NEOBOTIX

thinking ▸ forward

MMO-700

Neobotix GmbH

Apr 02, 2024

Introduction

1.1 About This Documentation

1.1.1 Symbols and Conventions

The following symbols and highlighting are used in this documentation:

> **Danger:** Indicates a hazardous area or an immediately dangerous situation that could lead to serious injury or even death.

> **Warning:** Indicates a hazardous area or a potentially dangerous situation that could lead to serious injury or damages.

> **Attention:** Indicates hazards or situations that can lead to minor injuries, damages or other negative effects.

Note: Indicates important information that must be observed for safe operation.

Tip: Provides helpful tips to make working with the mobile robot easier and more efficient.

- Lists contain several items of information on the same topic.
- Where possible and appropriate, they are prioritised, with the most important entry at the top.
- Lists do not claim to be exhaustive unless otherwise stated.
1. Instructions are numbered.

2. Numbered instructions must be followed in the given order.

1.1.2 Further Information

Further information, especially on customised configurations and systems, will be provided with your robot on delivery or on request[1]. In most cases, all documents relating to your customised robot are also available in the download area[2] of our website.

1.2 Legal Notes

1.2.1 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.

1.2.2 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.

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. Neobotix makes no warranty of any kind with regard to the material contained within this document, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. 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.

1.2.3 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.

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[1] https://www.neobotix-robots.com/contact/contact-details
[2] https://www.neobotix-roboter.de/login

First Steps

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.

2.1 Accessories and Preparations

Tip: In the documentation supplied with the robot, you will also find the access data for your personal customer area[3] 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.

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[3] 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 56) 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 36). 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.

2.2 Starting up and Moving by Joystick

A detailed description of the controls and LED indicators can be found *here* (page 34).

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.

2.2.1 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 34). As soon as the robot lights up constantly in green, it is ready for use.

2.2.2 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 32).

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.

2.2.3 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.

2.3 Connecting the GUI

2.3.1 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[4] that you can download from your customer area[5] on the Neobotix website.

2.3.2 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[6].

2.4 Shutting Down the Robot

2.4.1 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.

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[4] https://neobotix-docs.de/pilot/#pilot-gui
[5] https://www.neobotix-roboter.de/login/
[6] 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.

2.4.2 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.

2.5 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.

2.5.1 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.

2.5.2 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
```

MMO-700

The mobile manipulator MMO-700 combines the omnidirectional *MPO-700* (page 18) with a light-weight robot arm, for example from Universal Robots.

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[7] https://neobotix-docs.de/hardware/en/MMO-700.pdf

The MMO-700's four *Omni Drive Modules* (page 59) create very smooth omnidirectional movements. This is a significant advantage over vehicles with Mecanum wheels when handling or transporting fragile or expensive parts.

The platform's movement can be controlled by the free Robot Operating System. The Universal Robots arm, like most suitable robot arms, can be configured with its original control software and manual control unit and connected to ROS.

3.1 Product Information

3.1.1 Intended Use

The MMO-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.

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

3.1.2 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 safety assessment. 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!

3.1.3 Working Area

The same conditions as for the MPO-700 apply and can be found at *Product Information* (page 19) .

3.1.4 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 56).

3.1.5 Safety Instructions

Please refer to the safety instructions for the MPO-700 which can be found at *Safety Instructions* (page 20).

Additionally, refer to *Safety Instructions (Manipulators)* (page 54).

3.2 Operating Elements

Please refer to the corresponding page for the MPO-700: *Operating Elements* (page 20).

When installing some options please follow the instructions at *Changes in Handling* (page 12).

3.3 Changes in Handling

3.3.1 With Radio Emergency Stop System

If the robot is equipped with a radio emergency stop system the reset procedure changes slightly.

3.3.1.1 Starting The Robot

After starting up the robot it is necessary to turn the key switch clockwise once more in order to activate the radio receiver.

3.3.1.2 Engaging The Radio Connection

1. Pull the red button on the handset upwards to activate the sender.

2. Wait until the two LEDs next to the red button have stopped blinking.

3. Press the green button on the handset to engage the safe connection.

4. Turn the key switch clockwise to reset the safety system and switch to normal operation.

3.3.1.3 Stopping The Robot Remotely

There are four ways to raise an emergency stop remotely:

- Press the red button on the handset. This is the intended operation and can be reset as described above.

- Placing the handset in the charging bay. Whenever the handset is charged in the charging bay it is considered inaccessible to the operator who might be needing it. Since this would be an unsafe situation the system will trigger an emergency stop. To reset this remove the handset from the charging bay and follow the steps stated in the paragraph above.

- The handset's battery runs out. The radio connection between handset and receiver is constantly maintained as long as the red button is not in its lower (pressed) position and will drain the battery. If the battery level is too low to keep up a stable connection the receiver will switch to emergency stop. Please press the red button or recharge the handset whenever it is not in use.

- The radio connection is interrupted. The connection between handset and receiver can also be lost when the distance is too big or when the radio signal is dampened or blocked by obstacles like machines or building structures. In rare cases high electromagnetic noise from big machinery might also cause connection problems.

3.3.2 With Flexi Soft Safety Controller

If the robot features a Flexi Soft safety controller from Sick all safety functions are shifted from the RelayBoard to the Flexi Soft. In this case the LCD will only report SCANNER STOP for all kinds of emergency stop. Please connect to the Flexi Soft directly to get detailed status information

3.4 Arm

3.4.1 Properties of the Universal Robots Arms

The hardware of the UR robot arm has not been modified. All features and properties of the arm remain unchanged as stated in the manufacturer's documentation. Please refer to this documentation for further information.

The platform's emergency stop system was integrated into the arm's safety system as external machine. Technical details on this connection can be found in the electrical circuit diagram of the MMO-700 UR and in the operating instructions of the robot arm. In case the arm is to be operated separately this connection has to be bridged with the white connector -X32' that was included in delivery.

Tip: The configurable inputs CI0 and CI1 have been changed to "Unassigned". The configurable outputs CO0 and CO1 have been set to "Emergency stop". The safety configuration password was set to `neobotix`. Please contact Neobotix if you have any questions concerning the safety system.

3.4.2 Standalone Operation

The mobile platform can be operated without switching on the arm or completely without arm. To do so please plug in the bridging connector -X32 instead of the cable to the UR arm controller. This connector can be found at the cables from platform to cabinet at the right side of the platform's top plate.

The robot arm can be operated independently of the mobile platform if the corresponding bridging connector -X32 is connected to the cable leading to the controller box.

When operating the arm without the platform it is recommended to power it from an ordinary 230V power outlet and not from the mobile robot's integrated DC/AC inverter.

Please check the robot arm's operating instructions for details on the power requirements.

3.5 Mechanical Properties

3.5.1 Dimensions of the Robot

See *Dimensions* (page 22).

3.5.2 Dimensions of the Manipulator

All dimensions are in millimetres.

Description	Symbol	Value
Height of the mounting plane	H1	348
Height of the control cabinet's top plate	H2	767
Offset between arm base and platform centre	O	161
Distance to the front of the cabinet	L1	115
Length of the cabinet's top plate	L2	492
Width of the cabinet's top plate	W	515
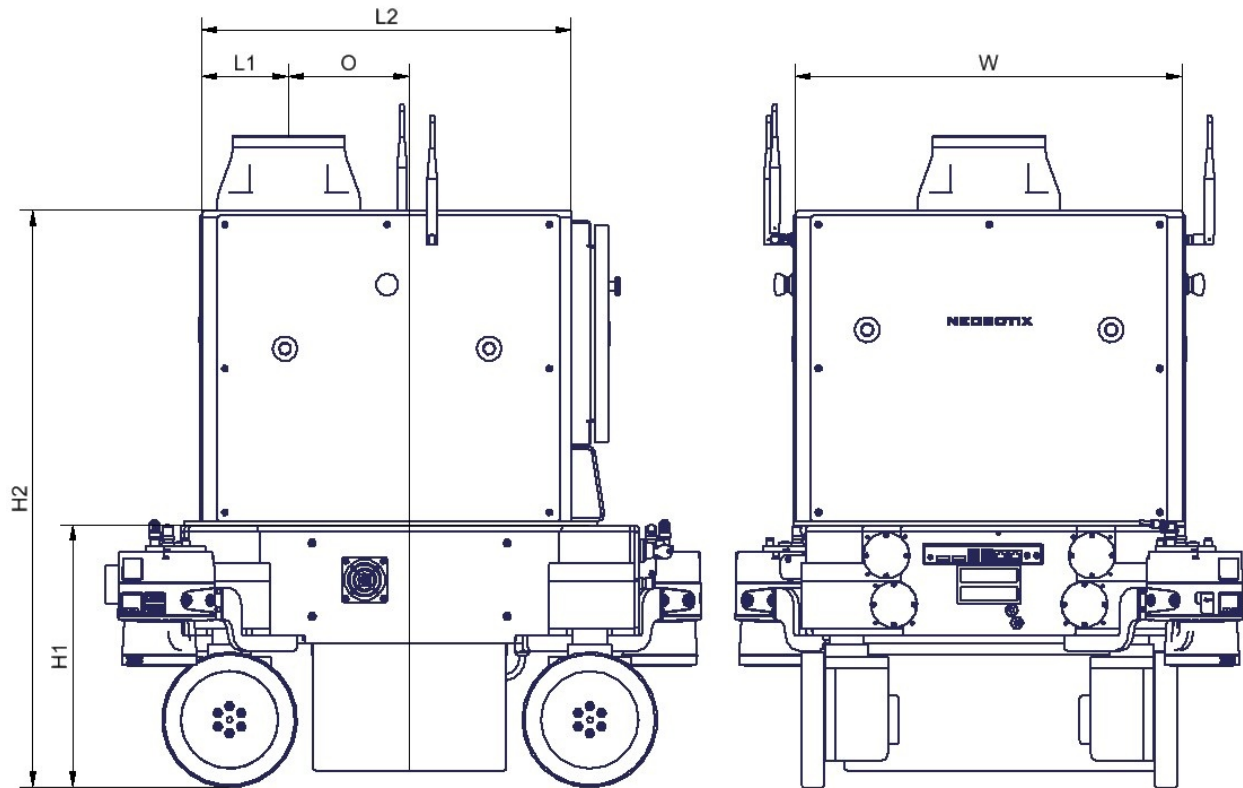
Fig. 1: Dimensions of the MMO-700 UR10e

3.6 Transport

Note: The corresponding conditions of the MPO-700 also apply and can be found at *Transport* (page 26).

3.6.1 Unpacking and Assembly

The mobile robot MMO-700 is packed in a rugged wooden box which can be reused for future transports.

Carefully lift the control cabinet onto the platform's top plate and position it as shown in the figure. Make sure that the countersunk holes in the cabinet's base plate are aligned with the threaded holes in the platform's top plate.

Now fasten the control cabinet to the mobile platform using the counter sunk screws that were included in delivery. The cover plates at the front and the sides of the control cabinet (marked in red in the picture) can be removed to provide easy access to the inside of the cabinet.

If the UR10e controller box was shipped separately, place it inside the cabinet and fix its base to the cabinet's base plate with four M6 screws and washers. Then connect the black AC power cable and the cable with the white Molex connector to the appropriate connectors of the cabinet.

If the robot arm was shipped separately, position it on top of the control cabinet as shown above. Then fasten it securely using the M8 screws included in the delivery. Finally plug the robot arm's cable into the socket at the underside of the controller box.
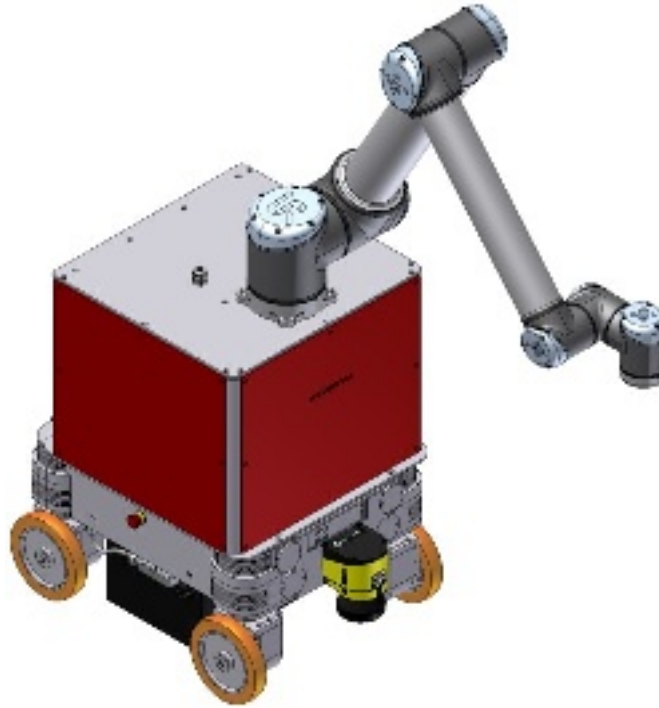
Fig. 2: Controller cabinet and robot arm mounted to mobile platform

Connect the cables inside the control cabinet to the appropriate plugs of the mobile platform. Please see the electrical circuit diagram for details.

3.6.2 Installing the Auxiliary Batteries

In order to extend the robot's uptime, a second battery set can be installed into the controller cabinet. Before installing the auxiliary batteries, please turn off the robot and fully charge both the batteries that are currently used in the robot as well as the additional battery pack.

> **Warning:** It is very important to fully charge both sets of batteries before connecting them. This will prevent internal currents between battery sets of different charge levels. Such currents may cause overheating and damage to the robot.

For charging the auxiliary batteries please use the adapter that was included in delivery to connect the battery charger directly to the green 2 pin power connector -X42 inside the cabinet.

Remove the front plate of the controller cabinet and place the batteries inside the aluminium frame on the cabinet's base plate, with the battery cables facing to the right side of the robot.

Plug the battery cables into the four green connectors inside the cabinet. The connectors are protected against wrong polarity.

Now put the front and side plates back in place, fasten them securely and start the robot.

> **Danger:** When the auxiliary batteries have been used, the robot must only be recharged by connecting the battery charger to the robot manually or by using the automatic charging station. Do not recharge either set of batteries
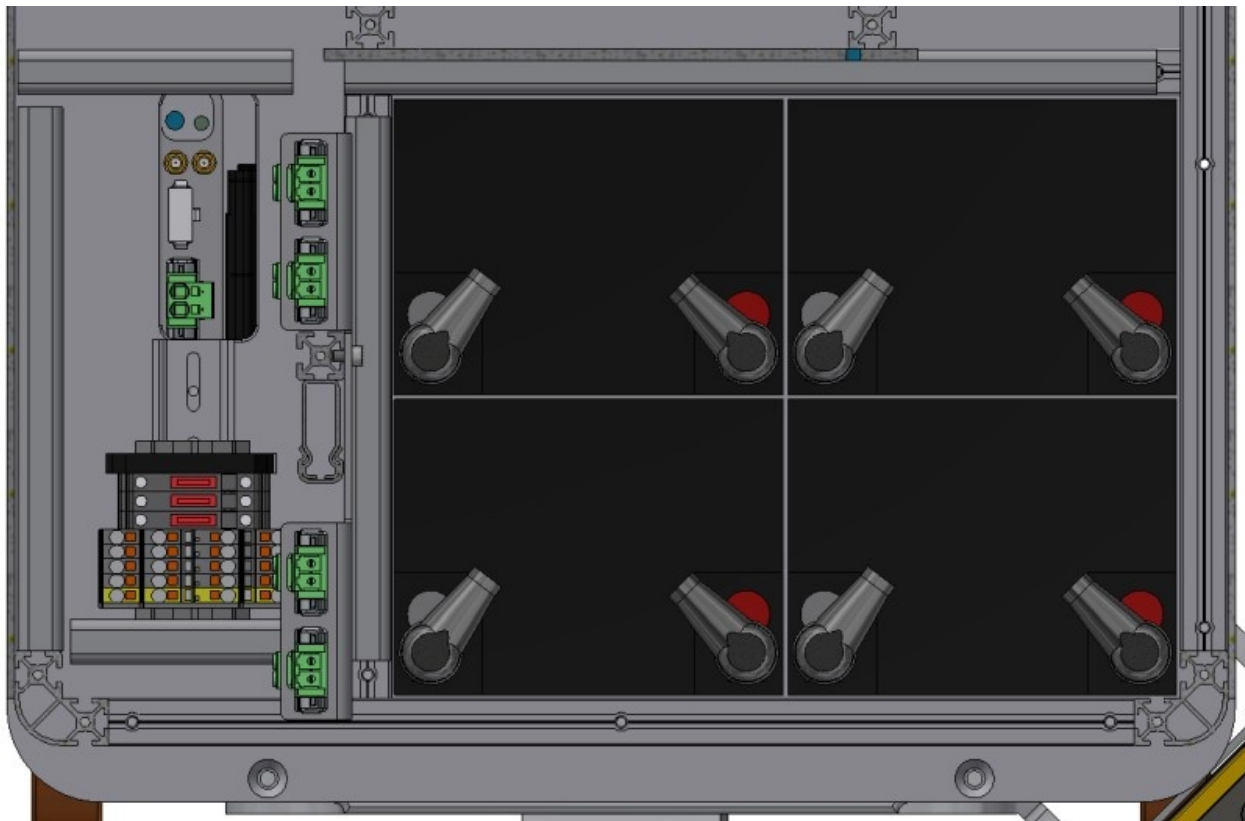
Fig. 3: Position of the auxiliary batteries and battery connectors

> individually by connecting them to the battery charger directly.

Three ATO fuses (80 V) inside the cabinet protect the electrical system from excessive currents. Please see the electrical circuit diagram for details.

3.7 Taking out of Service

You can find information about taking out of service and about recycling *here* (page 57).

3.8 Legal Notes

The general legal notes can be found at *Legal Notes* (page 2).

3.8.1 EU Declaration of Incorporation

This product is a partly completed machinery and sold without CE marking.

This partly completed machinery must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of Directive 2006/42/EC and all other applicable EU directives.

3.8.2 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.

MPO-700

The omnidirectional MPO-700 is the ideal base for high-end service robots. Its four *Omni Drive Modules* (page 59) enable it to move extremely smoothly into any direction. This robot is even capable of rotating freely while driving to its destination. The Omni Drive Modules of the MPO-700 feature important benefits compared to other omnidirectional drive kinematics, like for example the MPO-500's Mecanum wheels.

- Fully omnidirectional manoeuvrability

- Very steady movements

- High stability and payload

- Compact, easily integrated drive units

This makes the MPO-700 a premium alternative for applications that require omnidirectional movements without the limitations of traditional kinematics.

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[8] https://neobotix-docs.de/hardware/en/MPO-700.pdf

4.1 Product Information

4.1.1 Intended Use

The mobile robot has been designed for daily operation in factory workshops and test halls. It can be used for transportation of materials, parts and devices. Furthermore the mobile robot can easily be used in research projects as mobile carrier of sensor equipment, robot arms and other special devices.

Depending on the intended application the mobile robot 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 mobile robot has been designed with focus on indoor operation. It is not recommended to operate the mobile robot outdoors, especially during rain, fog or snow.

4.1.2 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!

4.1.3 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 places.

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

4.1.4 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 56).

4.1.5 Safety Instructions

Please also check the general safety instructions for Neobotix robots which can be found at *Safety Instructions* (page 49).

4.1.5.1 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 such injuries or damages. Depending on the application it can be necessary to design and mount protective covers around the drive modules.

4.2 Operating Elements

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

4.2.1 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. This state can be reset by unlocking the emergency stop buttons and turning the *Key Switch* (page 31) clockwise to position II for a few seconds.

4.2.2 Key Switch

See *Key Switch* (page 31).

4.2.3 Charging Connector

This connector provides direct, not fuse protected access to the battery. The battery charger can be plugged in here. Please see the chapter *Maintenance* (page 55) to know more.
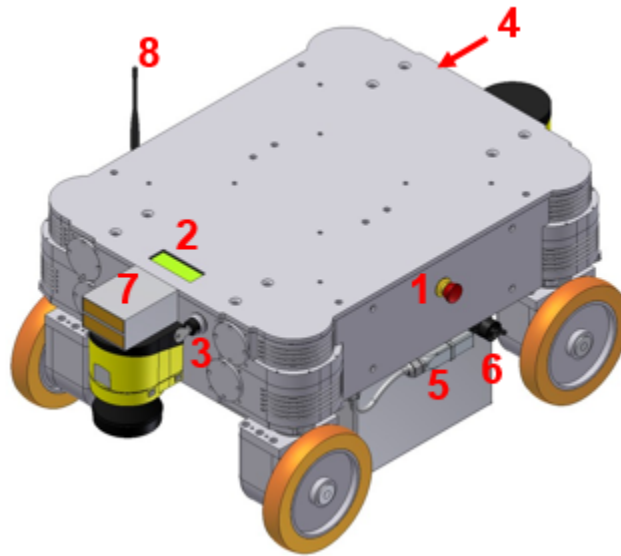
Fig. 1: Basic control elements of the MPO-700

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

4.2.4 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.

4.2.5 LC-Display

This display shows the most important status information. A detailed description of the LCD can be found in *LC Display* (page 32).

4.2.6 Access to the On-Board Computer

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

4.3 Mechanical Properties

4.3.1 Dimensions
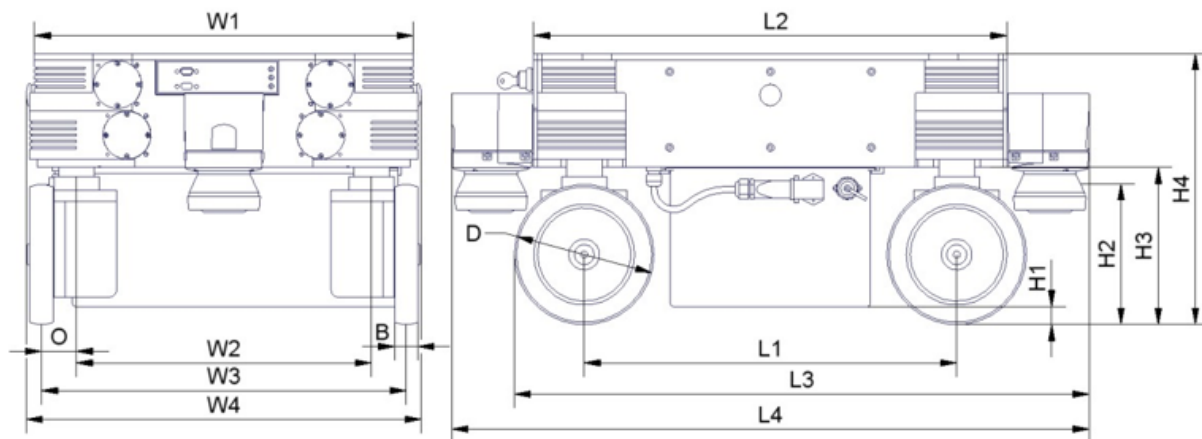
Fig. 2: Dimensions of the MPO-700

Description	Symbol	Value (mm)
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
Maximum width of the platform with diagonal scanners	W4'	656
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
Overall length with two diagonal laser scanners	L4'	756
Ground clearance with battery	H1	23
Height of scan plane	H2	181
Ground clearance without battery	H3	202
Height of top plate	H4	348

4.3.2 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	kg	400
Maximum speed	m/s	0.9
Maximum bumpiness to pass over ($\leq$ 0.25m/s)	mm	15
Maximum bumpiness to pass over (full speed)	mm	5

4.3.3 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.	b-angle
Front center laser scanner	LS1	360	0	181	0
Rear center laser scanner	LS2	-360	0	181	180
Front left laser scanner	(Option)	327	277	201,5	45
Rear right laser scanner	(Option)	-327	-277	201,5	225
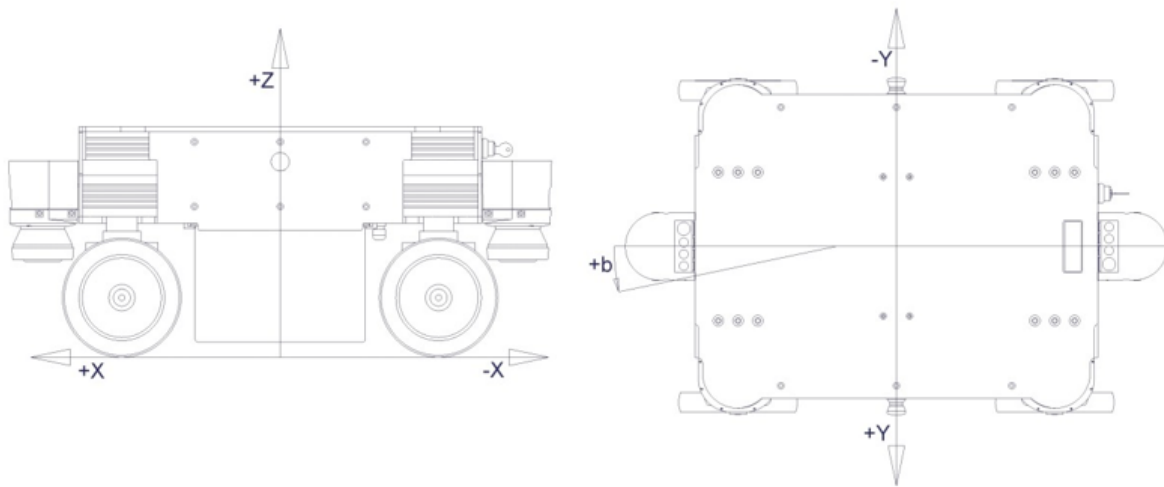
Fig. 3: Coordinate system of MPO-700
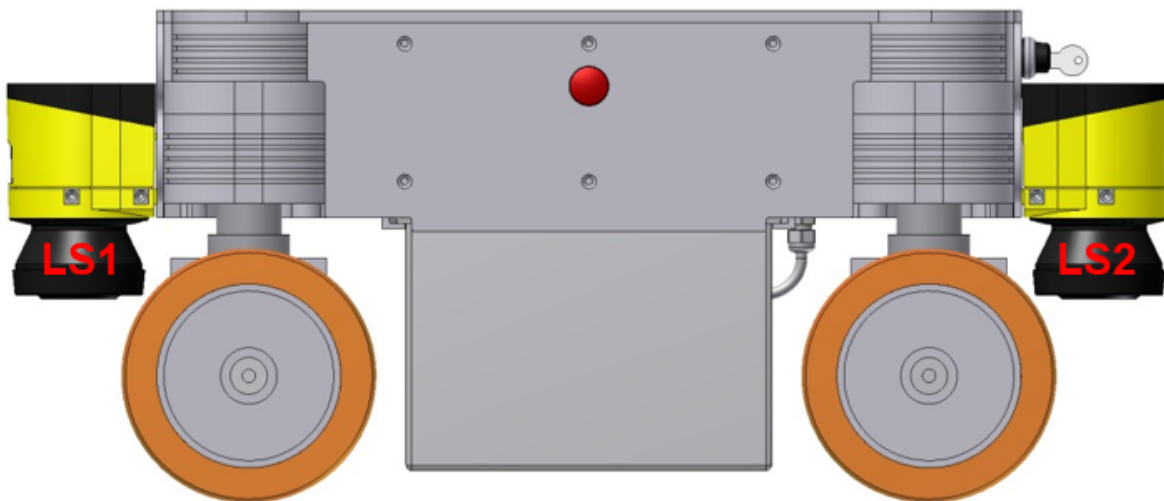
Fig. 4: Positions of the laser scanners

4.3.4 Electrical Properties and Miscellaneous Data

4.3.4.1 Properties of Internal Components

All data are taken from the respective data sheets.

Description	Units	Value
Motor power	W	400
Rated motor speed	rpm	3000
Rated motor torque	Nm	1.27
Maximum motor torque	Nm	2.32
Encoder resolution	Increments/Revolution	10000
Gear ratio of orientation drives	1	19:1
Gear ratio of traction drives (stage1)	1	15:1
Gear ratio of traction drives (stage2)	1	2:1
Rated battery voltage	V	48
Maximum battery voltage	V	59
Battery capacity	Ah	28

4.3.4.2 Other Properties

Description	Units	Value
Weight	kg	142
Expected working time	a	10

4.3.5 Communication To Internal Devices

4.3.5.1 RelayBoard

The Neobotix RelayBoard communicates with the platform's on-board computer via a USB connection. Detailed information on the RelayBoard and the protocol can be found in its documentation (available on request).

4.3.5.2 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 an adapter cable. Please contact Neobotix in case you need to modify the controllers' settings.

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[9]. An introduction on how to configure the Omni Drive Modules can be found *here* (page 72).

The amplifiers use the CANopen protocol for CAN communication. The node IDs are as follows. All amplifiers use group ID 30.

---

[9] https://www.elmomc.com/

Device	Position	Traction drive ID	Orientation drive ID
A2	Front left	2	1
A3	Rear left	4	3
A4	Rear right	6	5
A5	Front right	8	7

4.3.5.3 Connectors

See chapter *Connectors* (page 45).

4.4 Transport

4.4.1 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 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 affect the MPO-700, the robot should be wrapped in plastic foil prior to packing.

Tip: 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 at *Operating Elements* (page 20).

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.

4.4.2 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 taking hold of the bottom side of the platform. The best places for holding the robot are the areas beside the Omni Drive Modules.

Warning: 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.

4.4.3 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.
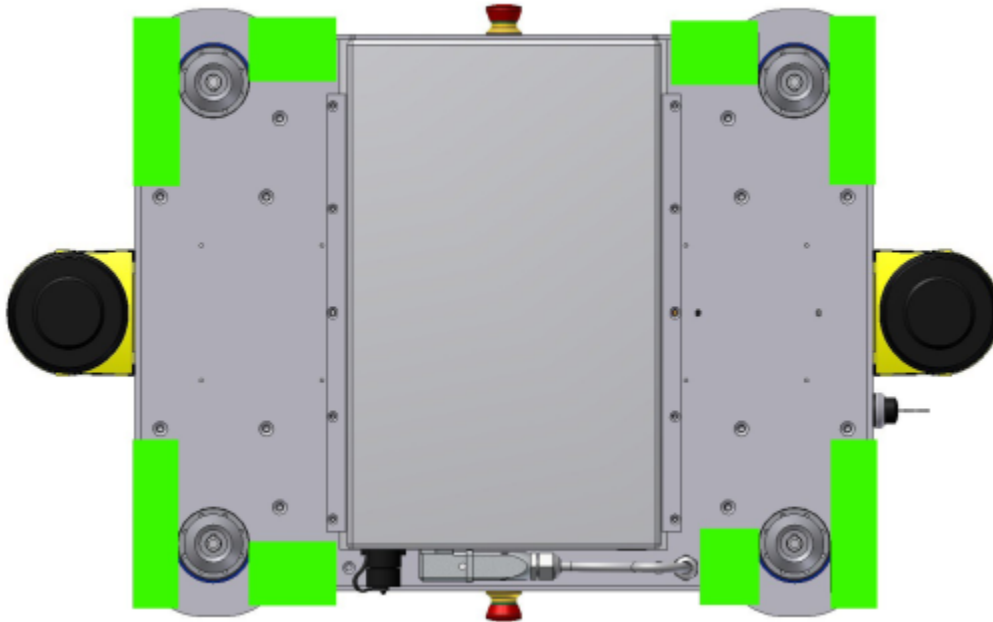
Fig. 5: Gripping areas of the MPO-700

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.

> **Warning:** 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.

4.4.4 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.

4.4.5 Shipping with AGM 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.

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

4.4.6 Shipping with LiFePO4 Battery

Due to safety regulations any shipment of a lithium based battery has to follow certain procedures.

Please contact Neobotix if you plan to ship a robot with LiFePO4 battery.

4.5 Maintenance

Information on hardware maintenance, cleaning and general precautions when working on the mobile robot can be found in *Maintenance* (page 55).

Maintenance of the Neobotix MPO-700 is very easy and does not cause much work. As long as the advice in this chapter is 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 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.

- Never connect or disconnect any connectors under load. Always turn the robot off before changing any connections.

> **Warning:** 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!

4.5.1 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 55).

4.5.2 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.

4.5.3 Batteries

General information on the available battery type, as well as on battery maintenance and recycling, can be found at *Batteries* (page 35).

If the battery of the MPO-700 has to be replaced first shut down the on-board computer and turn off the robot. Disconnect the battery from the robot and move the battery cable aside. Then slowly slide the battery out of the carrier rails.

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

To insert a new battery simply follow the above steps in reverse order.

4.5.4 Fuses

ID	Circuit	Position	Type	Rated Current	Characteristics
F1	Main Battery Power	Beside Battery Cable	ATO blade fuse	15 A	default
F2	48 V Supply	DIN rail	ATO blade fuse	5 A	default
F1'	48 V Supply	RelayBoard	Micro 5x20	3 A	slow
F3	Emergency Stop Buttons	RelayBoard	Micro 5x20	2 A	fast

4.6 Taking out of Service

You can find further information about taking out of service and about recycling *here* (page 57).

4.7 Legal Notes

The general legal notes can be found at *Legal Notes* (page 2).

4.7.1 EU Declaration of Conformity

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

4.7.2 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

5.1 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.

5.1.1 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* .

5.1.2 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.

5.1.3 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.

5.1.4 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 I) 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.

5.2 LC Display

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

5.2.1 Main View

5.2.1.1 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".

5.2.1.2 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.

5.2.1.3 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	$\leq$ 22 V	23 V .. 25 V	25 V .. 29 V
48v	$\leq$ 44 V	46 V .. 52 V	52 V .. 59 V

5.2.1.4 Temperature

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

5.2.1.5 Uptime

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

5.2.2 The Info View

This view mode is not available in all robot types.

5.2.2.1 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.

5.2.2.2 Serial Number

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

5.2.2.3 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.

5.3 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.

5.4 Batteries

5.4.1 Battery Types

5.4.1.1 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.

5.4.1.2 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 recharing.

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 unusal 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.
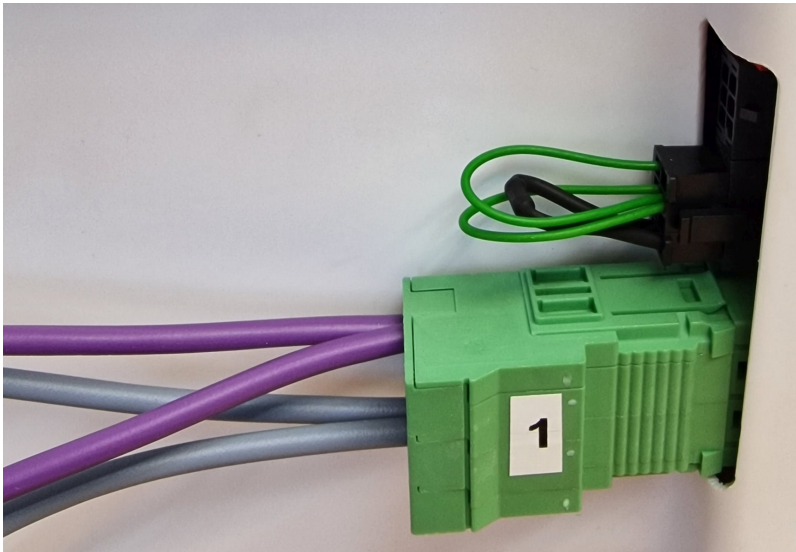
4. Plug the green high-current connector 2 into the main connection of the battery and unplug it again after approx. one second.
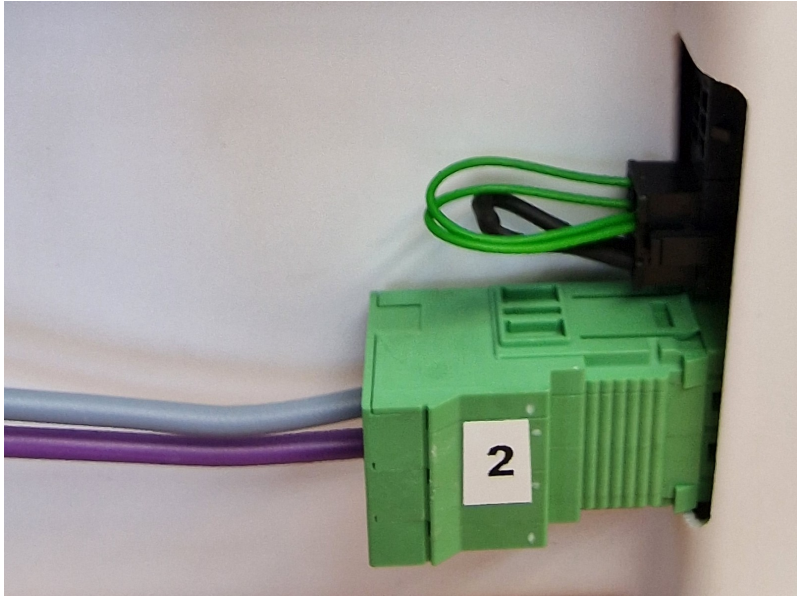
5. Unlock the dummy plug by pressing the catch and carefully pull it off the battery. Do not pull on the cables, but grasp the plug on the sides of the black housing.

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 communi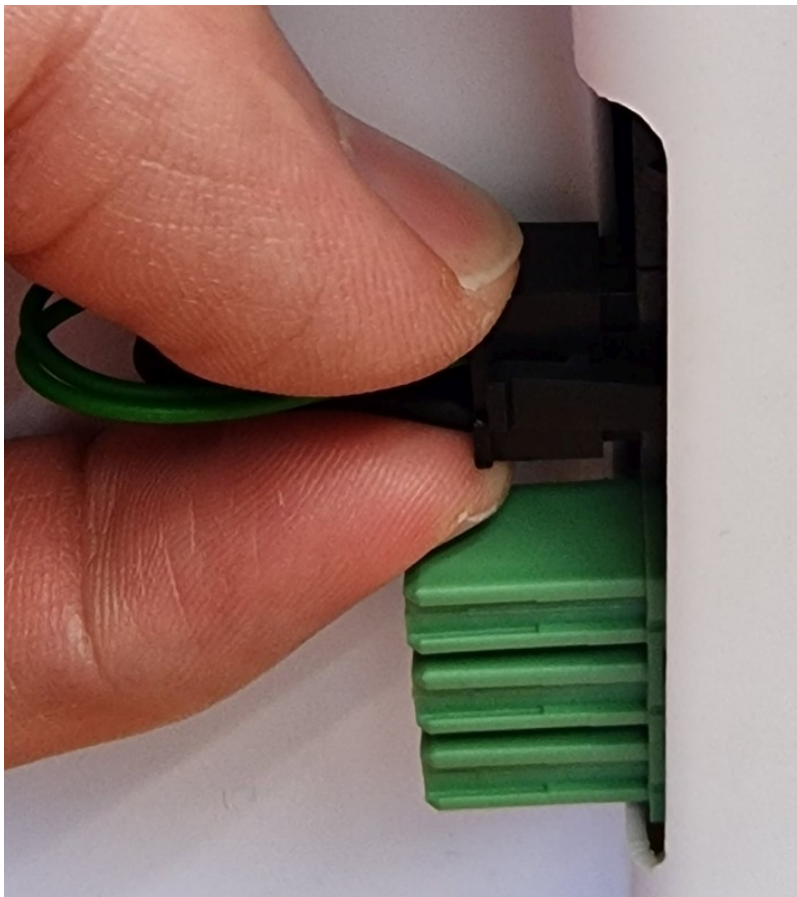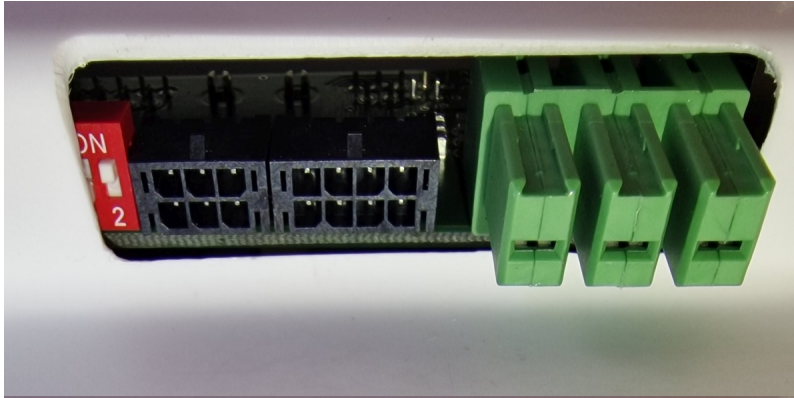cation cable with a black plug is connected, the CAN terminating resistor must be activated. To do this, push the white switch in the red DIP housing outwards to the ON position. If more than one battery pack is used, the resistor must not be activated on the remaining battery packs (position 2, inside).

5.4.2 Charging

5.4.2.1 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.

5.4.2.2 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.

5.4.3 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.

5.5 Laser Scanners

5.5.1 Mode of Operation

The safety laser scanners installed in mobile robots emit an invisible infrared laser beam that is reflected by obstacles and detected by the sensor head. The distance between the sensor and the obstacle can be precisely determined from the travel time of the beam. The sensor head rotates so that the beam effectively scans a plane perpendicular to the axis of rotation.

If the scanner is used in a mobile robot for localisation and collision avoidance, it is usually mounted upright so that the scanning plane is parallel to the floor. According to common AMR standard (DIN EN ISO 3691-4), the scanner

should be mounted at a maximum height that allows objects 200 mm high to be reliably detected. This ensures that people lying on the floor are also detected and protected. Modern safety laser scanners have a field of view of over 270° and, when mounted on opposite corners of the robot platform, enable seamless monitoring of the area around the robot.
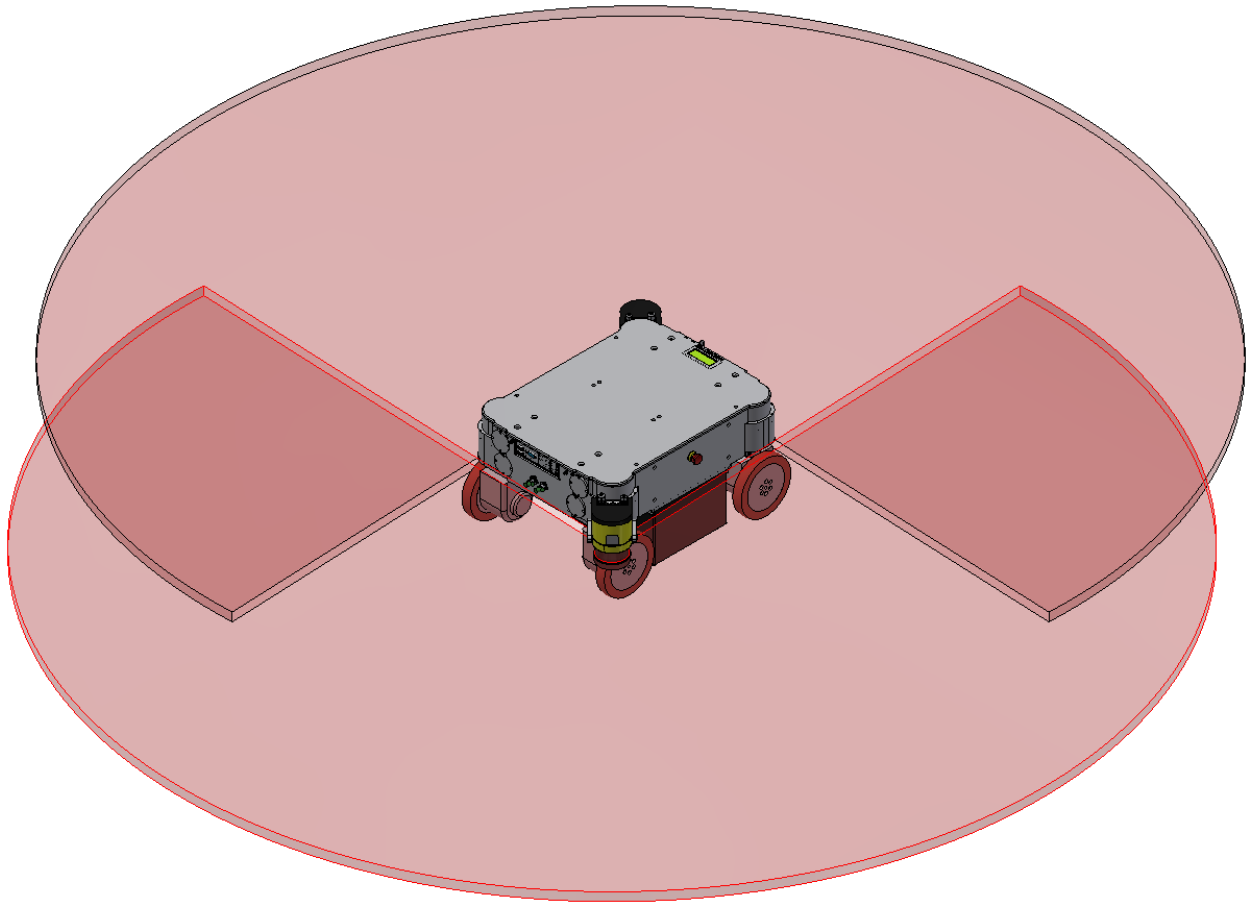
The safety laser scanners not only provide measurement data of the working environment, which is used for localisation and path planning, but also monitor the robot's surroundings for obstacles and possible collisions. For this purpose, areas around the robot can be defined in which detected objects automatically trigger various reactions.

This function is a fundamental part of the safety concept of the mobile robots. You can find more information at *Safety Instructions* (page 49) and specifically at *Safety Fields* (page 52) as well as in the safety instructions that you receive on delivery.

5.5.2 Safety Instructions

The laser scanners are devices of laser class 1 or 1M and completely harmless during normal use.

Danger: Laser scanners that are laser class 1M devices might be used for special projects and requirements. These are only eye-safe as long as no optical instruments such as magnifying glasses or binoculars are used.

As it is usually not immediately recognisable from the outside which type of laser scanner has been installed, optical instruments should generally not be used to look into the laser beam.

5.6 Charging Stations

5.6.1 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.
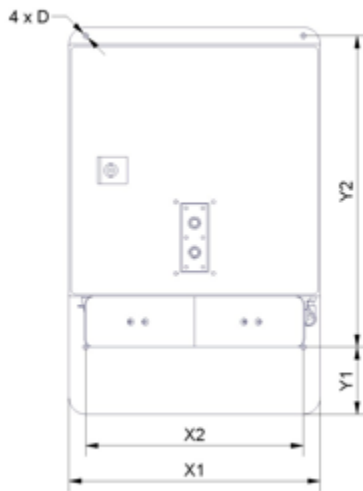
5.6.1.1 Dimensions

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

5.6.1.2 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.

5.6.2 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.

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.

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.
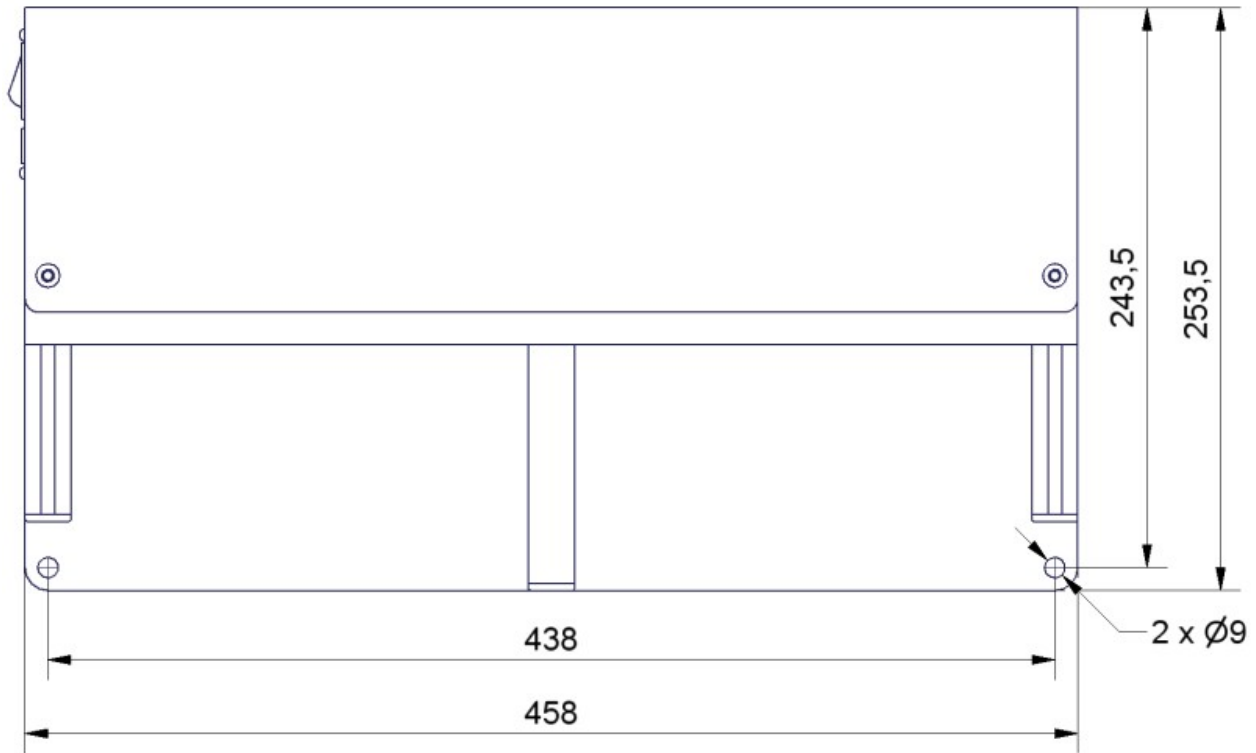
Fig. 1: Dimensions of the charging station

5.7 Connectors

5.7.1 TE Connectivity - HE14
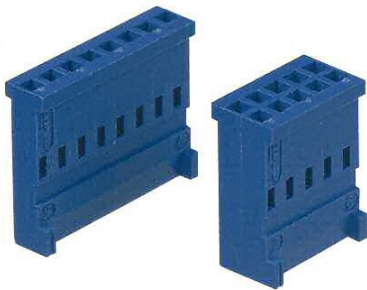
Pins	TE Connectivity	Farnell	RS Components
3 pins, 1 row	281838-3	429582	532-333
4 pins, 1 row	281838-4	429594	532-349
5 pins, 1 row	281838-5	429600	532-355
6 pins, 2 rows	281839-3	429650	532-406
8 pins, 2 rows	281839-4	429661	532-412
10 pins, 2 rows	281839-5	429673	532-428
12 pins, 2 rows	281839-6	429685	532-434
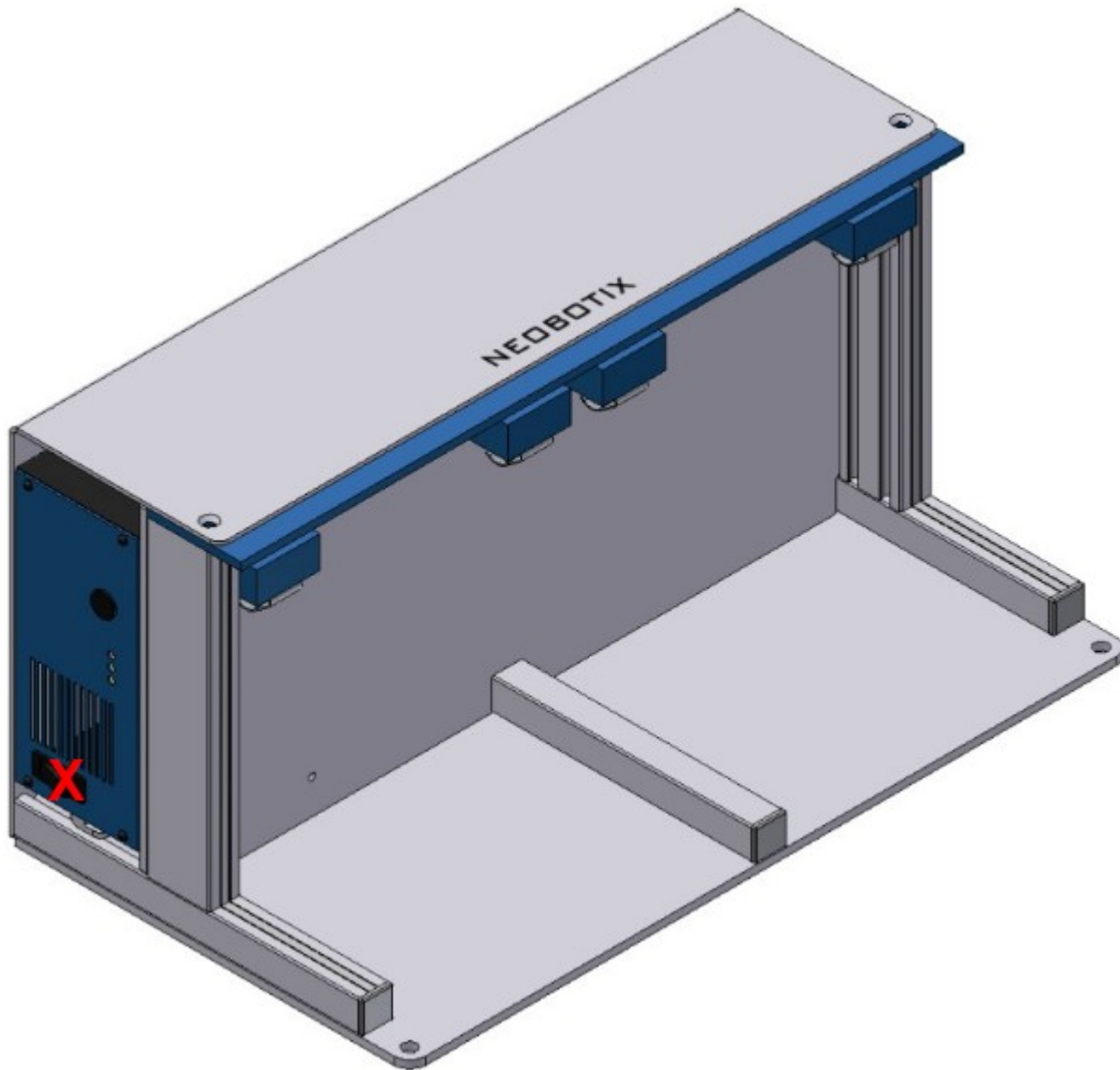
Fig. 2: Position of the main power switch (X)

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.
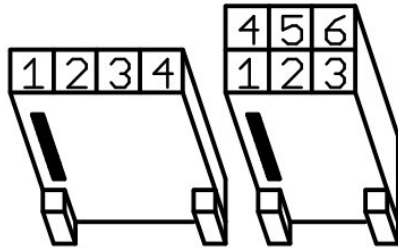
5.7.2 Würth Elektronik - MPC4

Please check the Würth Elektronik online catalogue[10] for details on the MPC4[11].

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

---

[10] https://www.we-online.com/en/products/components/overview
[11] https://www.we-online.de/katalog/de/em/connectors/wire-to-board/wr_mpc4/

Crimp contacts	Würth Elektronik
AWG 24-18	64900613722

In Neobotix products the pin assignment of the MPC4 connectors is as shown below.
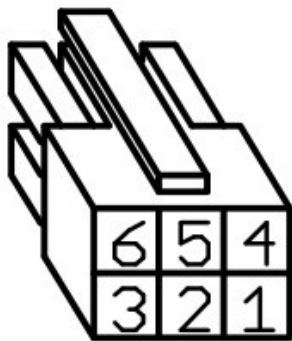
5.7.3 Würth Elektronik - MPC3

Please check the Würth Elektronik online catalogue[12] for details on the MPC3[13].

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

[12] https://www.we-online.com/en/products/components/overview
[13] https://www.we-online.de/katalog/de/em/connectors/wire-to-board/wr_mpc3/

Crimp contacts	Würth Elektronik
AWG 24-20	66200113722

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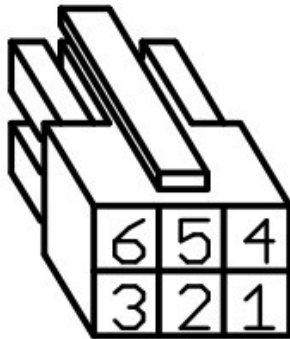
5.8 Safety Instructions

5.8.1 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.

5.8.1.1 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. Further information can be found at *Laser Scanners* (page 41).

- The ultrasonic sensors are safe for both humans and animals.

- None of the electronic devices and components will heat up to a dangerous degree.

5.8.2 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.

5.8.3 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!

5.8.3.1 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.

5.8.3.2 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.

5.8.3.3 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.

5.8.4 Cooperating with the Robot

5.8.4.1 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.

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

5.8.4.2 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.

5.8.4.3 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.

5.8.5 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.

5.8.6 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.

> **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.

5.8.7 Expected Misuse

5.8.7.1 Passenger Transportation

> **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.

5.8.7.2 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.

5.8.7.3 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.

5.8.7.4 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.

5.8.7.5 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.

5.8.7.6 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 55).

5.8.8 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`.

5.9 Safety Instructions (Manipulators)

5.9.1 Robot Arms

5.9.1.1 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.

5.9.2 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.

5.9.3 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!

5.10 Maintenance

5.10.1 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!

5.10.1.1 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.

5.10.1.2 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!

5.10.2 Maintenance and Repairs

5.10.2.1 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 56).
- 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.

5.10.2.2 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.

5.10.2.3 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.

5.10.2.4 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 35).

5.11 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 quests,

- all members of other departments of the company or institution in which the product is operated.

This list is not intended to be exhaustive.

5.12 Taking out of Service

5.12.1 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 56).

5.12.2 Recycling

5.12.2.1 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 safe a significant amount of money.

5.12.3 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.

5.12.4 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.

5.12.5 Batteries

Note: You can find information about the batteries and the recycling process at *Batteries* (page 35).

OmniDriveModule

The Neobotix OmniDriveModules have been designed to allow engineers and designers to easily create their own, customised mobile robot platform. Different from other solutions, the kinematics of the ODM enables the mobile robot to move omnidirectionally even on a floor that is not perfectly flat.

These modules are intended for research and experiments and need to be modified and completed by the customer. Several important issues must be considered when working with them:

- The OmniDriveModule is a partly completed machine and not ready for immediate operation.

- The drive amplifiers have been configured with general purpose settings. Some of these settings might need to be adjusted according to the individual application in order to achieve the best performance.

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[14] https://neobotix-docs.de/hardware/en/OmniDriveModule.pdf

- Being only partly completed machines, the OmniDriveModules are not conform with all EC Directives applicable for turnkey machinery.

- To achieve the level of safety required by the applicable directives the customer must integrate the ODM into another machine. Additional measures might be necessary to ensure the safe operation of the completed machine.

- An independent assessment of risks has to be performed by the customer to verify conformity with all applicable directives.

- Only the customer can be held responsible for the safe operation of the OmniDriveModule.

6.1 Product Description

The Neobotix OmniDriveModule is a two-axes drive unit for use in a mobile robot or a similar application.

The module contains two high-performance servomotors with an industrial grade servo amplifier each ("Whistle 10/60" from Elmo Motion Control), mounted to a common printed circuit board. One of the motors drives the module's driving wheel while the other motor rotates the wheel around its vertical axis. Both motors can rotate infinitely without mechanical boundaries, thus allowing an omnidirectional robot to move continuously and without the need to re-align the wheels due to any limits. The orientation drive features an inductive position switch which can be used for homing.

Due to the high transmission ratio of both worm gearings, no brake is required. This significantly reduces the module's power consumption and heating. Fail-safe brakes can be integrated for additional safety.

6.1.1 Components

The OmniDriveModule is made up from the following components:
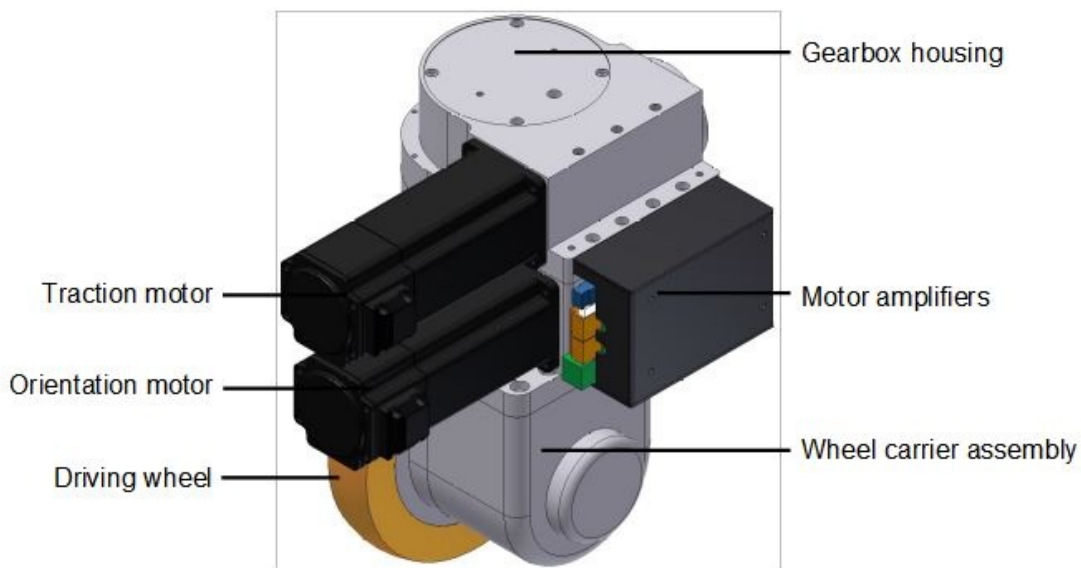
6.1.2 Possible Drive Kinematics

The OmniDriveModules can be used to build several different drive kinematics according to the application's requirements. Each configuration has its own advantages and disadvantages. The most commonly used configurations are the

following:

6.1.2.1 1 OmniDriveModule with 2 fixed rollers
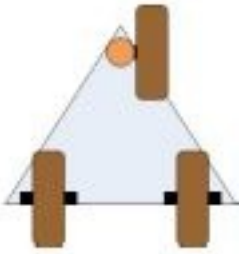
This configuration is the cheapest and easiest to control. Although possible, it is very rare that the OmniDriveModule is moved in a way that will make the fixed wheels jam.

In this configuration, true omnidirectional motion is not possible since the vehicle will always follow the drive unit.

6.1.2.2 3 OmniDriveModules
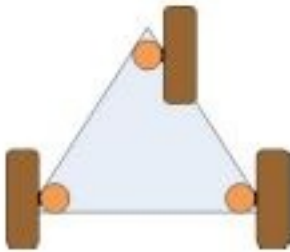
This configuration ensures high stability for smaller robots, avoids static indeterminacy and allows fully omnidirectional movement.

All three wheels must be aligned correctly at all times to avoid jamming or slippage. Please mind that the angle between the wheels must change according to the movement's centre of rotation.

6.1.2.3 4 OmniDriveModules
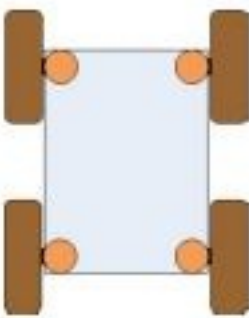
This configuration is most commonly used for service robots. It guarantees highest stability even for big and heavy robots. Although it is statically indeterminate this will not cause problems in most applications because all wheels are aligned actively.

All four wheels must be aligned correctly at all times to avoid jamming or slippage. Please mind that the angle between the wheels must change according to the movement's centre of rotation.

6.1.3 Special Features

6.1.3.1 Logic Power Supply

The drive amplifiers of the OmniDriveModule feature a separate power supply pin for the internal logic unit. In case of an emergency stop the main power line can be cut without affecting the internal microcontroller or the motors' feedback devices.

This means that during emergency stop all important functions of the drives (CAN-communication, position detection, etc.) are maintained even if the possibly dangerous power is switched off and motions are stopped.

6.1.3.2 Position Switch

An internal inductive position sensor is connected to the amplifier of the orientation drive and can be used for homing.

Due to variances in the assembly process the homing position may slightly differ from module to module. Therefore the control software must implement an adjustable offset for each orientation drive.

Tip: Proper functioning of the overall drive system can only be achieved by aligning all wheels correctly at all times.

6.1.3.3 Digital and Analogue I/Os

Each drive amplifier provides six digital inputs, two digital outputs and one analogue input. Three digital inputs and one digital output can be accessed via the PCB's connectors. Please refer to *Digital-I/Os* (page 70) for details. One of the inputs is used for the position switch of the orientation drive. Further information about the I/Os can be found on the Elmo Motion Control homepage[15].

6.1.3.4 Programming

Each drive amplifier contains an integrated logic capable of running simple user programs. This feature can be used to shift some basic functions from the main control software to the drive amplifiers. Possible functions are:

- Automatic homing after power on
- Automatic realignment of the drives after emergency stop
- Automatic motor off after a predefined time of inactivity

Details on the programming feature can be found on the Elmo Motion Control homepage[16].

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[15] https://www.elmomc.com/
[16] https://www.elmomc.com/

6.2 Safety

6.2.1 Intended Usage

6.2.1.1 Fields of Application

The OmniDriveModule is intended to be used as part of the drive system of a mobile robot. It has been designed for use in fields like robotics, autonomous vehicles and intralogistics. Vehicles based on the Neobotix OmniDriveModule may be used in laboratories and similar controlled indoor environments without public access.

6.2.1.2 Environmental Conditions

The OmniDriveModule must only be used indoors. Outdoor use may significantly reduce the system's life expectancy and may result in damages to the module.

Due to the unsealed drive amplifiers at the side of the OmniDriveModule it has to be protected against collisions, dirt, metal objects (e.g. screws or washers) and moisture.

Under normal operating conditions the massive aluminium body of the drive module serves as a sufficient heat sink for the amplifiers, the motors and the gears. In case the module is to be covered completely, appropriate ventilation or other means of cooling might become necessary.

The drive module must be kept clean at all times. Exposure to excessive dirt or moisture may lead to damage of the ball bearings or other moving parts. Neobotix cannot be held responsible for damages caused by dirt or moisture.

6.2.2 Improper Usage

Warning:

- Using a vehicle based on the OmniDriveModules for any kind of passenger transportation is strictly prohibited. Climbing onto any vehicle that is based on the Neobotix OmniDriveModules is also prohibited.

- It is prohibited to operate a vehicle based on the OmniDriveModule in public areas without supervision by a qualified trained person.

- The Neobotix OmniDriveModules must be kept dry at all times. Exposing the modules to rain, mist or splash-water may cause severe damage to the electronic components.

Tip: The control software for aligning and moving two or more ODMs must be tested with special care. Using an untested or faulty control software may damage the modules or even the complete vehicle.

6.2.3 Qualified Personnel

This product must only be modified, commissioned, operated and serviced by qualified personnel. More information can be found at *Qualified Personnel* (page 56).

6.2.4 Safety Measures and Precautions

In order to ensure a safe and successful operation of the OmniDriveModule, please mind the following:

- Always take care to protect the drive amplifiers at the side of the module against collisions and moisture.

- Always lift the wheels off the ground while working on the control software.

- Always test any new or changed control software thoroughly with the wheels lifted off the ground. Make sure that the alignment of all wheels is correct at all times and under all conditions.

- The wire diameter of the power supply to the OmniDriveModules as well as any relays must be chosen according to the maximum expected current.

Warning: If three or more modules are used, very high sum currents might occur.

6.3 Mounting

6.3.1 Integrating the Module into a Platform

Six threaded holes in the bottom side of the OmniDriveModule can be used to mount the module onto a carrier plate.

The OmniDriveModule is not designed to be mounted under a vehicle but into it. The base plate of your vehicle must be in between the wheel carrier assembly and the gearbox housing.

A U-shaped cut-out of 60 mm to 70 mm width is recommended for the vertical axle of the wheel carrier assembly.

6.3.2 Mounting Components onto the Module

If all OmniDriveModules are mounted to a common base plate, additional components may be placed on top of the modules. The step above the drive amplifiers can be used for mounting an auxiliary plate. This might be used to carry smaller components, for example electronic devices.

Using a single plate on top of and screwed to all modules will significantly improve the structure of the overall drive system. It will also optimise the distribution of forces thus allowing a high payload.

6.4 Electrical Installation

6.4.1 Power Supply

6.4.1.1 Main Power

Both drive amplifiers are connected to common supply lines. Use the following components for the power supply:

- Plug: Würth Elektronik, Series 351 WR-TBL, 691 351 500 003

- Plug (alternative): Phoenix Contact, MSTB 2,5 HC/ 3-ST, 1911868

- Power cable: H07V-K or better, 2,5 mm^2 or bigger

- Logic supply cable: H05V-K or better, 0,5 mm^2 or bigger
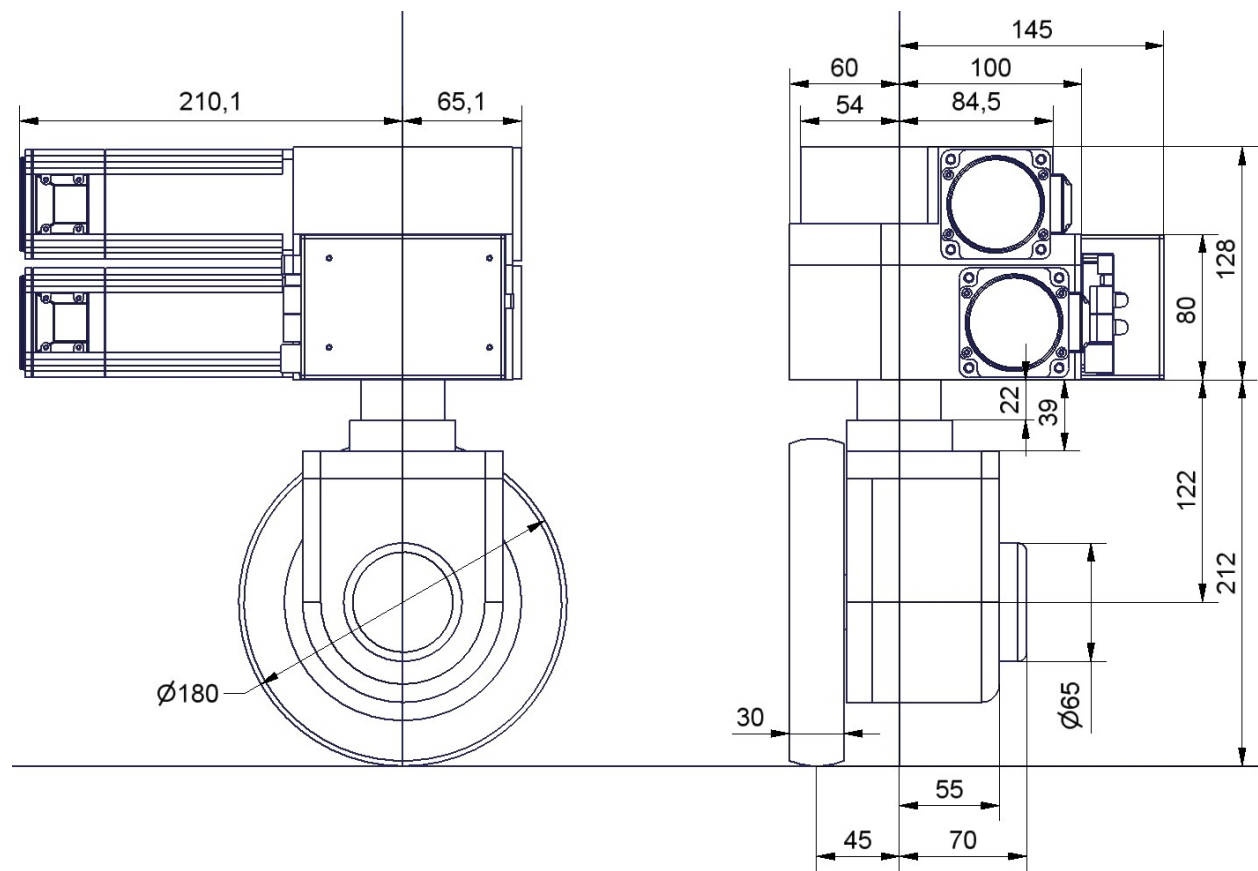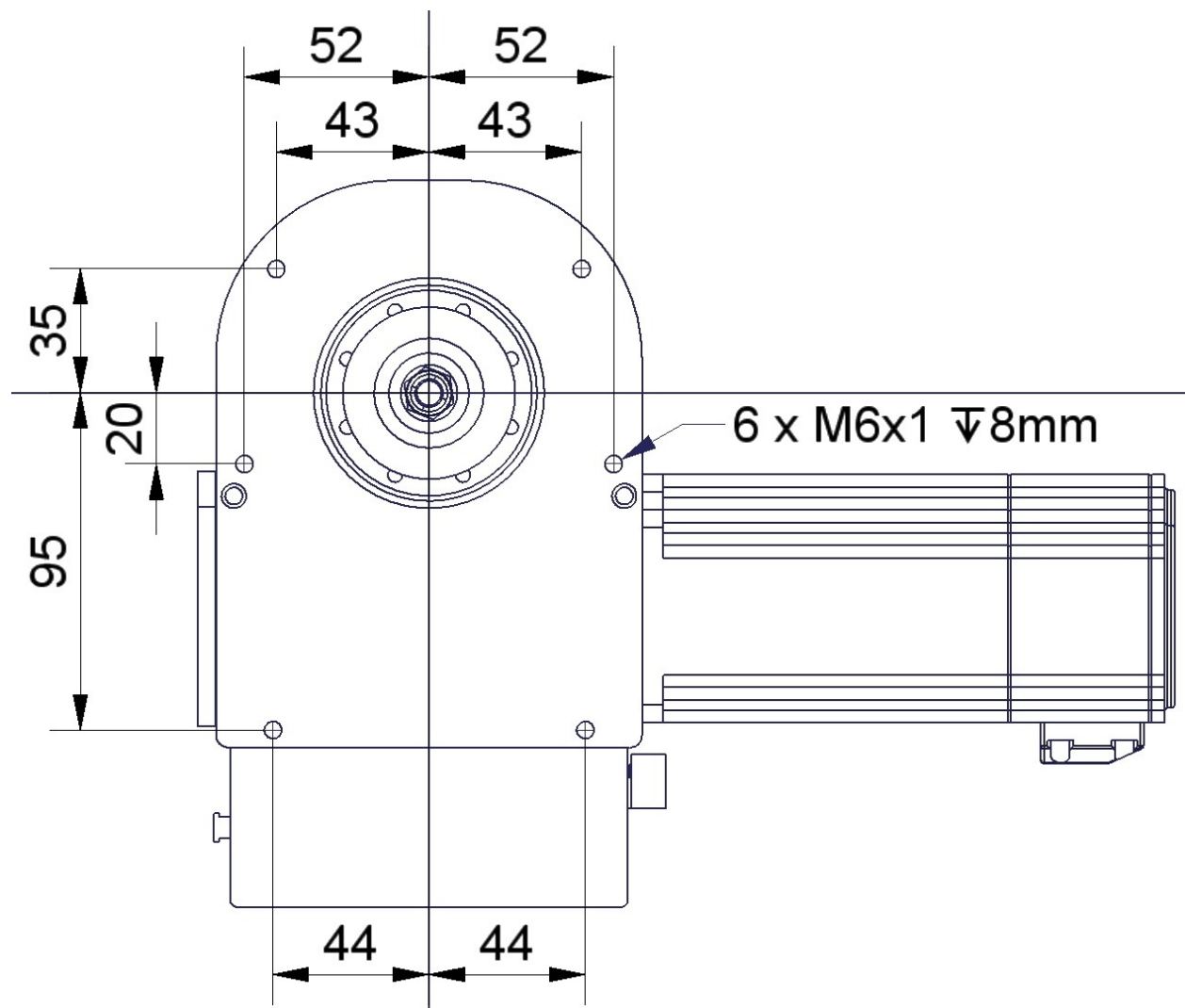
Fig. 1: Dimensions of the OmniDriveModule
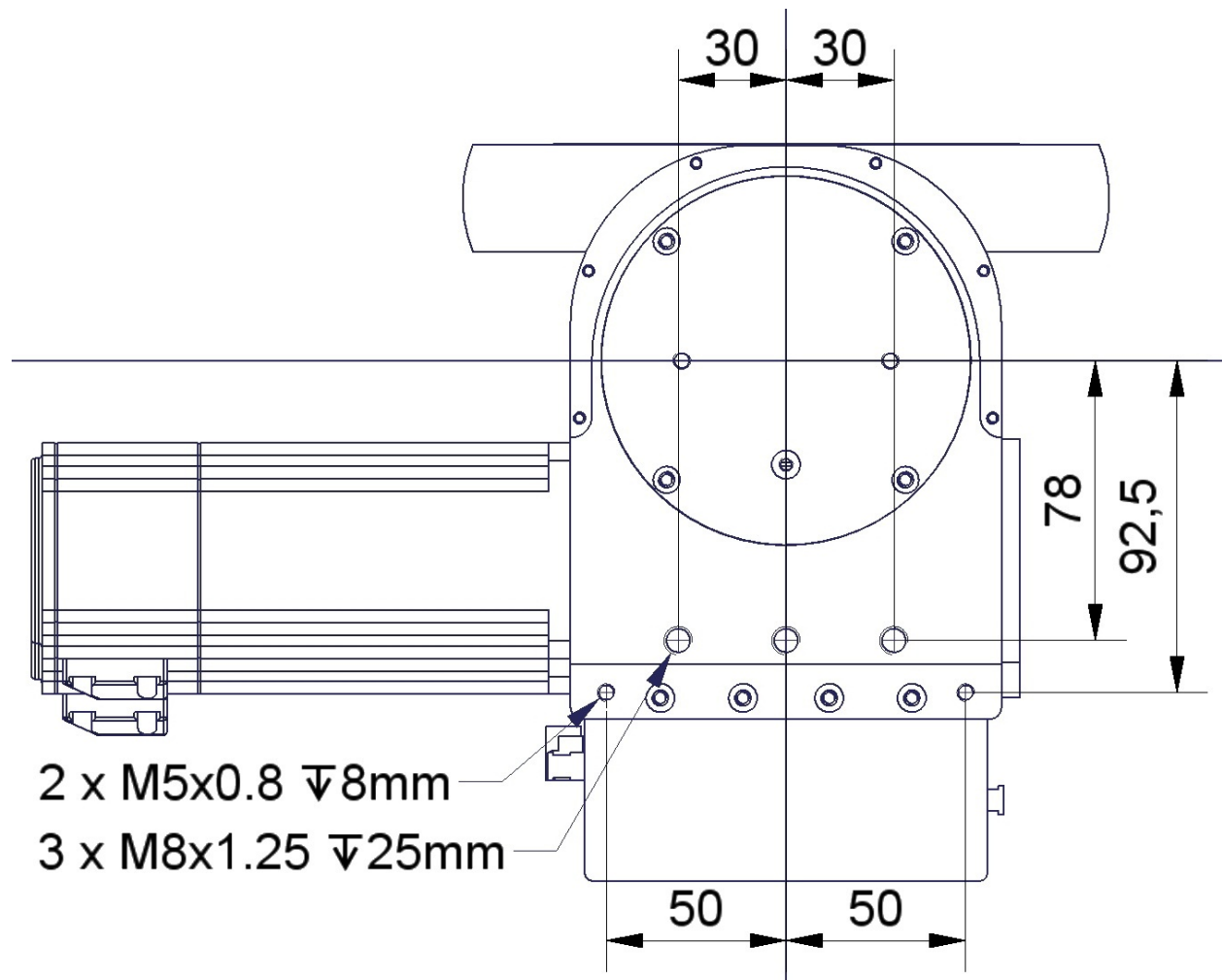
Fig. 2: Bottom view of the OmniDriveModule

Fig. 3: Top view of the OmniDriveModule

The internal logic unit of the drive amplifiers can be powered independently from the main power supply. In case of an emergency stop the amplifiers will still be running, keeping track of the motor position and communicating on the CAN-bus.

Tip: By default the OmniDriveModule is configured for 24 V logic supply voltage. Please contact Neobotix if you want to use other supply voltages.

The pin assignment is as follows:

Pin	Function	Voltage / VDC	Description
1	Common ground	0	Common return line
2	Motor power supply	20 – 59	Main power supply, may be switched off
3	24V logic supply	11 – 30	Auxiliary supply, not to be switched at stop

6.4.1.2 Position Switch

If 24 V are used as logic supply voltage, the inductive position switch of the orientation drive is powered directly from the amplifiers' PCB. If different voltages are used, they must be connected to a common ground.

Attention: The ground line of the digital input is by default connected to the common ground of the amplifier power supply. In case independent supply voltages are required, please contact Neobotix.

Use the following components for the power supply of the switch in case you are not supplying 24 V for the amplifiers' logic:

- Housing: Würth Elektronik, MPC4, receptacle, dual row, 2 circuits, 649002113322

- Contacts: Würth Elektronik, MPC4, crimp terminal female, 18-24 AWG, 64900613722DEC

The pin assignment is as follows:

Pin	Function	Voltage / VDC	Description
1	Supply	24	Position switch power supply
2	Ground	0	Return line

6.4.1.3 Brakes

The servomotors can optionally be equipped with fail-safe brakes that need to be released while the motor rotates. A 24 V supply capable of providing 0.75 A is required for the brake.

Use the following components for the power supply of the brakes:

- Housing: Molex, series KK receptacle 2 circuits, 22-01-2021

- Contacts: Molex, series KK crimp terminal 22-30 AWG, 08-50-0032

The pin assignment is as follows:

| Pin	Function	Voltage / VDC	Description
•	Ground	0	Return line
•	Supply	24	Brake power supply

6.4.2 Communication Interfaces

6.4.2.1 CAN

Both drive amplifiers are connected to the PCB's CAN-bus connector. Please use the following components for the CAN-bus connection:

- Housing: TE Connectivity, HE14 receptacle double row 8 circuits, 281839-4

- Contacts: TE Connectivity, HE14 crimp terminal female 28-24 AWG, 182734-2

The pin assignment is as follows:
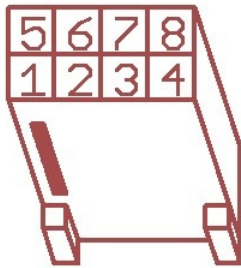
Pin	Function
1,5	GND
2,6	CANL
3,7	CANH
4,8	Shield

If the CAN bus ends at one of the OmniDriveModules a terminating resistor of 120 Ω has to be activated. Please move switch S1 beside the LEDs to position ON.

6.4.2.2 RS-232

Each drive amplifier has a separate RS-232-interface which can be used for configuration and for communication with the control software.
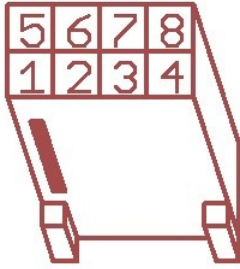
Pin	Function	Description
1	GND (Orientation)	Reference ground line (orientation drive)
2	TxD (Orientation)	Transmit line (orientation drive)
3	RxD (Orientation)	Receive line (orientation drive)
4	GND (Traction)	Reference ground line (traction drive)
5	TxD (Traction)	Transmit line (traction drive)
6	RxD (Traction)	Receive line (traction drive)

6.4.3 Digital-I/Os

The drive amplifiers each feature 6 digital inputs, 2 digital outputs and 1 analogue input which may be used for special functions if required. They can be assigned to predefined functions (torque off, hard stop, etc.) or be accessed by the user program running on the amplifier. Their current state can also be read by the control software via the CAN-bus or the serial interface.

The connectors X2 and X5 of the PCB provide easy access to three of the digital inputs and one digital output. These inputs can be equipped with a limiting resistor if the signal voltage is higher than 5 V. The positions for these are marked "Rin1", "Rin2" and "Rin3" and are located right beside the connectors.

Please keep in mind that the limiting resistor has to be bridged if the default signal level of 5 V is used.

The digital input 1 of the orientation drive amplifier is connected to the output of the position switch and cannot be used for customised functions.

Tip: The ground line of the digital inputs of the orientation drive amplifier is by default tied to the common ground of the amplifier power supply. In case independent voltage levels are required, please contact Neobotix.

The return line of the digital inputs of the traction drive amplifier can also be tied to the common ground by bridging the solder jumper marked "G←I-".

The motors' encoder signals are also available at the IO connectors. They can for example be used for motion monitoring by an external safety device.

Furthermore the IO connectors provide power supply for additional low power sensors. The module's logic supply voltage is available at pins "VL" (supply) and "G" (ground).

Further information can be found in the documentation of the drive amplifier "Whistle" on the homepage of Elmo Motion Control[17].

Use the following components for the I/O connection:

- Housing: TE Connectivity, HE14 receptacle double row 12 circuits, 281839-6

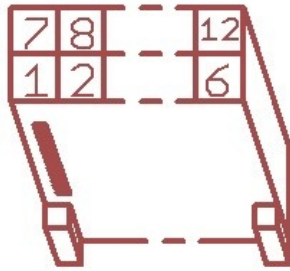- Contacts: TE Connectivity, HE14 crimp terminal female 28-24 AWG, 182734-2

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[17] https://www.elmomc.com/

Pin	Function	Description
1	A+	Channel A of the TTL motor encoder, for motion monitoring
2	B+	Channel A of the TTL motor encoder, for motion monitoring
3	O-	Emitter contact of the optocoupler of digital output 1
4	G	Main ground
5	I-	Common ground of the digital inputs
6	I2	Digital input 2 (mind the limiting resistor)
7	A-	Channel A (inverted) of the TTL motor encoder, for motion monitoring
8	B-	Channel B (inverted) of the TTL motor encoder, for motion monitoring
9	O1	Collector contact of the optocoupler of digital output 1
10	VL	Logic supply (output)
11	I1	Digital input 1 (mind the limiting resistor)
12	I3	Digital input 3 (mind the limiting resistor)

6.4.3.1 Motion Monitoring

On request the connectors can be prepared to provide direct access to the encoder signals of the traction and / or orientation motor from outside.

This option will change the pin assignment as follows.

Pin	Function	Description
1	O-	Emitter contact of the optocoupler of digital output 1
2	B+	Channel A of the TTL motor encoder, for motion monitoring
3	A+	Channel A of the TTL motor encoder, for motion monitoring
4	O1	Collector contact of the optocoupler of digital output 1
5	B-	Channel B (inverted) of the TTL motor encoder, for motion monitoring
6	A-	Channel A (inverted) of the TTL motor encoder, for motion monitoring

This option requires different connector housings:

TE Connectivity, HE14 receptacle double row 6 circuits, 281839-3

6.4.3.2 Enable Lines

On request the drive amplifiers can be configured to have two 24 V enable lines. The signals can be integrated into the CAN bus cable and then be conveniently patched through to all OmniDriveModules.

This option uses digital inputs 2 and 3 which then are no longer available for other functions.

> **Attention:** Please note that this feature is not safety approved.

The pin assignment of the CAN bus connector changes as follows:
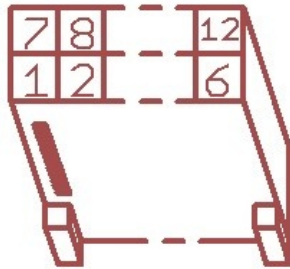
Pin	Function
1,7	GND
2,8	CANL
3,9	CANH
4,10	Shield
5,11	Enable1
6,12	Enable 2

This option requires the same connector housings as the digital I/Os.

6.5 Configuration

The best way to configure and optimise the drive amplifiers is by using the interface software Composer which is provided for free download from the homepage of the manufacturer Elmo Motion Control. The latest version can be found at:

https://www.elmomc.com/product/composer/

It is recommended to connect the computer that runs the Composer to the amplifier by a standard RS-232 serial connection (COM port). The appropriate configuration cable can be supplied on request.

The drive amplifiers are configured with general purpose settings and ready for operation. Before the OmniDriveModule can be used in a mobile robot, the communication parameters have to be adjusted according to the features of the control system.

If extraordinary kinematics are to be realised or if the modules are to be used under extreme conditions (very heavy vehicle or payload, uneven or soft floor, asymmetric centre of gravity, . . .) it might be necessary to adjust the control loop parameters of some or all amplifiers. Please contact Neobotix in such cases.
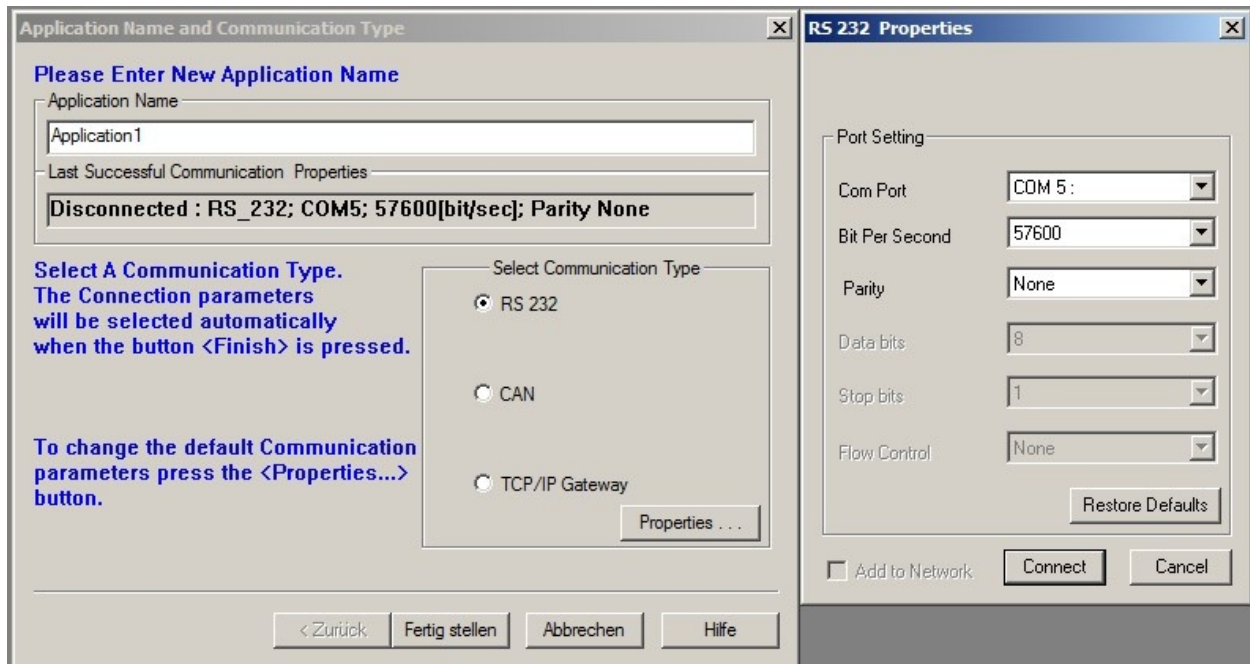
6.5.1 Connecting to the Amplifiers

After installing and starting the Composer the start dialogue will appear. Connect the computer to the amplifier by using the configuration cable and turn on the power supply of the amplifier.

Note: Please be careful to actually connect to the amplifier which you currently want to access.


Choose *Open Communication Directly* to open the communication settings dialogue. After selecting RS 232 as interface and clicking Properties you can select the COM port that you are using. Please select a baud rate of 57600 Bit Per Second and click Connect. The dialogue should close and the configuration toolbox, called Smart Terminal, should appear.

In case you cannot connect to the amplifier, please check the following:

- Amplifier power: Is the amplifier connected to a sufficient power supply and is the power supply turned on? In case the module is connected to a laboratory power supply: Is the current limit high enough to provide the inrush current and a sufficiently fast rise of the logic supply voltage?

- Cable: Is the computer actually connected to the correct amplifier? When handling several drives in a row it sometimes happens that only the power supply is connected to the next module while the configuration cable is still plugged to the previous module.

- Baud rate: The baud rate of the serial connections has been changed to 57.6 kBaud to make working with the modules more convenient. The default baud rate of the *Composer* is only 19.2 kBaud.

- COM port: Try other COM port numbers. If a USB-to-serial converter or a similar device is used, please check which number has currently been assigned to the interface. Close the *Composer*, re-connect the converter and restart the *Composer*.
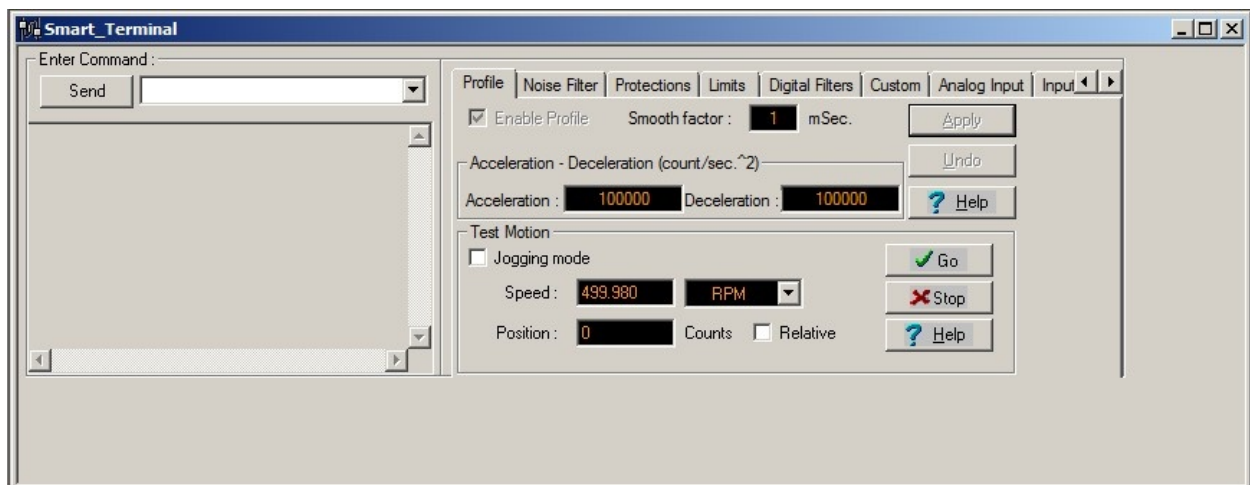
Use the button *Disconnect* on the right end of the main toolbar to close the connection to the amplifier. Disconnect button is shown below:

6.5.2 Handling Different Configurations

There are basically three ways of handling different configurations.

Main buttons: Create New Application, Open Existing Application, Save Application (f.l.t.r.)

6.5.2.1 Saving the Current Configuration

After connecting to an amplifier the current configuration is automatically uploaded to the *Composer* and can be saved in a file by clicking the button *Save Application* in the top left corner of the main window. The *Composer* will always ask whether the current configuration should also be written to the amplifier's non-volatile memory or if it should only be written to a file on the computer.

A Save-As-dialogue will always appear. If the configuration has been saved before (in the current session), the last used file name will be selected automatically but will also automatically have an extension indicating the currently used interface. To avoid having duplicate files please select the appropriate file manually before clicking Save.

Any changes to the configuration on the amplifier can also be written to the non-volatile memory without creating a file on the computer. Simply type "sv" into the command line of the Smart Terminal and hit Enter or click on Send.

6.5.2.2 Using an Existing File

To use a backup file simply click the button Open Existing Application, select the file and click Download in the open dialogue. In case the current interface differs from the settings stored in the file, you will need to open the properties dialogue by clicking Change in the Communication Info area of the file open dialogue.

After the connection has been established successfully, the configuration is downloaded to the volatile memory of the amplifier. To save the configuration permanently, please refer to the previous section.

The motor specific commutation parameters are also stored in the configuration file. This means that any known motor can be run by any amplifier after downloading the correct file to the amplifier. It also means that after connecting a new motor to any amplifier, the unique commutation parameters of the new motor have to be determined even if all other settings that are already saved in the amplifier may remain unchanged. Please contact Neobotix if you intend to replace the motor.

6.5.2.3 Creating a New Configuration

All motor parameters can be defined anew by using an integrated wizard. Since the OmniDriveModules are not meant to be run with different motors, it is not recommended to modify any settings with this feature.

In case you intend to modify the drives or need any further assistance please contact Neobotix.

6.5.2.4 Basic Settings

The Smart Terminal of the Composer shows all the basic settings that can easily be changed. In case you need to modify any other settings or need in-depths information, please refer to the documentation on the Elmo MC homepage or contact Elmo MC or Neobotix directly.
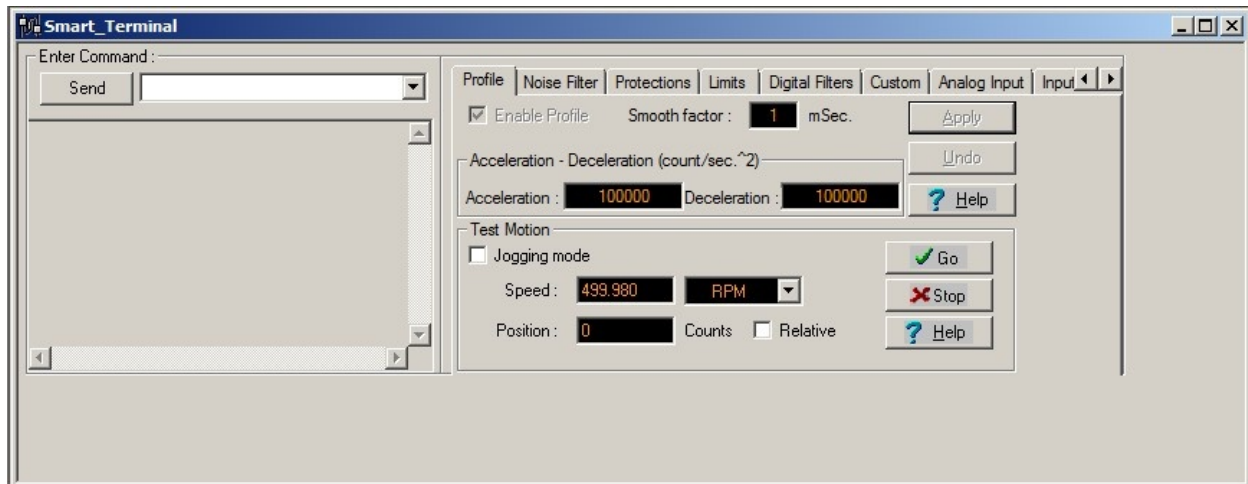
The communication settings can be changed by entering the command "PP" plus an index number in square brackets in the command line at the top left of the *Smart Terminal*. Enter the command and either hit enter or click the *Send* button to read the current value. Add the equals sign and the new value right after the command to change a setting.

The following commands may be necessary:

Command	Description	Common values
PP[2]	RS-232 baud rate	4: 57600 Baud (Default)
		3: 38400 Baud
		2: 19000 Baud
PP[13]	CAN ID	1-8
PP[14]	CAN baud rate	0: 1000 kBaud (Default)
		1: 500 kBaud
		2: 250 kBaud
PP[15]	CAN group ID	1 – 128 (Default: 30)

6.5.3 Advanced Settings

The motor must be deactivated for some settings to be applied. Use the button Stop & Motor Off to deactivate the motor.

6.5.3.1 Acceleration and Deceleration

The maximum permitted acceleration and deceleration can be set by editing the two according fields in the tab *Profile* of the Smart Terminal and clicking *Apply*. These values are the limiting values and will be used by the internal control loop of the amplifier. The actual acceleration and deceleration in normal operation is mainly determined by your motion control software and will be (and should be) significantly lower.

6.5.3.2 Speed Limits and Stop Deceleration

Several speed limits can be set on the tab *Limits*, sub tab *Velocity*. The Command limits define the velocity range that will be accepted by the amplifier. Motion commands with velocities exceeding this range will be rejected.

The *Feedback* velocities define the range in which the motor is allowed to operate without raising an error. Therefore the Feedback limits should be set wider than the command limits.

The *Stop* deceleration is the deceleration that is used when a stop command is sent to the amplifier. This deceleration can be much higher than the values defined as normal acceleration and deceleration. It is meant to provide the fastest yet safest stopping of the axis in case of an emergency.

6.5.3.3 Control Loop Parameters

The internal parameters of the velocity and position control loop can be changed in the Digital Filters tab.

The values of the current control loop should not be changed manually.

In the unlikely case that the behaviour of the OmniDriveModule does not meet the application's requirements the internal parameters may be changed carefully. Please consult your local Elmo Motion Control department before modifying these values.

6.5.4 Testing and Debugging

The *Test Motion area* in the Profile tab can be used to move the motor under manual control for testing purposes. Activate Jogging mode to make the motor rotate continuously with the given Speed, or deactivate the check-box to move the motor to the given Position. Simply click the Go button to start the motion and Stop to set the velocity back to zero.

The Composer also offers a function to record high definition measurements of the motor's movements and to plot these data graphically. Please contact Neobotix or Elmo Motion Control if you need further information on this topic.

6.6 Maintenance

The Neobotix OmniDriveModule does not require excessive maintenance. Please check the following details approximately every month to ensure the best function and a long life expectancy.

6.6.1 Cleaning

The gearbox housing of the OmniDriveModule is completely sealed and will not be affected by dirt. Nevertheless it is recommended to regularly remove dust and dirt in order to optimise heat dissipation, especially if the module is integrated into a closed hull and has only limited convection cooling.

Please keep the PCB and the amplifiers as clean as possible. This will prevent short circuiting and damage to the electronics.

Depending on the environment the module is used in, some amount of hairs and dust will accumulate on the wheel's axle near the bearing. Please clean this area regularly to avoid damage to the seals of the ball bearing and to minimise friction.
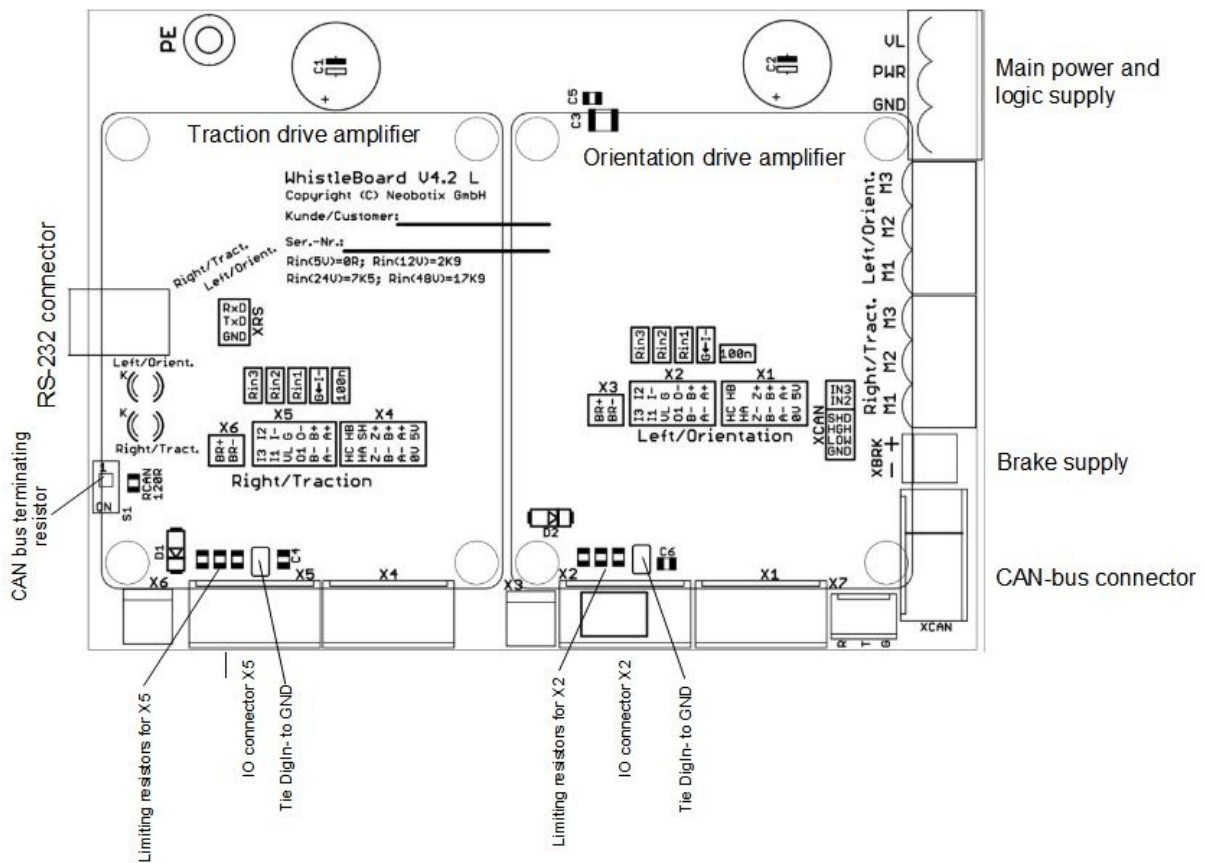
6.6.2 Traction Wheel

The traction wheel is very hard-wearing and not expected to show any signs of damage or wear within the expected lifetime of the module. In case you find any signs of wear, please contact Neobotix.

6.7 Technical Data

6.7.1 Dimensions

Dimensional drawings of the OmniDriveModule can be found in chapter *Mounting* (page 64).

6.7.2 Board-Layout

6.7.3 Properties

Description	Unit	Value
Weight	kg	18
Traction drive gear ratio (second stage)	1	2:1
Traction drive gear ratio (first stage)	1	15:1
Rated wheel torque @ 48V	Nm	34
Rated wheel torque @ 48V	rpm	100
Position sensor supply voltage	VDC	24
Orientation drive gear ratio	1	19:1
Motor encoder resolution	Inc. / Rev.	10.000
Maximum payload per module	kg	150
Expected working time	a	10
Amplifier supply voltage (minimum / recommended)	VDC	24 / 48

6.8 Taking out of Service

You can find information about taking out of service and about recycling *here* .

6.9 Legal Notes

The general legal notes can be found at *Legal Notes* .

6.9.1 Declaration of Incorporation

This product is a partly completed machinery and sold without CE marking.

This partly completed machinery must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of Directive 2006/42/EC and all other applicable EU directives.

6.9.2 RoHS Information

This product complies to the RoHS directives 2011/65/EU (RoHS 2) and 2015/863/EU of the European Parliament and the Council on the restriction of the use of hazardous substances in electrical and electronic equipment.