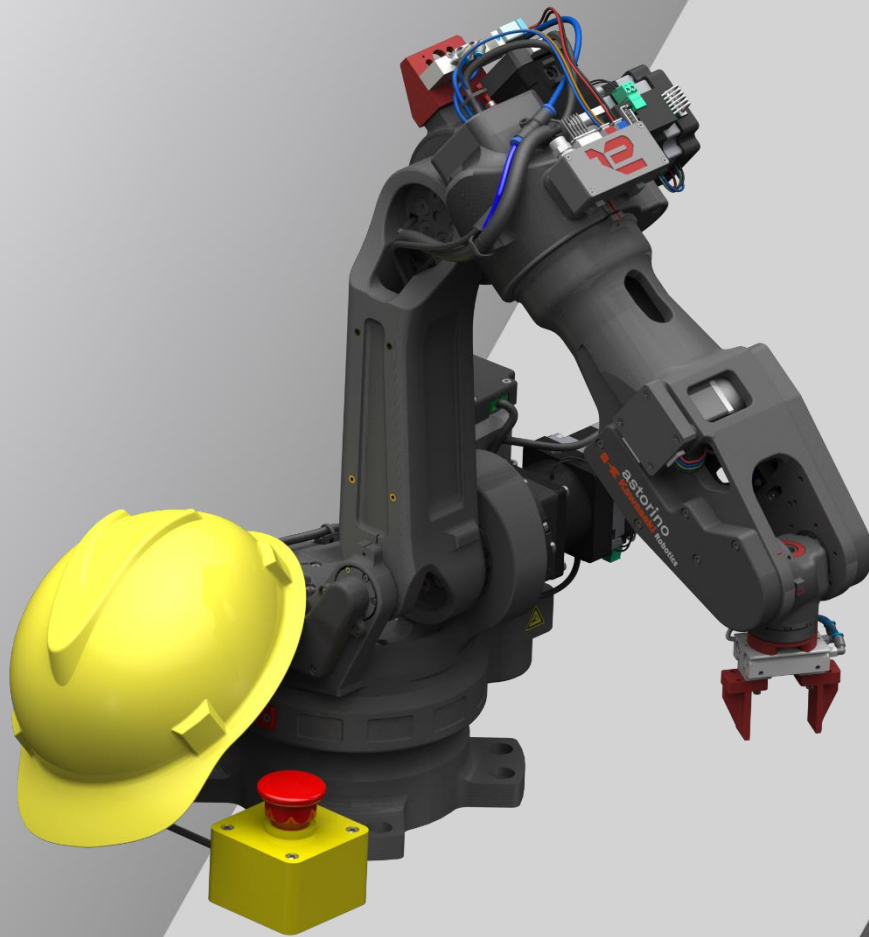


ASTORINO

Safety Manual



Preface

This manual describes the safety of the 6-axis robot "astorino" and the associated "astorino" software.

The ASTORINO is a learning robot specially developed for educational institutions. Pupils and students can use the ASTORINO to learn robot-assisted automation of industrial processes in practice.

ASTORINO Safety Manual

1. The "astorino" software included with the ASTORINO is licensed for use with this robot only and may not be used, copied or distributed in any other environment.
2. Kawasaki shall not be liable for any accidents, damages, and/or problems caused by improper use of the ASTORINO robot.
3. Kawasaki reserves the right to change, revise, or update this manual without prior notice.
4. This manual may not be reprinted or copied in whole or in part without prior written permission from Kawasaki.
5. Keep this manual in a safe place and within easy reach so that it can be used at any time. If the manual is lost or seriously damaged, contact Kawasaki.

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All rights reserved.

Symbols

Items that require special attention in this manual are marked with the following symbols.

Ensure proper operation of the robot and prevent injury or property damage by following the safety instructions in the boxes with these symbols.



WARNING

Failure to observe the specified contents could possibly result in injury or, in the worst case, death.

[ATTENTION]

Identifies precautions regarding robot specifications, handling, teaching, operation, and maintenance.



WARNING

- 1. The accuracy and effectiveness of the diagrams, procedures and explanations in this manual cannot be confirmed with absolute certainty. Should any unexplained problems occur, contact Kawasaki Robotics GmbH at the above address.**
- 2. To ensure that all work is performed safely, read and understand this manual. In addition, refer to all applicable laws, regulations, and related materials, as well as the safety statements described in each chapter. Prepare appropriate safety measures and procedures for actual work.**

Paraphrases

The following formatting rules are used in this manual:

- For a particular keystroke, the respective key is enclosed in angle brackets, e.g. <F1> or <Enter>.
- For the button of a dialog box or the toolbar, the button name is enclosed in square brackets, e.g. [Ok] or [Reset].
- Selectable fields are marked with a square box . If selected a check mark is shown inside the symbol .

ASTORINO Safety Manual

List of contents

Preface	I
Symbols	1
Paraphrases	2
List of contents.....	3
1 Nomenclature in this manual	5
2 Overview of ASTORINO	6
3 Technical specifications	7
4 Range of motion	8
5 Mounting dimensions	9
6 Intended operation	10
7 Declaration of incorporation.....	11
8 Safety instructions	12
8.1 General information on safety	12
8.1.1 Signal words used	13
8.1.2 Hazard warnings	13
8.1.3 Guidelines, laws and standards	13
8.1.4 Validity	14
8.2 Safety instructions for personel	14
8.3 Specific compoments	14
8.3.1 Safety devices	14
8.3.2 Safety-relevant functions	14
8.4 Electrical	15
8.5 Specific life cycles of the product	15
8.5.1 Transport.....	15
8.5.2 Installation/Robot environment/Cleaning	15
8.5.3 Dismantling.....	16
9 Installation instructions.....	16
9.1 Maximum payload	17
9.2 Emergency stop circuit	17
9.3 Emergency stop plug	18
9.4 Safety Fence circuit (OPTION).....	18
9.5 Safety Fence stop plug (OPTION)	19

ASTORINO Safety Manual

9.6	Switching ON	19
9.7	Connecting and moving the robot	19
10	Risk assessment.....	20
10.1	Safety features	20
10.2	Residual risks	21
10.2.1	Warning labels.....	21
10.2.2	Pinch or hand injury places	24
10.2.3	Residual risks in case of power loss	25
11	Installation	26
11.1	Installation environment.....	26
11.2	Safety measures concerning robot installation	27
12	Manufacturer information	28

1 Nomenclature in this manual

The author of the manual tries to use generally valid terminology while achieving the greatest possible logical sense. Unfortunately, it must be noted that the terminology is reversed depending on the point of view when considering one and the same topic. Also it is to be stated that in the course of the computer and software history terminologies developed in different way. One will find therefore in a modern manual no terminologies, which always satisfy 100% each expert opinion.

2 Overview of ASTORINO

The ASTORINO is a 6-axis learning robot developed specifically for educational institutions such as schools and universities. The robot design is based to be 3D printed with PET-G filament. Damaged parts can be reproduced by the user using a compatible 3D printer.

Programming and control of the robot is done by the "astorino" software.

The latest software version and 3D files can be downloaded from the KAWASAKI ROBOTICS FTP server:

<https://ftp.kawasakirobot.de/Software/Astorino/>

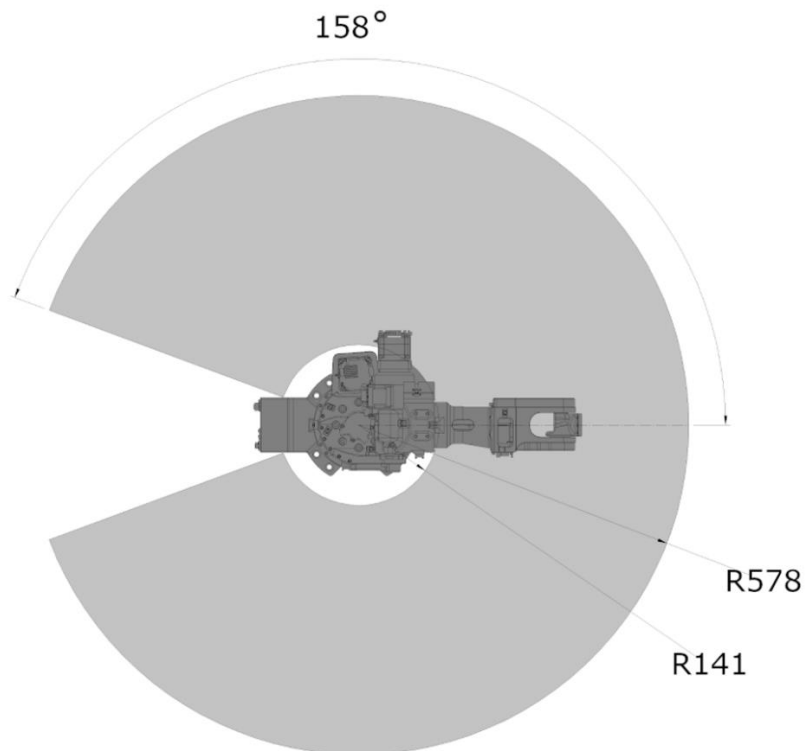
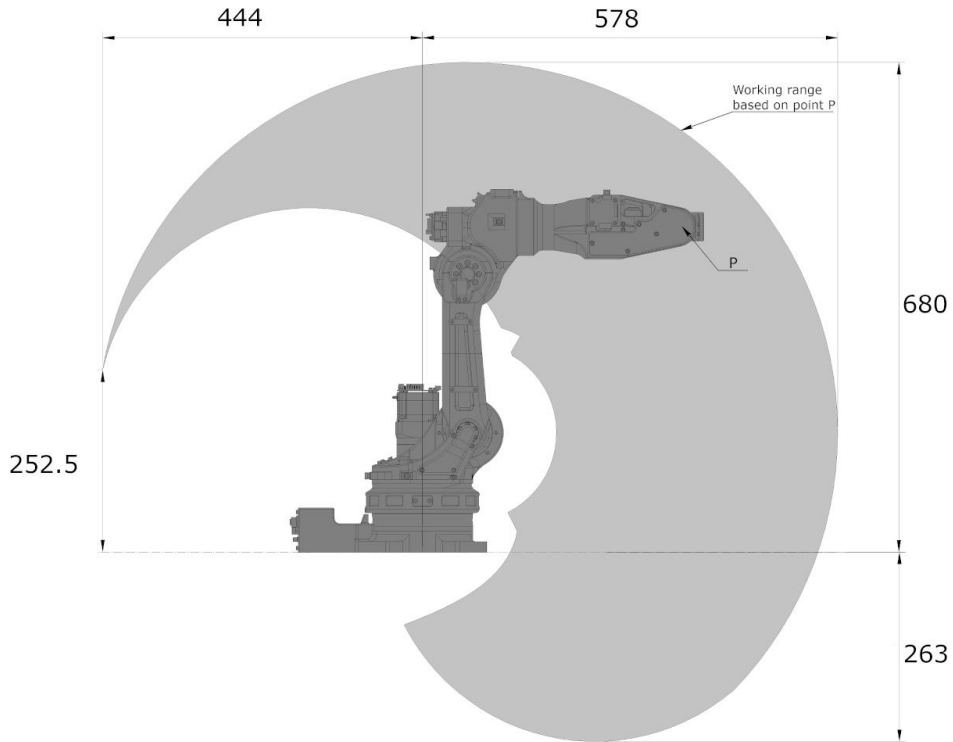
Just like Kawasaki's industrial Robots the ASTORINO is programmed using AS language. Providing transferable programming skills from the classroom to real industrial applications.

3 Technical specifications

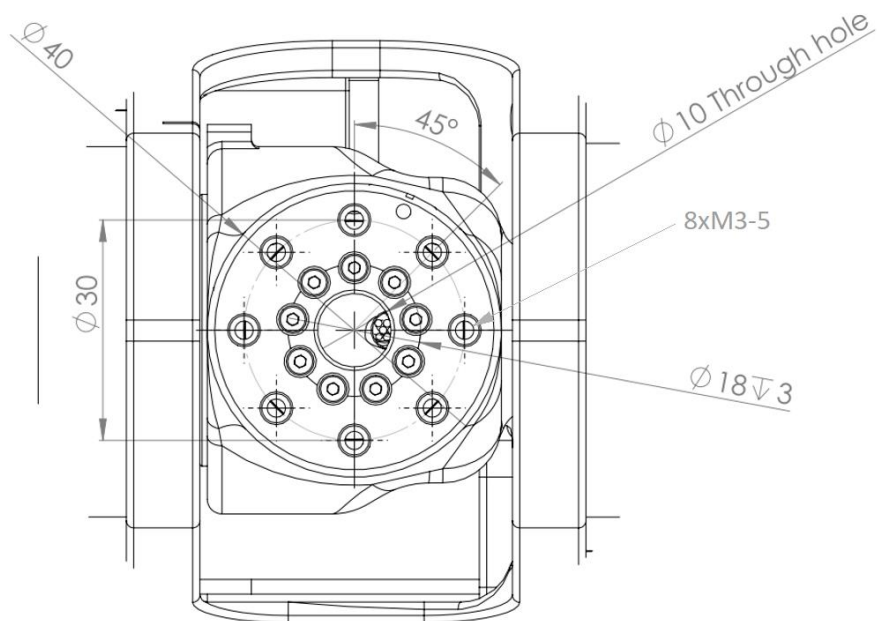
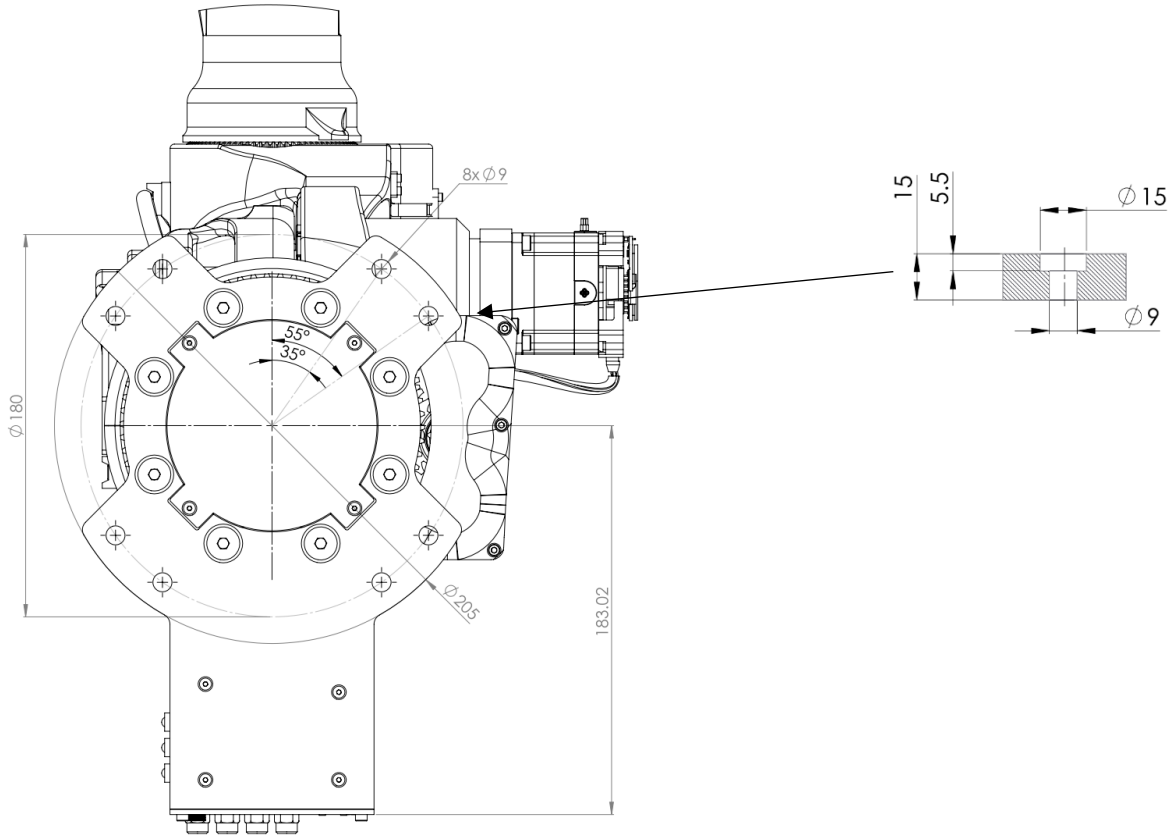
Characteristics		ASTORINO
Type		6-axis robot
Max. lifting capacity		1 kg
Number of axes		6
Max. range		578 mm
Repeatability		±0.1 mm
Motion range	Axis 1 (JT1)	±158°
	Axis 2 (JT2)	-90°÷127°
	Axis 3 (JT3)	0°÷168°
	Axis 4 (JT4)	±240°
	Axis 5 (JT5)	±120°
	Axis 6 (JT6)	±360°
Max. single axis speed	Axis 1 (JT1)	38°/s
	Axis 2 (JT2)	26°/s
	Axis 3 (JT3)	26°/s
	Axis 4 (JT4)	67.5°/s
	Axis 5 (JT5)	67.5°/s
	Axis 6 (JT6)	128.5°/s
Allowable moment	Axis 4 (JT4)	6.2 Nm
	Axis 5 (JT5)	1.45 Nm
	Axis 6 (JT6)	1.1 Nm
Working environment	Temperature	0–40°C
	Humidity	35–80%
Controller		Teensy 4.1
Inputs/Outputs		8/8 (PNP 8 mA, NPN 15 mA)
		2/2 (24V PNP on the JT3)
Max. current consumption		144 W
Power supply		100–240 V, 50–60 Hz
Weight		12 kg
Mounting position		Floor
Material		PET-G
Colour		Black
Communication		MODBUS TCP, TCP/IP, UDP, SERIAL
Collision detection		Accelerometer
Power loss safety		Brakes on JT2 and JT3
Options	24V I/O-module	8 × Inputs / Outputs
	7 th axis	Linear Track
	Vision system	OpenMV
	Belt tracking	Max. 2 Encoder

4 Range of motion

The motion ranges shown in the figures below are based on point P. For specifications of robot arms not shown in this manual, see the specification sheets, delivered separately.



5 Mounting dimensions



6 Intended operation

The astorino robots are designed to move and position small loads or objects. astorino robots are meant to be educational robots, working in controlled environment of laboratories as training machines.

According to the Machine Directive 2006/42/EC astorino robot is a machinery specially designed and constructed for research purposes for temporary use in laboratories.

Furthermore, if are intended to be incorporated into or assembled with other machinery or other incomplete machinery or equipment in order to form a machine along with them in accordance with Machinery Directive 2006/42/EC

7 Declaration of incorporation

DECLARATION OF INCORPORATION OF PARTLY COMPLETED MACHINERY

Astor Sp. z o.o.

Ul. Smoleńsk 29, 31-112 Kraków

Declares with full responsibility that the product:

ASTORINO robot with any options

Serials numbers: B002-001 to B002-100

is intended to be incorporated into machinery or to be assembled with other machinery to constitute machinery covered by:

Machinery Directive
2006/42/EC

Low Voltage Directive
2006/95/EC relating to electrical equipment supplied voltage below 1000V

EMC Directive
2004/108/CE relating to electromagnetic compatibility

the following standards have been applied:

PN-EN ISO
12100:2012

Machine safety - General design principles - Risk assessment and risk reduction

PN-EN 61000-6-2:2008

Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Resistance in industrial environments

PN-EN ISO 10218-1:2011

Robots and equipment for robotics - Safety requirements - Part 1: Industrial robots (ISO 10218-1: 2011)

PN-EN ISO 10218-2:2011

Robots for work in an industrial environment - Safety requirements - Part 2: Robotic system and integration (ISO 10218-2: 2011)

Authorized representative and Person authorized to compile the Technical Documentation:

ASTOR Sp. z o.o
Smoleńsk 29, 31-112 Kraków
Marek Niewiadomski
Chief designer

.....
(Place and Date)

.....
Andrzej Garbacki, Vice-President, Robotization Director

8 Safety instructions

8.1 General information on safety





Astorino robot does not incorporate breaks on any joint. During power failure robot might collapse. User safety and vigilance is necessary.





Always ensure the personal safety of users and others when operating the robot arm or starting the robot cell!

- In its basic version, the robot has no safety-related components for the robotic workstation. Such components may be required, depending on the target application. The basic version of the robot is provided with an emergency stop button.
- CE marking: The robot arm, when operating in factory applications, must undergo a risk assessment and comply with applicable safety regulations to ensure personal safety. Depending on the outcome of the assessment, further safety features should be integrated. These typically include safety relays and door switches. The person responsible here is the commissioning engineer. Educational applications do not require additional safety components.
- The robot controller includes a 24 V power supply that must be supplied with mains voltage (100/240 V). Please check the label on the power supply. Only qualified personnel can connect the power supply to the mains and put it into operation.
- Works carried out on the robot's electronic components should only be performed by qualified personnel. Check current guidelines for electrostatic discharges (ESD).
 - Always disconnect the robot from the power supply (100/240 V) when working on the robot base (controller) or any electronic components connected to the robot controller.
- Hot-plugging is forbidden! It could lead to a permanent damage to motor modules. Do not install or remove any modules or plug/disconnect connectors (e.g. emergency stop button, DIO modules, motor connectors) while the power is on.
- The robot arm must be placed on a stable surface and bolted or otherwise secured.
- Use and store the robot only in a dry and clean place.
- Use the system only in a room temperature (15° to 32°C) — recommended.

8.1.1 Signal words used

	<p style="text-align: center;">GENERAL WARNING SIGNS</p> <p>They are used to alert the product user to potential hazards. All safety statements that follow this symbol must be followed in order to prevent possible damage</p>
	<p style="text-align: center;">SAFETY INSTRUCTIONS</p> <p>This pictogram indicates safety-relevant behaviour of the operator</p>

8.1.2 Hazard warnings

	<p style="text-align: center;">WARNING OF PINCH INJURIES</p> <p>There is a risk of crushing due to driven moving parts (connecting plates). If grippers or other electrical or pneumatic components are used as actuators, therelevant regulations of the manufacturer must be observed.</p>
	<p style="text-align: center;">WARNING OF ENTANGLEMENT HAZARD</p> <p>There is danger of hair and/or clothing being drawn in. Do not wear open hair, loose clothing or jewellery. There is a risk of injury from getting entangled or pulled in! Do not put any part of body to the places market by this sign</p>
	<p style="text-align: center;">WARNING OF HOT SURFACE</p> <p>There is danger of burn on when in contact with a skin</p>
	<p style="text-align: center;">WARNING OF DANGEROUS ELECTRICAL VOLTAGE</p> <p>The electrical drive should only be connected by qualified personnel. The applicable regulations must be observed and applied. The assembly device must be integrated in the local protective conductor system</p>

8.1.3 Guidelines, laws and standards

The machine has been designed according to the guidelines and standards given in the declaration of incorporation

Failure to observe the safety instructions increases the risk of accidents as well as the risk of damage to the machine.

8.1.4 Validity

Significant changes to the articulated arm with drive units can lead to this declaration of incorporation becoming invalid. User can change 3D printed parts without making modifications to the 3D models.

8.2 Safety instructions for personnel



Staff must be trained and be familiar with hazardous situations that arm can perform.
Only trained persons must be employed on the machine!

8.3 Specific components

8.3.1 Safety devices

It is forbidden to remove or disable any safety device. If protective devices must be dismantled or disconnected for maintenance, repair or cleaning purposes, they must be re-installed and checked for efficacy after completion of the work.



The machine must not be operated in automatic mode if the protective equipment is not working or disassembled!
Robot cannot operate with more speed that 250mm/s therefore protective device other that Emergency stop button is not needed when working with safety clearance of at least 0.5m

8.3.2 Safety-relevant functions

The basic version of the robot control package does not include any safety-relevant functions. Depending on the application, they may possibly have to be added.

The robot arm as delivered is an incomplete machine in the sense of Machine Directive 2006/42/EC and does not yet fulfil all basic health and safety requirements. Before being used for the first time, the robot arm must be subjected to an EC conformity assessment procedure by the user, possibly together with other (incomplete) machines. For safe use, additional protective measures are necessary.

ASTORINO Safety Manual

Note that the Machinery Directive has an exemption for 'machinery specially designed and constructed for research purposes for temporary use in laboratories'. However, a risk assessment should be conducted.

8.4 Electrical

Work on robot electronics should only be done by qualified personnel. Check the directives for electro- static discharge (ESD). The robot control system includes a 24V mains adapter that itself need a mains voltage (120/240V). Please check the label on the mains adapter. Only qualified personnel are permitted to connect the mains adapter to the mains and start it up. Always disconnect the robot from the mains (120/240V) on the electronics that are connected to the robot control system. NO hot plugging! This can permanently damage the motor modules. Do not install or remove any modules (e.g emergency OFF switch, 24V DIO modules or external relays, motor connections) while they are switched on.

8.5 Specific life cycles of the product

8.5.1 Transport

Transport of the machine should be done only in original box delivered with a robot. Transporting in any other way can damage the robot arm and will lead to invalidation of warranty.

8.5.2 Installation/Robot environment/Cleaning

Only trained and appropriately qualified personnel, who are familiar with the structure of this type of machine, must be assigned to install and commission the machine. The robot arm must be placed on a robust surface and screwed on.

- Use and store the robot arm only in a dry, clean environment.
- Use the system only at room temperature (5° to +40°C).
- Do not cover stepper motor drivers and stepper motor to ensure a sufficient flow of air to cool them down.



Cleaning work must only be carried out when the machine is at a standstill. Before starting the cleaning work, the machine must be switched off and isolated against accidental restart!

8.5.3 Dismantling

Decommissioning and disassembly of the machine must only be carried out by properly trained and qualified personnel.

9 Installation instructions

The robot must be installed on rigid surface. Only the existing mounting holes must be used. The articulated arm must be able to move freely in all directions for zeroing of all joints.

The machine used in other environment than laboratories is an INCOMPLETE MACHINE. In the delivered condition, it does not yet fulfil all safety requirements. It must only be operated after all the requirements of the Machinery Directive 2006/42/EC have been met.

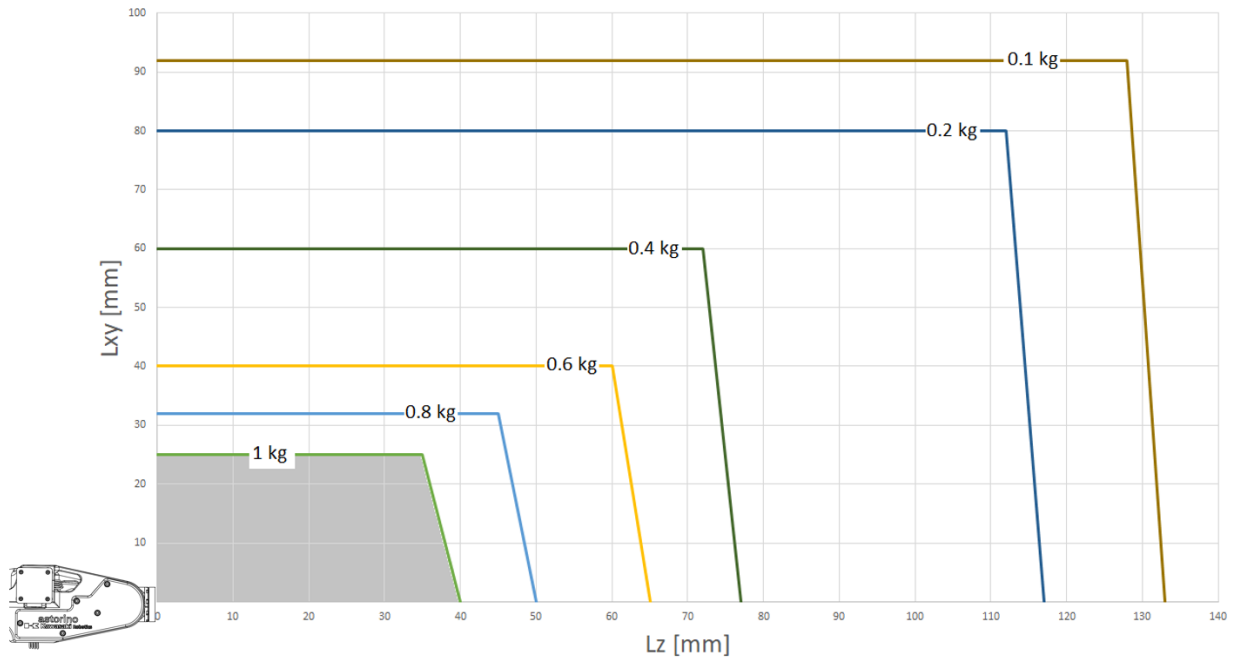


Zero position of the Astorino robot arm.

ASTORINO Safety Manual

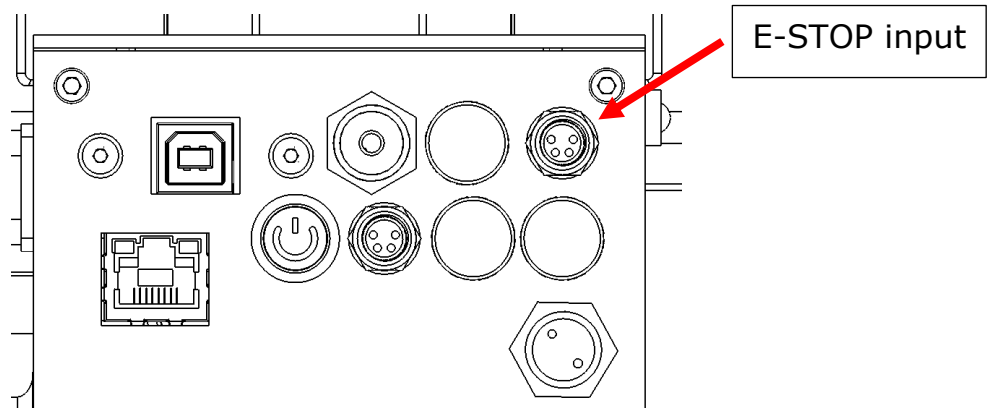
9.1 Maximum payload

Do not exceed rated payload of astorino robot, doing so might result in unpredictable behaviour for example drive oscillations.

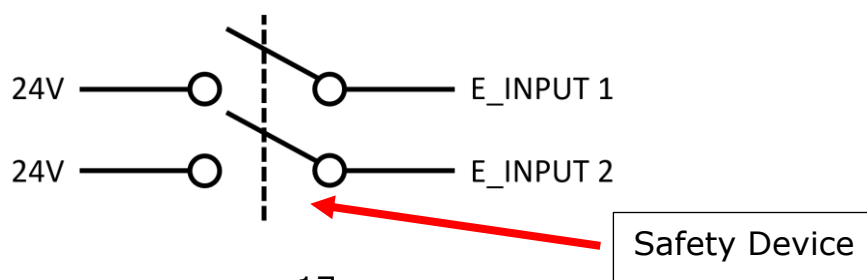


9.2 Emergency stop circuit

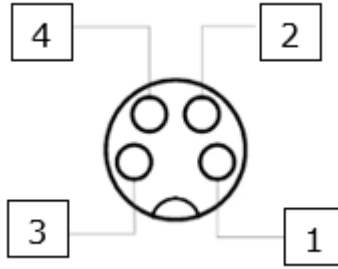
Robot is delivered with emergency stop button, but this button can be replaced by external safety system.



Emergency stop circuit is two channel, to connect external safety device follow listed below diagram.



9.3 Emergency stop plug

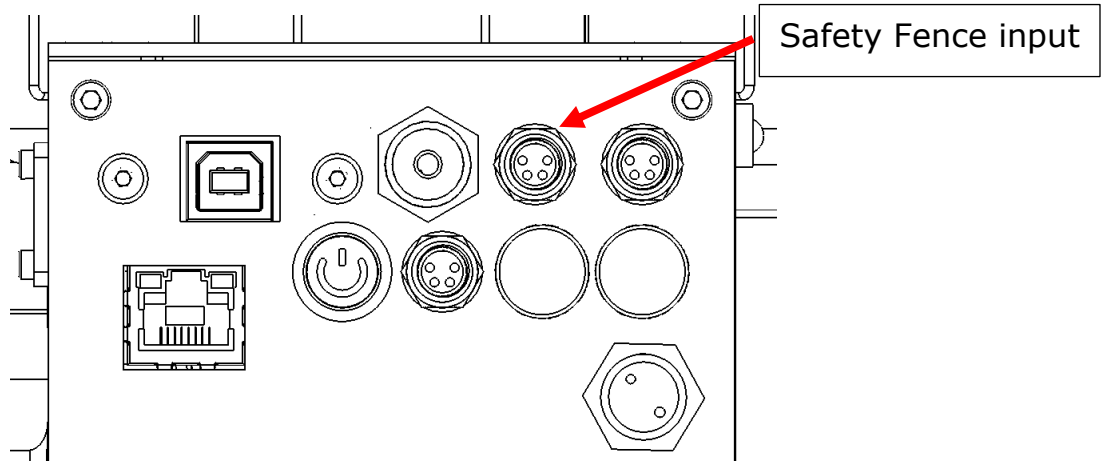


1	2	3	4
E_INPUT_1	24V	E_INPUT_2	24V

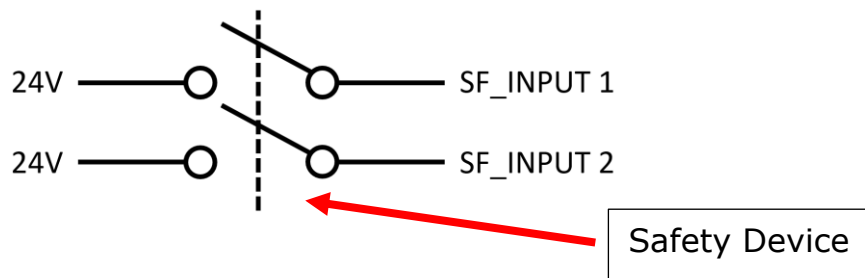
9.4 Safety Fence circuit (OPTION)

[ATTENTION]
Safety Fence emergency stop works only in Teach Mode!

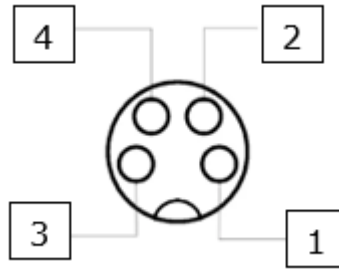
Robot is delivered with emergency stop button, but this button can be replaced by external safety system.



Emergency stop circuit is two channel, to connect external safety device follow listed below diagram.



9.5 Safety Fence stop plug (OPTION)



1	2	3	4
SF_INPUT_1	24V	SF_INPUT_2	24V

9.6 Switching ON

<p>Connect and screw the power supply connector and ESTOP connector to the robot.</p>	
<p>Turn on the power supply and press the on/off switch. The green light diode (LED) should light up. On the side of the robot arm leds should light UP. Green – 5V indicator Red – error indicator</p> <p>If there is no error on the robot red diode should turn off after few seconds.</p>	

9.7 Connecting and moving the robot

	<p>Please refer to Operation manual of the astorino robot.</p>
--	--

10 Risk assessment

For each procedure of system setting, installation, teaching, operation, maintenance, disposal, etc., always make sure the instructions and specifications match the requirements of the purpose of robot use. Also, perform the adequate risk assessment without fail to reduce any avoidable risk.

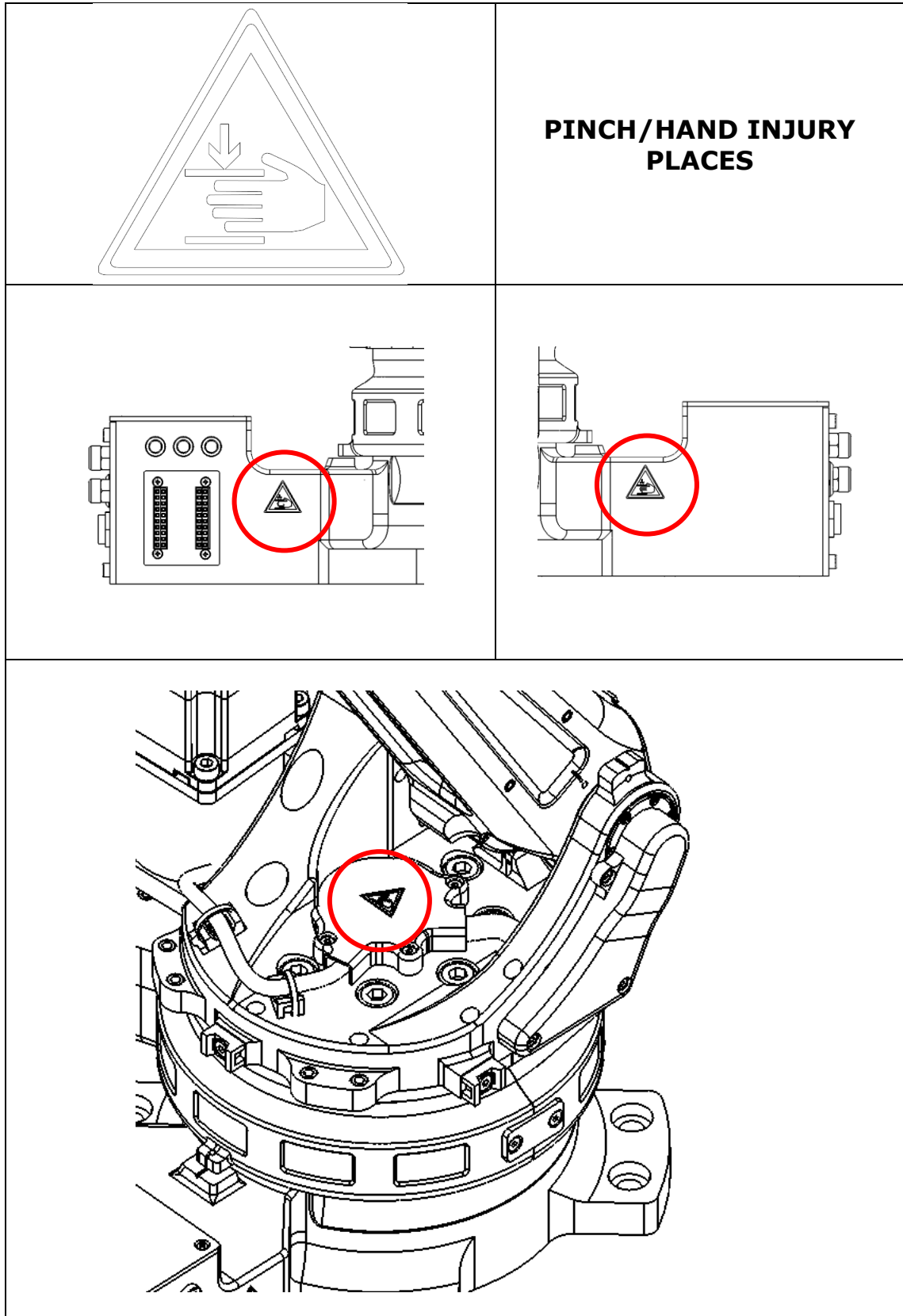
10.1 Safety features

To safeguard the user, robot astorino is equipped with many safety features, including the following:

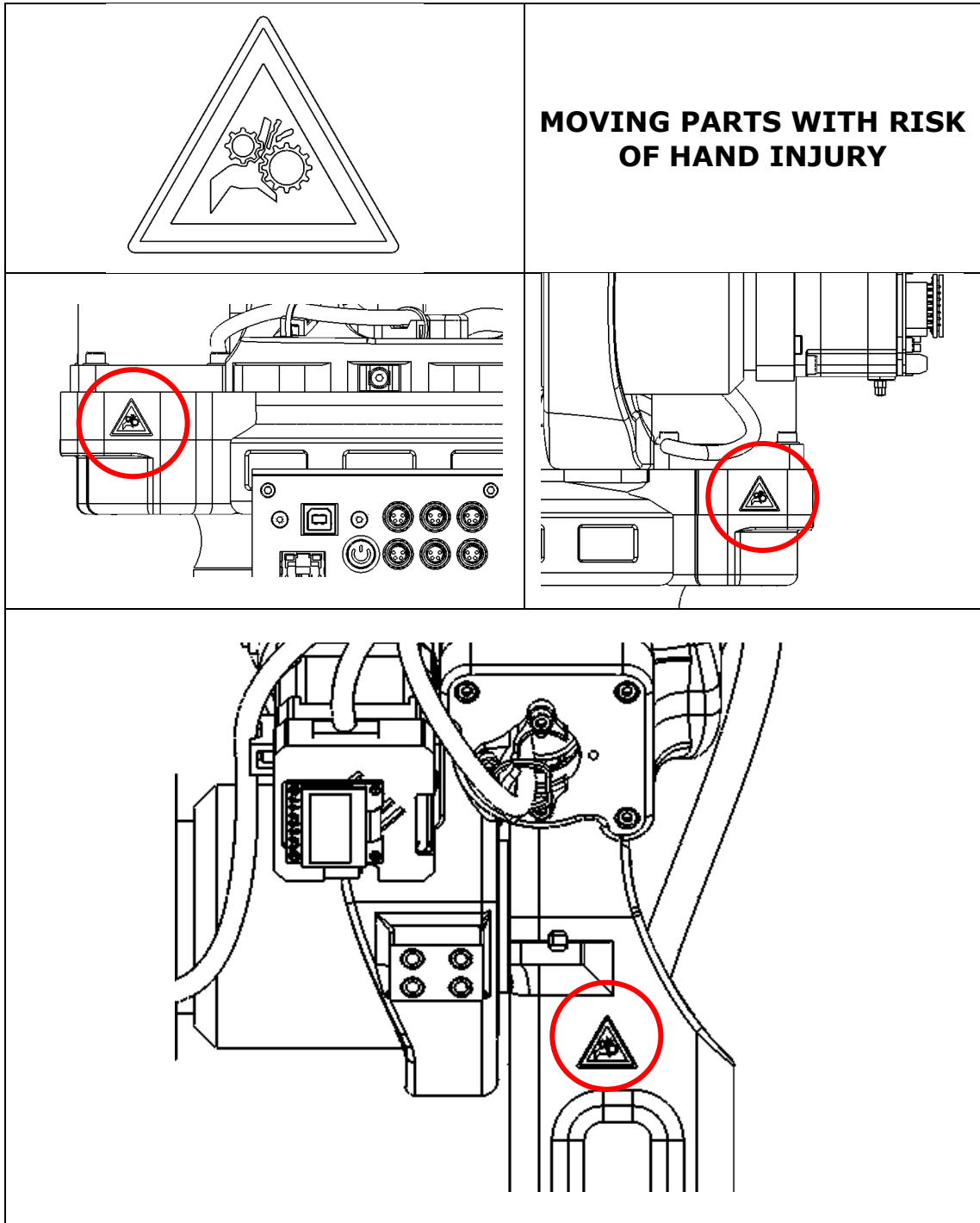
- All E-stops and Safety Fence inputs are hard-wired.
- All robot controllers are equipped with a redundant dual channel safety circuit. Both channels of the safety circuit must be closed to allow for robot operation in the teach and automatic playback modes.
- Velocities are limited to a maximum of 250 mm/s (10.0 in/s).
- JT1-JT3 are equipped with overtravel hardstops. Mechanical hardstops are capable of stopping the robot moving at full speed and with maximum payload.

10.2 Residual risks

10.2.1 Warning labels



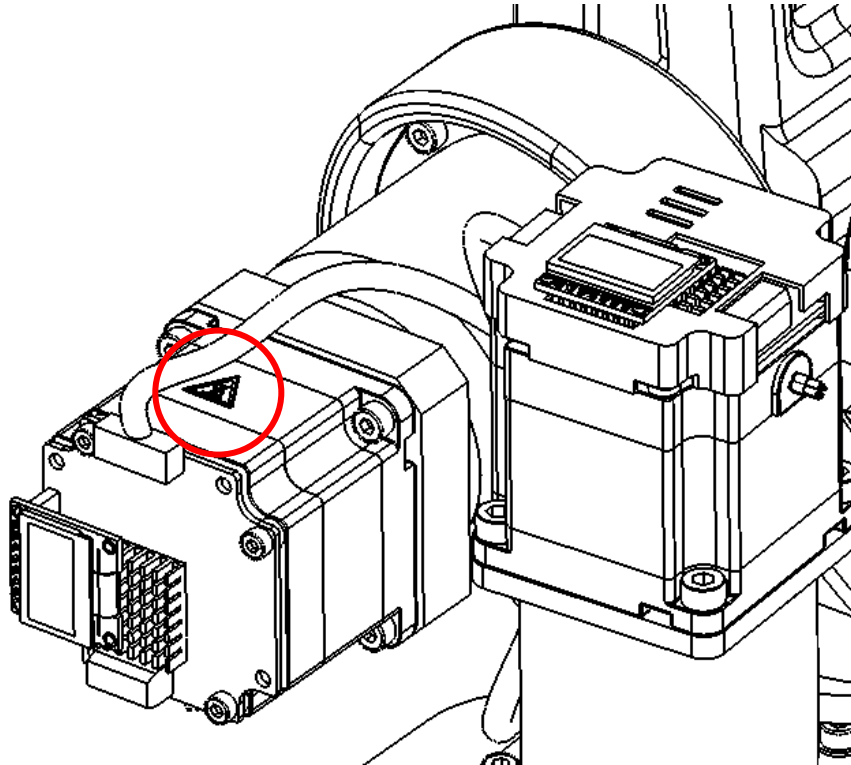
ASTORINO Safety Manual



ASTORINO Safety Manual

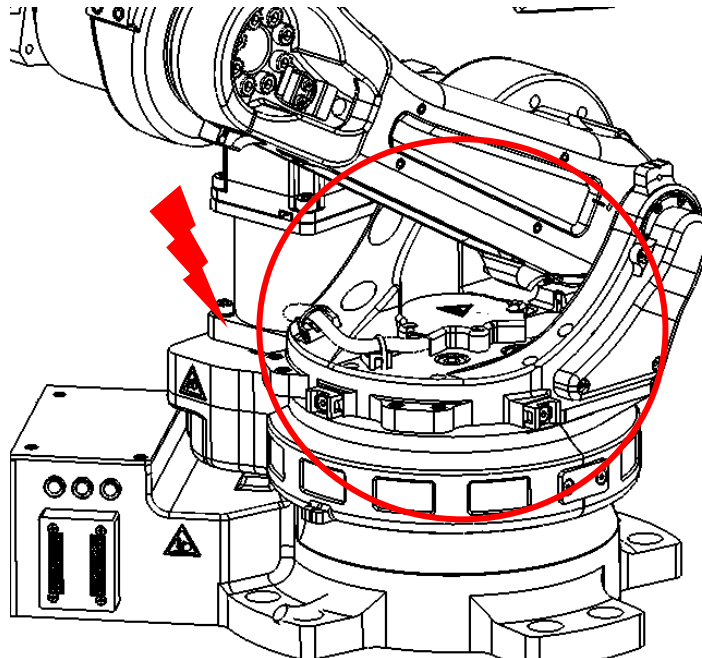
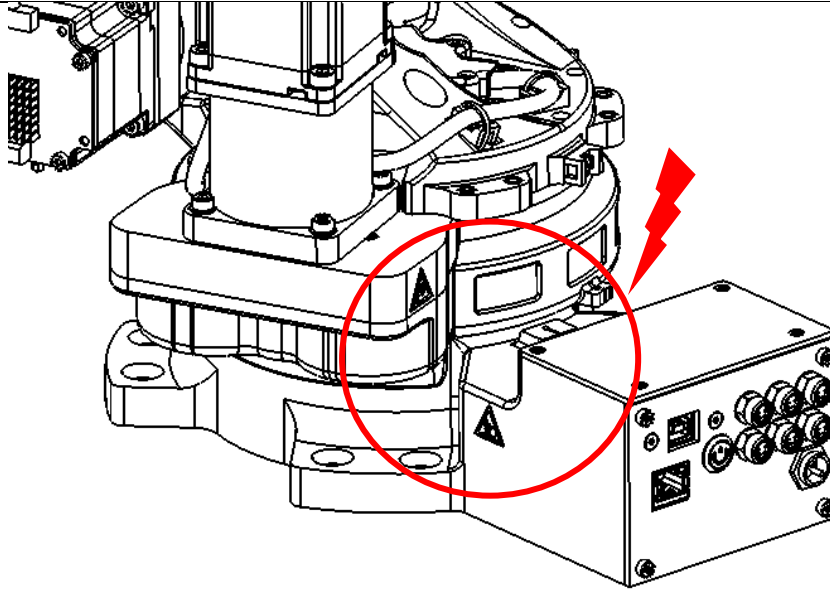


HOT SURFACE



10.2.2 Pinch or hand injury places

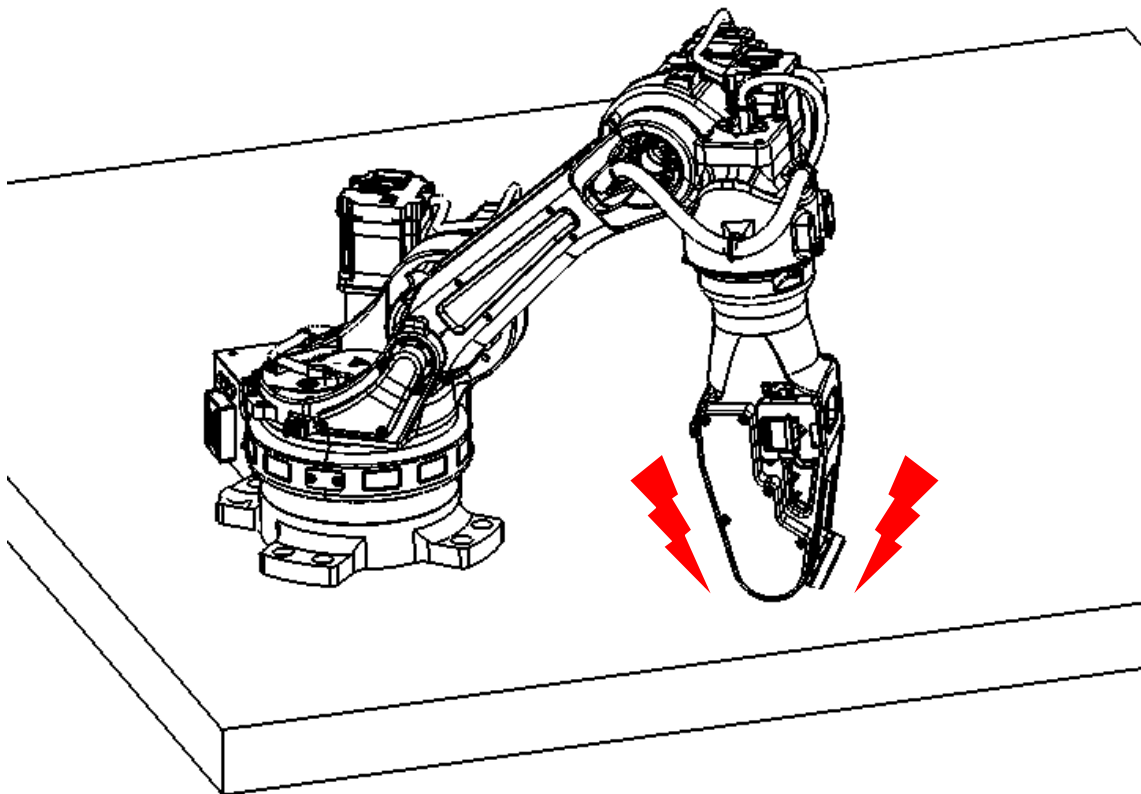
PINCH OR CRUSH INJURY – DO NOT PLACE ANY OBJECT ON THIS PLACE



10.2.3 Residual risks in case of power loss



Astorino robot does incorporate breaks on joint 2 and 3. During power failure robot might collapse on other axes. User safety and vigilance is necessary.



During power loss when there is heavy gripper installed JT5 might make a sudden movement!

11 Installation

11.1 Installation environment

- The installation site of the robot must fulfil all the following environmental conditions:
- When robot arm is installed on the floor, the levelness must be within $\pm 5^\circ$.
- Be sure that the floor/stand has sufficient rigidity.
- Secure a flat place to prevent the base section from receiving undue force.
- Keep the ambient temperature during operation within the range of 0°C to 45°C
- Keep the relative humidity during operation within the range of 35% to 85%RH without dew condensation.
- The altitude of the installation place should be within the range of 0 m to 1000 m above mean sea level.
- The robot installing place should be free from dust, dirt, smoke, water, and other foreign matters.
- The robot installing place should be free from flammable or corrosive liquid or gas.
- The robot installing place should be free from excessively strong vibration. (0.5 G or less)
- The robot installing place should be free from electric noise interference.
- Place where power satisfying the specification is supplied.
- The robot installing place should be sufficiently larger than the motion range of robot arm.

Safety fence must enclose area larger than the maximum motion range of fully equipped robot arm (with tools) so it does not interfere with the surrounding objects.

11.2 Safety measures concerning robot installation

When astorino robot arm is not being installed in the laboratory then place the robot arm within the safeguarding devices (guard, fence, equipment, etc. provided for preventing hazards) so that the robot arm is put off limits. Also, install an emergency stop device in an easily accessible area within reach of the operator.

Safety guarding zone (area surrounded by the safety fence) should be built so as to prevent the robot arm from jumping over or extending beyond the fence in the event of breakdown and/or error.

Minimize the number of doors on the safeguarding devices (preferably only one). The door should be equipped with a safety plug which must be removed manually in order to open/close the door. Then, set motor power to be turned OFF if plug is removed during automatic operation. Confirm that safety devices such as EMERGENCY STOP switch and safety plug function normally before entering the safeguarding devices.

Display the robot state clearly, such as: automatic mode, teaching, and emergency stop, etc. on the safeguarding devices so the current condition of the robot can be seen by everybody.

Limit the robot operating personnel to only those who have taken and completed the training course(s) authorized by Astor/Kawasaki.

12 Manufacturer information

For further questions, contact Kawasaki Robotics support.

Contact:

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Kawasaki Robot
Safety Manual

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