



MPO-500

Neobotix GmbH

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Operating Instructions

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This chapter describes the first steps to take your robot into operation for the first time. Following the steps below allows you to confirm the integrity of the robot's hardware and software and to test its basic functionality.

1.1 Accessories and Preparations

Tip: In the documentation supplied with the robot, you will also find the access data for your personal [customer area](#)¹ on our website. Individual documents and information on customised adjustments to your robot as well as the configuration files of all relevant components as they were on delivery are stored there. If you use PlatformPilot, you can also download the GTK GUI for setting up the robot here.

In addition to the mobile robot, you will also find a wired charger, various small parts and some documentation in the transport box. You will need the master key, the wireless gamepad and the WLAN access point to start up your robot for the first time.

¹ <https://www.neobotix-roboter.de/login/>



Unpack the access point and connect it to the power supply unit or to a USB port on your computer using the cable supplied. Optionally connect the access point to your company/home network via ethernet to enable internet access on the platform when needed.

The access point sets up an independent local WLAN network into which the robot automatically connects after start-up. The network name (SSID) and password can be found in the documentation supplied with the robot. You can connect to this network with any laptop and then communicate with the robot as described below.

The key is used to switch the robot on and off and to release the safety system. For the first tests, simply insert it into the key switch. For regular operation, however, the key should not remain on the robot but should be under the supervision of a suitably *qualified* (page 43) and trained operator who is responsible for the safe operation of the robot.



The gamepad batteries have either been insulated or removed for transport to prevent premature discharge. Open the battery compartment on the underside of the gamepad and insert the enclosed batteries or remove the insulating tape

from the batteries before closing the compartment again.



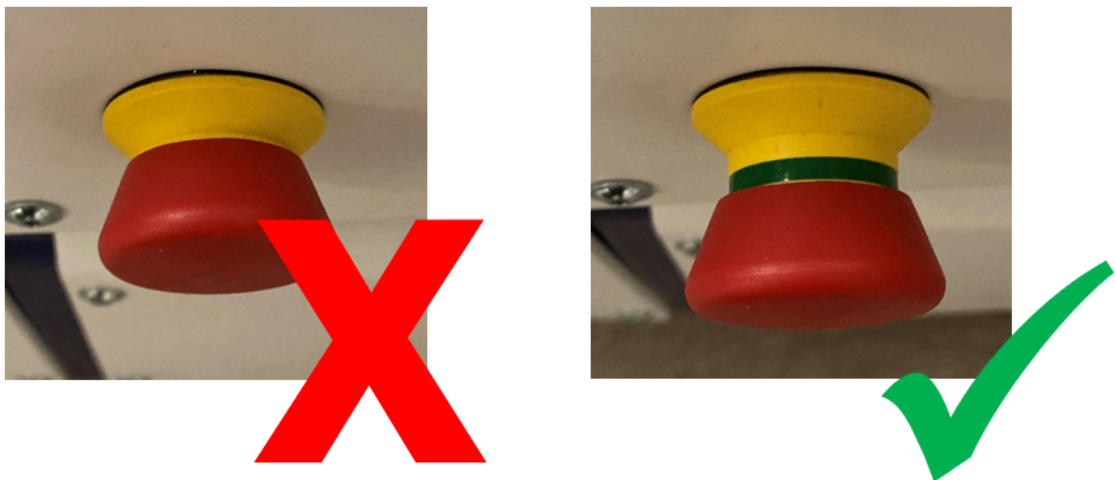
Depending on the type of batteries used and the transport route, the batteries must first be reinstalled and connected after unpacking the robot. The exact procedure for this is described in the Maintenance chapter of the manual of your robot.

If your robot uses LiFePO4 batteries, they may need to be woken up from transport mode, as explained [here](#) (page 25). In any case, LiFePO4 batteries must first be activated by flipping the rocker switch next to the charging socket. Only then can the robot be switched on.

1.2 Starting up and Moving by Joystick

A detailed description of the controls and LED indicators can be found [here](#) (page 23).

Before switching on the robot, unlock all emergency stop buttons by turning them. When the buttons are unlocked, a green band can be seen between the red mushroom button and the yellow base.



Turn the key switch clockwise to switch on the robot.

1.2.1 ROX and EMROX Robots

After a few seconds you will hear the fan of the on-board computer start up and a little later the LED strips around the platform will light up. The robot first performs a self-test and cycles through all available colours before switching to the regular *status indication* (page 23). As soon as the robot lights up constantly in green, it is ready for use.

1.2.2 MP and MPO Robots

The LCD will immediately light up, showing the basic status of the robot. After about one minute the display will show “Ready”. This means that the software has successfully started up and is able to communicate with all hardware components. You can find more information about the LCD [here](#) (page 21).

Please note that the MPO-700 and MMO-700 will perform a homing of the OmniDriveModules after start-up and before the robot is ready for operation. To do so all emergency stop buttons must be unlocked and the scanners’ safety fields must be clear of obstacles. All OmniDriveModules will slowly rotate around the vertical axis and then stop with the wheels facing outwards. The robot will stay in place during this procedure.

1.2.3 Joystick Usage

Now press any button on the gamepad. The green LED in the centre of the gamepad lights up briefly and indicates that a wireless connection to the robot platform has been established.

Note: Depending on the control software the gamepad has to be set to the correct mode via the small sliding switch at its front.

- When using PlatformPilot please switch to X.
 - For ROS please use setting D.
-



Press the blue X button to switch the robot to manual joystick mode. You can then move the robot using the two analogue sticks. The top right should button RB on the gamepad works as deadman switch. It must be pressed continuously for the robot to move.

- The left stick controls the translational movement, i.e. forwards and backwards movement on the Diff and Trike models, and movement in the plane on the omnidirectional Argo and Meca models.
- The right stick controls the turns, i.e. cornering and turning on the spot for Diff and Trike, and all superimposed turns at any time for Argo and Meca.

Warning:

- On delivery, only the basic safety functions are active and only basic protective fields are configured. Depending on the environment, superstructure and speed, collisions are still possible. Please take appropriate care during your first driving attempts and adapt the safety configuration to your individual requirements as soon as possible!
- In joystick mode, predictive collision avoidance is not active and the safety system works purely reactively via the protective fields of the laser scanners. Automatic intelligent collision avoidance is only available in automatic mode.

1.3 Connecting the GUI

1.3.1 PlatformPilot-GUI

Connect your computer to the `neo-training` network set up by the access point as described above.

The default IP addresses of your mobile robots are `192.168.0.50` for the first one, `192.168.0.51` for the second one, and so on. Please see the documentation that came with each platform to get a definite answer. Open a web browser (we recommend Firefox) and enter `http://192.168.0.50:8888` as the address. This address will take you to the WebGUI integrated in PlatformPilot and give you an immediate overview of the robot's status.

For mapping and further setup of your application, please use the [GTK GUI](#)² that you can download from your [customer area](#)³ on the Neobotix website.

1.3.2 ROS

If you are using ROS to control the robot, RViz is a good tool for the first connection and check after delivery. A description of the first steps can be found [here](#)⁴.

1.4 Shutting Down the Robot

1.4.1 ROX and EMROX Robots

To shut down your robot turn and hold the key in counter-clockwise direction. The LEDs will flash white to indicate that the shutdown signal has been detected. Hold the key in this position until the light stops flashing and turns to constant white instead. It will then slowly fade out until the robot switches itself off.

² <https://neobotix-docs.de/pilot/#pilot-gui>

³ <https://www.neobotix-roboter.de/login/>

⁴ https://neobotix-docs.de/ros/ros2/starting_with_ROS.html#visualize-the-data-with-rviz

In case the robot uses LiFePO4 batteries and will probably not be used or charged for some time, please remember to deactivate the batteries as described here.

1.4.2 MP and MPO Robots

To shut down your MP or MPO robot turn and hold the key for at least 3 seconds in counter-clockwise direction until the LC-Display shows that the shutdown has been triggered. Depending on the model of on-board computer the robot may switch itself off before the countdown has finished or simply when reaching zero.

1.5 Important Basic Settings

Depending on the location and the network infrastructure to be used, various settings may need to be made directly in the operating system of the on-board computer. All Neobotix robots offer the option of accessing the on-board computer directly via monitor and keyboard/mouse. However, VNC remote access is often faster and more convenient.

1.5.1 Remote Desktop Connection (VNC)

Once the platform has booted and your computer is connected to the same WLAN network you can connect to the robot using a software tool. The Remmina Remote Desktop Client should already be installed on most Ubuntu distributions. When using Windows we have had good experience with TightVNC.

The image shows a 'Remote Desktop Preference' dialog box with a dark title bar and a close button. The dialog is divided into two main sections. The top section contains fields for 'Name' (mpo_700), 'Group' (empty), 'Protocol' (Remmina VNC Plugin), 'Pre-command' (command %h %u %t %U %p %g -option), and 'Post-command' (/path/to/command -opt1 arg %h %u %t -opt2 %U %p %g). Below this is a tabbed interface with 'Basic', 'Advanced', 'Autostart', and 'SSH Tunnel' tabs. The 'Basic' tab is active and contains fields for 'Server' (10.1.30.50), 'Repeater' (empty), 'Username' (neobotix), 'User password' (masked with dots), 'Color depth' (True color (32 bpp)), 'Quality' (Best (slowest)), and 'Keyboard mapping' (empty). At the bottom are buttons for 'Cancel', 'Save as Default', 'Save', 'Connect', and 'Save and Connect'.

1.5.2 System Time and Hardware Clock

By default the hardware clock is set to UTC and the time zone is set to Berlin. If you operate the platform in a different time zone it is necessary to change the time zone.

In addition the system time should always be set correctly if possible, since otherwise some functionality may not work properly (when connecting to the platform from another PC).

Automatic network time synchronization is disabled by default because it can cause the platform to fail during operation. In order to adjust the time, it is best to first set the system time (which is only temporary) using `Xfce Settings >> Time and Date` and then synchronize the hardware clock to the current system time as follows:

```
sudo hwclock -w
```

↓ Download as PDF⁵



The mobile robot MPO-500 features four Mecanum wheels which provide an extraordinary manoeuvrability. Each Mecanum wheel has several independent rollers mounted along its circumference. The axles of the rollers are rotated at 45° to the wheel's main axle. This design enables the robot to instantly move into any direction: **The Mecanum wheels make it truly omnidirectional.**

This kinematics offers a number of interesting advantages over other systems like Omni wheels or the Omni Drive Modules of the MPO-700:

- Mecanum wheels have proven themselves worldwide since 1973,
- they require only a very simple and robust drive system,
- they allow instantaneous motion without alignment and
- the required control software is very simple.

⁵ <https://neobotix-docs.de/hardware/en/MPO-500.pdf>

These extraordinary features have made Mecanum wheels a very popular solution especially in robotics research.

2.1 Product Information

2.1.1 Intended Use

The MPO-500 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-500 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-500 may only be used in laboratories, test halls or similar environments. It is not recommended to use the MPO-500 in any other surrounding, especially not outdoors, in offices or factories.

2.1.2 Improper Use

Danger:

- The mobile robot must not be used for transportation of passengers in any way. No person must ride on the robot itself, nor must the robot be used to move any other vehicle or hanger with passengers aboard.
- The mobile robot must not be operated in any publicly accessible area without assessment of risks. If the robot is to be modified either permanently (e.g. by mounting additional components) or temporarily (e.g. by loading cargo) its safe operation must be assessed and approved.
- Without the safety approval described above, the mobile robot 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!

2.1.3 Working Area

The working area of the mobile robot must be protected against rain and have a sufficiently firm and clean floor. The floor must be even and horizontal.

Tip: 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.

Under certain conditions, rain or heavy splash water might enter the robot and cause damages. Flying sparks, heavy dust and similar dirt may affect or damage the sensors and thus might make the operation of the mobile robot inefficient or unsafe. Dirt and liquids on the floor may lead to slippage and problems of localisation and navigation.

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 place

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

2.1.4 Qualified Personnel

This product must only be modified, commissioned, operated and serviced by qualified personnel.

The requirements on qualified personnel can be found at *Qualified Personnel* (page 43).

2.1.5 Safety Instructions

Please also check the general safety instructions for Neobotix robots which can be found at *Safety Instructions* (page 37).

2.1.5.1 Danger Areas

Wheels

Due to their unique design, the four Mecanum wheels of the MPO-500 have a higher potential for danger than normal wheels. Please mind the following in order to prevent injuries or damages:

- Never touch the wheels of the moving robot and also prevent guests, passers-by and especially children from touching them.
- Take care that no part of the cargo or additional components (e.g. cables, wires) can touch the wheels.
- Make sure that the working space of the MPO-500 is free of all objects which might be caught in the wheels. Different from normal wheels Mecanum wheels may not only run over objects but objects might also get stuck in the wheels and might be moved along.
- In case additional safety measures are required please contact Neobotix. We will provide wheel housings designed for your application.

Battery Drawer

Both the outsides of the robot and the battery drawer are completely safe to touch while the robot is in use. Nevertheless, opening the battery drawer allows one to reach into the robot platform and to touch powered components.

Warning: Never reach into the robot platform while the system is turned on. There is risk of electric shock!

All cables and wires on the batteries and inside the drawer are placed and cut to length in a way that will prevent damages during normal operation. Modifying or moving these parts might cause damage to the wires.

Warning: Always take great care that no cables are clamped between drawer and platform or get caught in the telescopic slides. Please contact Neobotix immediately when noticing any damages to the cables.

A robot with damaged battery cables must not be operated in any case!

Laser Scanner Positions

The height of the scanning plane of the laser scanners must be chosen according to the applications safety requirements. In case the robot is to operate fully autonomously and without supervision in an area where it might encounter unconscious people the scanning plane should be no more than 200 mm above the ground.

Each laser scanner has a 270° wide field of view which is symmetric to the scanner housing. Therefore the positions of the laser scanners must also be chosen in consideration of blind spots.

Please contact Neobotix if the positions of the laser scanners has to be modified.

2.2 Operating Elements

The figure below shows the tail of the MPO-500 and the most important operating elements.

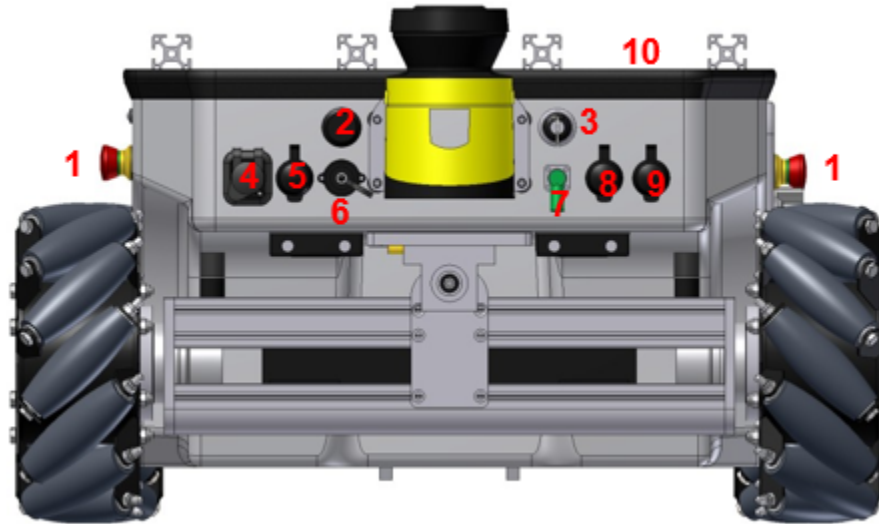


Fig. 1: Operating elements of the MPO-500

1	Emergency stop buttons
2	Brake release button
3	Key switch
4	HDMI socket
5	Wireless joystick receiver
6	Charging socket
7	Connector for 2nd scanner
8	Ethernet socket
9	USB socket
10	LC-Display

2.2.1 Emergency Stop Buttons

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 are engaged. This state can be reset by unlocking the emergency stop buttons

and turning the *Key Switch* (page 20) clockwise to position II for a few seconds.

2.2.2 Key Switch

See *Key Switch* (page 20).

2.2.3 Brake Release Button

Pressing this button will open the motors' brakes allowing the robot to be moved even while it is turned off.

2.2.4 Charging Socket

The battery charger can be manually connected to this socket. Further information can be found at *Charging* (page 29).

2.2.5 LC-Display

This display shows the most important status information.

A detailed description of the LCD can be found in *LC Display* (page 21).

2.2.6 Access to the On-Board Computer

An HDMI socket, a USB socket and an Ethernet port can be used to work on the computer and to prepare the robot for the next application.

2.3 Mechanical Properties

2.3.1 Dimensions

Description	Symbol	Value (mm)
Wheel diameter	D	254
Ground clearance	G	45
Height of the mounting plane	H1	386
Height of the scanner cover	H2	409
Overall length of platform	L1	988
Length of inner aluminium profiles	L2	680
Length of outer aluminium profiles	L3	380
Distance from platform centre to wheel axes	L4	250
Maximum length to platform centre	L5	494
Width of top plate	W1	500
Distance from platform centre to outer aluminium profiles	W2	219
Distance from platform centre to inner aluminium profiles	W3	73
Track width	W4	548
Maximum width	W5	662
Size of aluminium profiles	P	30

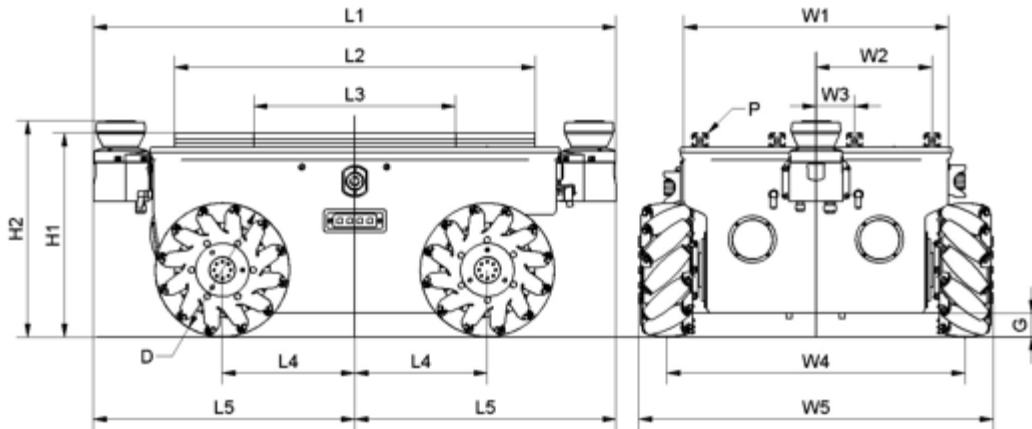


Fig. 2: Dimensions of the MPO-500

2.3.2 Absolute Maximum Ratings

Warning: Exceeding these ratings might cause malfunctions or damage the robot!

Description	Units	Value
Storage temperature	°C	-20 .. +50
Operating temperature (environmental temperature)	°C	+0 .. +25
Payload (equally distributed to aluminium profiles, default version)	kg	80
Payload (equally distributed to aluminium profiles, high payload version)	kg	250
Maximum speed	m/s	0.9
Maximum bumpiness to pass over	mm	5
Maximum acceleration	m/s ²	2.4

2.3.3 Positions of Sensors

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

Sensor	Symbol	X-pos.	Y-pos.	Z-pos.	a-angle	b-angle
Front laser scanner	LS1	442	0	372	0	0
Rear laser scanner	LS2	-442	0	372	0	180

2.3.4 Electrical Properties and Miscellaneous Data

2.3.4.1 Properties of Internal Components

All data are taken from the respective data sheets.

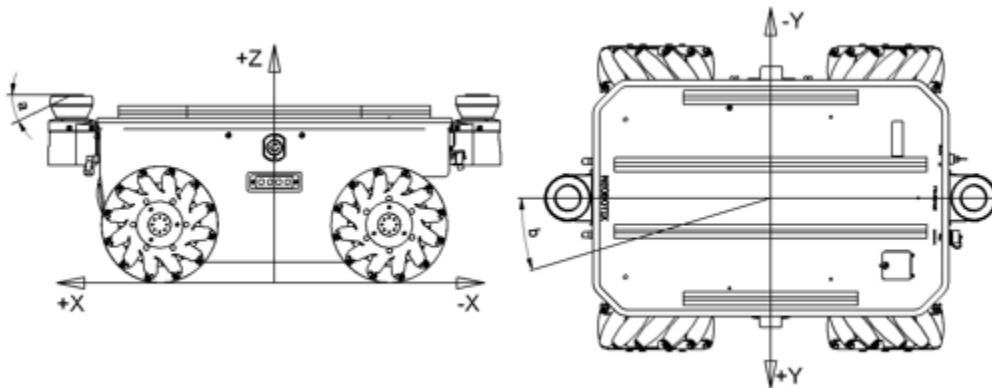


Fig. 3: Coordinate system of MPO-500

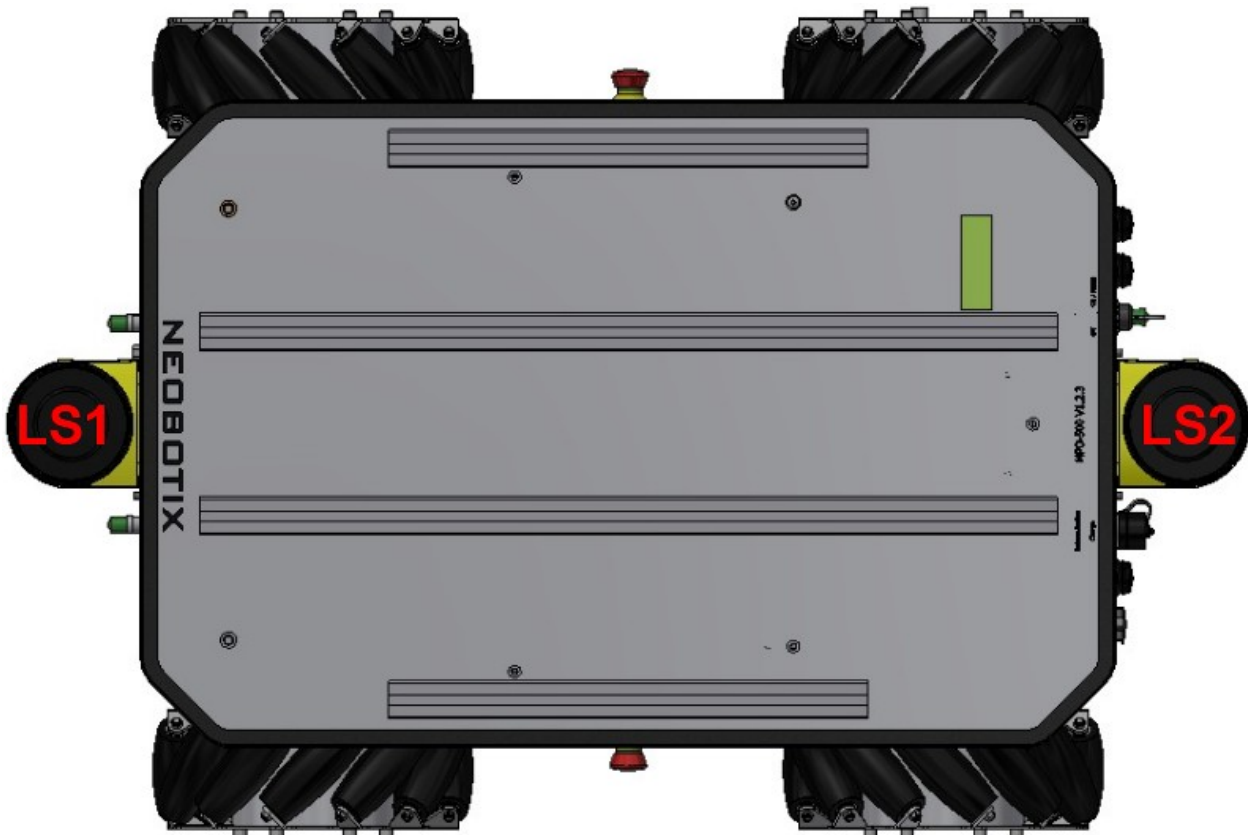


Fig. 4: Positions of the laser scanners

Description	Units	Value
Motor power	W	300
Rated motor speed	rpm	3000
Maximum motor speed	rpm	5000
Possible motor speed (at battery voltage)	rpm	1800
Rated motor torque	Nm	0.95
Maximum motor torque	Nm	1.91
Brake torque (static)	Nm	1.47
Encoder resolution	Increments/Revolution	10000
Gear ratio	1	25:1
Rated battery voltage	V	24
Maximum unregulated voltage	V	29
Battery capacity	Ah	50

2.3.4.2 Metering Capacities of Sensors

All data are taken from the respective datasheets. Distances are measured in meters, angles are measured in degree.

Sensor	Resolution	Min.range	Max. range	Hor. angle	Vert. angle
Laser scanner	0.5°	0	30	±135	0
Ultrasonic sensors	~±0.01 m	0.25	1.5	±60	±30

2.3.4.3 Other Properties

Description	Units	Value
Weight	kg	80
Expected working time	a	10

2.3.4.4 Connectors

See chapter *Connectors* (page 34).

2.4 Transport

2.4.1 Packaging

The mobile robot MPO-500 is packed in a rugged wooden box which can be reused for future transports. If the original box cannot be used anymore 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 enter the robot, the maintenance opening should be closed and all connectors should be fastened or covered prior to packing the robot.

Tip: Depending on the cushioning material it might be advisable to protect the brake release button against unintended activation. If this button is pressed during transport, the robot may move inside the box and the batteries might get

discharged. Furthermore, the key of the key switch should be removed and transported separately to avoid damages to the key and the switch. Further information on the control elements can be found at *Operating Elements* (page 11).

2.4.2 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 can take hold at the bottom of the hull.

Warning: Never try to lift the robot by holding it at the exterior components mounted to the hull or at the aluminium profiles on the top plate! Neither the exterior components nor any part of the platform's top plate has been designed for lifting forces and they may be damaged.

2.4.3 Short Distance Transport

For short distances the MPO-500 can also be transported in the trunk of a car without the wooden box. It still must be secured against sliding and should not be driven outdoors.

2.4.4 Long Distance Transport

As long as the robot is packed properly there are no special requirements when shipping the MPO-500. 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.

If the brake release button was covered and the key switch was removed there is no risk of the robot being turned on during the transport or the batteries being discharged.

Tip: To eliminate every risk when shipping the robot it is recommended to disconnect all the batteries and to ship them outside the robot. This will prevent short-circuiting and other damages. The batteries are leak proof and approved for airfreight.

2.5 Maintenance

Information on hardware maintenance, cleaning and general precautions when working on the mobile robot can be found in *Maintenance* (page 42).

The robot's hardware is almost maintenance-free and the platform is not intended to be opened unless when used for research. Please contact Neobotix before disassembling the robot!

2.5.1 Software

Apart from research or maintenance it will not be necessary to connect mouse or keyboard because the robot can be controlled via wireless LAN and the graphical user interface. Even most software updates can be performed by remote access.

In order to access the platform's on-board computer directly, an HDMI, a USB and an Ethernet socket are available at the rear side of the platform.

Please refer to chapter *Operating Elements* (page 11) for further information.

2.5.2 Cleaning

To achieve a long life of the platform and guarantee a satisfying operation, the platform should be checked and cleaned regularly. General information on how to clean the robot and its sensors can be found in *Maintenance* (page 42).

Warning: The robot is only splash-water proof if the battery drawer is closed and locked, the charging socket is sealed by its cap, all computer access sockets are covered and the cables of both laser scanners are connected properly. Do not wet the robot while one of these components is not assembled correctly!

2.5.3 Batteries

General information on the available battery type, as well as on battery maintenance and recycling, can be found at *Batteries* (page 24).

In case you want to replace the batteries yourself please follow these steps:

1. Switch off the robot.
2. Switch off and disconnect the battery charger.
3. Remove all additional modules from the robot's top plate.
4. Remove the screws holding the top plate (seven screws by default).
5. Carefully lift up the top plate and disconnect any remaining cables.
6. Remove the top plate.
7. Disconnect the connectors of both batteries.
8. Remove the cushioning from in between the batteries.
9. Slowly lift the batteries out of the platform and take care not to damage any cables.
10. Slowly place the new batteries into the platform while taking care not to damage any cables.
11. Connect both batteries to the robot.
12. Replace the cushioning and check if the batteries are locked in place.
13. Place the top plate back on the robot and reconnect its cables if necessary.
14. Align the top plate and arrange the foam rubber sealing properly to achieve best splash water protection.
15. Fasten the top plate to the platform and mount all modules removed earlier.

If you encounter any problems, please contact Neobotix immediately.

2.5.4 Battery Replacement (Quick Change)

The quick change system allows the batteries to be replaced without the use of tools. Please follow these steps:

1. Switch off the robot.
2. Switch off and disconnect the battery charger.

3. Unlock the battery drawer by turning the three black knobs counter-clockwise for 180°.
4. Slowly open the drawer.
5. Disconnect the batteries.
6. Lift the batteries out of the drawer.
7. Carefully place the replacement battery with the long cable into the drawer and push it fully inside.
8. Place the battery with the short cable into the drawer while taking care not to damage any cables.
9. Connect both batteries to the connectors inside the drawer.
10. Slowly close the drawer while taking care not to damage the cables.
11. Turn all three knobs clockwise for 180° to lock the drawer.

2.5.5 Fuses

The mobile robot features the following fuses:

ID	Circuit	Position	Type	Rated Current	Characteristics
F1	Main Battery Power	Inside Battery Drawer / Next to Charging Socket	ATO blade fuse	20 A	default
F1'	24 V Terminals	RelayBoard	Micro 5x20	5 A	slow
F3'	Emergency Stop Buttons	RelayBoard	Micro 5x20	2 A	fast
F4'	Brake Release Button	RelayBoard	Micro 5x20	3A	slow

2.6 Taking out of Service

You can find further information about taking out of service and about recycling [here](#) (page 44).

2.7 Legal Notes

The general legal notes can be found at [Legal Notes](#) (page 45).

2.7.1 EU Declaration of Conformity



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

2.7.2 RoHS Information



As *non-road mobile machinery* our mobile robots are explicitly exempted from the scope of the RoHS directive 2011/65/EU. We have nevertheless followed the underlying principles of RoHS and tried to reduce the use of harmful and dangerous substances in our products as much as possible.

General Hardware Information

3.1 Key Switch

All Neobotix robots are equipped with a key switch to turn the robot on and off and to reset emergency stops. It can only be operated as long as the key is inserted.

3.1.1 Turning on

To start the robot, turn the key clockwise (towards position II) and then release again.

If the robot has an LC display, it will light up instantly. If the robot has LED lighting, the LEDs will cycle through all available colors once the robot becomes operational and then change to one of the signals described at *LED Lighting* (page 23).

3.1.2 Emergency Reset

After an emergency stop was issued and the emergency buttons have been unlocked again, the safety system can be reset. Turn the key clockwise (towards position II), hold for about one second and then release again.

Depending on the model, the robot will show the status change either through the LC display or through the LEDs.

3.1.3 Shutting down

Turn the key counter-clockwise (towards position I) and hold for a few seconds to initiate the shutdown. If an LC display is present, it will show a message, if LEDs are present, they will signal the shutdown procedure.

During the shutdown process, the platform software (if running) terminates and shuts down the operating system.

In case the on-board computer is shut down remotely via the GUI of the control software, the robot will turn off automatically.

3.1.4 Switching off

To immediately turn off the robot without waiting for the on-board computer to shut down, turn the key switch counter-clockwise (towards position \perp) and hold it until the LCD or LED light switches off.

Note: With this method, the robot is shut down by cutting the power supply. This may damage the on-board computer's hard- and software.

3.2 LC Display

Some Neobotix robots are equipped with an LC display to display current status information.

3.2.1 Main View



3.2.1.1 Messages

The first line can be used to print messages sent from ROS, PlatformPilot or any other high level control software. The default message is "NEOBOTIX GmbH".

3.2.1.2 Status

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 Flexi Soft 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 your software.

3.2.1.3 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
24 V	≤ 22 V	23 V .. 25 V	25 V .. 29 V
48v	≤ 44 V	46 V .. 52 V	52 V .. 59 V

3.2.1.4 Temperature

T:20C This is the temperature (in °C) inside the platform, measured at the RelayBoard.

3.2.1.5 Uptime

00d:00h:02m:37s The bottom line shows the uptime since startup in days, hours, minutes and seconds.

3.2.2 The Info View

This view mode is not available in all robot types.



3.2.2.1 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.

3.2.2.2 Serial Number

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

3.2.2.3 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.

3.3 LED Lighting

All ROX platforms feature LED lights on all sides in the gap between upper and lower platform cover. The robot's current status is indicated as follows.

Color	Pattern	Description
All	Changeover	Self-check at startup. In case of interruptions or unusual patterns please shut down the robot and contact Neobotix.
Red	Constant	Regular emergency stop, check emergency stop buttons and wireless emergency stop system, unlock them, and reset the system by turning the key switch clockwise.
Red	Blinking, slow	Non-critical error, e. g. brake release button is pressed.
Red	Blinking, fast	Critical error, please contact Neobotix.
Yellow	Constant	Scanner stop, remove obstacle from the safety field or switch safety field, robot will continue operating automatically.
Yellow	Blinking, slow	Platform is moving.
Yellow	Blinking, fast	Working device or robot arm is active.
Green	Constant	Robot is ready but idle.
Green	Pulsing, slow	Robot is in standby mode.
Blue	Blinking, slow	A manual reset via the key switch is required.
Turquoise	Constant	Charging is finished
Turquoise	Pulsing	Charging in progress.
White	Blinking, fast	Command to shut down has been detected, hold the key switch until the LEDs light up white and start fading.
White	Fading	Robot is shutting down and will switch off in a few seconds.

3.4 Batteries

3.4.1 Battery Types

3.4.1.1 AGM Batteries

AGM batteries (Absorbent Glass Mat) are lead acid batteries that contain a fibreglass mesh between the battery plates. This mesh contains the electrolyte and prevents leakages even if the batteries are stored upside down or when the outer casing is cracked. This technology is well proven, cheap and widely available. Its drawbacks are a low energy density, resulting in high weight for a given capacity, and a limited number of charge-discharge cycles.

Their capacity will reduce over time until at some point (approximately after two years of use) the robot's available uptime is no longer sufficient and the batteries need to be replaced.

There are several measures to prolong the life of AGM 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, for example while programming for several hours.
- Do not leave the robot with empty batteries for a long time.

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

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

- Deformation or stretching of the battery's casing
- 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.

3.4.1.2 LiFePO4 Batteries

Lithium iron phosphate batteries, also known as LiFePO4 or LFP batteries, are a rather recent development in lithium-ion battery technology. They provide several benefits compared to AGM batteries as well as other lithium-ion designs.

LiFePO4 batteries are not necessarily smaller than AGM batteries but save about 60% of weight at the same nominal capacity. Under actual use conditions their usable capacity is even higher than that of AGM batteries, because they can be fully discharged. Similar deep discharge of AGM batteries quickly leads to loss of capacity or other damages.

Thanks to their chemistry LiFePO4 batteries provide a very stable output voltage and support fast charging. This not only reduces the recharge time significantly but also allows short periodic charging at convenient locations inside the workspace. When done properly this in-process-charging enables the robot to operate 24/7 without being taken out of operation for recharging.

LiFePO4 batteries are intrinsically much more stable than other lithium based designs. In addition our LiFePO4 batteries also contain a sophisticated battery management system (BMS) that constantly monitors their condition and health. The status information of the BMS is read by the robot's control software and used to indicate potential problems.

Warning: If you notice anything unusual about the LiFePO4 batteries immediately switch off the robot, stop charging and contact Neobotix!

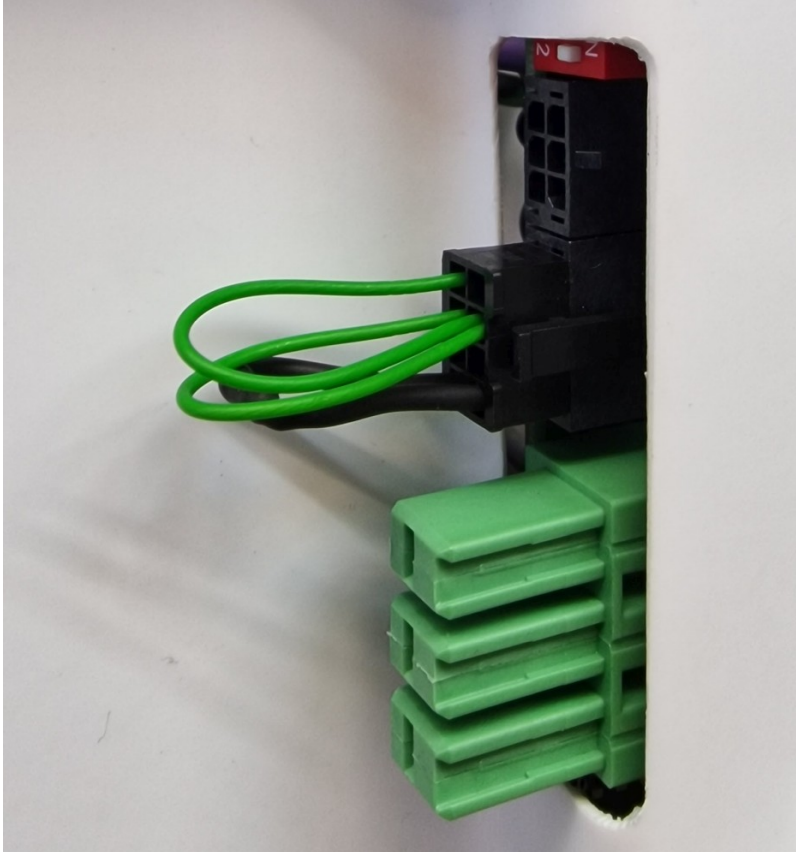
Waking up of LiFePO4 Battery Packs

Lithium-based batteries may only be transported with a low residual charge and in a safe condition. For this purpose, the rechargeable batteries used by Neobotix can be set to a special power-down mode in which the battery management system only consumes minimal energy and the battery can no longer be activated without further ado.

Note: In the event of a fault or deep discharge, the batteries also switch to power-down mode and can be woken up again in most cases as described here.

To wake up a battery pack, proceed as follows:

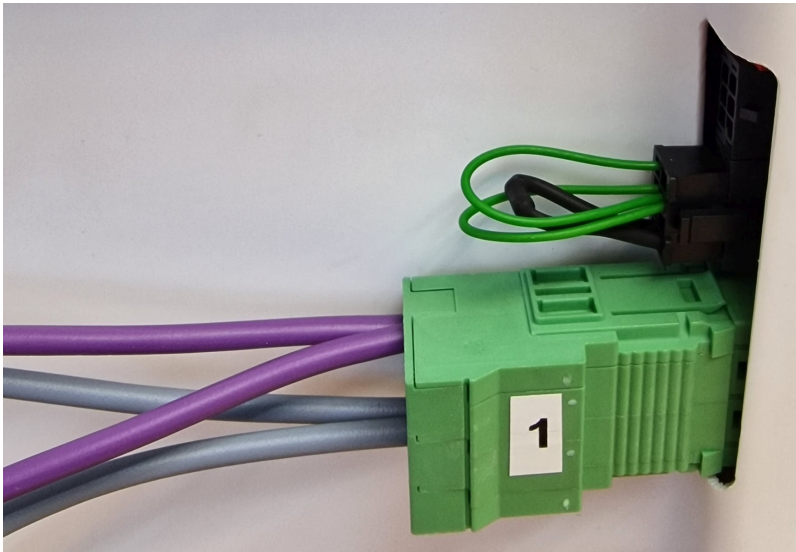
1. Plug the supplied dummy plug into the 8-pin communication connector of the battery.



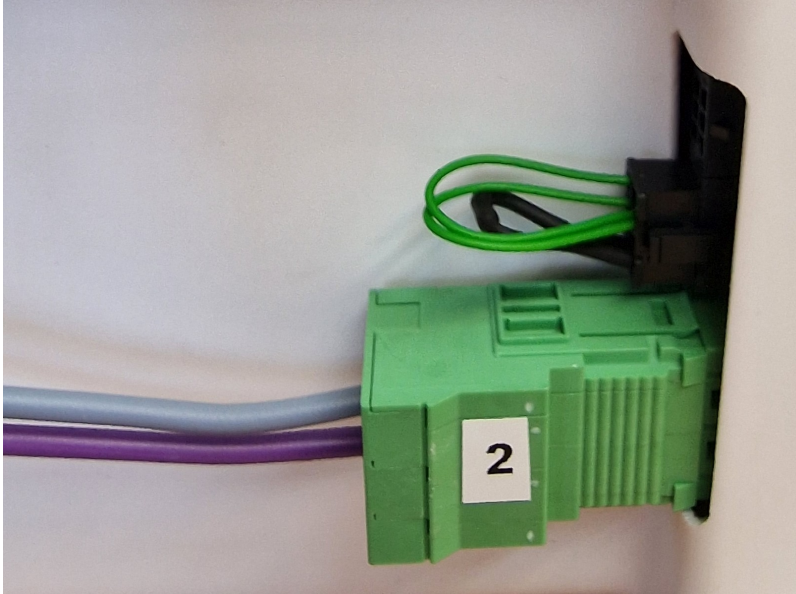
2. Connect the power supply unit to mains.



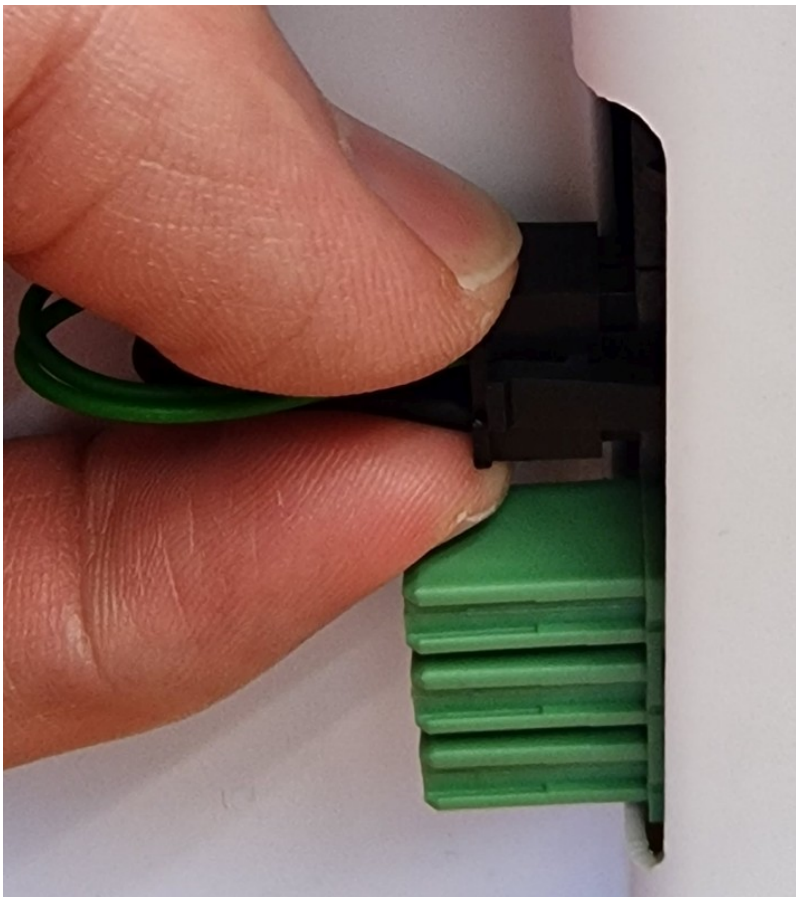
3. Plug the green high-current connector 1 into the main connection of the battery and unplug it again after approx. one second. To do this, do not pull on the cables but grasp the plug on the sides of the green housing.



4. Plug the green high-current connector 2 into the main connection of the battery and unplug it again after approx. one second.



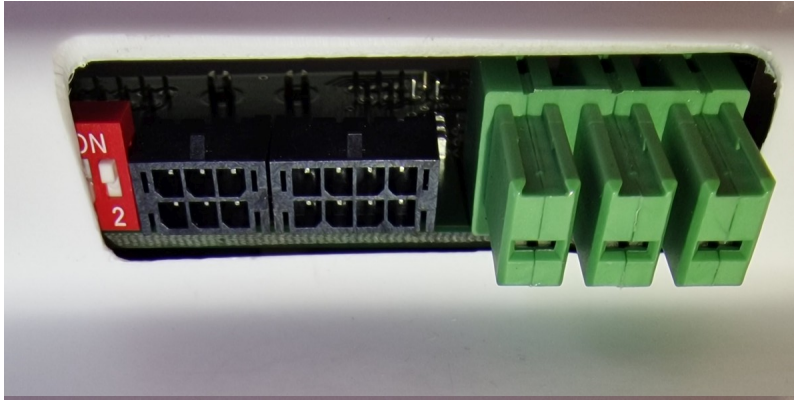
5. Unlock the dummy plug by pressing the catch and carefully pull it off the battery. Do not pull on the cables, but grasp the plug on the sides of the black housing.



6. The battery is now in sleep mode and can be installed and used.

Warning: When installing the batteries, make sure not to mix batteries from several robots. The combination of battery packs of different ages and especially with different charge levels can cause damage to the batteries and the electrical system of the robots.

Note: Also make sure that the battery packs are installed in the correct position in the robot. For the last battery pack in the system, to which only one communication cable with a black plug is connected, the CAN terminating resistor must be activated. To do this, push the white switch in the red DIP housing outwards to the ON position. If more than one battery pack is used, the resistor must not be activated on the remaining battery packs (position 2, inside).



3.4.2 Charging

3.4.2.1 With external Battery Charger

The battery of the mobile robot consists of several batteries connected in series and / or in parallel. The resulting battery pack can be charged conveniently and safely by using the provided battery charger.

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

The charger must be placed in a dry environment. Do not cover the housing, so appropriate cooling is possible, and avoid direct sunlight.

First connect the battery charger to the charging connector and then turn on the charger. After the battery has been fully charged first turn off the battery charger and then disconnect the cable.

Warning:

- 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.
- Always make sure that the charging connector is fully inserted into the socket and properly secured. An incomplete or insufficient connection can cause high heat and significant damages.
- Only use batteries and chargers supplied by Neobotix. Using unsuitable batteries or battery chargers can lead to serious damages, injuries and hazards!

Recharging is done completely automatic after the connection is established and the battery charger is connected to the main power supply and switched on. 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.

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

3.4.2.2 With integrated Battery Charger

Some robots feature an integrated battery charger. These robots can be charged by first plugging the charging cable into the robot's charging socket and then plugging the other end into a normal power outlet as described above.

Warning: Always make sure that the charging connector is fully inserted into the socket and properly secured. An incomplete or insufficient connection can cause high heat and significant damages.

The charging process starts automatically once the connection to mains has been made. As with the external charger the robot can be charged both when switched on or off.

3.4.3 Recycling

Both battery types used in Neobotix robots are leak proof and very safe.

Warning: They still contain highly reactive chemicals and must never be opened or damaged to avoid serious damage or injuries!

Attention:

- Under European law all kinds of batteries must only be returned to certified recycling companies. Please get in touch with Neobotix if you are unsure about how to recycle or dispose of used batteries.
- You can also return all old or wasted batteries from your Neobotix product to Neobotix free of charge for proper recycling.
- Please make sure to fully cover the battery contacts to guarantee their electrical insulation before shipping or disposing of old batteries. This will prevent short circuiting, damages and injuries.

3.5 Charging Stations

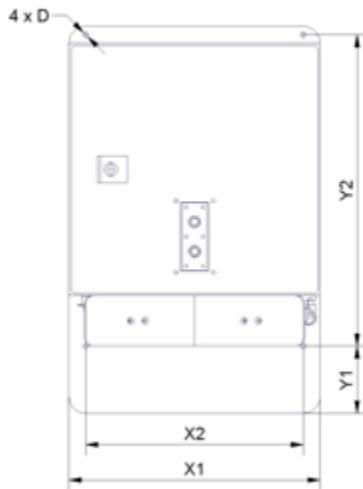
3.5.1 Automatic Charging Station

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 1.0 m wide.
- When using more than one station, please keep a grid of at least 1.0 m width.



3.5.1.1 Dimensions

The dimension of the charging station varies depending on the robot. The dimensions can be found in the table below:

Robot	X1	X2	Y1	Y2	D
MP-400	300	260	80	370	6.6
MP-500	300	260	110	360	6.6
MPO-700	300	260	192	370	6.6
MPO-500	340	320	40	290	6.6

3.5.1.2 After Installation

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

Attention: 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.

Note: In normal operation, the platform's charging contacts are disconnected from the batteries by a power relay on the platform's RelayBoard. This relay can be controlled by software.

Attention: 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.

3.5.2 External Battery Charging Station

If the robot is equipped with the battery quick change system the battery set that is currently not in use can be recharged in an external battery charging station.

Place the charging station on the floor and make sure that it will not slip. The station can either be placed directly in front of a wall or can be screwed to the floor.

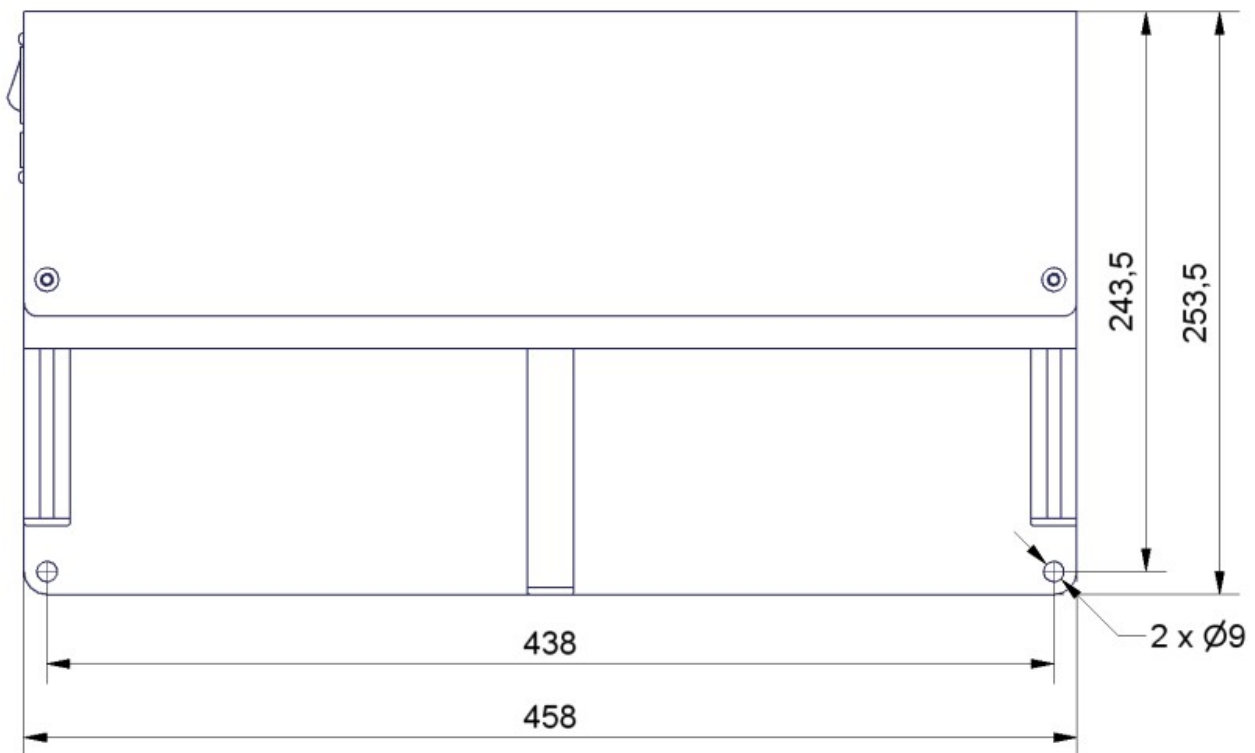


Fig. 1: Dimensions of the charging station

Make sure that the input voltage selection switch is set correctly and then connect the charging station to an ordinary power outlet. Before installing any batteries always make sure that the integrated battery charger is switched off. The main power switch is located directly beside the power cable connector.

Batteries can only be charged as a complete set of two identical batteries with the same charge level. Place the batteries onto the station's base plate between the aluminium profiles with the handles on top and the battery contacts facing towards the station's rear. Then slowly push the batteries into the station until they touch the vertical plate and are flush with the station's front.

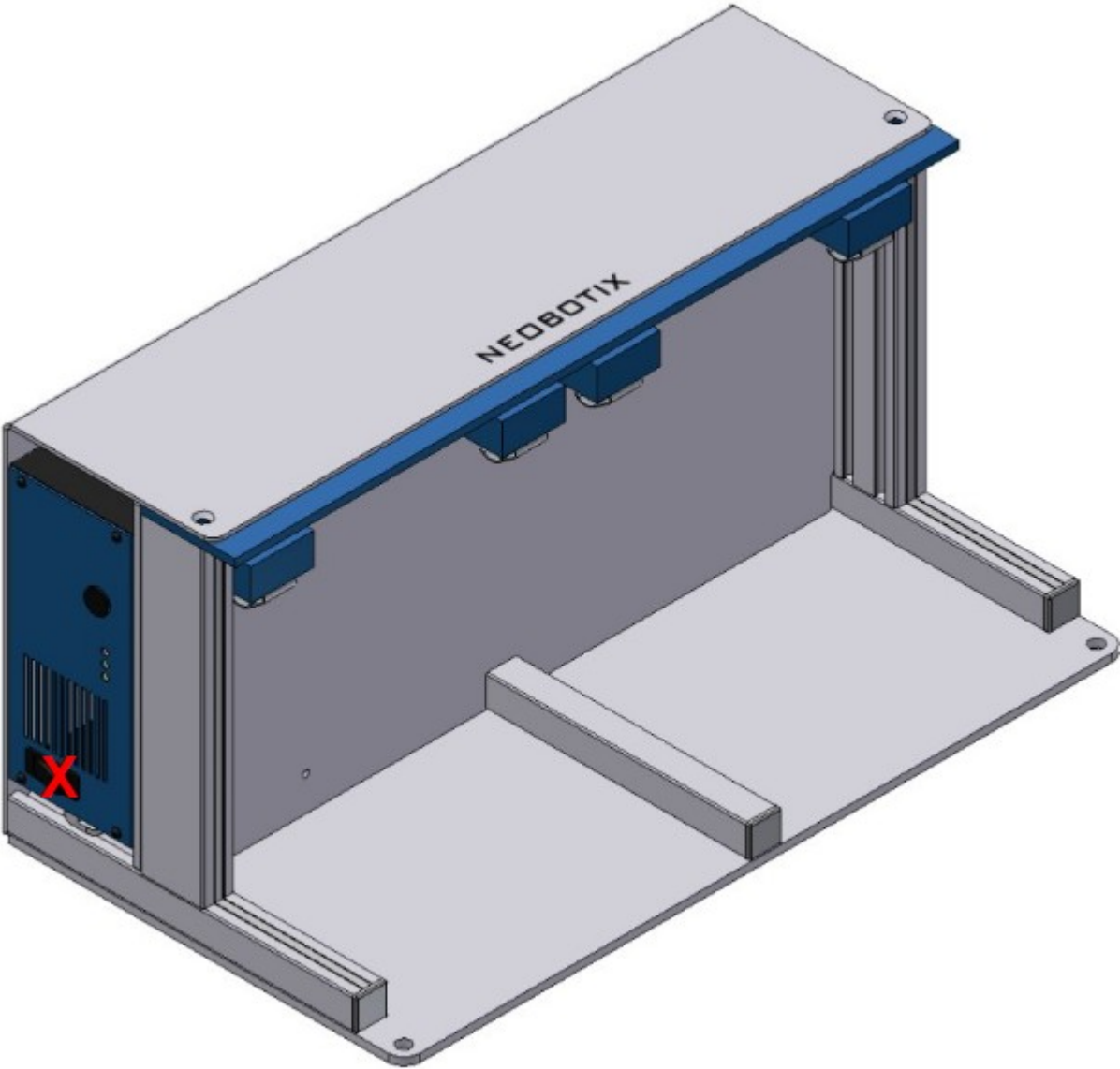
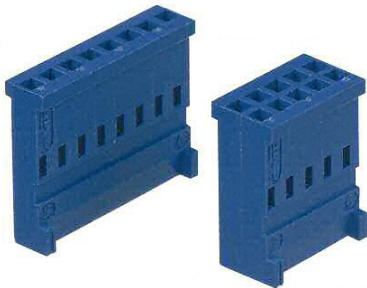


Fig. 2: Position of the main power switch (X)

The green LED at the side of the battery charger will light up constantly when the batteries are fully charged. They can remain inside the charging station until they are needed.

3.6 Connectors

3.6.1 TE Connectivity - HE14

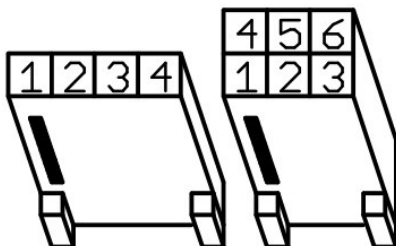


Pins	TE Connectivity	Farnell	RS Components
3 pins, 1 row	281838-3	429582	532-333
4 pins, 1 row	281838-4	429594	532-349
5 pins, 1 row	281838-5	429600	532-355
6 pins, 2 rows	281839-3	429650	532-406
8 pins, 2 rows	281839-4	429661	532-412
10 pins, 2 rows	281839-5	429673	532-428
12 pins, 2 rows	281839-6	429685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



Crimp contacts	TE Connectivity	Farnell	RS Components
AWG 28-24	182734-2	429715	532-456

In Neobotix products the pin assignment of the HE14 connectors is as shown below.



3.6.2 Würth Elektronik - MPC4

Please check the Würth Elektronik online catalogue⁶ for details on the MPC4⁷.

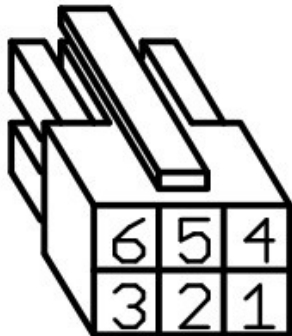


Pins (in 2 rows)	Würth Elektronik
2	649002113322
4	649004113322
6	649006113322
8	649008113322
10	649010113322
16	649016113322



Crimp contacts	Würth Elektronik
AWG 24-18	64900613722

In Neobotix products the pin assignment of the MPC4 connectors is as shown below.



⁶ <https://www.we-online.com/en/products/components/overview>

⁷ https://www.we-online.de/katalog/de/em/connectors/wire-to-board/wr_mpc4/

3.6.3 Würth Elektronik - MPC3

Please check the Würth Elektronik online catalogue⁸ for details on the MPC3⁹.

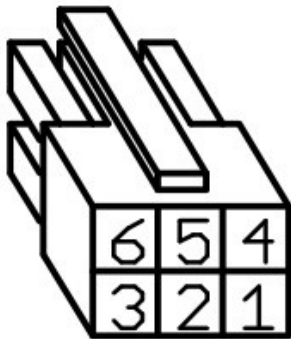


Pins (in 2 rows)	Würth Elektronik
4	662004113322
6	662006113322
12	662012113322



Crimp contacts	Würth Elektronik
AWG 24-20	66200113722

In Neobotix products the pin assignment of the MPC3 connectors is as shown below.



⁸ <https://www.we-online.com/en/products/components/overview>

⁹ https://www.we-online.de/katalog/de/em/connectors/wire-to-board/wr_mpc3/

3.7 Safety Instructions

3.7.1 General Safety Instructions

This page contains general safety instructions and information that applies to all Neobotix robots.

Note: Depending on the chosen options and customisation of your robot additional safety instructions may apply. Please also check the documentation of the actual robot model that you are working on to ensure a safe and trouble free operation.

The mobile robot (in all varieties and models based on it) is an autonomous vehicle that 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 robot 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.

3.7.1.1 Emissions

All the components and sensors used in Neobotix robots are safe to use and do not emit any dangerous radiation.

- The laser scanners are devices of laser safety class 1 or 1M.
- The ultrasonic sensors are safe for both humans and animals.
- None of the electronic devices and components will heat up to a dangerous degree.

3.7.2 Briefing

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

Attention: 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.

3.7.3 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 risk assessment may be required to determine whether the present safety features provide a sufficient level of safety.

Warning: 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!

3.7.3.1 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 (if equipped) are engaged.

Additional information on the emergency stop buttons and the reset procedure can be found in the specific documentation of your robot model.

3.7.3.2 Laser Scanners

The safety approved laser scanners can monitor user-defined safety fields in front of or around the robot which are dynamically activated according to the current velocity of the platform. If required these fields can also be activated by an application specific control software. In this case only the control software is responsible for the correct activation of the safety fields according to the current condition

Note: Please note that in omnidirectional robots the safety fields can only be activated by software and not depending on the robot's speed.

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 scanners have been approved as safety device with Performance Level d and SIL2. They fully replace the mechanical safety bumpers which have been required for autonomous vehicles in their early days.

3.7.3.3 Special Functions

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

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

3.7.4 Cooperating with the Robot

3.7.4.1 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.

<p>Warning: Climbing up onto the mobile platform and / or riding on it are not allowed at any time.</p>
--

3.7.4.2 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 can be 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.

3.7.4.3 General Surrounding

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

All people 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 are necessary.

3.7.5 Bringing into Service

After installing the mobile robot and also 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.

Note: 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.

3.7.6 Modification of the System

If you intend to perform any kind of mechanical, electrical or software modification and feel unsure about the process, please contact Neobotix. 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.

<p>Attention: All warranties 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.</p>
--

3.7.7 Expected Misuse

3.7.7.1 Passenger Transportation

<p>Danger: Transporting passengers on or by the mobile robot is dangerous and strictly prohibited. The Neobotix GmbH cannot be held responsible for any injuries and / or damages caused to or by transporting passengers with the mobile robot.</p>

3.7.7.2 Safety Fields

The laser scanners' safety fields must 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.

Warning: 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.

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

The localisation system of the mobile robot requires clearly visible landmarks and a high quality map of the surrounding. Further information on this topic can be found in the documentation of the used software. Please contact Neobotix in case of any problems.

The motion control system of the mobile robot will only work reliably 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.

Danger: The robot must never be operated in areas where it might fall down staircases, loading ramps or similar.

3.7.7.4 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 might even cause the robot to leave the predefined paths.

3.7.7.5 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.

3.7.7.6 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.

Note: Additional information on maintenance and hardware modifications can be found at [Maintenance](#) (page 42).

3.7.8 Configuring the Safety Fields

To achieve both high agility and a safe operation, the safety fields of the laser scanners must be configured and activated according to the intended motion. Prior to the first operation the safety fields have to be defined with consideration of the application's requirements, the working environment and the desired speed. If the safety fields are to be actively selected instead of being automatically activated, the wiring may need to be changed and a routine to select and activate the safety fields has to be implemented in the control software.

Warning: At delivery a set of safety field is defined which will avoid collisions in most situations. These settings must be tested and, if necessary, be adjusted prior to the first operation. Otherwise the required level of safety cannot be guaranteed.

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.

Note: The Sick default password is SICKSAFE.

3.8 Safety Instructions (Manipulators)

3.8.1 Robot Arms

3.8.1.1 Universal Robots

The robot arms from Universal Robots were designed for direct interaction with humans. Their safety features limit their speed and power and significantly reduce the potential to cause injuries or damages.

Warning: Nevertheless the robot arm may hit people or obstacles before its safety features come into effect. When equipped with a dangerous tool, serious injuries may be caused.

3.8.2 Laser Scanners

The robot arm may reach beyond the laser scanners' safety fields that were originally set up for transport and delivery. In order to ensure a safe operation of the mobile manipulator, the safety fields must be adjusted to cover the robot arm's work space whenever possible and to prevent collisions between the arm and any person nearby.

3.8.3 Working required from the Customer

Mobile manipulators are very complex robot systems. The applications in which they will 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 mobile manipulator 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 higher level control software for the mobile manipulator 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 manipulator, several measures might be required. The following list gives a short and incomplete overview of possible measures.

- 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 arm.
- Adding covers and shielding on the mobile maipulator.

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

3.9 Maintenance

3.9.1 Cleaning

Before any cleaning starts the robot should be set into emergency stop by pressing one of the emergency stop buttons. It can also be switched off altogether. This precaution is recommended both for cleaning the robot and for cleaning the robot's workspace.

Attention: If the robot is not set to emergency stop or switched off it might move in an unexpected way, causing collisions or injuries!

3.9.1.1 Wheels

Over time the wheels might pick up dirt which should be removed regularly. A thick layer on the wheels can cause vibrations and noise when the robot is moving.

A layer of dirt on the castor wheels or the trailing cable also may reduce the robot's capability to safely discharge electrostatic charge.

3.9.1.2 Sensors

Cleaning the various sensors is indispensable to assure that the robot can move safely and swiftly through its environment.

Attention: Be very careful not to scratch the cover of the laser scanner or the membranes of the ultrasonic sensors. Damaging these components might cause severe malfunctions!

3.9.2 Maintenance and Repairs

3.9.2.1 General Precautions

Please mind these general precautions that will make working on the robot safer and more efficient.

- Only qualified personnel may do maintenance, repairs or modifications on the robot. The requirements on qualified personnel can be found at *Qualified Personnel* (page 43).
- Before starting any work always unplug the mains connection and disconnect the robot from the battery charger and the automatic charging station.

- Disconnect all batteries from the robot.
- Follow the applicable common safety guidelines for working on electrical systems.

3.9.2.2 Wear and Tear

The mobile robot has been designed for longest possible operational life and is almost maintenance free. It is nevertheless advisable to regularly check the robot and all related devices and components for signs of wear.

- Mechanical damages to operating elements, covers and other components will reduce protection against contact. They might also cause delayed and surprising malfunctions.
- Damages, deformations or dirt on the drive and castor wheels can cause unsafe or inaccurate movements and lead to loss of localisation.
- Vibrations and increased noises during operation can be indicators of something chafing or of mechanical overload.
- Unusual heat can point to mechanical or electrical overload or to batteries that are worn out and should be replaced.
- A reduced uptime between charging cycles is often caused by old batteries that have lost a significant part of their capacity.

3.9.2.3 Repairs

In case of any questions regarding repairs or replacement parts please get in touch with Neobotix. We are always happy to support you.

Please mind the following points in any case:

- Only use replacement parts with features and properties identical to those of the original parts.
- Always mount all covers and hull parts properly and securely after finishing your work.
- Make sure to reconnect and fix all electrical connections, especially shieldings and earthing straps.

3.9.2.4 Batteries

The batteries need to be checked regularly and have to be replaced after some time. Additional information on the batteries can be found at [Batteries](#) (page 24).

3.10 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,
- have been instructed by the responsible robot operator in the operation of the robot or its parts and the currently valid safety guidelines,
- 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 product and
- 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 product,
- visitors and guests,
- all members of other departments of the company or institution in which the product is operated.

This list is not intended to be exhaustive.

3.11 Taking out of Service

3.11.1 Disassembly

Once the mobile robot has reached the end of its lifetime it should be disassembled and its components should be recycled.

Tip: Before the robot can be disassembled the battery charger, any other external power supply and the batteries 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 robot should be done by qualified personnel 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 and
- proper sorting of parts according to materials and way of recycling.

More information on qualified personnel can be found at *Qualified Personnel* (page 43).

3.11.2 Recycling

3.11.2.1 Reusable components

Many components of the mobile robot (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.

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

3.11.3 Mechanical parts

The frame and the other mechanical parts of the robot are mostly made from aluminium or steel. Both materials should be separated completely and can then be sold to certified recycling companies.

3.11.4 Electrical components

Electronic scrap and electrical wires are both a source of valuable resources as well as a threat to the environment and must not be treated like consumer waste.

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

3.11.5 Batteries

Note: You can find information about the batteries and the recycling process at *Batteries* (page 24).

3.12 Legal Notes

3.12.1 Version Information

The English part of this online documentation has been translated and is not the original. Please refer to the German version in case of uncertainties or questions.

3.12.2 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.

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3.12.3 Downloads and Further Information

Additional information, data sheets and documentations, also for other products of Neobotix, can be found in the download section on our homepage: <https://www.neobotix-robots.com/service/downloads>.