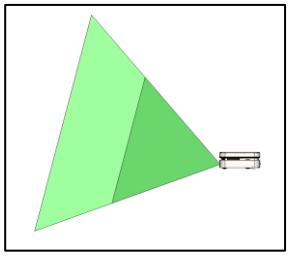
Under rare circumstances the projected light pattern may interfere with other optical sensors using a similar near-infrared wavelength.

11.1 3D Perception Field of View

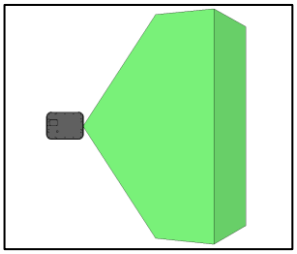
The single 3D camera on the front of the OTTO 100 V2.4 AMR has a 90° horizontal Field of View (FoV) and a 47° FoV above the floor.

See ICD-000078 - OTTO 100 V2.4 AMR Sensor Footprint for more detail. These documents are available on the OTTO Support Center at help.ottomotors.com.

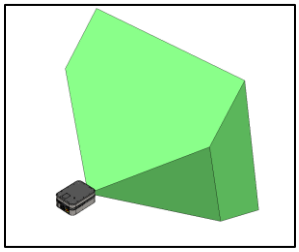
Table 7 Approximate camera FOV as a green polygon (side, top, and rear isometric views)



Left Side View



Top View



Rear Isometric View

11.2 Notes

OTTO Motors continues to test the 3D Perception Attachment to increase its capabilities and the vision of each 3D-equipped OTTO AMR.

All tests and their results outlined here are subject to change and will be updated periodically.

11.3 Detection Observations

- Large textured objects (20 cm x 20 cm or greater) are detected at 3 m
- Detection distance for smaller objects (50 cm^2 minimum, no side less than 3 cm) varies and depends on the object's texture, shape, color, and robot speed
- 3D Perception Attachment has a greater chance of detecting obstacles at lower robot speeds

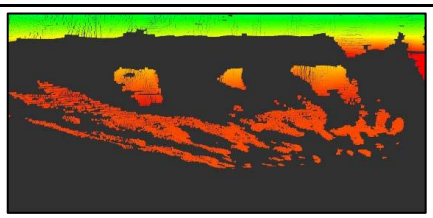
11.4 Potential False Positive Objects

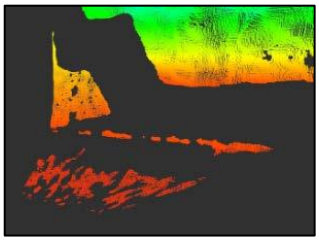
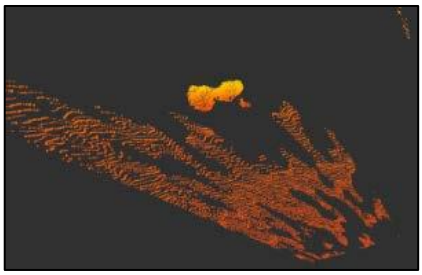
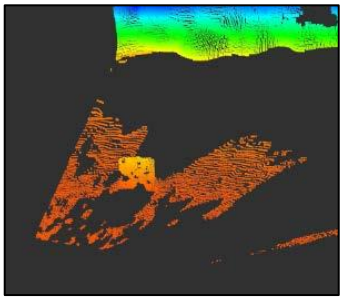
- Glare from windows and doors
- Objects with patterns (eg. fencing, shelves, etc.)
- Floors with excessive markings/patterns/grating

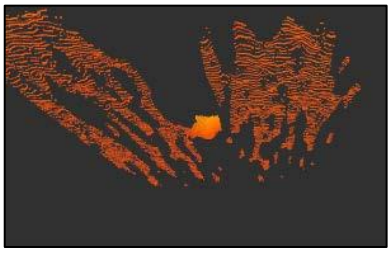
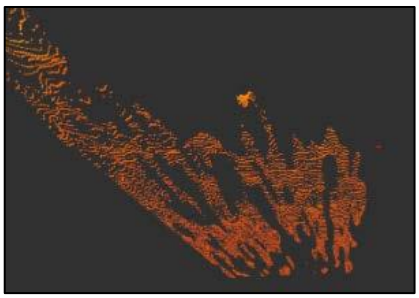
11.5 Test Results

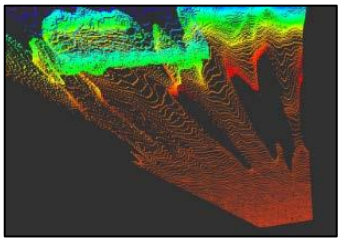
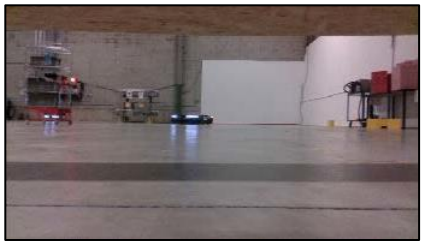
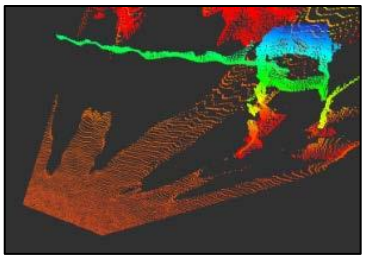
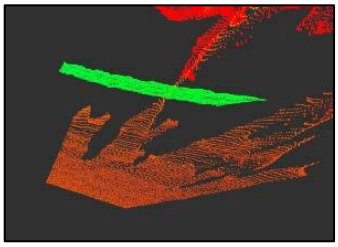
All tests were performed with obstacles approaching the OTTO AMR from the front with the robot driving straight at the obstacle.

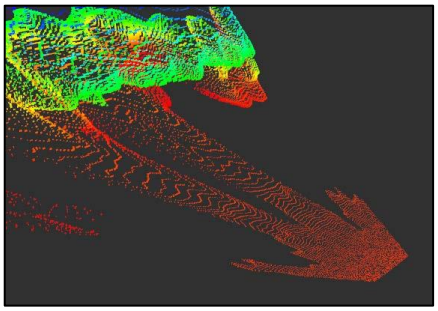
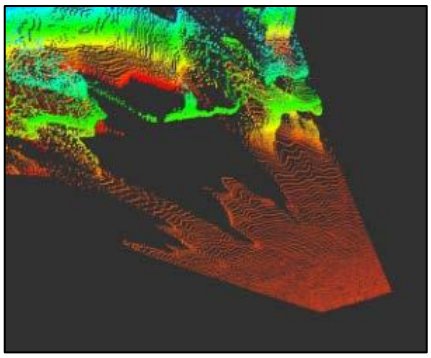
- Tests did not allow for re-planning and simply determined if a collision would occur by driving straight at the obstacle.
- There were typically two outcomes after a collision:
    - The OTTO AMR did not detect the obstacle at all and continues attempting to navigate to its goal
    - At some point the OTTO AMR is able to detect the obstacle but is unable to stop in time, resulting in the robot being placed in a Safety Stop
- A test is considered passed ✅ when the robot doesn't collide with the obstacle.
- A test is considering conditionally passed ⚠️ when the robot is capable of detecting the obstacle under certain conditions.

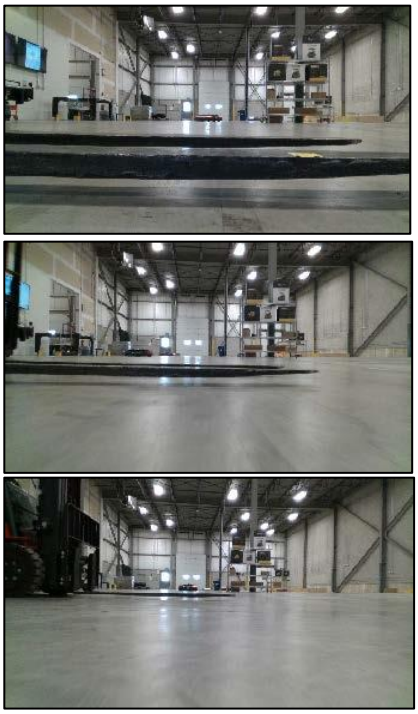
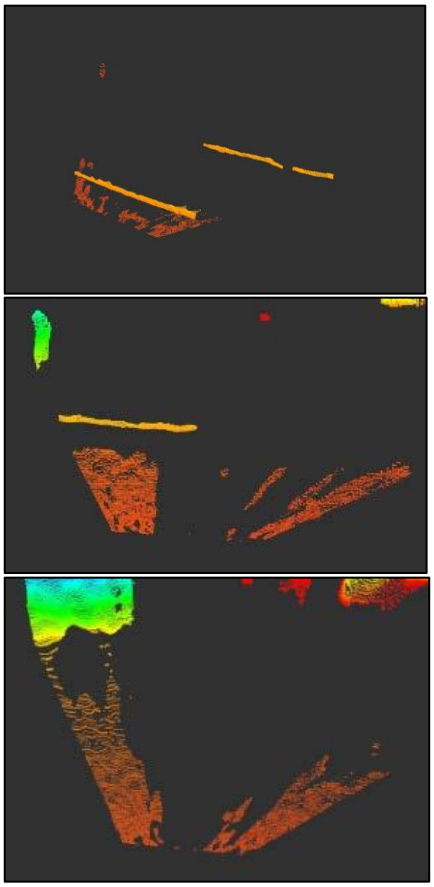
OBSTACLE	COLOR IMAGE	OTTO AMR VIEW	PASS/FAIL
Pallet			✅

Pallet Jack			✓
Large Textured Underhang			✓
Medium Textured Underhang			✓

Small Textured Underhang	 	 	⚠ **Conditional Pass** Depending on the texture of the object, its surroundings, and robot speed, it is possible that the OTTO AMR will not detect the small textured underhang in time to stop and avoid a collision. At low speeds, the object is detected in time and avoided. **Top Images** Close small object depicting a pass **Bottom Images** Small object far away, depicting a fail
Large Uniform Underhang	No image available	No image available	✓

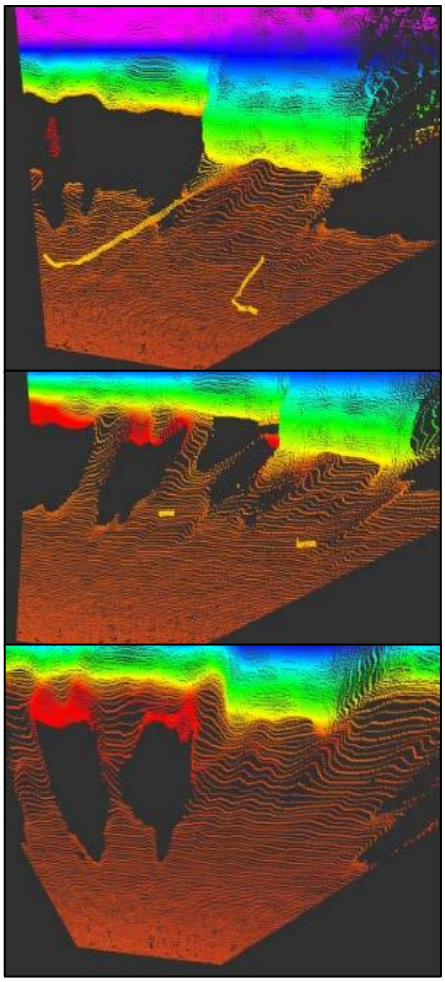
Large Textured Overhang			✅
Thin Textured Overhang	 	 	⚠ **Conditional Pass** When driving at high speeds, the OTTO AMR can end up with a bottom view of the obstacle, leaving the OTTO AMR capable of continuing forward to escape, which can cause a collision. **Top Images** Shows thin object being detected by the 3D Perception Attachment **Bottom Images** Shows overhanging object detection while OTTO AMR is underneath

Large Uniform Overhang			✔
Elevated Pole			✔

Fork Truck Tines on Floor Profile			⚠ **Conditional Pass** Tines can only be detected at approximately 1.5 m from the robot. This means that if travelling at speeds greater than 1 m/s, the OTTO AMR can't stop in time to avoid a collision. **Top Images** Shows successful detection of tines at a close distance **Middle Images** Shows successful detection of tines at maximum detection distance (3.5 m) **Bottom Images** Shows a failure to detect tines

Detection beyond 3.5 m is disabled within the software as beyond that distance the camera data is too noisy.

Fork Truck Tines on Floor Frontal



⚠

Conditional Pass

Tines can only be detected at about 1.5 m from the robot. This means that if travelling at speeds greater than about 1 m/s the AMR cannot stop in time to avoid a collision.

Top Images

Shows successful detection of tines at a close distance

Middle Images

Shows successful detection of tines at maximum detection distance from tines

Bottom Images

Shows a failure to detect tines

12 UNBOXING

12.1 Time Required

Approximately 30 Minutes.

12.2 Required Materials

• #2 Robinson or #2 Phillips screwdriver

12.3 What's Inside

- OTTO 100 AMR
- Wooden placeholders (2 x 2x4 wood pieces)
- Ramp (wooden plank)
- Lens wipes

12.4 What to Look For

- Circles in marker around crate which define placement of screws
- Wooden placeholders (two 2x4's) overtop product keeps product secure from rising

12.5 Unboxing the OTTO 100 AMR

1. Unscrew crates screws and open crate.

Figure 22 Crate Screws

2. Remove top and front crate panel.
3. Remove wooden placeholders (2 x 2x4 wood pieces).

Figure 23 Crate Wooden Placeholders

4. Remove the wooden plank from the top of the crate. Place the wooden plank at the base of the crate to use as a ramp.

Figure 24 Using Crate Top Panel as Ramp

5. Push and carefully slide the OTTO 100 AMR down the ramp to remove it from the crate.

13 BASIC USAGE

This section describes the operation of the OTTO 100 V2.4 autonomous mobile robot (AMR).

Danger

Prior to using the OTTO 100 V2.4 AMR, the surrounding area must be approved for autonomous navigation by an OTTO Motors representative. Never use the OTTO 100 V2.4 AMR in an area without prior consultation by an OTTO Motors representative.

13.1 Lock-Out/Tag-Out

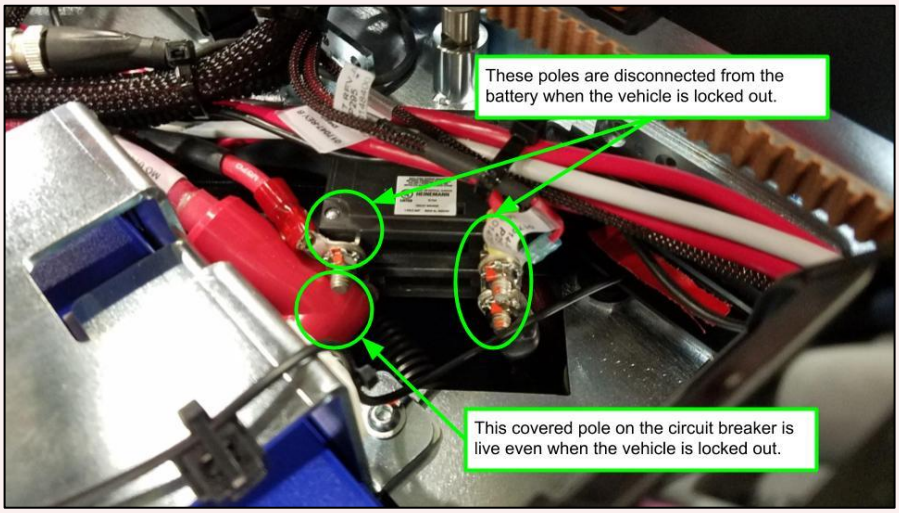
Only trained personnel authorized by OTTO Motors shall open the OTTO 100 AMR.

Prior to performing any maintenance, **always follow the Lock-Out Tag-Out** procedure to deactivate an OTTO™ autonomous mobile robot (AMR).

Danger

The circuit breaker terminal connected to the battery (displayed below) is live even when the robot is locked out. This terminal is protected with a rubber cover. Do not remove this or any other terminal covers. The main chassis will act as the negative side of the battery. It the robot is correctly locked out, all live terminals are protected. The robot must be locked out to properly protect the remaining connections.

Normal maintenance will not require the user to open the OTTO 100 V2.4 AMR to expose these connections.



Warning

If the OTTO 100 V2.4 AMR has been operating immediately prior to performing maintenance, the motors and motor drivers on the traction circuit board (located on the bottom of the robot) may be at elevated temperatures which could cause a burn to the technician if contacted.

Caution

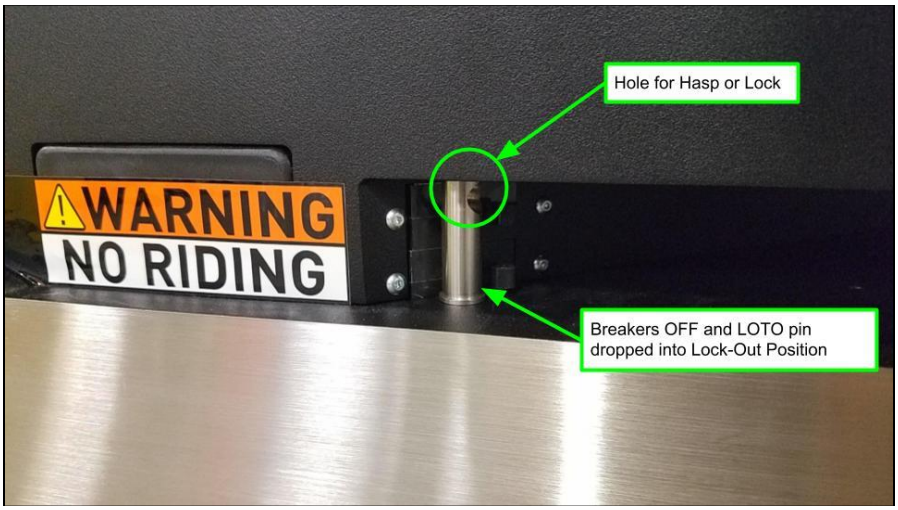
Safety boots or shoes with steel toes should be worn at all times while working with an OTTO 100 autonomous mobile robot.

13.1.1 OTTO 100 V2.4 Lock-Out Tag-Out

1. Press the **Emergency Stop** button.
2. Press and hold the **Power** button located on the rear of the robot for one second.

   Note that holding the power button for too long will cause the robot to automatically restart. If this happens, the power will need to be turned off again once the start-up process has completed.

3. Wait until all lights on the OTTO AMR are OFF (at least 30 seconds). This signifies that the main computer and all electronics have successfully powered down.
4. Push both circuit breakers in towards the center of the robot. The Lock-Out-Tag-Out pin will fall into the LiDAR cavity.



5. Clamp your Lock-Out Tag-Out lock through the pin to secure the breaker.
6. Test that the breaker cannot be pulled to the ON position while your lock is secured.

13.2 Starting Up

See the Components Overview for details on button locations and robot state indicators.

1. Raise the Lockout Pin.
2. Switch the two circuit breakers to the *ON* position by moving the switch towards the rear of the robot.

   If necessary, press the Power button. The light pipe should indicate that the robot is starting up.

3. The OTTO 100 V2.4 AMR will begin to boot up.
4. The OTTO 100 V2.4 AMR will indicate an Emergency Stop state. Clear/pull the **Emergency Stop** button.
5. Press the **Safety Reset** button. The OTTO 100 V2.4 AMR will indicate a Normal Travel state.

13.3 Shutting Down

1. Press the **Emergency Stop** button.
2. Press and hold the **Power** button for one second.

   Note that holding the Power button for too long will cause the robot to automatically restart. If this happens, the power will need to be turned off again once the start-up process has completed.

3. Wait until all lights on the OTTO 100 V2.4 AMR are OFF (at least 30 seconds). This signifies that the main computer and all electronics have successfully powered down.

If you are servicing, transporting, or storing the OTTO 100 V2.4 AMR, perform the Lock-Out/Tag-Out procedure.

13.4 Charging

Danger

Only original OTTO Chargers from OTTO Motors should be used when charging the OTTO 100 V2.4 AMR to avoid any damage to the batteries

If the OTTO 100 V2.4 AMR included an OTTO 100 Charger/Fast Charger, robots can be sent to charge autonomously without human intervention.

If running a mixed fleet of OTTO 100 V2.2 and V2.4, the following conditions need to be addressed:

- Robot fleet is on software version 2.14.8 or later
- Utilize separate chargers, using Teams in Fleet Manager organized by robot version, or configure their existing charge to the OTTO 100 V2.4 AMR setting (lower voltage). This results in a negligible decrease in battery capacity for the OTTO 100 V2.2 AMR and should not affect usability. OTTO Motors test fleets run with all chargers configured to OTTO 100 V2.4 AMR settings without incident.

  Contact OTTO Motors Support for details on changing the charger setup.

If the installation relies on a Manual Charger, perform the following steps:

1. Command or manually drive the OTTO 100 V2.4 AMR to the location of the Manual Charger.
2. Connect the Manual Charger to the robot.

   Red dots on the plug and receptacle must be aligned before they can be connected. Connecting the Manual Charger will force the OTTO 100 V2.4 AMR into an Emergency Stop state to prevent the robot from driving while charging.

3. Verify that the LCD screen on the charger displays the charge amount (max current 8A).

   It may take up to 8 hours to complete the charge.

4. Once charged, disconnect the Manual Charger from the robot.

Warning

Never use an OTTO 100 Charger/Fast Charger and the OTTO 100 Manual Charger at the same time as this may damage the chargers and/or the robot battery.

13.5 Moving an Unpowered or Disabled OTTO 100 V2.4

It is much easier to manually push an unpowered robot than one that is powered, as a powered robot will resist and attempt to hold its position, possibly resulting in damage to the robot. Pushing an unpowered robot at normal speeds will not damage it.

To shut down the robot and move it manually:

1. Press the **Emergency Stop** button to disengage the drive motors.
2. Press and hold the **Power** button for one second.

   Note that holding the Power button for too long will cause the robot to automatically restart. If this happens, the power will need to be turned off again once the start-up process has completed.

3. Wait until all lights on the OTTO 100 V2.4 AMR are OFF (at least 30 seconds). This signifies that the main computer and all electronics have successfully powered down.
4. Turn off the OTTO 100 V2.4 AMR at the main breaker in order to prevent an accidental startup.
5. Carefully remove any loads on the robot, followed by the Staging Cart (if present).
6. After moving the OTTO 100 V2.4 AMR, make sure to position it on level ground to prevent it from rolling.

Warning

Pushing an OTTO 100 V2.4 AMR using a powered device to push it at higher speeds, such as pushing it with a forklift, can damage the internal circuitry. Do not do this under any circumstances. If an OTTO 100 V2.4 AMR needs to be moved manually over longer distances, it should be lifted and secured to a traveling robot or palette for transport.

13.6 Moving and Unpacking

The OTTO 100 V2.4 AMR has a robust structure that allows it to be picked up or reoriented by hand or with the use of lifting machinery such as a forklift. When lifting the OTTO 100 V2.4 AMR, it is required to lift from the bottom of the robot using straps that are positioned behind the drive wheels and castors. The lifting equipment and straps used rated to minimum weight equal to the weight of the OTTO 100 V2.4 AMR, see **System Overview** for weight of the OTTO 100 V2.4 AMR.

Warning

Caution should be taken around the LiDAR and light pipe to avoid damaging these components as they are not as robust and not suitable for lifting (see below).

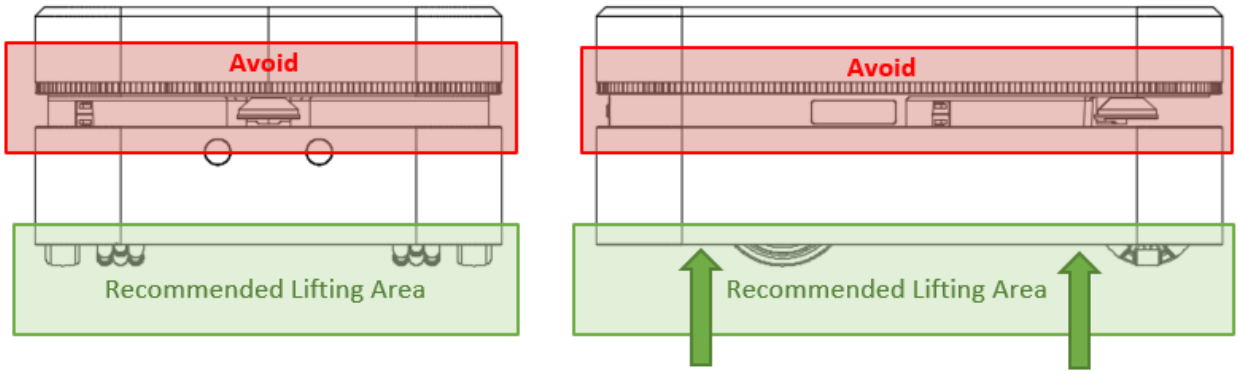


Figure 25 Recommended Lifting Locations

Warning

The OTTO 100 V2.4 AMR exceeds the weight to be lifted by a single individual. If lifting by hand, ensure to ask for assistance and use proper lifting techniques.

13.7 Storage

Before storing the OTTO 100 V2.4 AMR for an extended period of time (greater than two days), it is best to reduce the battery state to approximately 50% State of Charge (approximately 24 V open circuit at 25 C).

You must completely power off the robot using the circuit-breaker switches when storing the OTTO 100 V2.4 AMR for an extended period of time.

See Shutting Down for details.

13.8 Long-Term Storage

The OTTO 100 V2.4 AMR or any spare battery/batteries outside of the robot should be stored within the temperature range outlined in the **System Overview**. If storing for an extended period of time (> 2 days), it is recommended that the battery be discharged/charged to ~50%.

The robot must be completely powered off using the circuit-breaker switches when storing the OTTO 100 V2.4 AMR for an extended period of time. Even with the batteries disconnected from the system, the batteries will discharge over time and require to be charged to ~50% every 12 months or sooner.

If the OTTO 100 V2.4 AMR is at a higher SoC then mentioned above for storage the battery will need to be discharged, this can be done either by;

1. Set up two Waypoints and have the OTTO 100 V2.4 AMR travel between them until the desired SoC is reached.
2. If it is desired to keep the robot stationary, move it to a place free of traffic, press the **Emergency Stop** button, and wait until the desired SoC is reached.

Once the desired SoC is reached, shut down the robot.

See Shutting Down for details.

13.9 OTTO App

OTTO™ App software enables single-robot control. The main functions of the OTTO App include:

1. Driving the associated OTTO autonomous mobile robot (AMR).
2. Recording and updating a map of the facility.
3. Basic map configuration using markers and some Zone types.
4. Basic route configuration for an individual OTTO AMR.

If you're managing a fleet of OTTO AMRs using Fleet Manager, you will need to use OTTO App to record the facility map, which can then be exported and uploaded to Fleet Manager for use by the fleet and advanced editing.

13.10 Driving an OTTO AMR Manually

Caution

While operating an OTTO autonomous mobile robot (AMR) in Manual mode, robot LiDAR safeguards are still active; however, personnel can still command the robot to drive into Exclusion Zones or into obstacles that are over/under the LiDAR plane. To avoid injury from crushing or colliding with the robot or secondary injuries from the OTTO AMR colliding with another object, personnel should visually monitor the robot while it is being manually driven in OTTO App.

1. Launch the OTTO App for the OTTO AMR that you want to drive.

See OTTO App for more detail on accessing OTTO App.

Caution

Use caution when driving OTTO 100 AMRs manually - particularly in reverse - as the rear sensor safety system will be disabled.

2. Select either **Drive** or **Map** from the **Main Menu** ☰ to display the navigation controls in the bottom-right corner of the screen.
3. Select the **Drive Mode** toggle to activate **Manual** mode. The **Drive Mode** toggle will turn green and a white joystick will appear.

If Drive Assist is enabled and a robot has no current goal, the Drive Mode toggle will display Assisted mode instead of Manual mode.

If Drive Assist is enabled and the robot has an existing goal, the Drive Mode toggle will place the robot into Manual mode, allowing one to perform goal recovery with the joystick. As soon as the existing goal is cancelled or completed, the robot will then enter Assisted mode.

4. Drive the OTTO AMR by selecting and holding the white joystick and moving it in the direction you want the OTTO AMR to travel. You can also drive an OTTO AMR using the arrow keys on your keyboard.

Driving with the joystick affects the speed at which the OTTO AMR travels - the farther you push the joystick, the faster the OTTO AMR will travel.

To adjust the top speed at which an OTTO AMR will travel, tap the Speed toggle. OTTO AMRs will drive slower when the Speed toggle is disabled and its field sets will narrow for easier navigation around close objects.

Click Main Menu ☰ then click OTTO to customize the joystick sensitivity using the Joystick Sensitivity slider.

13.10.1 Enabling Drive Assist

Drive Assist is a beta feature introduced with software version 2.18, leaving safety rules enabled through a robot's Navigation Specification - the same as an OTTO AMR operating in the Autonomy State - to avoid nuisance Safety Stops, preventing accidental collisions with obstacles, and robot entry into Exclusion Zones.

Note that OTTO AMRs being driven manually with Drive Assist enabled will not respect Preferred Direction Zone rules and will traverse the Zone both forwards and backwards.

See the Hardware Library for Navigation Specification information applicable to your robot model.

To enable Drive Assist:

2. Launch the OTTO App for the OTTO AMR that you want to drive.

   See OTTO App for more detail on accessing OTTO App.

3. Select **Main Menu** ☰.
4. Select **OTTO**.
5. Select **Enable Beta Features**.
6. Select the **Enable Drive Assist** toggle.
7. Select **Save**.

OTTO AMRs will not be affected by Preferred Direction or Assumed Cost (with a cost less than 1.0) Zones when operating under Drive Assist control. These Zones influence the path that the robot would prefer to take and said path is being commanded manually by the user in this mode.

13.11 Driving an OTTO AMR Autonomously

If the OTTO AMR has been added to Fleet Manager, the Map in OTTO App must match the Map in Fleet Manager. If the maps don't match, an OTTO AMR cannot be driven autonomously via OTTO App.

Caution

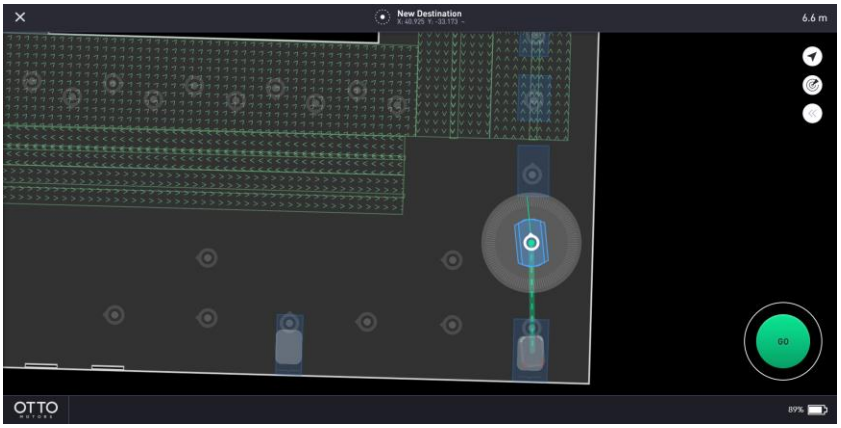
Drive with caution and make sure to never lose sight of the OTTO AMR.

1. Launch the OTTO App for the OTTO AMR that you want to drive.
2. Select either **Drive** or **Map** from the Main Menu ☰ to display the navigation controls in the bottom-right corner of the screen.

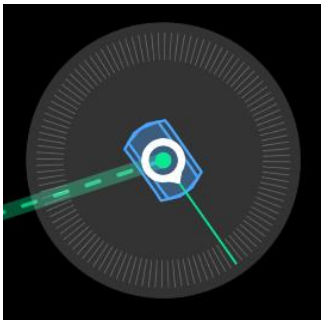
3. Make sure the **Drive Mode** toggle is disabled and **Manual Mode** is off. When disabled, the **Drive Mode** toggle is gray and the joystick will be a blue **Move** button.
4. Select **Move**. The joystick button will turn gray.

> Select the X in the top-left of the screen to cancel the move command.

5. Select the location on the Map to which you want to send the OTTO AMR. The joystick button will turn green and the orientation circle will be displayed at the selected location on the Map.



6. Move the green line inside the orientation circle to define the direction in which you want the OTTO AMR to be facing when it stops at the selected location.



7. Select **Go** to send the OTTO AMR on its way. A "Moving" notification is displayed.
8. Select **Stop** to stop the OTTO AMR at any time.

> You can select the Drive Mode toggle at any point to enter Manual drive mode.

13.12 Driving with Markers

If at least one Marker is set up in the Map, OTTO can be sent directly to it.

1. Launch the OTTO App for the OTTO AMR that you want to drive.
2. Select **Main Menu** ☰ then select **Drive**.
3. Select **Markers**.
4. Select a Marker from the list.
5. Select **Go** to send the OTTO AMR on its way. A "Moving" notification is displayed.
6. Select **Stop** to stop the OTTO AMR at any time.

> You can select the Drive Mode toggle at any point to enter Manual drive mode.

13.13 Driving with Waypoints or Routes

Use the OTTO App Workstation functionality to send an OTTO AMR to any previously configured Waypoint or Route.

1. Launch the OTTO App for the OTTO AMR that you want to drive.
2. Select **Main Menu** ☰ then select **Workstation**.
3. Select the desired Waypoint or Route.
4. Select **OK** to send the OTTO AMR on its way. A "Moving" notification is displayed.
5. Select **Stop** to stop the OTTO AMR at any time.

> You can select the Drive Mode toggle at any point to enter Manual drive mode.

13.14 Connecting to the OTTO 100 V2.4 AMR

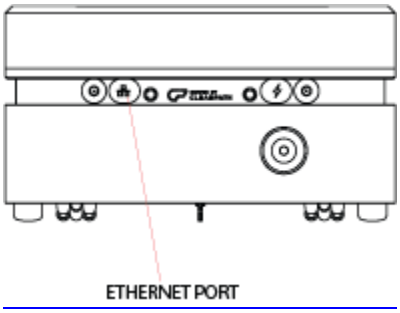
OTTO™ autonomous mobile robots (AMR) can be interfaced with on an individual basis using a computer and network cable.

13.14.1 Connecting Network Cable

1. Using a network cable, connect the OTTO AMR to your computer.

   OTTO 100 autonomous mobile robot

   The Ethernet port is located in the exposed service port at the rear of the OTTO AMR.



13.14.2 Setting Your Computer's Network Address

In order to connect a computer to an OTTO autonomous mobile robot, the computer must have the following configurations:

- **Network Address**: 10.255.255.20
- **Netmask**: 255.255.255.0

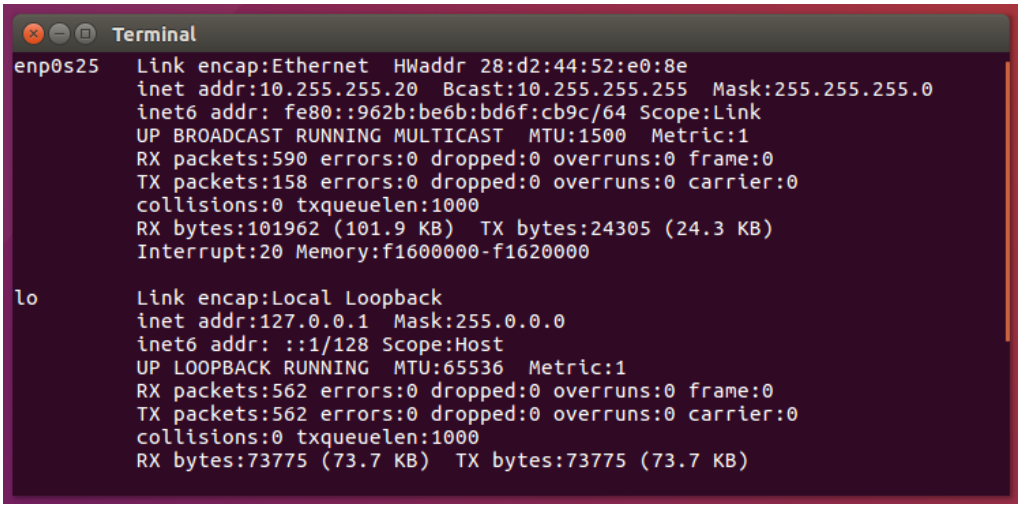
The steps below outline how to do this on Linux and Windows 7; for other operating systems, refer to the relevant documentation. Note that these steps will only need to be performed once per computer.

13.14.2.1 Linux

1. From the system tray, click the **Network Manager icon** and select **Edit Connections**. The **Network Connections** screen is displayed.
2. Click **Add.** The **Choose a Connection Type** dialog box is displayed.
3. Select *Ethernet* from the drop-down menu and click **Create**.
4. Click the **IPv4 Settings** tab and do the following:
    a. Enter a distinctive name for the network in the **Connection name** field.
    b. From the **Method** drop-down list, select *Manual*.
    c. Click **Add** and in the new line added under **Addresses**, enter 10.255.255.20 for the Address and 255.255.255.0 for the Netmask.
    d. Click **Save**.
5. Select the newly created network connection by clicking the **Network Manager** icon.
6. Open a **Terminal** window and confirm the IP is set correctly:

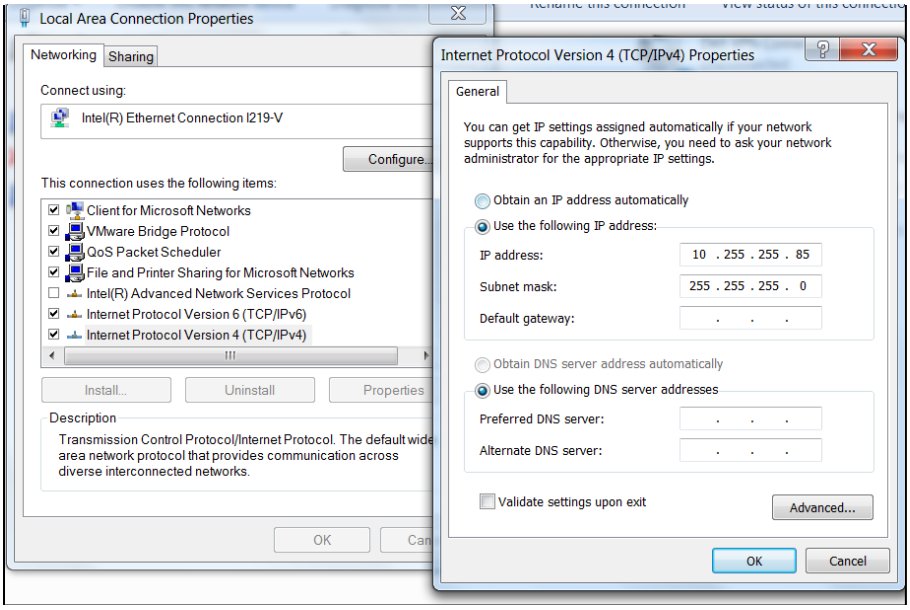
```
ifconfig
```

7. In the data that is returned, the `inet addr` should match the address entered in Step 4c above.



13.14.2.2 Windows 7

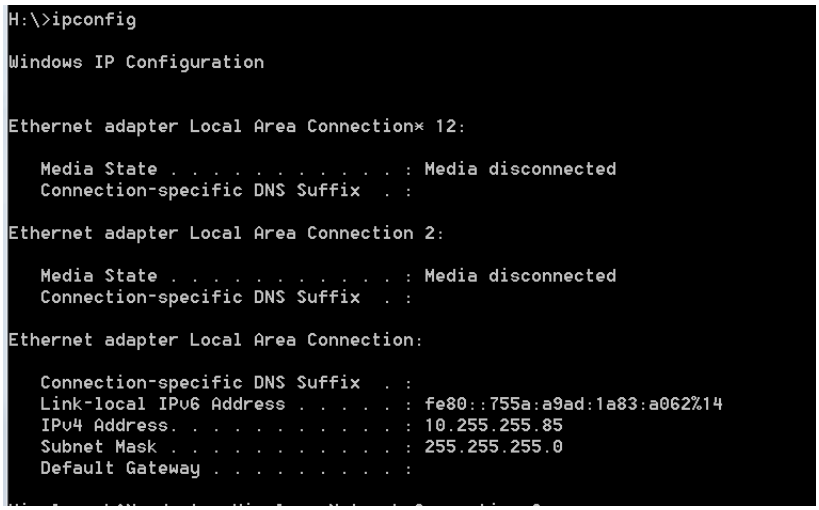
1. In the bottom-right corner of the screen, right-click the **Network icon** and click **Open Network and Sharing Center**.
2. Click **Change adapter settings**.
3. Right-click **Local Area Connection** and click **Properties**.
4. Select **Internet Protocol Version 4 (TCP/IPv4)** and click **Properties**.



5. In the **IP address** field, enter 10.255.255.20 and in the **Subnet mask** field, enter 255.255.255.0.
6. Click **OK** > **OK**.
7. Open a **Command** window and enter the following command:

```
ipconfig
```

8. In the data that is returned, the `IPv4 Address` should match the address entered in **Step 5** above.

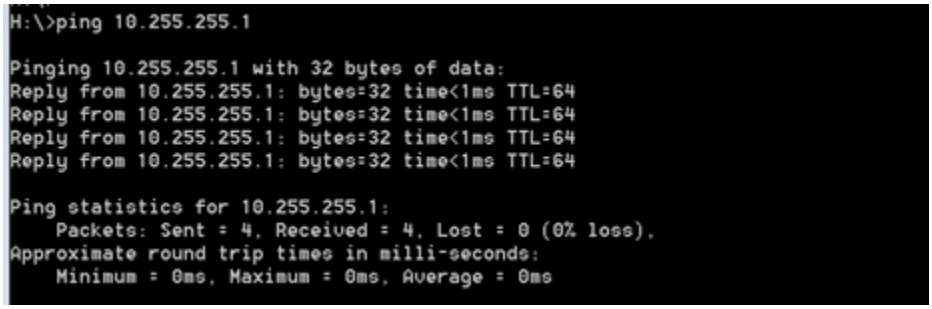


13.14.3 Pinging the OTTO AMR

1. Confirm that you can ping the OTTO AMR you plan to configure from the terminal window in Linux or the command prompt in Windows by entering the following command:

```
ping 10.255.255.1
```

You should receive a response similar to the following:



13.15 Connecting the OTTO 100 V2.4 AMR to the Network

You'll need to connect your OTTO™ autonomous mobile robot (AMR) to your network to truly take advantage of the AMR's autonomous capabilities.

1. Connect your computer to the OTTO AMR via ethernet cable.

   > See Connecting to the OTTO 100 2.4 AMR for more information.

2. From a browser, navigate to `10.255.255.1:8090`.
3. OTTO Network Setup will be displayed. Expand **Hostname Settings**. Enter a **Hostname** for the OTTO AMR. Hostnames must begin with a letter as hostnames beginning with a number aren't supported.

   > If the Configuration screen becomes slow to respond after changing the hostname, restart the OTTO AMR.

4. Click **Apply**.
5. Expand **Network Settings**:

   a. Enter your network's **Access Point Name** (ssid) and **Passkey**, then click **Apply**.
   b. Select an **IP Type**.

      i. To assign a Static IP address, select *Static IP* from the **IP Type** drop-down. Configure the fields as required and click **Apply**.
      ii. To use a Dynamic IP address assigned by the network, select *Dynamic IP* from the **IP Type** drop-down and click **Apply**.

6. Restart the OTTO AMR using its restart button.

   The OTTO App can now be accessed over Wi-Fi for the configured OTTO AMR. From a Google Chrome browser, go to <hostname>:5000. If your network isn't set up to resolve hostnames, use the IP address of the OTTO AMR in place of the hostname.

14 MAINTENANCE

Table 8 Maintenance and Inspection Schedule Summary

COMPONENT	WEEKLY	3 MONTHS	36 MONTHS
Visually inspect grounding strap	✓		
Visually inspect LiDAR for dirt, dust, and debris and clean it	✓		
Confirm that light pipe is functioning correctly	✓		
Confirm that speaker is functioning correctly	✓		
Visually inspect the 3D Perception camera windows for debris. If necessary clean it with a lint-free cloth or a cleaning wipe. Clean the rear sensor window.	✓		
Visually inspect the charge contacts for damage or debris	✓		
Check the castors for damage or debris		✓	
Check the Drive Wheels for damage or excessive wear		✓	
Contact OTTO Motors to check battery health			✓

To order any of the part numbers referenced in the following maintenance procedures, please contact OTTO Motors Support.

In the event that the below maintenance cannot be completed or the OTTO 100 V2.4 autonomous mobile robot requires further repairs, contact OTTO Motors.

Maintenance inside of the warranty period is to be performed by OTTO Motors authorized personnel or OTTO Motors maintenance certified personnel only. For more information, please contact OTTO Motors directly.

Electrical Shock

Prior to performing any maintenance, always follow the **Lock-Out Tag-Out** procedure to deactivate an OTTO™ autonomous mobile robot (AMR).

Warning

If the OTTO 100 V2.4 AMR has been operating immediately prior to performing maintenance, the motors and motor drivers on the traction circuit board (located on the bottom of the robot) may be at elevated temperatures which could cause a burn to the technician if contacted.

14.1 Weekly Preventative Maintenance

Perform the following tasks once every week:

14.1.1 Circle Check

Perform a circle check around the OTTO 100 V2.4 autonomous mobile robot daily to ensure no damage has occurred since the robot last ran.

During this visual inspection, ensure the robot is turned on and verify that:

- The light pipe is functioning correctly by pressing the Emergency Stop button and checking for the Emergency Stop light pattern.
- The speaker is functioning correctly by pressing the Emergency Stop button and listening for the horn.
- The robot was not damaged during the last operation.
- The robot's LiDAR are functioning correctly. To test, place a lightweight object, such as a cardboard box, approximately 5 cm in front of the stationary robot and confirm that a safety stop is triggered. The safety stop will be observable with the sounding of the horn and the corner lights flashing red. Do not step in front of the robot to test the safety function.

14.1.2 LiDAR Inspection and Cleaning

When dust and debris accumulate on the LiDAR lens, the OTTO 100 V2.4 autonomous mobile robot may safety stop unexpectedly. For optimal performance, ensure the LiDAR lens and LiDAR cavity is clean.

14.1.2.1.1 Materials/Tools Required

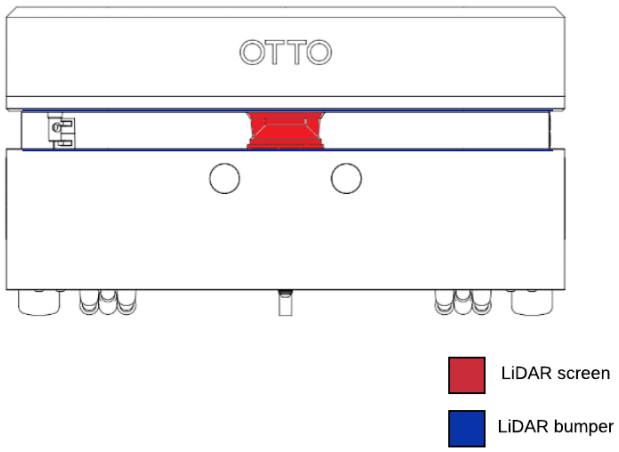
- Flashlight
- Antifog/Antistatic Lens Cleaning Wipes (OTTO Motors Part Number 015591)

Caution

Do not use abrasive items or solvents on the LiDAR assembly, as this will damage the LiDAR. Used and dirty cleaning cloths or wipes will scratch the window over time. The LiDAR window is a wear item but proper care and cleaning can significantly extend its life.

14.1.2.1.2 Procedure

1. Inspect LiDAR and LiDAR cavity with flashlight for any dust and/or debris.
2. Using the Lens Cleaning Wipes, clear the LiDAR cavity of any dust/debris. Clean the LiDAR and the cavity with different wipes.



14.1.3 Grounding Strap Inspection

The grounding strap must fully contact the floor as the OTTO 100 V2.4 autonomous mobile robot moves. A grounding strap that cannot fully reach the floor poses an increased risk of accumulating static charge, which may influence the robot's performance and increase the risk of static discharges to people and other equipment.

Caution

Be aware of the weight of the robot and any tooling affixed to it. Any lifting or tipping of the OTTO 100 V2.4 autonomous mobile robot should be carried out by two people. Use appropriate lifting techniques to avoid back injury.

Ensure that any attached tooling is properly secured and handled, or removed before performing the checks detailed below.

After performing the checks detailed below, place the OTTO 100 V2.4 autonomous mobile robot carefully and gently on its wheels before turning it back on and returning it to service.

14.1.3.1 Procedure

1. Turn off the OTTO 100 V2.4 autonomous mobile robot and follow the **Lock-Out Tag-Out Procedure**.
2. With the OTTO 100 V2.4 autonomous mobile robot on the ground in a driving position, elevate the front of the robot approximately 2 cm so that the grounding strap can be visually inspected.

Crush

Crushing hazard. Use wooden blocks to support the front of the robot. Do not place tools or body parts underneath the robot.

Be aware of the weight of the robot and any tooling affixed to it. This task should be performed by two people. Use appropriate lifting techniques to avoid back injury.

3. Ensure the grounding strap is making full contact with the floor.
4. Very gently place the robot back on the ground.

14.1.4 Checking Charge Contacts

Observe the OTTO 100 V2.4 AMR in the charger or use OTTO App to raise the lift to charge height. Look for excessive wear of the copper charge contacts or excessive copper dust buildup. If the charge contacts are worn replace the parts. If copper dust completely coats areas of the plastic you may remove this dust with a soft long bristled brush when the OTTO 100 V2.4 is NOT in the charger.

If removing dust ensure that the OTTO 100 V2.4 AMR is powered down and locked-out and gently brush off the dust with a long soft-bristled brush such as a hand-broom. Do not use compressed air or gas to blow the dust away.

14.1.5 3D Perception Camera Inspection

The 3D Perception camera at the front of the OTTO 100 V2.4 AMR is protected by a glass lens.

1. Visually inspect the window and confirm there is no dust or debris on the cover.
2. If necessary, carefully clean the cover with a microfiber cloth or an OTTO Motors-approved cleaning wipe.

> **Caution**
>
> Do not apply excessive pressure to the glass cover.

14.1.6 Battery Calibration

OTTO 100 V2.4 AMRs use a NEC ALM 12V35i battery to power the robot. The function and health of this battery is monitored by a Battery Management Unit (BMU) which is internal to the battery pack itself.

Over the operating life of the OTTO 100 V2.4 AMR, the State of Charge (SoC) of the battery may drift from what is being calculated by the BMU. This occurs when the battery is charged and discharged multiple times within a particular range and never hits 0 or 100% SOC. When this occurs, the OTTO 100 V2.4 AMR's battery may suddenly drop in SoC while operating or the OTTO 100 V2.4 AMR may unexpectedly shut off.

> **Caution**
>
> The frequency of the SoC calibration, although suggested once a week, can be determined by the end user, as the frequency of charge cycles will vary between sites. For software 2.20 and later the calibration of SoC is done automatically, users may notice that the OTTO AMR stays in the charger a little longer than normal.

14.1.6.1 Required Materials

- OTTO 100 V2.4 AMR experiencing a battery SOC misalignment
- OTTO 100 Charger/Fast Charger
- Laptop or tablet connected to the same network as the OTTO 100 V2.4 AMR
- A pylon at least 300 mm (11.8 in) in height

14.1.6.2 Procedure

Battery calibration is performed by charging the battery with the OTTO 100 Charger/Fast Charger at 2.5 C (100 amps (A)) in the constant current (CC) mode of the charge cycle until it hits the threshold.

14.1.6.3 Setup

1. OTTO Charger Setup
    a. Place a pylon in front of the OTTO 100 Charger/Fast Charger to ensure no OTTO 100 V2.4 AMRs drive into the Dock while it is being used.
    b. On the OTTO 100 Charger/Fast Charger (Ecotec battery charger) display, press the **OK** button to enter the charger's menu and double-check the charging parameters:
        i. Navigate to **Service** and press **OK.**
        ii. Navigate to **Charging param** and press **OK.**
2. OTTO 100 V2.4 AMR Setup
    a. If battery calibration is required due to a sudden SOC drop and the robot is dead, use a Manual Charger to charge the robot to 10-14% SoC before sending to OTTO 100 Charger/Fast Charger
    b. If the OTTO 100 V2.4 AMR is connected to Fleet Manager, navigate to **Monitor** > **Fleet** > **Robots** in Fleet Manager, click the OTTO 100 V2.4 AMR, and set the OTTO 100 V2.4 AMR to **Unavailable**

14.1.7 Calibration

1. CC Charge Mode
    a. Navigate to the OTTO App interface for the OTTO 100 V2.4 AMR.
    b. Remove the pylon blocking the OTTO 100 Charger/Fast Charger.
    c. Using OTTO App, send the OTTO 100 V2.4 AMR to charge at the OTTO 100 Charger/Fast Charger.
    d. Wait for at least 30 minutes and you will see the current on the charger drop below 500 mA. This is visible on the display of the wall unit for the OTTO 100 Charger/Fast Charger.

Once the battery hits this threshold, the OTTO 100 V2.4 AMR can be moved out of the OTTO 100 Charger/Fast Charger.

14.1.7.1 Post-Maintenance

1. Restore OTTO 100 V2.4 AMR availability

    a. If the OTTO 100 V2.4 AMR is connected to Fleet Manager, navigate to **Monitor** > **Fleet** > **Robots** in Fleet Manager, click the OTTO 100 V2.4 AMR, and set the OTTO 100 V2.4 AMR to **Available**.

2. If the profile on the OTTO 100 Charger/Fast Charger was changed, return the charger to the profile needed for the installed fleet before making the charger available to the fleet.

14.1.7.2 Confirmation

1. To verify that the calibration has been performed correctly, return the OTTO 100 V2.4 AMR to service so it can be assigned to regular Jobs.
2. The OTTO 100 V2.4 AMR can be left unattended but the SoC should be checked every 30 minutes before the next charge cycle to make sure it is discharging as expected.
3. If the battery voltage does not suddenly jump and the OTTO 100 V2.4 AMR does not turn off unexpectedly during this time, the calibration was successful.

If the OTTO 100 V2.4 AMR continues to experience issues with battery performance after completing this calibration procedure, contact OTTO Motors Support for further direction.

14.2 Monthly Preventative Maintenance

Perform the following tasks once a month:

14.2.1 Battery Cell Balancing

OTTO 100 V2.4 AMRs use a NEC ALM 12V35i battery to power the robot. The function and health of this battery is monitored by a Battery Management Unit (BMU) which is internal to the battery pack itself.

Over the operating life of the OTTO 100 V2.4 AMR, the State of Charge (SoC) of the battery may start being misreported accompanied by a higher voltage difference between the battery cells. Typically battery cells should be within a range of 50 mV - if not, the OTTO 100 V2.4 AMR's battery may suddenly drop in SoC while operating or the OTTO 100 V2.4 AMR may unexpectedly shut off. To resolve this issue, it is required to perform the cell balancing of the battery and BMU.

> This process will perform a battery calibration as well. If only SoC drift is the issue, follow the Battery Calibration procedure.

14.2.1.1 Required Materials

To perform this maintenance, you will require the following:

- OTTO 100 V2.4 AMR
- OTTO 100 Charger/Fast Charger
- OTTO 100 Manual Charger
- Laptop or tablet connected to the same network as the OTTO 100 V2.4 AMR
- A pylon at least 300 mm (11.8 in) in height

14.2.1.2 Procedure

The cell balancing is performed by discharging the battery to 10% - 14% SoC and then charging the battery with the OTTO 100 Charger/Fast Charger at 2.5 C (100 amps (A)) in the constant current (CC) mode of the charge cycle.

Once the CC mode of charging is complete, switch to using the Manual Charger to charge the robot in constant voltage (CV) mode and keep the battery floating at its maximum voltage.

14.2.1.3 Setup

1. OTTO 100 V2.4 AMR Setup

    a. Ensure that the battery in the OTTO 100 V2.4 AMR has been drained down to around 10% - 14% as seen in the OTTO App or Fleet Manager.
    b. Ensure that the battery in the OTTO 100 V2.4 AMR has been drained down to around 10% - 14% as seen in the OTTO App or Fleet Manager.
    c. If the OTTO 100 V2.4 AMR is connected to Fleet Manager, navigate to **Monitor** > **Fleet** > **Robots** in Fleet Manager, click the OTTO 100 V2.4 AMR, and set the OTTO 100 V2.4 AMR to **Unavailable**.

> **Caution**
>
> If the battery charge is too high, the cell balancing procedure will not work correctly.

14.2.1.4 Cell Balancing

1. Stage 1 (CC Charge Mode)

    a. Navigate to the OTTO App interface for the OTTO 100 V2.4 AMR.
    b. Remove the pylon blocking the OTTO 100 Charger/Fast Charger.
    c. Using OTTO App, send the OTTO 100 V2.4 AMR to charge at the OTTO 100 Charger/Fast Charger.
    d. Wait for at least 30 minutes and you will see the current on the charger drop below 500 mA. This is visible on the display of the wall unit for the OTTO 100 Charger/Fast Charger.

        Once the battery hits this threshold, the OTTO 100 V2.4 AMR can be moved out of the OTTO 100 Charger/Fast Charger.

    e. Send the OTTO 100 V2.4 AMR to a Waypoint outside of the OTTO 100 Charger/Fast Charger close to the Manual Charger. These locations should be as close together as possible. Delay in performing Stage 2 of the balancing may affect the process

2. Stage 2 (CV Charge Mode)

    a. Press the Emergency Stop button on the OTTO 100 V2.4 AMR to prevent it from driving away while connected to the charger.
    b. Plug the Manual Charger into the OTTO 100 V2.4 AMR immediately to avoid voltage drop (longer delays might affect the process).

c. Leave the OTTO 100 V2.4 AMR turned on and connected to the Manual Charger for 8 hours - this will give the battery time to perform any required internal balancing.
d. Unplug the Manual Charger and turn off the OTTO 100 V2.4 AMR.
e. Turn off the breakers so the batteries are at complete rest for 30 minutes

14.2.1.5 Confirmation

1. After the OTTO 100 V2.4 AMR has sat turned off for 30 minutes, the cell balancing procedure is complete.
2. To verify that it has been performed correctly, run the OTTO 100 V2.4 AMR from 100% SOC to 10%:
3. Configure two Waypoints and have the OTTO 100 V2.4 AMR drive a route repeatedly between them.

    a. The OTTO 100 V2.4 AMR can be left unattended but the SoC should be checked every 30 minutes to make sure it is discharging as expected.
    b. If the battery voltage does not suddenly jump or the cells voltages are in acceptable range and the OTTO 100 V2.4 AMR does not turn off unexpectedly during this time, the cell balancing was successful

If the OTTO 100 V2.4 AMR continues to experience issues with battery performance after completing this calibration procedure, contact OTTO Motors Support for further direction.

14.2.1.6 Post-Maintenance

1. Restore OTTO 100 V2.4 AMR availability

    a. If the OTTO 100 V2.4 AMR is connected to Fleet Manager, navigate to **Monitor** > **Fleet** > **Robots** in Fleet Manager, click the OTTO 100 V2.4 AMR, and set the OTTO 100 V2.4 AMR to **Available**.

2. If the profile on the OTTO 100 Charger/Fast Charger was changed, return the charger to the profile needed for the installed fleet before making the charger available to the fleet.

14.3 3-Month Preventative Maintenance

Perform the following tasks once every 3 months:

14.3.1 Wheel/Castor Inspection

14.3.1.1 Materials/Tools Required

- Two people
- Flashlight
- Water (if required)
- Scratch Free Sponge or Lint-Free Cloth (if required)

14.3.1.2 Procedure

1. Ensure the OTTO autonomous mobile robot's lift is lowered and its contactors are not exposed.
2. Ensure the OTTO autonomous mobile robot is turned off.
3. Ensure the breaker switches have been locked out and tagged as per the **Lock-Out Tag-Out Procedure**.
4. Place two small planks of wood under the robot and against each wheel on one side.

5. Along with another person, lift the opposite side of the robot so that its side is now on the wooden planks. One person must keep the robot stable and prevent it from falling over.

6. Visually inspect the wheels.
7. Turn the wheels by hand to ensure proper function/alignment.
8. 2 mm of wear is allowed on the drive wheels, greater wear will negatively affect the performance of the OTTO AMR.

   When new, the OTTO 100 / OTTO 100 V2.4 Drive wheels have 10 mm of rubber thickness. If this is 8 mm or less, the wheel should be replaced. If any damage to the wheel is greater than 2 mm x 2 mm in size, greater than 2 mm in depth, results in raised areas on the wheel or causes the wheel to not roll smoothly (eg. flat spots), then the wheel should be replaced.

9. Visually inspect and turn the bi-directional casters by hand and remove any dust/debris. Ensure that the casters spin and that the smaller rollers on the caster also spin.
10. Along with another person, place the OTTO autonomous mobile robot back on the ground. Avoid letting the robot fall.

14.4 36-Month Preventative Maintenance

Perform the following task once every 36 months:

14.4.1 Battery Health Check

The OTTO 100 V2.4 autonomous mobile robot battery is expected to last for at least 36 months of continuous operation. The actual lifetime experienced will vary greatly depending on the usage and operating environment. Contact OTTO Motors for an in-depth assessment of the battery's health if you have any concerns.

15 DISPOSAL

Always observe environmental protection regulations valid to your region.

If disassembling the OTTO 100 V2.4 AMR for disposal, pass on any commercially-viable disassembled components for recycling. Separate materials as far as possible by type.

15.1 Battery Disposal

Do not incinerate or dispose of the batteries. Return end-of-life or defective batteries to your nearest recycling center per appropriate local regulations.

16 TROUBLESHOOTING

Examine the following table for possible methods to recover from an unexpected state of the OTTO autonomous mobile robot (AMR). If possible, consult the OTTO Fleet Manager application and view Exceptions for the specific robot from Fleet View to begin your assessment.

See Components Overview for detail on button locations and robot state indicators.

Table 9 Troubleshooting Actions

STATE	ACTION
Robot will not turn on	First, check that both circuit breakers are enabled. Next, push the Power On-Off button momentarily. If neither of the above work, connect the manual charger to recover the battery.
Robot is stuck in Emergency Stop State	First, check that the Emergency Stop Button is pulled out. Next, press the Safety Reset Button to try and clear the Emergency Stop state. If the Emergency Stop state has not cleared, check the area near and within the LiDAR cavity for obstacles that may be tripping the safety LiDAR. If the above fails, complete a Firmware Reset by holding the Power On-Off Button for 10 seconds to reset the system.
Robot is stuck displaying Safety Stop light pattern	Check for nearby obstacles or debris in the LiDAR cavity. Clean the LiDAR with a microfiber cloth. Check area for retroreflective material (a surface that reflects light back to its source with a minimum of scattering).
Robot is making a loud or unusual mechanical noise	If the sound is coming from the bottom of the robot, check the castors and drive wheels to ensure no debris or object is jammed in the wheel cavities or the wheels. If the sound is coming from the top of the robot, check to make sure the lift/attachment has not caught on anything externally or internally. Contact OTTO Motors Support if the issue cannot be resolved.

OTTO AMR will not move to instructed location	Check surrounding area for obstacles blocking the robot path. Note this may include yourself. Check that a valid LiDAR field set and Navigation Specification are loaded onto the OTTO AMR. Talk to OTTO Motors Support for instructions on diagnosing a blown traction motor fuse. The Navigation Specification will include information about the space required by the OTTO AMR for autonomous navigation.
Robot stuck in charger	The charge cycle will not complete if a LiDAR Safety Stop is triggered in the Dock. Check that the areas directly in front of the OTTO AMR is clear of obstacles. If the above was not the issue, look between the robot and the charge contacts to confirm that the charge contacts on the OTTO AMR physically connect with the charge contacts in the charger. Check that the OTTO AMR is not physically jammed in the charger, either on the charge contacts or on the rollers on the sides. Are the wheels moving? If the drive wheels attempt to turn, but the OTTO AMR cannot leave the charger, then it is physically jammed. Check that the Map is using the correct Steps to exit the charger. Using an invalid Marker Move Step (possibly sourced from an out-of-date Map) when exiting the charger may cause the robot to remain in the charger.
Robot movement is jerky and inconsistent	Check that both circuit breakers are closed and not only one.

17 DECLARATIONS

17.1 Supplier's Declaration of Conformity

47 CFR § 2.1077 Compliance Information

OTTO 100 V2.4

Responsible Party

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This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Contains Transmitter Module FCC ID: PD98265NGU

18 REFERENCES

[1] *ECS-8000 User Manual*, Vecow Co., Ltd., New Taipei City, Taiwan, 2016

[2] *RF1V Force Guided Relays / SF1V Relay Sockets*, IDEC Corp., Osaka, Japan, 2009