Mobile Robot LD-250

Assembly Instructions

According to Machinery Directive 2006/42/EC (ANNEX VI)

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1.1.8 Alert Notation

The icon that starts each alert can be used to indicate the type of hazard. These will be used with the appropriate signal word - Danger, Warning, or Caution - to indicate the severity of the hazard. The text following the signal word will specify what the risk is, and how to avoid it.

Icon	Meaning	Icon	Meaning
	This is a generic alert icon. Any specifics on the risk will be in the text following the signal word.		This identifies a hazardous entanglement situation.
	This identifies a hazardous electrical situation.		This identifies a fire risk.
	This identifies a hazardous burn-related situation.		This identifies a laser emitter eye damage situation.
	This identifies a hazardous ESD situation.		

1.1.9 Abbreviations and terminology

Abbreviation / term	Description
EHSR	Essential health and safety requirements relating to the design and construction of machinery
LD-250	Light-duty mobile robot, 250 kg max payload
PL	Performance Level as per EN ISO 13849-1
PL_r	Required Performance Level as per EN ISO 13849-1
PL_a	Achieved Performance Level as per EN ISO 13849-1

Performance Level	Discrete level used to specify the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions
Required performance level PLr	Performance level (PL) applied in order to achieve the required risk reduction for each safety function
Risk assessment	Overall process comprising risk analysis and risk evaluation
Safety Function	Function of the machine whose failure can result in an immediate increase of the risk(s)

2 Introduction

2.1 Assembly Instructions

The assembly instructions in this document deal with all safety-related aspects of the LD-250 mobile robot, as partly-completed machinery, and of the interface between the partly-completed machinery and the final machinery, which have to be considered by the assembler when incorporating the partly-completed machinery into the final machinery.

The LD-250 mobile robot as a partly-completed machine is intended to be incorporated into other machinery and must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of EC Machinery Directive 2006/42/EC, where appropriate.

The assembler, when incorporating the LD-250 mobile robot into the final machinery, shall need to take the necessary measures to deal with the EHSRs from ANNEX I of the Machinery Directive, applicable to the LD-250 mobile robot, that have not been applied and fulfilled or that have only been partly fulfilled by OMRON.

The assembly instructions shall then form part of the technical file for the final machine.

These assembly instructions for the LD-250 mobile robot as a partly-completed machinery, provide the necessary information to enable the manufacturer of the final machinery to draft the parts of the instructions as required from ESHR 1.7.4.

2.2 Definitions

- **AMR** (Autonomous Mobile Robot) - This term describes the LD-250 with an attached payload structure, creating a complete mobile robot.
- **Fleet Manager** - A rack-mount computing appliance used to manage a fleet of AMRs. The appliance consists of the EM2100 appliance (EM2100) and the FLOW Core software.
- **Fleet** - Two or more AMRs operating in the same workspace.
- **LD-250** - This is the model name of the platform. This document uses the model name LD-250 when describing the setup, configuration, and connections.
- **Mobile Robot** - An alternate industry term for AMR.
- **Payload Structure** - Any passive or dynamic device attached to and possibly powered by the LD-250. This could be as simple as a crate for carrying objects such as factory parts or as complicated as a robotic arm that picks up and manipulates factory parts.

- **Platform** - The base LD-250, including:
  - The chassis, drive motors, suspension, wheels and light discs, casters, battery, lasers, and rear sensors.
  - An on-board LD-250 Core with a built-in gyroscope, navigation software, and data and power connectors for a payload structure.
  - An Operator panel, also referred to as the Human-Machine Interface (HMI).
  - The LD-250 skins (external covers) and a payload bay for attaching a payload structure.

2.3 Product Description

The LD-250 is a general-purpose mobile robot, designed to work in an indoor industrial environment and around trained personnel. It is self-guided and self-charging, with an automated docking station. It has a maximum capacity of 250 kg. Capacity includes the payload structure and any load carried by that structure.

The LD-250 combines hardware and mobile-robotics software to provide an adaptive, mobile platform to transport your payload. After it scans physical features in its environment, the LD-250 navigates safely and autonomously to any accessible destination. It moves continuously and without human intervention, autonomously recharging itself as necessary.

The LD-250 uses range data from a Safety Scanning Laser as its primary means of detecting obstacles and of maintaining an accurate knowledge of its location in the environment. Additionally, it uses data from the following sensors:

- A low front (or toe) laser to detect objects below the plane of the main laser.
- A rear sensor that detects and stops the LD-250 if it senses objects close behind the AMR.
- A gyroscope in the LD-250 Core to detect and report LD-250 rotation.
- An encoder on each drive motor that provides odometry data for the distance travelled by each drive wheel.

Wheel encoders provide the navigation system with odometry information (how far each wheel has travelled, and in which direction). In addition, the LD-250 Core contains an internal gyroscope to track the LD-250's rotation. The LD-250 analyzes this odometry data together with LIDAR data from its navigation laser to calculate its position. This process is called *localization*.

For dynamic work environments that are difficult for laser localization, OMRON offers Acuity Localization. Acuity Localization uses a camera to detect overhead lights, enabling the AMR to localize itself in environments where laser localization alone is not an optimal solution. Laser localization is tolerant of changing environments. However, it becomes difficult if changing features exceed 80% of the objects detected by the laser. This includes workspaces such as warehouses, where objects such as shipping pallets or rolling carts either change locations often or block the laser’s view of mapped features. Acuity is also useful when

wide-open spaces do not provide enough features to map for laser localization. The *LD Platform Peripherals User's Guide* describes how to install and configure the Acuity option.

LD-250 users typically add attachments (a payload structure) to the LD-250 base platform to customize it for use in specific applications. The LD-250 provides a payload bay that includes aluminum extruded load bars. T-slots in the load bars provide a strong and adaptable method of attaching payload structures to the Platform.

A payload structure can be as simple as a crate that contains manufacturing parts or a more complicated device such as a conveyor or robot arm. The LD-250 Core provides power, logic, data communication, and safety connections for the payload structure. This includes user connections for warning lights and additional lasers. For more information, see:

- *Payload Structures* on page 77 (LD-250 Platform User's Guide, Rev-B) for information about designing a payload.
- *Connectivity* on page 93 (LD-250 Platform User's Guide, Rev-B) for information about available user connectors on the LD-250 Core.

2.3.1.1 Chassis and Drive Train

Each LD-250 uses a two-wheel, differential-drive, with passive casters front and rear for balance. The drive-wheels have independent spring suspension, with solid, polyurethane tread. The wheel axles are located near its center line, making the LD-250 highly maneuverable and able to rotate in place.

You can disengage the drive wheels by turning a cam lever on the gearbox. This is required for some set up and maintenance operations. See: *Engage and Disengage the Drive Wheel Motors* on page 148 (LD-250 Platform User's Guide, Rev-B).

CAUTION: BRAKES DISABLED. When the drive wheels are disengaged, the AMR brakes are inoperable. Take care when you move the LD-250 on inclined surfaces.

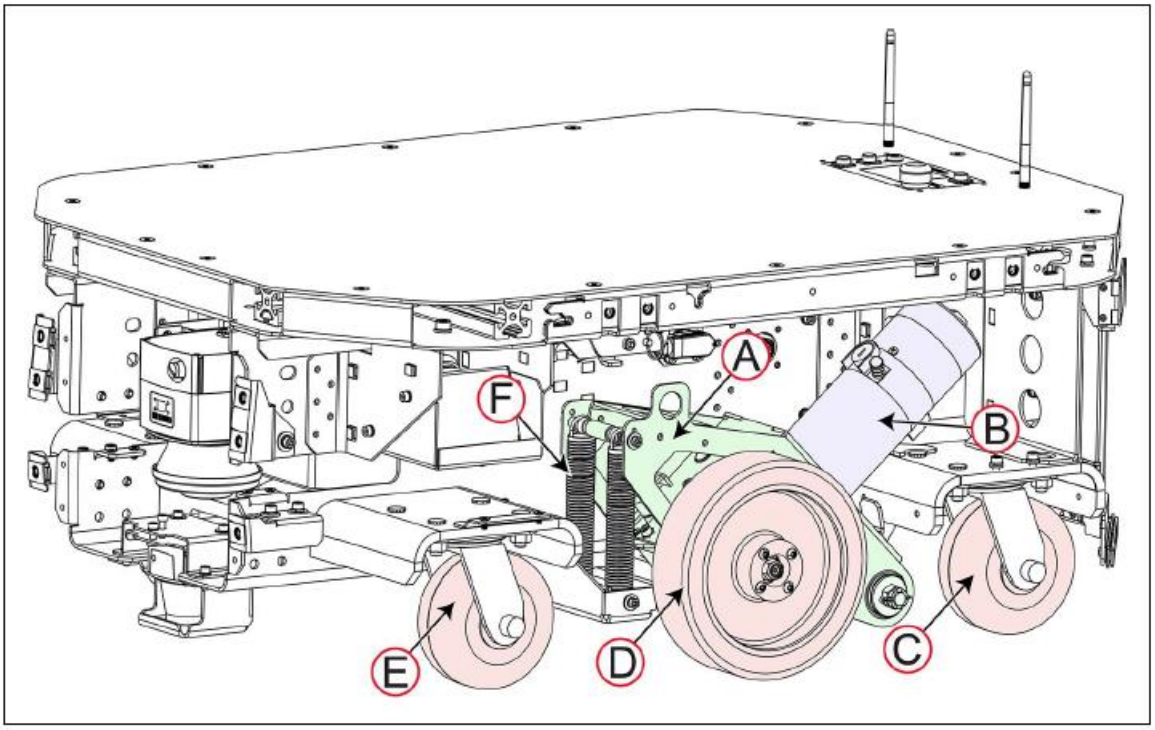


Figure 1: Drive Assembly in LD-250 (skins removed)

Callout	Description
A	Drive Train assembly (wheel, suspension and motor).
B	Drive motor assembly, containing the gears, encoders, and electric brake.
C	Rear caster.
D	Drive wheel, aluminum with polyurethane tread.
E	Front caster.
F	Suspension springs.

2.3.1.2 What's Included - Basic Components

- One fully assembled LD-250 model platform that includes the following:
  - OMRON OS32C Safety and Navigation Laser (main laser).
  - Low Front Laser.
  - Rear sensor.
  - Differential drive train.
- LD-250 Core housed inside the LD-250 which consists of:
  - A computing appliance that runs the SetNetGo operating system and the Advanced Robotics Automation Management (ARAM) software.
  - A microcontroller that runs the Mobile Autonomous Robot Controller (MARC) firmware.

    - Other sensor components such as a gyroscope and accelerometer.
    - The amplifiers that supply power to the drive wheels.
- One battery.
    - Shipped separately from the LD-250 to comply with dangerous goods shipping regulations.
- Three emergency stop (E-Stop) buttons:
    - One on the Operator panel.
    - One on each side of the chassis.
- Operator Panel.
    - You can move the operator panel to any preferred position on your payload structure. However, because the operator panel contains one of the three E-Stop buttons, there are important safety considerations when relocating or removing this panel. The standard Operator Panel includes:
        - 6-line status and message display screen.
        - E-Stop button.
        - Vehicle power ON and OFF buttons.
        - Brake release button.
        - 2-position key switch for access control. Lock the key switch to disable the off button and prevent accidental or unauthorized shutdowns.
- Also available is an optional touch screen that shows more AMR status information and provides additional functions. See *Touchscreen* on page 188 (LD-250 Platform User's Guide, Rev-B).
- Automated docking station.
    - The docking station enables the LD-250 to charge itself, without user intervention. It includes a wall-mount bracket and a floor plate, for a choice of installation methods. See *Installing the Docking Station* on page 58 (LD-250 Platform User's Guide, Rev-B).
    - When the docking station is not occupied, a manual charging cord enables you to charge a battery outside the LD-250.
- A USB flash drive containing software and documentation.
- In addition to the items included with every LD-250, you need at least one pendant per robot fleet. Use this pendant to manually drive the LD-250 and to create a digitized map of the work environment.
- For a fleet of AMRs, the Fleet Operations Workspace Core (FLOW Core) software (running on a Fleet Manager appliance) shares a map of the work area between all AMRs in the fleet. This provides a common frame of reference for navigation and localization, preventing contention between AMRs.

2.3.1.3 Options for Enhancing Your Payload Structures

- **Rear Lasers**—A rear-facing obstacle-detection laser that scans the horizontal plane to the rear of the AMR.
- **Side Lasers**—Side-mount obstacle-detection lasers that scan the vertical plane on each side of the AMR. These lasers detect obstacles that are outside the scanning

plane of the main safety laser. You might use side lasers on your payload structure to avoid obstacles that the main safety and navigation laser cannot detect.

- **Touchscreen**—The Touchscreen complements the standard Operator Panel, enabling operators to interact with the AMR and the FLOW Core software directly from the payload structure. See the *LD Platform Peripherals User's Guide* for more information about the Touchscreen.

2.4 Related Manuals

These assembly instructions cover safety-related aspects of the LD mobile robot, as a partly completed machinery. There are additional manuals that cover related topics. The following manuals provide information on general safety, related products, advanced configurations and system specifications.

Manual Title	Description
Mobile Robot LD Safety Guide	Contains general safety information for all Omron AMRs.
Fleet Operations Workspace Core User's Guide	Describes Fleet management, MobilePlanner software, the SetNetGo OS, and most of the configuration procedures for an LD-250.
EM2100 Installation Guide	Describes the installation of an EM 2100 appliance, as a Fleet Manager, which runs the Fleet Operations Workspace software to manage a fleet of AMRs.
Advanced Robotics Command Language Reference Guide	Describes how to use the Advanced Robotics Command Language (ARCL) a text-based, command line operating language Use ARCL to integrate a fleet of AMRs with an external automation system.
LD Platform Peripherals User's Guide	Describes optional peripherals (Touchscreen, Call box or Door box, Acuity Localization, HAPS, and rear-facing laser.)

3 Safety

3.1 Intended Use

The LD-250 is designed to operate in indoor industrial environments. In general, if a wheelchair user can safely and easily navigate the environment (open, and mostly flat with only gentle inclines and wide doorways), then it is navigable by an LD-250.

DANGER: PERSONAL INJURY RISK
There is risk of serious injury by crushing if the AMR tips over as a result of improper operation on inclines that do not comply with the operating specifications.

The following guidelines apply:

- **Floor**—Clean and dry floors that you sweep regularly and routinely keep free of debris, dust, and liquids.
- **Typical Inclines**—The LD-250 is intended to operate in a workspace that has a mostly flat floor. If the workspace includes inclined areas, OMRON recommends a gentle incline typical of wheelchair ramps. Be aware that the payload structure and any loads transported can:
    - Reduce the AMR's ability to traverse an incline.
    - Change its operating center of gravity (CG).
- **Inclines (Ramps)**—With a properly designed and stable payload, the LD-250 can operate on ramps at full payload capacity. However, extended periods of operation on ramps will affect battery duration and speed is limited to 600 mm/sec on inclines such as ramps. Operational recommendations are:

Slope	Payload Restriction	Speed Limit
1.7 degrees (3% grade)	No restriction	No restriction
3 degree slope	200 kg	600 mm/s
4.75 degrees (1:12 slope, typical wheelchair ramp)	165 kg	600 mm/s

- **Temperature** 5 to 40°C, with a recommended humidity range of 5% to 95%, non-condensing. Operating the LD-250 at high or low ambient temperatures (particularly with a full payload and high speeds) can cause the battery to exceed its operating temperature limits. If this happens, you are notified by escalating software messages as follows:
    - The battery is approaching a high or low temperature limit. Change the LD-250's operating conditions so that the battery can return to within its temperature limits.

    - The battery has exceeded an initial limit, the LD-250 continues to operate but charging is deferred until the battery has returned to within its temperature limits.
    - The battery has exceeded its temperature limits and the LD-250 will shut down immediately.
- The LD-250 has an ingress protection rating of IP20 and is not liquid-proof. Keep floors dry because liquids might get into the AMR. Damp, dusty, or greasy floors might also cause its drive wheels to slip or skid. Such traction problems can affect both braking and accuracy.

3.2 Non-intended Use

When deploying an AMR, anticipate potential risks to personnel and equipment. OMRON intends the LD-250 for use in a carefully controlled and managed environment with restricted access granted only to trained personnel.

You should conduct a risk analysis before you deploy the LD-250 in other environments. For example, deployments in areas that are open to general public access such as retail stores. Application of the LD-250 in such areas generally requires additional safety measures. OMRON does not intend the LD-250 for deployment in environments that contain:

- Hazardous (explosive or corrosive) atmospheres.
- Ionizing or non-ionizing radiation.
- Extreme heat or humidity.
- Floors that are damp or have any standing water.

IMPORTANT: The LD-250 is not waterproof. Keep all floors dry. Dampness can cause drive wheels to slip, affecting both braking and navigation.

In addition, OMRON does not intend the LD-250 for deployment in the following environments:

- Life-support systems.
- Residential installations.
- Mobile installations, including moving floors or any type of land vehicle, watercraft, or aircraft. (LD-250 navigation is assisted by a gyroscope embedded in the LD-250 Core. For accuracy, the gyroscope requires a stationary environment).

IMPORTANT: Observe all instructions for operation, installation, and maintenance provided in this guide and in the Mobile Robot LD Safety Guide.

Non-intended use of an LD-250 can:

- Cause injury to personnel.
- Damage the LD-250 or other equipment.
- Reduce reliability and performance.

If there is any doubt concerning the application, ask your local OMRON Support to determine whether it is an intended use.

3.3 User's Responsibilities

You are responsible for continuous safe use of the AMR.

WARNING: PERSONAL INJURY RISK
It is the end-user's responsibility to perform a task-based risk assessment and to implement appropriate safety measures at the point of use of the AMR in accordance with local regulations.

WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK
It is the end-user's responsibility to make sure that the AMR design and implementation complies with all local standards and legal requirements.

Safe use of the AMR requires that you:

- Read the installation and operation instructions, in addition to the Mobile Robot LD Safety Guide, before using the AMR.
- Make sure that the environment is suitable for safe operation of the AMR.
- Two or more AMRs require a Fleet Management appliance unless you confine and operate each AMR in a separate workspace. See: Fleet Operations Workspace Core User's Guide.
- Make sure that any person working with or near an AMR is trained, and has read the Mobile Robot LD Safety Guide for safe AMR operation.
- Mechanically maintain and service AMRs for proper operation of all control and safety functions.

3.4 General Hazards

This section describes potentially hazardous situations and conditions.

WARNING: The following situations could result in injury or damage to the equipment.

- Do not ride on the AMR.
- Do not exceed the maximum weight limit. Be aware that the maximum payload decreases as the floor's incline increases.
- Do not exceed the maximum recommended speed, acceleration, deceleration, or rotation limits. See *Center of Gravity (CG)* on page 86 (LD-250 Platform User's Guide,

Rev-B) and *Acceleration, Deceleration, and Rotation Limits* on page 74 (LD-250 Platform User's Guide, Rev-B).

- Rotational speed becomes more significant when the payload's center of gravity is increasingly offset from the AMR's center of gravity.
- At speeds of less than 225 mm/sec, the safety laser is not active. There is a risk of injury or property damage.
- Do not disconnect the drive motor encoder cables unless required to do so as part of a maintenance procedure. See *Maintenance* on page 141 (LD-250 Platform User's Guide, Rev-B).
- Do not drop the AMR, run it off a ledge, or otherwise operate it irresponsibly.
- Do not allow the AMR to drive through an opening that has an automatic gate or door unless the door and AMR are configured correctly with the Call Box or Door Box option. Refer to the *LD Platform Peripherals User's Guide* for details on the Call Box or Door Box.
- Do not expose the AMR to rain or moisture.
- Do not continue to run the AMR if hair, yarn, string, or any other items have become wound around its axles, casters, or wheels.
- Do not use unauthorized parts to repair the AMR.
- Do not power on the AMR without its wireless antennas in place.
- Although the lasers used are Class 1 (eye-safe), OMRON recommends that you not look into the laser light.
- Sunlight and reflective surfaces can affect the AMR's laser operation.
- Do not operate the AMR in a flammable gas environment.

3.4.1.1 Falling Hazards

WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK
The AMR can cause serious injury to personnel or damage to itself or other equipment if it drives off of a ledge, such as a loading dock, or down stairs.

Physical Barriers

Use physical barriers together with logical barriers (map restrictions) to prevent the AMR from approaching any fall hazard that is within its operating area. Such hazards include:

- The edge of a loading dock or ramp.
- Entrance to downward stairs.
- Any other vertical drop that exceeds the AMR's maximum step height.

Required characteristics of physical barriers are:

- **Strength**—The barrier must be attached to a solid wall or floor and should be strong enough to stop a fully-laden AMR traveling at maximum speed.
- **Continuity**—The barrier must extend around the hazard completely.

- **Visibility**—Mark all physical barriers to make sure that the AMR's safety and navigation laser can detect them easily. Barriers must extend above and below the laser's sensing plane, particularly if the floor is not flat.

Logical Barriers

In addition to physical barriers, create forbidden areas or lines on the workspace map to prevent AMRs from closely approaching a fall hazard. These restrictions must be continuous so that the AMR cannot plan a path around the logical barrier.
You can also use the configuration parameters **FrontPaddingAtSlowSpeed** and **FrontPaddingAtFastSpeed** to increase the AMR's safety clearances. This causes the AMR to decelerate as it approaches a hazard. See Fleet Operations Workspace Core User's Guide.

3.4.1.2 Electrical Hazards

WARNING: ELECTROCUTION RISK
The docking station has AC power inside. Docking station covers are not interlocked.

- Do not use power extension cords with the docking station unless properly rated.
- Never access the AMR's interior while it is attached to a charger.
- Immediately disconnect the battery after you open the battery compartment door.
- Avoid shorting the battery terminals.
- Do not use any charger not supplied by OMRON.
- If the AMR comes into contact with any liquid:
    - Power-off the AMR.
    - Clean off as much liquid as is possible.
    - Allow the AMR to air dry thoroughly before restoring power.
    - Contact your local OMRON Support if you suspect that liquid has penetrated the skins or contaminated the AMR's interior.

3.4.1.3 Magnetic Field Hazards

The docking funnel creates a strong magnetic field. This component is located on the underside of the LD-250. Persons with medical implants should not approach the docking funnel.

WARNING: MAGNETIC FIELD - MEDICAL IMPLANT RISK
Magnetic fields can be hazardous if you have a medical implant. Keep a minimum of 30 cm (12 inches) away from the LD-250 when its underside is exposed during maintenance procedures.

3.4.1.4 Qualification of Personnel

You must make sure that all personnel who work with or around AMRs have appropriate training and have a thorough working knowledge. Provide the necessary additional training for all personnel that work with the system.
As described in this guide, and the *Mobile Robot LD Safety Guide*, you should allow only skilled persons or instructed persons to do certain procedures:

- **Skilled persons** have technical knowledge or sufficient experience to enable them to avoid either electrical or mechanical dangers.
- **Instructed persons** are adequately advised or supervised by skilled persons to enable them to avoid either electrical or mechanical dangers.

For example, replacing a battery is a task for a skilled person, while an instructed person can complete the task of charging a battery. All personnel must observe industry-prescribed safety practices during the installation, operation, and testing of all electrically-powered equipment.

IMPORTANT: Before working with the AMR, every person must confirm that they:

- Have the necessary qualifications and training.
- Have received the manuals (both the robot user's manual, and the Mobile Robot LD Safety Guide).
- Have read the manuals.
- Understand the manuals.
- Will work in the manner specified by the manuals.

3.4.1.5 Payload Movement and Transfer

A typical AMR application uses a payload structure to transport objects within a facility. For example, the AMR might pick up and carry a crate of engine parts from one conveyor belt then deliver it to another conveyor belt.
During movement and transfer, you must actively monitor and confirm the transfer operation to make sure that it completes successfully. If any operation fails, a fail-safe interlock must trigger an AMR E-Stop condition. An E-Stop condition prevents the AMR from moving until you resolve the problem and confirm that it is safe to restart operations.
Your facility should provide such fail-safe interlocks between the AMR and any facility equipment with which it interfaces. After you attach your payload to the AMR, verify the correct operation of the fail-safe interlock as part of your risk assessment.

3.4.1.6 Configurable Warning Buzzer

The LD-250 has a configurable warning buzzer. Configure this buzzer as appropriate for the facility in which the AMR operates. By default, the buzzer sounds when the AMR is moving in any direction other than forward motion.

You can also configure the buzzer to activate in other specific situations, or to operate continuously whenever the AMR moves. The buzzer does not have a volume control and you should make sure it is audible in all workspace locations, particularly where ambient noise levels are high.
MobilePlanner provides the buzzer configuration parameters described below:

CAUTION: PERSONAL INJURY RISK. Changing buzzer parameter values might make the AMR unsafe and affect compliance with safety standards. Refer to the applicable safety standards for your locale before you change any parameter values.

Table 2-1 Buzzer Parameters

Parameter	Default Setting
safetyBuzzerDisable_All	0 (Disabled)
safetyBuzzerDisable_Safedrive	0 (Disabled)
safetyBuzzerDisable_FwdMotion	1 (Enabled)
safetyBuzzerDisable_AllMotion	0 (Disabled)

3.4.1.7 Fleet Management

When two or more AMRs operate in the same workspace they might not be able to accurately detect other AMRs, or to precisely determine the dimensions of other AMRs. This might result in collisions or deadlocks where both AMRs must halt and wait for human intervention.
To manage and administer multiple AMRs in the same workspace, you must use an EM2100 appliance configured as a Fleet Manager, running the Fleet Operations Workspace (FLOW) software.
Regardless of its safety laser type, an individual AMR always operates safely and within specifications. If a fleet includes different LD-series AMRs that also have different types of safety laser, all AMRs always operate safely and within specifications. However, a fleet that includes different LD-series AMRs that have the same type of safety laser will have improved fleet performance.
The Fleet Manager controls AMRs over a wireless network (WiFi), reducing the risk of AMR collisions by sharing the information between all AMRs in the fleet. The shared information includes:

- Dynamic X, Y, position and heading (velocity and direction of travel) of the AMR.
- AMR size (including payload structure).
- Path planning information (the individual AMR's intended route).

CAUTION: PERSONAL INJURY OR PROPERTY DAMAGE RISK
Improper path planning can result in personal injury or property damage.

AMRs factor this data into their obstacle avoidance algorithm.

IMPORTANT: Fleet Manager is not an interlocked method of collision prevention. It is your responsibility to implement interlocked methods of collision prevention where necessary.

For operational redundancy and fail-over you can add a second EM2100 appliance. See the *Fleet Operations Workspace Core User's Guide* for more information.

3.5 Environment

3.5.1.1 General Environmental Conditions

Make sure that the LD-250‘s operating environment remains safe for the LD-250.

WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK
An AMR can be unsafe if operated under environmental conditions other than those specified in this manual.

- **Environmental Hazards**—These are areas where it is unsafe for the LD-250 to operate. For example, steep ramps (greater than 1:12 or 4.7 degrees unloaded), docks, or shelves. Provide physical barriers that the LD-250 can detect accurately with its scanning laser so that it does not attempt to drive near the hazard. Be aware that in addition to being easily detectable, a barrier must be strong enough to resist a fully-loaded AMR traveling at full speed.
- **Restricted Areas**—You can also use map features such as preferred lines and forbidden zones to keep AMRs within their designated area of operation. See the *Fleet Operations Workspace Core User's Guide* for information about editing your workspace map.

While you can use either or both physical barriers and map features to keep AMRs within their designated workspace, OMRON recommends that you always install physical barriers where there is a risk of damage or personal safety.

3.5.1.2 Public Access

The LD-250 is designed to operate in indoor industrial environments. You must deploy it only in applications where you anticipate and mitigate potential risks to personnel and equipment.

OMRON does not intend the LD-250 for use in uncontrolled areas without risk analysis. For example, in areas open to general public access. Use of the LD-250 in such areas requires that you deploy additional safety measures not described in this guide. For assistance, contact your local OMRON Support.

3.5.1.3 Clearances when Operating

Side Clearances

The LD-250 is designed to operate in environments that contain doors, passageways, or other constrained areas that are wide enough for it to traverse.

However, you must maintain adequate *side clearance* (free space) on both sides of the AMR so that it cannot trap a person against a wall or other fixed object. Consult the applicable Autonomous Vehicle and Robotics operating standards for your locale.

An AMR must often maneuver close to machinery, conveyors, or other fixed objects. In such cases, operating standards usually allow an exception to side clearance requirements.

For more information, see: *Side Clearance* on page 114 (LD-250 Platform User's Guide, Rev-B), and refer to the *Fleet Operations Workspace Core User's Guide* for information about software parameters that you can use to control the LD-250's front and side clearance zones.

Clearances During Rotation

The LD-250 generally travels in a forward direction and cannot do path planning in the reverse direction. It reverses only if you create a MobilePlanner macro task that requires it to move in reverse. Otherwise, the LD-250 only reverses onto its docking station to recharge. To change direction, the LD-250 rotates on its center of rotation (turns in place). However, when the LD-250 rotates, obstacles in its path do not trigger a safety system event.

The LD-250's Light Discs display a distinct turn signal pattern when it rotates. For more information, refer to *Indications Provided by Light Discs Light Outputs* on page 127 (LD-250 Platform User's Guide, Rev-B).

CAUTION: PERSONAL INJURY RISK
Personnel who work with or around the AMR should not stand close to the AMR when it is rotating with no forward motion.

Docking Clearances

You should set a 1.5 m distance between docking goals and physical docks to allow sufficient room to maneuver around other AMRs when docking.

3.5.1.4 Obstacles

Before an AMR enters a high-traffic area, you must take appropriate precautions to alert people working in those areas:

- The LD-250 provides active warning features such as a warning buzzer, speech synthesis, and warning indicator lights.
- The LD-250 Core provides user ports that enable you to add warning indicators to your payload structure. Refer to: *Indications Provided by Light Discs Light Outputs* on page 127 (LD-250 Platform User's Guide, Rev-B).

If high-traffic areas include other moving vehicles such as fork-lift trucks or autonomous moving machines, consider adjusting the AMR's operating parameters to reduce the risk of a collision. You can do this by:

- Editing the workspace map to include map features that restrict the AMR's **local** operation such as restricted entry zones, slow speed zones, or preferred lines.
- Editing the AMR's operating parameters to restrict its **global** operation, such as reducing its maximum speed or minimum approach distance.

For more information, refer to: *Fleet Operations Workspace Core User's Guide*.

3.6 Battery Safety

The LD-250 requires one lithium ion battery. Use only the battery of the correct model number supplied by OMRON. The FLOW software determines whether the battery is the correct type for the LD-250.
Effective April 1, 2016, IATA regulations (UN 3480, PI 965) require that air-shipped lithium ion batteries must be transported at a state of charge not exceeding 30%. Fully charge the battery immediately upon receipt to avoid total discharge. (The battery might arrive fully charged if it is not shipped by air.)

CAUTION: BATTERY DAMAGE RISK
Fully charge the battery immediately after delivery. Failing to do so might cause the battery to discharge below a usable state, requiring its replacement.

3.6.1.1 Battery Safety Precautions

- Store batteries upright and within the following temperature range:
- One month: +5 to 45°C
- One year: 20 to 25°C
- Batteries stored at temperatures greater than 54°C or less than -6°C must stabilize for an hour or longer until within the nominal operating temperature before use.
- Never expose the battery to water. If the battery is leaking, submerge it in mineral oil and contact your local OMRON Support.
- In case of fire, use a type ABC or BC extinguisher: foam, dry chemical, or CO2.

3.6.1.2 Battery Maintenance

Every six months:

- Inspect the battery for damage or leaks.
- Connect the battery to a charger and allow it to fully balance all cells.

3.7 LD-250 Modifications

OMRON recognizes that customers or integrators make modifications to the LD-250 to adapt it to a specific application. When doing so, make sure that:

- You use the LD-250 Core's User Interface connection to include appropriate safety devices into the LD-250's integrated safety systems.
- The modification causes no hazardous sharp edges, corners, or protrusions and does not extend further than the LD-250 footprint. (This might affect the safety zones.)
    - If the payload extends beyond the footprint of the robot, you will need to adjust the configured size of the robot in the Robot Configuration, the Robot Physical, General section.
    - Additionally, you will need to augment the safety zones of the OS32C laser using the OS32C-EX configuration software and a direct connection to the laser from a PC.
- There is no reduction in functionality.
- All safety features (such as lasers and brakes) are functional and operate within the specifications determined by local standards for AMRs.

3.8 Additional Safety Information

Contact your local OMRON Support for other sources of safety information.

3.8.1.1 Mobile Robot LD Safety Guide

The *Mobile Robot LD Safety Guide* is included with your LD-250 and provides detailed information about safe operation of your LD-250. It also provides resources for information about relevant standards.

3.9 Disposal

Dispose of in accordance with applicable regulations.

Customers can contribute to resource conservation and protecting the environment by the proper disposal of WEEE (Waste Electronics and Electrical Equipment). All electrical and electronic products should be disposed of separately from the municipal waste system via designated collection facilities. For information about disposal of your old equipment, contact your local OMRON Support.

3.10 Risk Assessment

Safety standards in many countries require that appropriate safety equipment to be installed as part of the system. Safeguards must comply with all applicable local and national standards for the location where the AMR is installed.
We have performed a Risk Assessment for OMRON AMRs, based on the intended applications of the AMR. The conclusions are summarized in this section.

3.10.1.1 Exposure

Based on the risk assessment performed by OMRON, the hazards associated with exposure to the AMR are minimal. However, these significantly rely on the awareness and training of the personnel around the AMR. Along with common sense, the following should be observed and practiced in order to avoid the minimal risks associated with exposure to the AMR.

- Do not ride on the AMR. Riding on the AMR or staying in the vicinity of the AMR for long periods (when ON or while charging) will expose you to the magnetic fields generated by the AMR.
- When the AMR is turning in place, while not moving forward, personnel must stay away from the AMR.

3.10.1.2 Severity of Injury

The severity of injury depends on the type of payload and how the payload is integrated with the AMR. The severity of injury increases with the mass of the payload. Follow all industrial safety practices, such as use of steel-toe shoes around the AMR, and adding additional protection like side lasers, etc. depending on how the AMR is configured, to reduce any work-related injuries.

3.10.1.3 Obstacle Avoidance

The AMR will avoid obstacles unless modified or the safety systems are intentionally defeated. The AMR has a dual-channel, safety-rated laser to avoid obstacles.

IMPORTANT: The AMR observes safety navigation laser protection fields only at speeds greater than 225 mm/s for LD-250. Below this speed, the AMR still uses scanner data to detect and avoid obstacles.
IMPORTANT: When the pendant is connected to the AMR, the operator must maintain control of the pendant and AMR at all times.

In addition, there are side lasers (standard on the LD Platform Cart Transporter and optional for the LD Platform OEM), bumpers and SONAR on the LD Platform OEM, and rear sensors on the LD-250 that enable the AMR to avoid obstacles and persons.

The LD-250, LD Platform OEM and LD Platform Cart Transporter are fully-autonomous AMRs that, once configured, work around people in industrial settings with no intervention needed.
Risks associated with integrating the AMR in the industry can be avoided, with a few basic steps.

- Only trained personnel, who understand what the AMR does, should be in the vicinity of the AMR.
- Audio and visual alarms are built into the AMR. Do not modify these unless necessary.
- Additional safety measures may be implemented as deemed necessary by the integrator after risk assessment is completed.

3.10.1.4 Safety System Behavior

The standard control system is fully-hardened to all EMI influences. In addition, software monitors and controls all dual redundancy safety-rated features for certainty.

3.11 EHSRs fulfilled

The LD-250 mobile robot as partly-completed machinery, fulfils the following essential requirements of the EC Machinery Directive 2006/42/EC:

EHSRs fulfilled from ANNEX I, Machinery Directive 2006/42/EC

EHSR, Annex I	Title
1.1.1	General Remarks - Definitions
1.1.2	Principles of safety integration
1.1.3	Materials and products

EHSR, Annex I	Title
1.1.5	Design of machinery to facilitate its handling
1.2	Control Systems
1.3.2	Risk of break-up during operation
1.3.4	Risks due to surfaces, edges or angles
1.5.1	Risks due to other hazards - Electricity supply
1.5.2	Risks due to other hazards - Static electricity
1.5.4	Risks due to other hazards - Errors of fitting
1.5.5	Risks due to other hazards - Extreme temperatures
1.5.10	Risks due to other hazards - Radiation
1.5.11	Risks due to other hazards - External radiation
1.5.12	Risks due to other hazards - Laser radiation
1.6.1	Machinery maintenance

3.12 PL and PFH

The Performance Level (PL) calculation for safety functions of the OMRON mobile robot products are based on the ISO 13849 standard. PL evaluation has been performed for the LD models, including the supplied pendant.
The PL achieved and the Probability of Dangerous Failure per Hour (PFH) are calculated using SISTEMA as per ISO 13849-1, based on requirements of EN 1525 and UL 3100, for the following Safety Functions:

No.	LD-250 Function	PL Achieved	PFH [1/h]
1	ESTOP Logic - Speed Control. Forward and reverse control.	e	3.9E-8
2	Charge Contact Shutoff Circuit	c	1.1E-6
3	ESTOP Logic - Emergency Stop (E-Stop buttons	e	2.9E-8
4	ESTOP Logic - User Emergency Stop (ESTOP)*	e	3.6E-8
	*The ESTOP pins on the User Interface connector are provided for use with a user-supplied external E-Stop. The user is responsible for calculating the overall PL and PFH, inclusive of user-supplied components, and performing a final risk assessment.		
5	LIDAR Velocity-Based Field Zone (Object Detection)	d	1.2E-7
6	ESTOP Logic - Manual (Joystick) Override	e	5.8E-8

3.13 E-Stop Operational Considerations

Engaging the E-Stop through the external connector (or Operator Panel) faster than 250 ms causes the drive motors to re-engage when you release the E-Stop. Motor re-engagement occurs because the LD-250 Core is designed to receive a consistent E-Stop signal for at least 250 ms. Signals that engage and disengage in under 250 ms cause the LD-250 Core to interpret the signal as a bumper press, which automatically re-engages the motors.

No signal on the E-Stop chain can cause the robot to operate while the E-Stop remains engaged. Thus, you must keep the E-Stop engaged, if your intent is to keep the AMR in an E-Stop state.

WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK
If you are using a user-supplied E-Stop, you must run the Safety

Commissioning to verify that the E-Stop functions properly before returning an AMR to service.

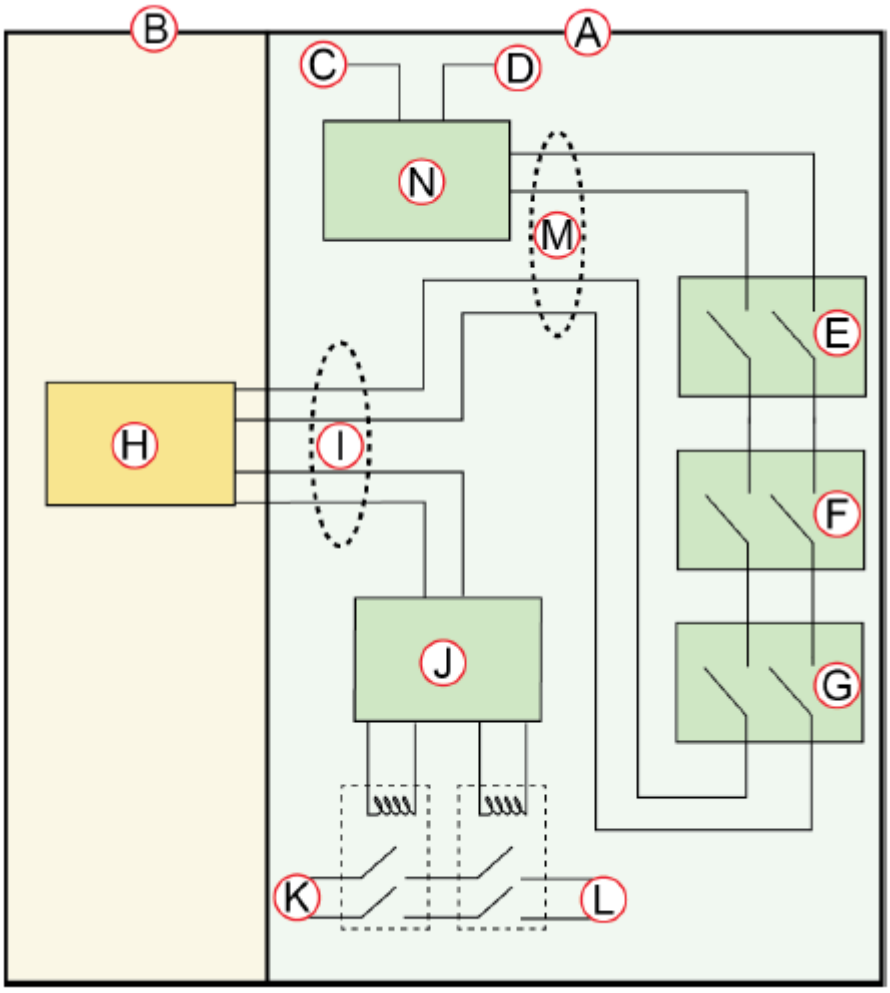


Figure 2: Estop Circuit

Callout	Description	Callout	Description
A	Standard Circuits	H	User E-STOP[a]
B	User-Supplied Circuits	I	User Interface Connector
C	E-STOP Source	J	E-STOP Relay Control Logic
D	Ground	K	Voltage of the Battery
E	Operator Panel E-STOP	L	High Power to Amplifiers
F	Right E-STOP (LD-250 only)	M	HMI Connector
G	Left E-STOP (LD-250 only)	N	Factory E-STOP
[a] Close with a jumper if unused. Both channels must open independently when used.			

Function #	LD -250 Safety Function	PL	Cat	PFHd
SF0	ESTOP Logic - Emergency Stop	e	3	2.9E-8
SF1	LIDAR Velocity-Based Field Zone (Object Detection)	d	3	1.2E-7
SF2	ESTOP Logic - User ESTOP	e	3	3.6E-8
SF3	ESTOP Logic - Speed control. Forward and reverse control.	e	3	3.9E-8
SF4	ESTOP Logic - Manual (Joystick) Override	e	3	5.8E-8

4 Sensors

4.1 Lasers

The LD-250 uses an on-board laser for navigation and safety. A second low front laser detects obstacles that are too close to the ground for the main laser to detect. An optional rear-facing laser is also available.

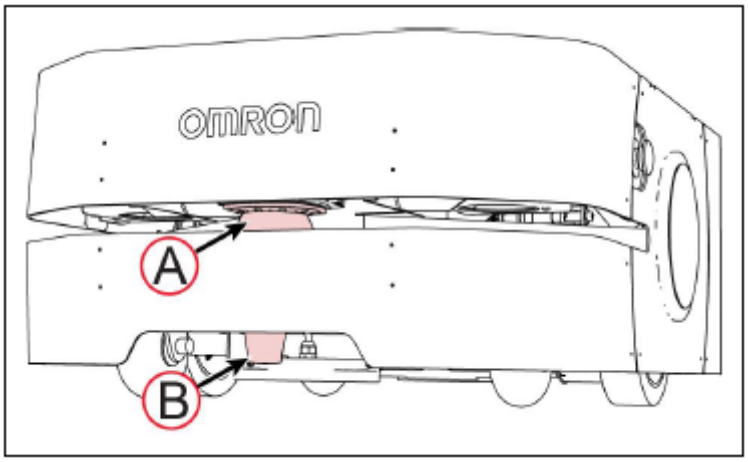


Figure 3:LD-250 lasers

Callout	Laser
A	Safety and navigation (primary) laser.
B	Low (toe) laser.

4.1.1 Safety Scanning Laser

The LD-250 Safety Scanning Laser [Figure3(A)] is an OMRON OS32C model. It is a precise scanning and navigation sensor with the following characteristics:

- Single horizontal plane, parallel to the floor at a height of 190 mm.
- 601 beam readings in a 240° field of view (0.4 degrees per beam).
- Maximum safety protection range of 3 m.
- Typical distance for range readings of 15 m.

4.1.2 Constraints on Laser Operation

The laser cannot reliably detect glass, mirrors, and other highly-reflective objects. Use caution when operating the LD-250 in areas that contain such objects. If the LD-250 must operate close to reflective objects, OMRON recommends that you use a combination of markings on the objects, such as highly visible tape or painted stripes. In addition, specify

forbidden sectors in the workspace map so that the LD-250 can plan paths to avoid these objects.

4.1.3 Low Front Laser

The low front laser [Figure3(B)] detects obstacles below the scanning plane of the safety laser, such as an empty pallet or a human foot. This laser also detects obstacles that might be significantly wider at the base, such as a column base, where the main safety laser might detect only the upper portion of the column.

4.2 Rear Sensor

The LD-250 includes a rear-facing sensor that detects obstacles that are close to the rear, such as person stepping behind the LD-250. The sensor also detects obstacles that the AMR might encounter when reversing or rotating.

The LD-250's rear sensor consists of an array of individual time-of-flight sensors in three segments (right, left and center) as shown below.

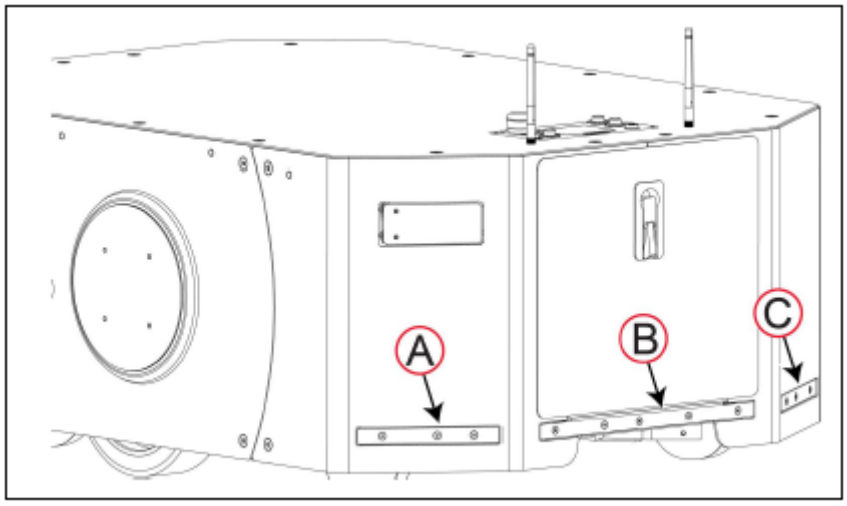


Figure 4: Rear Sensor: Left (A), Center (B), and Right (C) segments

These sensors are not safety-rated. If the sensor detects an obstacle, the AMR stops, waits two seconds and then resumes operation under the following conditions:

- The object that the AMR originally detected is no longer detected by the rear sensor or by supplemental lasers.
- No other obstacles are detected by the AMR's main laser and it can maneuver safely.

For information about cleaning the rear sensor, see: *Cleaning the Rear Sensor* on page 157 (LD-250 Platform User's Guide, Rev-B).

4.2.1 Rear Sensor Operational Considerations

The figure below is a top-down view of the LD-250 showing the approximate locations of the sensor fields (not to scale). As the figure below shows, there are sensor blind spots to the left and right of the AMR.

WARNING: PERSONAL INJURY RISK
To prevent the risk of a person approaching too close to a moving AMR, follow the operational guidelines in this section.

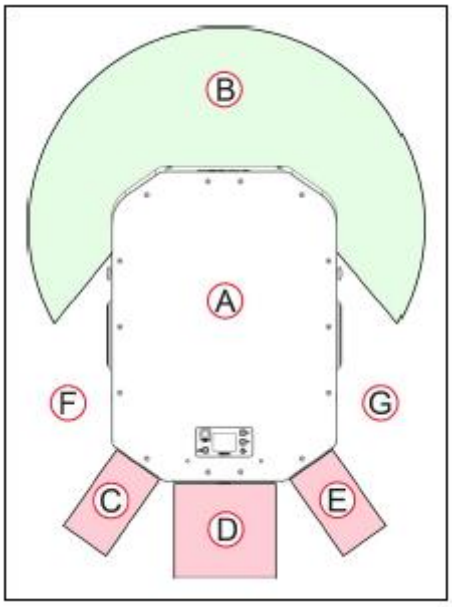


Figure 5: Sensor fields of view (approximate)

Callout	Description	Callout	Description
A	LD-250 top view	E	Right rear sensor
B	Safety and navigation laser 240-degree field of view.	F	Left potential blind spot
C	Left rear sensor	G	Right potential blind spot
D	Center rear sensor		

It is unlikely that an AMR can drive into a person because of these sensor blind spots, and when path planning, the AMR never drives autonomously in a reverse direction. However, under certain circumstances, the AMR can be commanded to move in a reverse direction and it is possible that a person or object might move into the sensor blind spot without being detected by the AMR.

The AMR is operating at a low speed (225 mm/sec) during such maneuver, but an AMR with its payload has considerable mass, and might tip a person over. If your AMRs operate in the same workspace as people, provide information and training for people so that they:

- Have complete understanding of the potential directions of movement that an AMR might take, such as rotating in place and reversing.
- Know not to stand in or move toward the immediate vicinity of a working AMR.
- Understand the significance of the warning buzzer.
- Do not leave or place obstacles where the AMR might not detect the obstacle.

To mitigate the possibility of an accident, adhere to the recommendations in the following sections.

4.2.2 Warning Buzzer When Reversing or Rotating

Make sure that the warning buzzer is configured to operate at least when the AMR is docking or moving in a commanded reverse direction. (The AMR will not reverse autonomously.)

4.2.3 Docking to Recharge

When docking, the AMR reverses onto the docking station. Its rear sensors are inactive during this maneuver.

Clearly mark the floor area around docking stations as No Step areas. For example, use yellow stripes on the floor to delineate the area. Inform and train any persons operating the AMR to avoid walking into these areas when an AMR is approaching to dock.

4.2.4 Using Move or GotoStraight in MobilePlanner

A **Move** task is a commanded operation that can cause the AMR to reverse if you specify a negative value. While the AMR is reversing, the rear sensor is operational. You might need to adjust the value of the **FrontClearance** parameter to add a margin of safety.

The default clearance is 200 mm. You can reduce this value if you want to approach an object more closely. However, when moving in a reverse direction lower values of FrontClearance will increase the risk of colliding with a person or object that might move into the AMR's path.

Similarly, the **GotoStraight** command might cause the AMR to reverse to a specified goal if the goal is behind the AMR's heading. During **GotoStraight** travel, the rear sensor is active and you should consider adjusting the value of the **FrontClearance** parameter.

The **GoToStraight** parameter provides a **FailSeconds** attribute that enables you to make the AMR wait X seconds for the obstacle to move. If the obstacle is no longer detected within the elapsed time, the AMR either proceeds or fails depending on the value of other **GoToStraight** attributes.

4.2.5 Manual Driving

WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK
When driving the AMR either with the joystick or remotely from a computer it is your responsibility to make sure that no people or objects are in the immediate vicinity of the moving AMR. You must be able to see the AMR and its operating environment at all times.

You can drive the AMR manually with an attached pendant or remotely through MobilePlanner (teleoperation). The following considerations apply:

- **Pendant Driving** - During manual driving by pendant (see *Driving by Pendant* on page 139 (LD-250 Platform User's Guide, Rev-B)) the rear sensor does not operate. Take care when driving the AMR in reverse. The safety scanning laser's protective fields are still equivalently active during manual driving with the pendant. Note that the forward facing laser scanner is still active in software, but it will not make use of a hardware safety field when the robot is travelling in reverse. For this reason, the robot is not permitted to travel in reverse at speeds greater than 225 mm/s.
- **Driving Remotely** - If you use MobilePlanner to drive the AMR remotely (either with the on-screen virtual pendant or through the computer keyboard) the rear sensor operates normally.

IMPORTANT: When driving through the computer keyboard, if you press and hold the reverse key the AMR will persistently attempt to move in reverse. This might cause it to reverse into a person or obstacle. Using the keyboard or MobilePlanner interface to drive a robot is not advisable unless you are at the robot system and aware of its surroundings.

4.2.6 Payload Overhangs

If your payload overhangs the LD-250's default footprint, there are several adjustments you must make to AMR operating parameters to stay within safe operation limits. (See: *Payload Dimensions and Design* on page 80 (LD-250 Platform User's Guide, Rev-B).) In particular, see: *Overhanging Payloads and the AMR Swing Radius* on page 194 (LD-250 Platform User's Guide, Rev-B).

4.3 Other Sensors

4.3.1 Encoders and Gyroscope

Each motor has two redundant wheel encoders that enable an accurate estimation of the AMR's speed. Wheel encoders also provide the LD-250's navigation system with odometry information (how far each wheel has traveled, and in which direction.) In addition, the LD-250 Core contains an internal gyroscope to track the LD-250's rotational velocity.

4.3.2 Rear Sensor

An infrared time-of-flight (ToF) sensor array is mounted at the rear of the LD-250 for remote sensing obstacles when traveling in reverse or when obstacles move close behind the LD-250.

A User Bumper connector enables you to add your own payload structure bumpers. The LD-250 Core's rear upper panel (in the payload bay) provides connections for front left, center, and right sensors, and rear right, center, and left sensors. See: *User Bumper* on page 105 (LD-250 Platform User's Guide, Rev-B).

IMPORTANT: The User Bumpers connector is not safety-rated. These user bumpers will act to stop the robot, but they are not redundant signals and should not be relied on as part of a PL=d rated safety system. These bumpers should be considered for protection of your machinery.

5 Payload Structures

A payload structure is any mechanical equipment that you attach to the LD-250 for the purpose of performing a task. It might be as simple as shelves to receive bins of parts or as complex as a robot arm. In some cases, OMRON designs and constructs a custom payload structure for a specific application. In most cases the OMRON customer or an integrator designs and implements their own payload structure.

The LD-250 provides the mobility and navigation for the payload structure together with the electrical power and data signal connections required to operate a payload structure. This chapter describes considerations and requirements when designing payload structures for the LD-250.

5.1 Safety

5.1.1 Warning Label

A No Riding label ships, unattached, with each LD-250. You must place this in a prominent location on the payload, so operators will see it. Other warning labels are applied at the factory.

5.1.2 Warning Lights

Your AMR should include warning lights appropriate for its application.

CAUTION: To comply with CE requirements, an AMR must have a readily-visible warning device, such as a flashing light (user-supplied) to indicate when it is either ready to move or is moving.

The LD-250 provides the following:

- Colored light discs on each side that provide visual cues about the AMR's status and its pending movement. See: *Light Discs* on page 109 (LD-250 Platform User's Guide, Rev-B).

- Provision for an auxiliary warning light on the LD-250 Core (the Light Pole connector, described in *LD-250 Core Rear Upper Connectors* on page 100 (LD-250 Platform User's Guide, Rev-B). You can use this connector to mount a warning light in a more prominent location, which might be appropriate for AMRs that have taller payloads.

5.1.3 Warning Buzzer

The LD-250 Core provides an output for controlling a warning buzzer as an auditory warning device. The default behavior of the buzzer is to sound when the AMR is moving in reverse, or when its safety systems are off.

You can configure the buzzer's operation. For example, you can set it to make a warning noise whenever the AMR is moving.

5.2 Considerations

5.2.1 Performance

Performance factors to consider when designing a payload structure are:

- Size, weight, and center of gravity of the payload structure.
- Power requirements for any electrical devices on the payload.
- Serviceability and maintenance requirements.

Adding weight to the LD-250 tends to have less effect on battery run time than does increasing electrical power consumption.

Operating your AMR over soft surfaces (such as carpet) significantly shortens battery runtime than compared to hard surfaces.

5.2.2 Weight Constraints

The total operating weight of the AMR should comply with its specifications for payload and any objects carried.

DANGER: PERSONAL INJURY OR PROPERTY DAMAGE RISK
The end-user of the AMR must perform a risk assessment to identify and mitigate any additional personal and property damage hazards caused by the payload.

When designing and implementing your payload, consider the following items. You may need to adjust your emergency deceleration values in order to prevent tipping. Note that lowering emergency deceleration values will affect the AMR's stopping distance, which may require that the safety scanning laser's protection fields are increased in size to account for this additional distance.

- If you operate the LD-250 on the recommended hard, flat surface, additional payload mass has a minimal effect on battery duration and operating time between recharges.
- If the payload is tall and also has substantial weight, consider its effect on the AMR's center of gravity.
- If the AMR transports containers of liquids, consider the effect of the fluid motion on the AMR's stability.
- If the payload overhangs or extends outward dynamically from the AMR (such as a robot arm), it has a greater effect on the center of gravity. This is particularly important if the payload is also conveying objects that add additional mass.
- The AMR might become unstable at lower speeds compared to the platform alone.

NOTE: The total weight of your payload structure plus any objects carried by the payload must not exceed the rated capacity of your LD-250. See: *Technical Specifications* on page 191 (LD-250 Platform User's Guide, Rev-B).

5.2.3 Power Consumption

Any electrical devices on your payload structure that consume significant power will noticeably shorten the AMR's run time.

Minimize power consumption whenever possible. The battery is rated at 1840 W*hr (1.84 kWh). Examples of power-consuming payload structures are robot arms attached, or a motorized conveyor.

5.2.4 Power Limits

The tables in the following sections describe the available power circuits and power output

- *Aux Power* on page 105 (LD-250 Platform User's Guide, Rev-B)
- *User Power* on page 105 (LD-250 Platform User's Guide, Rev-B)
- *Power Connections* on page 101 (LD-250 Platform User's Guide, Rev-B)

OMRON recommends that you use external current limiting devices to prevent transient current overload. The limits are:

- For the 5 VDC, 12 VDC and 20 VDC connections max inrush peak current is 2 A.
- For Battery_Out_1 and Battery_Out_2 max inrush peak current is 10 A.
- For Battery_Out_3_and_4 max inrush peak current is 20 A.

Momentary current spikes over these thresholds will activate current limiting protection causing power loss at the connector. Simultaneous inrush loads might trip the overcurrent protection at the battery. The maximum permitted duration of an overcurrent level is as follows:

Overcurrent Level	Overload Duration
40 A	8 sec
64 A	250 ms
96 A	250 us

5.2.5 Payload Bay Access

The area between the LD-250 and your payload structure is the payload bay. This is where you access the LD-250 Core's power and I/O connectors, in addition to any mechanical fasteners that secure your payload to the LD-250.

Considerations when designing your payload structure are:

- Provide access to the payload bay for serviceability.
- If the payload structure is small and light enough, you might be able lift it off the LD-250 or loosen it and slide it along the load bars to access the payload bay
- Always take care to not damage any cabling between your payload structure and the LD-250. Provide adequate slack in all cables, or include connectors
- Label all cables for accurate reconnection.
- Larger, heavier payload structure might require a hinge, so you can tilt the payload structure out of the way while you access the payload bay.

5.2.6 Payload Dimensions and Design

5.2.6.1 Avoid Projections and Overhangs

Your payload structure should not overhang or project beyond the outer dimensions of the payload bay. Doing so might place parts of the structure outside the safety envelope provided by the safety laser.

If you do design an overhanging payload, be aware that you might also need to:

- Change the size of the main laser's safety zones. See:
  - Lasers on page 133 (LD-250 Platform User's Guide, Rev-B).
  - Modify the Safety Zones on page 197 (LD-250 Platform User's Guide, Rev-B).
- Repeat the safety commissioning. See: E-Stop Commissioning on page 177 (LD-250 Platform User's Guide, Rev-B).
- Modify the Robot Physical: General parameters to change the AMR's width, **LengthFront**, **LengthRear**, and potentially its Radius

These modifications make sure that the AMR's accurate dimensions are used during path planning and obstacle avoidance.

- Modify the value of the **AbsoluteMaxRotVel** parameter so that no part of the AMR exceeds a speed of 300 mm/sec during rotation. See: Overhanging Payloads and the AMR Swing Radius on page 194 (LD-250 Platform User's Guide, Rev-B).

Side lasers are useful only if the overhang might cause the AMR to encounter obstacles that are not visible to the main scanning laser, or its low front laser.

5.2.6.2 Do Not Block AMR Sensors

The payload, and anything it carries, must not extend below the height of the payload bay. If the payload blocks any of the LD-250's sensors, it cannot function correctly.

If you install optional rear or side-mount lasers, make sure that the payload structure does not interfere with the laser's beams. Mount side (tilted) on each side of the payload structure in such a way that they do not detect the structure itself. See: Side Lasers (Supplemental) Lasers on page 189 (LD-250 Platform User's Guide, Rev-B).

If it is not possible to prevent some interference between the structure and the side laser's sensing plane, you might be able to use the **LaserIgnore** parameter to constrain sensing to zones that do not include the payload structure. However, this might compromise the detection ability of that sensor, and you should avoid using **LaserIgnore** if at all possible.

Consider using a protective guard over side lasers to protect them from damage. Make sure that guards do not block the laser beam or extend outward too far.

5.2.7 Mounting Locations in the Payload Bay

The payload bay is located under the LD-250's top skin. It provides access to the LD-250 Core for power and data connections, and attachment points for your payload structure.

5.2.7.1 Payload Mount Points - T-Slotted Extrusions

The top plate in the payload bay contains longitudinal and transverse load-bearing extrusions that provide adaptable mount points. Additional clip nuts are provided around the edge of the plate. The figure below shows the location of mount points and the center lines. For the location of the center of gravity, refer to: *Dimension Drawings* on page 191 (LD-250 Platform User's Guide, Rev-B).

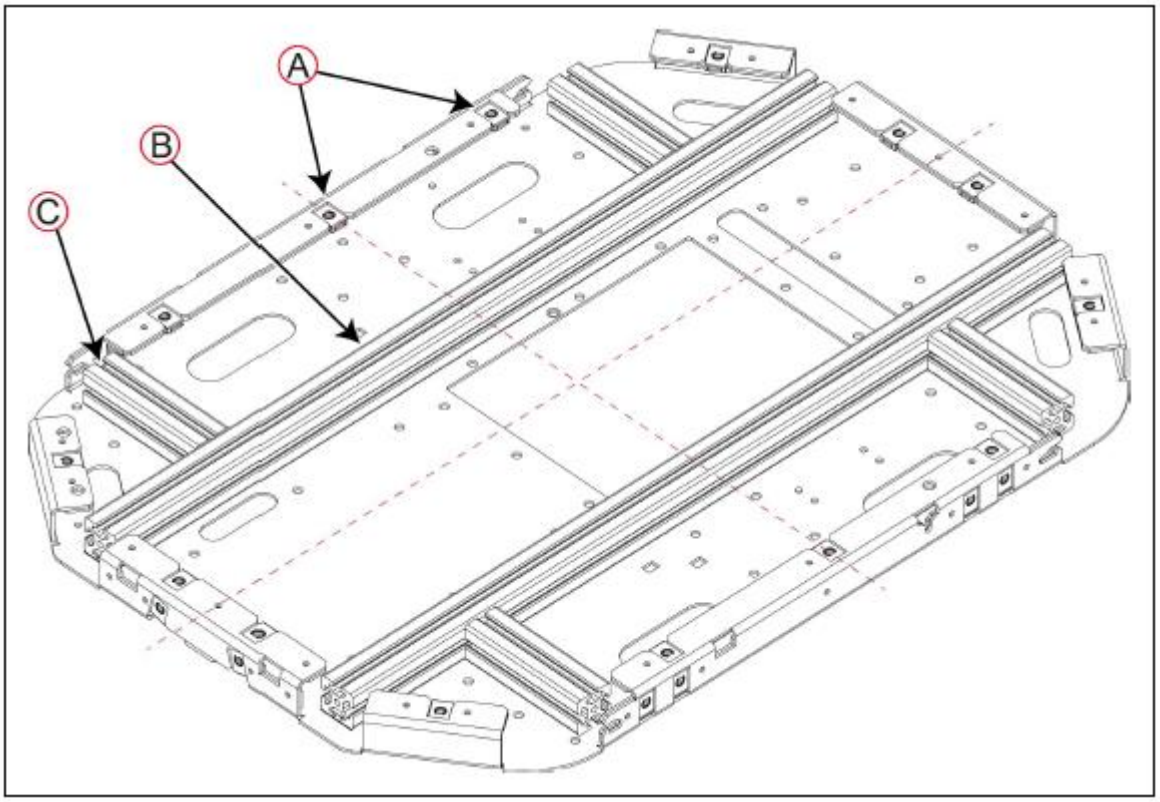


Figure 6: Payload Mount Locations

Callout	Description
A	Location of the clip nuts
B	Longitudinal T-nut extrusion
C	Transverse T-nut extrusion

The extrusion's cross section is a 40 mm x 40 mm square T-slot profile with three open T-slots, one on each 40 mm face.

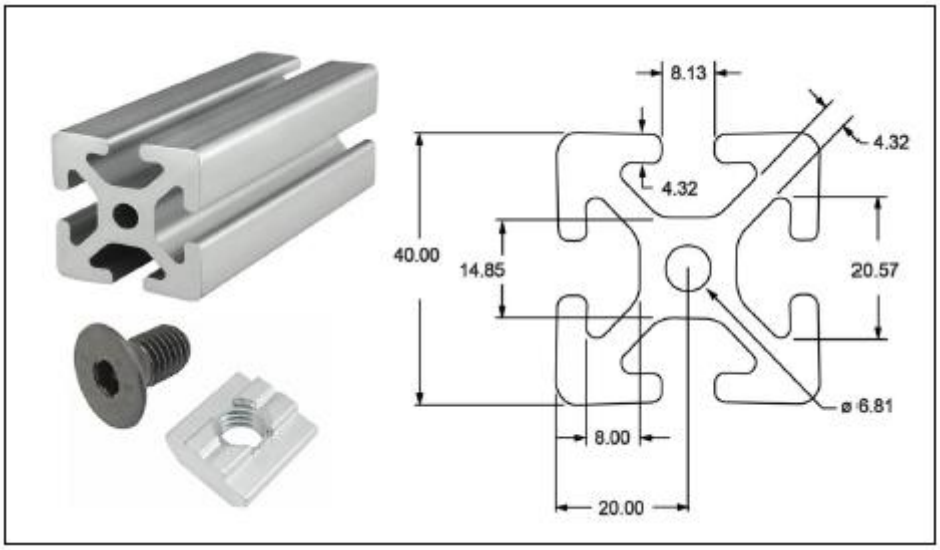


Figure 7: Payload mount extrusion, dimensions in mm and T-Nut

These extrusions bear the main structural load of any payload, transferring stresses directly to the LD-250's formed steel chassis. You can easily adjust and move your payload in relationship to the LD-250's center of gravity (see: *Center of Gravity (CG)* on page 86 (LD-250 Platform User's Guide, Rev-B)).

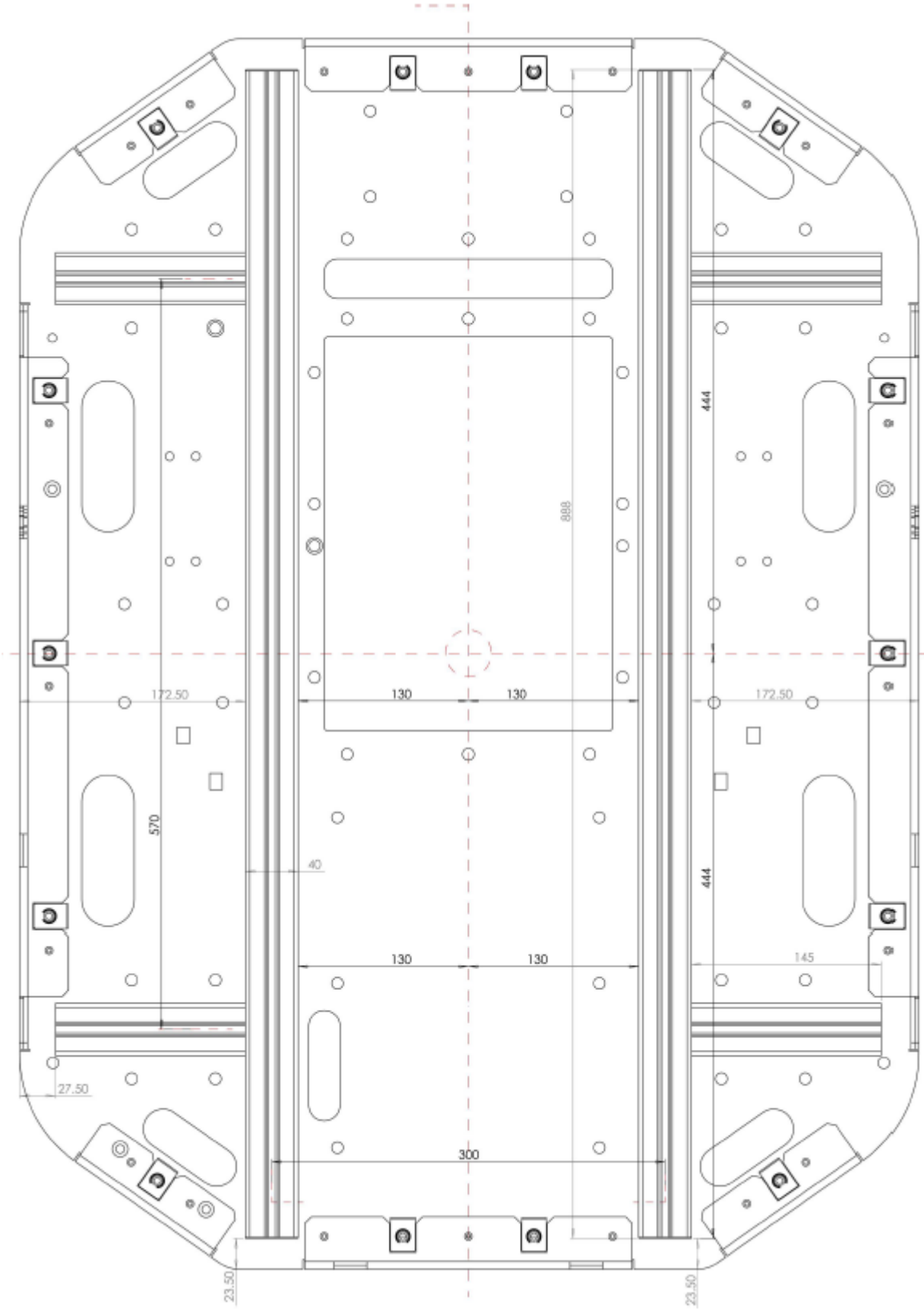


Figure 8: T-Nut extrusion location on the top plate

Use T-nuts appropriate for the mass of your payload. To maintain access to the payload bay, consider incorporating hinged attachment points on one side of your payload structure so that you can tilt it away from the bay.

5.2.7.2 Secondary Mount Points - Top Plate Clip Nuts

Clip nuts (14) around the rim of the top plate can accept smaller loads such as payload skins or covers. These locking-thread M6 clip nuts provide attachment points for the standard top skin option provided for the LD-250.

IMPORTANT: Do not use the clip nuts to support the payload itself, make all load-bearing attachments only to the T-slot aluminum extrusions.

The figure below shows the approximate positions of the clip nuts relative to the edge of the top plate and its center lines. You can obtain the CAD and engineering drawing sources from the OMRON web site if you need to determine the precise locations.

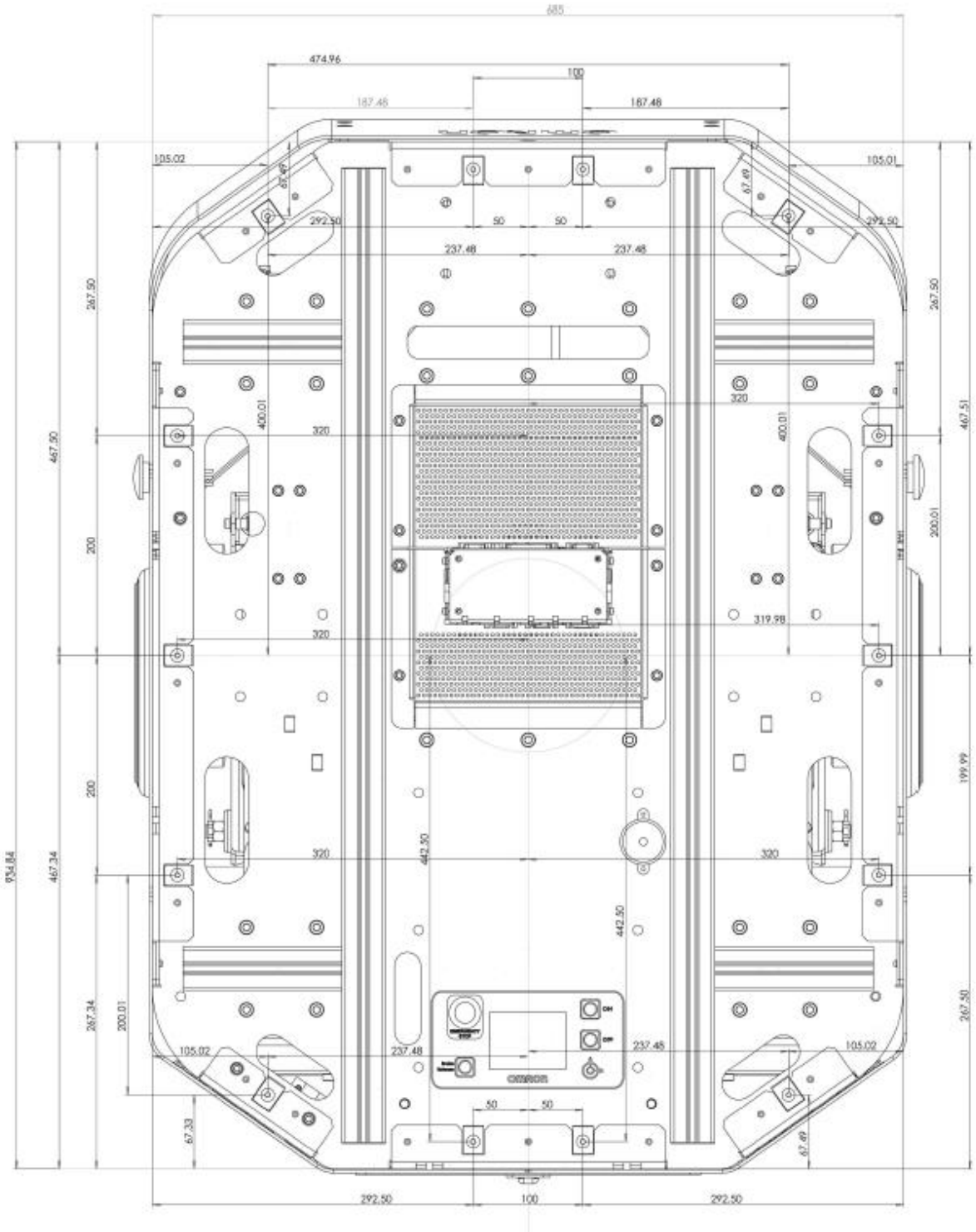


Figure 9: Position of the Clip Nuts around the payload bay

5.2.8 AMR Coordinate System

OMRON AMRs use the X, Y, Z and Theta (θ) coordinate system. This information is relevant for some of the procedures used in this manual, such as identifying which are the left or

right skins. For example, the pendant port is located in the rear left skin. The origin of the coordinate system is the AMR's center of rotation, not its geometric center.

Coordinates are required for procedures such as installing and configuring options such as lasers and the Acuity camera, and for understanding the center of gravity envelope. The AMR's coordinates also relate to the map coordinates.

The rotation value Theta (θ) specifies the AMR's angle of rotation, which determines its heading, or direction of travel.

The vertical coordinate (Z) is required when you calculate the mount position of options (such as side lasers). You then specify the position of the option in MobilePlanner.

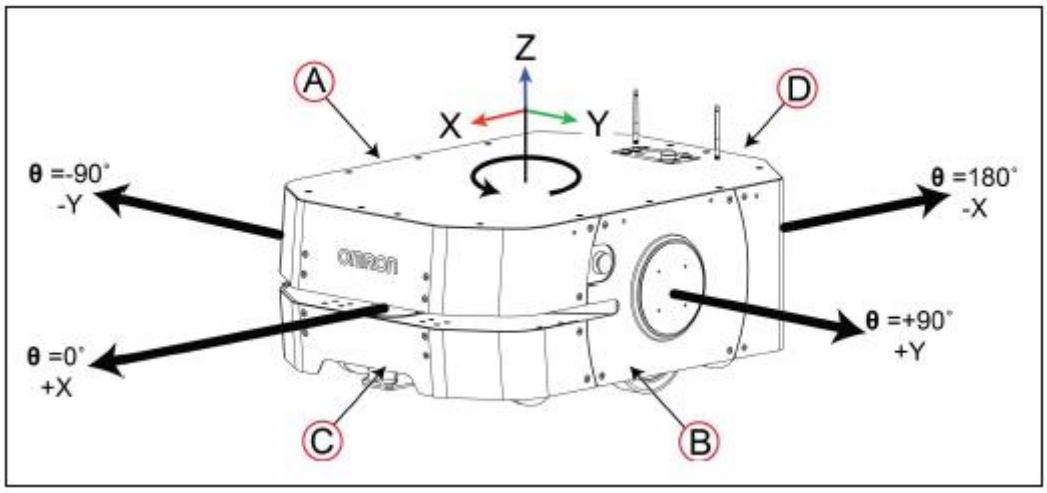


Figure 10: AMR coordinate system

Callout	AMR Reference	Theta θ (Rotation)	X, Y Coordinate
A	Right side	-90 degrees	Negative Y
B	Left side	+90 degrees	Positive Y
C	Front	0 degrees	Positive X
D	Rear	180 degrees	Negative X

See: *Dimension Drawings* on page 191 (LD-250 Platform User's Guide, Rev-B) for the location of the AMR's center of rotation.

5.2.9 Center of Gravity (CG)

Keep your payload structure's center of gravity (CG) centered over the LD-250's own center of gravity and as low (close to the LD-250's top) as possible. This provides optimum stability, particularly when the LD-250 crosses raised thresholds or irregularities in the floor.

See: *Dimension Drawings* on page 191 (LD-250 Platform User's Guide, Rev-B) for information that will help you design and locate the payload, in particular:

- **Center of Rotation**—The mid-point of a line between the center of the wheel hubs, about which the LD-250 will rotate.
- **Geometric Center**—The center of two lines bisecting the LD-250's outline.
- **Center of Gravity**—The unloaded LD-250's center of gravity.
- **X and Y Axis Mid-lines**—Lines that cross in the geometric center of the LD-250.
- **AMR Coordinate System**—The X,Y,Z, and Theta reference system relating the AMR to its environment, and to the relative position of other devices such as the optional side lasers. See: *AMR Coordinate System* on page 86 (LD-250 Platform User's Guide, Rev-B).

5.2.9.1 Tilt Detection and Reporting

If the AMR tilts more than 60 degrees in any direction, an E-Stop event occurs. This is not intended to prevent the AMR from tipping over. However, it can notify you if the AMR runs off a ramp or tilts over for any reason. See: *Releasing an E-Stop* on page 31 (LD-250 Platform User's Guide, Rev-B).

5.2.9.2 Safe Payload Placement

The graphics in this section show the calculated safe CG dimension and placement for payload structures (that must also comply with the specified weight limit). The payload structure's CG, in each instance, must be within the defined area.

Assumptions in these calculations are:

- The payload is securely attached to the AMR and does not overhang.
- The suspension is set at the factory default (2nd hole). If you adjust the suspension for any reason, it affects the payload center of gravity.
- The AMR does not exceed its specified maximum limits for:
    - Acceleration, deceleration, or velocity.
    - Angular velocity, particularly on inclines.
    - Incline angle (ramp).

In the following graphical representations:

- A is the top of the payload bay.
- B defines the recommended envelope of the payload.
- X is the direction of the AMR's motion (front to rear).
- Y is perpendicular to the AMR's direction of motion (side to side).
- Z is the vertical dimension (height).

All dimensions are in millimeters (mm). See also: *AMR Coordinate System* on page 86 (LD-250 Platform User's Guide, Rev-B).

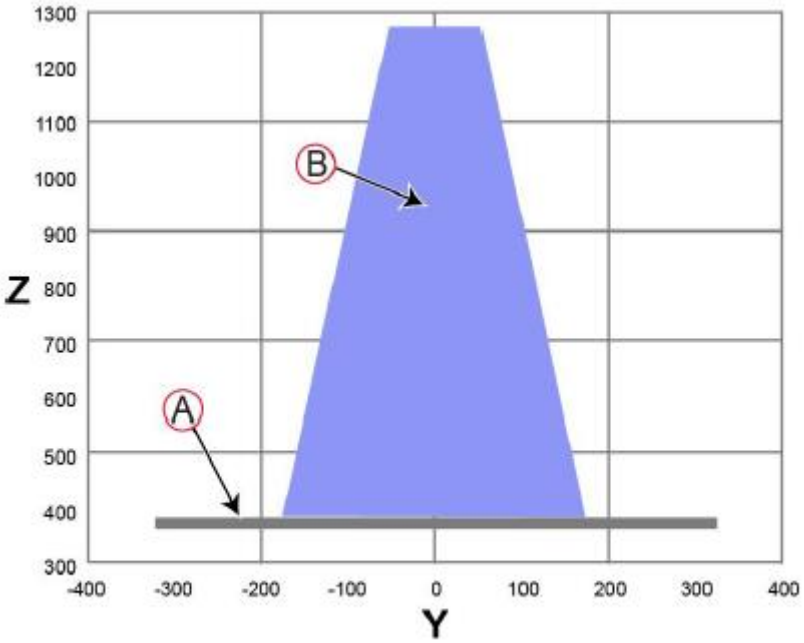


Figure 5-6 Front View (Y) of Recommended Payload CG (mm)

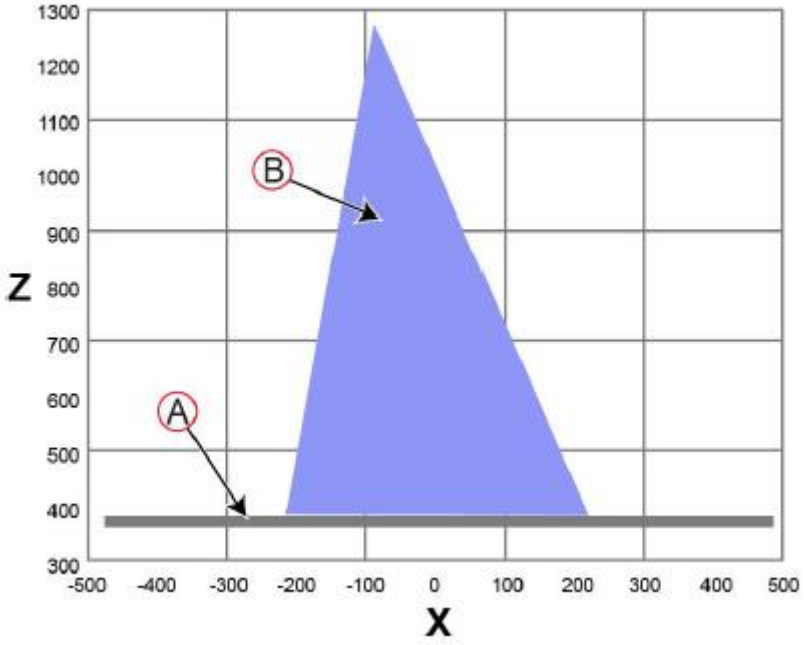


Figure 11: Side view (X) of recommended payload CG (mm)

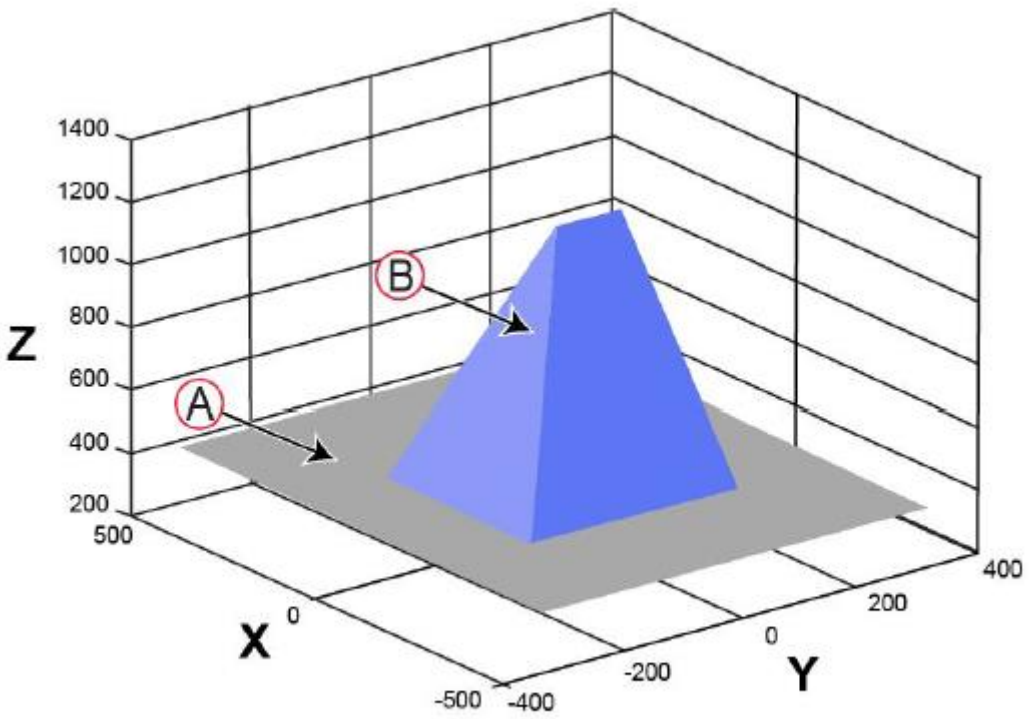


Figure 5-8 3D View of Recommended Payload CG (mm)

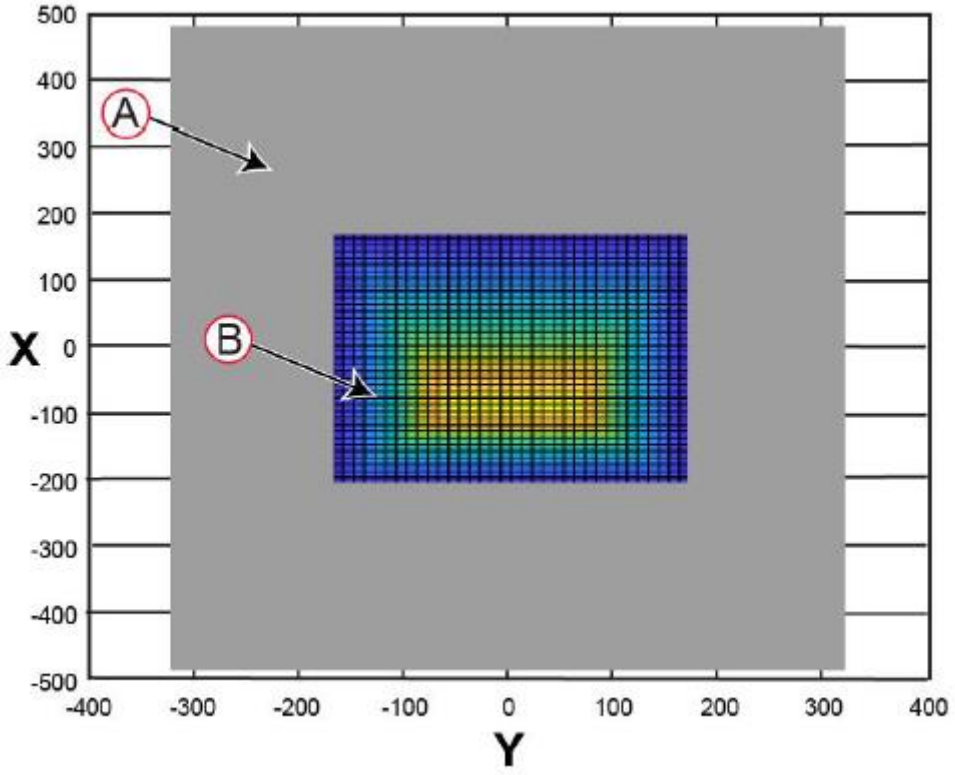


Figure 12: Top view (Z) of recommended payload CG (mm)

5.3 Payload-Related Trade-offs

If you extend your center of gravity beyond the guidelines given here, you must adjust various parameters in MobilePlanner software to compensate for changes in its driving characteristics. This is necessary so that the AMR remains consistent and safe in operation.

Contact your local OMRON Support If your parameters differ from those described in this section. In general, you must reduce the maximum acceleration, deceleration, and rotational velocities. See: *Acceleration, Deceleration, and Rotation Limits* on page 74 (LD-250 Platform User's Guide, Rev-B).

5.4 Connections between LD-250 and Payload Structure

The LD-250 Core provides user connections for data communications (I/O) and power. Use these connections for OMRON options, or for powering and controlling your payload structure.

5.5 Operator Panel (HMI) on the Payload

You can move the Operator Panel, with its integrated E-Stop, Brake-release, ON, and OFF buttons, by routing a single connector cable (the HMI Panel connector). This portability enables you to put many of the more common operator controls in a convenient location on the payload.

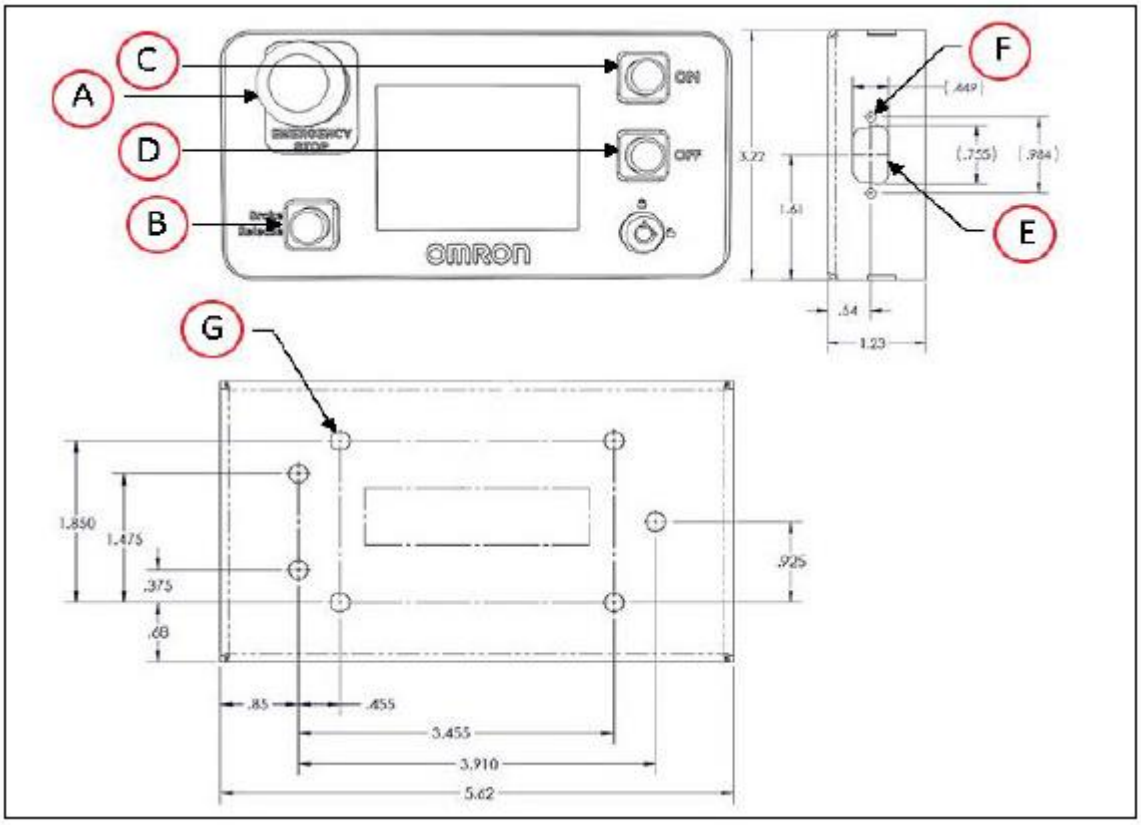


Figure 13: Standard operator panel (units are mm)

Callout	Description	Callout	Description
A	Emergency Stop	E	15 Pin High Density D-Sub
B	Brake Release	F	D-Sub hex nuts
C	On Button	G	7x 0.213 Through Hole
D	Off Button		

An additional touchscreen panel, is available as an option to display MR status, The touchscreen does not include the switch an button controls integrated into the Operator panel (HMI). See *Touchscreen* on page 188 (LD-250 Platform User's Guide, Rev-B). Many other LD-250 Core connections are available. For details and specifications of available connections, refer to *Connectivity* on page 93 (LD-250 Platform User's Guide, Rev-B).

5.5.1 E-Stop Considerations when removing the Operator Panel

If you remove the Operator Panel, you should replace its E-Stop button with an alternate Estop button located on the payload. This E-Stop must be:

- Wired to the Operator Panel (HMI) E-Stop chain via the Operator Panel cable, and not through the User E-Stop.

If not, you must properly terminate the Operator Panel E-Stop chain:

1. Keep the Operator Panel's cable in place, connected to the LD-250 core.
2. Securely attach a jumper (Part Number 13387-000) to terminate the end of the cable (in place of the Operator Panel).
3. Loop the cable and secure it with zip ties within the payload bay so that it does not interfere with the payload or any other moving parts.

- Located within the 600 mm reach requirement. See: *Positioning an Optional Payload Estop* on page 126 (LD-250 Platform User's Guide, Rev-B).

WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK
Failing to properly terminate the Operator Panel cable can prevent E-Stop buttons from operating correctly. This can prevent you from stopping the AMR during an emergency, and could result in injury or damage to property.

5.5.2 Option Connections

You can connect:

- Optional user bumpers for your payload. See: *User Bumper* on page 105(LD-250 Platform User's Guide, Rev-B)
- Warning lights. See:
    - *LIGHTS (Light Pole)* on page 102 (LD-250 Platform User's Guide, Rev-B)
    - *Indications Provided by Light Discs Light Outputs* on page 127 (LD-250 Platform User's Guide, Rev-B)

6 Connectivity

LD Core connections available to the user are accessible in the payload bay under the LD-250's top cover plate. The payload bay provides strong mechanical connection points and access to data and signal (I/O) and electrical power connections.

The two connections outside of the payload bay are the pendant port and the Maintenance Ethernet port, which are located under an access door on the rear of the LD-250. Both external ports are connected to the LD-250 Core inside the payload bay.

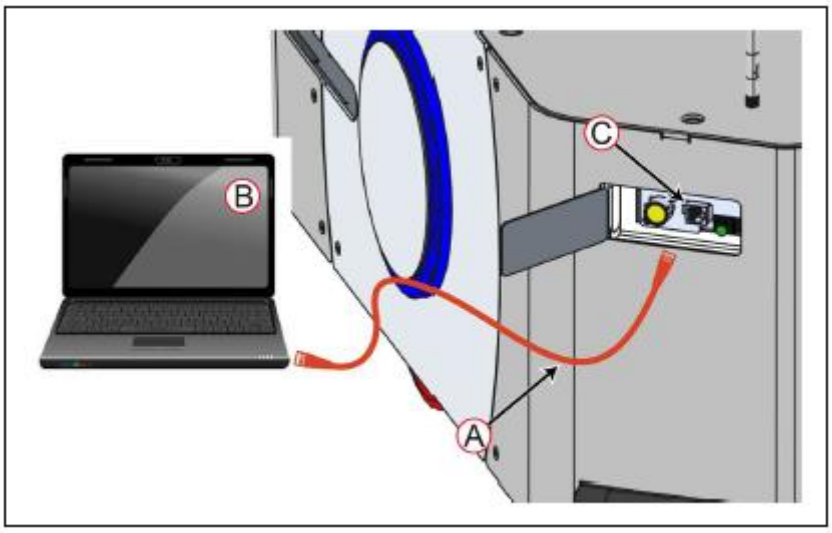


Figure 14: Connecting an Ethernet cable

Callout	Description
A	Minimum specification Cat 5 Ethernet Cable.
B	Microsoft Windows PC with Ethernet LAN port.
C	LD-250 Maintenance Ethernet port (under a door in the rear skin).

6.1 Connections Required for Set Up

At a minimum, you require the following connections.

Connection Type	Purpose
Joystick port	To create a workspace map, connect a joystick to the LD-250's Joystick port. The Joystick port is located under a small access panel on the LD-250's rear skin. This is internally connected to the LD-250 Core in the payload bay.
Maintenance Ethernet	The Maintenance Ethernet port is located under a small access panel on the LD-250's rear skin. This is internally connected to the LD-250 Core in the payload bay. Connect to the port using an RJ-45 Ethernet cable.
Wireless Ethernet	The LD-250 Core provides two connections for wireless antennae. Two 2.3 m (7 feet) RG58A/U, 1C/20AWG low loss extension cables are provided. The cable has two 6.35 mm (0.25 in) SMA coaxial connectors. Use the same specification if you require a longer cable for your payload. Do not relocate the antenna to a payload position where the signal might attenuated.
Docking Station	Power only.

6.2 Payload Bay Connections – LD-250 Core

The connections described in this section are available for use with standard options and user supplied accessories. The LD-250 ships with dual antennas that you can relocate if necessary. If you relocate the antenna, make sure that they are not in a position that might attenuate the WiFi signal, depending on the AMR's orientation.

Standard connectors, such as audio, are not described here. This includes all of the connectors on the right side of the LD-250 Core.

6.2.1 LD-250 Core Front, Upper

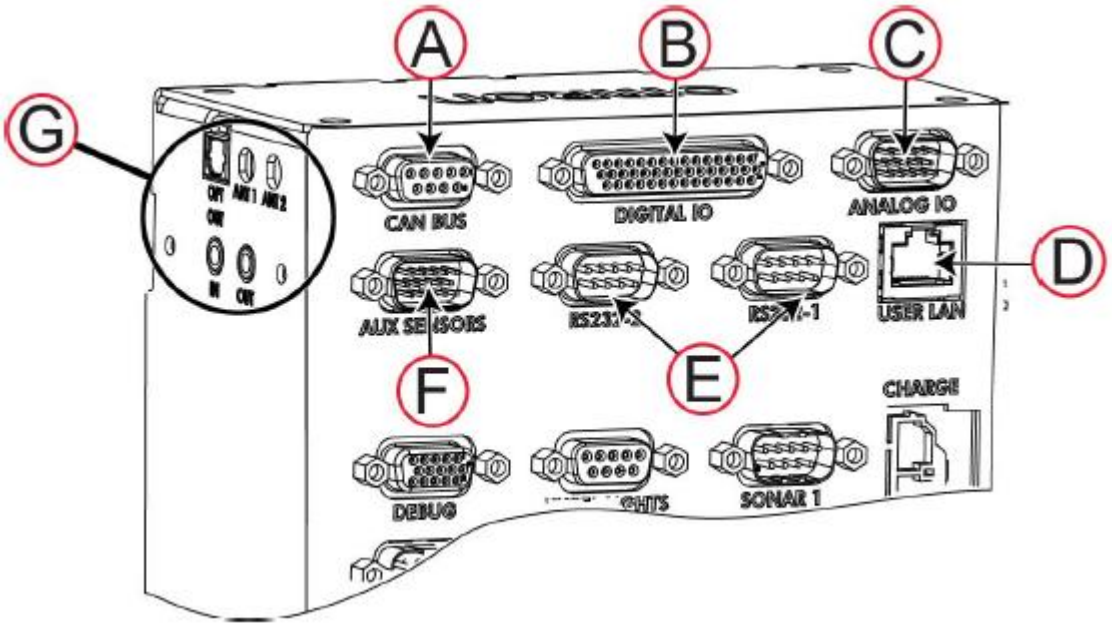


Figure 15: Front Upper LD-250 Core

ID	Connection	Type	Description
A	CAN Bus B	DB9F	Consult your local Omron Support for use.
B	Digital I/O[a]	HDB44F	16 digital inputs, in 4 banks of 4. Each bank can be wired as active high or active low depending on the connection of the BANK# terminal. V_{IN} range for each input is 0 to 30 V. The input is ON when V_{IN} > 4 V, OFF when V_{IN} < 1.3 V.
C	Analog I/O		General use.
D	User LAN	RJ45	General Ethernet, Auto-MDIX, shielded
E	RS-232 x 2	DB9M	Port 1 and Port 2, general use
F	Aux Sensors	HDB15M	Low front and optional side lasers
G	Right-Side Connectors	Various	Not described in this manual.
[a] 16 digital outputs, protected low-side drivers. Wire these outputs to positive voltage through the load. Output is open when OFF and grounded when ON. Each open-drain output is capable of sinking 500 mA. May be used with loads connected to VBAT, AUX_20V, _12V, or _5V. You must stay within the allowed current capacity of the VBAT or AUX power supplies.			

6.2.1.1 Digital I/O

The LD-250 Core's Digital I/O HDB44F connector provides the user with digital inputs and outputs for payload customization.

	Designation		
Pin No.	Hardware	Software	Notes
1	INPUT_1.1	Input_1.1	0 – 30 V Range, R_{in} = ~3.9 kΩ
2	INPUT_1.2	Input_1.2	0 – 30 V Range, R_{in} = ~3.9 kΩ
3	INPUT_1.3	Input_1.3	0 – 30 V Range, R_{in} = ~3.9 kΩ
4	INPUT_1.4	Input_1.4	0 – 30 V Range, R_{in} = ~3.9 kΩ
5	BANK1		Common for INPUT_1.X
6	INPUT_2.1	Input_2.1	0 – 30 V Range, R_{in} = ~3.9 kΩ
7	INPUT_2.2	Input_2.2	0 – 30 V Range, R_{in} = ~3.9 kΩ
8	INPUT_2.3	Input_2.3	0 – 30 V Range, R_{in} = ~3.9 kΩ
9	INPUT_2.4	Input_2.4	0 – 30 V Range, R_{in} = ~3.9 kΩ
10	BANK2		Common for INPUT_2.X
11	INPUT_3.1	Input_3.1	0 – 30 V Range, R_{in} = ~3.9 kΩ
12	INPUT_3.2	Input_3.2	0 – 30 V Range, R_{in} = ~3.9 kΩ
13	INPUT_3.3	Input_3.3	0 – 30 V Range, R_{in} = ~3.9 kΩ
14	INPUT_3.4	Input_3.4	0 – 30 V Range, R_{in} = ~3.9 kΩ
15	BANK3		Common for INPUT_3.X
16	INPUT_4.1	Input_4.1	0 – 30 V Range, R_{in} = ~3.9 kΩ
17	INPUT_4.2	Input_4.2	0 – 30 V Range, R_{in} = ~3.9 kΩ
18	INPUT_4.3	Input_4.3	0 – 30 V Range, R_{in} = ~3.9 kΩ
19	INPUT_4.4	Input_4.4	0 – 30 V Range, R_{in} = ~3.9 kΩ
20	BANK4		Common for INPUT_4.X
21	OUTPUT_1	Output_1	
22	OUTPUT_2	Output_2	
23	OUTPUT_3	Output_3	
24	OUTPUT_4	Output_4	
25	OUTPUT_5	Output_5	
26	OUTPUT_6	Output_6	
27	OUTPUT_7	Output_7	
28	OUTPUT_8	Output_8	
29	OUTPUT_9	Output_9	
30	OUTPUT_10	Output_10	

	Designation		
Pin No.	Hardware	Software	Notes
31	OUTPUT_11	Output_11	
32	OUTPUT_12	Output_12	
33	OUTPUT_13	Output_13	
34	OUTPUT_14	Output_14	
35	OUTPUT_15	Output_15	
36	OUTPUT_16	Output_16	
37	VBAT_IO_OUT4		VBAT @ 0.5 A Max (shared with light pole)
38	VBAT_IO_OUT3		VBAT @ 0.5 A Max
39	VBAT_IO_OUT2		VBAT @ 0.5 A Max
40	VBAT_IO_OUT1		VBAT @ 0.5 A Max
41 - 44	GND		

6.2.1.2 Digital Input and Output Specifications

The following tables describe specifications for the LD-250 Core's digital inputs.

Parameter	Value
Operational voltage range	0 to 30 VDC
OFF state voltage range	0 to 1.3 VDC
ON state voltage range	4 to 30 VDC
Operational current range	0 to 7.5 mA
OFF state current range	0 to 0.5 mA
ON state current range	1.0 to 7.5 mA
Impedance (V_{in}/I_{in})	3.9 kΩ minimum
Current at V_{in} = +24 VDC	$I_{in} \leq 6$ mA

NOTE: The input current specifications are provided for reference. Voltage sources are typically used to drive the inputs.

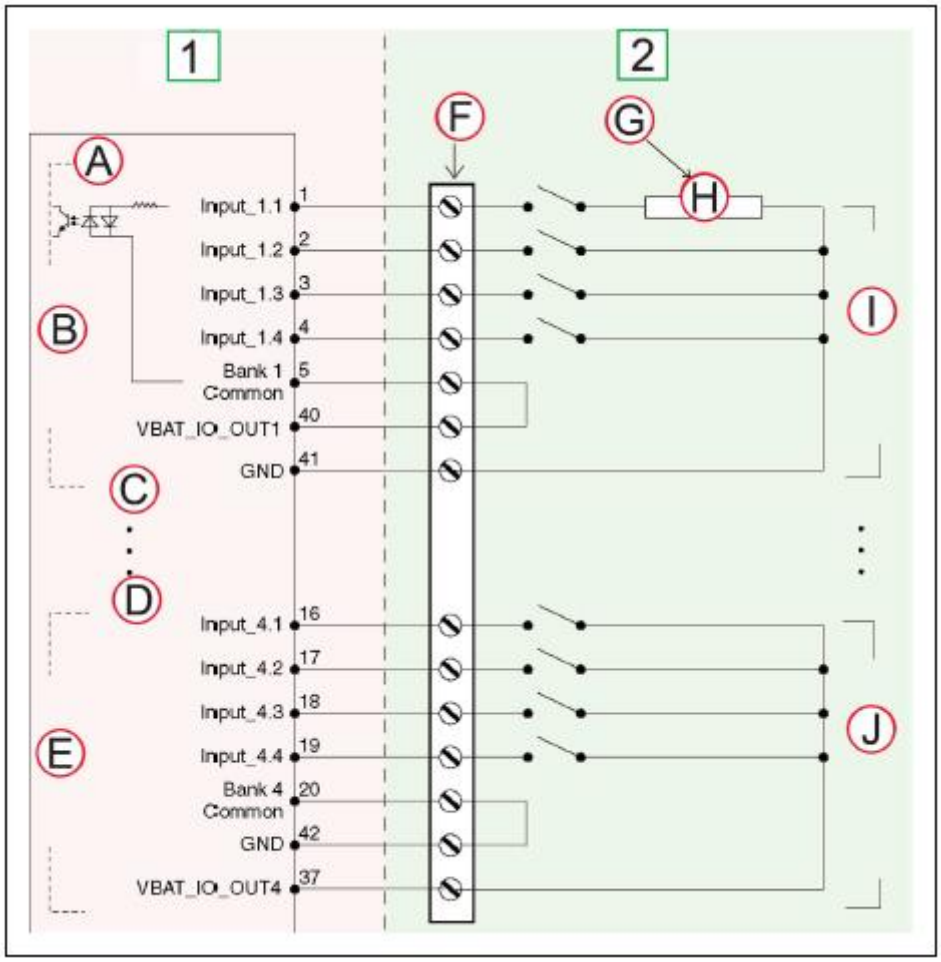


Figure 16: Typical digital input wiring example

Callout	Side 1 (Left) I/O Connector	Callout	Side 2 (Right) User-Supplied Equipment
A	Equivalent Circuit	F	Terminal Block
B	Input Bank 1	G	Typical User Input Signal
C	Input Bank 2	H	Part Present Sensor
D	Input Bank 3	I	Bank 1 configured for sinking (NPN) inputs
E	Input Bank 4	J	Bank 4 configured for sinking (PNP) inputs

NOTE: You can use all input signals for either sinking or sourcing configurations.

Parameter	Value
Power supply voltage range	5 - 30 VDC
Operational current range, per channel	$I_{out} \leq 500$ mA
ON state resistance ($I_{out} = 0.5$ A)	$R_{on} \leq 0.14\ \Omega$ @ 85°C
Output leakage current	$I_{out} \leq 5$ µA
DC short circuit current limit	$0.7\ A \leq I_{LIM} \leq 1.7\ A$

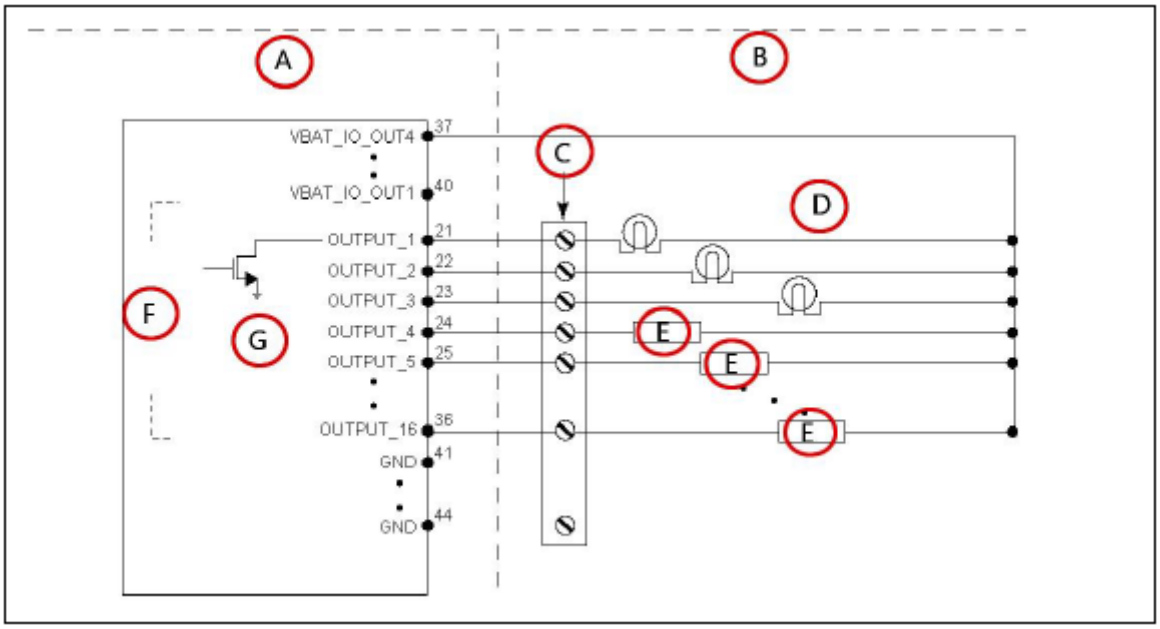


Figure 17: Typical digital output wiring example

Callout	Description	Callout	Description
A	Standard Equipment	E	Load
B	User-Supplied Equipment	F	Outputs 1-16
C	Wiring Terminal Block	G	Equivalent Circuit
D	Typical User Loads		

6.2.1.3 Analog I/O

The LD-250 Core's Analog I/O HDB15M connector is reserved for internal use only. Contact your local OMRON Support before attempting to use these circuits.

6.2.1.4 Aux Sensors

The LD-250 Core's Aux Sensors HDB15M connector provides circuits used by the Low Front

Laser and optional Side Lasers (tilted lasers).

	Designation		
Pin No.	**Hardware**	**Software**	**Notes**
1	RS232_VERT1_TXD		/dev/ttyUSB5 (side lasers)
2	RS232_VERT2_TXD		/dev/ttyUSB6 (side lasers)
3	RS232_FOOT_TXD		/dev/ttyUSB7 (low front laser)
4	5V_SW1	USB_1_and_2_Power	5 V @ 1 A (shared with USB port 1)
5, 10	SW_20V_VERT	Vertical_Laser_Power	20 V @ 300 mA (side lasers)
6, 7, 8	GND		
9	5V_SW2	USB_1_and_2_Power	5 V @ 1 A (shared with USB port 2)
11	RS232_VERT1_RXD		/dev/ttyUSB5 (side lasers)
12	RS232_VERT2_RXD		/dev/ttyUSB6 (side lasers)
13	RS232_FOOT_RXD		/dev/ttyUSB7 (low front laser)
14	5V_SW3	USB_3_Power	5 V @ 1 A (shared with USB port 3)
15	SW_20V_FOOT	Foot_Laser_Power	20 V @ 150 mA (low front laser)

6.2.1.5 RS232 1 and 2

The LD-250 Core's RS232 1 and 2 DB9M connector provides two ports for use with peripheral devices such as the HAPS sensors (See: High-Accuracy Positioning System (HAPS) on page 190 (LD-250 Platform User's Guide, Rev-B).)

If not used for other devices, you can also use the ports for port forwarding information from other RS232 devices. See the SetNetGo chapter in the *Fleet Operations Workspace Core User's Guide*.

Pin No.	Designation	Notes
1, 4, 6, 9	No Connection	
2	RS232_USR#_RXD	#=1 or 2
3	RS232_USR#_TXD	#=1 or 2
5	GND	
7	RS232_USR#_RTS	#=1 or 2
8	RS232_USR#_CTS	#=1 or 2

6.2.2 LD-250 Core Rear Upper Connectors

Figure shows the connectors on the LD-250 Core's upper rear interface panel. Some if these connectors are available for customer use.

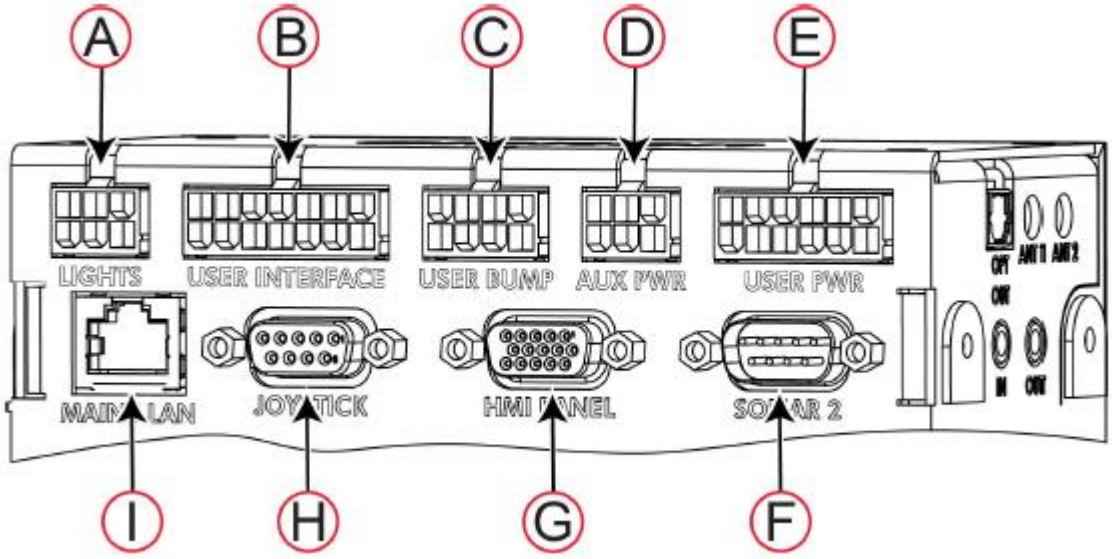


Figure 18: LD-250 core rear upper interface panel

ID	Connection	Type	Description
A	Lights	Mini-Fit 2 x 3	Connect to a supplied splitter that powers a buzzer using a default configuration, and provides power for a user-supplied light tower with 3 lights.
The following four functions are pins on the User Interface connector.			
B	Brake-release	Mini-Fit 2 x 7	Pins for user-supplied brake release
	ON		Pins for user-supplied ON button; same function as Operator Panel ON
	OFF		Pins for user-supplied OFF button; same function as Operator Panel OFF
	E-STOP		Pins for user-supplied E-Stop. Jumper if not used.
C	User Bumpers	Mini-Fit 2 x 4	Payload structure bumpers, user-supplied, connected between E-STOP_SRC and USER_BMP# (for each of the 6 inputs). Contacts 1 - 3 are for a front bumper, 4 - 6 for rear. Contacts should be 12 V @ 10 mA.
D	Aux Power	Mini-Fit 2 x 3	5, 12, and 20 VDC Outputs
E	User Power	Mini-Fit 2 x 6	Battery and switched battery power
F	Sonar 2	DB9M	Not used
G	HMI Panel	HDB15F	Operator screen, E-Stop, Brake_Rel, ON, OFF.
H	Joystick	DB9F	Directly connected to the externally-mounted Joystick port
I	Maint LAN	RJ45, Shielded	Directly connected to the externally-mounted Maintenance Ethernet, Auto-MDIX.
[a] Molex Mini-Fit Jr™ 5557 series receptacles.			

6.2.2.1 Pendant Connector

The LD-250 Core's pendant DB9F connector is replicated on the AMR's exterior under a small door on the rear (refer to: *LD-250 Features.* on page 12 (LD-250 Platform User's Guide, Rev-B))

Use the pendant for manual driving and mapping.

6.2.2.2 Power Connections

The LD-250's battery provides conditioned 5, 12, and 20 VDC, and raw (battery) 22 - 30 VDC power to the LD-250's accessory electronics, including the LD-250 Core and laser LIDAR (Light Detection And Ranging).

All power connectors are Mini-Fit®.

Refer also to *Power Consumption* on page 79 (LD-250 Platform User's Guide, Rev-B)

Nominal	Qty	Actual	Maximum Current	Description
5 VDC	1	5 VDC±5%	1 A	Switched Aux power
12 VDC	1	12 VDC±5%	1 A	Switched Aux power
20 VDC	1	20 VDC±5%	1 A	Switched Aux power
22 - 30 VDC	2	battery	4 A	Switched
22 - 30 VDC	1*	battery	10 A	Switched
22 - 30 VDC	1*	battery	10 A	Safe, Switched
* 10 A Switched and 10 A Safe, Switched share the 10 A of current.				

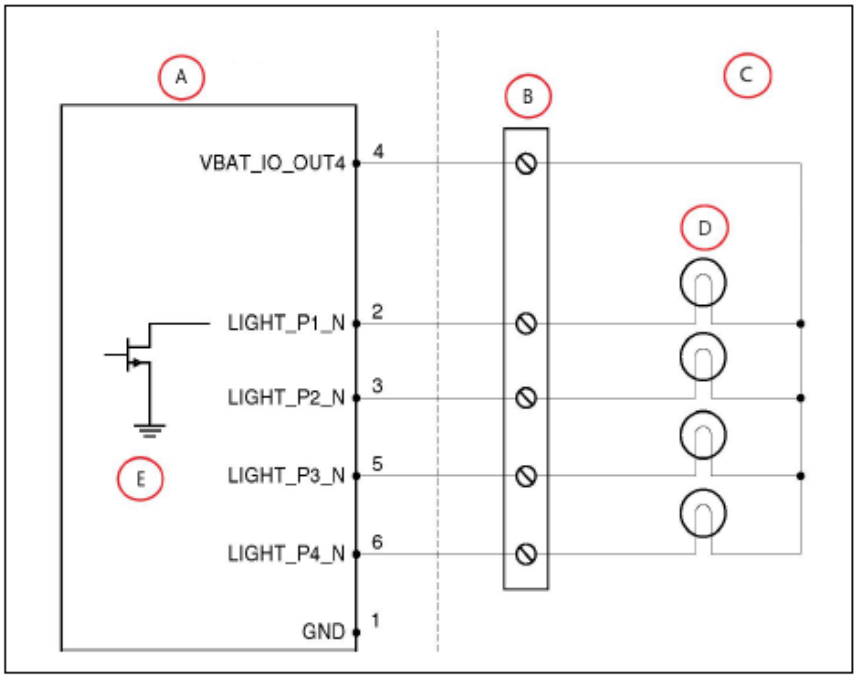
Each supply has an associated LED which, when lit, indicates that the port is actively powered. See *LD-250 Core Status Indicators* on page 132 (LD-250 Platform User's Guide, Rev-B).

When you press an E-Stop button (or if the rear sensor or a user bumper contacts an obstacle), it disconnects the Safe 22 - 30 VDC.

6.2.2.3 LIGHTS (Light Pole)

The LD-250 Core's light pole Mini-Fit® 2 x 3 connector enables you to connect a light pole or other payload warning lights.

Pin	Designation	Notes	Pin	Designation	Notes
1	GND	Cable shield	4	VBAT_IO_ OUT4	VBAT @ 0.5A Max (shared with DIO)
2	LIGHT_P1	Red	5	LIGHT_P3	Green
3	LIGHT_P2	Yellow or orange	6	LIGHT_P4	Buzzer



Callout	Description	Callout	Description
A	Standard Equipment	D	Typical User Load
B	Wiring Terminal Block	E	Equivalent Circuit
C	User-Supplied Equipment		

6.2.2.4 User Interface (Brake and E-Stop)

The LD-250 Core's User Interface Mini-Fit® 2 x 7 connector provides circuits for the Brake release, ON, OFF, and E-Stop buttons.

Pin No.	Designation	Notes
1, 2, 3	FBAT_ALWAYS	Fused VBAT @ 500 mA
4	E-STOP_USR_1L	Short 4 & 11 to close E-STOP_USR_1
5	E-STOP_USR_2L	Short 5 & 12 to close E-STOP_USR_2
6	E-STOP_OUT_1L	Pins 6 & 13 short when E-STOP_CH1 is closed
7	E-STOP_OUT_2L	Pins 7 & 14 short when E-STOP_CH2 is closed
8	OFF_BUTTON	Short to FBAT_ALWAYS to signal OFF (min 1 s pulse)
9	START_BUTTON	Short to FBAT_ALWAYS to signal ON (min 1 s pulse)
10	MOTOR_BRAKE	Short to FBAT_ALWAYS for manual brake release
11	E-STOP_USR_1H	Short 4 & 11 to close E-STOP_USR_1
12	E-STOP_USR_2H	Short 5 & 12 to close E-STOP_USR_2
13	E-STOP_OUT_1H	Pins 6 & 13 short when E-STOP_CH1 is closed
14	E-STOP_OUT_2H	Pins 7 & 14 short when E-STOP_CH2 is closed

6.2.2.5 User Bumper

The LD-250 Core's User Bumper Mini-Fit® 2 x 4 connector provides 6 circuits for optional user-supplied payload bumpers.

Pin No.	Designation	Notes
1	USER_BUMPER_1	Short to E-STOP_SRC to signal bumper hit Front left bumper sensor.
2	USER_BUMPER_2	Short to E-STOP_SRC to signal bumper hit Front center bumper sensor.
3	USER_BUMPER_3	Short to E-STOP_SRC to signal bumper hit Front right bumper sensor.
4	USER_BUMPER_4	Short to E-STOP_SRC to signal bumper hit Rear right bumper sensor.
5	USER_BUMPER_5	Short to E-STOP_SRC to signal bumper hit Rear center bumper sensor.
6	USER_BUMPER_6	Short to E-STOP_SRC to signal bumper hit Rear left bumper sensor.
7, 8	E-STOP_SRC	12 V E-STOP Source Output @ 10 mA

6.2.2.6 Aux Power

The LD-250 Core's Aux Power Mini-Fit® 3 x 2. connector provides auxiliary power outputs. Refer also to *Power Consumption* on page 79 (LD-250 Platform User's Guide, Rev-B) which specifies limits on power draw.

	Designation		
Pin No.	**Hardware**	**Software**	**Notes**
1, 2, 3	GND		
4	AUX_5V_OUT	Aux_5V	5 V @ 1 A max
5	AUX_12V_OUT	Aux_12V	12 V @ 1 A max
6	AUX_20V_OUT	Aux_20V	20 V @ 1 A max

6.2.2.7 User Power

The LD-250 Core's User Power Mini-Fit® 2 x 6 connector provides battery power for payload devices. Refer also to *Power Consumption* on page 79 (LD-250 Platform User's Guide, Rev-B) which specifies limits on power draw.

IMPORTANT: Pressing an E-Stop interrupts the power output on pins 11 and 12 (SAFE_VBAT_OUT). This is useful if you want to interrupt power to both the AMR and its payload devices.

	Designation		
Pin No.	**Hardware**	**Software**	**Notes**
1, 2, 3, 4, 5, 6	GND		
7	SW_VBAT_OUT1	Battery_Out_1	VBAT @ 4 A max (switched in SW)
8	SW_VBAT_OUT2	Battery_Out_2	VBAT @ 4 A max (switched in SW)
9, 10*	SW_VBAT_OUT34	Battery_Out_3_and_4	VBAT @ 10 A max (switched in SW) Limit to < 5 A per pin.
11, 12*	SAFE_VBAT_OUT		SW_VBAT_OUT34 gated by dual-channel E-STOP relays
*9, 10, 11, and 12 share the 10 A of current.			

6.2.2.8 HMI Panel (Operator Panel)

The LD-250 Core's HMI panel HDB15F connector provides circuits for the Operator Panel screen and its buttons (ON, OFF, EMERGENCY OFF, and Brake Release.).

	Designation	
Pin No.	**Hardware**	**Software**
1	RS422_HMI_TX+	
2	RS422_HMI_TX-	
3	MOTOR_BRAKE	
4, 5	E-STOP_FP_1H, _2H	
6	RS422_HMI_RX+	
7	RS422_HMI_RX-	
8	START_BUTTON	
9, 10	E-STOP_FP_1L, _2L	
11	HMI_5V_SW	HMI_Power
12, 14	GND	
13	OFF_BUTTON	
15	FBAT_ALWAYS	

If you are using the optional touchscreen instead of the Operator Panel, it is possible to use this port for custom connections. However, OMRON recommends that you use the User Interface port, which is intended for customization. See: *User Interface (Brake and E-Stop)* on page 103 (LD-250 Platform User's Guide, Rev-B).

Important considerations if customizing this port are:

- You must provide buttons for ON (Start), OFF, Brake Release, and E-Stop functions, or at least jumper the E-Stop circuit using the jumper part number: 13387-000. Attach this jumper to the Operator Panel's cable, and not directly to the LD-250 Core.
- It is not possible to use the RS-422 data connections.

6.2.2.9 Sonar 1

The LD-250 Core's Sonar 1 DB9M connector is connected to the rear sensor in the LD-250.

7 Technical Specifications

7.1 Dimension Drawings

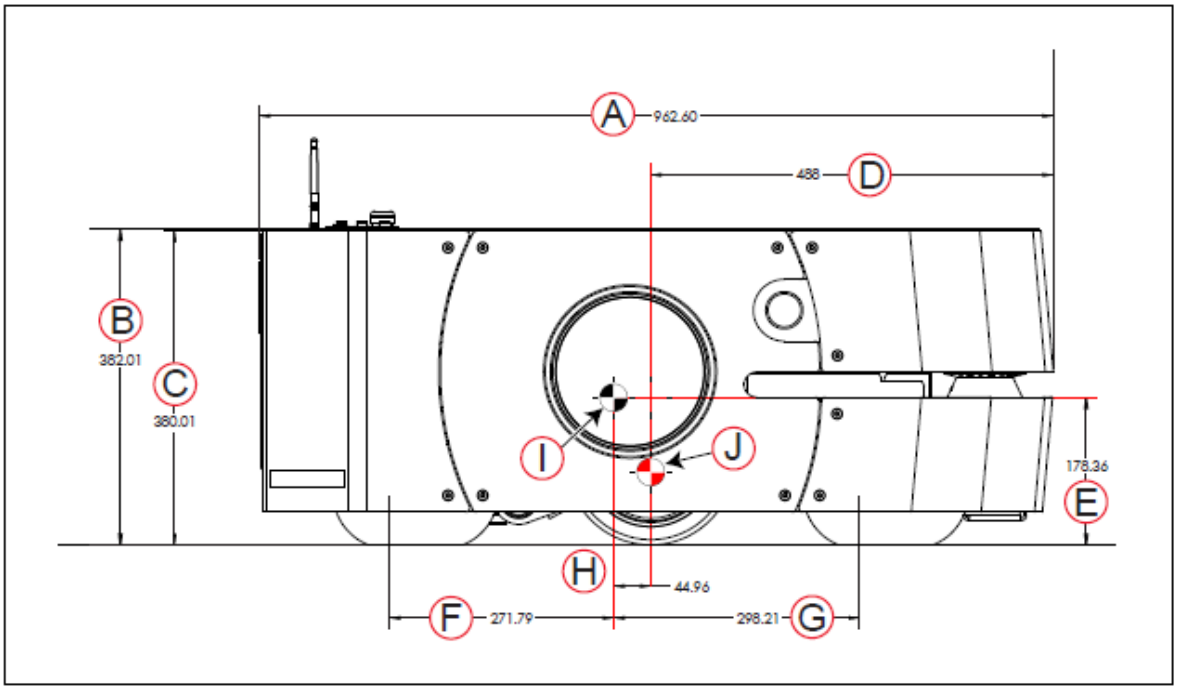


Figure 19: Length Dimensions from side of AMR

Callout	Description	MM	Inch
A	Length	963	38
B	Height to top cover plate	383	15
C	Height to load bars in the payload bay	380	15
D	Front to wheel axis	488	19
E	Center of gravity to the floor	178	7
F	Rear caster axle to center of gravity	272	11
G	Front caster axle to center of gravity	298	12
H	Wheel axis to center of gravity	45	2
I	Center of gravity	N/A	N/A
J	Center of rotation	N/A	N/A

7.1.1 Width Measurements

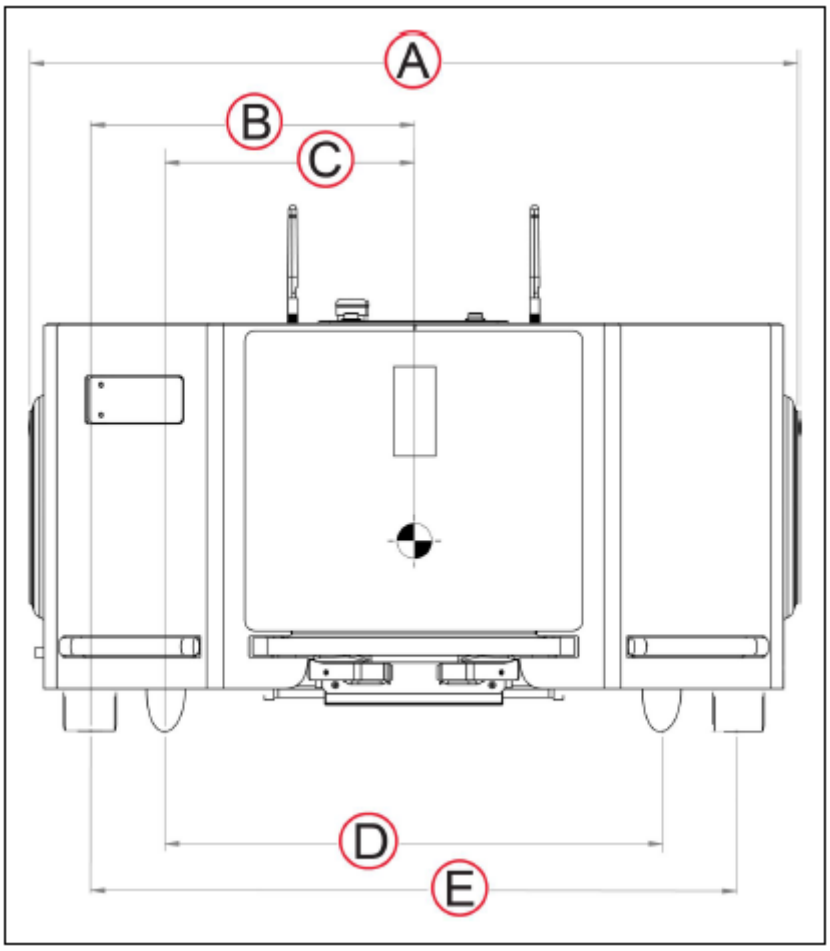


Figure 20: Width dimensions from rear of AMR

Callout	Description	MM	Inch
A	Width, including light discs	718	28
B	Drive wheel to center of gravity	301	12
C	Caster to center of gravity	232	9
D	Caster wheelbase	465	18
E	Drive wheel wheelbase	605	35

7.1.2 Component Weight

Mass Characteristic	kg	lbs
Vehicle weight with skins and battery installed	146	321.9
Vehicle weight without skins	126	277
Battery weight	18.5	41

7.1.3 Capabilities

	LD-250Capability	Value
	Vehicle Max Speed	1.2 m/sec
	Run time	8-10 hours

NOTE: Refer also to Payload Structures (Section 5) for information about the payload mount location and dimensions.

7.2 LD-250 Specifications

7.2.1 Physical Dimensions

Description	Specification
Default LengthFront	488 mm
Default Lengthrear	480.8 mm
Rating	
IP Rating	IP20
Cleanroom rating	None
Joystick IP rating	IP56
Drive Train	
Drive wheels	Aluminum with polyurethane tread
Passive Casters	2 front, 2 rear, ESD
Brakes	2 (one each motor)
Steering	Differential

7.2.2 Performance

Description	Specification
Performance	
Max payload – level	250 Kg
AMR Radius	1050 mm
Swing radius (see note below)	525 mm
Turn radius	0 degrees
Translational speed, max	1200 mm/sec
Rotational speed, max	120 degrees/sec
LIDAR Stop position repeatability	+/-100 mm

Description	Specification
Triangle Target Drive Stop position repeatability	+/-50 mm
Traversable step, max [a]	10 mm
Traversable gap, max	15 mm
Climb grade.	3% (Frequent operation on grades affects battery duration.)
Traversable terrain	Generally, "wheelchair accessible"
Noise Level - Ambient	38 Db(A)
Noise Level - Peak	60 Db(A)
Minimum floor flatness [b]	F_F25 (based on the ACI 117 standard)
Battery	
Run-time	8 hrs
Typical Lifespan	2000 charge cycles
Weight	19 Kg
Voltage	22-30 VDC
Capacity	72 Ah (Battery cell nominal)
[a] Steps should have smooth, rounded profiles. A speed limit of 600 mm/s is required for traversing steps. Faster or frequent driving over such steps or gaps will shorten the lifespan of the drive train components. Lower speeds may not traverse the step.	
[b] ACI 117 is the American Concrete Institute's standard for concrete floors. F_F is flatness, F_L is the level. Higher F_F numbers represent flatter floors. F_F 25 is a fairly lenient specification.	

7.2.3 Overhanging Payloads and the AMR Swing Radius

If your payload overhangs the default LD-250 footprint, it alters the AMR's swing radius and exponentially affects its maximum safe rotational speed. Should the AMR size increase significantly, you might need to adjust the AMR's maximum rotation speed to stay within 300 mm/sec or slower.

If you increase the AMR's default swing radius, reduce the value of the **HeadingRotSpeed** parameter to compensate for its increased size and increased rotational speed.

For example, if you increase the AMR's radius to 625 mm and v represents threshold linear velocity of 300 mm/s:

ω = v / r

ω = (300 mm/s) / (625 mm) = 0.48 radians/s

ω = 0.48 rad/s * 180/π = 27.5 deg/s

In MobilePlanner, set the value of the **HeadingRotSpeed** parameter to 27.5 deg/sec.

7.2.4 Sensors

Description	Specification
Sensors	
Safety Scanning Laser	1 at front of LD-250 Single horizontal plane, parallel to the floor at a height of 190 mm (7.48 inches). 601 beam readings in a 240° field of view (0.4 degrees per beam). Maximum safety protection range of 3 m (9.8 ft). Maximum distance for range readings of 15 m (49 feet). Class 1, eye-safe. PLd Safety per ISO-13849
Position encoders	One encoder for operation and navigation. A second encoder for safety.
Analog gyroscope (LD-250 Core)	320 deg/sec max rotation
Rear sensor	1 at rear of LD-250 The sensor has right, center, and left segments. (MobilePlanner indicates which segment is activated by an obstacle.)
Low Front Laser (Toe Laser)	1 in toe-laser well.
Side Lasers (option)	One rear-facing. 2 on sides of payload structure, user-mounted.
Upward-facing camera (Acuity option)	1 on payload structure, user-mounted
Payload Structure bumpers (option)	6 inputs, user-designed and mounted sensors (3 front, 3 rear)

7.2.5 ESD Compliance

The LD-250 provides a path for ESD grounding through the casters. While adequate to protect the LD-250 and any other equipment it touches, this method is not IEC compliant.

Keep both the floor and casters clean so that there is adequate conductivity. See:

- *Cleaning ESD Casters* on page 156 (LD-250 Platform User's Guide, Rev-B).
- *Environment and Floor* on page 115 (LD-250 Platform User's Guide, Rev-B).

7.3 Docking Station Specification

Description	Specification
Current	8 A
Circuit protection	Thermal circuit breaker rated at 10A (IEC) or 15A (UL).
Contacts	2
Voltage	100-240 VAC, 50/60 Hz
Power consumption	800 W
Short circuit current rating (SCCR)	Fuse: 1500 A, Circuit Breaker 2000 A
Humidity	5% to 95% non-condensing
Temperature	5 to 40°C (41 to 104°F)
Dimensions - WxDxH with Floor plate	349 x 369 x 315 mm [13.75 x 14.5 x 12.4 inches] 495 x 495.5 x 317 mm [16 x 19.5 x 12.5 inches]
Weight	8.2 kg (18 lbs)
Mounting	Wall bracket, directly to floor, or on floor with floor plate
Indicators	Power on - blue Charging - amber
Connector	For manual charging of spare batteries

NOTE: The LD-250 can also use older model docking stations that use a 10 A time-lag fuse.

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