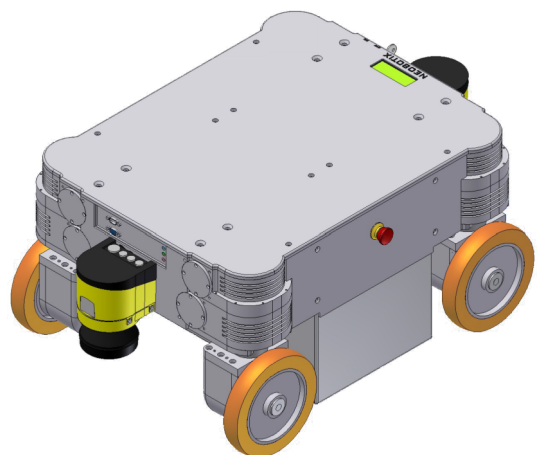


## MPO – 700

### Operating Manual



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## 1 Introduction

### 1.1 General information

Mobile robot platforms are also known as automatic guided vehicles (AGV). This means the mobile system is capable of moving freely without the need of guide wires, optical guide strips or a magnetic sensor strip stuck to the floor marking the planned route.

Instead of hardware installations in the surrounding the approached stations and the connecting pathways are defined by software. Using a simple 2D map of the surrounding, there are just a few mouse clicks necessary to define routes for the robot. After this the controller software is able to:

- move on predefined pathways
- plan a path by itself between target stations
- detect and evade obstacles on the pathway
- execute programmed actions within the map

The mobile robot navigates autonomously by acquiring sensor data of environment features such as walls and corners and comparing this data to an internal map.

### 1.2 Range of applications

The mobile robot may be used in a large variety of applications:

- Autonomous transportation tasks in industrial environments
- Automatic measurement of physical data in large areas (e.g. gas concentrations, temperatures, noise, etc.)
- Autonomous operations within large areas (e.g. surveillance, part handling, etc.)
- Telepresence while controlled via wireless LAN

### 1.3 About this document

This document describes the basic handling of the MPO-700 omnidirectional robot. It is meant as a guideline when installing the hardware and as a quick reference for troubleshooting. Basic operation and handling instructions are included as well.

Only hardware drivers and single software modules are part of this product. The mobile robot cannot be operated without an appropriate, sophisticated software package. Therefore the general operation of the mobile robot is not described in this document.



**The warning triangle marks paragraphs that concern the danger of injuries, damages or both. Please read these paragraphs very carefully!**



The prohibition sign marks actions or applications the robot is not intended for and which might result in damages, reduced life expectancy and loss of warranty.



The light bulb marks paragraphs that mention common problems, misunderstandings or errors and is meant to be a help in troubleshooting.

## 2 Intended usage

### 2.1 Product description

The mobile platform MPO-700 (and all varieties and models based on it) is an autonomous robot vehicle for a wide range of applications.

It features four Neobotix Omni-Drive-Modules which allow the MPO-700 to move in any direction as well as turning the vehicle at any time. Measurement data from one or two laser scanners can be used for localisation, navigation and collision avoidance. These scanners also monitor up to four different user-defined safety fields around the robot. As soon as an object is detected within the currently activated field, the robot is immediately set to emergency stop.

These features enable the MPO-700 to exactly determine its current position within the working area, to plan paths to arbitrary positions and to safely avoid collisions with passers-by or other dynamic obstacles.

Additional components and systems can be mounted onto and into the robot. They can be powered by the robot's internal power supply and can be controlled by the on-board computer.



**Please note that the MPO-700 comes without control software.**

A Linux operating system with all basic drivers is installed and a usable version of the free "Robot Operating System" (ROS) is prepared free of charge for first tests. The open source software ROS is made up from different modules which are constantly under development by large parts of the robotics developer community and mostly free. Therefore Neobotix cannot guarantee the usability of the available software modules for a certain application and cannot provide in-depth support for the control software of the MPO-700.

### 2.2 Intended use

The MPO-700 has been designed for use in service robotics research. It can be used for a wide range of different experiments and tests in fields such as autonomous vehicles, mobile manipulation and factory automation.

Depending on the intended application the MPO-700 can be used on its own, in combination with other robot vehicles and in combination with stationary systems. Furthermore, application specific extensions can be integrated into the basic platform. These might be a customised cargo area, a robot arm or special sensors.

The MPO-700 may only be used in laboratories, test halls or similar environments. It is not recommended to use the MPO-700 in any other surrounding, especially not outdoors.

### 2.3 Working required from the customer

The MPO-700 is a very complex robot. The applications in which it will later be used could not be foreseen in detail during the development of the robot.

Therefore, beside any modifications needed for certain research work or experiments, some very basic tasks must be completed before the robot can be used safely.

- An assessment of risks must be performed by the customer to identify the different measures needed to guarantee a safe operation.
- **All safety measures required for safe operation have to be implemented by the customer according to the assessment of risks and under the customer's responsibility.**
- The control software for the robot has to be provided and installed by the customer. The safe operation of the robot greatly depends on the proper and reliable functioning of this software. Therefore it must be made sure that the robot's speed and workspace are limited to a safe level and that all axes are coordinated properly



at all times.

In order to achieve a safe operation of the mobile robot, several measures might be required. The following list gives a short and incomplete overview of possible measures.

**Additional actions might be required to guarantee the appropriate level of safety!**

- Using the laser scanners area monitoring feature for collision avoidance
- Adding safety bumpers to the robot
- Limiting speed, power and work area of the robot
- Adding covers and shielding on the frame of the robot

## 2.4 Improper use



The MPO-700 must not be used for transportation of passengers in any way. No person must ride on the robot itself, nor must the MPO-700 be used to move any other vehicle or hanger with passengers aboard.



The MPO-700 must not be operated in any publicly accessible area and is not approved for this kind of operation.



The MPO-700 must at no times be used without supervision of a qualified operator if there are guests, passers-by or other people unfamiliar with the robot within the working area.



**The robot must never be operated in areas where there are staircases leading down, elevated platforms or other possibilities for falling or dropping down. This may cause serious injuries or death!**

## 2.5 Working areas



The working area of the MPO-700 must be protected against moisture and have a sufficiently firm and clean floor. The floor must be even and horizontal.

Slopes, edges, steps and unevenness can result in problems when the robot is moving or with the localisation. Under some circumstances the robot might not be able to continuously determine its exact position and therefore might plan unnecessary or problematic paths or might even be unable to reach its destination.

Rain, splash water, flying sparks, dust and dirt might enter the robot and cause short-circuiting or other damages to both the electrical and mechanical components. Dirt and liquids on the floor may not only lead to slippage and problems of localisation and navigation but may also reduce the life expectancy of the drive components.

The robot does not feature any sensor for detecting staircases, holes or other areas where it may drop down. In case of loss of localisation or faulty programming the robot might fall down such places.



**Always check for and secure all places where the robot might drop down before bringing it into operation.**

## 2.6 Qualified personnel

This product must only be modified, commissioned, operated and serviced by qualified personnel. Qualified personnel are defined as persons who

- due to their specialist training and experience have adequate knowledge for the work at hand

**and**

- who have been instructed by the responsible robot operator in the operation of the robot or its parts and the currently valid safety guidelines

**and**

- are sufficiently familiar with the applicable official health and safety regulations, directives and generally recognised engineering practice (e.g. DIN standards, VDE stipulations, engineering regulations from other EC member states) that they can assess the work safety aspects of the robot

**and**

- who have access to this manual and who have read it.

The following groups of persons are generally not considered qualified:

- Employees, interns or other academic staff not familiar with the robot,
- visitors and guests,
- all members of other departments of the company or institution in which the robot is operated.

This list is not intended to be exhaustive.

### 3 Safety Instructions

The autonomous omnidirectional robot vehicle MPO-700 is not only capable of performing very different tasks but can also react dynamically to its environment. Under some circumstances this might result in situations in which the robot's behaviour appears to be surprising or incomprehensible to persons who do not know the MPO-700 in detail.

Because of this it is essential that all of the following safety instructions are followed at all times. A safe and efficient operation of the robot can only be achieved under this condition.

#### 3.1 Briefing



**Always make yourself familiar with the robot, its control and behaviour before starting your work or setting up autonomous processes. Every other concerned person (e. g. workers, programmers, visitors etc.) should also be briefed accordingly.**

Due to the complexity of the robot system it is strongly recommended to attend a schooling. This document is only provided as a work of reference when facing minor and easy to solve problems concerning the hardware. All other problems, mistakes and difficulties can best be avoided by an in-depth schooling for programmers and a proper briefing for operators.

#### 3.2 Safety system

The mobile robot is equipped with several safety features. Additional features can be installed if necessary. Before starting to work with the robot a thorough check is required to determine whether the present safety features provide a sufficient level of safety.



**Some of the safety features, especially the laser scanner, might have been reduced or even disabled in order to make transport to the customer's site possible or more convenient. These features must be set up and tested by a qualified technician prior to the first operation of the robot system!**

##### Emergency stop buttons

As soon as one of the emergency stop buttons is pressed, all drives are immediately disconnected from power and the safety brakes of all motors are engaged. This is implemented completely in hardware and cannot be overridden or changed by software thus guaranteeing maximum safety.

##### Radio controlled emergency stop system

The radio controlled emergency stop system enables the operator to set the robot to emergency stop mode from a location outside the robot's potentially dangerous workspace. By default only the most basic system configuration is installed. Depending on the individual application, more complex configurations with additional features can also be realised.

##### Laser scanner

The safety approved laser scanner S300 can monitor user-defined safety fields around the robot which can be dynamically activated by an application specific control software. Only this control software is responsible for the correct activation of the safety fields according to the current condition.

As soon as a person or obstacle is detected within the currently active safety field the robot is immediately set to emergency stop. The stop will be reset automatically after the field has been cleared. No manual reset is required in this case.

The laser scanner has been approved as safety device with Performance Level d and SIL2. It fully replaces the safety bumpers which have been required for autonomous vehicles before.

### Special functions

In case third-party software is meant to run on the robot or the remote control computer this software can be enabled to trigger an emergency stop and or to reset the safety system. Additional safety devices (e.g. radio controlled emergency stop systems) can also be integrated into the mobile robot.

Please contact Neobotix if you plan to implement any special functions.

## 3.3 Cooperating with the robot

### Close proximity

As long as the robot is not in full emergency stop, a minimum distance should always be kept. Direct contact to the active robot system is to be avoided.



**Climbing up onto the mobile platform and / or riding on it are not allowed at any time.**

### Medium proximity

When approaching the robot or working in its presence, increased attention and caution are required. The safety features of the mobile robot have to be set at such a level that imminent dangers are being detected and that injuries or damages can be avoided.

In case the safety features have to be reduced due to the requirements of the process it might be necessary to prohibit the presence of people in the robot's surrounding. In these cases only the owner of the robot system can be held responsible for the safe operation.

### General surrounding

As long as the safety features of the mobile robot are set up properly, the presence of persons or vehicles in the robot's wider working area is allowed. Please contact Neobotix for further advise if needed.

All persons working in the same area as the robot should nevertheless be informed about the robot's behaviour and the possible dangers. Appropriate behaviour and consideration is necessary.

## 3.4 Danger areas

### Omni-Drive-Modules

The four Omni-Drive-Modules integrated into the MPO-700 are touch proof while not moving and protected against dust and splash-water. It is nevertheless possible that objects or body parts (e.g. hands or feet) get damaged or injured when touching the drive modules during operation. Objects or limbs may get squeezed or crushed if they get pulled in by a drive wheel or when the robot drives over them.

Great care is required while working on or with the robot to avoid injuries or damages. It is strongly recommended to design and mount protective covers around the drive modules.

### Li-Ion-Battery

The optional lithium-ion-battery requires a higher degree of care and understanding than the default lead-gel-battery.



**The lithium-ion-battery must be protected against physical damage, over-heating and over-current. Due to their chemical composition lithium-ion-batteries always have a risk of burning in case they are heavily damaged, over-**



**heated or over-charged.**

Please contact Neobotix immediately if you notice any change in the physical appearance of the lithium-ion-battery or have any questions or doubts concerning the battery.

### Wiring and electronics

Most of the MPO-700's wiring and electronic components are covered only by the outer plates to allow easy access for modifications and to ease the integration process when building a complex robot system. Work on the electrical components must only be done by suitably trained personnel. Great care is required to avoid injuries or damages due to short-circuiting, over-loading or other errors.

## 3.5 Bringing into service

After installing the mobile robot as well as after making changes to the environment or the work processes a supervised test-run has to be performed. This test has to cover all possible steps of the process. Autonomous operation must not be resumed without a successful test-run.

This also applies to modifications of routes and target positions, parameters, environmental conditions and higher level control systems.

Repairs, maintenance work and other changes in the system's hardware should also be followed by a test-run.

**The Neobotix GmbH cannot be held responsible in any way for injuries or damages which are caused by any problem that could have been detected or prevented by a supervised test-run.**

## 3.6 Modifications of the system

Please inform Neobotix before executing any kind of mechanical, electrical or software work or modification. Some detailed information or instruction might be necessary.

In case one or more robots are to be modified, it is strongly recommended to consult Neobotix in order to provide the appropriate training and information for all technicians and programmers. The functions and safety of all modified robots have to be checked and ensured before bringing them into service.



**All guaranties are void in case of any unauthorised or improper modification of the mobile robot system. All responsibilities for the further operation of the robot are devolved to whoever commands or executes such modifications.**

## 3.7 Expected misuse

### Passenger transportation

Transporting passengers on or by the MPO-700 is dangerous and strictly prohibited due to a number of reasons.

**The Neobotix GmbH cannot be held responsible for any injuries and / or damages caused to or by transporting passengers with the mobile robot.**

### Safety fields

The laser scanners' safety fields have to be configured and tested by the operator prior to taking the robot into service. If more than one safety field are to be used they need to be dynamically activated according to the current state and intended action of the robot.

**The operator takes full responsibility for the safe activation of the safety fields. Safety fields that are set up incorrectly or have been activated faultily will result in an unsafe and possibly dangerous operation of the mobile robot.**

## Working area

When choosing and preparing the working area special care has to be taken to ensure both a reliable localisation and motion control. The MPO-700 was designed for indoor use only. Outdoor operation may lead to increased wear and damages to the robot.

The localisation system of the MPO-700 requires clearly visible, unique landmarks and an exact, easy to match map of the surrounding. Further information on this topic can be found in the documentation of the control software package that is to be used. Please contact Neobotix in case of any problems.

The omnidirectional kinematics of the MPO-700 works best on an even ground and without slippage. Dirt like dust, sand, oil or water may cause the wheels to slip and the robot to move uncontrolled. This might even result in a loss of localisation which might make the robot leave the predefined path and enter prohibited or dangerous areas.

The robot must never be operated in areas where there are staircases leading down, elevated platforms or other possibilities for falling or dropping down.

## Mechanical overload

The defined maximum payload must not be exceeded. Overloading the robot may lead to reduced life expectancy of the drives and to damages to the robot. It might also affect the driving properties, resulting in unwanted movements and leaving the predefined paths.

## Electrical overload

The robot's on-board power supply must not be overloaded. Extreme overload may lead to overheating, damages to the electrical installation and to short-circuiting.

Please contact Neobotix before modifying the electrical system of the mobile robot.

## Battery charging

Charging the default lead-gel-battery with the provided battery charger is not dangerous or difficult. Charging the optional lithium-ion-battery on the other hand should only be done with the power supply provided by Neobotix and only according to the directions given in chapter "Maintenance – Charging the battery - The lithium-ion-battery".



**Charging the lithium-ion-battery with any other power source or in any other way might damage the battery or even cause fire.**

## Modifications

The robot must always be turned off and disconnected from all power sources before any modification is carried out. Working on the robot while it is connected to a power source or turned on results in the risk of electrical shock to the worker and damages to the robot.

## 4 Transport

### 4.1 Packaging

The mobile robot MPO-700 is packed in a rugged wooden box which can be reused for future transports. If the original box cannot be used any more it is recommended to build a new box of similar design.

The base plate of the box has to be strong enough to carry the robot and to take asymmetric forces, e.g. when moving the box with a forklift. When packing the robot it has to be secured against unintended slipping by sufficient cushioning. In order to prevent dust and dirt from the cushioning material to affect the MPO-700, the robot should be wrapped in plastic foil prior to packing.



Depending on the cushioning material it might be advisable to remove the key switch and to transport it separately in order to avoid damages to the key or the switch. Further information on the control elements can be found in chapter "Hardware description – Operating elements".

It is recommended to remove the battery from the mobile platform if possible. This will eliminate the forces that effect the parts carrying the battery and the battery cover. If the battery cannot easily be removed from the robot, e.g. due to an overall cover, the battery should be supported and fixed in position by wooden bars or other appropriate means.

#### Unpacking the robot

If the robot is shipped in the original transport box only the lid should be removed. Then all small components and the cushioning material can be taken out.

Once the robot is free of all cushioning it can be lifted out of the transport box. This should be done by at least two people who take hold at the bottom side of the platform's bottom plate.



**Never try to lift the robot by holding it at the laser scanner or the control elements! None of these components has been designed for lifting forces and they may be damaged.**

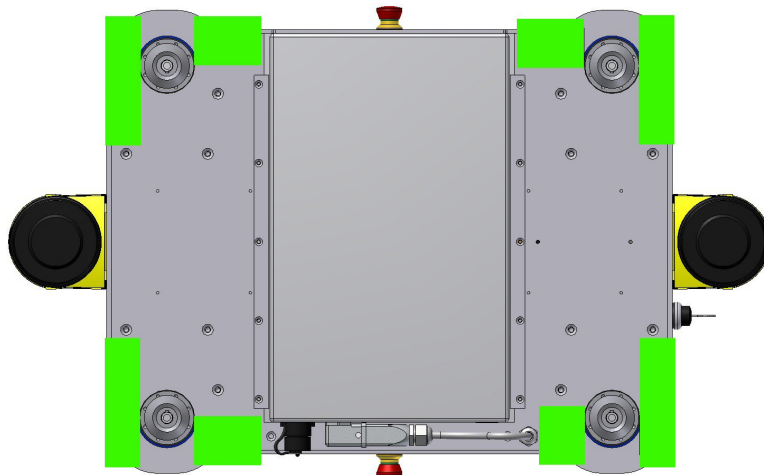


Figure 1: Recommended gripping areas at the bottom side of the MPO-700

The lead-gel-battery is not fixed to the robot during shipment and can be lifted out of the transport box after the robot was taken out. Please see chapter "Maintenance" for information on how to insert and connect the battery.

## 4.2 Long distance transport

As long as the robot is packed properly there are no special requirements when shipping the MPO-700. Only in case the robot has been exposed to very low temperatures (below -10°C) it should be left to reach room temperature again before turning it on. This will prevent damages to the electrical and electronic components.

### Shipping with lead-gel-battery

If the key switch was removed there is no risk of the robot being turned on during the transport or the battery being discharged.



To eliminate every risk when shipping the robot as airfreight it is recommended to disconnect the battery prior to shipping. The lead-gel-batteries are leak-proof and approved for airfreight.

### Shipping with lithium-ion-battery

Due to safety regulations the lithium-ion-battery has to be shipped in a separate transport box which provides a sufficient level of safety in case of an accident.



**Please follow the applicable transportation directives for hazardous goods of level 9 when shipping the lithium-ion-battery.**

## 4.3 Short distance transport

For short distances the MPO-700 can also be transported in the trunk of a car without the wooden box. It must still be secured against sliding and should never be driven outdoors. If the MPO-700 is transported in a car, the battery should be removed to increase transport safety and to reduce wear of the battery cover and carrier parts.

If the robot has to be moved across uneven or dirty grounds, e.g. to and from a parking area, it is best put onto a creeper and pushed carefully and slowly.



**Never leave the robot unattended and / or unsecured when it is on a rolling carrier. Avoid slopes and any unevenness that might block the wheels of the carrier.**

## 5 Setting up the hardware

### 5.1 Battery charger

The battery charger needs a power supply of 110VAC, 60Hz or 230VAC, 50Hz.

The charger must be placed in a dry environment. Do not cover the housing, so appropriate cooling is possible, and avoid direct sunlight. If the robot is meant to use the automatic charging station, connect the charger's power outlet to the station's cable and screw the connectors tightly together.

The robot can be manually recharged by connecting the battery charger's plug to the socket on the platform (see chapter "Operating elements"). The socket is covered by a cap that can be unscrewed by hand.

Recharging is done completely automatic after the connection is established and the battery charger is connected to the main power supply. For recharging it does not matter whether the robot is switched on or off. The only difference is the time needed for a full recharge. With the on-board electronic active, a recharge might take significantly longer, depending on the workload of the on-board computer.

The battery charger features an overload protection, thus allowing the robot to be permanently (e.g. overnight) connected to the charger. If the robot remains switched on while being connected to the charger (e. g. while programming) it might be necessary to switch the battery charger off and on once a day.



**Do not disconnect the cable while the platform is still recharging! Always switch off the battery charger first or disconnect it from the main power supply before removing the charging cable to avoid wear of contacts.**

### 5.2 Automatic charging station

#### Preparations for automatic charging

The automatic charging station is very robust and can easily be installed and integrated into the robot's program.

In order to allow a fast and trouble-free docking, there needs to be some free space to each side of the station and to the front. Find a place that can be easily accessed by the robot when it needs to recharge but in which neither station nor robot are obstacles to anybody. A power outlet must be nearby for the battery charger to be plugged in.

Please mind the following when choosing the stations mounting place:

- In order to have the charging contacts on the correct height, the bottom edge of the station's backplate must be placed directly on the floor.
- The charging station must be mounted to a stable wall. Please contact Neobotix if you need a free-standing charging station.
- The station must be mounted centred at the rear end of a free path that is at least **1,0m** wide.
- When using more than one station, please keep a grid of at least **1,0m** width.

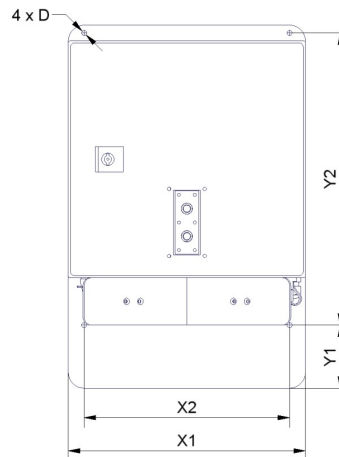


Figure 2: Mounting holes of the charging station

Robot	X1	X2	Y1	Y2	D
MP-400	300	260	80	370	6,6
MPO-700	300	260	192	370	6,6
MPO-500	340	320	40	290	6,6

Table 1: Dimensions of the charging station (in mm)

After installing the charging station please check the height of the charging contacts and if the robot can reach the station without problems.

**Only plug in the power cable after successfully checking these two points. The charging station requires the same power supply as the external battery charger.**



To allow automatic charging the battery charger inside the station needs to remain switched on at all times. Despite the open contacts which the robot needs for charging, there is no danger of electric shock or short-circuiting due to the charger's control mechanism. There will only be a current if the device has detected the correct batteries.



In normal operation, the platform's charging contacts are disconnected from the batteries by a high current relay on the platform's RelayBoard. This relay can be controlled by a programmed routine or be manually switched via the hardware monitor of the PlatformCtrlGUI.

**The wear of the electrical components can be reduced by stopping the charging process only after the batteries have been fully charged and the charging current is reduced.**

## 6 Bringing into service

### 6.1 Operating elements

The locations of the basic operating elements of the MPO-700 are shown in the picture below.

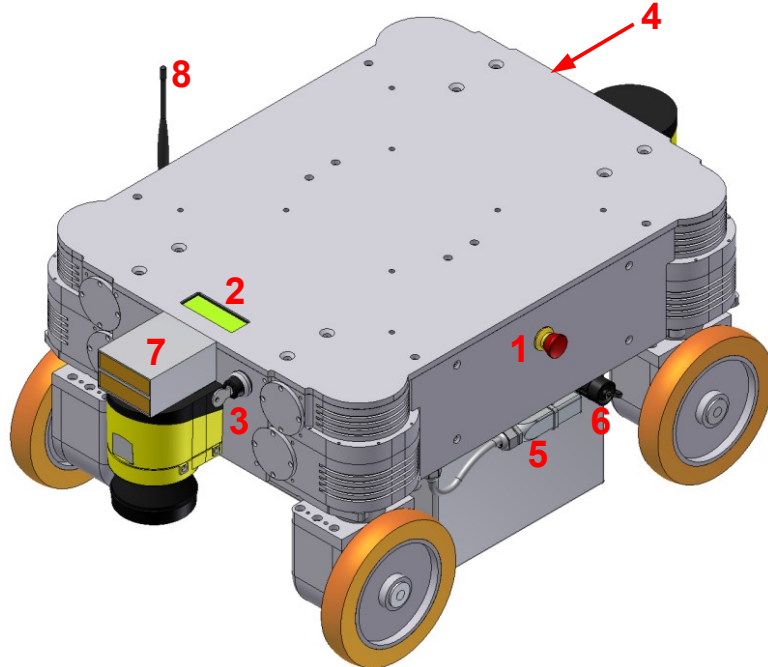


Figure 3: Basic control elements of the MPO-700

- |                          |  |                       |
|--------------------------|--|-----------------------|
| 1: Emergency stop button | 2: LC-Display  | 3: Key switch         |
| 4: Computer access       | 5: Battery connector                                     | 6: Charging connector |
| 7: Charging contacts     | 8: Antenna of the radio controlled emergency stop system |                       |

#### Emergency stop button

When one of these buttons is pressed the robot is immediately set to emergency stop. All drives are disconnected from power supply and the fail-safe brakes (if installed) are engaged. This state can be reset by unlocking the emergency stop buttons and turning the key switch clockwise to position II for a few seconds.

#### LC-Display

This display indicates the current state of the robot. Detailed information can be found in chapter "The LC-Display".

#### Key switch

Turning on: Turn the key clockwise and release to start up the robot.

Resetting after emergency stop: Turn the key to clockwise for about one second.

Shutting down: Turn the key counter-clockwise for five seconds to shut the robot down within 30 seconds. In this time the control software PlatformCtrl can close all files and shut down the operating system. When using ROS the computer will not be shut down but switched off after 30 seconds.

Switch off: To immediately turn off the robot without waiting for the on-board computer to shut down turn the key switch to the left and hold it there for another three seconds.

In case the on-board computer is shut down remotely (via the GUI or remote access) the robot will turn off automatically.

### Computer access

All peripheral connections of the on-board computer are accessible at the front of the platform.

### Battery connector

This is the connection between the battery and the mobile robot. If the robot is prepared for using the lithium-ion-battery then the connector also features a CAN-bus for communication with the cell monitoring system of the lithium-ion-battery and two signal contacts which can be used to activate this battery.

### Charging connector

This connector provides direct, not fuse protected access to the battery. The battery charger can be plugged in here. Please see chapter “Maintenance – Charging the battery” for details.

### Charging contacts

These contacts can be connected to the battery via a high power relay if the MPO-700 has been prepared for use of the automatic charging station.

## 6.2 Preparations

After the MPO-700 has been lifted out of its transport box, as described in chapter “Transport”, it should be cleaned from dust and any remaining bits of the cushioning. Especially the black covers of the laser scanners' optics need to be clean for the robot to operate properly.

To move the robot by hand all four Omni-Drive-Modules must be aligned to the intended direction. The robot can then be pushed for short distances. This will only work with robots without brakes.

**Never touch the covers of the laser scanners or the emergency stop buttons to move the robot!**

The battery has to be installed before the robot can be started. Please see chapter “Maintenance – Replacing the battery” for details. It is advisable to completely recharge the battery after every long shipment before the robot is turned on.



In case more than one mobile robot is to be used in the same area the robots should be controlled by wired joysticks. This will ensure an unambiguous allocation of the joysticks. The joysticks can be plugged into any USB-socket of the on-board computer.

## 6.3 First tests

Turn the key switch clockwise to position II to start up the robot.

Insert the according batteries into the joystick if necessary and wait until the platform has started the control software and finished the initialisation. The LCD will show “Board connected” as soon as the robot is ready for operation.





Figure 4: The wireless joystick

Press the activation button on the joystick to start the hardware-joystick-mode. In this mode the robot can be controlled manually by using the two analogue joysticks. The left stick controls translational movements while the right stick controls the rotation. The speed of the robot is proportional to the sticks which allows very accurate movements at low speed.

The robot will only move as long as the dead man's button is pressed. This prevents unintended movements and will stop the robot if the radio connection is interrupted.



**In hardware-joystick-mode most safety features, including obstacle avoidance, are disabled. Collisions at a high speed are possible!**



The emergency stop buttons might be pressed, caused by the cushion or the transport. If the robot does not move and the display shows "Emergency stop", release both buttons by turning them clockwise, turn the key switch clockwise and try again. Further information on the status messages can be found in chapter "The LC-Display".

If the optional radio controlled emergency stop system has been installed, a permanent radio connection between the hand-held transmitter and the robot has to be established before the emergency stop system can be reset. Unlock the transmitter's emergency stop button, wait for the green LED on the transmitter to light up and press the green start button, to create the connection. Then turn the key switch to position II as described above.

Move the robot carefully to a position where it does not obstruct anybody and press the activation button again to leave the hardware-joystick-mode. By doing so, the robot will switch to parking mode with the brakes locked and minimum power consumption.

## 6.4 Safety system

The MPO-700 features two emergency stop buttons and one or two safety approved laser scanners. In case the circuits of the emergency stop buttons need to be modified or additional safety devices need to be installed, please contact Neobotix for further information.

Because the MPO-700 can move into any direction, the safety fields of the laser scanners must be activated according to the intended motion. Prior to the first operation the safety fields have to be defined in consideration of the application's requirements, the working environment and the desired speed. Furthermore a routine to select and activate the safety fields has to be implemented in the control software.

The configuration and diagnostics software CDS from Sick can be used to conveniently configure the scanners' safety fields. The configuration cable that was included in delivery can be used to connect the scanners to the serial port of any external computer running the CDS.

By default the digital inputs A and B of the front laser scanner receive antivalent signals from two relays on the robot's main control board. If two scanners are installed they communicate via a safe direct connection. The input status of the front scanner is then



automatically forwarded to the rear scanner. The CDS can be used to show the current state of the inputs as well as the selected safety field and the live scan.

The Sick default password is **SICKSAFE**.



**At delivery only one safety field is defined which is permanently active. This safety field is very small and hardly exceeds the robot's footprint in order to allow an easy transportation and testing. It should only be used for early checks and short, supervised driving tests. It is not designed to prevent collisions or for use in any application.**

## 7 Component diagram

The figure below shows a component diagram of the MPO-700.

The platform is moved by four Neobotix Omni-Drive-Modules, each with two independent motors with servo controllers. Only when all drives are coordinated properly the forces generated by the wheels will result in a controlled motion.

Sensor data for navigation are acquired by one or two laser scanners and odometry of drives.

Possible collisions between the platform and obstacles are detected with the laser scanners. The laser scanners can also be used to monitor the surrounding of the robot and to set the platform to emergency stop in case an obstacle is detected in a critical distance. Two emergency stop buttons can be pressed in case of danger to also stop the robot immediately.

In case of an emergency stop two high power relays disconnect all drives from the power supply. If the motors are equipped with fail-safe brakes, these brakes are also engaged immediately.

User interface components are an LC-Display in the top plate of the platform and a joystick for remote control. The on-board computer can be accessed directly via USB and VGA interfaces or indirectly via Ethernet.

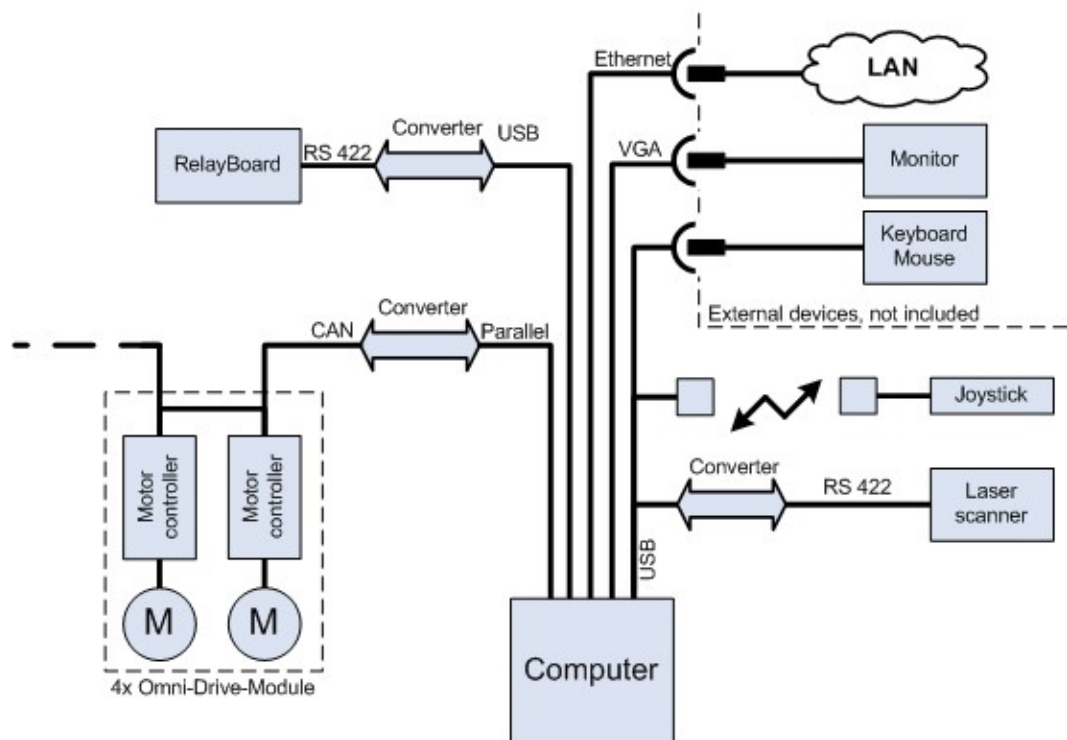


Figure 5: Component diagram of MPO-700

## 8 Technical data

### 8.1 Mechanical properties

#### Dimensions

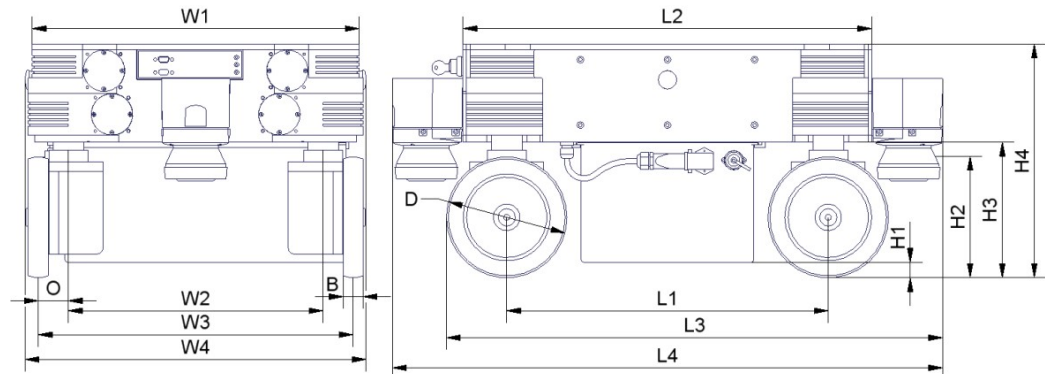


Figure 6: Dimensions of the MPO-700

All dimensions are in millimetres.

Description	Symbol	Value
Width of the top plate	W1	488
Width of the Omni-Drive-Module configuration	W2	380
Recommended track width	W3	470
Maximum width of the platform	W4	509
Wheel eccentricity of the Omni-Drive-Modules	O	45
Width of the wheels	B	30
Diameter of the wheels	D	180
Length of the Omni-Drive-Module configuration	L1	480
Maximum length of the platform	L2	610
Overall length with one laser scanner	L3	741
Overall length with two laser scanners	L4	822
Ground clearance with battery	H1	23
Height of scan plane	H2	181
Ground clearance without battery	H3	202
Height of top plate	H4	348

#### Absolute maximum ratings

Exceeding these ratings might cause malfunctions or damage the robot!

Description	Units	Value
Payload (on cargo space)	kg	300
Maximum speed	m/s	1.0
Maximum bumpiness to pass over ( $\leq 0.25\text{m/s}$ )	mm	15
Maximum bumpiness to pass over (full speed)	mm	5
Storage temperature	°C	-20 .. +50
Operating temperature (environmental temperature)	°C	+0 .. +35

## Positions of sensors

All distances are in millimetres, measured relative to the platform's coordinate system. All angles are in degree, measured counter-clockwise from the driving direction.

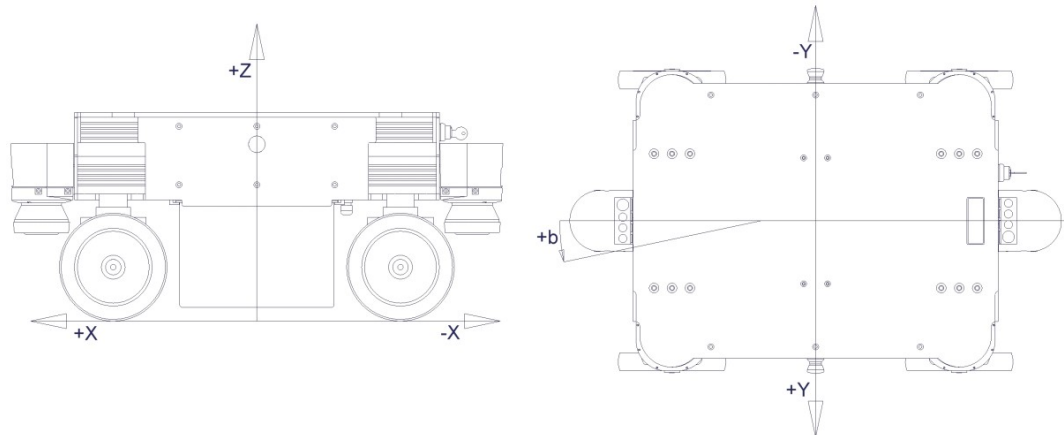


Figure 7: Coordinate system of the MPO-700

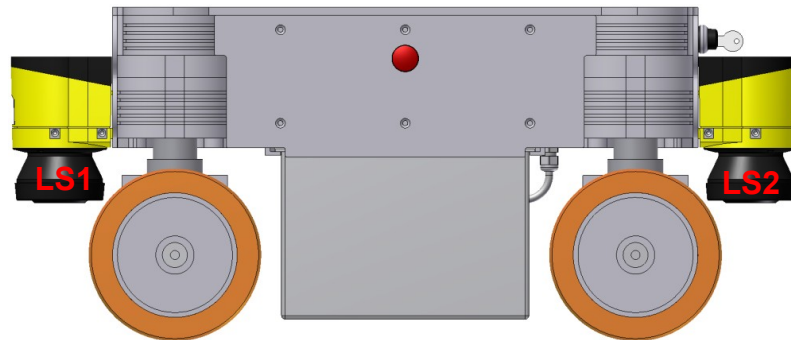


Figure 8: Positions of sensors

Sensor	Symbol	X-pos.	Y-pos.	Z-pos.	b-angle
Front laser scanner	LS1	360	0	181	0
Rear laser scanner	LS2	-360	0	181	180
Front left scanner	(Option)	327	277	201,5	45
Rear right scanner	(Option)	-327	-277	201,5	225

## 8.2 Electrical properties and miscellaneous data

### Properties of internal components

All data are taken from the respective data sheets.

Description	Unit	Value
Motor power	W	400
Rated motor speed	RPM	3.000
Rated motor torque	Nm	1,27
Max. motor torque	Nm	2,32
Encoder resolution	Inc./Rev.	10.000

Gear ratio of orientation drives		19:1
Gear ratio of traction drives (first stage)		15:1
Gear ratio of traction drives (second stage)		2:1
Rated battery voltage	V	48
Max. battery voltage	V	59
Battery capacity (lead-gel)	Ah	28
Battery capacity (lithium-ion)	Ah	55

## Other properties

Description	Unit	Value
Weight	kg	120
Expected working time	a	10

## 8.3 Communication to internal devices

### RelayBoard

The Neobotix RelayBoard communicates with the platform's on-board computer via a RS-422 connection. Detailed information on the RelayBoard and the protocol can be found in the documentation of this board.

### Motor amplifiers

All motor amplifiers and the platform's on-board computer are connected to the same CAN-bus and set to a baud-rate of 1 Mbaud. The amplifiers' settings might need to be changed to match the communication requirements of the used control software.

The configuration software "Composer" from Elmo Motion Control can be used to configure, test and retune all motor amplifiers. Each amplifier can be connected to a COM-port (57600 Baud, no parity) of the configuration computer which runs the "Composer" by using the adapter cable included in delivery.

The documentation of the motor amplifiers ("Whistle" WHI 10-60) and the latest version of the configuration software can be found on the homepage of Elmo Motion Control under [www.elmomc.com](http://www.elmomc.com). An introduction on how to configure the Omni-Drive-Modules can be found in the "Omni-Drive-Module – Assembly Instructions".

The CAN-IDs of the amplifiers are as follows, all amplifiers use group ID 30.

Device	Position	Traction drive ID	Orientation drive ID
A5	Rear right	6	7
A6	Front left	2	3
A7	Front right	8	9
A8	Rear left	4	5

Table 2: CAN-IDs of the motor amplifiers

## 8.4 Connectors

### TE Connectivity – HE14



	Pins	TE Connectivity	Farnell	RS Components
	3 pins, 1 row	281838-3	429582	532-333
	4 pins, 1 row	281838-4	429594	532-349
	5 pins, 1 row	281838-5	429600	532-355
	6 pins, 2 rows	281839-3	429650	532-406
	8 pins, 2 rows	281839-4	429661	532-412
	10 pins, 2 rows	281839-5	429673	532-428
	12 pins, 2 rows	281839-6	429685	532-434
	Crimp contacts AWG 28-24	182734-2	429715	532-456

Table 3: HE14 connectors

### Molex – Mini-Fit Jr.



	Pins	Molex	Farnell	RS Components
	2 pins	39-01-2020	151866	484-1748
	4 pins	39-01-2040	151867	484-1754
	6 pins	39-01-2060	151868	484-1760
	8 pins	39-01-2080	151869	484-1782
	10 pins	39-01-2100	151870	484-1798
	16 pins	39-01-2160	4138399	172-9011
	Crimp contacts AWG 24-18	39-00-0039	9732195	172-9134

Table 4: Mini-Fit Jr. connectors

## 9 The LC-Display

The LC-Display shows the current state of the robot's hardware in two different views.

### 9.1 Main view

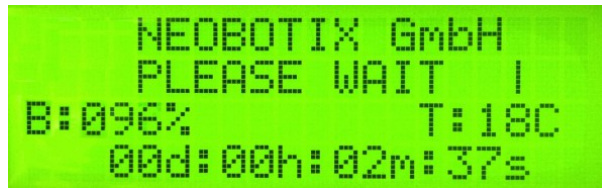


Figure 9: The LCD main view

#### Messages

The first line can be used to print messages sent from PlatformCtrl or a higher level control software. The default message is "NEOBOTIX GmbH".

#### Status information

The second line indicates the robot's current status.

**PLEASE WAIT:** The control software is not yet connected to the robot's main control board.

**READY:** The control software is active and the robot is fully operational.

**EMERGENCY STOP:** One of the emergency stop buttons has been pressed.

**TURN KEY →:** Reset the safety system by turning the key switch clockwise for about one second.



**SCANNER STOP:** An obstacle has been detected within the laser scanner's safety field. As soon as the obstacle has been removed, the safety system will be reset automatically. If a FlexiSoft safety controller is installed, all stops are indicated with this message.

**CHARGING:** The robot is currently charging its batteries.

**SHUTDOWN IN XXs:** The robot will turn itself off in a few seconds.

**BATTERY VOLTAGE LOW:** The battery voltage is critically low and the robot will soon shut down to prevent a deep discharge. Further information can be found in the next section.

**MOTOR ERROR:** At least one motor is reporting an error. This state is quit automatically as soon as all motors are operational again.

**SAFETY RELAY FAIL:** One of the safety relays is damaged. Please contact Neobotix.

**POWER RELAY FAIL:** The power relays are damaged. Please contact Neobotix.

**EMSTOP BUTTON FAIL:** One of the emergency stop buttons does not operate properly. Please contact Neobotix.

**CHARGE RELAY FAIL:** The charging relay is damaged. Please contact Neobotix.



**The charging contacts might still be connected to the batteries!**

**Checksum error:** The protocol versions of the control software and the RelayBoard do not match. Please check the wiring and the log output of PlatformCtrl.



## Battery charge level

**B:096%**

The current charge level of the batteries. Due to the batteries characteristics the actual battery voltage may be higher than the platform's rated main voltage.

Nominal voltage	Shut-down	Working range	Charging
24V	$\leq 22V$	23V .. 25V	25V .. 29V
48V	$\leq 44V$	46V .. 52V	52V .. 58V

Table 5: Voltages of different batteries

## Temperature

**T:20C:**

This is the temperature inside the platform, measured at the main control board.

## Uptime

**00d:00h:02m:37s**

The bottom line shows the uptime since startup in days, hours, minutes and seconds.

## 9.2 Info view

This view mode is not available in all robot types.



Figure 10: The LCD info view

### Version information

The first line of this view shows the hardware version (HV) and the software version (SV) of the RelayBoard. For software updates please contact Neobotix.

### Serial number

The second line shows the serial number (SN) of the RelayBoard.

### Status information

The third line indicates the current configuration of the software and the state of the hardware components.

The asterisk (\*) indicates that the RelayBoard did not yet receive a valid configuration from the control software. After configuration it will be replaced by a C.

The right part shows the state of all CAN bus devices. Motors are indicated by an M, the IOBoard by an I and the USBoard by a U. Devices that are not installed are marked by a dash (-) and devices that failed to connect are marked by an F.

## 10 Maintenance

### 10.1 General maintenance

Maintenance of the Neobotix MPO-700 is very easy and does not cause much work. As long as the advises in this chapter are kept in mind and the robot is treated accordingly, no major work is necessary.

Please mind the following:

- Always keep the robot clean. Dust and dirt might damage the moving parts, especially the synchronous belt and the bearings, or reduce the life expectancy. Metal splinters might cause short-circuiting.
- Check all connectors, especially the high current connectors, regularly and replace them if they show signs of wear or in case the crimped connections of the cables are getting loose.
- Never connect or disconnect any connectors under load. Always turn the robot off before changing any connections.

**Always turn off the robot completely and disconnect both the battery and the charging device before working on the robot. Serious injuries and / or damages might occur if the robot is modified while it is still connected to a power supply!**

### 10.2 Omni-Drive-Modules

In order to optimise the performance of the omnidirectional platform and to maximise its life expectancy, please mind the following:



- Always treat the mobile platform very carefully. Do not overload the platform, do not operate it on uneven ground and do not drop the platform or drive down steps.
- Keep both the mechanical and electrical parts of the modules clean. Dirt on the bearings will cause increased wear and will reduce the life expectancy of the modules.
- Using a faulty control software might lead to severe damages. An insufficient alignment of the modules or bad coordination will also result in damages to the drives.
- Regularly check the drive units for smooth rotation and a constant, soft sound.



- Adjust the filter parameters of the amplifiers in case the behaviour of the drive units does not match the application's requirements. After some time of operation the gear boxes might be running differently which might also affect the drives' behaviour. Use the Composer from Elmo Motion Control ([www.elmomc.com](http://www.elmomc.com)) to access the amplifiers' settings. Please contact Neobotix before you modify the motor controllers.

### 10.3 Fuses

This mobile robot features the following fuses:

ID	Circuit	Position	Type	Current	Speed
F1	Main battery power	Beside battery connect.	Blade	15A	default
F2	Platform device supply	DIN rail	Blade	5A	default
F1'	48V supply terminals	RelayBoard	Micro 5x20	3A	slow
F3	Emerg. stop buttons	RelayBoard	Micro 5x20	2A	fast

## 10.4 Replacing the battery

If the battery of the MPO-700 has to be removed first shut down the on-board computer and turn off the robot. In case a lithium-ion-battery is used it should be switched off after the robot was turned off.

Disconnect the battery from the robot and remove the latch that holds the battery in place. Then slowly slide the battery out of the carrier rails.

**Take care not to drop the battery once it comes free completely.**

To insert a new battery first make sure that the battery is switched off (in case of a lithium-ion-battery) then simply follow the above steps in reverse order.

## 10.5 Charging the battery

### Lead-Gel-Battery

The default battery of the MPO-700 consists of four 12V-lead-gel-batteries connected in series. This battery pack can be charged conveniently and safely by using the provided battery charger. First connect the battery charger to the charging connector at the side of the battery and then turn on the charger. After the battery has been fully charged first turn off the battery charger and then disconnect the cable.



**Never connect or disconnect the battery charger while it is switched on! Increased wear of the contacts due to electric arcs may occur. The battery or other electrical components may be damaged.**

Please also read the documentation that was supplied together with the battery charger.

The robot's battery has sufficient capacity for approximately five hours of operation.

This capacity will reduce over time until at some point (approximately after 1000 charging cycles or two years) the available runtime is no longer sufficient and the batteries need to be replaced.

There are several measures to prolong the life of the batteries and to save costs and resources:

- Recharge the robot whenever possible
- Avoid deep discharge and reaching the automatic shut-down voltage
- Charge the robot while it does not need to move (e. g. while programming)
- Do not leave the robot with discharged batteries for a long time

Lead batteries in AGM design are generally very tolerant and significantly less dangerous than lithium-ion-batteries. Heat, age or wrong treatment may nevertheless cause damages.



**Regularly check the batteries' condition, at least once every month! The following points indicate battery damages:**

- Deformation or stretching of a battery's body
- White or brownish spots at the battery contacts or other metal parts
- Excess heat
- Strong smell of sulphur
- Liquid below the battery



**As soon as you notice any kind of damage the batteries must no longer be used and must not be charged any further!**

**Please contact Neobotix immediately.**

In chapter "Recycling" you can find information on how to treat old batteries.

## Lithium-Ion-Battery

In order to optimise the performance of the lithium-ion-battery and to maximise its life expectancy, please mind the following:



- Always treat the battery very carefully. Do not drop the battery and avoid heat or direct sunlight.
- Try to run complete charging / discharging cycles whenever possible to increase the battery's life expectancy. Recharging the battery only partially will decrease its capacity in the long run.

- Disconnect the battery whenever the robot is to be operated stationary (e. g. when programming) and use the external charging device as power supply. This will prevent micro-charging cycles.

- Always set the battery charger to an output voltage of **52V** and a maximum current of **10A**. Use the preset program **P1** and mode **Preset** to ensure that the correct values are used.



- **Never connect or disconnect the battery charger while it is switched on! Increased wear of the contacts due to electric arcs may occur. The battery or other electrical components may be damaged.**



- The battery is fully charged when the charging current has decreased to **0,5A**.

- The battery must be activated before it can be charged. Use either the rocker switch on the battery itself or the appropriate contacts of the battery's connector to activate it. See the electric circuit diagram for further information.

## 11 Taking out of service

### 11.1 Disassembly



Once the MPO-700 has reached the end of its lifetime it should be disassembled and its components should be recycled.

Before the robot can be disassembled the battery charger, any other external power supply and the battery must be disconnected from the robot. It is strongly recommended to wait for at least 30 minutes after disconnecting all power sources before starting the disassembly. This will help to discharge any electrical energy that might be left in the system.

Disassembly of the MPO-700 should be done by technicians only, preferably someone who has already worked on the robot in the past and knows its technical details. This will ensure:

- Fast and trouble-free disassembly
- Reduced risk of injuries or damages to components that are to be reused
- Proper sorting of parts according to materials and way of recycling

### 11.2 Recycling

#### Reusable components

Many components of the MPO-700 (e. g. the servo motors and the amplifiers) have a very long life expectancy and will most probably still be usable when the overall system has reached the end of its lifetime.

Please check carefully which components can be reused immediately or in later projects and make sure that they are removed with care.



**Reusing components does not only help the environment by reducing resource consumption but will also save a significant amount of money.**

#### Mechanical parts

The frame of the MPO-700 and the Omni-Drive-Modules are made up from aluminium parts and steel connectors and only very few parts are made from other materials. When separated properly, all these parts can be recycled easily by selling them to companies specialised in metal recycling.

#### Electrical components

Electronic scrap is both a source of valuable resources and a threat to the environment and must not be treated like consumer waste.

**All electrical wires and components must therefore be collected and sold to or deposited at the appropriate recycling facilities.**

#### Batteries

The default batteries used for the MPO-700 are Lead-Gel-Batteries.

**Under European law this kind of battery must only be returned to certified recycling companies.**

In case there is no local battery recycling facility available, that accepts the lithium-ion-battery, this battery can be returned to the manufacturer.

**The lithium-ion-battery must not be opened or disassembled!**

**Please follow the transportation directives for hazardous goods of level 9 when shipping the lithium-ion-battery.**



## 12 Legal notes

### Version information

This document has been translated and is not the original. Please refer to the German version in case of uncertainties or questions.

### Liability

Every care has been taken in the preparation of this manual which represents the state of technology at the time of its composing. However, inaccuracies or omissions might occur. Please inform Neobotix in case you notice any.

The Neobotix GmbH cannot be held responsible for any technical or typographical errors and reserves the right to make changes to the product and manual without prior notice.

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Neobotix GmbH shall not be liable or responsible for incidental or consequential damages in connection with the improper use of one or more of the products described in this manual.



### Declaration of conformity

This product fulfils all relevant directives of the European Union. For further information please contact Neobotix.

### Downloads and further information

Additional information, data sheets and documentations, also for the other products of Neobotix, can be found on our homepage [www.neobotix-roboter.de](http://www.neobotix-roboter.de).

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