NEURA ROBOTICS

MAiRA®

Multi-Sensing Intelligent Robotic Assistant

User Manual

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1. ABOUT THIS DOCUMENT

1.1. How to Use This Manual

This manual contains information that is necessary to use the robot. Please read this manual and make sure that you understand the safety, assembly, maintenance, and operation of the MAiRA robot series before attempting to use it.

Always keep this manual in a safe place where it will be available for reference during operation.

Please read and understand the instructions in *chapter 2,"General Safety Instructions" on page 4*. The user manual provides instructions for MAiRA operators from the following aspects:

- Safety Issue: The operator shall keep all safety instructions in mind.
- Mechanical Installation: The operator shall follow the instructions when installing the robot.
- Electrical Ports: Open ports of MAiRA are introduced to provide convenience for secondary development.
- Software Control: Is described in the MAiRA software user manual. It can guide the operator to install software and run the robot.
- Safety Configuration: It introduces the basic safety settings.
- Assembly instructions as per MD (2006/42/EC).

1.2. Related Documents

The MAiRA robot system can be used both as stand-alone and as part of a machine. Also refer to the following instructions:

- MAiRA Software user manual
- Quick Start Guide

1.3. Robot Models

This manual provides information for the following MAiRA models.

- MAiRA **S**mall
- MAiRA **M**edium
- MAiRA **L**arge

If information varies between different robot models, details are provided. If information is common to all robot models, an illustration of a single robot model is typically shown.

1.4. Used Characters and Symbols

In this user manual, various elements are used to indicate special text meanings or especially important text passages.

Symbols and terms used in warnings

The table below defines the common safety warnings, symbols and terms that may exist in the content of using robots:

⚠	The general danger symbol warns of risk of serious injury when used with the signal words **CAUTION**, **WARNING** and **DANGER**. Follow all instructions to avoid injuries or death.
NOTICE	Indicates a hazardous situation which, if not avoided, results in damage to or destruction of the device.
CAUTION	Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
WARNING	Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
DANGER	Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

Structure of warnings

⚠ SIGNAL WORD
Type and source of danger **Consequences resulting from non-observance** ► Action for danger avoidance

Symbols and marks

🗐	**Prerequisite** Indicates a prerequisite that must be satisfied before one of the following actions is performed, e.g.: 🗐 You are in the measurement display
►	**Action** Indicates a single action, e.g.: ► Switch on device.
1. **2.** **3.**	**Sequence of actions** Indicates a sequence of actions that must be performed in the specified order
	Result Indicates the result of an action, e.g.: The device starts a self-test.
Bold text	**Operating element or menu name** Indicates operating elements and menu names, e.g.: ► Press the **OK** button.
NOTE:	Important additional information or notes regarding exceptions and special cases.

1.5. Abbreviations

Abbreviation	Description
AC	Alternating Current
AI	Analog Input
ANSI	American National Standards Institute
AO	Analog Output
DC	Direct Current
DI	Digital Input
DIN	German Institute for Standardization
DO	Digital Output
EMC	Electromagnetic Compatibility
EN	European Standard
ESD	Electrostatic Discharge
GND	Ground
GUI	Graphical User Interface
HMI	Human Machine Interface
I/O	Input / Output
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
PLC	Programmable Logic Controller
PL d	Performance Level d
TCP	Tool Center Point
USB	Universal Serial Bus

1.6. Technical Support

NEURA Robotics GmbH will provide long-term technical services. If you have any technical problems or other needs during use, please visit our company website www.NEURA-robotics.com, or directly contact your local NEURA Robotics support.

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2. GENERAL SAFETY INSTRUCTIONS

The MAiRA Robot System has been manufactured according to the accepted rules of safety and current technology. There is, however, still a danger of personal injury or damage to equipment if the following general safety instructions and the warnings before the steps contained in these instructions are not complied with.

- Read these instructions completely before working with the MAiRA robot. The contents with warning signs need to be mastered and strictly followed.
- Always keep this manual in a safe place where it will be available for reference during operation.
- Always include the operating instructions when passing the MAiRA robot on to third parties.

This chapter introduces the safety principles and specifications that must be followed when operating the robot or robot system. Because the robot system is complex and dangerous, users need to fully understand the risks of operation and strictly abide by and implement the specifications and requirements in this manual. Operators and integrators need to have sufficient safety awareness and comply with the industrial robot safety standard ISO 10218.

MAiRA robots are equipped with a variety of built-in safety functions and safety inputs and outputs (I/O), digital and analog control signals to and from the electrical interface, used to connect other machines and additional protective devices. Each safety function and I/O are designed in accordance with EN ISO13849-1:2008. The performance level (PL d) of the three types of structures is used to understand the configuration of safety functions, inputs, and outputs in the user interface.

About the connection of safety equipment and I/O.

- The use and configuration of safety functions and interfaces must follow the risk assessment procedures of each robot application.
- If the robot finds a fault or violation in the safety system (for example, a line in the emergency stop circuit is cut off or a safety limit violation occurs), the robot will immediately go into a safe stage and stop.
- The stop time should be considered as part of the application risk assessment.
- The difference between the safety configuration parameters used and the risk assessment can lead to risks that cannot be reasonably eliminated or risks that cannot be sufficiently reduced.
- Make sure that the tool and connectors are properly connected to avoid danger if the power supply is interrupted.
- The end effector is not protected by the safety system of NEURA Robotics GmbH. The end effector and/or connection cable function is not monitored.

The following general safety precautions must be followed during all phases of operation, service, and repair of this robot.

NEURA ROBOTICS SHALL NOT BE LIABLE FOR FAILURE, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, LOSS OF PROFITS OR PRODUCTION OR COMMERCIAL LOSS IN ANY WAY CONNECTED WITH THE MAiRA SAFETY STANDARDS.

2.1. General Instructions

- Do not use the robot if it is damaged. Please contact the technical support personnel of NEURA Robotics immediately.
- Observe the regulations for accident prevention and environmental protection for the country of operation.
- Only authorized and qualified personnel is permitted to work with the robot (assembly, installation, configuration, commissioning, operation, maintenance).
- Disconnect the power supply and install the robot and all electrical equipment in accordance with the requirements and specifications in this manual. Follow the safety instructions and warnings as per section 6.3, Electrical Installation.
- Do not connect the safety device to the regular I/O interface. Only use the safe I/O interface.
- Do not place any objects or any mechanical loads on the device under any circumstances.
- Ensure that power supply is within the specified tolerance for the module.

- Take care of stored energy (e.g. weight force) when dismounting parts of the robot. The parts must be secured using suitable aids.
- NEURA Robotics GmbH shall not be liable for any damage or personal injury caused to the robot due to errors in this script or improper operation of the robot.
- The robot system is designed to be used at altitudes lower than 2000 meters above sea level.
- The robot system is designed for a lifetime of 7 years in a typical use case scenario.
- Take care of potential hazards leading to injuries and equipment damage when working with the robot system. Potential hazards are, for example:
  - Fingers being hurt by robot base or joint.
  - Sharp edges and sharp points on tool or tool connector piercing the skin.
  - Sharp edges and sharp points on obstacles near the robot trajectory piercing the skin.
  - Injuries by a robot collision.
  - Sprains or fractures due to the impact between the robot's payload and a solid surface.
  - Consequences due to insecure bolts used to fix the robot arm or tool.
  - Items fall from the tool, for example due to inadequate clamping or power failure.
  - Operation errors due to different emergency stop buttons on different machines.
  - Movement without drive power. Gravity and the loss of braking devices lead to additional hazards.
  - Stored hazardous energy. (e.g. weight force, air, hydraulic pressure accumulators)

2.2. Assembly and Installation

- The procedures for safe handling in the IFU needed to be followed.
- Make sure that there is enough space for robot arms to move freely.
- Make sure that the arms and tools of the robot are installed properly and safely.
- Avoid sharp edges for additional equipment to hinder injuries.
- Make sure that installation settings (such as robot's installation angle, weight in tool center point, TCP offset, safety configuration) are correct. Save the installation file and load it into the program.
- Free drive function mode (impedance / reverse drive) can only be used in the installation process after passing the risk assessment. Tools and obstacles should not have sharp corners or twists. Ensure that the head and face of all people are beyond the reach of the robot.
- If software gives out a fatal error message, please activate the emergency stop quickly, write down the situation that caused the error, find out the related error codes on the log page, refer to chapter 67 Malfunctions and Failures, and contact NEURA Robotics.
- Connecting different machines may pose risks or cause new danger. A comprehensive risk assessment on the whole installation process always must be carried out. If different safety and emergency stop performance levels are required, the highest performance level always must be selected. Always read and understand the user manual of all devices used in the installation.
- When the robot is connected to or works together with other machines that may damage the robot, it is strongly recommended that all functions of the robot and robot program should be checked separately. It is recommended to use other temporary points outside the mechanical workspace to test the robot program.
- After the robot installation and construction are completed, a safety specialist must complete the comprehensive risk assessment and documentation must be stored for the record purpose.
- The safety parameters are set and changed by authorized personnel, and passwords or isolation measures are used to prevent unauthorized personnel from changing or setting security parameters. After modifying safety relevant components or parameters, relevant safety functionality must be analyzed.
- After integration of the incomplete machine into the final machine, all additional safety circuits shall be designed according to IEC 60204-1:2019 9.2.3.2.
- After integration of the incomplete machine, additional control devices and visual indicators need to be marked clearly and durable regarding their functions.
- Additional provision of emergency stop devices at each location where the initiation of an emergency stop is required may be needed.

- After integration of the incomplete machine, additional relevant circuits must be started automatically.
- After installing additional devices, fir suitable safety devices to prevent unintentional operation.
- Ensure that the start of an operation is only possible if all relevant safety functions and/or protective measures are in place and operational.
- The final integration of the robot with end effectors must be able to withstand the overload in the dynamic tests with a coefficient of 1,1. Deformations or defects may not be the result
- The final integration of the robot with end effectors must be able to withstand the overload in the static tests with a coefficient of 1,25. Deformations or defects may not be the result.
- Emergency stop devices shall be in accordance with IEC 60947-5-5.
- Instructions for programming and restarting the robot, see software manual.

2.3. Commissioning

- Before using the robot for the first time and putting it into operation, preliminary testing and inspection of the robot and its protective system are required.
- The operator/user must check and ensure that all safety parameters and user programs are correct and that all safety functions (e.g. emergency stop buttons) are working properly. A person qualified to operate the robot is required to check each safety function. The robot shall only be started after passing a comprehensive and careful safety test.
- Before starting the system and equipment for the first time, ensure that the equipment is complete, free from any damage for safe operation.
- During this inspection, it is necessary to observe whether it complies with the effective safety production regulations of the country or region, and all safety functions must be tested.
- Make sure that the robot's arm and tools are installed correctly and safely.
- Make sure that the robot has enough space to move freely.
- Make sure to set the correct installation settings (such as the installation angle of the robot body, the weight in TCP, TCP tool coordinates, safety configuration). Save and load the installation file into the program.
- Make sure that the installation settings (such as robot’s installation angle, weight in TCP, TCP offset, safety configuration) are correct. Save the installation file and load it into the program.
- Tools and obstacles must not have sharp corners or twisted points. Make sure that no one is in reach of the robot.

2.4. Operation

- When operating the robot system, you must first ensure the safety of the workers. The general precautions are listed below:
  - Take appropriate measures to ensure the safety of the workers.
  - Each operator shall complete the training course offered by NEURA Robotics GmbH or authorized partners.
  - The user needs to fully master the safe and standardized operation process and has the qualification for robot operation.

  For details of the training, please inquire with our company, see the official website for contact information: https://www.NEURA-robotics.com.
- The robot system can be used in different operational modes.
  - Manual/Teach mode: is used to set up an application. Tasks can be performed including jog mode, teach mode, writing a program or verifying a program.
  - Automatic mode: is used to operate the robot in pre-defined tasks.
- Pay attention to the movement of the robot when using the teach pendant.
- Do not enter the safety area of the robot or touch the robot when the system is running.
- Do not wear loose clothes when operating the robot. Please be sure to tie your long hair up and keep it behind your head when operating the robot.

- During operation of the equipment, even if the robot seems to have stopped, it may be because the robot is waiting for the start signal and is in a state where it is about to move. Even in this state, the robot shall be regarded as being in motion.
- Make sure that safety measures (such as guard rails, ropes, or protective screens) are taken near the robot operation area to protect the operator and surrounding people. Locks should be set according to the needs, so that the person in charge of the operation cannot access the robot power supply.
- Lines shall be drawn on the floor to mark the range of motion of the robot, so that the operator understands the range of motion of the robot including its tools (manipulators, tools, etc.).
- Do not wear gloves while working on the operation panel and teach pendant. It may cause operational errors.
- Robot and electrical control cabinet will produce heat in the operating process.
  - Do not operate or touch the robot while working or just after stopping work.
  - Never touch hot areas of the control cabinet.
- Generally, the robot cools down within one hour after disconnecting the power.
- In the event of an accident or abnormal operation of the robot, you must press the emergency stop switch to stop the robot immediately. In rare cases, it may be necessary to move one or more robot joints in an emergency situation where the power supply of the robot fails or does not want to use the power supply (see section *8.4 Emergency Handling* on page *63*.)
- In an emergency or abnormal situation such as a person being caught or surrounded by a robot, push or pull the robot arm with force (at least 500 N) to force the joint to move.
- Manually moving the robot arm without electric drive is limited to emergency situations and may damage the joints.

2.5. Modification

Do not perform unauthorized modification to the robot. Any modification of the robot may cause unpredictable hazard to the user. Reconfigure the robot in accordance with the latest edition of all related service manuals. NEURA Robotics shall not be liable for failure or consequential damages. Do perform relevant tests and examinations after change of component parts or addition of optional equipment which can affect the safety-related functions.

2.6. Repair and Maintenance

Obey all safety instructions in this manual before carrying out any maintenance and repair work.

- Repair and maintenance work may only be carried out by qualified personnel.
- Remove the main input cable from the electrical control box to ensure that it is completely powered off.
- Disconnect other energy sources connected to the robot arm or electrical control box. Take necessary precautions to prevent others from reconnecting the system energy during maintenance.
- Check the ground connection before restarting the system.
- Observe ESD regulations when disassembling the robot arm or electrical control box.
- Do not disassemble the power supply system of the control box. The power supply system may retain high voltage (up to 600 V) after turning off the electrical control box.
- Avoid water or dust entering the robot arm or electrical control box.
- After maintenance and repair, a check must be carried out to ensure the safety level required by the service. When verifying, you must abide by effective national or local safety laws and regulations. Meanwhile, all safety functions should be checked.
- MAiRA series robot joint modules are equipped with brakes to maintain the robot's posture when the power is turned off. Do not artificially break the power supply system frequently to avoid excessive wear of the brakes. It is recommended that the time interval for switching on and off each time should be greater than 10 s.

2.7. Environmental Conditions

- Only operate the device under ambient conditions as specified in the technical data in this manual (see *Technical Specifications* on page *93*).
- Prevent the robot from being exposed to permanent magnetic fields. A strong magnetic field can damage the robot.

2.8. Device Malfunctions

- Only operate the device under the conditions and for the purposes for which it was designed.
- Periodically inspect the device for damages.
- Repair activities must be carried out by specialists only.

2.9. Qualified Personnel

Qualified personnel are those who can recognize possible hazards and institute the appropriate safety measures due to their professional training, knowledge, and experience as well as their understanding of the relevant conditions pertaining to the work to be done. Qualified personnel must observe the rules relevant to the subject area.

The table below shows who is allowed to carry out tasks in the phases of the robot’s life cycle.

Necessary operator qualifications in different phases of the robotic system life cycle

Phase of Robotic system life cycle	Task	Qualification of Operator		
		Non-professional	Trained	Specialist
Transport (Original packaging)	Lifting, transportation, handling	X		
Transport (unpacked)	Unpacking, lifting, transportation, handling		X	
Installation	Mounting		X	
	Assembly		X	
	Connection of original cables (plugs)		X	
	Connection of custom cables (GPIOs)			X
	Testing		X	
Teaching & Programming (initial/ changes)	Setting of parameters (e.g. speed, force, travelling limits)		X	
	Functional tests		X	
	Verification of final system			X
Operation	Normal operations		X	
	Starting/restarting system		X	
	Stopping system		X	
Maintenance	Cleaning		X	
	Resetting		X	
Service	Troubleshooting		X	
	Verification of repairs			X
	Rescue of trapped persons	X		
Decommissioning/ Disabling	Disconnecting from mains		X	
	Packing		X	

Operator: A person or persons installing, operating, adjusting, maintaining, cleaning, repairing, or moving machinery. These persons must be appropriately instructed to perform the assigned tasks.

Non-professional: A person or persons without specified training by NEURA robotics or authorized partner. These persons must be appropriately instructed to perform the assigned tasks.

Trained personnel: A person or persons who have been instructed by NEURA Robotics or an authorized partner and trained in the duties with which they are entrusted and the risks which may arise from incorrect behavior. They also have been advised on the necessary protective devices and precautions.

Specialist: A qualified person, which based on professional training, knowledge and experience can assess assigned duties and will be aware of possible risks. Furthermore, this person knows the relevant regulations.

2.10. Integrator

The integrator is a person who designs, provides, manufactures, or assembles an integrated manufacturing system and is responsible for the safety strategy, including protective measures, control interfaces and connections of the control system.

2.11. Risk Assessment

Risk assessment is one of the most important tasks that the integrator must complete. The robot itself is a partially completed machine, and the safety of the installed robot depends on how the robot is integrated (considering e.g. tool), obstacles, and other machinery.

It is recommended that the integrator uses at least the guidelines of ISO12100 and ISO10218-2 to carry out risk assessment.

The risk assessment needs to consider three situations: the risk of robot installation, robot demonstration and the risk of running the robot.

For the non-collaborative installation of the robot (e.g., when using dangerous tools), risk assessment may infer that integrators need to connect additional security devices to protect themselves when programming the robot system.

The integrator is responsible for providing means of visual or audible indication to give the operator information about the status of the robot.

Hazard Identification

The risk assessment should consider all potential contact between the operator and the robot during normal use and foreseeable misuse. The operator's neck, face and head should not be exposed to avoid touching. Using robots without using peripheral safety guards requires a risk assessment to determine whether the relevant hazards will constitute an unacceptable risk, such as:

- The use of sharp end effectors or tools connectors may be dangerous.
- It may be dangerous to handle toxic or other harmful substances.
- The operator's fingers may be caught by the robot base or joints.
- The danger of colliding with the robot.
- The danger that the robot or the tool connected to the end is not fixed in place.
- Danger caused by impact between the robot payload and a solid surface.

Integrators must measure such hazards and their associated risk levels through risk assessment and determine and implement appropriate measures to reduce the risk to an acceptable level. Please note that there may be other major hazards with certain robotic devices.

By combining the inherent safety design measures applied by MAiRA robots with the safety specifications or risk assessments implemented by integrators and end users, the risks associated with the collaborative operation of MAiRA robots are reduced to a reasonable and feasible level as much as possible. This document can be used to communicate any remaining risks of the robot before installation to the integrator and end user.

If the integrator's risk assessment determines that there are hazards in its specific application that may cause unacceptable harm to the user. In that case, the integrator must take appropriate risk reduction measures to eliminate or minimize the hazards to an acceptable level. It is unsafe to use it before taking appropriate risk reduction measures (if necessary).

If the robot is installed in a non-collaborative manner (for example, when using dangerous tools). In that case, the risk assessment may infer that the integrator needs to connect additional safety equipment (for example, safe start-up equipment) to ensure the safety of personnel and equipment during their programming.

2.12. Emergency Stop Mechanism

All the moving parts of robot will stop when the emergency-stop is activated. After releasing the emergency-stop, no action of the robot is started. The emergency stop cannot be used as a risk reduction measure, but it can be used as a secondary protection device. If multiple emergency-stop buttons need to be connected, they should be included in the risk assessment of robot application.

2.13. Freeing a stuck/trapped person

When freeing a stuck/trapped person always press any system emergency stop button before following any suggested measures described below:

- When there is no expected harm or immediate danger to life, the robot can be activated and carefully jogged away with <10% override.
- When the activation of the robot is not possible, carefully loosen the 4 screws at the robot base so the robot can be slightly tilted, and the person can escape. At least two people shall always hold on to the robot during procedure, preventing it from tipping over.
- In case there is immediate danger to life, forcefully pull the robot away from the stuck person with at least two people. Please note that the robot could take damage from this action and an inspection through NEURA Robotics or authorized partner is necessary.

⚠ DANGER
► Moving the Robot without drive power (meaning with manual force) will result in mechanical damage. If the robot was moved without drive power the robot system must be sent to NEURA Robotics or authorized partner for inspection.

2.14. Responsibilities and Specifications

MAiRA series robots can be combined with other equipment to form a complete machine. Therefore, the information in this manual does not include how to fully design, install, and operate a complete robot, nor does it include all the possibility of affecting the safety of the peripheral equipment of this complete system. The safety of a complete robot installation depends on how the robot is integrated.

Integrators need to follow the laws and regulations of the host country and safety regulations and standards to conduct a risk assessment of the design and installation of the complete system.

Risk assessment is one of the most important tasks that integrators must complete.

Integrators can refer to the following standards to perform the risk assessment process.

- ISO 12100:2010 Safety of machinery-General design principles-Risk assessment and risk reduction.
- ISO 10218-2:2011 Robots and robotic equipment-Safety Requirements-Part 2: Industrial robot systems and integration.
- ISO/TS 15066:2016 Robots and robotic devices – Safety requirements for industrial robots – Collaborative operation.
- ISO 13857:2019 Safety of machinery-Safety distances to prevent hazard zones being reached by upper and lower limbs.

The integrator of MAiRA robot needs to perform but not limited to the following responsibilities:

- Comprehensive risk assessment of complete robot systems.
- Additional measures for risk reduction are required after integration of the incomplete machine into a final machine.

- Emergency stop devices need to be colored in general accepted colors.
- Ensure that there are additional emergency stop switches at every location where the activation of an emergency stop switch is required.
- Ensure that the emergency stop devices of the robot are linked with the emergency devices of other machines if used in an assembly of machines.
- Connection of electrical end effectors needs to have adequate safety factor.
- Prevention of electrostatic charging in the end application is necessary.
- Mark additional enclosures that do clearly show that they contain electrical equipment that can give rise to risk of electric shock with the graphical symbol ISO 7010-W012.
- Mark additional control devices and visual indicators clearly and durably regarding their functions.
- Additional warning signs shall be plainly visible on the enclosure door or cover.
- Connection of pneumatic power source and end pneumatic effectors need to have adequate safety factor
- Confirm that the design and installation of the entire system is accurate.
- Provide training to users and staff.
- Create a complete system of operating specifications and clearly explain the use process.
- Establish appropriate security measures.
- Use appropriate methods during final installation to eliminate hazards or minimize all hazards to an acceptable level.
- Communicate residual risks to end users.
- Mark the integrator's logo and contact information on the robot.
- Archive related technical documents.

For access to applicable standards and legal guidelines, please visit www.NEURA-robotics.com.

All safety information contained in this manual should not be regarded as a guarantee of NEURA Robotics GmbH even if all safety instructions are followed, personal injury or equipment damage caused by operators may still occur.

NEURA Robotics GmbH is committed to continuously improving the reliability and performance of the product, and therefore reserves the right to upgrade the product without prior notice. NEURA Robotics GmbH strives to ensure the accuracy and reliability of the contents of this manual but is not responsible for any errors or missing information.

2.15. Intended Use

MAiRA is an industrial product designed for general use in industrial, manufacturing and research settings to manipulate objects with high precision and accuracy. MAiRA is only allowed to be used under specified environmental conditions mentioned in this document (e.g., reach limits, pay load etc.). It is intended for use by trained personnel only and should not be used by individuals without training and authorization. Operating the robot arm not within its specified operational limits or misuse it may lead to serious injuries or damage to equipment.

MAiRA should be used in an environment, free from hazards, and with appropriate safety measures in place. It should not be used in environments with flammable or explosive materials, high voltage equipment, or other potential hazards.

The robot has a special safety level feature that can be used for collaborative operation, where the robot system operates without any safety protection devices and/or together with a human. Collaborative operation is only intended for non-hazardous applications, where the complete application, including tool/end effector, work piece, obstacles, and other machines, is without any significant hazards according to the risk assessment of the specific application.

The robot arm should only be used in conjunction with appropriate software and control systems, with programming and operation performed by trained personnel. Robot controllers and robots are limited to the use of general industrial equipment and must not be used in applications that violate the intended use.

2.16. Non-intended Use

The robot arm is designed and intended for specific applications in industrial, manufacturing, and research settings. Any use of the robot arm outside its intended purpose may result in serious injury of humans or damage to equipment. NEURA Robotics GmbH will not assume any liability for misuse. Misuse (= non-intended use) includes, but not limited to:

- Hazardous environments: The robot arm is not designed for use in flammable, explosive and other hazardous environments.
- Special environments: The robot arm is not designed for use in vibration environments of vehicles, ships, etc.
- Medical procedures: The robot arm is not intended for use in medical procedures, including surgical procedures or any other medical applications.
- Lifting device: The robot arm is not designed as lifting device for any living species.
- Childcare or supervision: The robot arm is not intended for use in childcare or supervision of children, and it should not be used as a babysitter or caregiver.
- Military or tactical use: The robot arm is not intended for use in military or tactical applications or products, including weapons, defense systems, or any other military or tactical use including manufacturing of mentioned.
- Unapproved modifications: Any modifications made to the robot arm not approved by the manufacturer are considered non-intended use and may result in serious injury or damage to equipment.

2.17. Warranty

In the principle of no prejudice to any claim agreement that may be reached between users (customers) and distributors or retailers, the manufacturer shall give customers a product quality warranty according to the following terms: If any defect occurs due to defective manufacturing or materials within 12 months after new equipment and its components are put into operation (not more than 15 months if transportation time is included), NEURA Robotics shall provide necessary spare components while users (customers) shall provide labor for replacement with spare components. Related components shall be maintained or replaced with another component embodying the up-to-date technological level. This product quality warranty is invalid if equipment defects are caused by improper handling or failure to observe related information described in the user manual. This product quality warranty does not apply to or extend to any maintenance performed by authorized distributors or customers such as installation and software downloading. Users (Customers) must provide a purchase receipt and purchase date as valid evidence of enjoying the product quality warranty. According to this product quality warranty, any claim must be made within two months when the product quality warranty is not obviously fulfilled. Any equipment or components replaced or returned to NEURA Robotics shall be owned by NEURA Robotics. Any other claim arising from or in connection with equipment is not within the scope of this product quality warranty. Any terms of this product's quality warranty do not try to limit or exclude customers' legal rights as well as the manufacturer's liability for any casualties due to its negligence. The duration of this product quality warranty shall not be extended due to any services provided according to the terms of this product quality warranty. NEURA Robotics reserves the right to collect replacement or maintenance costs to customers without violating the principles of this product quality warranty. The preceding regulations do not imply any change of burden of proof, harming the interests of customers.

If equipment shows any defect, NEURA Robotics shall not bear any resulting damage or loss, e.g., production loss or damage to other production equipment.

Disclaimer

NEURA Robotics reserves the right to upgrade products without prior notice because it devotes itself to continual improvement on product reliability and performance. NEURA Robotics does its best to ensure the accuracy and reliability of the contents of this manual but disclaims any liability for any error or missing information.

3. PRODUCT DESCRIPTION

MAiRA (Multi-sensing Intelligent Robotic Assistant) is the first commercially available cognitive robot with a configuration of six or seven degrees of freedom. Thanks to its integrated artificial intelligence and sensors, MAiRA can perceive its surroundings and is able to easily adapt to all kinds of industrial environments.

Novel touchless safe human detection technology gives MAiRA the ability to perceive humans and enables true collaboration between human and robot. The integrated 3D voice recognition allows users to easily give commands and let MAiRA execute orders at ease.

The robust and rigid design merges the performance of a high-end machine with easy programming and infinite possibilities for interaction – both for beginners and experts: the tablet-based user interface visualizing MAiRA in a three-dimensional space enables users to easily move all joints of MAiRA and to create new applications using a convenient drag-and-drop system. Furthermore, MAiRA offers special control buttons and a dedicated zero gravity mode, allowing users to move MAiRA with just a fingertip.

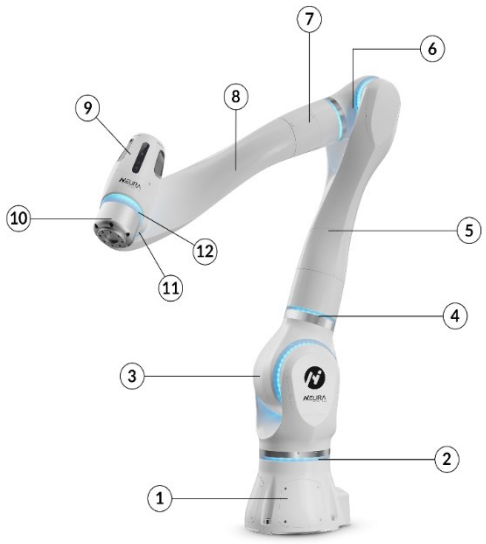
Precision and accuracy at micron level for pathing, positioning and repeatability are made possible through special encoder technology. This way, MAiRA can even handle small or sensitive objects in a safe manner, thus avoiding waste or costly collisions.

This manual provides information for the following models of MAiRA:

- MAiRA Basic/Pro **S** with 15-18 kg of payload and reach of 1100 mm.
- MAiRA Basic/Pro **M** with 12-14 kg of payload and reach of 1400 mm.
- MAiRA Basic/Pro **L** with 9-11 kg of payload and reach of 1600 mm.

3.1. Robot body

3.1.1. Overview



1 Base
2 Joint 1 (J1)
3 Joint 2 (J2)
4 Joint 3 (J3)
5 Lower Arm
6 Joint 4 (J4)
7 Joint 5 (J5)
8 Upper Arm
9 MAiRA Head
10 Connector Flange
11 Joint 6 (J6)
12 Joint 7 (J7)

Fig. 1: Overview robot body

1 Speaker
2 MAiRA head
3 Joint 6 (J6)
4 Connector flange
5 Camera
6 Microphone
7 Touch field

Fig. 2: Overview robot head

3.1.2. Dimensions

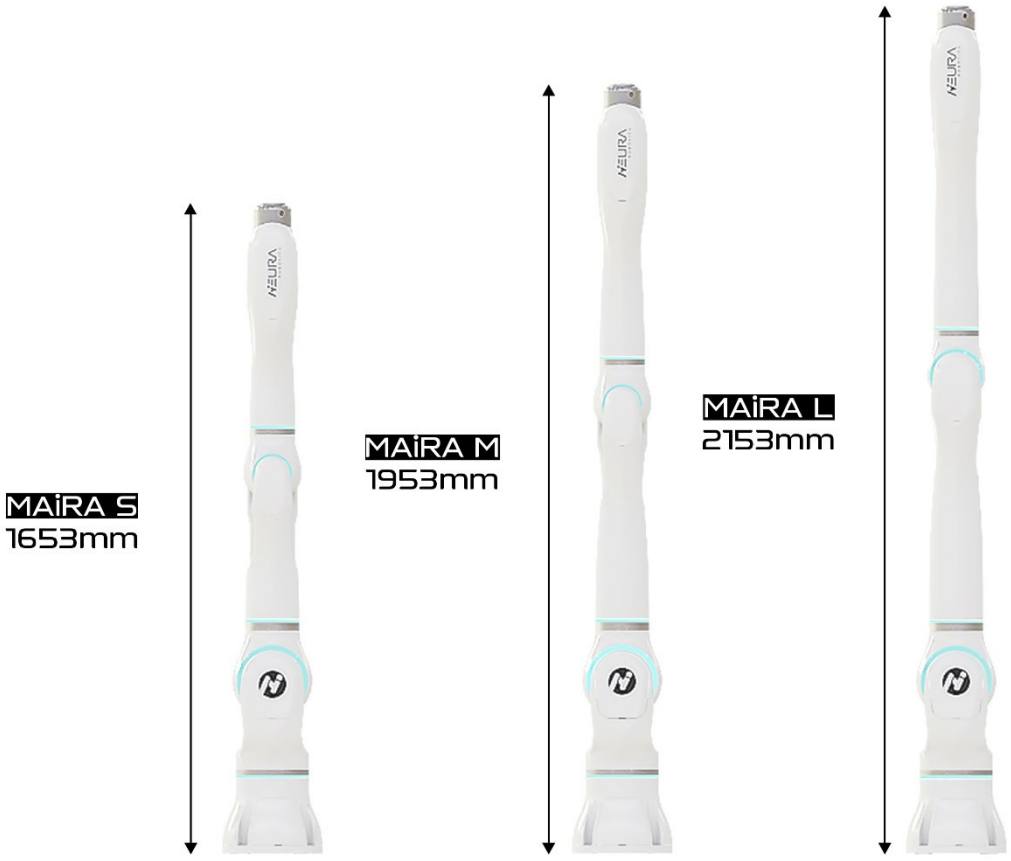


Fig. 3: Robot Dimensions for different types S, M and L

3.1.3. Tool Payload Range

Due to different distances between the load center at the end of robot and the center of installed flange, the allowable payload of robot will change accordingly. The relationship between the centroid distance and allowable payload is shown below:

Item	Specification		
	MAiRA Pro S	MAiRA Pro M	MAiRA Pro L
Payload	15–18 kg	12–14 kg	9–11 kg
Reach	1100 mm	1400 mm	1600 mm

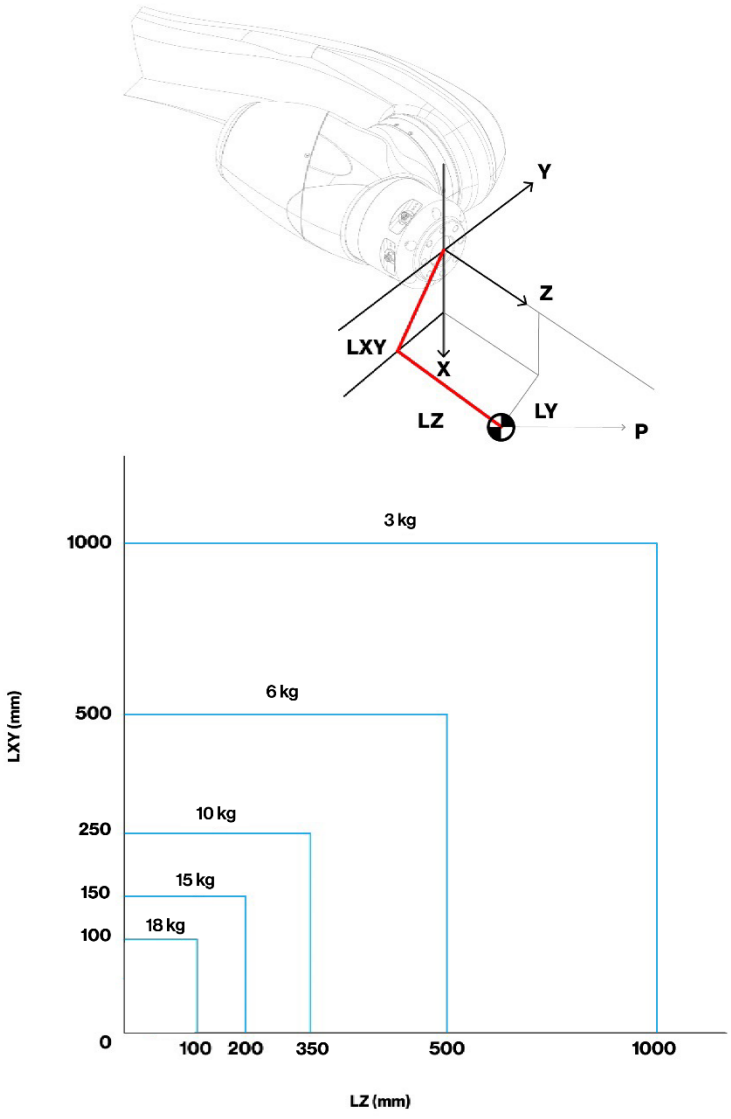


Fig. 4: Payload diagram MAiRA S robot

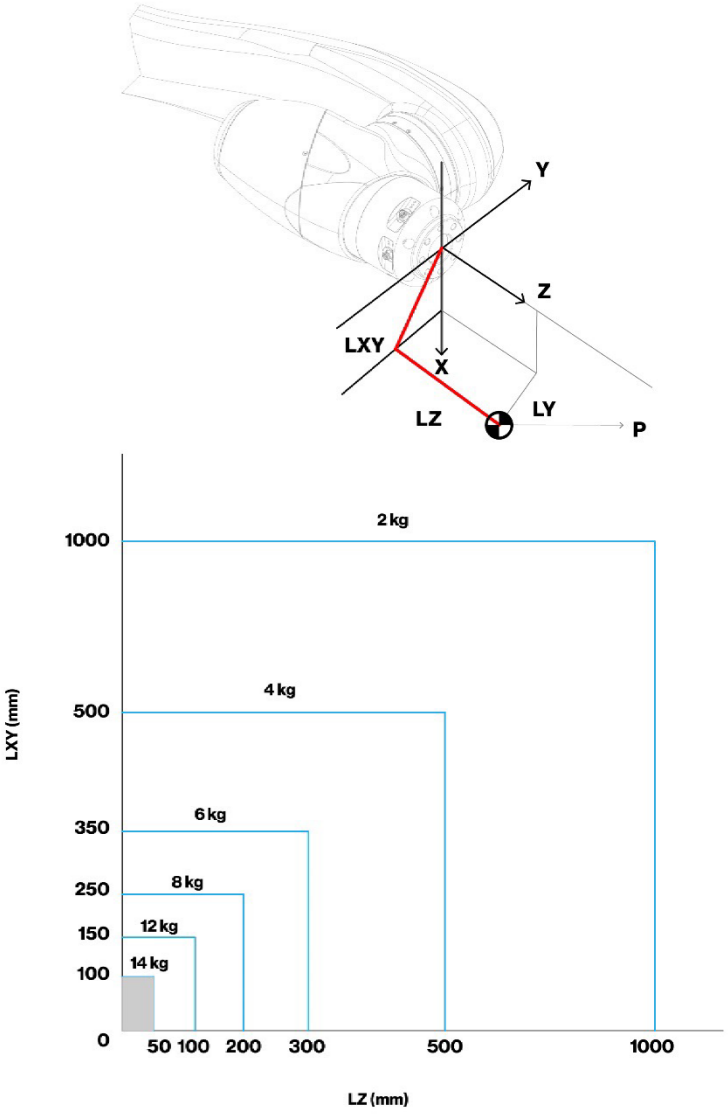


Fig. 5: Payload diagram MAiRA M robot

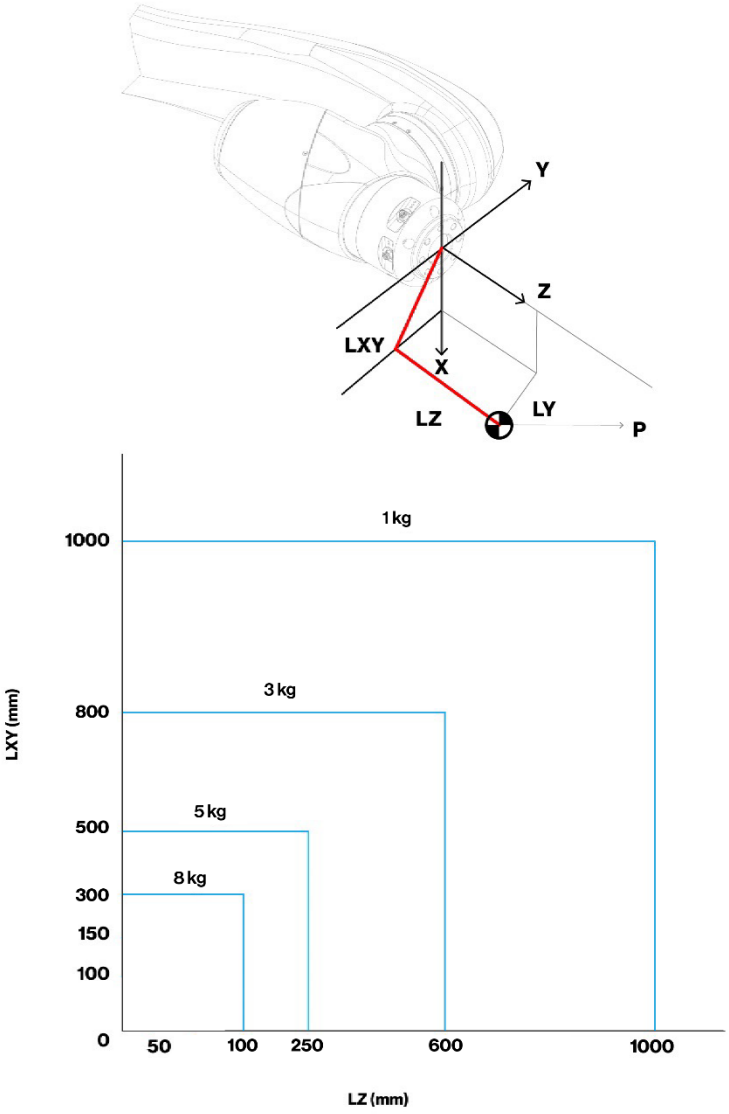


Fig. 6: Payload diagram MAiRA L robot

3.2. Control Box

3.2.1. Overview

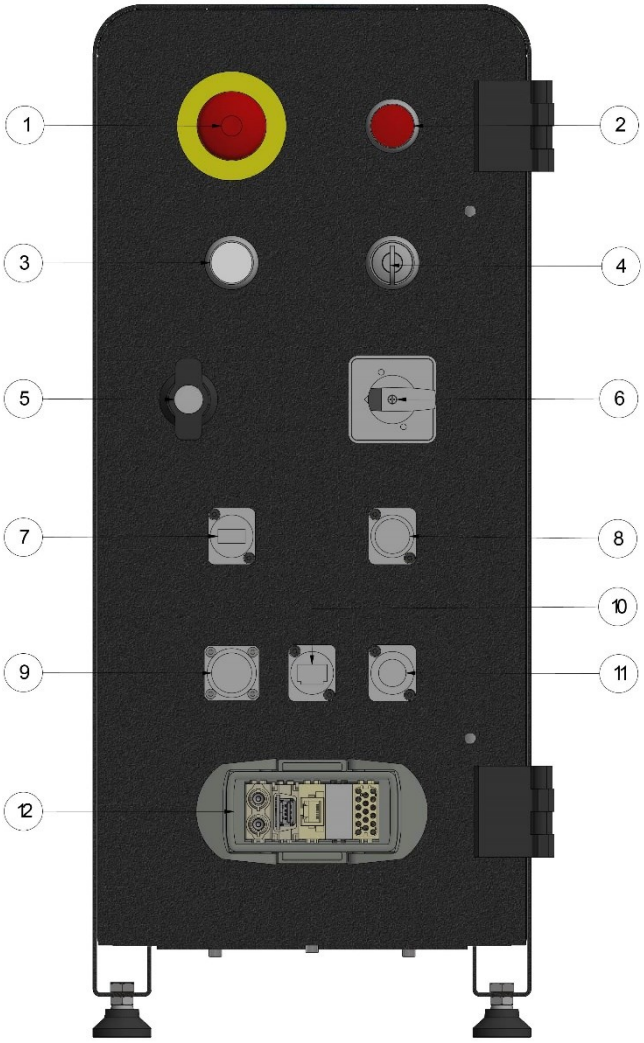


Fig. 7: Electrical control box overview switches and connectors

1 Emergency stop
2 Fault indicator
3 Enable push button/ indicator
4 Key switch
5 Rotary latch
6 Power switch
7 RJ45 connector
8 Power supply connector
9 HMI connector
10 RJ45 connector
11 External e-stop connector
12 Robot cable connector

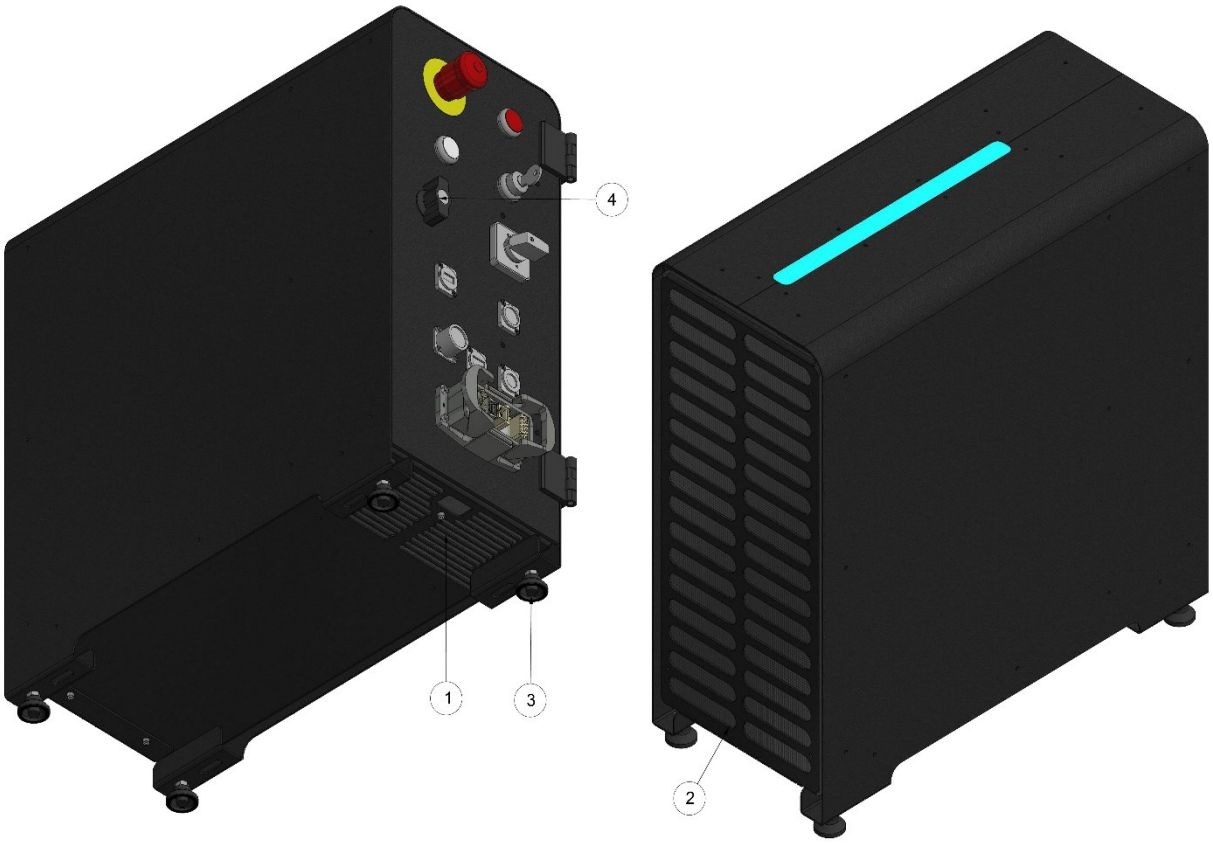


Fig. 8: Electrical control box overview ventilation vents and base feet

1 Air inlet and customer cable pass-through cut out
2 Air outlet
3 Cabinet foot
4 Rotary latch

3.2.2. Dimensions

Fig. 9: Dimensions control box

3.2.3. Specifications electrical control box

Item	Specification
Weight	35 kg
Working temperature range	0–40 °C
Electrical cabinet size	592 mm x 253 mm x 567 mm
Paint color	Black, coated
External power input	100-240 VAC, 50/60 Hz, max. 16 A

4. SCOPE OF DELIVERY

Ensure that all parts and materials have been delivered. The scope of delivery is shown below.

Tab. 1. List of parts

Device	Quantity	Checklist
Robot Arm	x1	☐
Electrical control box	x1	☐
Power cable	x1	☐
Connecting cable	x1	☐
Emergency stop including cable	x1	☐
M10 screw	x4	☐
Flat washer	x4	☐
Teach Pendant	x1	☐
Teach Pendant Tablet	x1	☐
USB-C cable	x1	☐
Teach Pendant cable	x1	☐
Teach Pendant Key	x1	☐
Online robot documentation	x1	☐

Fig. 10: List of parts

5. TRANSPORT AND STORAGE

⚠ WARNING

Heavy weight of the device

The robot system is, packed or unpacked, heavy. Improper handling may result in injury or damage to the device.

- ► Do not lift the robot (packed or unpacked) unassisted.
- ► Ensure that at least two people carry the robot together and hold firmly at the base while moving the robot.
- ► Obey all safety precautions while lifting the robot.
- ► Make sure not to overload your back or other body parts when lifting the equipment.
- ► Make sure that only certified personnel operate the lifting equipment.
- ► Use proper lifting equipment and ensure that the lifting equipment can withstand the weight of the robot.
- ► NEURA Robotics cannot be held responsible for any damage caused by transportation of the equipment.

NOTICE

Condensation within the device

Condensation can damage the system electronics.

- ► Do not store, ship, or use your module under conditions where temperature fluctuations could cause condensation within the device.
- ► If your device was shipped in cold weather, leave it in its box and allow it to warm slowly to room temperature to avoid condensation.

5.1. Transportation

The following measures must be observed and need to be followed when transporting the robot:

- When lifting the robot, the moving parts should be fixed by appropriate measures to avoid unexpected movements during lifting and transportation, which may cause damage.
- Use proper lifting equipment. All regional and national guidelines for lifting shall be followed.
- Pay attention to your posture when moving the arm and control box cartons to avoid back injury.
- NEURA Robotics is not responsible for any damage that occurs during transportation of the equipment.
- Before moving or transporting the robot, it must be moved to its ground position.
- During transportation, ensure that the robot is stable and remains in place.
- After fixing, turn on the robot and use the robot's learning function to adjust the robot's posture to a suitable position.
- Make sure that you follow the safety precautions while transporting the robot.

5.2. Storage Conditions

- This product must be shipped and stored in a temperature-controlled environment, within the range **-25°C to 55°C (-13°F to 131°F)**. The recommended **humidity is up to 75 percent**, non-condensing. It should be shipped and stored in the supplied package, which is designed to prevent damage from normal shock and vibration. You should protect the package from excessive shock and vibration.
- The product must always be stored and shipped in an upright position in a clean, dry area that is free from condensation. Do not lay the package on its side or any other non-upright position: this could damage the product.
- Make sure that you follow the storage safety instructions.

5.3. Unpacking

The following measures must be observed when unpacking the robot (procedure see *Unpacking the robot* on page *29*):

- The packed robot is placed at ground level near the installation site and in a stable position.
- Carefully remove the original packaging.
- Keep the original packaging after transport. Keep the packaging material in a dry place in case you need to repack and transport the robot in the future.
- When moving the robot out of the packing material and to the installation site, hold the robot firmly until all screws of the robot base are tightened.
- Lift the robot arm and stabilize the robot elbow at the same time when moving it from the packaging to the installation place. Hold the robot in place until all mounting screws are securely tightened at the base of the robot.

5.4. Packing

The following measures must be implemented when packing the robot:

- When packing and transporting, the robot shall be packed in accordance with the applicable packaging guidelines and the required markings shall be applied to the outside of the box. All regional and national guidelines shall be followed.
- Protective measures should be taken to protect the robot against collisions, which may result in scratches on the robot's surface or damage to its internal structure.
- Only use the original packaging for the transport of the robot.

Packing procedure:

- Move the robot to parking position (A1: 0°, A2: -30°, (A3: 0°), A4: 150°, A5: 0°, A6: 60°, A7: 0°)
- Power off the system in the GUI (**PC / PowerOff / Yes**)
- Turn off the Control Box by turning the main switch to "OFF".
- Disconnect all cables, pack them appropriately.
- Hold the robot firmly while loosening the screws at the base of the robot so that it does not tip over.
- Attach the lifting aids and screw in the M12 screws to fix them.
- Insert straps on the lifting aid on both sides.
- With two people, use one hand to lift the robot (e.g. on inserted straps) while holding it at the elbow joint with the other hand.
- Place it on the wooden plate on the pallet.
- Screw the lifting aids into the pallet.
- Carefully add the foam wrapping from both sides of the robot.
- Slide the carton box over the foam.
- With two people, lift the Control Box into the smaller package. Make sure it stands stable.

- Put all cables and the Teach Pendant into the smaller box as well. Make sure everything is packed securely. Add filling material to ensure the Control Box is not tipping over.
- Add straps to secure the packages to the pallet.

6. ASSEMBLY AND INSTALLATION

6.1. Site Requirements

6.1.1. Installation environment requirements

The robot should be installed indoors and meet the following requirements:

- Room temperature of 0–40 ºC (avoid excessive temperature change).
- Relative humidity of 10–75 % (dew is not allowed).
- Avoid direct sunlight.
- Keep it away from dust, soot, salt, metal powder and water.
- Protect it against shock and vibration.
- Keep it away from flammable, explosive, and corrosive gas, solid materials, and liquids.
- Keep it away from sources of electrical interference.
- For installation space requirements, please refer to the robot dimension chart and the specification table of electrical control box.

6.1.2. Robot workspace

The workspace of the robot refers to the area around the joint of robot base. Please try to keep the tool away from vertical axis, otherwise it will cause the situation where the tool moves slowly and joints move too fast, which leads to the low efficiency of robot and brings difficulties in carrying out risk assessment. For details about singularity please contact NEURA Robotics.

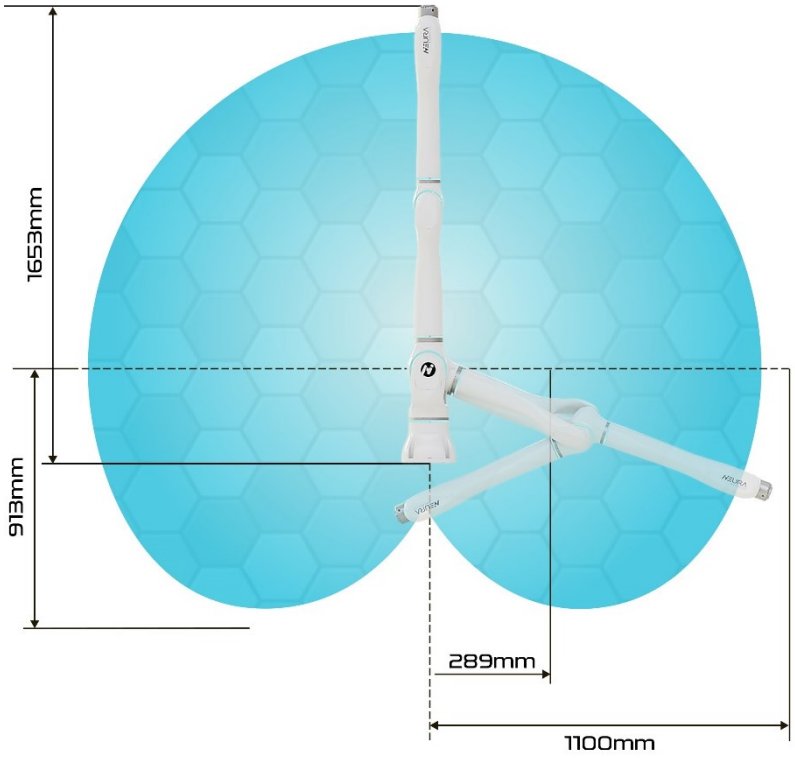


Fig. 11: Workspace for MAiRA S

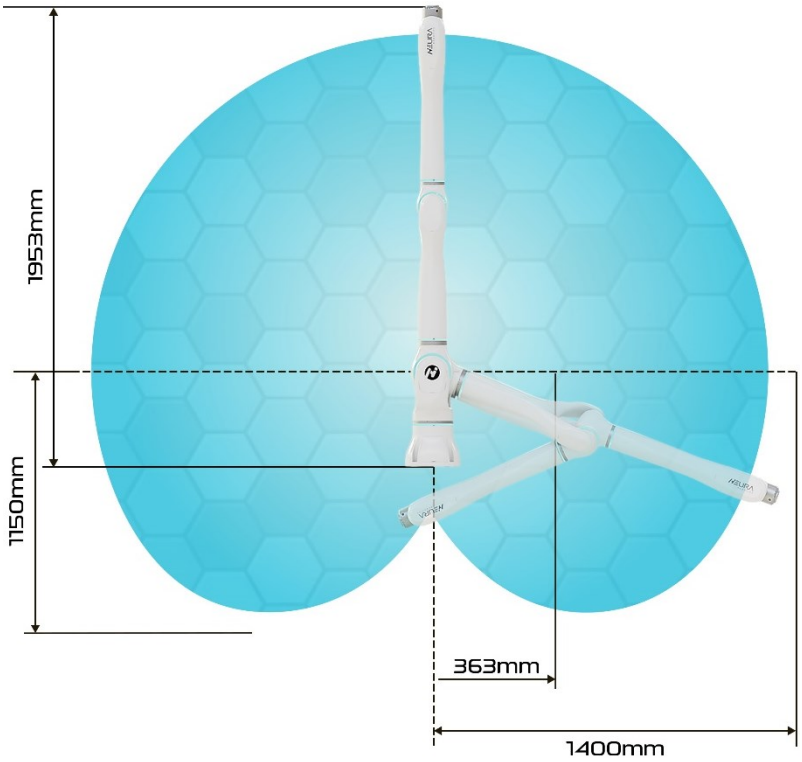


Fig. 12: Workspace for MAiRA M

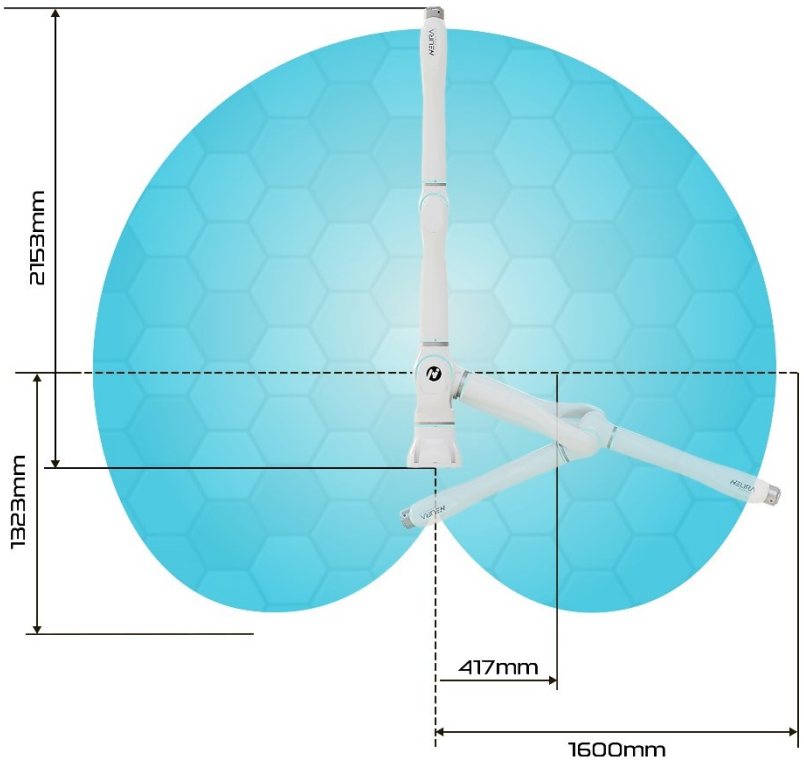


Fig. 13: Workspace for MAiRA L

6.1.3. Installation space / Workstation

When installing the robotic system, make sure to reserve room for the robot workspace and the electrical control box. Also consider the cable reach of the teach pendant.

⚠ WARNING

Not enough safety distance

Serious injuries can result if not enough safety distance is provided to the robot.

- ► Make sure that the safety distance is at least 100 mm longer than the maximum workspace of the robot after installing the end-effector at the robot terminal.

NOTICE

Excessive bending of cables

Excessive bending of cables might lead to damage them.

- ► The minimum bending radius of the robot power cable is 90 mm. When installing the cable, make sure that there is enough space to install power supply signal line and other cables, to prevent the cable from overbending.

In addition to the space required for installing the robot and electrical control box, ensure the minimum space required for the following conditions:

- to install robot terminal fixtures and workspace installations (if applicable).
- for robot teaching (expected movement of trained operator).
- for operators to implement installation, inspection, and repair activities.
- for pneumatic hoses attached to robot and base (applies to optionally available pneumatic hose package).

6.2. Mechanical Installation

⚠ WARNING

Heavy weight of the device

The robot system is heavy, packed or unpacked. Improper handling may result in injury or damage to the device.

- ► Do not lift the robot (packed or unpacked) unassisted.
- ► Ensure that at least two people carry the robot together and hold firmly at the base while moving the robot.
- ► Obey all safety precautions while lifting the robot.
- ► Make sure not to overload your back or other body parts when lifting the equipment.
- ► Make sure that only instructed personnel operate the lifting equipment.
- ► Use proper lifting equipment and ensure that the lifting equipment can withstand the weight of the robot.
- ► NEURA Robotics cannot be held responsible for any injuries or damage caused by transportation of the equipment.

NOTICE

Condensation within the device

Condensation can damage the system electronics.

- ► Do not store, ship, or use your module under conditions where temperature fluctuations could cause condensation within the device.
- ► If your device was shipped in cold weather, leave it in its box and allow it to warm slowly to room temperature to avoid condensation.

6.2.1. Unpacking the robot

NOTICE

Damage to the robot due to improper handling and transportation

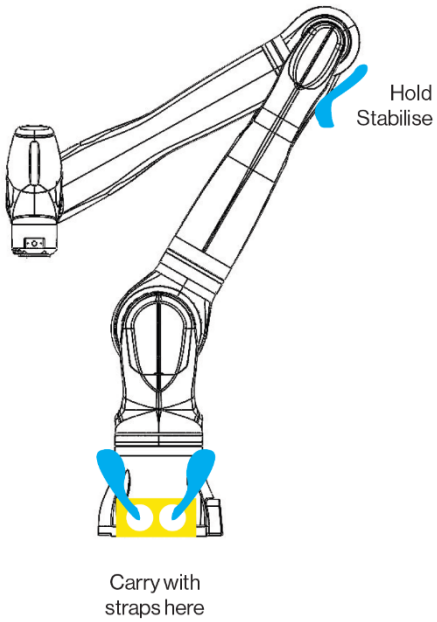
Improper handling can lead to damage of the device.

- ► Do not use force to open the shipping box.
- ► Prevent the robot surface from scratches or impact and collision when opening the carton.
- ► Open the carton in a dry and clean external environment.
- ► When taking the machine out of the carton, pay attention to protecting the robot against any damage, and avoid collision and scratches.
- ► Observe the notes in section *Transport and Storage* on page *23*.

Unpacking procedure:

It is recommended to have the mounting surface prepared so the robot can be fastened immediately after unpacking.

1. Place the pallet on a clean and stable surface on the ground.
1. Carefully open the smaller box by cutting the sealing with a knife. Make sure not to damage the contents.
1. Take the Teach Pendant, all cables and the screw set out of the box. Remove the filling material from the box.
2. Cut the vertical edges of the smaller box and fold down the sides of the box. This way, the Control Box can easily be accessed from the sides.
3. With two persons, carefully lift the Control Box and place it at its destination. Make sure it stands upright and stable on its feet.
4. With two people, lift the big carton shell of the larger package.
5. Remove the foam cover of MAiRA to the sides.
6. Inspect the entire robot for damage before proceeding with further installation. If any damage is evident, contact NEURA Robotics GmbH.
7. Unscrew the yellow mounting aids from the pallet (while keeping it attached to the robot's base). From now on, make sure another person supports the robot at the elbow, so it does not tip over.
8. Insert carrying straps (not part of the shipment) through the holes of the yellow lifting aids.
9. With two people, lift the robot holding the carrying straps with one hand and supporting it at the elbow with the other hand. Carry the robot to its designated spot. Alternatively, use a crane and support the robot at the elbow joint.
10. Once robot is placed at its destination, remove the M12 screws of the yellow lifting aids. The other person should keep holding the robot at the elbow, so it doesn't fall over until the robot is securely fastened.



11. Fasten the robot to the mounting surface. Refer to *Fastening* the robot 6.2.2.
12. After the robot is fastened to the mounting surface, the unpacking procedure is complete.

⚠CAUTION

At this stage, do not connect the control box power cable to any electrical outlet, or it may cause equipment damage.

6.2.2. Fastening the robot

No installation platform is provided when you purchase the robot. The size and shape of general-purpose installation platforms vary greatly due to different robot systems, but the following basic requirements should be met:

- The installation platform should be at least 20 mm thick. It is recommended that the steel plate should be used to suppress the vibration.
- It is recommended that the surface roughness of the installation platform should not exceed Rz 25 µm.

⚠ CAUTION

Fastening the robot

Improper sequencing or torquing of the screws may result in damage.

► Ensure that the screws are correctly tightened in a crosswise pattern with two torque steps (50% and 100%).

Fasten the robot

► Use 4x flat washers and 4x M10 screws (whose specifications meet ISO 898-1 performance level 10.9 or 12.9 mark) to fasten the robot onto the mounting base.

► Tighten the screws crosswise in two steps of 30 Nm and 63.2 Nm.

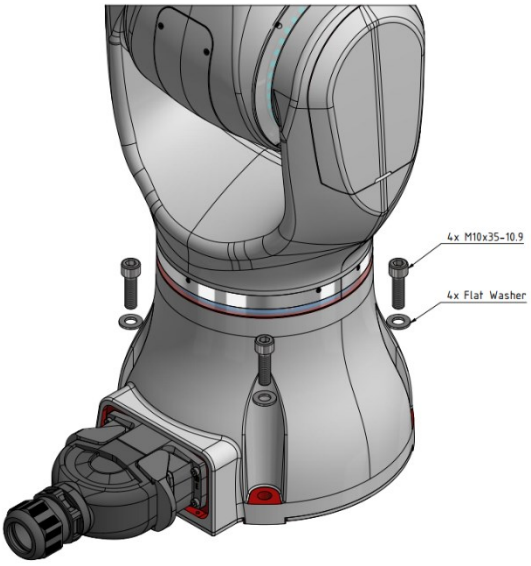


Fig. 14: Fixing points for MAiRA robot

The installation dimensions of the robot base are shown in the following figure.

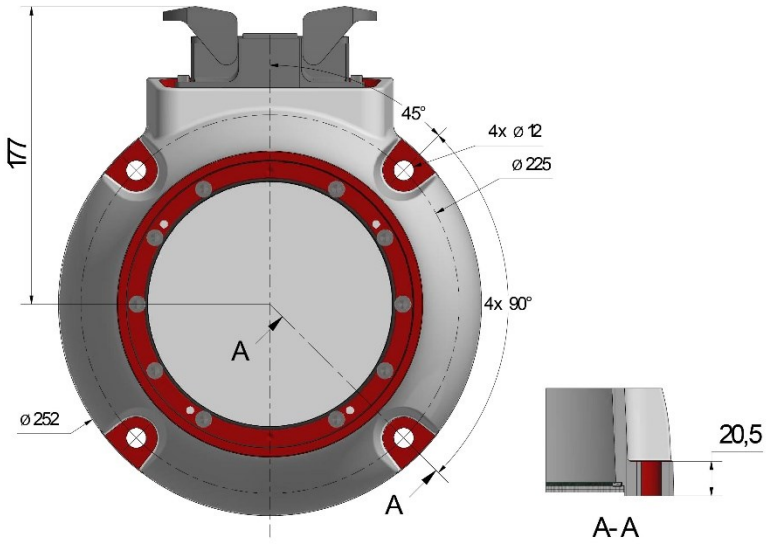


Fig. 15: Installation dimensions of robot base (all dimensions in mm)

6.2.3. Installing tools to the robot flange

No end-effector is provided when you purchase the robot. The screw holes of tool center point (TCP) flange are M6.

⚠CAUTION

Installing tools to the robot flange

Improper sequencing or torquing of the screws may result in damage.

► Ensure that the screws are correctly tightened in a crosswise pattern with equal two torque steps (50% and 100%).

Installing tools to the robot flange

► Use 7x M6 screws (whose specifications meet ISO 898-1 performance level 10.9 or 12.9 mark) to install tools to the robot flange.
► Use the torque of 9.9 Nm to tighten screws.

TCP dimensions are shown in the below Fig. 16:

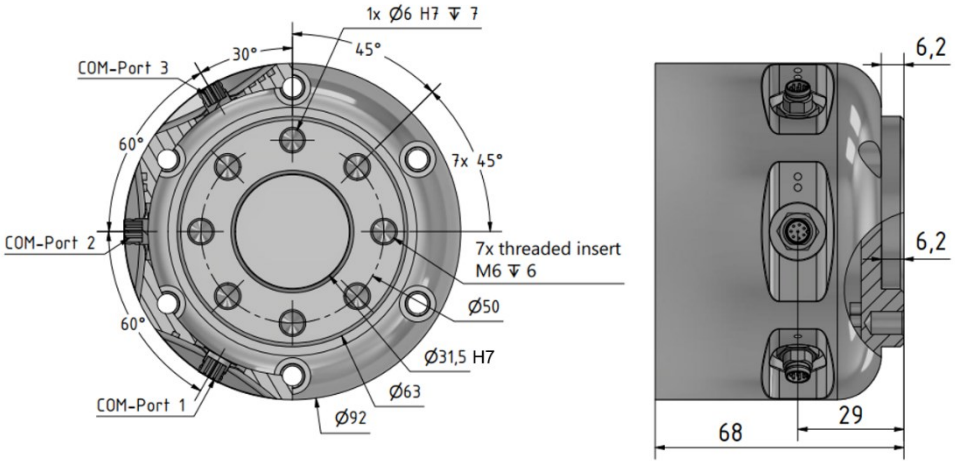


Fig. 16: MAiRA tool flange (ISO 9409-1-50-7-M6) dimensions (all dimensions in mm)

6.3. Electrical Installation

⚠ WARNING

Improper installation and handling of the device

Improper installation and handling of the device can lead to serious injuries.

- ► Read and observe all safety instructions in this document.
- ► Read the MAiRA electrical control box interface instructions before installing the electrical control box.
- ► Do not disassemble the electrical control box (unless instructed by NEURA Robotics or authorized partner), otherwise it may cause electric shock.
- ► Never use cables other than the ones supplied by NEURA Robotics GmbH to ensure that the proper functionality and compliance with safety or EMC regulations. If you need longer cables, contact NEURA Robotics GmbH.
- ► Verify the voltage range and frequency of your electrical network matches the specifications of the control box.
- ► Ensure that the robot is properly grounded. If the grounding is not correct, it may cause a fire or electric shock.
- ► Ensure that all connections are properly established before turning the power ON.

⚠ DANGER

Improper installation and handling of the device

Improper installation and handling of the device can lead to serious injuries.

- ► Do not disassemble the electrical control box, otherwise it may cause electric shock

NOTICE

Negligent installation and handling of the device

Negligent installation and handling may lead to damage to the device.

- ► Read and observe all safety instructions in this document.
- ► Do not apply excessive force when connecting the connector(s) to the control box because that can cause damage to the connector(s).
- ► Do not bend the cables too much during connecting as that can cause damage to the cables.
- ► Do not excessively touch or bend the USB-C cable connected to the teach pendant to prevent it from early failure.
- ► The electrical control box is equipped with fans at the back end. Do not block or limit the air flow.
- ► The location of the control box should be as far away as possible from noise or vibration sources. If they are too close, there may be positional deviations or malfunctions.

6.3.1. Electrical interfaces

The MAiRA robot system features the following electrical interfaces:

- Main connections (see *6.3.2.1 Power supply cable* on page *33* and *6.3.3.1 Peripheral interface and connection instructions* on page *35*).
- Robot connection (see 6.3.2.2 Connecting cable on page *34* and 6.3.3.1 *Peripheral interface and connection instructions* on page *35*).
- I/O connections for controlling the robot (see *Controller* customer I/O on page *36* to *Safe* on page *53*).
- I/O connections for controlling the robot tool (see *Robot flange communication ports* on page *53*).

6.3.2. Cables

To properly operate the robot system, various cables are contained in the shipment and need to be correctly connected.

6.3.2.1. Power supply cable

The cable shown below is the power cord of the electrical control box. The cable line is 3 m long. The control box must be connected to the power supply. This process must be completed using the corresponding CEE 7/7 (Schuko) plug connected to a CEE 7/3 (Schuko) or CEE 7/5 socket. The other end of the power supply cable has a locking mechanism, and it is plugged in the power connection of the control box. If a different connection of main power supply is desired, please get in touch with NEURA Robotics.

POWER SUPPLY

The power supply shall be equipped with at least the following protection devices:

- Grounding
- Fuse of electric supply
- Residual current circuit breaker

It is recommended that all the devices connected to the robot application should have a disconnecting switch, to lock and post a sign during repair and maintenance.

Fig. 17: Power supply cable

6.3.2.2. Connecting cable

The cable shown below is the connecting cable to connect the robot to the control box. The cable line is 3 m long.

Connect the end “A” to the robot, and the end “B” to the electrical control box socket (below image of connector layout may differ to supplied connector).

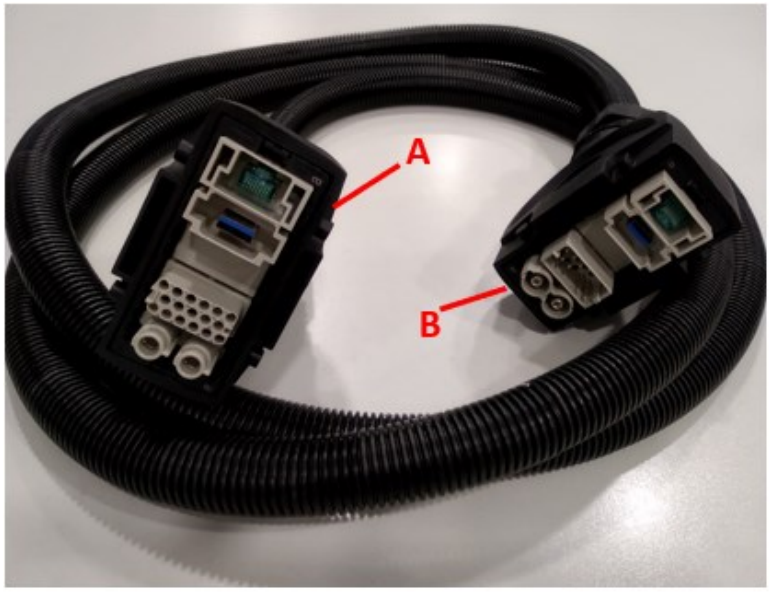


Fig. 18: Connecting cable

6.3.3. Electrical control box

6.3.3.1. Peripheral interface and connection instructions

Electrical control box overview for switches, connectors, and socket, refer to *Overview* on page *14*.

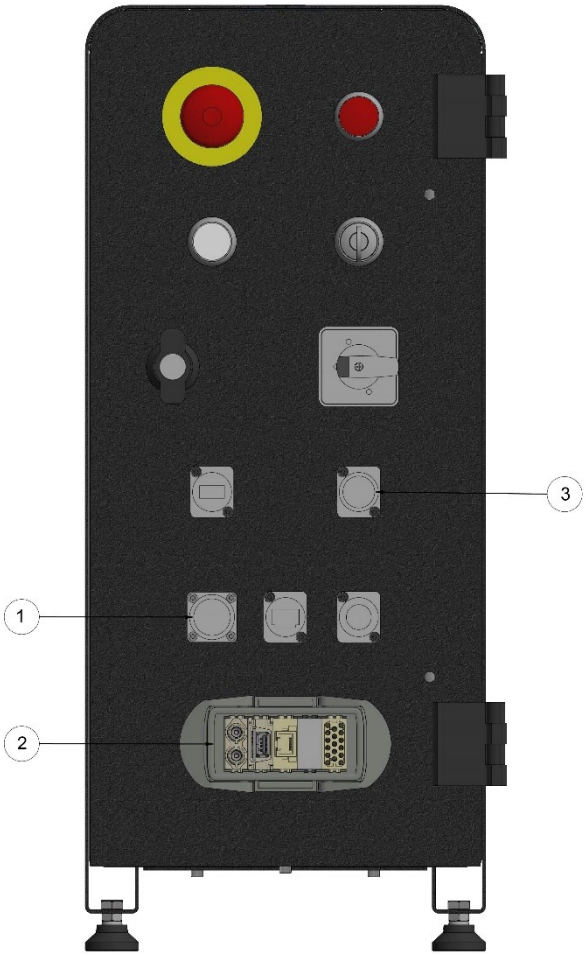


Fig. 19: Electrical control box overview switches and connectors

1 HMI connector for Teach Pendant **2** Robot cable connector **3** Power supply

Installing the control box

1. Place the control box on a flat surface and make sure that the air vents (backside and front bottom) are not covered.
2. Connect the control box to the Teach Pendant (**1**).
3. Connect the control box to the robot arm (**2**).
4. Connect the control box to the power supply (**3**).
5. Turn the main switch to power on control box
6. Key-Switch Position (I = Cobot speed active / II = full speed active)

6.3.3.2. Controller customer I/O board

The controller provides a series of external ports, which can connect controller I/O with various devices such as external relays, PLCs, sensors, and emergency stop devices.

IO BOARD VERSIONS

- There are currently different versions of external ports available. Make sure that you refer to the documentation of the Version matching your IO Board.
- Look at the figures of each version to see which design matches your Board.

DANGER

Bridges on safety inputs.

Improper installation of safety equipment can lead to serious injuries.

- ► The wire bridges (displayed in orange or red) bridge the Safety In- and Outputs of the system when external safety devices are not used.
- ► Always make sure safety equipment is correctly connected and working as expected.
- ► Refer to the safety manual for more details.

Version 1:

The port layout of the controller panel I/O is shown below:

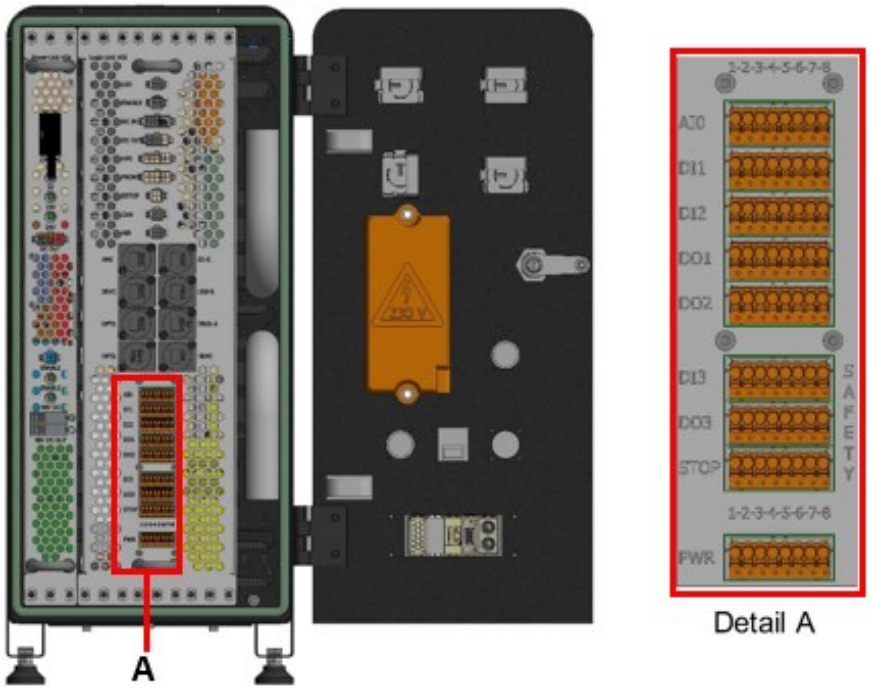


Fig. 20: Version 1 port layout of the controller panel I/O

Type	Contacts	Use	Description
AI0	1-2-3-4-5-6-7-8	General	• Combined analog input and output connector • 4 AI (1, 2, 3, 4) and 4 AO (5, 6, 7, 8). • Common ground can be connected to power plug terminals 7,8
DI1 DI2			• 8 digital inputs spread over 2 connectors • DI1: 1 + 2= channel1, DI1: 3 + 4= channel2, etc. • 1, 3, 5, ... are +24 V • 2, 4, 6 are the signals
DO1 DO2			• 8 digital outputs spread over 2 connectors • DO1: 1 + 2 = channel1, DO1: 3 + 4 = channel2, etc. • 1, 3, 5, ... are GND • 2, 4, 6 are the signals
DI3	1-2-3-4-5-6-7-8	Safety	• 4 safe DI • DI3: 1 + 2 = channel1, DI3: 3 + 4 = channel2, etc.
DO3			• 4 safe DO • DO3: 1 + 2 = channel1, DO3: 3 + 4= channel2, etc.
STOP			• Customer E-STOP or S-STOP connection (see *Fig. 24:* on page *48*)
Power	1-2-3-4-5-6-7-8	Power	• Customer external 24 V connection (see *Fig. 28:* on page *50*)

The digital I/O follows the requirements of IEC61131-2. The electrical specifications are as follows:

Terminal	Parameter	Minimum-Value	Typical Value	Maximum-Value	Unit
Digital output					
DOx	Current	0	-	0.5	A
DOx	Current consumption (power contacts)		15 + load		mA
DOx	Function	-	PNP	-	Type
Sum of all non-safe DOs	Total current	0	-	5	A
Note: Recommended nominal power consumption for actuators connected to these digital outputs is 4.8W. Exceeding the maximum sum of all non-safe DOs may lead to permanent damage to the customer I/O board.					
Digital input					
DIx	Voltage	-3	-	30	V
DIx	OFF area	-3	-	5	V
DIx	ON area	11	-	30	V
DIx	Input current	-	3		mA
DIx	IEC 61131-2	-	1/3	-	Type

Version 2

The port layout of the customer I/O board is shown below:

Fig. 21: Customer I/O board factory default electrical bridges

In Summary customer I/O board **version 2** offers the following IOs:

- 13 safe digital inputs
- 10 safe digital outputs
- 8 non-safe digital input
- 8 non-safe digital outputs
- 8 non-safe analogue outputs (current/voltage)
- 8 non-safe analogue inputs (current/voltage)

Type	Contacts	Name	Description
Left Column			
Safe inputs	1-2-3-4-5-6-7-8	SDI1	1 ... 8: Input signals
		P1	1 ... 8: Safe PULSE signal for each input in Safe DI 1
		SDI2	1 ... 5: Input signals
		P2	1 ... 8: Safe PULSE signal for each input in Safe DI 2
Safe outputs	1-2-3-4-5-6-7-8	SDO1	1 ... 8: Output signals
		GND	1 ... 8: GND signal for each output in Safe DO 1
		SDO2	1 ... 2: Output signals
		GND	1 ... 8: GND signal for each output in Safe DO 2
Optional serial interface		COM	1: Functional GND 2: GND 3: Signal - 4: Signal +
Power		PWR	1: (24V internal), 3 (GND internal): Connected to internal 24 V Power Supply 2: (24V external), 4 (GND external): Connect here the power to supply it to the customer I/O board.
Right Column			
Digital inputs	1-2-3-4-5-6-7-8	DI	1 ... 8: Input signals
		DI-24V	1 ... 8: 24V for each sensor connected in DI
		DI-GND	1 ... 8: GND for each sensor connected in DI (optional, for 3-wire sensors)
Digital outputs	1-2-3-4-5-6-7-8	DO	1 ... 8: Output signals
		DO-GND	1 ... 8: GND signal for each output in DO
Analog outputs	1-2-3-4	AO1	1 ... 4: Output signals (Voltage 0-10V)
	1-2-3-4	AO1V	1 ... 4: 0V common for voltage outputs
	1-2-3-4	AO2	1 ... 4: Output signals (Current 4...20mA)
	1-2-3-4	AO2I	1 ... 4: 0V common for current outputs
Analog inputs	1-2-3-4	AI1	1 ... 4: Input signals (Voltage 0-10V)
	1-2-3-4	AI1V	1 ... 4: GND common for voltage inputs
	1-2-3-4	AI2	1 ... 4: Input signals (Current 4...20mA)
	1-2-3-4	AI2I	**0** ... 4: +24V common for current inputs

The digital I/O follows the requirements of IEC61131-2. The electrical specifications are as follows:

Terminal	Parameter	Minimum-Value	Typical Value	Maximum-Value	Unit
Digital output					
DOx	Current	0	-	0.5	A
DOx	Current consumption (power contacts)		15 + load		mA
DOx	Function	-	PNP	-	Type
Sum of all non-safe DOs	Total current	0	-	7	A
Note: Recommended nominal power consumption for actuators connected to these digital outputs is 4.8W. Exceeding the maximum sum of all non-safe DOs may lead to permanent damage to the customer I/O board.					
Digital input					
DIx	Voltage	-3	-	30	V
DIx	OFF area	-3	-	5	V
DIx	ON area	11	-	30	V
DIx	Input current	-	3		mA
DIx	IEC 61131-2	-	1/3	-	Type

Version 3

Fig. 22 illustrates the port layout of the controller panel I/Os:

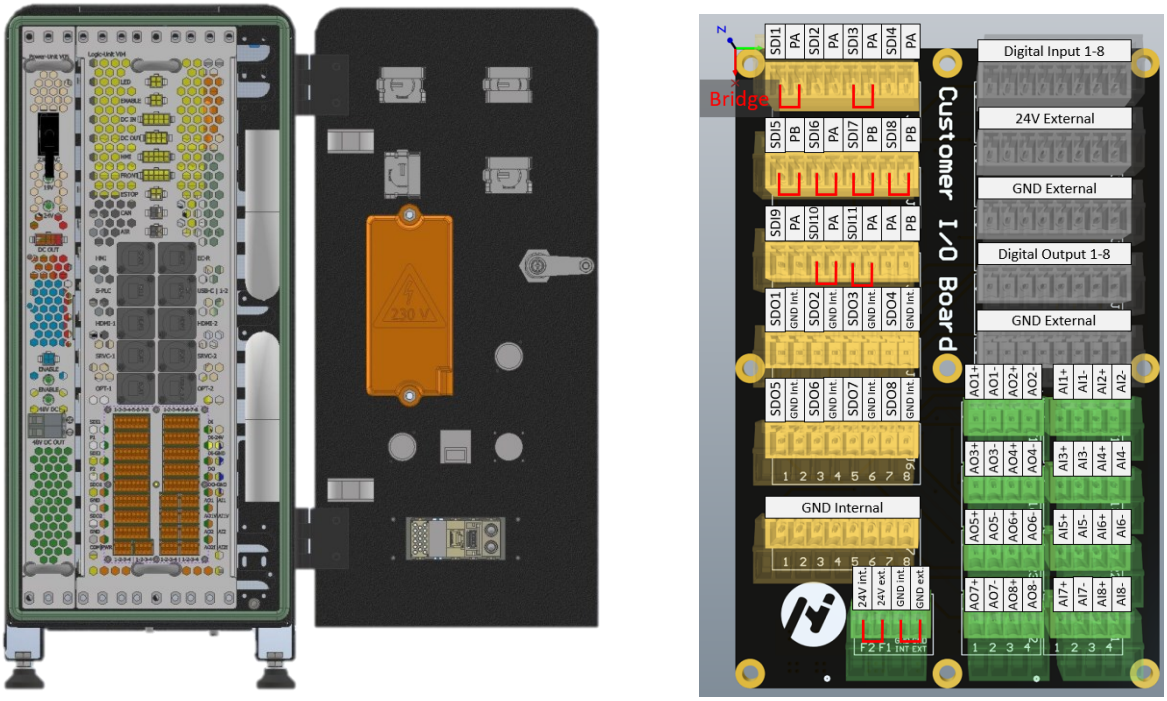


Fig. 22: Customer IO board factory default electrical bridges

In summary the customer I/O board **version 3** offers the following IOs:

- 11 safe digital inputs
- 8 safe digital outputs
- 8 non-safe digital input
- 8 non-safe digital outputs
- 8 non-safe analog outputs (current/voltage)
- 8 non-safe analog inputs (current/voltage)

Safe Input	Pulse	Function
SDI1	PA	E-Stop SS1
SDI2	PA	48V Enable Button
SDI3	24V/PA	Safeguard Stop 2 SS2
SDI4	PA	Safeguard Reset
SDI5	PB	E-Stop SS1
SDI6	24V/PA	Safeguard Stop 1 SS2
SDI7	24V/PB	Safeguard Stop 1 SS2
SDI8	24V/PB	Safeguard Stop 2 SS2
SDI9	PA	Zero G
SDI10	PA	Reduced Mode (SLS)
SDI11	PA	Reduced Mode (SLS)

Safe Output	Function
SDO1	System Emergency Stop (SS1)
SDO2	System Error
SDO3	Robot Moving
SDO4	Safeguard Stop active (SS2)
SDO5	Reduced Mode (SLS)
SDO6	Not Reduced Mode (not SLS)
SDO7	Safe Home (Home Position)
SDO8	Robot Not Stopping

Other Functions		(for pin characteristics please see below)
Power		1: (24V internal), 3 (GND internal): Connected to internal 24 V Power Supply 2: (24V external), 4 (GND external): Connect here the power to supply it into the customer I/O board.
Digital inputs	1-2-3-4-5-6-7-8	1 ... 8: Input signals
24V External		1 ... 8: 24V for each sensor connected in DI
GND External		1 ... 8: GND for each sensor connected in DI (optional, for 3-wire sensors)
Digital outputs	1-2-3-4-5-6-7-8	1 ... 8: Output signals
GND External		1 ... 8: GND signal for each output in DO
Analog outputs	1-2-3-4	Pin 1 (AO1+) & Pin 3 (AO2+): Output signals (Current 4...20 mA)
		Pin 2 (AO1-) & Pin 4 (AO2-): 0V common for current outputs
	1-2-3-4	Pin 1 (AO3+) & Pin 3 (AO4+): Output signals (Voltage 0...10 V)
		Pin 2 (AO3-) & Pin 4 (AO4-): 0V common for voltage outputs
	1-2-3-4	Pin 1 (AO5+) & Pin 3 (AO6+): Output signals (Current 4...20 mA)
		Pin 2 (AO5-) & Pin 4 (AO6-): 0V common for current outputs
	1-2-3-4	Pin 1 (AO7+) & Pin 3 (AO8+): Output signals (Voltage 0...10 V)
		Pin 2 (AO7-) & Pin 4 (AO8-): 0V common for Voltage outputs
Analog inputs	1-2-3-4	Pin 1 (AI1+) & Pin 3 (AI2+): Input signals (Voltage 0...10V)
		Pin 2 (AI1-) & Pin 4 (AI2-): GND common for voltage inputs
	1-2-3-4	Pin 1 (AI3+) & Pin 3 (AI4+): Input signals (Current 4...20mA)
		Pin 2 (AI3-) & Pin 4 (AI4-): GND common for current inputs
	1-2-3-4	Pin 1 (AI5+) & Pin 3 (AI6+): Input signals (Voltage 0...10V)
		Pin 2 (AI5-) & Pin 4 (AI6-): GND common for voltage inputs
	1-2-3-4	Pin 1 (AI7+) & Pin 3 (AI8+): Input signals (Current 4...20mA)
		Pin 2 (AI7-) & Pin 4 (AI8-): GND common for current inputs

The digital I/O follows the requirements of IEC61131-2. The electrical specifications are as follows:

Terminal	Parameter	Minimum-Value	Typical Value	Maximum-Value	Unit
Digital output					
DOx	Current	0	-	0.5	A
DOx	Current consumption (power contacts)		15 + load		mA
DOx	Function	-	PNP	-	Type
Sum of all non-safe DOs	Total current	0	-	7	A
Note: Recommended nominal power consumption for actuators connected to these digital outputs is 4.8W. Exceeding the maximum sum of all non-safe DOs may lead to permanent damage to the customer I/O board.					
Digital input					
DIx	Voltage	-3	-	30	V
DIx	OFF area	-3	-	5	V
DIx	ON area	11	-	30	V
DIx	Input current	-	3		mA
DIx	IEC 61131-2	-	1/3	-	Type

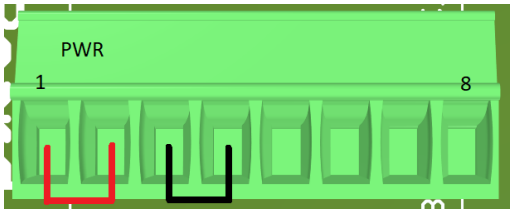
General specification for digital I/O (all versions)

The electrical specifications for internal and external power supply connected to PWR are as follows:

Terminal	Parameter	Minimum-Value	Typical Value	Maximum-Value	Unit
Internal 24 V Power Supply					
PWR:1 – PWR:3	Voltage	22.8	24	25.2	V
PWR:1 – PWR:3	Current	0	-	5	A
External 24 V Power Supply					
PWR:2 – PWR:4	Voltage	-	24	-	V
PWR:2 – PWR:4	Current	0	-	10	A

This section describes the electrical specifications of digital I/O provided by the controller. The digital I/O power supply is provided by the controller and can be supplied externally when needed. The current is internally fuse protected to 5 A when using the internal power supply. If no external 24VDC power supply is used, terminals PWR: 1,2 and PWR: 3,4 should be connected according to Fig. 23. If an external 24 VDC power supply is used, V+ should be connected to terminal PWR: 2 and V- to PWR: 4, max. current is internally fuse protected to 10A. PWR wiring when no external power supply is connected is shown below.

customer I/O board v1



customer I/O board V2

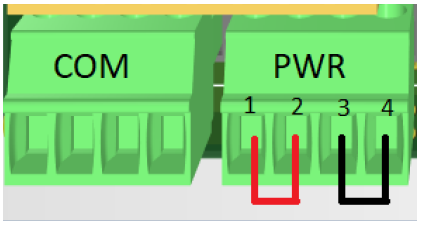


Fig. 23: Connection of external power supply

6.3.3.3. Safety I/O

⚠ DANGER

Failure of safety functions

False configuration or connection of safety signals may lead to casualty accidents caused by failure of safety functions.

- ► Do not connect the safety signal to a non-safe PLC. Be sure to separate safety signals from standard I/O signals. Safety signals can only be connected to designated safety terminals (DI3, DO3 for version 1 or SDI1, SDI2, SDO1, SDO2 for version 2).
- ► All Safety I/O are redundant (two independent channels). Keep two channels independent to ensure that the safety function will not fail when one channel fails.
- ► If you bridge the safety inputs, the safety equipment will not be functional!
- ► Some safety I/O might be bridged when the robot is delivered.
- ► Robot's safety functions must be checked before operation, and safety functions must be tested on a regular basis.

This section introduces special safety input (yellow connectors), please follow digital I/O general specification during use. Safety inputs also include **emergency stop** and **protective stop.**

Emergency stop inputs are used only for stopping equipment under emergencies with e.g. an external emergency switch.

Protective stop inputs are used for all types of safety protection devices like light curtains or safety scanners. Functional differences are shown in the following table.

As the safety signals rely on "normally closed" logic, the safety inputs must be bridged as shown in Fig 42to enable robot operation.

Functional differences between emergency stop and protective stop:

Terminal	Emergency Stop	Protective/Safeguard Stop
Robot stops moving	Yes	Yes
Run program	Stop	Paused
Robot power supply	Turned off	Remains on
Initiation	Manual	Manual or automatic
Frequency of use	Infrequent	Variable
Reset	Manual	Manual or automatic
Shutdown category (IEC 60204)	1	2
Performance level (ISO 13849-1)	PL d	PL d

The functionality of contact blocks for safe input and output signals is shown below. P1 = PA, P2 = PB

Contact block	Contact number	Functionality	Information
SDI1	1	Emergency Stop	Bridged to P1
	2		Bridged to P2
	3	48V enable button	Normally open (n.o.)
	4	Safeguard Stop	Bridged to P1
	5		Bridged to P2
	6	Safeguard Stop	Bridged to P1
	7		Bridged to P2
	8	Safeguard Reset	Normally open (n.o.) Connect to P1
SDI2	1	Not configured	
	2	Reduced Mode	Bridged to P1
	3		Bridged to P2
	4	Not configured	
	5	Not configured	
	6	NA	Not available
	7	NA	Not available
	8	NA	Not available
SafeDO1	1	System Emergency Stop	
	2	System Error	
	3	Robot Moving	
	4	Safeguard Stop active	
	5	Reduced Mode (SLS)	
	6	Not Reduced Mode (not SLS)	
	7	Safe Home (Home Pos.)	
	8	Robot Not Stopping	
SafeDO2	1	Not configured	
	2	Not configured	
	3	NA	Not available
	4	NA	Not available
	5	NA	Not available

6	NA	Not available
7	NA	Not available
8	NA	Not available

External connections for emergency stop (e-stop function) and safety protection stop (s-stop function)

An example of a safety configuration for an external emergency stop (e-stop) and a safety protection stop (s-stop) is shown below in *Fig. 24:*.

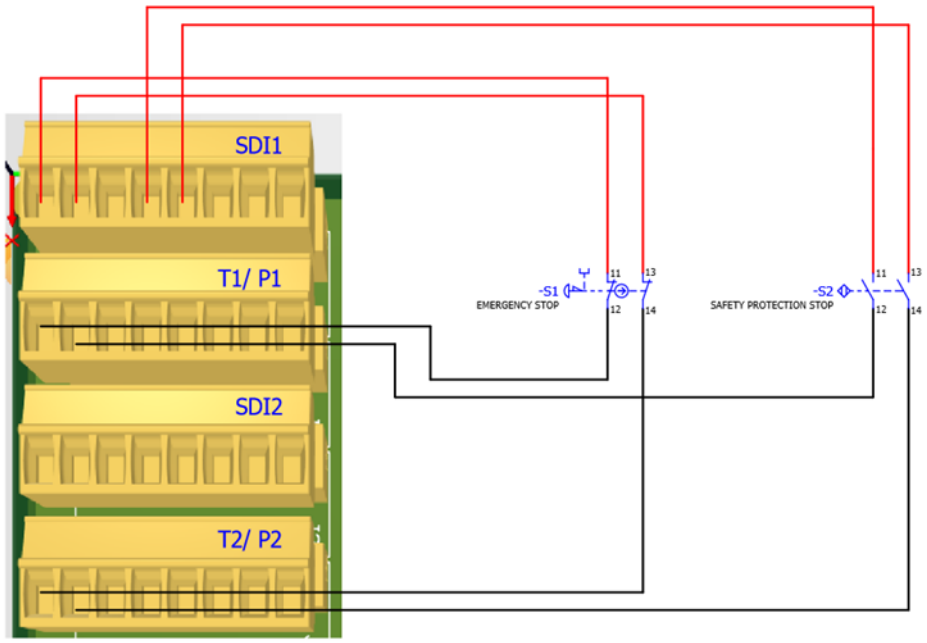


Fig. 24: Configuration for emergency stop (e-stop) and safety protection stop (s-stop) function

RESET THE EMERGENCY STOP

Pull out E-STOP push button, press the white reset button and reset error message in graphical user interface to reset emergency stop.

External connection of multiple emergency stops.

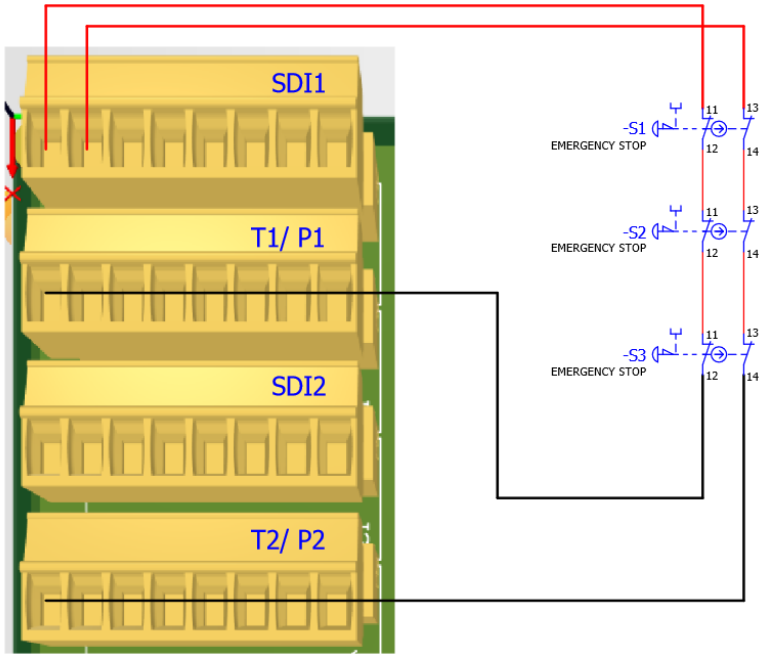


Fig. 25: Safety connection of multiple external e-stops.

6.3.3.4. Connect a general-purpose digital I/O

The below Fig. 26: and Fig. 27: shows the example of a DO connection and DI connection.

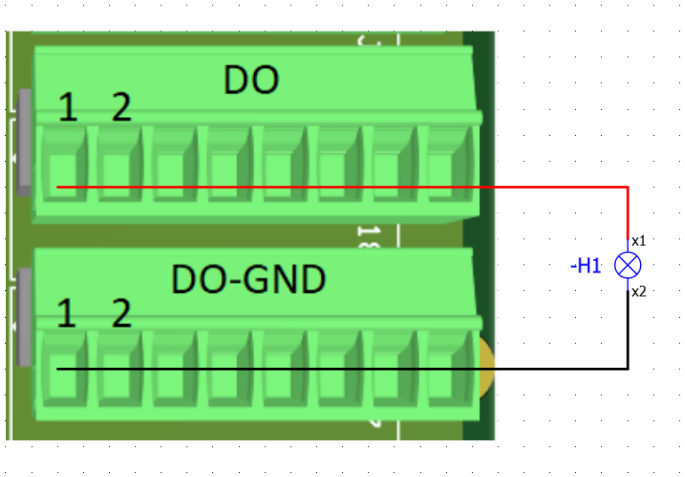


Fig. 26: Digital output signal wiring

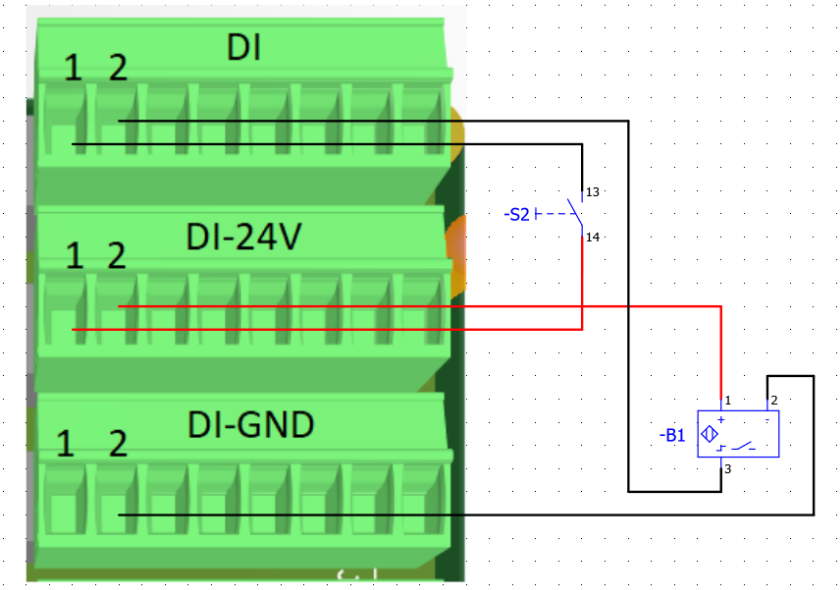
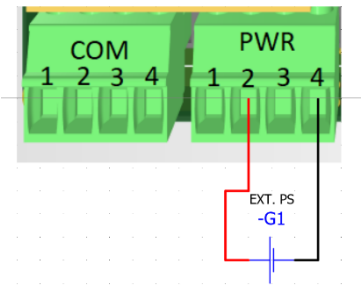


Fig. 27: Digital input signal wiring, 2-wire and 3-wire connection

6.3.3.5. I/O Power supply configuration

WITHOUT EXTERNAL POWER SUPPLY

If no external 24 V DC power supply is used terminals PWR:1,2 and PWR:3,4 shall be bridged as shown left. Max current 5 A



WITH EXTERNAL POWER SUPPLY

If an external 24 V DC power supply is used V+ should be connected to PWR:2 and V- should be connected to PWR:4. Max. Current 10 A

Fig. 28: Internal power supply configuration

6.3.3.6. General analog I/O

There are two types of analog inputs available. Analog voltage inputs AI1 (0-10V) and analog current inputs AI2 (4...20mA). The same applies for analog outputs, analog voltage outputs AO1 (0-10V) and analog current outputs AO2 (4...20mA) are available.

To prevent unnecessary issues, please follow the rules below in use:

- Use the dedicated terminals for every I/O.
- The sensor / actuator and the controller use the same ground (GND), and the analog I/O is not potentially isolated from the controller.

The corresponding I/O configuration is as follows:

Terminal	Parameter	Minimum-Value	Typical Value	Maximum-Value	Unit
Voltage mode input					
AI1x	Voltage	0	-	10	V
AI1x	Resistance	130	-	-	kΩ
AI1x	Resolution	-	12	-	Bit
Current mode input					
AI2x	Current	4	-	20	mA
AI2x	Resistance	-	85	-	Ω
AI2x	Resolution	-	12	-	Bit
Voltage mode output					
AO1x	Voltage	0	-	10	V
AO1x	Current consumption	-	25	-	mA
AO1x	Load resistance	5	-	-	kΩ
AO1x	Resolution	-	12	-	Bit
Current mode output					
AO2x	Current	4	-	20	mA
AO2x	Current consumption	-	25	-	mA
AO2x	Load Resistance	-	-	350	Ω
AO2x	Resolution	-	12	-	Bit

Analog output wiring example

The following example shows how to connect an analog output (voltage or current AO).

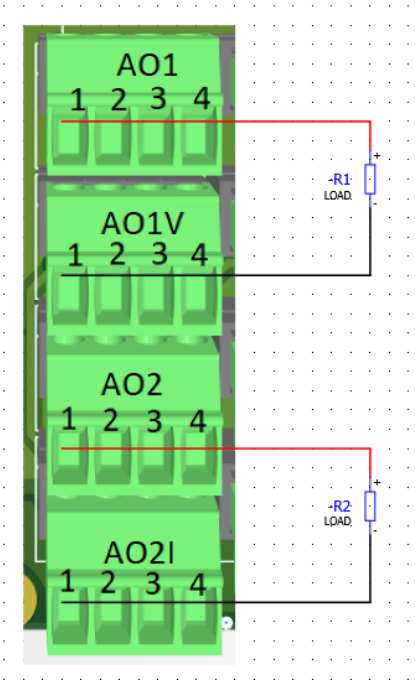


Fig. 29: Using analog output configuration

Analog input wiring example

The diagram below shows how to connect an analog sensor. Terminals AI1 and AI1V are used for voltage inputs and AI2, AI2I for current inputs.

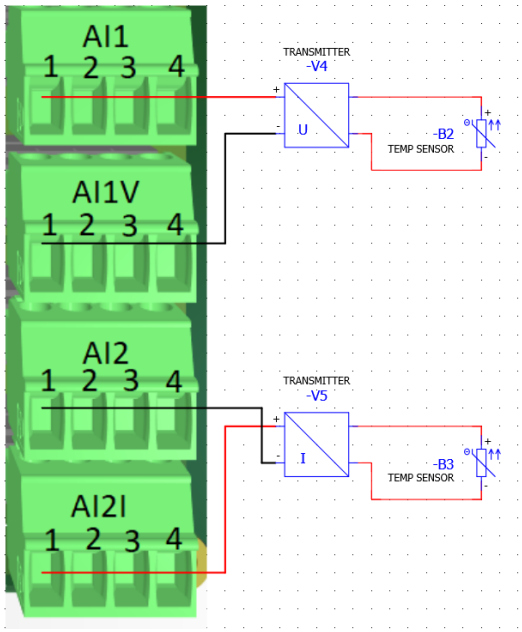


Fig. 30: Using analog input configuration for voltage (top) and current (bottom) inputs

6.3.3.7. Safe workspace

Users should carry out risk assessments for specific robot applications to determine whether to install safeguard components in the actual operating environment. If a safeguard component is needed, the user should calculate the space of the workspace.

⚠WARNING

The safety area with guard device is not well defined.

If the safety area is not well defined, this can result in personal injury or damage to property during operation.

- ► The working area must be marked and secured/barricaded.
- ► Working area must be defined in graphical user interface.
- ► Specification for the area to be barricaded: The circular radius of the guard components > length of the mechanical arm + length of the end attachment of the mechanical arm.
- ► Place information and warning signs in a clearly visible position.
- ► Install an emergency stop circuit for access doors (if needed).

6.3.3.8. Robot flange communication ports (TCP Connection)

Read the instructions below carefully before connecting any device or gripper to the flange connectors. Connecting wrongly will result in **permanent damage** to the robot.

External flange connections

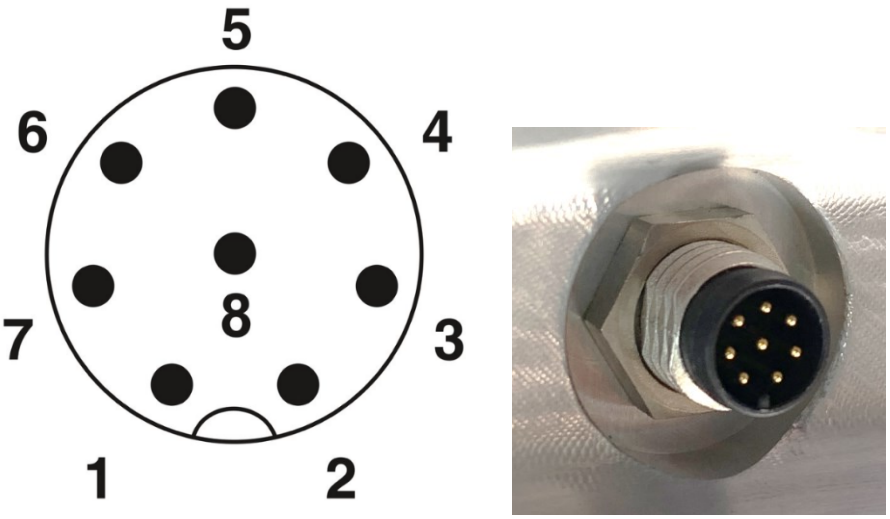


Fig. 31: M8 connectors, pin assignment (SACC-DSI-M8MS-8CON-M8/0,5)

IO external flange connections are defined as follows:

Pin	Line color	Definition	Notes
Port1 (EtherCat)			Currently not available
1	White	TX+	
2	Brown	RX-	
3	Green	TX-	
4	Yellow	RX+	
5	Gray	+24V	
6	Pink		Not used
7	Blue		Not used
8	Red	GND	
Port 2 (GPIO)			
1	White	DI_0	
2	Brown	DI_1	
3	Green	DO_0	
4	Yellow	DO_1	
5	Gray	+24V	
6	Pink	AI_0	
7	Blue	AI_1	
8	Red	GND	
Port 3 (Modbus RTU)			
1	White	RS485_A	
2	Brown	RS485_B	
3	Green		Not used
4	Yellow		Not used
5	Gray	+24V	
6	Pink		Not used
7	Blue		Not used
8	Red	GND	

Internal power supply

Specifications:

Parameter	Minimum-Value	Typical Value	Maximum-Value	Unit
24 V source voltage		24		V
24 V source current		1	1.5	A

If the current exceeds its limit, the software will protect and turn off the output, and the internal control system will generate error messages and display them in the robot log.

The power output of two ports is the output of the same power source.

Digital output end

Specifications:

Terminal	Parameter	Minimum-Value	Typical Value	Maximum-Value	Unit
DO 0/1	Voltage drop	0	-	0.5	V
DO 0/1	Current	0	-	1	A
DO 0/1	Leakage current	0	-	0.1	mA
DO 0/1	Features	-	PNP	-	Types

At the digital output terminal, the current can only be irrigated into the GND (0V), rather than adopting pull current. Once the digital output terminal is activated, the corresponding joint will be driven to connect GND and once the digital output is disabled, the corresponding joint will be in the open circuit (open set/open drain).

NOTICE

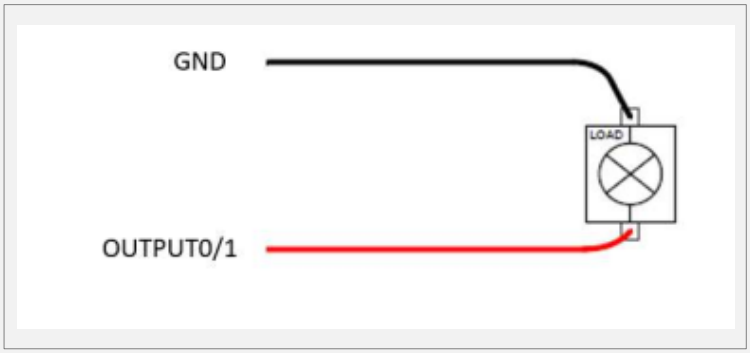
Exceeding current

There is no current restriction in the digital output terminal of tools, permanent damage may occur if it exceeds the specified data.

► Do not exceed specified current values.

EXAMPLE OF USING DIGITAL OUTPUT TERMINAL

In this diagram, the IO board provides power for the external equipment. If the external system uses its own power supply, grounding treatment is required.



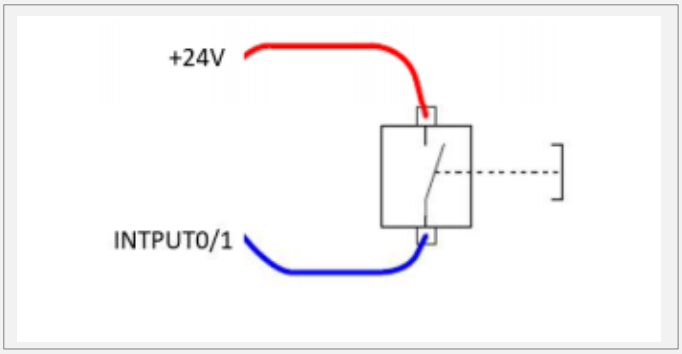
Digital input end

Specifications:

Terminal	Parameter	Minimum-Value	Typical Value	Maximum-Value	Unit
DI 0/1	Voltage	-3	-	30	V
DI 0/1	OFF area	-3	-	5	V
DI 0/1	ON area	11	-	30	V
DI 0/1	Current (11–30 V)	2	-	15	mA
DI 0/1	Features	-	PNP	-	Types

EXAMPLE OF USING DIGITAL INPUT TERMINAL

The diagram shows how to connect simple buttons or switches. In this diagram, the IO board provides power for the external equipment. If the external system uses its own power supply, grounding treatment is required.



Analog input

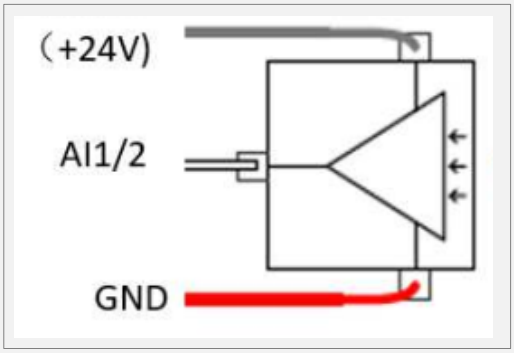
Specifications

Parameter	Minimum-Value	Typical Value	Maximum-Value	Unit
Input voltage in voltage mode	0	-	10	V
Input voltage in current mode	4	-	20	mA
Input resistance from 0 V–10 V	-	25	-	kΩ
Input resistance within 4 mA–20 mA current range	-	500	-	Ω

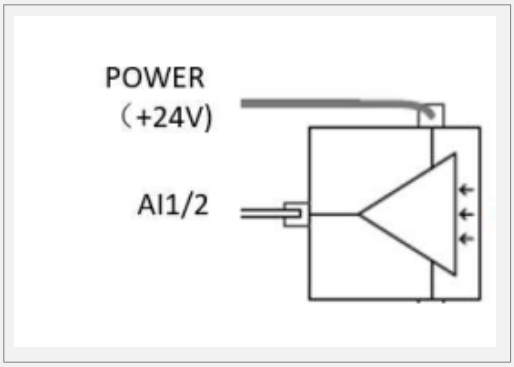
First, the input mode of the analog input must be the same as the setting in the communication card of the host computer. The output end of the sensor can be set to the current mode or the voltage mode. Please check to make sure that the sensor with voltage output can drive the internal resistance of this board, otherwise the measured value may be invalid.

To clearly illustrate the ease of using analog input, here are some simple examples:

EXAMPLES



Wiring diagram of analog input voltage mode and current three-wire mode.



The analog input is the current two-wire mode wiring diagram.

RS232 serial port line

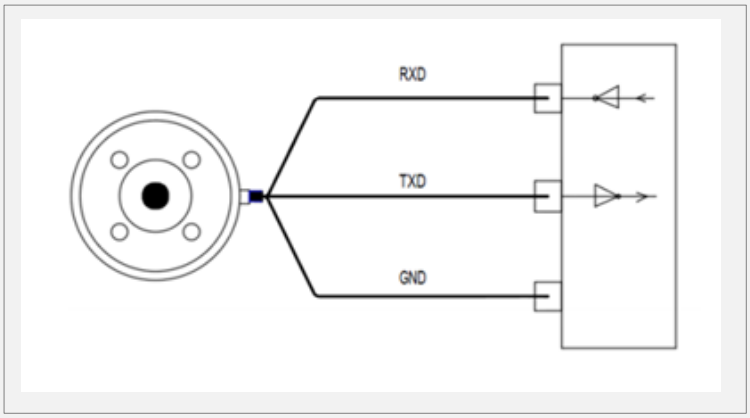
Type	Function	Description
TXD	send data	RS232 data communications, connected to personal computers/industrial cameras/other equipment.
RXD	receive data	
GND	ground signal	

Specifications

Parameter	Value	Unit
Baud rate	115200	Bps
Data bits	8	Bit
Stop bit	1	Bit

EXAMPLE OF USING A SERIAL PORT

This example is that the RS232 of IO communicates with the external device. The power supply can be IO's power supply (24 V) or external device power supply, but it should be processed collectively.



6.4. Software Installation

For installing the operation software follow the procedure described in the MAiRA Software User Manual.

6.4.1. Software updates

Software-Updates can be done with update files on hard disk or USB drive (see MAiRA Software User Manual).

7. OPERATING ELEMENTS AND DISPLAYS

7.1. Power On/Off Switch

The MAiRA robot system provides one power switch:

- Main power switch at the control box (I = on, 0 = off)

Fig. 32: Main power switch at control cabinet

7.2. Key switch

The MAiRA robot system provides a key switch to enable Cobot speed (position I, <= 250mm/s) or enable full speed (position II, up to 4.5m/s).

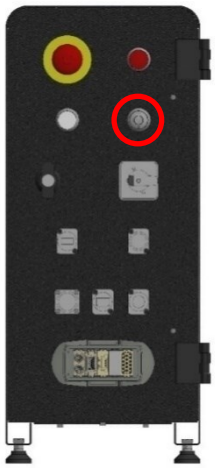
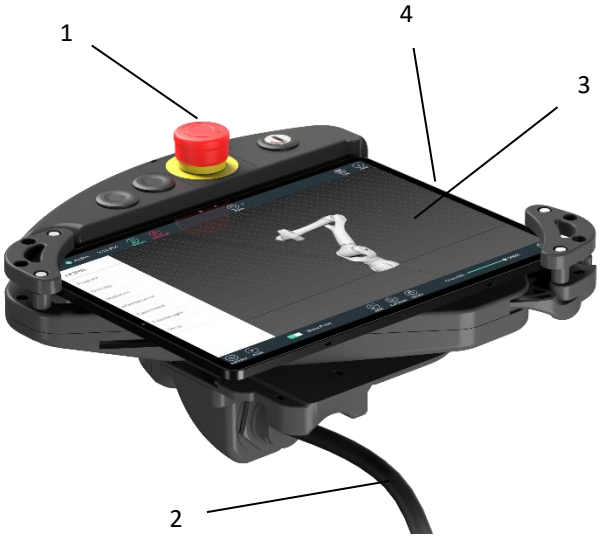


Fig. 33: Key switch to enable cobot speed or full speed

7.3. Teach Pendant

The MAiRA Teach Pendant is an easy programming user interface for teaching, programming, and operating the robot system.



1 Emergency Stop button
2 Connection cable to the control box
3 Display (touch screen)
4 USB-C Cable

Fig. 34: Teach Pendant with its main operating and display features

7.4. GUI Interface

The MAiRA software NEURON OS offers an easy-to-use Graphical User Interface with various programming functions.

Programming Features	
Smart GUI	NEURON OS Easy Programming Interface
Fast programming	Shortcut Buttons, Voice Control, Gesture Control, Dynamic Path and Force Recording
Human-Robot-Interaction	Visual-, Audio- and Force-Feedback, Face Recognition, Motion Tracking, voice recognition, and gesture recognition
Environment Visualization	3D CAD Data & Sensor Data and 3D point cloud data

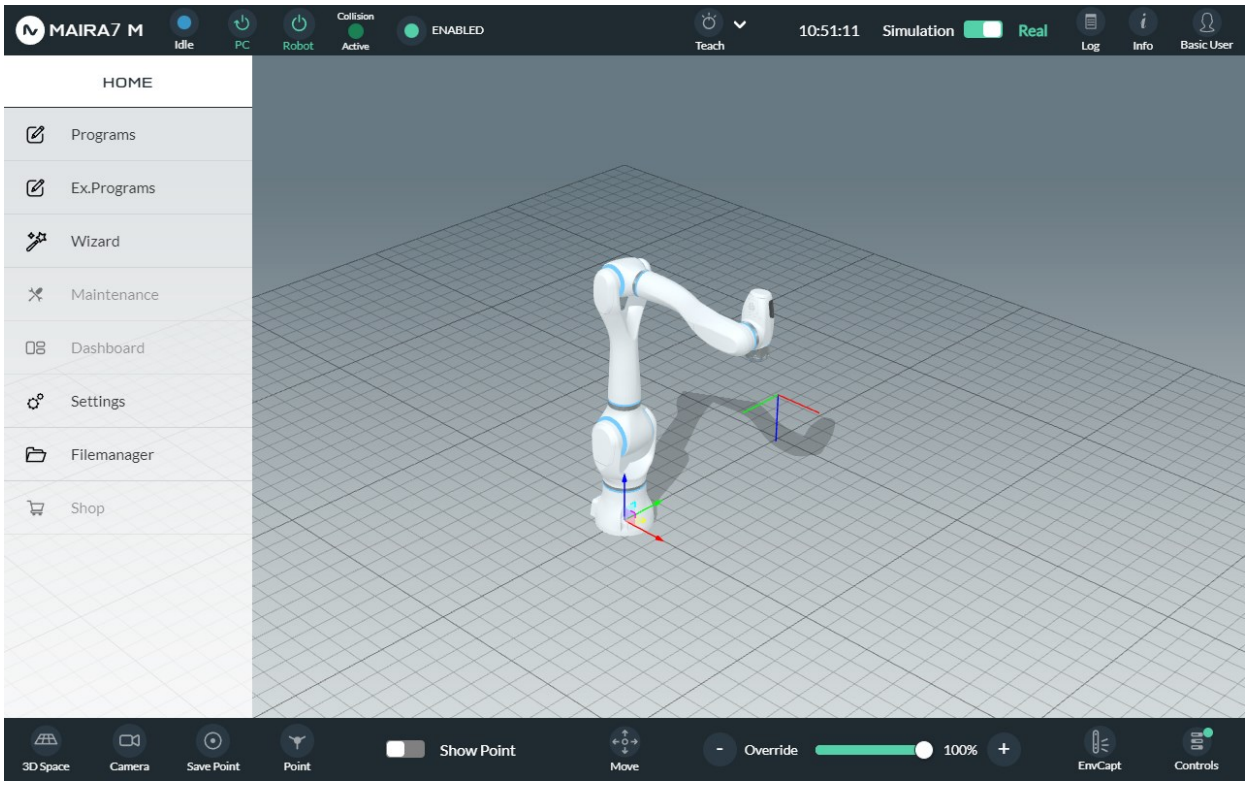


Fig. 35: MAiRA Smart GUI interface, main screen

Detailed information about the software operation can be found in the MAiRA Software User Manual.

7.5. Voice Assistant

The voice assistant can be activated or deactivated via the Graphical User Interface. More information including a list of commands can be seen in MAiRA Software User Manual.

8. COMMISSIONING AND OPERATION

⚠ DANGER

Improper installing and using of the system

Improper installing and using of the robot system can lead to serious injuries or death.

- ► Before switching on the robot, check the correct installation of the system (see *Assembly and Installation* on page *26*)).
- ► All security measures (see *General Safety Instructions* on page *4*) have been implemented and their functionality has been checked.
- ► Observe all general safety instructions in this user manual.

8.1. Commissioning of the Robot

In principle, the following steps are carried out during commissioning:

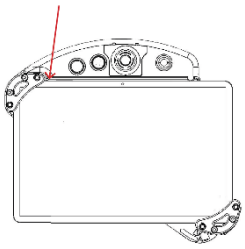
1. Powering on the system (Boot Process)
2. Configuring the system (Teach Pendant or manually).
3. Starting the specified process (GUI Button or voice command)

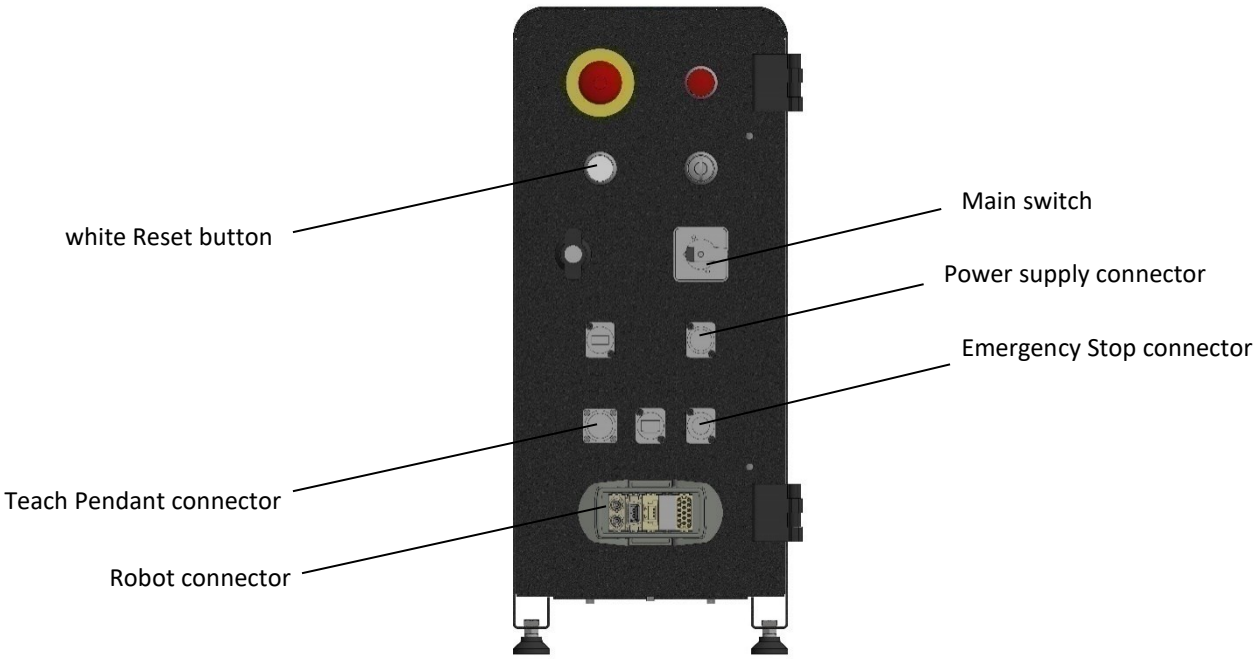
For information about configuring the robot system, refer to the MAiRA Software User Manual.

8.2. Boot Process

Connecting and booting the robot system

1. Connect the silver Plug of the Teach Pendant cable to the Teach Pendant connector of the control cabinet. Make sure it is completely screwed on else communication errors with the robot will occur (rubber seal inside plug should not be visible anymore after screwing on the plug.).
2. Connect the control cabinet to the robot with the connecting cable (see Connecting *cable* on page *34*. Make sure the connectors of plug and socket align. Close the flaps after plugging in.
3. Connect the control cabinet with the AC power supply using the power cord (see *Power supply cable* on page *33*) of the control cabinet.
4. Connect the external emergency stop button.
5. Turn on the power supply switch on the electrical cabinet.
6. Wait for about 20 seconds and press the white button. When the white button lights up, the robot is ready for motion and the NEURON OS Software starts automatically.
7. Turn on the Teach Pendant tablet by holding the power button on the side of the tablet with a flat screwdriver-like tool.
8. It is advised to wait 5-10 minutes after boot-up (or full power cycle) to fully load all Ai-Features of MAiRA Pro.





8.3. NEURA Robotics Software Operation

The NEURON OS software for the Teach Pendant is an interface operation software for manual robot operation, programming, parameter configuration and robot/program monitoring and for starting a program.

For more information about the Software refer to the MAiRA Software User Manual.

8.4. Emergency Handling

8.4.1. Emergency stop device

DANGER

Not integrated tools to emergency stop device.

Failure to observe this warning may result in death, serious personal injury, or significant property damage.

► Tools or equipment connected to the terminal must be integrated into the emergency stop circuit of the system if they pose a potential threat.

MAiRA series robots are equipped with an emergency stop button on the control cabinet, the teach pendant, and an external emergency stop button connected to the control cabinet. This button must be pressed in any dangerous or emergency situation. Pressing the emergency stop button will stop all movement of the robot.

The control box is equipped with an external emergency stop button safe signal, which can be used by integrators or users according to the actual situation.

Fig. 36: Emergency stop button at control cabinet

Fig. 37: Emergency stop button at Teach Pendant

Fig. 38: External emergency switch

- Emergency shutdown cannot be used as a risk mitigation measure, but it can be used as a secondary protective device.
- If multiple emergencies stop buttons must be connected, they must be included in the risk assessment of the robot application.
- The emergency stop button meets the requirements of IEC 60947-5-5.

Execute emergency stop

► Press any emergency stop button.
All movement of the robot stops.

8.4.2. Recovery from emergencies

All emergency stop devices have a "Safety lock mechanism (IEC60947-5-5)" function. It must be released to end the emergency stop state of the device.

Recovering from the emergency stop state is a simple but particularly crucial step, this step can only be operated after ensuring that the danger of the robot system is eliminated.

Open the emergency lock

► Push to lock the emergency stop button and
► pull or turn the emergency stop button to release.

8.5. Singularity operations

The wrist center is the point where Axis 5, Axis 6 and Axis 7 intersect.

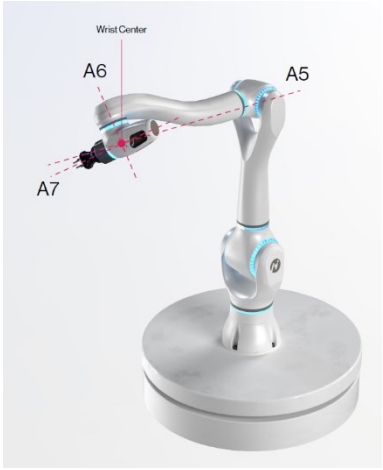


Fig. 39: Wrist center singularity

Arm is fully stretched out (Axis 4 = 0 degrees) in any configuration of the robot during cartesian motion

Fig. 40: Elbow singularity

Wrist center coincides with Axis 1 in any configuration of the robot during cartesian motion

Fig. 41: Shoulder singularity

If Axis 7 and Axis 5 are colinear (happens if Axis 6 = 0 degrees) for all configurations during cartesian motion.

Fig. 42: Wrist singularity

9. MALFUNCTIONS AND FAILURES

9.1. Troubleshooting

For detailed support or if the issue is not listed below, consult NEURA Robotics or authorized partners for assistance.

9.1.1. MAiRA GUI error messages

Error Code	State Description	Solution
General error messages		
1002	Warning: Point not reachable: Position out of Workspace	Change the position to be inside the workspace or change the workspace settings.
1003	Warning: Invalid Input Value	Change to a valid input value and try again.
1004	Warning: Invalid Input Type	Change to a valid input type and try again.
1005	Warning: Invalid unit	Change to a valid unit and try again.
1007	Warning: Wrong number of Joints	Configuration file needs to be checked. Contact NEURA for details.
1008	Warning: Invalid Joint Position	Joint value is not valid. Check the Position.
1009	Error: Joint Velocity to high	(1) Restart the robot control with **PC->Reset Control** from GUI. (2) Change commanded joint velocity range according to operation guide.
1010	Warning: Joint Velocity to low	Check the velocity set point.
1011	Warning: Invalid Joint Acceleration	Check the acceleration limits and set points
1012	Warning: Invalid end effector Position	TCP position should be changed by jogging
1013	Error: End effector Velocity to high	(1) Restart the robot control with **PC->Reset Control** from GUI. (2) Change commanded end effector Velocity range according to operation guide.
1014	Warning: End effector Velocity to low	Check the velocity set point.
1015	Error: Invalid end effector Acceleration	(1) Restart robot control with **PC->Reset Control** from GUI. (2) Change commanded end effector acceleration range according to operation guide.
1016	Warning: Cannot move in desired direction from current configuration	Change the desired direction of movement.
1017	Warning: Desired Position cannot be reached, out of workspace	Change the position to be inside the workspace.

Error Code	State Description	Solution
1018	Warning: Wrong input vector size. Size must be a multiple of 6	Change the input vector size to be a multiple of 6.
1019	Error: Generation of circular path failed	Restart robot control with **PC->Reset Control** from GUI.
1020	Error: Wrong input vector size. Size must be 18 for a MoveCircular	(1) Create a program with 3 different target points. (2) Restart robot control with **PC->Reset Control** from GUI.
1021	Error: Given points for move circular create to big radius	Restart robot control with **PC->Reset Control** from GUI.
1022	Error: Generation of Linear path failed	Restart the robot control with **PC->Reset Control** from GUI.
1023	Error: Cannot generate the required Blending path	Restart the robot control with **PC->Reset Control** from GUI.
1024	Warning: Invalid Position requested, recheck the input values	Check the input values.
1025	Warning: Cannot active ZeroG, Close to the joint limit	Move the robot via jogging mode out of software limits and turn on ZeroG again.
1026	Error: Cannot move in desired direction from current configuration	Restart robot control with **PC->Reset Control** from GUI.
1027	Warning: Axis 1 at limits	(1) Use the jogging slider at (**Move->Joint->A1 to A7**) to bring back the axis at a limit within the permissible operating range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1028	Warning: Axis 2 at limits	(1) Use the jogging slider at (**Move->Joint->A1 to A7**) to bring back the axis at a limit within the permissible operating range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1029	Warning: Axis 3 at limits	(1) Use the jogging slider at (**Move->Joint->A1 to A7**) to bring back the axis at a limit within the permissible operating range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1030	Warning: Axis 4 at limits	(1) Use the jogging slider at (**Move->Joint->A1 to A7**) to bring back the axis at a limit within the permissible operating range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For

Error Code	State Description	Solution
		maximum and minimum joint limits refer to the operation guide.
1031	Warning: Axis 5 at limits	(1) Use the jogging slider at (**Move->Joint->A1 to A7**) to bring back the axis at a limit within the permissible operating range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1032	Warning: Axis 6 at limits	(1) Use the jogging slider at (**Move->Joint->A1 to A7**) to bring back the axis at a limit within the permissible operating range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1034	Warning: X-Axis at limits	(1) Use the cartesian jogging slider at (**Move->Cartesian->X, Y and Z**) to bring back the axis at a limit within the permissible operating range. (2) It's possible to change the cartesian limit operation range. Check **settings->Robot->Cartesian->Limits**. For maximum and minimum cartesian limits refer to the operation guide.
1035	Warning: Y-Axis at limits	(1) Use the cartesian jogging slider at (**Move->Cartesian->X, Y and Z**) to bring back the axis at a limit within the permissible operating range. (2) It's possible to change the cartesian limit operation range. Check **settings->Robot->Cartesian->Limits**. For maximum and minimum cartesian limits refer to the operation guide.
1036	Warning: Z-Axis at limits	(1) Use the cartesian jogging slider at (**Move->Cartesian->X, Y and Z**) to bring back the axis at a limit within the permissible operating range. (2) It's possible to change the cartesian limit operation range. Check **settings->Robot->Cartesian->Limits**. For maximum and minimum cartesian limits refer to the operation guide.
1037	Warning: Desired value of Axis 1 at limits. The motion in the direction is not possible.	(1) Check Current operation range of joint limits. Make sure the desired position is within permissible operation range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.

Error Code	State Description	Solution
1038	Warning: Desired value of Axis 2 at limits. The motion in the direction is not possible.	(1) Check Current operation range of joint limits. Make sure the desired position is within permissible operation range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1039	Warning: Desired value of Axis 3 at limits. The motion in the direction is not possible.	(1) Check Current operation range of joint limits. Make sure the desired position is within permissible operation range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1040	Warning: Desired value of Axis 4 at limits. The motion in the direction is not possible.	(1) Check Current operation range of joint limits. Make sure the desired position is within permissible operation range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1041	Warning: Desired value of Axis 5 at limits. The motion in the direction is not possible.	(1) Check Current operation range of joint limits. Make sure the desired position is within permissible operation range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1042	Warning: Desired value of Axis 6 at limits. The motion in the direction is not possible.	(1) Check Current operation range of joint limits. Make sure the desired position is within permissible operation range. (2) It's possible to change the joint limit operation range. Check **settings->Robot->Joint->Limits**. For maximum and minimum joint limits refer to the operation guide.
1044	Warning: invalid joint velocity	Check the joint velocity parameter. Values below 0 are not allowed.
1045	Warning: Desired value of Axis 1 near limits. The motion in the direction will be slowed down.	Move this specific axis into the opposite direction to not reach the limitation of the axis.
1046	Warning: Desired value of Axis 2 near limits. The motion in the direction will be slowed down.	Move this specific axis into the opposite direction to not reach the limitation of the axis.
1047	Warning: Desired value of Axis 3 near limits. The motion in the direction will be slowed down.	Move this specific axis into the opposite direction to not reach the limitation of the axis.
1048	Warning: Desired value of Axis 4 near limits. The motion in the direction will be slowed down.	Move this specific axis into the opposite direction to not reach the limitation of the axis.

Error Code	State Description	Solution
1049	Warning: Desired value of Axis 5 near limits. The motion in the direction will be slowed down.	Move this specific axis into the opposite direction to not reach the limitation of the axis.
1050	Warning: Desired value of Axis 6 near limits. The motion in the direction will be slowed down.	Move this specific axis into the opposite direction to not reach the limitation of the axis.
1052	Warning: Robot TCP is at cartesian workspace limits in X-direction. The motion in this direction is not possible.	Move the robot the opposite X-direction to move the robot out of the limitation.
1053	Warning: Robot TCP is at cartesian workspace limits in Y-direction. The motion in this direction is not possible.	Move the robot the opposite Y-direction to move the robot out of the limitation.
1054	Warning: Robot TCP is at cartesian workspace limits in Z-direction. The motion in this direction is not possible.	Move the robot the opposite Z-direction to move the robot out of the limitation.
1055	Warning: Robot TCP is near cartesian workspace limits in X-direction. The motion in the direction will be slowed down.	Move the robot the opposite X-direction to move the robot away from the limits.
1056	Warning: Robot TCP is near cartesian workspace limits in Y-direction. The motion in the direction will be slowed down.	Move the robot the opposite Y-direction to move the robot away from the limits.
1057	Warning: Robot TCP is near cartesian workspace limits in Z-direction. The motion in the direction will be slowed down.	Move the robot the opposite Z-direction to move the robot away from the limits.
1058	Warning: Modifier configurated without path.	Please contact your NEURA Robotics representative or distributor for further assistance with troubleshooting.
1059	Warning: Weaving configurated with invalid weaving pattern.	The specified parameters for the weaving pattern are invalid and need to be adapted. Please refer to the Software Manual for the details on how to define them.
1060	Warning: Weaving configurated with invalid amplitude.	The amplitude for the weaving pattern is invalid and needs to be adapted. Please refer to the Software Manual for the details on how to define them.
1061	Warning: Weaving configurated with invalid frequency.	The frequency of the weaving pattern is invalid and needs to be adapted. Please refer to the Software Manual for the details on how to define them.
1062	Warning: Weaving configurated with invalid velocity, velocity value	The specified parameters for the weaving pattern are invalid and need to be adapted. Please refer to

Error Code	State Description	Solution
	exceeds 16.67 mm/s. Please reduce velocity.	the Software Manual for the details on how to define them.
1063	Warning: Weaving configurated with invalid dwell time. Dwell time exceeds time given by frequency.	The specified parameters for the weaving pattern are invalid and need to be adapted. Please refer to the Software Manual for the details on how to define them. The dwell time exceeds the period duration specified by the weaving frequency.
1064	Warning: Collision detection stopped. Unable to read collision parameters from the json file.	Please contact your NEURA Robotics representative or distributor for further assistance with troubleshooting.
1065	Warning: Setting new joint limits is not possible. The current robot configuration violates the new limits. Please move the robot into the new limits.	Please move the robot into the new limits.
1070	Warning: Tool mass is not valid. Please check the tool parameters and try again.	Please check the tool parameters and try again.
1071	Warning: Desired motion violates X-Axis limits. The motion is not possible.	Please move other X-direction.
1072	Warning: Desired motion violates Y-Axis limits. The motion is not possible.	Please move other Y-direction.
1073	Warning: Desired motion violates Z-Axis limits. The motion is not possible.	Please move other Z-direction.
1080	Warning: Axis 1 beyond limits. The motion in the desired direction is not possible. Please move the robot back into the limits.	Please move the robot back into the limits.
1081	Warning: Axis 2 beyond limits. The motion in the desired direction is not possible. Please move the robot back into the limits.	Please move the robot back into the limits.
1082	Warning: Axis 3 beyond limits. The motion in the desired direction is not possible. Please move the robot back into the limits.	Please move the robot back into the limits.
1083	Warning: Axis 4 beyond limits. The motion in the desired direction is not possible. Please move the robot back into the limits.	Please move the robot back into the limits.
1084	Warning: Axis 5 beyond limits. The motion in the desired direction is	Please move the robot back into the limits.

Error Code	State Description	Solution
	not possible. Please move the robot back into the limits.	
1085	Warning: Axis 6 beyond limits. The motion in the desired direction is not possible. Please move the robot back into the limits.	Please move the robot back into the limits.
1086	Warning: Axis 7 beyond limits. The motion in the desired direction is not possible. Please move the robot back into the limits.	Please move the robot back into the limits.
Collision error messages		
2001	Warning: Obstacle in trajectory detected	Remove the obstacle from the trajectory path.
2002	Warning: Collision occurred	(1) Remove the object that caused the collision from the robot workspace. (2) Reset the collision to continue the motion.
2003	Warning: Movement blocked by something	Remove the object that caused blocking from the robot workspace.
2004	Warning: Object to grasp not reachable	Make sure that the grasp location is within the robot workspace.
2005	Warning: Object to grasp not reachable	Make sure that the grasp location is within the robot workspace. The object shape should be compatible with the current tool. Refer to the operation guide for more information about the robot workspace and tools.
2006	Warning: Could not find/detect object	Make sure the object is positioned correctly with appropriate lighting. Refer to the operation guide for more information about object detection.
EtherCAT communication error messages		
3001	Error: Communication Problem with Host IP	(1) Check the cable with the host pc for damage. Replace it if is necessary. (2) Restart robot control with **PC->Reset Control** from GUI.
3002	Error: Communication Problem with a Joint	Restart robot control with **PC->Reset Control** from GUI.
3004	Error: Queue overload, data loss	Restart robot control with **PC->Reset Control** from GUI.
3005	Warning: Communication Problem with Host PC	Check connection to Host PC
3006	Warning: Communication Problem with GUI server! Jog Motion was stopped. Check the connection to the Teach Pendant!	Check the connection to the Teach Pendant!

Error Code	State Description	Solution
Robot status error messages		
4001	Error: Current too High	(1) Shutdown both pc with **PC->Power Off** from GUI. (2) Power off the Control Cabinet by switching off the power switch. (3) Wait until all the colling fans in the Control Cabinet is at a complete standstill. (4) Make sure the power supply ratings are as per the operation guide. (5) Power on the Control Cabinet again. Release all the emergencies and press the white E-Stop reset button. (6) Make sure the mounted tool does not exceed the maximum payload of the robot.
4002	Error: Current too Low	(1) Shutdown both pc with **PC->Power Off** from GUI. (2) Power off the Control Cabinet by switching off the power switch. (3) Wait until all the cooling fans in the Control Cabinet is at a complete standstill. (4) Make sure the power supply ratings are as per the operation guide. (5) Power on the Control Cabinet again. Release all the emergencies and press the white E-stop reset button.
4003	Error: Voltage too High	(1) Shutdown both pc with **PC->Power Off** from GUI. (2) Power off the Control Cabinet by switching off the power switch. (3) Wait until all the colling fans in the Control Cabinet is at a complete standstill. (4) Make sure the power supply ratings are as per the operation guide. (5) Power on the Control Cabinet again. Release all the emergencies and press the white E-stop reset button. (6) Make sure the mounted tool does not exceed the maximum payload of the robot.
4004	Error: Voltage too Low	(1) Shutdown both pc with **PC->Power Off** from GUI. (2) Power off the Control Cabinet by switching off the power switch. (3) Wait until all the colling fans in the Control Cabinet is at a complete standstill. (4) Make sure the power supply ratings are as per the operation guide. (5) Power on the Control Cabinet again. Release all the emergencies and press the white E-stop reset button.
4005	Warning: Temperature	(1) Shutdown PC with **PC->Power Off** from GUI. (2) Power off the Control Cabinet by switching off the power switch.

Error Code	State Description	Solution
		(3) Before powering on the robot, make sure the operating temperature range of the robot is as per the operation guide. (4) Check if all fans are working
4006	Error: Cycle could not achieve real time, high CPU	Restart robot control with **PC->Reset Control** from GUI.
4007	Warning: Calibration failed	Restart robot control with **PC->Reset Control** from GUI.
4008	Error: Emergency Stop Pressed	(1) Release the emergency stop. (2) Press the white E-stop reset button in the Control Cabinet of the robot. (3) Restart robot control with **PC->Reset Control** from GUI.
4009	Error: Communication with some EtherCAT clients not completing within allotted time	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4010	Error: Transmitting data to EtherCAT clients	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4011	Error: Receiving Data from EtherCAT clients failed completely. click on PC button and reset control	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4012	Error: Communication with High Level timed out	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4013	Error: Robot did not transition to ready to power on within 75 lotted time. Click on PC button and reset control. If the error reappears power off and power cycle the Control Cabinet	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4014	Error: Robot did not transition to operation enable i.e. robot did not power on within 75 lotted time. Click on PC button and reset control. If the error reappears power off and power cycle the Control Cabinet	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4015	Error: Robot did not power off within 75 lotted time. Click on PC button and reset control. If the error reappears power off and power cycle the Control Cabinet	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.

Error Code	State Description	Solution
4016	Error: Some axes are powered on while others are powered off after 76 lotted time	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4017	Error: Axes are in fault state according to DS402 profile. Check if some drives are in fault	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4018	Error: Emergency Pressed or not reset. Release all Emergency PB and press illuminated white PB on Control Cabinet. It should glow white. Then press reset on HMI	(1) Release all the emergency stops. (2) Press the white E-stop reset button in the Control Cabinet of the robot. (3) Restart robot control with **PC->Reset Control** from GUI (4) If Point (3) doesn't solve the issue à Power cycle the robot.
4019	Error: Robot Switched Off During Execution	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4020	Warning: Did not receive data from EtherCAT clients for one cycle	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4021	Error: Jump in Position Command in Axis 1	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4022	Error: Jump in Position Command in Axis 2	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4023	Error: Jump in Position Command in Axis 3	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4024	Error: Jump in Position Command in Axis 4	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4025	Error: Jump in Position Command in Axis 5	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4026	Error: Jump in Position Command in Axis 6	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.

Error Code	State Description	Solution
4028	Warning: End effector board not initialised	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4029	Error: Axis is not ready to take command	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4030	Error: EtherCAT Robot slave lost	(1) Restart robot control with **PC->Reset Control** from GUI (2) If Point (1) doesn't solve the issue à Power cycle the robot.
4031	Warning: Turning On collision detection as per the safety logic	Informational warning.
4032	Warning: Turning Off collision detection as per the safety logic	Informational warning.
Robot calibration error messages		
5001	Warning: Joint not calibrated	Joint needs to be calibrated according to the calibration documentation.
5002	Warning: Axis not calibrated	Axis module needs to be calibrated according to the calibration documentation.
5003	Warning: Sensor not calibrated	Sensor needs to be calibrated according to the calibration documentation of manufacturer.
5004	Warning: Permissible load capacity exceeded	Lower the payload on the robot.
Motion planning error messages		
6001	Warning: Could not generate path	(1) Check the robot for points that are out of reach. (2) Check the path and points for axes singularities. (3) Check the software / hardware limits are not exceeded
6002	Warning: Inverse Kinematic could not find a solution	(1) Check the robot for points that are out of reach. (2) Check the path and points for axes singularities. (3) Check the software / hardware limits are not exceeded
6003	Warning: desired trajectory leads to a Singularity	Check the path and points for axes singularities.
6004	Error: Could not generate spline	(1) Check the robot for points that are out of reach. (2) Check the path and points for axes singularities.

Error Code	State Description	Solution
		(3) Check the software / hardware limits are not exceeded (4) Restart robot control with **PC->Reset Control** from GUI
6005	Error: Two points in the blending motion are the same	Separate or delete the points that are too close to each other.
6006	Error: Two points in the blending motion are too close to each other (for given blend radius)	Restart robot control with **PC->Reset Control** from GUI
6007	Error: Angle between two path segments is 180°	Restart robot control with **PC->Reset Control** from GUI
6008	Error: Could not Transfer Spline	Restart robot control with **PC->Reset Control** from GUI
6009	Error: Generated Spline dimension is invalid	Restart robot control with **PC->Reset Control** from GUI
6010	Warning: Could not generate spline	(1) Check the robot for points that are out of reach. (2) Check the path and points for axes singularities. (3) Check the software / hardware limits are not exceeded (4) Restart robot control with **PC->Reset Control** from GUI
6011	Warning: Could not reset with the current configuration	Check the configuration settings
6012	Warning: Could not pause, the robot is not running	Use the Pause function when the robot is running.
6013	Warning: Could not stop, the robot is not running	Use the Stop function when the robot is running.
6014	Warning: Operation finished in an invalid state	Check the last movement or function at the end of the Program
6015	Warning: Command failed reached timeout	Check the commanding cycle. Too many commands in short time can lead to this error.
6016	Warning: Trajectory Generator in Error	Restart robot control with **PC->Reset Control** from GUI
6017	Error: Generated Spline total time is zero.	Restart robot control with **PC->Reset Control** from GUI
6018	Warning: MoveJointComposite cannot be generated. Two points are similar in the path	Create a program with 3 different target points. Re-teach the points accordingly.
6019	Warning: MoveJointComposite cannot be generated. Waypoints are less than 3	Create a program with a minimum of 3 target points.

Error Code	State Description	Solution
6020	Warning: MoveJoint cannot interpolate to starting point.	Use the jogging slider at (**Move->Joint->A1 to A7**) to move the robot near the starting point.
6021	Warning: MoveCircular Could not generated cartesian trajectory	(1) Check the robot for points that are out of reach. (2) Check the path and points for axes singularities. (3) Check the software / hardware limits are not exceeded (4) Restart robot control with **PC->Reset Control** from GUI
6022	Warning: MoveJoint Input of waypoints is not correct	Check the program for correct values of MoveJoint
6023	Warning: MoveJointComposite joint list generation failed	(1) Check the robot for points that are out of reach. (2) Check the path and points for axes singularities. (3) Check the software / hardware limits are not exceeded (4) Restart robot control with **PC->Reset Control** from GUI
6024	Warning: MoveLinear Spline cannot be generated. Number of trials has been exceeded !!	(1) Check the robot for points that are out of reach. (2) Check the path and points for axes singularities. (3) Check the software / hardware limits are not exceeded (4) Restart robot control with **PC->Reset Control** from GUI
6025	Error: MoveLinear Spline cannot be generated. Transitioning to ERROR	Restart robot control with **PC->Reset Control** from GUI
6026	Warning: MoveCircularComposite Trajectory Duration invalid, aborting	Check the MoveCircular values and used points
6027	Warning: MoveCircularComposite Circular Trajectory Cyclic is NULL	Check the MoveCircular values and used points
6028	Warning: MoveCircularComposite Circular Trajectory Base is NULL	Check the MoveCircular values and used points
6029	Warning: MoveLinear Trajectory Duration invalid, aborting	Check the MoveLinear values and used points
6030	Warning: MoveLinear Input of waypoints is not correct	Check the MoveLinear values and used points
6031	Warning: MoveJoint jump in position and velocities	1) Check the parameters of the motion command. ➢ Restart robot control with **PC->Reset Control** from GUI

Error Code	State Description	Solution
6032	Warning: Radius is too small	Check the points for MoveCircular, the total diameter of the circle needs to be re-defined.
6033	Warning: Radius is too big	Check the points for MoveCircular, the total diameter of the circle is too big.
6034	Warning: MoveCircular tilt angle is too big	Check the points for MoveCircular, the angle cannot be solved.
6035	Warning: Starting point of trajectory is far from current point	Check the programmed points and bring the starting point closer to the current point.
6036	Warning: Not enough target points	Add the minimum of points.
6037	Warning: MoveRecordedPath - Cannot read from file	File not saved properly. Re-teach the recorded path and save it again. If it does not work: ➢ Restart robot control with **PC->Reset Control** from GUI
6038	Warning: Error during allocating/deallocating memory	➢ Restart robot control with **PC->Reset Control** from GUI ➢ If needed, Power Cycle the robot
6039	Warning: MoveLinear cartesian limit violated	Change the points closer inside the cartesian space
6040	Warning: MoveCircular Too Many Points in Target	Change the points for circular motion to the correct amount.
6041	Warning: Wrong Angle Input for MoveCircular. use angle = 0.0	Use angle = 0.0
6042	Warning: Collision with Bounding Box detected.	Informational warning that Bounding Box limits were violated.
6043	Warning: MoveCircular circle plane is undefined.	Verify the taught points. If necessary, reteach some or all circular points.
6044	Warning: Runtime error occured while planning a motion.	Verify the taught points. If necessary, reteach some or all circular points.
6045	Warning: MoveComposite Motion Command does not start where last Motion Command ended.	Please start MoveComposite from where the last motion command ended.
Controller cabinet status error messages		
7001	Error: Unable to open file	(1) Check if the file exists. (2) Check if the file has the correct file type (3) Restart robot control with **PC->Reset** Control from GUI.
7002	Error: Unable to read from file	(1) Check the contents of the file as described in the operation guide. (2) Restart robot control with **PC->Reset Control** from GUI.
7003	Error: Unable to write to file	(1) Check if the file exists

Error Code	State Description	Solution
		(2) Restart robot control with **PC->Reset Control** from GUI
7004	Error: Undefined Input	(1) Check the number of joints in the file matches with actual joints of the robot. (2) Restart robot control with **PC->Reset Control** from GUI.
7006	Error: Motor is Stuck	(1) Power off the robot with **PC->Power Off** from GUI. (2) Power off the Control Cabinet by switching off the power switch. (3) Wait until all the cooling fans in the Control Cabinet are at a complete standstill. (4) Power on the Control Cabinet again. Release all the emergencies and press the white E-stop reset button.
7007	Warning: ENI configuration file not found!	(1) Power off the robot with **PC->Power Off** from GUI. (2) Power off the Control Cabinet by switching off the power switch. (3) Wait until all the cooling fans in the Control Cabinet are at a complete standstill. (4) Power on the Control Cabinet again. Release all the emergencies and press the white E-stop reset button. If this error comes up repeatedly, please contact your robot supplier.
7008	Warning: Wrong ENI file with different number of slaves	(1) Power off the robot with **PC->Power Off** from GUI. (2) Power off the Control Cabinet by switching off the power switch. (3) Wait until all the cooling fans in the Control Cabinet are at a complete standstill. (4) Power on the Control Cabinet again. Release all the emergencies and press the white E-stop reset button. If this error comes up repeatedly, please contact your robot supplier.
Robot axis status error messages		
8001	Error: Robot configuration is in an Invalid State	Restart robot control with **PC->Reset Control** from GUI
8002	Error: Invalid Transition	Restart robot control with **PC->Reset Control** from GUI
8003	Error: Speed Tracking	Restart robot control with **PC->Reset Control** from GUI
8004	Error: Position Tracking	Restart robot control with **PC->Reset Control** from GUI
8005	Error: Communication with EtherCAT failed!	Restart robot control with **PC->Reset Control** from GUI

Error Code	State Description	Solution
Robot configuration status error messages		
9001	Warning: Close to a singularity	Change the robot position to avoid the singularity
9002	Warning: Torque too high could cause damage	Check the payload, equipment or external forces not exceeding the limits of the robot.
9003	Warning: Robot is not available during Emergency	Reset the E-Stop before enabling the robot.
9004	Error: External Torques detected, check the Tool Configuration	(1) Check the tool settings at **settings->Tools**. Make sure that the **Tool Description, Inertia and Settings** are correct. Save the configuration. (2) Restart robot control with **PC->Reset Control**
9005	Warning: Maximum Static torque is exceeded. Reduce the mass	Check if the mass is set up in the tool parameter correctly. Check if the mass does not exceed the maximum of the robot capabilities (Check the manual for the allowed payload on your robot) Run DPI again or reduce the mounted payload.
9006	Warning: Approaching a singularity limit. The motion in the direction will be slowed down.	No action required. The user is informed that the motion is slowed down.
9007	Warning: At a singularity limit. The motion in desired direction is not possible.	The desired motion is not feasible due to singularities.
9009	Warning: In zeroG safe speed limit exceeded. Please restart zeroG again.	The maximum speed in ZeroG is exceeded. This can be due to too fast movement by the operator. Then, simply restart ZeroG. If this error occurs without operator input, check the correct tool parameter setting, the correct gravity vector setting, the tuning parameters of ZeroG mode. Eventually, run the DPI wizard.
9010	Warning: In zeroG joint limit exceeded. Please check the limit in gui.	The robot was forcefully moved over its axis limit. Try leaving the limit via joint jogging. Else, if it is not possible to power on the robot, moving the axis out of its limit can be achieved via the brake release feature.
9011	Warning: Collision Detected. Check the workspace and reset collision error.	Check the workspace and reset collision error to continue the robot motion. If a false positive collision occurs, tuning the collision sensitivity is possible via the robot settings.
9012	Warning: Reduced mode activated.	Information that reduced mode is activated. The robot will only move at a slow speed.
9013	Warning: Protective stop activated.	Information that protective mode is activated.
9014	Warning: Enabling external freedrive mode.	Information that zeroG mode is activated via the external mode.

Error Code	State Description	Solution
9015	Warning: In ZeroG jump in locked axis position. Please restart zeroG again.	The robot was forcefully moved out of its locked axis configuration. Deactivate axis lock and check the normal ZeroG mode behaviour. Check the tool parameter setting, the gravity vector settings and the ZeroG settings. Reduce the load mounted on the robot.
9016	Warning: In ZeroG jump in locked axis velocity. Please restart ZeroG again.	The robot was forcefully moved out of its locked axis configuration. Deactivate axis lock and check the normal ZeroG mode behaviour. Check the tool parameter setting, the gravity vector settings and the ZeroG settings. Reduce the load mounted on the robot.
9031	Warning: HMI button pressed in non-Teach mode.	Please enable Teach mode and try again.
9032	Warning: In ZeroG axis lock is enabled.	Please disable axis lock and try again.
9033	Warning: Cannot initialize the robot, please press the white reset button and try again, switching to simulation mode.	Please try to reset control.
9034	Warning: Collision detected due to large dynamical model error. Please check tool settings, gravity vector settings or do DPI again.	Please check tool settings, gravity vector settings or do DPI again.
9035	Error: After collision in reflex mode large TCP movement detected. Please check tool settings, gravity vector settings or do DPI again.	Please check tool settings, gravity vector settings or do DPI again.
9036	Warning: The gravity vector is changed. Please move away from the robot, turn off reflex mode and then turn on ZeroG mode at 5 random positions to ensure its correctness.	Please move away from the robot, turn off reflex mode and then turn on ZeroG mode at 5 random positions to ensure its correctness.
9037	Warning: Optimization of Cartesian motion failed. Could not find solution for given parameters.	Please change the setting parameters, i.e. velocity, acceleration, blending radius (for static blending) for the failed motion segment or adjust the desired pose of targets.
9038	Warning: Cartesian motion was not able to find segment type.	Please change the setting parameters, i.e. velocity, acceleration, blending radius (for static blending) for the failed motion segment or adjust the desired pose of targets.
9039	Warning: Rotational Velocity was not correctly initialized, less than 0.0.	Please change parameter setting to be > 0.

Error Code	State Description	Solution
9040	Warning: ZeroG was turned off automatically due to inactivity for 10 minutes.	Please turn ZeroG back on again if desired.
Robot EtherCAT-Stack status error messages		
10001	Error FATAL error in EtherCAT stack	➢ Restart robot control with **PC->Reset Control** ➢ If needed, Power Cycle the robot ➢ If the error persists, contact your robot supplier
10002	Error non-fatal error in EtherCAT stack	➢ Restart robot control with **PC->Reset Control** ➢ If needed, Power Cycle the robot ➢ If the error persists, contact your robot supplier

9.1.2. MAiRA controller error processing

Description	Error Display	Solution
Normal	Normal	Click **Reset** to perform resetting and clearing. Click the **Servo On** button to enable the robot
Short circuit error	Error: Short circuit error!	
Overvoltage error	Error: Over voltage limit error!	
Undervoltage error	Error: Under voltage limit error!	
Overspeed error	Error: Over velocity limit error!	
Execution error	Error: Execute error!	
RMS overcurrent error	Error: Over current error!	
Encoder error	Error: Encoder error!	
Position following error	Error: Following position error!	
Speed following error	Error: Following velocity error!	
Negative limit error	Error: Negative limit error!	
Positive limit error	Error: Positive limit error!	
Servo overtemperature error	Error: Server over heating error!	
Peak current error	Error: Max current error!	
Hardware braking error	Error: Emergency stop error!	
UDM error	Error: UDM error!	
Servo parameter error	Error: Server parameter error!	
Enablement timeout	Error: Robot enable time out!	Check whether the robot body drive UDM operates normally. Click the **Servo On** button to re-enable the robot.
SDK collision detection	Error: Robot Collide with body!	(1) Manually open the brake using the demonstrator. (2) Manually drag the robot so that it leaves the self-collision posture. (3) Close the brake and perform clearing and enablement.
Joint limit	Error: Over joint limit error!	(1) In enabled state, let the axis move back to safe space in the reverse direction of the axis that exceeds safe space due to long jog movement. Click **Reset** to perform resetting and clearing. (2) In disabled state, Click Reset to perform clearing. Click **Servo On**. Let the axis move back to safe space in the reverse direction of the axis that exceeds safe space due to long jog movement.

Description	Error Display	Solution
Singularity	Error: Singularity error	Click **Reset** to perform clearing. Click **Servo On** to enable the robot.
Abnormal stop	Error: General stopping criterion	Click **Reset** to perform clearing.
SDK calculation error	Error: calculate failed	Click **Reset** to perform clearing.
UDM state error	Error: UDM Status Error!	Shut down the master; Start the master.
Slave error	Error: Init slave Error!	Click **Reset** to perform clearing.
HomeStep2 error	Error: Home Step2Error!	Click **Reset** to perform clearing.

9.1.3. Additional MAiRA error messages

Error Code HEX	Error Display	Solution
0x3130	AC fail: loss of phase	Check the Control Cabinet connection for AC. Replace the cable if necessary.
0x7381	Hall sensor speed is too high or disconnected	Check the connection.
0x8480	Speed tracking error	During robot motion there was a difference between speed set point and feedback detected.
0x8611	Position tracking error	During robot motion there was a difference between position set point and feedback detected.
0x5280	Gantry Yaw error limit exceeded	Check the Yaw-Value of gantry system
0x8130	Communication failed, loss of synchronization or frame loss was detected	Communication between EtherCat slaves interrupted or bad quality. Try to find the last available slaves and check the to the lost slave.
0x3120	Under voltage	Check supply voltage for 24V and 48V PSU. Inform NEURA / Distributor for solution
0x3310	Over voltage	Check supply voltage for 24V and 48V PSU. Also check possible short cuts on cabling inside the robot or control cabinet. Inform NEURA / Distributor for solution
0xFF20	Safe Torque Off	Torque limit exceeded; Collision might be causing the problem
0x2340	Short circuit	Electrical investigation necessary

Error Code HEX	Error Display	Solution
0x4210	Motor over temperature	Reduce Speed, Payload, or duty cycle. Motor might need to be exchanged. Inform NEURA / Distributor for solution
0x8481	Over speed protection	Reduce commanded speed for robot.
0x6180	SLT fault reaction	-
0x7121	Motor stuck	Motor or phase cables might be damaged. Replacement of Axis needed. Inform NEURA / Distributor for solution
0x8680	Position Limit Exceeded	Inform NEURA / Distributor for solution
0xFF40	Gantry slave disabled	Inform NEURA / Distributor for solution
0x5442	Motor disabled. Additional abort input is active	Inform NEURA / Distributor for solution
0x4310	Drive over-temperature	Servo Drive might be damaged. Replacement needed. Inform NEURA / Distributor for solution
0xFF50	Attached slave drive fault	Inform NEURA / Distributor for solution
0xFF10	Failed to enable the motor	Servo Drive might be damaged. Replacement needed. Inform NEURA / Distributor for solution
0xFF30	Motor disabled local	Servo Drive might be damaged. Replacement needed. Inform NEURA / Distributor for solution
0x5441	Motor disabled by INHIBIT or ABORT	Servo Drive might be damaged. Replacement needed. Inform NEURA / Distributor for solution
0x6300	RPDO failed	Inform NEURA / Distributor for solution
0x7300	Feedback error	Inform NEURA / Distributor for solution
0x7382	Commutation process fail during motor on	Servo Drive might be damaged. Replacement needed. Inform NEURA / Distributor for solution
0x8110	CAN Message lost (corrupted or overrun)	Servo Drive might be damaged. Replacement needed. Inform NEURA / Distributor for solution
0x8140	Recovered from bus off	Servo Drive might be damaged. Replacement needed. Inform NEURA / Distributor for solution

Error Code HEX	Error Display	Solution
0x8210	Attempt to access a non-configured RPDO	Inform NEURA / Distributor for solution
0xFF01	Request by user program EMCY(N) function	Inform NEURA / Distributor for solution

10. MAINTENANCE, SERVICE AND REPAIR

10.1. Maintenance and Repair

Regular maintenance work can be performed on a robot system to ensure its intended operations. See below for the maintenance tasks and intervals. Robots must be repaired when malfunctioning due to environmental influences or improper operation of the user, or a certain component of the robot system exceeds normal service life.

10.2. Safety Instructions

- Before performing maintenance operations, make sure that the robot has stopped in safe conditions.
- All maintenance and service/repair work must be performed or instructed by NEURA Robotics GmbH or authorized partners.
- All maintenance and service/repair work must be performed in accordance with safety instructions in this manual (see *General Safety Instructions* on page *4*).
- All replaced parts must be returned to NEURA Robotics according to the service manual.
- All personnel involved in maintenance and repair on robot systems must read and must comply with all local and national safety regulations for the location in which the robot is installed.
- Perform the inspection checks after maintenance and repair work on robot system.

When working on a robot arm or control box, you must observe the following procedures and warnings:

1. Remove the power cable from the control box to ensure that it is completely powered off. Take necessary precautions to prevent other people from reconnecting the system during the maintenance period (e.g. disconnect the main plug from socket).
2. Make sure that the ground connection is connected before turning the control box back on.
3. Make sure that all the electrical maintenance work must be performed in accordance with electrical safety instructions in this manual (see *Electrical Installation* on page *32*).
4. Replace faulty components with new components with the same part numbers or equivalent components approved by NEURA Robotics GmbH.
5. Reactivate any deactivated safety measures immediately after the work is completed.
6. Record all the maintenance operations and save the technical documentation.

10.3. Maintenance Intervals

Make sure that the following activities are checked as indicated to ensure the robot system functions and safety. When cleaning use a damp cloth. As cleaning agent use water.

Item	Period	Remark
Cables	1 day	► Check visible cables for any cracks or damage. ► If cables are damaged or cracked, please replace them immediately. ► Check for loose bolts cables or connections.
Warning, Safety labels	1 week	► Ensure labels are present and legible. ► Replace them if necessary.
Check control box filters	1 month	► Replace at least every 3 months.
Check emergency switch	1 month	► Press the emergency switch and the IO E-Stop in open-loop status. ► Verify that each shuts off power.
Check robot mounting screws	3 months	► Follow the robot installation process.

11. DISASSEMBLY AND MODIFICATION

Only NEURA Robotics or authorized partners are allowed to perform disassembly and modifications on the MAiRA robot system.

The same safety requirements apply as for maintenance and repair work (see *Maintenance, Service and Repair* on page *89*).

12. ENVIRONMENT AND DISPOSAL

Disposal of MAiRA Robot

The MAiRA robot is a high-quality device that can be expected to function for a long time. Nevertheless, this device will eventually reach its end of service. At that time, be aware that electrical devices must be properly disposed of.

Dispose of the device, device parts and consumables in accordance with the applicable guidelines and laws of the country in which the device is installed and operated.

NEURA Robotics products are produced with restricted use of hazardous substances to protect the environment as defined by the European RoHS directive 2011/65/EU. These substances include cameras, mercury, cadmium, lead, chromium VI, polybrominated biphenyls and polybrominated diphenyl ethers.

The below symbol on the robot indicates that the appliance must not be disposed of with unsorted common municipal waste. As the end-user, it is your responsibility to dispose of the end-of-life appliance in an environmentally sensitive manner by returning to NEURA Robotics GmbH or depositing it in a designated collection point.

Importers in countries covered by the European WEEE Directive 2012/19/EU must make their own registration to the national WEEE register of their country.

The following symbols are affixed to the robot to indicate conformity with the above legislation:

Disposal of batteries

During normal use, no environmental damage is caused by the batteries.
Both rechargeable and non-rechargeable batteries are, however, special waste and must be disposed of separately after use as they contain hazardous chemicals.
Both types of batteries must only be disposed of through an approved takeback system. Under no circumstances may batteries be disposed of with household waste.

13. APPENDIX

13.1. Technical Specifications

Type	Specification		
	S	M	L
Payload	15-18 kg	12-14 kg	9-11 kg
Reach	1100 mm	1400 mm	1600 mm
Weight	51 kg	53 kg	56 kg
Repeatability	> 0.01mm		
Installation area	Ø 252 mm		
Degree of freedom	6 or 7 rotating joints		
Control box dimensions	592 x 567 x 253 mm		
Tool flange I/O ports	EtherCAT, GPIO, Modbus via M8 8-pin-A-M | IEC 61076-2-104		
Tool I/O power supply	24 V 1.5 A		
Communication	GPIO, Modbus TCP, OPC UA (optional)		
Programming	On-screen manipulation director; remote access		
IP class	IP65		
Power	1,5 kW		
Main material	Aluminum alloy		
Operating ambient temperature	0-40 °C		
External power input	100-240 VAC, 50/60 Hz, max. 16 A		
Cables	Control box connecting cable: 3 m Teach pendant connecting cable: 5 m		

13.2. List of Figures

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