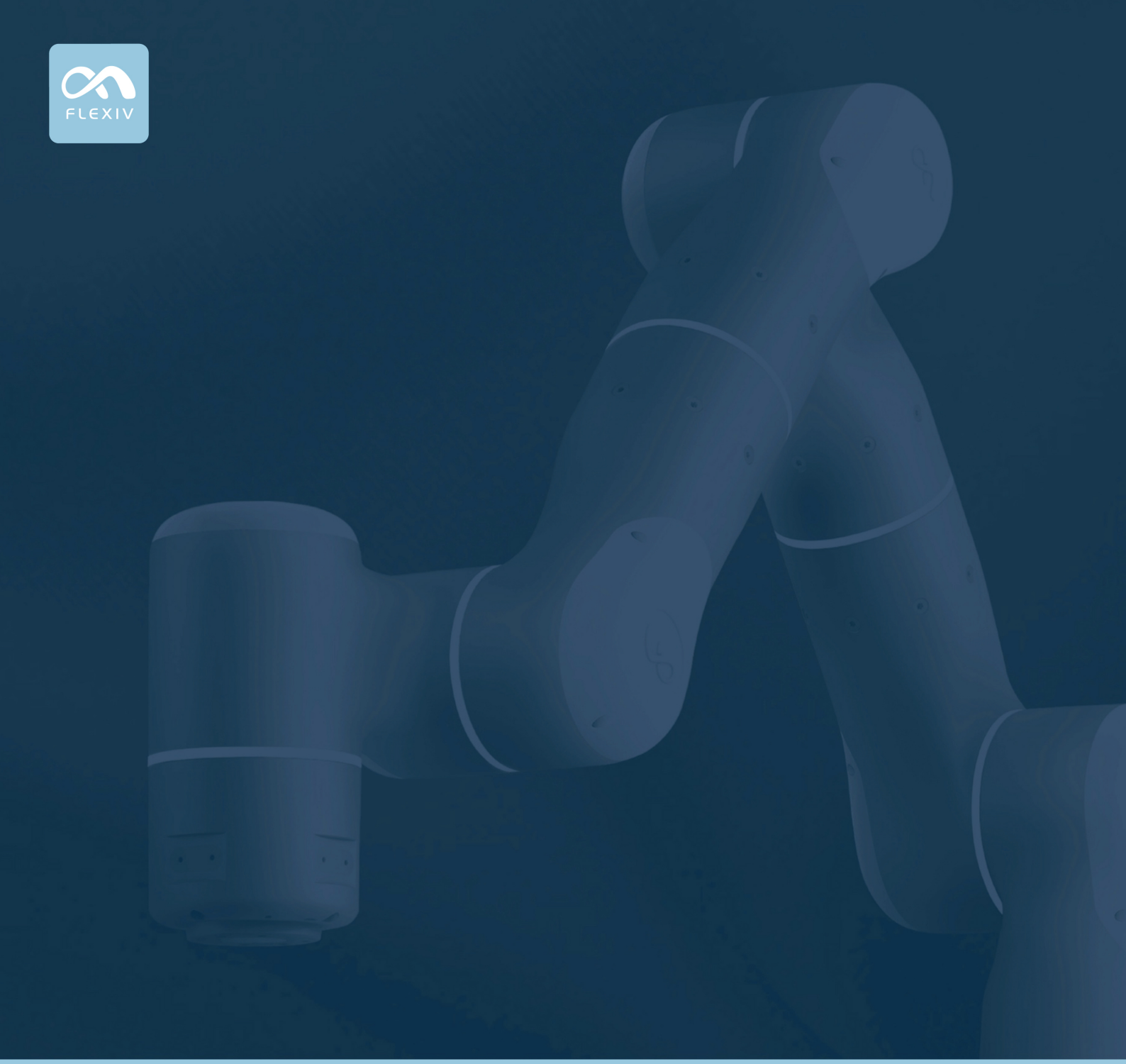

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RIZON

ADAPTIVE ROBOT

Flexible | Universal

Flexiv Rizon
User Manual

Rizon 4

Version 1.1

Instructions (EN)

Please read this manual carefully before the product installation and use.

CONTENTS

Flexible Universal

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PREFACE

CHAPTER I

This manual is an integral part of your new Flexiv Rizon. The robot can be programmed to move a tool, and communicate with other machines using electrical signals. It is an articulated manipulator composed of aluminum links connected together by joints.

With seven torque-controlled joints, Rizon offers enhanced dexterity in task execution and provides precise end-point force/torque control capability. By using our workflow-based programming interface, it is easy to translate complex tasks to reusable motion primitives. The wide range of I/O interfaces and industrial Fieldbus communication facilitates integration efforts.

1.1 Contents of The Box

What's in the package:

- *Robotic Manipulator*
- *Control Box*
- *Motion Bar*
- *Cable for Robot-Control Box connection*

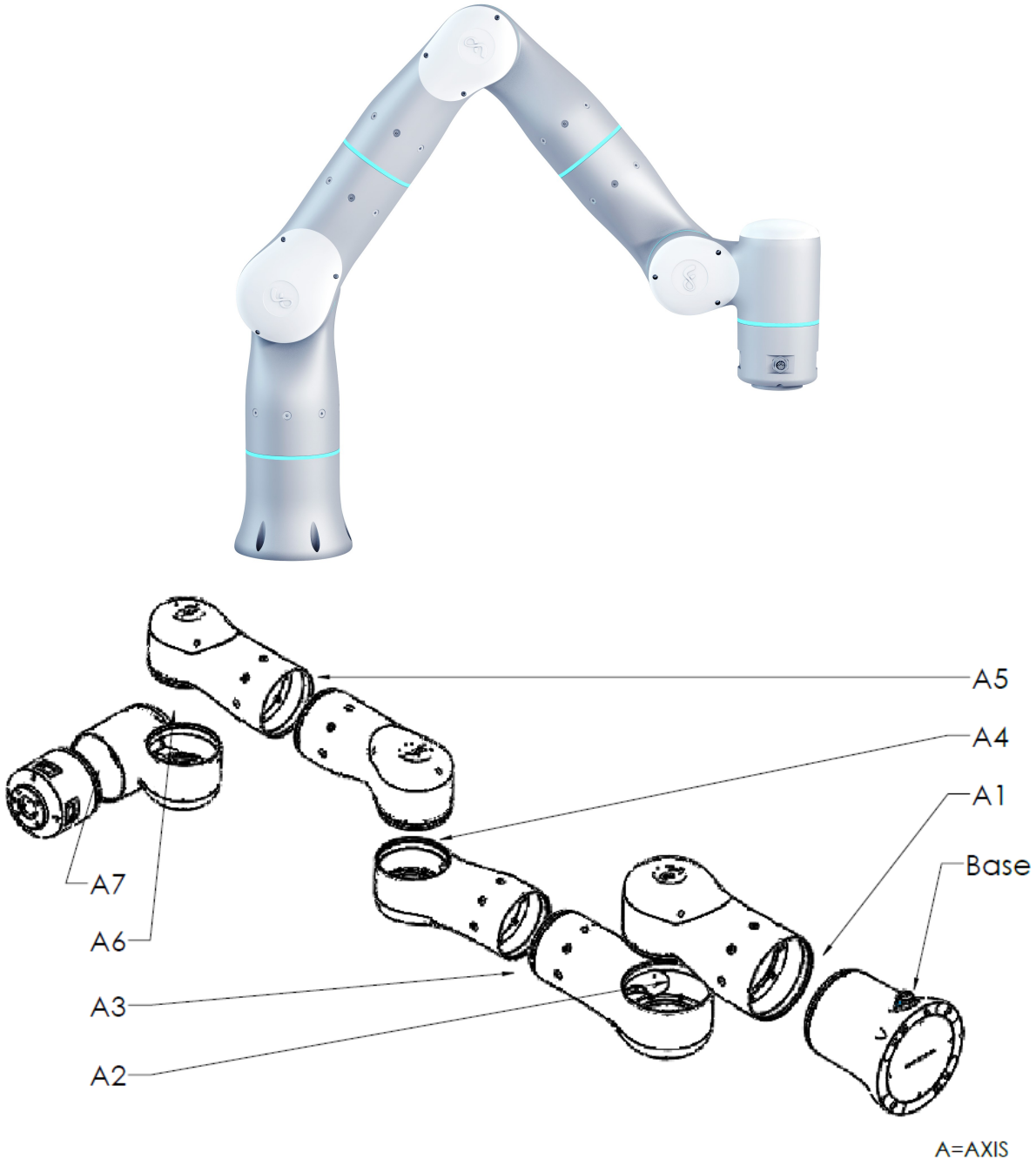

Figure 1.1: Exploded view of Rizon 4

1.2 Important Safety Notice

The robot is a partly completed machinery, and as such, a risk assessment is required for each installation of the robot.
Note: you must carefully follow all safety instructions in Chapter 2.

1.3 How to Read This Manual

This manual contains instructions for installing and programming the robot. The manual includes:

- *Safety-related Settings.*
- *Hardware Installation manual.*
- *Software Manual.*

This manual is intended for trained robot integrators.

1.4 Where to Find More Information

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SAFETY

CHAPTER 2

2.1 Introduction

This chapter provides information on the safety requirements that must be adhered to while operating Flexiv's Rizon robot system. Integrators and users must carefully go through this manual and fully understand relevant safety functionalities and potential hazards before operating the robot for the first time.

The following sections start with general descriptions of the warning symbols used throughout this manual. Subsequently, important information regarding the setup and programming of the robotic system is explained in detail. The next chapter then describes and defines safety functions that are integrated with the system.

It is essential that all instructions and guidance provided throughout the manual are observed and special attention is paid to texts with warning symbols.

Flexiv Robotics disclaims any and all liability if the robotic system (manipulator, control box, motion bar, and/or teach pendant) is damaged due to misuse, change, or modification in any way. Flexiv Robotics cannot be held responsible for any damages caused to the robot or any other equipment due to programming errors or malfunctioning of the robot.

2.2 Validity and Responsibility

The information in this manual does not cover the design, installation, setup, and operation of a complete robot application. It also does not cover peripheral equipment that can affect the safety levels of the complete system. Users and integrators are responsible for ensuring that the complete system is designed and installed in accordance with the safety requirements set forth in the standards and regulations of the country where the robot is installed. In addition, integrators are responsible for ensuring the applicable safety laws and regulations in the country concerned are fully adhered to and that any potential hazards in the complete system are eliminated or mitigated to the required levels. These responsibilities include but are not limited to:

- *Conducting a comprehensive risk assessment for the complete robot system*
- *Interfacing other machines and/or additional safety devices if required by the risk assessment*
- *Setting up the appropriate safety settings in the software*
- *Ensuring that the user will not modify any safety measures without proper authorization*
- *Validating that the system is designed and installed correctly*
- *Specifying detailed instructions for use*
- *Marking relevant signs and contact information of the integrator*
- *Collecting all relevant documentation, including the risk assessment and this manual, in a technical file.*

2.3 Limitation of Liability

The safety information provided in this manual does not constitute a warranty by Flexiv that the robotic system will not result in damage or injury, even if the system complies with all safety instructions.

2.4 Warning Symbols in this Manual

The following table defines the warning symbols used throughout this manual and describes the associated risks. These warnings, which are relevant to safety, must be observed.

Symbol	Description
 DANGER	This indicates an imminently hazardous electrical situation which, if not avoided, could result in death or serious injury.
 DANGER	This indicates an imminently hazardous situation which, if not avoided, could result in death or serious injury.
 WARNING	This indicates a potentially hazardous electrical situation which, if not avoided, could result in death or serious injury.
 WARNING	This indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
 WARNING	This indicates a situation which, if not avoided, could result in damage to the equipment.
 CAUTION	This indicates a situation which, if not avoided, could result in damage to the equipment.

2.5 General Warnings and Cautions

This manual includes general safety precautions to protect the users and prevent damage to the machine. These precautions will be repeated in various parts of this manual.

Symbol	Description
 DANGER	▪ Ensure that the robot and all electrical equipment are installed according to the robot's technical specifications. ▪ Perform a thorough check of all components upon installation to make sure they are set up correctly. ▪ Always power the robot on with all plastic covers installed.
 DANGER	▪ Ensure that the manipulator and end-of-arm tooling are properly mounted and the manipulator has sufficient workspace. ▪ Make sure safety configuration parameters are set up correctly only by authorized personnel to protect all operators, as defined in the risk assessment. ▪ Do not wear loose clothing or items that are dangling when working with the robot. Make sure long hair is tied back. ▪ Inspect the robot before use. If it is damaged, do not operate the robot. ▪ If the software prompts an error, immediately press down the emergency stop. Note down the error codes and contact your supplier. ▪ Do not connect any safety equipment to general-purpose I/O. Use only dedicated safety I/O. ▪ Ensure that the correct installation parameters are used. This includes, but not limited to: base mounting angle, payload, Tool Center Point (TCP) offset, and safety configurations. ▪ End-of-arm tooling shall not have sharp edges and pinch points. ▪ Take note of robot movement when using the teach pendant. Always use procedural and oral warnings to inform other people that are within the collaborative working space before executing a motion command on the teach pendant and motion bar. ▪ Never modify the robot. A modification might create hazards that are unforeseen by the integrator. ▪ Combining different machines may increase hazards or introduce new hazards. Thus, always make an overall risk assessment for the complete installation.

Symbol	Description
	▪ Be aware that the robot TCP speed can be up to 2000mm/s in auto mode. Mind the danger of possible crushing with the robot when entering the collaborative space, even with safety light curtains. Prior to selecting automatic mode, any suspended safeguards or light curtains shall be reset and resume their full functionality. ▪ Overloading the robot that may cause damage to mechanical components and lead to injury. ▪ Stopping distance needs to be considered during operation and emergency stops. Related risk assessments need to be carried out for robot integration. ▪ Be aware of electrical shock if exposed to live parts and connectors during maintenance. ▪ Be aware of the lighting colors and signals associated with the manipulator and teach pendant as they indicate the current modes of the robot. Misunderstanding of indicators may result in injury.
 WARNING	▪ The robot and its control box generate heat during operation. Do not touch the robot while in operation or immediately after operation. Contact can cause discomfort. ▪ The robot can generate acoustic noise during operation. Although comparatively quiet, the noise may impair hearing after prolonged exposure. For severe working conditions such as sanding and grinding, ear plugs are required.

Symbol	Description
 CAUTION	▪ Do not expose the system to strong electric and magnetic fields which can damage the system. ▪ When the robot is integrated with other machines, it is highly recommended that a combined test of all the functionalities is performed before running the system. ▪ When the robot power is turned off, wait for at least five seconds before turning it back on to avoid the unwanted electric charge remaining in the robot system. ▪ Any person who programs, teaches, operates, maintains or repairs robots or robot systems shall be trained and able to demonstrate competence to safely perform the assigned task. Personnel shall be trained to respond to emergency or abnormal situations. ▪ The robot system shall be installed to avoid interference with buildings, structures, utilities, other machines and equipment that may create trapping or pinch points. ▪ If a supplementary audible means of robot operation is installed by the user, it shall exceed the ambient noise at the end-use application.

2.6 Labels

The product and warning labels are listed as follows.

The label meanings for the motion bar buttons are listed in Figure 2.4.

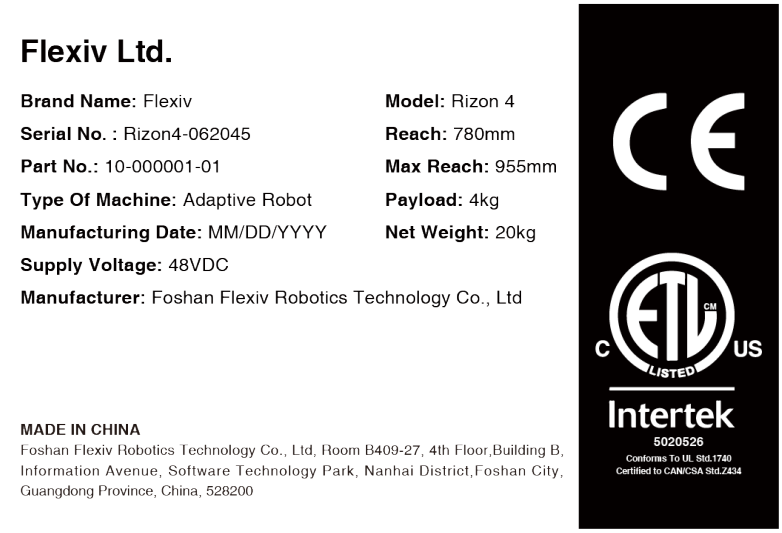

Figure 2.1: Rizon 4 robot product label.

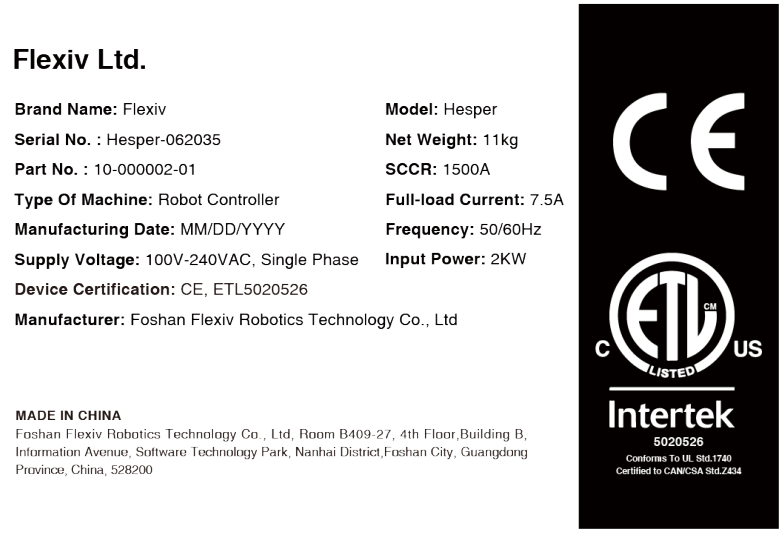

Figure 2.2: Hesper control box product label.

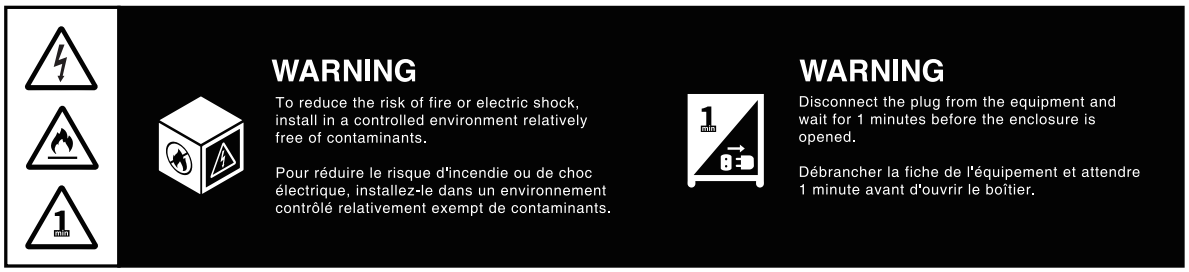

Figure 2.3: Warning label.

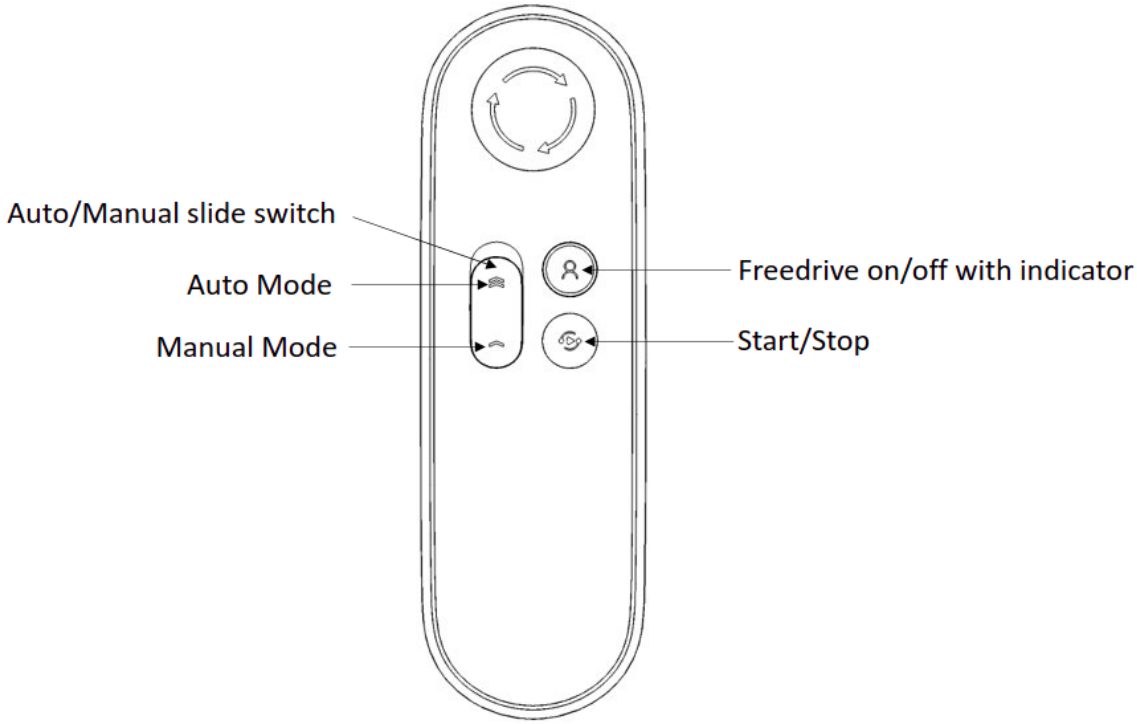

Figure 2.4: Motion Bar Label Meanings.

2.7 Intended Use

Flexiv's Rizon robotic manipulator is intended for manipulating objects, transferring components, and assembling parts. For information about environmental conditions under which the robot should operate, see appendix C for certifications and appendix A for associated technical specifications.

The robotic manipulator is designed with safety-related features intended to enable collaborative operation, where the robot system operates without fences and/or together with the human.

Collaborative operation is only intended for non-hazardous applications, where the application setup encompassing the end-of-arm tooling, workpiece and other related machines does not pose significant hazards according to the conducted risk assessment.

Any deviation from the intended use is not permitted and is deemed dangerous. This includes but is not limited to:

- *Potentially flammable and explosive environments*
- *Medical environments where human life is involved*
- *Use in vibration-prone environments*
- *Use outside of technical specifications*
- *Use without performing a risk assessment*

2.8 Risk Assessment

The robot itself is a partly completed machinery, as the safety of the robot installation depends on how the robot is integrated.

It is recommended that the integrator uses ISO 12100 and ISO 10218-2 to conduct the risk assessment.

The risk assessment that the integrator conducts shall consider all work tasks throughout the lifetime of the robot application, including, but not limited to:

- *Programming the robot during robot installation*
- *Troubleshooting and maintenance*
- *Normal operation of the robot*

A risk assessment must be conducted before the manipulator is powered on for the first time. A part of the risk assessment conducted by the integrator is to identify the proper safety configuration settings, as well as the need for additional emergency stop buttons and/or other protective measures required for the specific robot application.

Potential hazards list:

- *Mechanical Hazards: Crushing, impact, or bruising caused by contact with the robot or its sharp tools.*
- *Electrical Hazards: Electric burn or shock caused by contact with live parts.*
- *Thermal Hazards: Thermal radiation or skin burn caused by prolonged contact with hot surfaces of the robot.*
- *Noise Hazards: Reduced perception of acoustic signals caused by prolonged exposure to the noise of the robot with heavy payload and high speed.*
- *Vibration Hazards: None.*
- *Radiation Hazards: None.*
- *Material/Substance Hazards: None.*
- *Ergonomics Hazards: Fatigue, stress or physical discomfort caused by prolonged operation of multiple accessories of the robot.*
- *Environmental Hazards: None.*
- *Combination of Hazards: Combination of the above hazards caused by mis-coordination between multiple operators or system failures.*

2.9 Pre-Use Functional Assessment

Prior to any operation, the user is responsible for verifying that all safety inputs and outputs are appropriately and correctly connected. Tests should be conducted to further ensure that

the safety functions associated with these safety inputs and outputs are running as expected. Special attention must be given to tests that involve connecting the robot's safety function to other machines. Some of the possible tests include:

- *Test that the robot and the system emergency stop inputs remove power from the robot and engage the brakes.*
- *Test that the safeguard input stop halts the motion of the robot. Subsequently, if the safeguard reset is configured, verify that it allows the robot to resume its motion when a reset is triggered.*
- *Test that the reduced mode input can switch the robot to reduced mode.*
- *Test that the operational mode switch can switch the operational mode. The operational mode of the robot can be read from the teach pendant.*
- *Test that the 3-position enabling switch must be pressed to the center position to enable the motion of the robot in manual mode.*
- *Test that the system emergency stop outputs are able to bring the whole system including the connected machines to a safe state.*
- *Test the behavior of the systems connected to the safety outputs.*

2.10 Emergency Stop

The Rizon robot manipulator comes with an integrated robot emergency stop button on the motion bar. Activating the emergency stop removes power from the joints and applies the brakes right after.

Note: In accordance with IEC 60204-1 and ISO 13850, emergency stops are not safeguards and are not intended to prevent injury. The risk assessment of the robot application shall conclude if additional emergency stop buttons are needed. Emergency stop buttons must comply with IEC 60947 5-5.

2.11 Movement Without Drive Power

In the event of an emergency where the robot needs to be moved without drive power, for example, to release and save the human operators accidentally trapped in or by the robot, the following can be done:

- *Forced back-driving: In the absence of drive power, the robot can be back-driven by applying torques beyond 150 Nm at the first and second axes, beyond 90 Nm at the third and fourth axes, and beyond 52 Nm at the fifth, sixth, and seventh axes. The brake system in the joints is designed with a friction clutch that enables movement with high back-driving torques.*
- *Manual brake release: For the axes A2, A4, A6, and A7, the brakes can be manually disengaged by removing the plastic covers on the robot and pulling the brake plunger*

(see Figure 2.5). Due to the gravity of the manipulator, released joints are expected to drop and accelerate without external support. Thus, this should only be done with help from additional personnel.

Beware that the manipulator may drop due to gravity forces and hit the operator during manual brake release. Brake release should be performed with at least two people.

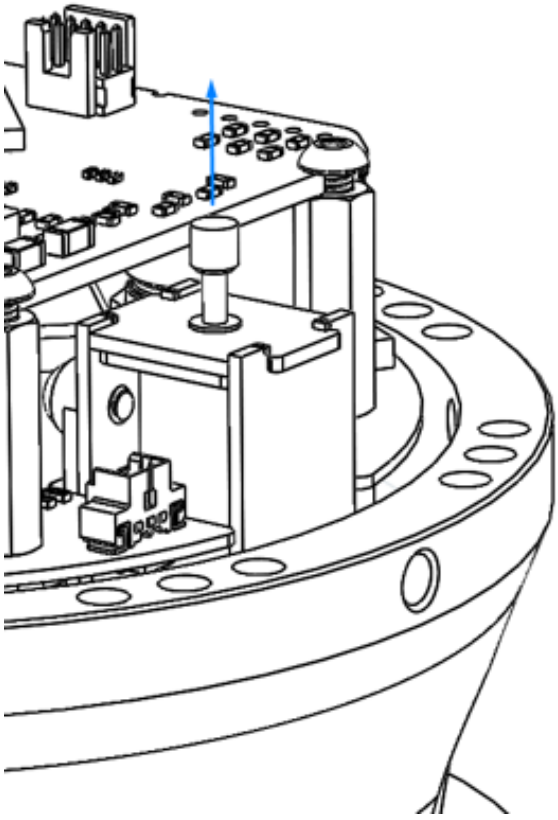

Figure 2.5: Manual brake release by pulling the brake plunger.

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SAFETY-RELATED FUNCTIONS AND INTERFACES

CHAPTER 3

3.1 Introduction

The Rizon robotic manipulator is designed with built-in safety-related functions as well as safety-related electrical interfaces to connect to other machines and additional safety devices. These safety-related functions are compliant with ISO 13849-1 with performance level Category 3, PLd.

Please refer to chapter 9 for the configuration of these safety functions, inputs and outputs in the user interface. For instructions on how to connect safety inputs, see chapter 7.

1. Configuration of the safety settings must strictly follow the conclusion from the risk assessment for each application.
2. When a critical fault or violation is detected by the safety system, a Stop Category 0 is issued. Note that, due to the delay in power removal, the stopping time of the robot needs to be taken into account during risk assessment.

3.2 Fault Handling and Stop Categories

During the operation of the robot, safety-related checks are executed periodically by the control system. These checks include the evaluation of safety functions, system health, and finally the status of the safety inputs. Depending on these checks, the robot executes three types of stops. These stops are categorized according to IEC 60204-1 and are summarized in Table 3.1.

Stop Category	Description
0	Robot stops with immediate removal of power.
1	Robot decelerates in a controlled manner. Power is removed when the robot stops.
2	Robot decelerates in a controlled manner and holds its position. Drive power is maintained.

Table 3.1: Stop categories for the Rizon robotic manipulator.

3.3 Safety Functions

The manipulator is designed with three categories of safety functions, namely motion related monitoring, safety inputs, and safety outputs. These functions ensure that the motion of the robot together with its attached tool is operating within safety limits and can be used to reduce risks identified from the risk assessment.

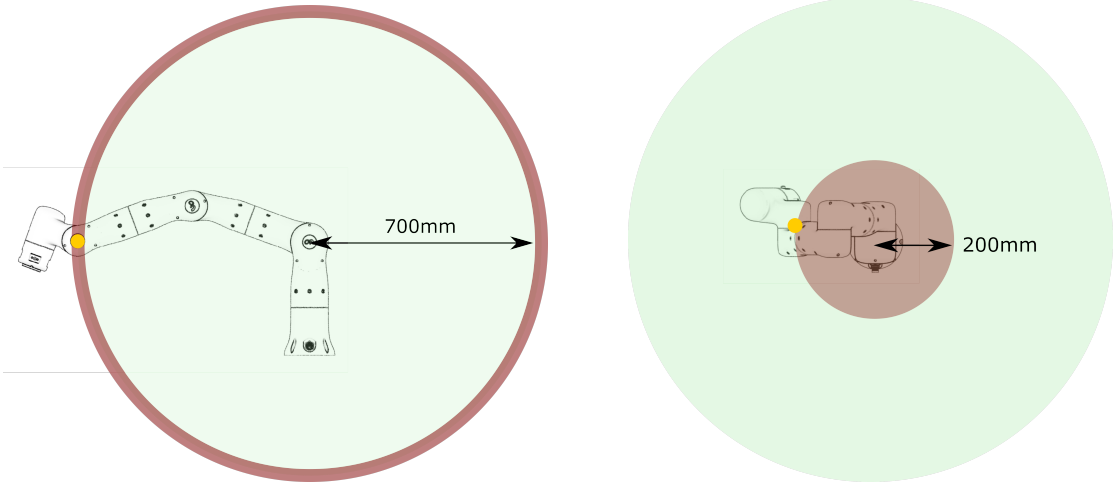
3.3.1 Motion Related Monitoring

Motion related monitoring functions take sensor feedback from the robot to ensure that the robot is operating safely. Configurations of these safety functions can only be edited with a safety access code from the teach pendant. Table 3.2 describes all the available monitoring functions.

Code	Safety Function	Description
SF3	Joint Position Limit	Violation of the allowed joint position limit triggers a Category 0 stop.
SF4	Joint Speed Limit	Violation of the allowed joint speed limit triggers a Category 0 stop.
SF5	Joint Torque Limit	Violation of the allowed joint torque limit triggers a Category 0 stop.
SF6	TCP Position Limit	Monitors the TCP position and checks it against the safety plane constraints. Depending on the configuration of the activated planes, violation of the constraint triggers a Category 0 stop or transition into reduced state.
SF7	TCP Speed Limit	Violation of the allowed TCP speed limit triggers a Category 0 stop.
SF8	TCP Force Limit	Violation of the allowed TCP force or torque limit triggers a Category 0 stop. *See the Warning below for exceptions.*
SF9	Momentum Limit	Violation of the allowed manipulator momentum limit triggers a Category 0 stop. *This function monitors the total momentum of the robot, which is calculated using mass matrix and joint angular speeds.*
SF10	Power Limit	Violation of the allowed manipulator power limit triggers a Category 0 stop. *This function monitors the total work output by the robot, which is the sum of joint torque times the joint angular speed of all joints.*

Table 3.2: Motion related monitoring for the Rizon robotic manipulator.

The TCP Force Limit safety function is disabled in the poses shown in Figure 3.1. In these poses, the robot is near a singularity and is capable of generating large forces or torques in specific directions. Take precautions to prevent crushing hazards, for example by removing objects in these regions, relocating the robot, or using TCP or joint position limits. In both automatic and manual modes, if singularity cannot be prevented in certain trajectories, the software has integrated singularity protections to smoothen the trajectory near singularity. Particularly in the manual Freedrive mode, the robot provides extra resisting forces as the operator moves the robot towards singularity.



(a) Robot wrist center is at least 700 mm from A2's center.

(b) Robot wrist center is within 200 mm of A1's axis.

Figure 3.1: Rizon 4: (a) When the wrist center (intersection of axes A5 and A6 indicated by the yellow dot) is far away from the A2 joint, large forces can be generated in the radial direction at low speeds. **TCP force limits are disabled** due to the singular configuration of the robot. (b) When the wrist center is close to the A2 axis, the robot can generate large forces in the tangential directions. **TCP force limits are disabled**. For both cases, it is recommended to use a combination of safety planes or joint limits to prevent the robot from moving into these regions of its workspace.

3.3.2 Safety Inputs

Physically, safety inputs consist of a pair of redundant inputs that will be processed by the safety software on the control box. The complete list of safety inputs is divided into two categories, namely, safety inputs that can be connected to external safety devices, and safety inputs on the motion bar. Information on these inputs can be found respectively in Tables 3.3 and 3.4. Information on the Tool Center Point (TCP) can be found in the Software User Interface Manual.

Code	Safety Function	Description
SF0	Emergency Stop (Category 0 stop)	Pressing robot E-stop on the motion bar or the external system E-stop results in a Category 0 stop. *This function is activated when **SF1** fails, which means the robot fails to stop within 700 ms after the E-stop is pressed. Upon activation, drive power is immediately removed.*
SF1	Emergency Stop (Category 1 stop)	Pressing robot E-stop on the motion bar or the external system E-stop results in a Category 1 stop. *When E-stop is pressed, this function is activated before **SF0**. Upon activation, the robot needs to decelerate and come to a complete stop within 700 ms, after which the drive power is removed.*

Table 3.3: Safety inputs on the motion bar of the robot.

Code	Safety Function	Description
SF2	Safeguard Stop (Protective Stop)	An external protective device connected to the safety inputs of the control box will trigger a Category 2 stop when activated.
SF11	Safeguard Reset Input	Resets the safeguard stop safety function **SF2** when a FALLING edge on the safeguard reset input is detected by the safety control system.
SF12	Reduced State Input	Reduced state is activated when the reduced state input is LOW. *The limit settings of several safety functions are affected in reduced state.*

Table 3.4: Safety inputs on the control box that are available to users.

3.3.3 Safety Outputs

Safety outputs are included to provide interfaces to extend the robotic manipulator's safety functions to other machines. These outputs are dual-channel outputs designed to provide redundancy in the event of single-channel failure. Table 3.5 lists all available safety outputs.

Code	Safety function	Description
SF13	Emergency Stop Output	This digital output is LOW when an emergency stop happens, and is HIGH otherwise.
SF14	Robot Moving Output	This digital output is LOW when the robot is moving, and HIGH when not moving.
SF15	Robot Not Stopping Output	This digital output is LOW when the robot is NOT in the process of stopping nor in a stopped condition.
SF16	Robot Reduced State Output	This digital output is LOW when the robot is in reduced state.
SF17	Robot Not Reduced State Output	This digital output is LOW when the robot is NOT in reduced state.

Table 3.5: Safety outputs on the control box that are available to users.

3.4 Workspace, safety zone and danger zone

Working zones are to be restricted to the necessary minimum size in order to prevent danger to persons or the risk of material damage.

The danger zone consists of the workspace and the reach of the human operators. Operators may interact with the robot in the danger zone in Reduced State. In the event of a stop, the manipulator is braked and comes to a stop within the danger zone. The safety zone is the area outside of the danger zone. Figure 3.2 shows the workspace, danger zone and safety zone. Figure 3.3 shows the position relationship between human operators and the robotic manipulator.

The danger zone must be protected by means of physical safeguards, e.g. by light barriers, light curtains or safety fences. The safeguards shall be rated at least Cat3 Pld as defined in ISO 13849-1, and the structures of the safeguards shall be compliant to ISO 13849-2. The electrical connections of such safeguards are defined in 7.3.6. If there are no physical safeguards present, the requirements for collaborative operation in accordance with EN ISO 10218 must be met. There must be no shearing or crushing hazards at the loading and transfer areas.

Below lists a few situations showing the typical setup and robot state:

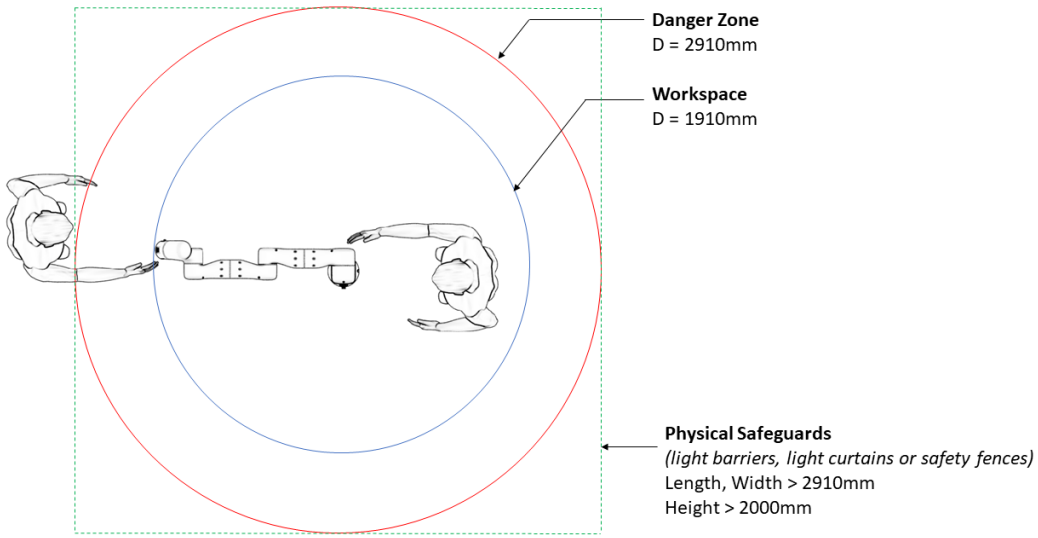


Figure 3.2: Rizon 4 workspace, danger zone and safety zone.

Situation A: When human operators work outside of the danger zone, physical safeguards must be present as shown in Figure 3.3. The robot manipulator can operate in normal state.

Situation B: When human operators enter the danger zone, safeguards will detect the presence of human operators, and make the robot operate in reduced state.

Even in Reduced State, the robot manipulator can still pose a danger to the human operator if the operator is in the danger zone and interacts with the robot manipulator. This risk can be reduced by avoiding direct contact with the robot manipulator with the fragile parts of the human body, such as the head, the face, and the eyes.

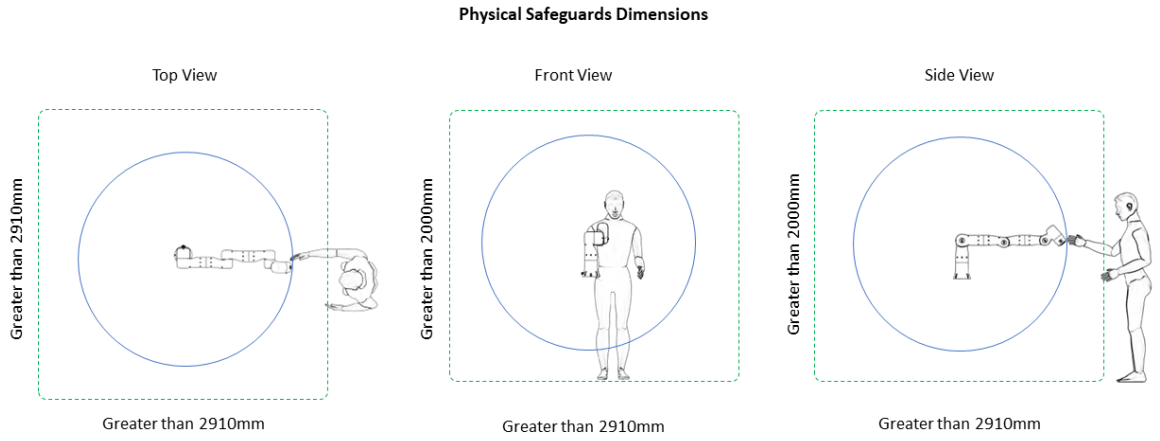


Figure 3.3: Human operators and the Rizon 4 robotic manipulator.

3.5 Mechanical Position Limits (Mechanical Hard Stops)

In addition to the safety workspace defined according to safety functions and joint operational ranges (Appendix A), mechanical position limiting devices on each joint provides further protection to the user in the cases of failures and power outage. The mechanical limiting ranges are as follows.

Axis	Mechanical Limit Ranges
A1	-165 ° to +165 °
A2	-135 ° to +135 °
A3	-175 ° to +175 °
A4	-112 ° to +159 °
A5	-175 ° to +175 °
A6	-85 ° to +265 °
A7	-175 ° to +175 °

Table 3.6: Rizon 4 mechanical limit ranges for each axis with 0 ° corresponding to the fully extended pose.

3.6 Robot States

The robot operates on normal, reduced and system recovery states. Separate safety limits can be assigned for normal and reduced states from the teach pendant. For system recovery states, the limits are fixed. Transitions between these states are automatically executed by the safety control system.

3.6.1 System Recovery State

When a safety limit is violated, the safety system triggers Stop Category 0. The system must then be restarted in order to continue. During startup, if the system is outside of a safety limit, for example, outside of a joint limit, the system goes into system recovery state. In this state, programming is not permitted. The robot, however, can be manually moved back within limits using the teach pendant. The safety limits configured for this state is shown below in Table 3.7. Should any limit violation occur during system recovery state, a Stop Category 0 is issued.

Safety Function	**Limit**
Joint Speed Limit	30 °/s
TCP Speed Limit	250 mm/s
Momentum Limit	5 kgm/s
Power Limit	80 W

Table 3.7: Rizon 4 safety limits configured for recovery state.

WARNING

During system recovery state, safety functions such as joint and TCP position limits are disabled. Exercise caution when moving the robot.

3.6.2 Transition between Normal and Reduced States

Transition between normal and reduced states can be triggered by two methods:

- *Reduced state input: When the reduced state input goes low, the safety control system switches to reduced state.*
- *Plane constraints: The TCP position limits are specified using plane constraints. These constraints can be configured to automatically switch to either state when the TCP passes through the plane. Please refer to section 3.6.3 for more details.*

3.6.3 Plane Constraints

A total of eight plane constraints can be configured from the teach pendant. These plane constraints can be configured to the following behaviors:

- *Space Limit Trigger: The plane constraints configured with this feature will be treated as hard space constraints. When the robot's TCP enters the hard space constraint side of the plane, a category 0 stop is issued.*
- *State Switch Trigger: Whenever the TCP goes through a plane configured with this feature, the state switches from the current normal (reduced) to reduced (normal) state.*

The plane constraints can be activated or deactivated on the teach pendant. A deactivated plane constraint will not trigger any of the above-mentioned functions.

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TRANSPORTATION

CHAPTER 4

As supplied in two boxes, the robot and the control box are a calibrated set. Do not separate them, or else the robot will not function properly.

Keep the packaging material in a dry place and do not flat, press, or fold the package materials. The robot is designed to best fit with the package box and vice versa. Do not use any other package design to transport the robot.

When un-boxing the robot, keep the package box's bottom side sit stable on the ground. Hold both the base (A1 & A2) and the elbow (A4 & A5) of the robotic manipulator to slowly move the robot from the packaging. Handle the robot and the control box with care. Do not pry, vibrate, drop, twist, or drag. Gently hold the robot with more than one person until all mounting bolts are securely tightened at the base of the robot.

The robot must be in the transport state before it can be transported. Do not force the robot into the package. The transport state has a pose and packaging layout as shown in Figures 4.1 and 4.2. The package boxes have the following outer dimensions as reference:

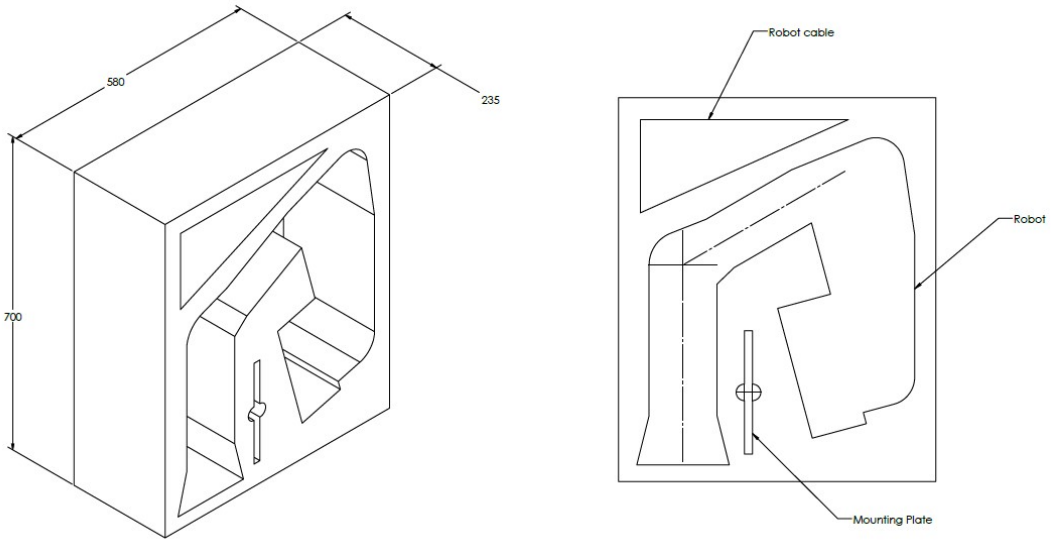

Figure 4.1: Package of the Rizon 4 robotic manipulator.

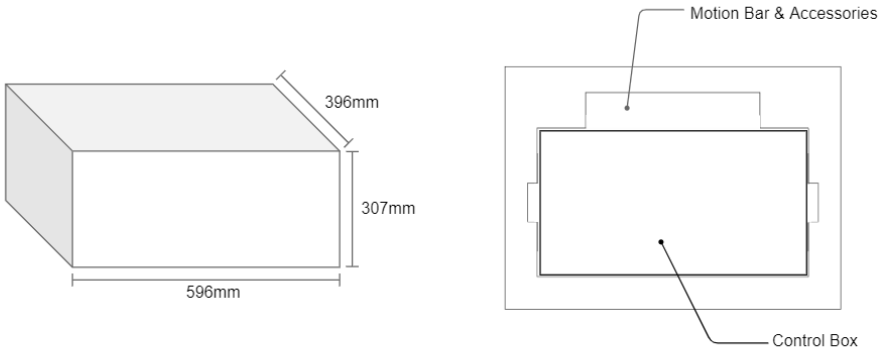

Figure 4.2: Package of the Hesper control box.

1. Consult your physician before handling and do not overload your body at all times. Use proper tools to move and mount the parts. Flexiv cannot be held responsible for any damage or injury caused by transportation and installation operations.
2. Make sure to mount the robot according to the instructions in this chapter. Practice all the safety measures include but not limited to safety glasses, gloves, steel toe shoes, etc.
3. Do not drop, shake or knock the package, or place the package upside down or on its side.

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INSTALLATION

CHAPTER 5

5.1 Mechanical Requirements

Installation of the robot shall be performed according to the orientation of the robot base flange. All orientations are allowed. An example of vertical mounting is illustrated in Figure 5.1. It is recommended to have at least two people, one holding the whole body of the robot and aligning to the target mounting flange, the other one adding 4x M6 bolts between the robot base flange and the target mounting flange, with the length of all bolts being at least 16 mm. Detailed mounting patterns are illustrated in Chapter 6. Note that for safe operations with high speed in the automatic mode, additional physical safeguard equipment is required. The position of the safeguard equipment shall be determined according to Chapter 3 Figure 3.3Figure **??**.

The control box can be lifted with the handle attached to the side for moving or mounting. The handle can be pulled out or retracted as shown in Figure 5.2.

CAUTION

- Make sure all the connectors have been disconnected before moving the robot or the control box.
- Gloves are recommended when lifting the robot or the control box.
- Watch out for possible contact with sharp objects to prevent cosmetic damage on the robot surface.

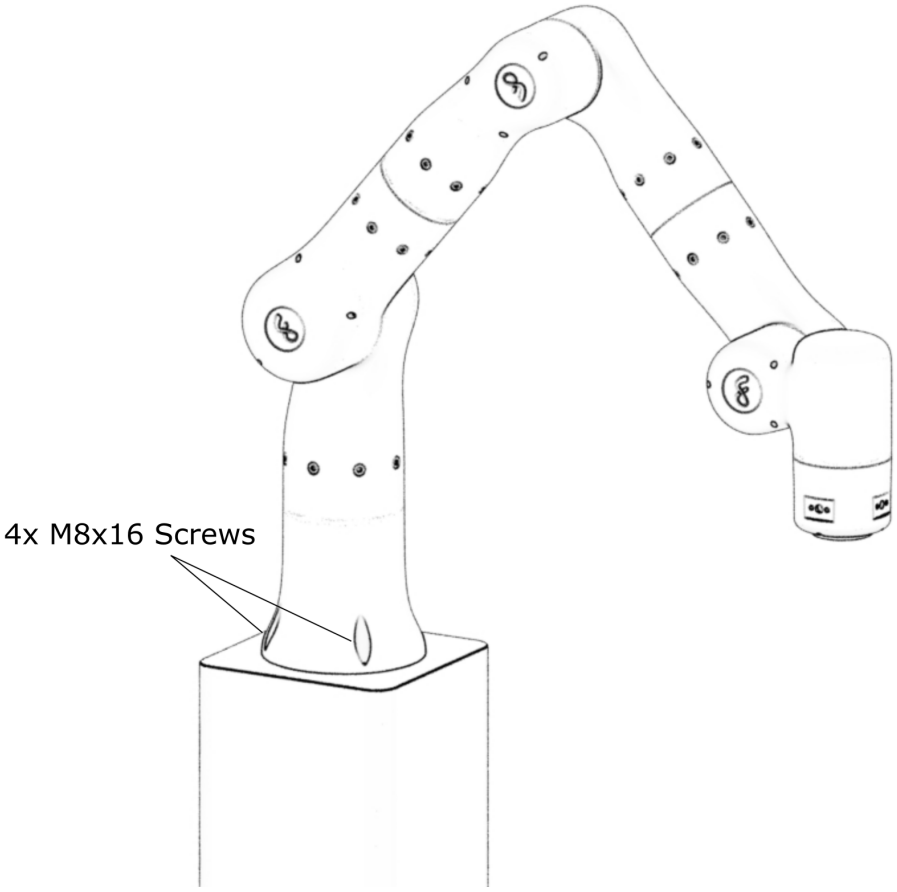

Figure 5.1: Illustration of exemplar vertical installation of the Rizon 4 manipulator.

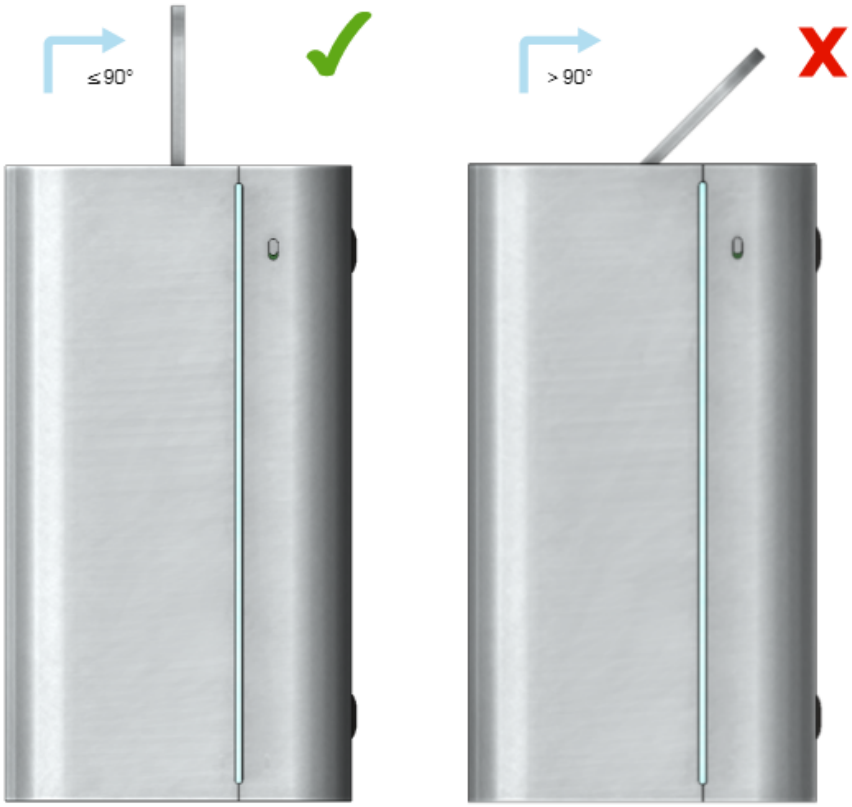

Figure 5.2: Guidance on the deployment of the handle on the control box.

5.2 Electrical Requirements

For robot manipulation under safe conditions, proper electrical installation should be carried out with considerations in the electrical specification (Appendix A), power usage, and electricity stability. Users should be aware of the sharing power of the electrical system to reduce the risk of electrical hazards.

- Users must follow the power requirements shown on the label on the control box.
- Make sure the power source can provide enough power for the robot.
- The power source needs to be equipped with a residual current device and provided with a suitable over-current protective device on the site in accordance with IEC 60947-2. The supply disconnecting device shall be within 6m from the electrical control box.
- Make sure the power cable has a proper connection before powering the system on.

5.3 Environmental Requirements

The robot has passed electromagnetic compatibility (EMC) tests provided by a third-party company. To reduce operational uncertainties, the robot shall be installed in an environment with minimal electromagnetic noises.

- Avoid installing the robot in high Electromagnetic Interference (EMI), Radio Frequency Interference (RFI) working environment.
- Robot installers should wear the ESD Wrist Strap to prevent static electricity shocks from damaging the system permanently.

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MECHANICAL INTERFACE

CHAPTER 6

6.1 Introduction

This chapter provides basic information on the mounting of the robot and the control box.

6.2 Workspace of the Robot

Dimension	Value
1	1255 mm
2	1145 mm
3	365 mm
4	395 mm
5	385 mm
6	330 mm
7	780 mm

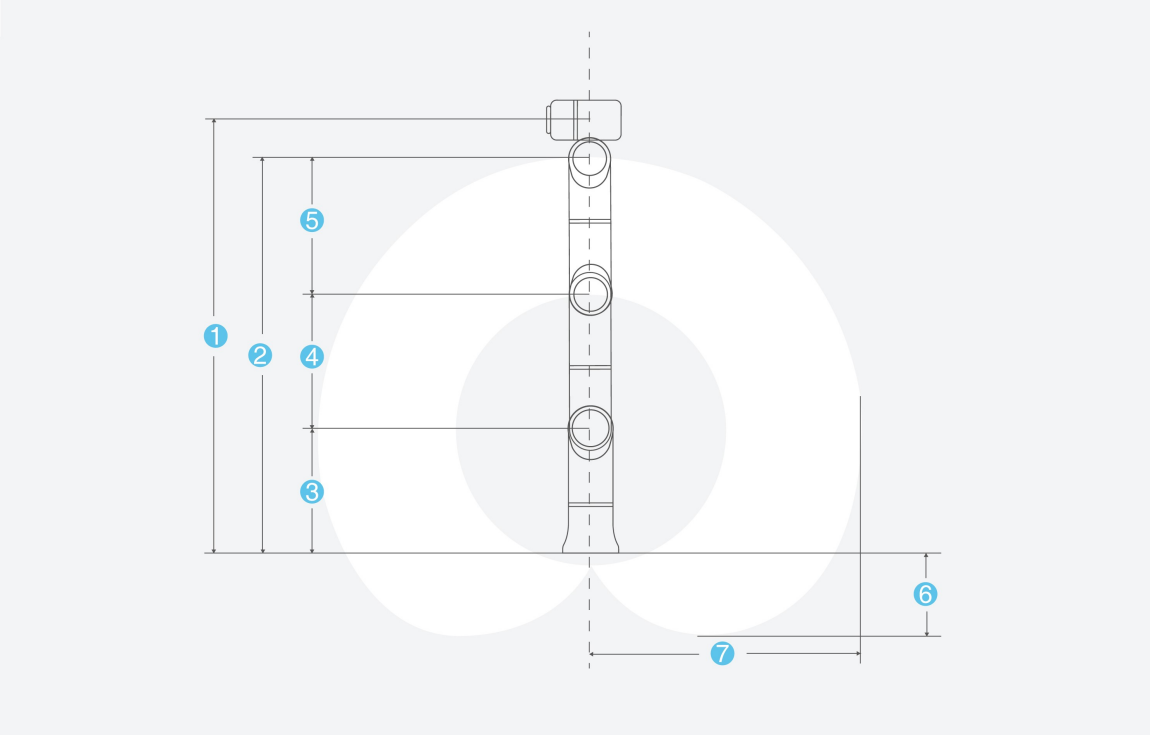

Figure 6.1: Workspace of the Rizon robotic manipulator.

6.3 Manipulator Base Mounting

The surface on which the base seats should be flat with better than 0.05mm flatness. Four ø9mm holes are for M8 bolts mounting, and there are a ø8mm dowel pin hole and a ø8mm dowel pin slot for locating. The suggested mounting conditions are as follows:

Mounting	Suggested Value
Screw Length	16 mm
Platform	Metal leveling platform

- Make sure to securely bolt the robot to a fixture. Loose fasteners can lead to mechanical injuries.
- The robot needs to be used in designated environments according to IP ratings (IP54 / IP65).

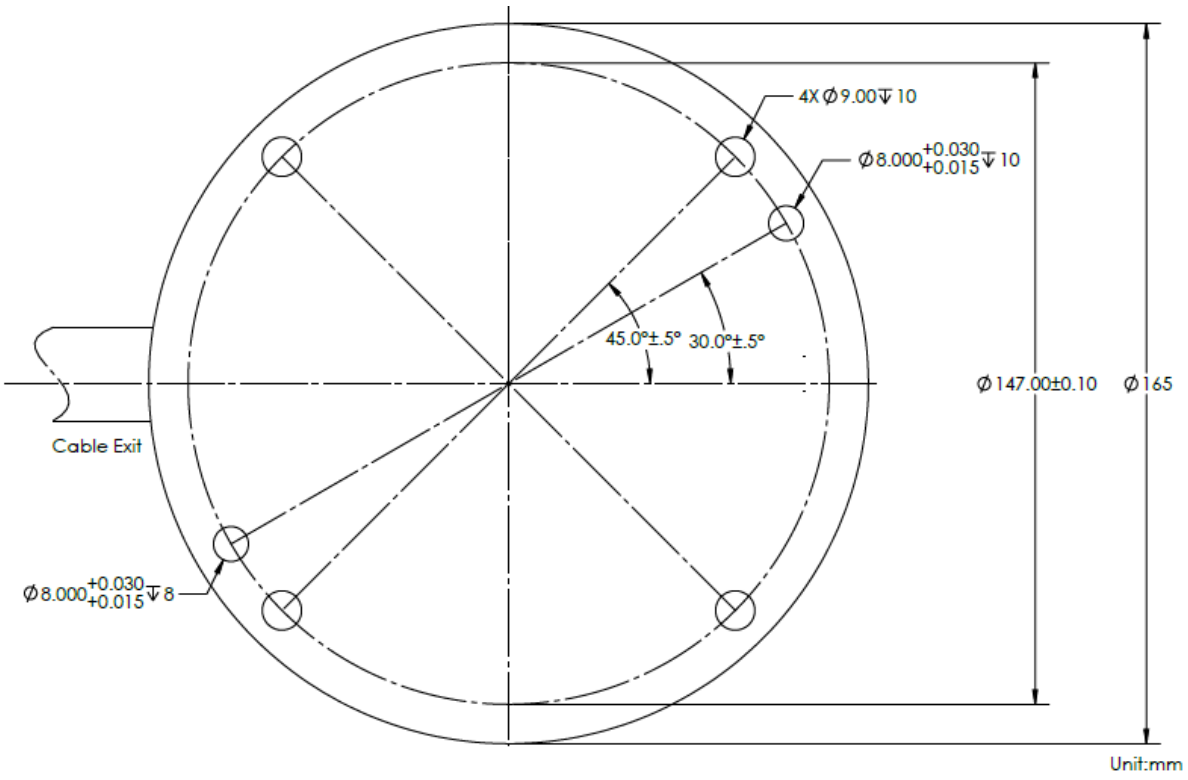

Figure 6.2: Base mounting of the Rizon 4 robotic manipulator.

6.4 End-of-Arm Tool Mounting

The output flange of the robot follows ISO 9409-1-50-4-M6 for the distribution of screw holes. Relevant dimensions are shown below in Figure 6.3.

Make sure to securely bolt the tool to the robot's end-effector. Loose fasteners can lead to the dropping of the tool and cause mechanical injuries.

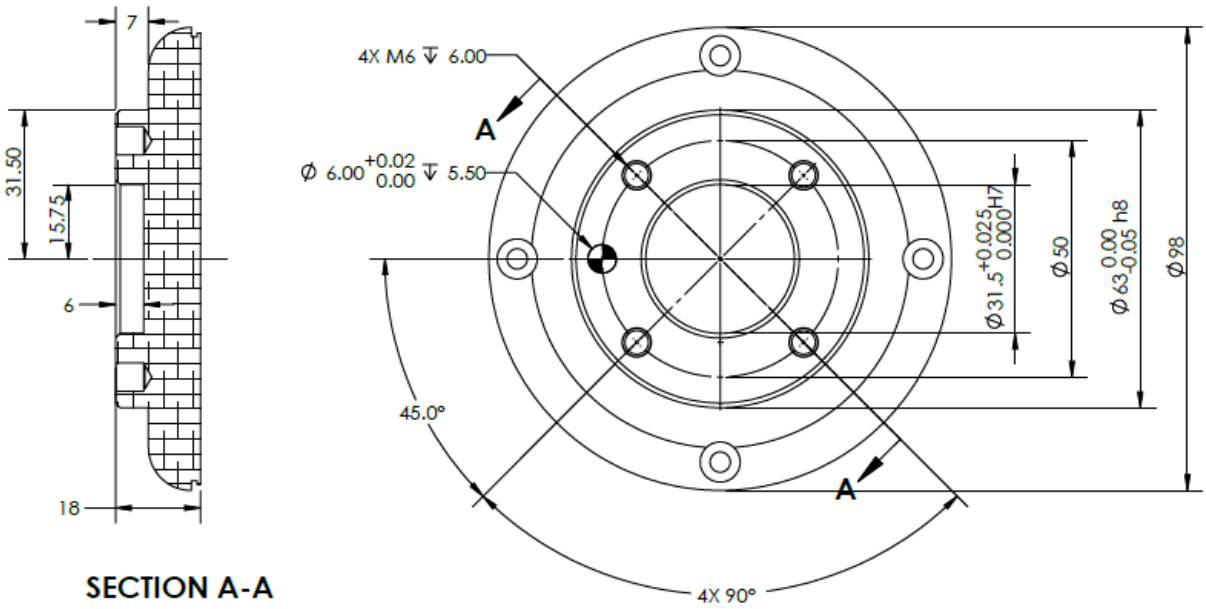

Figure 6.3: End effector mounting plate of the Rizon 4 robotic manipulator.

6.5 Control Box, Motion Bar, and Teach Pendant

- Make sure that all connections between the manipulator, control box, motion bar, and teach pendant are not in contact with any liquid.
- All parts need to be used in designated environments according to IP ratings (control box IP20, motion bar IP40, and teach pendant IP20).

6.6 Maximum Payload

Payload: maximum payload handled by the robot attached to the TCP is 4 kg when the manipulators are fully extended and oriented horizontally. The variation of the payload capability with respect to the location of the center of gravity is illustrated in Figure 6.4.

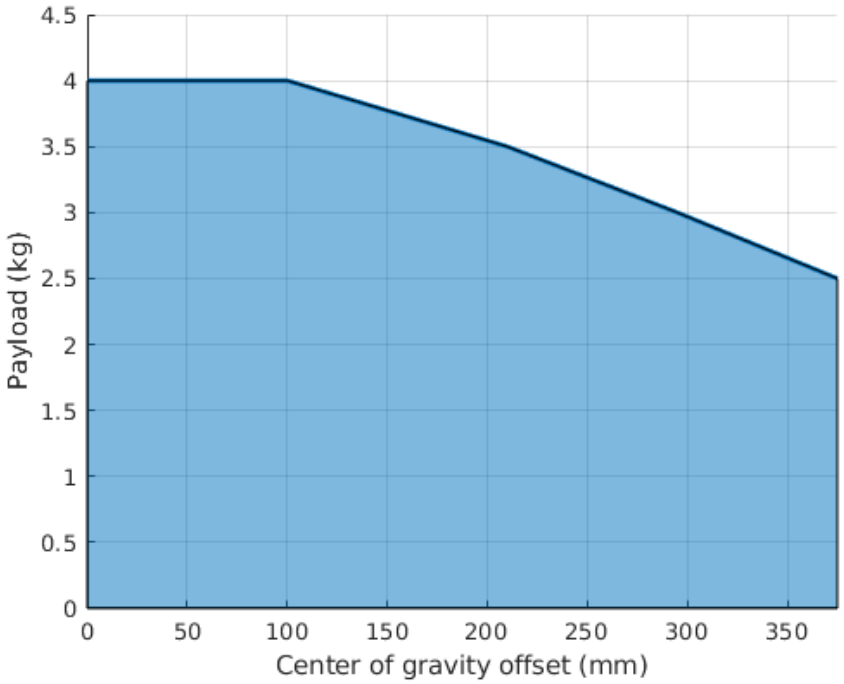

Figure 6.4: Relationship between the maximum allowed payload and the center of gravity offset.

6.7 Grounding

If the control box is connected to a power system without a grounded neutral, this may cause malfunctions in the control box and material damage to the power supply units. Electrical voltage can cause injuries. The control box may only be operated with grounded-neutral power supply systems.

In case external grounding is needed for the robot system, external grounding locations (screw holes) are provided as shown in Figure 6.5. Users may need external cables to connect the control box and/or the robotic manipulator to the ground.

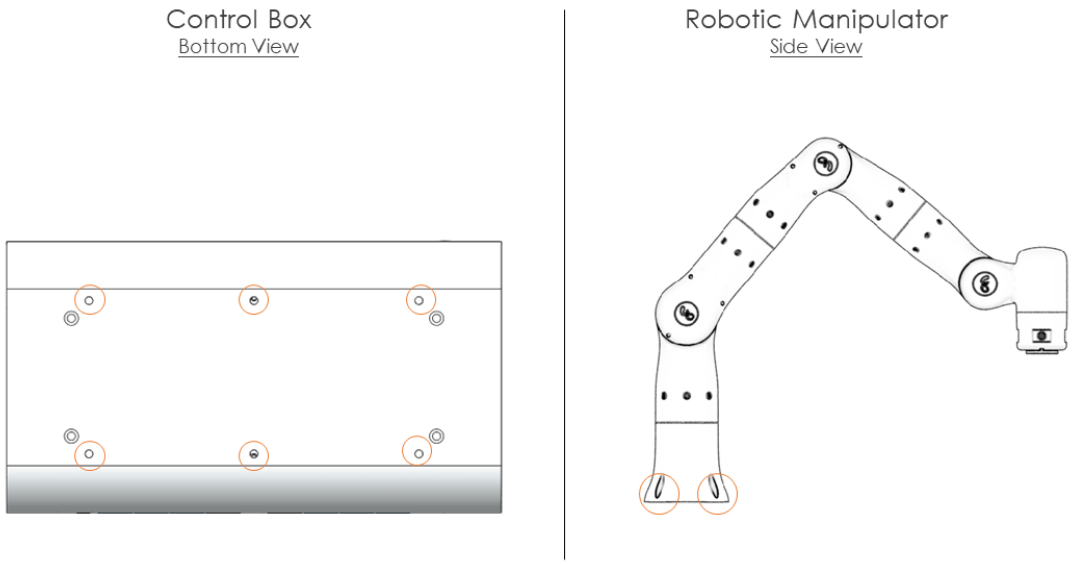

Figure 6.5: Optional external ground locations for the control box and the robotic manipulator. Marked by orange circles.

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ELECTRICAL INTERFACE

CHAPTER 7

7.1 Introduction

This chapter describes the electrical interfaces provided on the control box. Typical example usage is given for the general-purpose digital I/O. Information is also provided for communication interfaces.

7.1.1 Control Box Connections

On the front of the control box, general-purpose 24 V digital I/Os and several commonly used communication interfaces are available. In addition to these interfaces, a Wi-Fi enabling switch is also integrated. Details about all these interfaces are shown below in Figures 7.1 and 7.2 as well as Table 7.1.

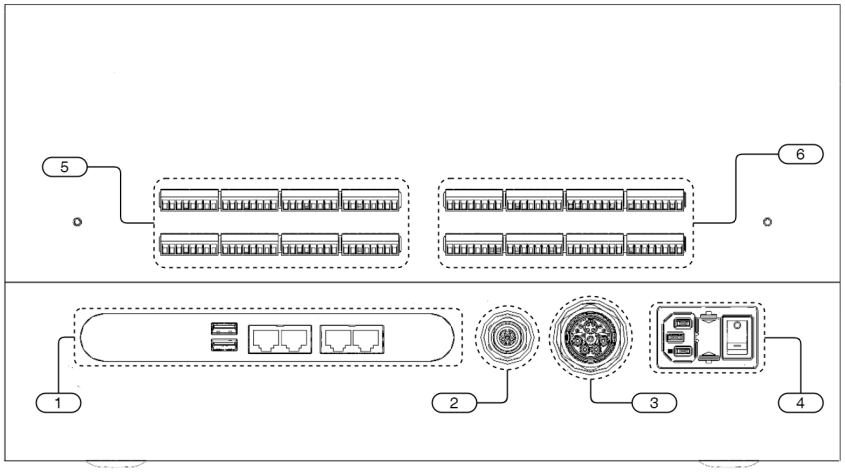


Figure 7.1: Connections on the control box.

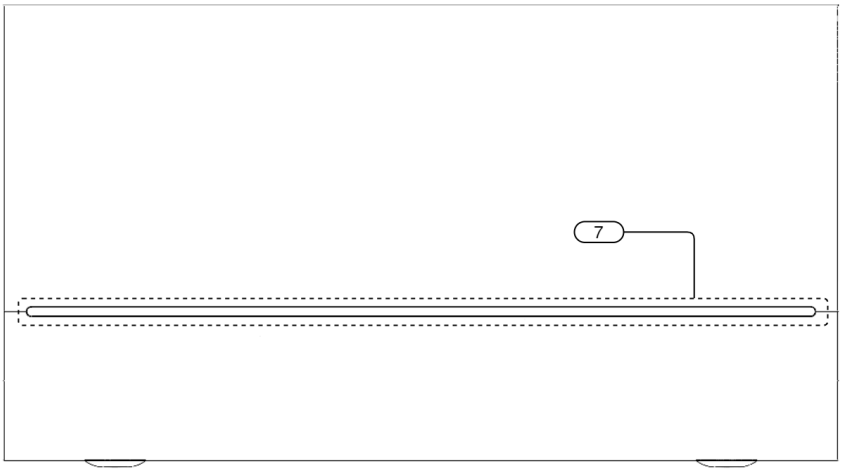


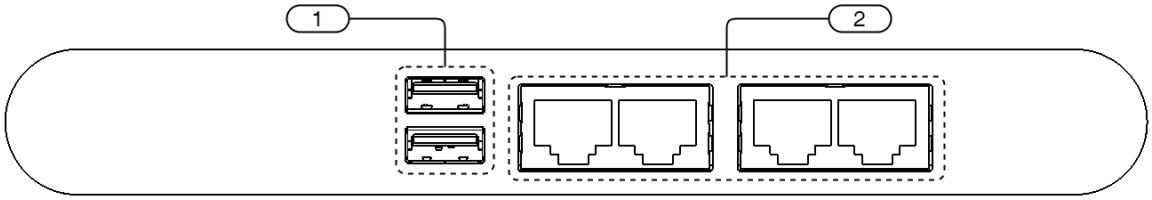
Figure 7.2: Connections on the control box.

Item	Description
1	Display and communication interfaces
2	Motion Bar connection socket
3	Robot connection socket
4	AC power socket*
5	General purpose 24 V digital I/O
6	Safety I/O
7	LED indicator strip

Table 7.1: Control box electrical interfaces.

** A 10-second delay is required between successive system reboot attempts. Otherwise, the system may not start properly.*

For the display and communication interfaces, USB and Ethernet connections are available to transfer files with a USB stick and to establish real-time industrial communication respectively. Figure 7.3 shows the specific purpose of each of the ports. Since the control box is designed with an optional AI computer for computer vision applications, some of the provided USB ports are dedicated to external cameras and other relevant accessories. Ethernet ports are available for maintenance, TCP/IP service into the local computers, and industrial communications.



Item	1	2			
Type	USB Type A	RJ45(8 position modular jack)			
Function	USB 1	Ethernet 1	Ethernet 2	NC	NC
	USB 2				

Figure 7.3: USB and Ethernet connections on the control box.

7.2 Industrial Communications

The control box for robot features configurable real-time Ethernet-based protocols that include Profinet I/O device, Modbus TCP, and EtherNet/IP. These protocols are not available by default and are purchased separately as options. Once installed, the user can select the desired protocol through the teach pendant (see chapter 9). Once selected, the system will need to be rebooted. The industrial communication port will be loaded with the corresponding communication driver.

7.3 Control Box Digital I/O

The control box comes equipped with 24 V digital I/O to support a wide range of equipment including PLCs, relays, and pneumatic and hydraulic valves. Figure 7.4 shows the layout of the general-purpose digital I/Os.

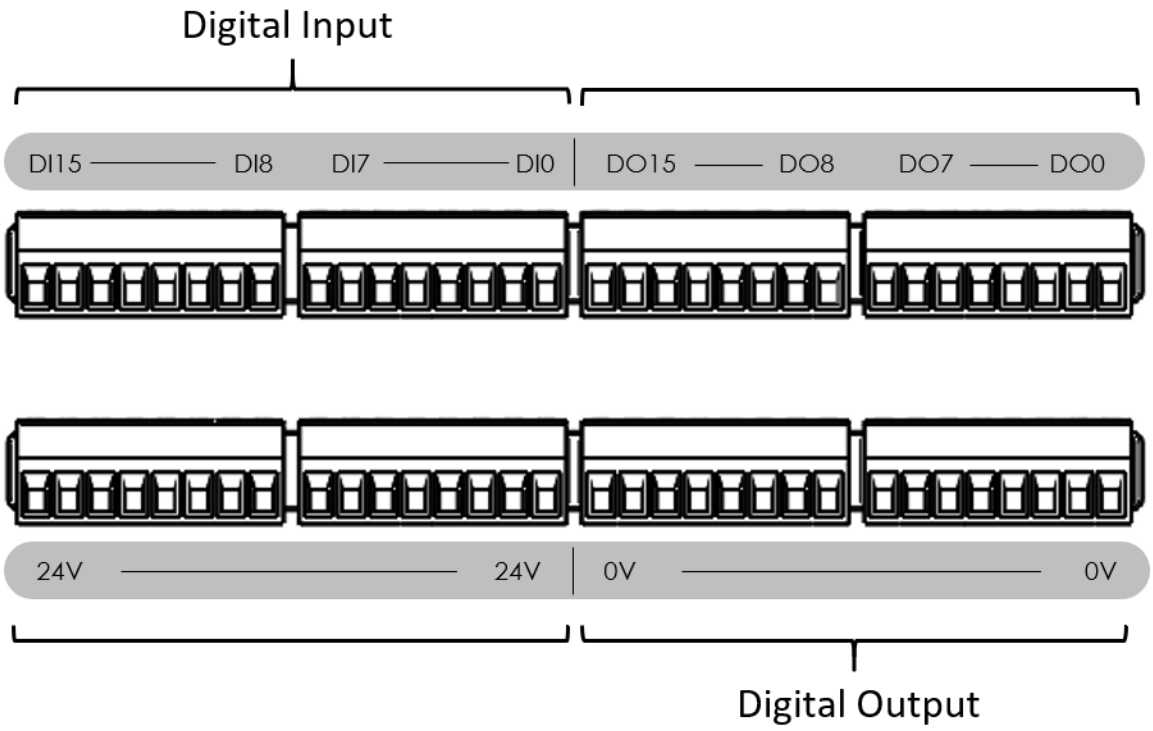


Figure 7.4: General purpose digital I/Os on the control box.

7.3.1 Specifications for all digital I/O

The specifications for digital I/O on the control box apply to general purpose and safety I/Os. The electrical characteristics of the 24V internal power supply are shown in Table 7.2.

Item	Min	Typ	Max
Voltage (V)	23	24	25
Current (A)	0	-	2
Input type		PNP	

Table 7.2: 24V internal power supply specifications.

The digital I/O are designed according to IEC 61131-2. The electrical specifications are shown in Table 7.3.

Item	Min	Typ	Max
Digital Outputs			
Voltage Drop (V)	0	-	0.5
Current (A)	0	-	0.625
Digital Inputs			
Voltage (V)	-3	-	30
High Region (V)	11	-	30
Low Region (V)	-3	-	5
Current (mA)	2	-	15
Output Type		PNP	
IEC 61131-2 Type		3	

Table 7.3: 24V digital I/O power supply specifications.

7.3.2 Safety I/O

This section describes the dedicated safety I/Os provided by the control box. The electrical specifications are as described in the previous section. Safety devices connected to these safety I/Os must be installed according to the safety instructions and risk assessment explained in chapter 2. These safety I/Os are constructed as dual channel I/Os and are denoted as safety inputs A and B on the control box. As such, connected devices must keep them as two separate channels. A single fault, thus, does not lead to the loss of the safety function.

The safety functions are internally wired to the dedicated safety I/Os of the control box. The complete layout of the safety I/Os is displayed in Figure 7.5. Note that only a subset of the safety I/Os are used, while the rest are reserved for future developments. The unused I/Os must be left unconnected.

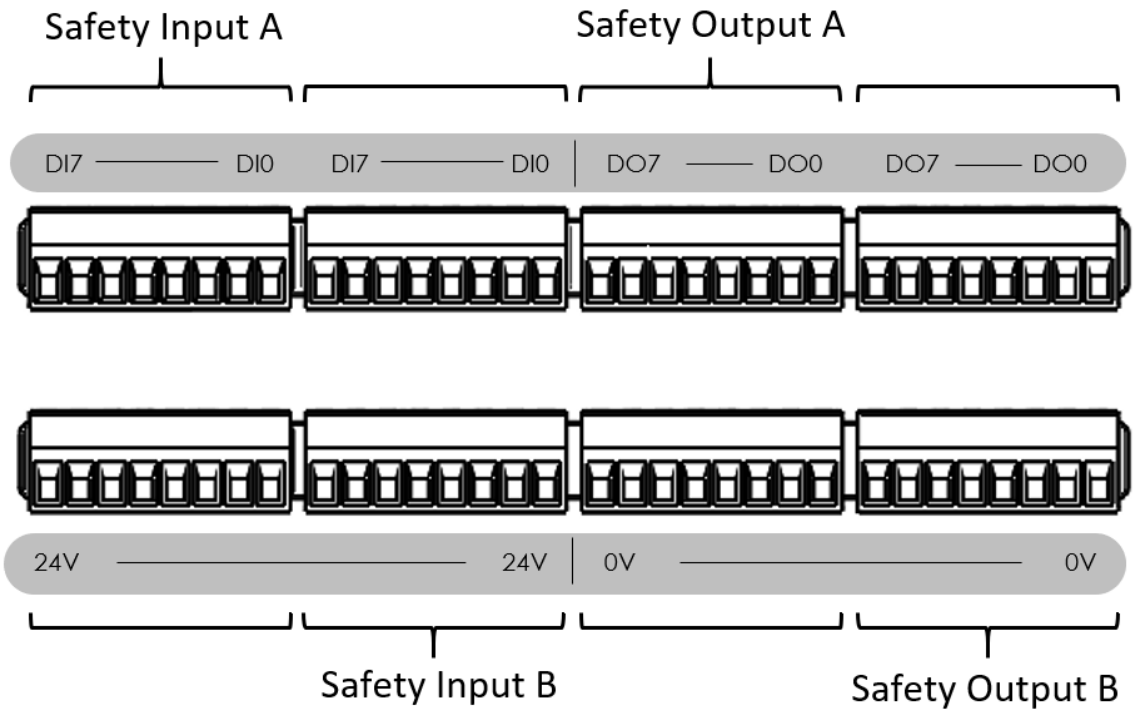


Figure 7.5: Safety I/Os on the control box.

Three dedicated safety inputs have been wired to the motion bar. The operational mode input allows the user to switch between manual and automatic modes. As for the robot emergency stop and enabling device inputs, they are described below in Table 7.4.

	Robot E-stop	**Enabling Device**
Trigger	Depressed	Not in center position
Robot motion	Stops	Stops
Program	Pauses	Pauses
Frequency of use	Infrequent	Frequent during programming
Resumption	Brake release	None
Stop Category	1	2
Performance level	PLd	PLd

Table 7.4: Safety input devices descriptions.

1. Connect only safety-rated devices to the safety I/Os and ensure that the safety level is appropriate as per the risk assessment.
2. It is important to keep safety signals separated from normal I/O signals.
3. All safety I/Os are constructed as redundant dual-channel signals. As such, these channels must be kept separated so that a single fault does not result in the loss of the safety function.
4. All safety I/Os channels are denoted on the control box as A and B.
5. Only a subset of the safety I/Os is used. They are mapped to specific safety functions. All unused safety I/Os must be left unconnected.
6. The robot installation shall conform to the safety specifications in this manual. Failure to do so could result in serious injury or death as the safety function could be unintentionally overridden.

7.3.3 Default Safety Configuration

The robot is shipped with a default configuration displayed in figure 7.6, which permits operation without further installation of safety devices. See chapter 9 on how to connect external safety devices to the safety input ports.

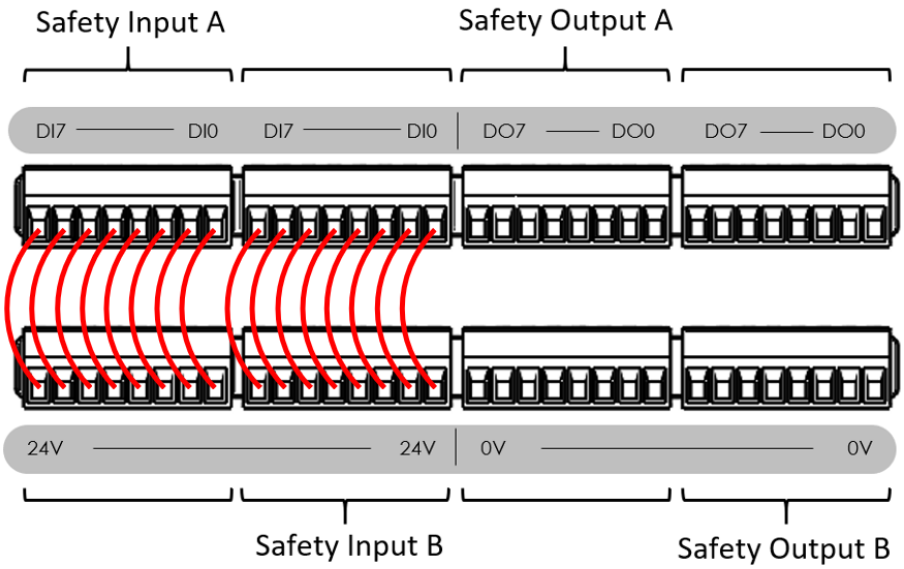


Figure 7.6: Default safety I/O layout.

7.3.4 Safety Input/Output Pin Definition

As mentioned in 7.3.2, all safety I/Os must have a dual-channel connection to meet the requirement of safety functions, which means a safety device must connect both channels to work properly with Rizon's safety control system. However, not all safety I/Os are used for safety functions, some of them are also used for non-safety functions, as shown in Table 7.5.

Digital Input Port	**Safety Function**
DI0	Emergency Stop
DI1	Reduced State Input
DI2	Safeguard Reset Input
DI3	Safeguard Stop
DI4-DI7	Reserved
Digital Output Port	**Safety Function**
DO0	Emergency Stop Output
DO1	Robot Moving Output
DO2	Robot Not Stopping Output
DO3	Robot Reduced State Output
DO4	Robot Not Reduced State Output
DO6-DO7	Reserved
Digital Output Port	**Non-safety Function**
DO5	Drive Power Indicator Output

Table 7.5: Safety input devices descriptions.

7.3.5 System Emergency Stop Input

The system emergency stop input is constructed to allow additional emergency stops to be wired to the control box so that the robot can be stopped from any of the connected emergency stops. The illustration in Figure 7.7 shows an example. Note that more emergency stops can be added by installing them in series.

7.3.6 Safeguard Stop Input

The safeguard stop input is designed to allow users to halt the motion of the robot without removing power. The safeguard stop input is a level-triggered function. As such, stopping

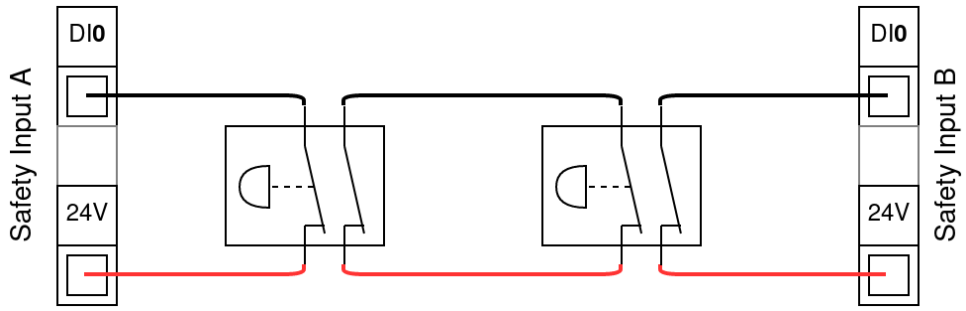


Figure 7.7: Wiring up additional emergency stops in series.

with automatic resumption is possible. Two commonly used examples are shown in Figures 7.8 and 7.9.

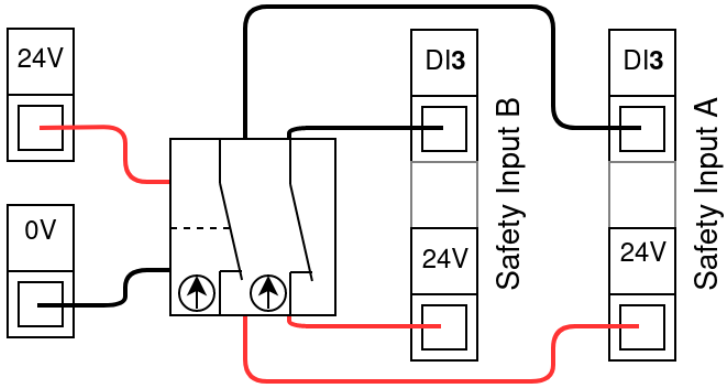


Figure 7.8: Wiring safety door switch to safeguard input.

- Since the robot resumes movement automatically when the safeguard stop is deactivated, do not use this setup if the deactivation can be established within the safety perimeter.

7.3.7 Safeguard Reset Input

In the case where automatic resumption of the safeguard stop is not permitted, for example, within the perimeter of a safety light curtain, a reset outside of the perimeter is required. This can be achieved using a safeguard reset button.

7.3.8 System Emergency Stop Output

The system emergency stop output is a dual-channel digital output that can be interfaced with other machines to trigger stops on these machines. Please perform a risk assessment for the

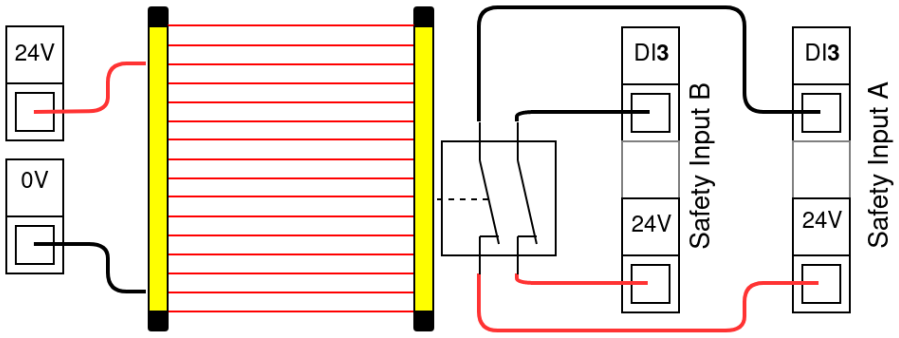


Figure 7.9: Wiring safety light curtain to safeguard input.

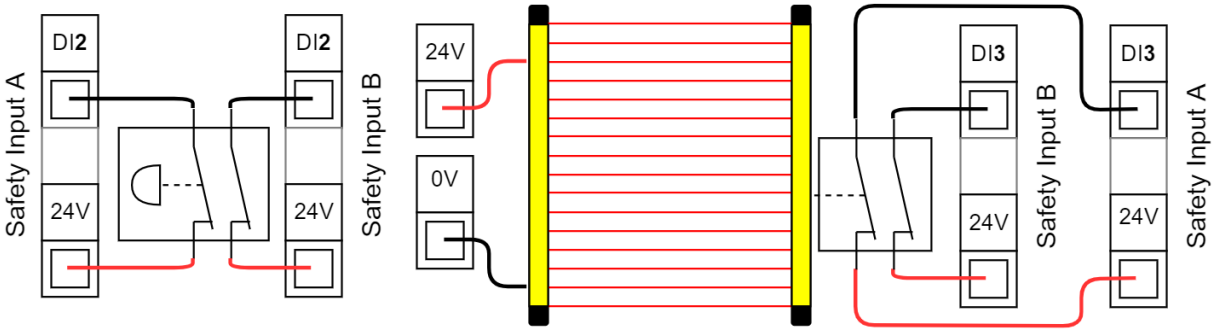


Figure 7.10: Using safeguard reset to reset the safety light curtain triggered safeguard state.

whole application prior to using the system emergency stop output. The system emergency stop output pair is provided by **DO0** on safety outputs A and B.

7.3.9 Moving, Not Stopping, Reduced State, Not Reduced State Outputs

In addition to the safety emergency stop outputs, several other safety outputs are available. Details on these outputs are available in section 3.3.3. Moving and Not Stopping outputs indicate the motion state of the system and are provided through **DO1** and **DO2** respectively on the safety outputs A and B. Reduced and Not Reduced state outputs indicate whether the system is in reduced state. These outputs are provided through **DO3** and **DO4**.

7.3.10 Drive Power Indicator Output

To indicate whether the robot is receiving power from the drives, a dual channel safety output is also provided through **DO5** of the safety outputs A and B. Usually, the outputs are wired to an amber lamp. The lamp shall not be a screw-in type or filament type, which may cause failure by manipulator vibration. Depending on the risk assessment, a single channel wiring is possible. This is shown in Figure 7.11.

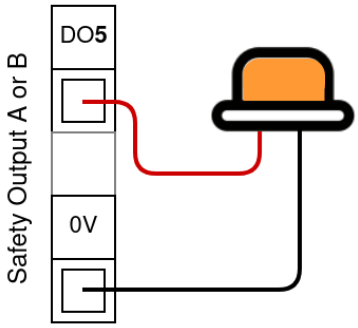
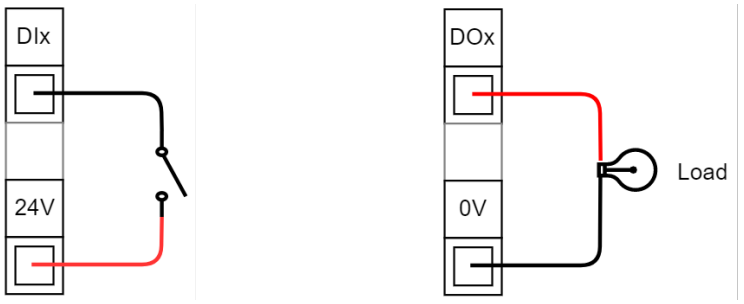


Figure 7.11: Wiring of the drive power indicator output to an amber lamp.

7.3.11 General Purpose Digital I/O

This section describes the 24V general-purpose digital I/O on the control box. The common specifications described in section 7.3.1 must be observed while setting up the I/Os.

These I/Os can be used to drive external equipment such as relays, pneumatic and hydraulic valves. These digital I/Os will be set to their passive state, i.e. low, when the program execution is stopped. Some examples of how these I/Os are used are shown in Figure 7.12.



(a) Using digital input with a switch.

(b) Using digital output with a load

Figure 7.12: Examples of digital I/O.

The I/Os can also be used as a form of communication with other machines as long as a common ground is established and if the machine has PNP I/Os. An example of wiring with a PLC is shown in Figure 7.13.

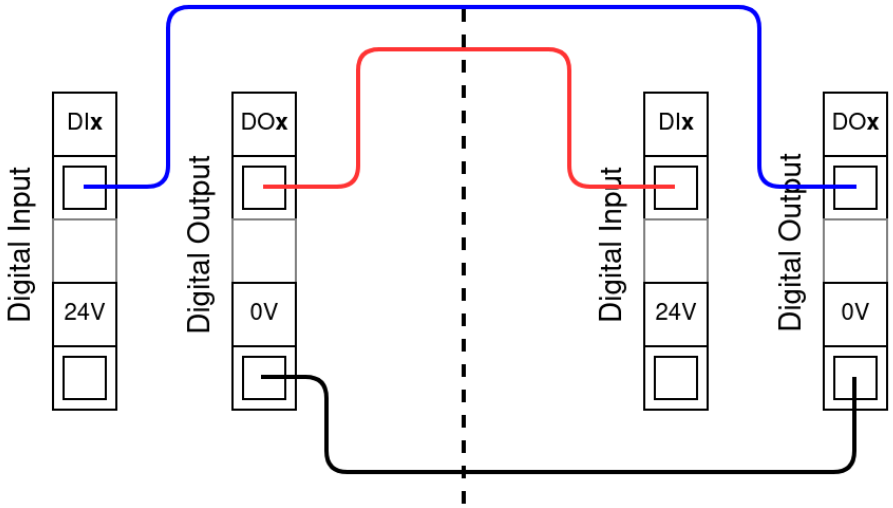


Figure 7.13: Wiring of the digital I/Os to a PLC.

7.4 Tool Connection

As shown in Figure 7.14, an eight-pinned flush-type connector is at the side of the robot wrist. It provides power and industrial communication to the device installed on the end effector mounting plate. Phoenix Contact 1407487 is the recommended cable for connecting the robot and the device, and each color code in the cable represents a different function provided by the robot.

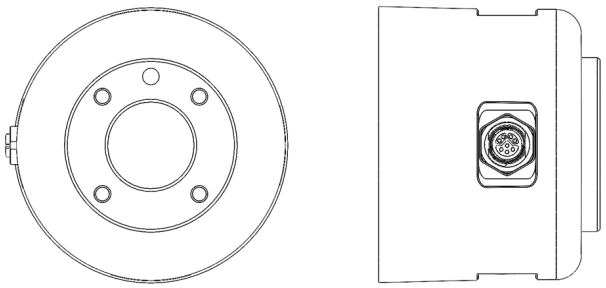


Figure 7.14: Views of the wrist connector.

The relationship between the color code and the function is listed in Table 7.6. All the color information is based on the spec sheet of Phoenix Contact 1407487.

Color Code	**Description**
White/green	RS485+
Green	RS485-
Blue	Ground
White	48V
Brown	24V
Black	Ground

Table 7.6: Function description related to wire color.

The electrical specifications of the tool are listed in Table 7.7.

Item	**Min**	**Typ**	**Max**
Supply voltage (V)	23.7	24	24.3
Supply current (A)	0	-	1.0

Table 7.7: Tool power specifications.

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MAINTENANCE AND REPAIR

CHAPTER 8

8.1 Safety Instructions

To ensure all safety requirements are implemented on the robot, users must carefully follow all safety instructions. Incorrectly using or modifying will cause dangers and permanent damage to the robot. The following warnings and procedures are the instructions which can enable/disable safety functions. Users should carefully read and check them before using the robot.

1. *Do not remove any disassembled parts on the robot, including wire, electric board, power supply, cover, screw, and mechanical part.*
2. *Do not change anything in the safety configuration of the software. If any safety parameter is changed, the complete robot system shall be considered new.*
3. *For maintenance or cleaning of the robot, make sure the system is powered off. To safely power off the robot, first turn the power switch to the OFF position, then unplug the AC cable from the wall. Before powering on and using the robot, make sure all of the settings are the same as the previous status.*
4. *Consider ESD regulations and the dry environment when the user needs to disassemble the robot or control box. Proper ESD protection or wearing an ESD wrist strap can prevent permanent damage by electrostatic discharge.*
5. *Check all of the connections properly before powering the system.*
6. *Check the AC power output voltage before powering the system.*
7. *Check the earth connection before re-powering the system.*

8. *Prevent water and dust from entering the manipulator or control box.*
9. *Rebooting must be performed at least once a week to ensure the proper function of the robot system.*

8.2 Verification of Safety Functions

To ensure the reliability of safety functions, it is recommended to verify the safety features according to the procedure detailed in section 2.9 once a week.

8.3 Maintenance Schedule

Yearly maintenance by professional technicians is recommended for all manipulators, control boxes, motion bars, and related parts. Grease used in the robot is rated for 3 million cycles with rated load or 10 years of use, whichever comes first. Grease shall be properly maintained with the following requirements.

- Flexiv manipulators use custom-designed strain wave gearing grease, and the grease is not compatible with the standard Harmonic Drive grease. Please contact Flexiv if grease maintenance is needed.
- Do not apply high payload or impact torque/force to the robot. High impact load exceeding the rated payload may lead to bearing damage. Grease is meant to prevent wear, but it will not help prevent such misuse.
- The grease is designed for use in room temperate or 25°C. Low or high temperature may lead to premature failure. Please see Appendix A for the rated operating temperature ranges.

8.4 Fuse Specifications

To change the fuses on the AC power header, make sure the control box is powered off first. Fuses with UL marks are required and shall be cartridge type. The required specifications are listed below.

- Rated current: 10A
- Rated voltage: 250VAC
- Interrupting Rating: 1500A at 250VAC

Exemplar photos of the AC fuses and their cartridge are illustrated as follows.

Figure 8.1: Exemplar photos of the AC cartridge fuses pulled out for maintenance.

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SOFTWARE

CHAPTER 9

9.1 Introduction

This chapter introduces the basic operations and usage of Flexiv Elements, which is Flexiv's software system for robotic programming and operations. Elements is pre-installed on the teach pendant and is used together with the motion bar to control and operate the robot. It is a graphical user interface for displaying detailed robot status, adjusting advanced settings, and controlling robotic operations. It allows users to develop customized programs with drag-and-drop function modules to control the robot with ease. With the wireless communication of Elements, users can easily connect to different robots through Wi-Fi network. Since Elements is mainly used for information visualization, it can be disconnected from the robot anytime without affecting the robot motion for operations such as offline programming.

The motion bar is hardwired to the control box and is used for executing safety-related operations such as switching between Auto/Manual mode, running tasks, enabling Freedrive, etc. It is required to keep the motion bar connected to the robot system at all times.

9.2 Motion Bar

The motion bar contains 5 functional buttons and a robot state indicator. The basic functionalities are summarized below.

Robot State Indicator: A LED light rim that goes around the motion bar. The color of the light indicates the current robot state.

Emergency Stop Button: It is used to cut off the power and stop robot motion immediately

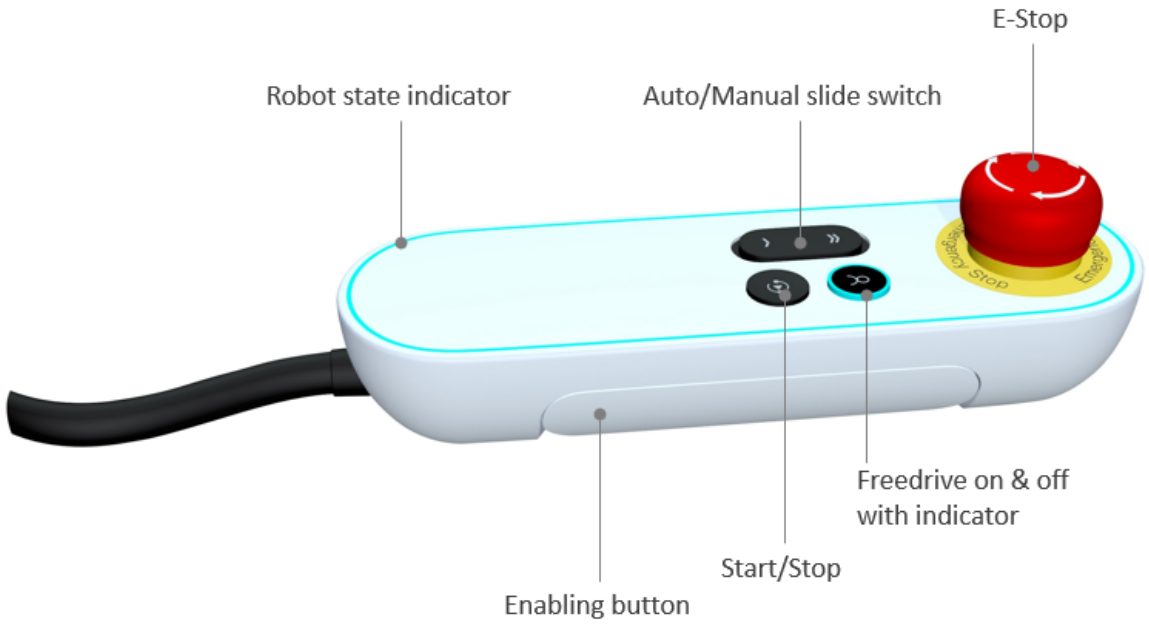

Figure 9.1: Motion bar.

during the run-time. The system will switch to Stop Category 1 when the Emergency Stop Button is pressed.

Enabling Button: This 3-position button is mainly used in Manual mode. When the enabling button is in half-pressed status, the system is enabled and allows to move in Manual mode. Otherwise, the system remains in Stop Category 2.

Auto/Manual Slide Switch: A slide switch that has two states. It is used to switch between Auto and Manual mode.

Start/Stop Button: It is used to start or (soft) stop the robot during the run-time.

Freedrive On/Off Button: It is used to enable or disable the Freedrive function. It has a built-in LED light rim to indicate the Freedrive status. The Freedrive function is available in both Manual mode and Auto mode.

9.3 Mode

There are two operational modes: Manual and Auto.

9.3.1 Manual Mode

The setting for Manual mode is more restrictive on robot motion. Human operator is only allowed to interact with the robot within the danger zone in this mode. Therefore, during human-robot interactions, the enabling button on the motion bar must be held down all

the time when executing a project. If the enabling button is released, the robot will stop immediately and switch to Stop Category 1.

9.3.2 Auto Mode

In Auto mode, the robot is capable of running at full speed and human operators are required to stay out of the danger zone. The danger zone must be protected by safeguards (e.g. light curtains). If a person is detected in the danger zone during Auto mode, the safety system will automatically slow down the robot motion. The enabling button on the motion bar is disabled in Auto mode.

	Manual	**Auto**
Motion settings	Constrained	Normal
Speed limit	Low	High
Operation	Must hold enabling button	Enabling button disabled
Freedrive	Allowed	Allowed
People in danger zone	Allowed	Not allowed

Table 9.1: Comparison of Auto mode and Manual mode.

Users can switch modes using the Auto/Manual slide switch on the motion bar. To switch from Auto mode to Manual mode, users only need to slide the switch to Manual mode; to switch from Manual mode to Auto mode, users need to slide the switch to Auto mode and confirm on Elements. Confirmation on Elements can only be executed outside of the safeguarded space by authorized persons with access codes.

9.4 State

The robot has a total of 5 states. Each state is associated with one LED light color. The LED light indicator is located on the motion bar.

Yellow	Locked	Robot joints are locked
White	Stopped	Robot is at rest, but not at start position yet
Green	Working	Robot is executing (Manual and Auto)
Red	Fault	An error has occurred
Blue	Freedrive	Freedrive is enabled

Table 9.2: Robot states and corresponding LED light color.

9.5 Operation

Freedrive

To use the Freedrive function, first, make sure the robot is in Stopped state, then check if it is in Manual or Auto mode. Freedrive in Manual Mode: dragging experience has more damping; Freedrive in Auto Mode: dragging experience is smoother. Then users need to press the Freedrive button to turn on this function. The robot would enter Freedrive state and the LED light rim around the Freedrive button would light up. Now users could drag the robot to a desired position while holding the enabling button on the Motion Bar. If the enabling button is released, the robot remains at Stop Category 2 and cannot be Freedriven unless the enabling button is triggered again. To terminate Freedrive, users can simply press the Freedrive button again.

Manual Mode: Execute and Stop

Before executing a project, the robot needs to be in Stopped state and the brake needs to be unlocked by releasing the emergency stop button. Then assign the project on Elements by clicking the "ASSIGN PROJECT" button. To start executing the assigned project (specific program), users should half-press the enabling button, then press the Start/Stop button on the Motion Bar, and the robot would start executing the assigned project immediately. The enabling button should be held in the Working state. If the enabling button is released in the Working state, the robot will stop immediately (when state changes from Working to Stopped). To re-execute the project, users need to repeat the above steps. To terminate the execution, users could either release the enabling button or press the Start/Stop button.

Auto Mode: Execute and Stop

Before executing a project in Auto mode, the robot needs to be in Stopped state, and users need to switch the robot to Auto mode on the Motion Bar and confirm the mode switch on Elements. The enabling button is automatically disabled in Auto mode and is not required for robot safety check. However, in Auto mode, users shall stay out of the danger zone and confirm the full functionalities of safeguards and light curtains before executing any project. After assigning the project from Elements, users can press the Start/Stop button to trigger the project execution, then the system would start executing the project. To stop the robot, users can simply press the Start/Stop button again.

Manual mode	Freedrive	Press the Freedrive button & hold the enabling button
	Execute	Hold the enabling button & press the Start/Stop button
	Stop	Release the enabling button or press the Start/Stop button
Switch mode	Manual to Auto	Switch to Auto mode on the motion bar & Confirm on Elements
	Auto to Manual	Switch to Manual mode on the motion bar
Auto mode	Execute	Stay out of the danger zone, then press the Start/Stop button
	Stop	Press the Start/Stop button

Table 9.3: Motion bar operations.

9.6 Workflow

9.6.1 Execute

On Elements, users can select a project and switch to the execute page by clicking the "Edit/Execute" button. It is not allowed to edit the project on the execute page. Please see the detailed workflow in Table 9.4.

Step	Elements	Motion bar	Robot reaction	State	Mode
1.Connect to Elements	Turn on the tablet. Connect to the robot through Wi-Fi		Connected to Elements	Stopped	Manual
2.Open the Project	Choose the project in the file list			Stopped	Manual
3.Assign project	Switch to execute page. Click "ASSIGN PROJECT"		Project assigned to the robot	Stopped	Manual
4.Manual Execute		Make sure the slide switch is on Manual.		Stopped	Manual
		Press and hold the enabling button, press Start/Stop button	Robot starts executing the project	Working	Manual
		Release the enabling button after completing execution	Execution completed	Stopped	Manual
5.Switch mode		Switch to Auto mode and stay out of the danger zone		Stopped	Manual
	Confirm switching		Switched to Auto mode	Stopped	Auto
6.Auto Execute		Press Start/Stop button	Robot starts executing the project	Working	Auto
			Execution completed	Stopped	Auto

Table 9.4: Workflow to execute a project.

9.6.2 Stop and Restart

Stop the robot when it is running in Auto mode, and then restart it. Please see the detailed workflow in Table 9.5.

Step	Elements	Motion bar	Robot reaction	State	Mode
			Moving	Working	Auto
1.Stop the robot		Press Start/Stop button	Stop working	Stopped	Auto
2.Restart in Auto mode		Press Start/Stop button	Robot starts executing the project	Working	Auto
			Execution completed	Stopped	Auto

Table 9.5: Workflow to stop and restart.

9.6.3 Clear Minor Fault

If the robot encounters a minor fault, clear the fault on Elements and restart executing in Auto mode. Please see the detailed workflow in Table 9.6.

Step	Elements	Motion bar	Robot reaction	State	Mode
1.Robot encounters fault			Robot brake locked, stopped moving	Fault	Auto
2.Check error	Check the error message			Fault	Auto
3.Clear fault		Switch to Manual mode if in Auto mode	Switched to Manual mode	Fault	Manual
	Click "CLEAR FAULT". (Must be in Manual mode)		Fault is cleared	Stopped	Manual
4.Switch mode		Switch to Auto mode and stay out of the danger zone		Stopped	Manual
	Confirm switching		Switched to Auto mode	Stopped	Auto
5.Restart in Auto mode		Press Start/Stop button	Robot starts executing the project	Working	Auto
			Execution completed	Stopped	Auto

Table 9.6: Workflow to clear minor fault.

9.6.4 Avoid Obstacles

If the robot encounters obstacles during execution, stop the robot and use Freedrive to move it away from the obstacles. Please see the detailed workflow in Table 9.7.

Step	Elements	Motion bar	Robot reaction	State	Mode
1.Robot encounters obstacles			Encounters obstacles when manual executing	Working	Manual
2.Avoid obstacles		Release the enabling button to stop executing	Stop moving	Stopped	Manual
		Press the Freedrive button	Freedrive turned on	Freedrive	Manual
		Trigger the enabling button, freedrive the robot to a position without obstacles	Freedriving	Freedrive	Manual
		Release the enabling button	Moved to a safe position	Freedrive	Manual
		Press the Freedrive button again to turn it off	Freedrive turned off	Stopped	Manual
3.Switch mode		Switch to Auto mode and stay out of the danger zone		Stopped	Manual
	Confirm switching		Switched to Auto mode	Stopped	Auto
4.Restart in Auto mode		Press Start/Stop button	Robot starts executing the project	Working	Auto
			Execution completed	Stopped	Auto

Table 9.7: Workflow to freedrive the robot to avoid obstacles.

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TECHNICAL SPECIFICATIONS

APPENDIX A

A.1 System Schematics

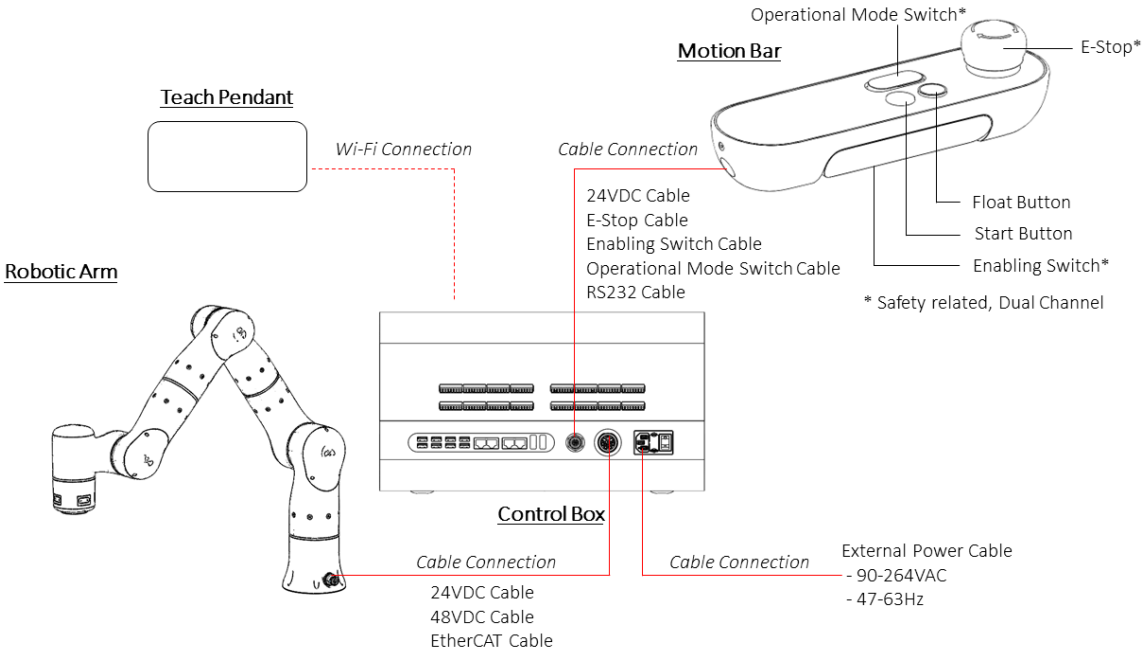
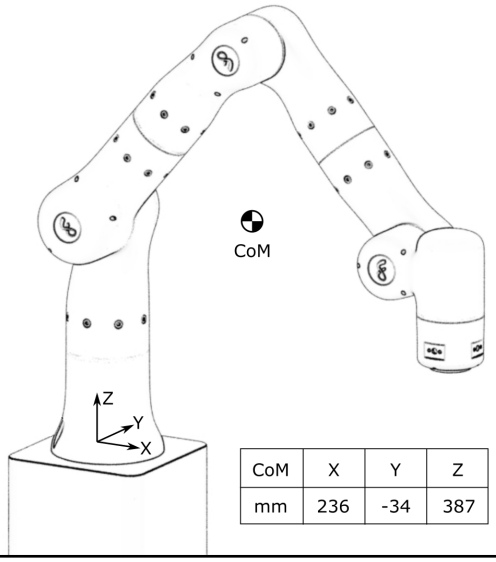


Figure A.1: Schematic view of Rizon 4.

A.2 Robotic Manipulator

Specification	Value
Robot Type	Rizon 4
Weight	20 kg
Payload	4 kg
Degrees of Freedom	7 rotating joints
Reach (A2 to A6, working range)	780 mm
Max Reach (A2 to flange center, full extension)	955 mm
Positioning Repeatability	0.05 mm (ISO 9283)
Joint Ranges	A1: -160 ° to +160 ° A2: -130 ° to +130 ° A3: -170 ° to +170 ° A4: -107 ° to +154 ° A5: -170 ° to +170 ° A6: -80 ° to +260 ° A7: -170 ° to +170 °
Maximum Joint Speeds	A1 through A2: 120 °/s A3 through A4: 140 °/s A5 through A7: 280 °/s
Maximum Joint Torques	A1 and A2: 123 Nm A3 and A4: 64 Nm A5 through A7: 39 Nm
TCP Typical Linear Speed	1 m/s
Power Consumption	Typically 500 W
Installation Position	Any
Air Humidity	20 % to 80 % non-condensing
IP Classification	IP54 / IP65
Noise	Comparatively noiseless
Operation Temperature	0 to 45 °C
Storage Temperature	-10 to 60 °C
Altitude	Up to 1000m
Tool Mounting	ISO 9409-1-50-4-M6

Center of Mass of Rizon 4



CoM	X	Y	Z
mm	236	-34	387

A.3 Control Box

Specification	Value
Dimensions	423 mm x 230 mm x 230 mm
Weight	11 kg
Power Supply	100-240 VAC, 50-60 Hz
GPIOs	24V digital inputs: 16 24V digital outputs: 16
Safety I/Os (dual-channel)	24V digital inputs: 4 active, 4 reserved 24V digital outputs: 5 active, 3 reserved
I/O Power Supply	24 V 2 A
Communication Interface	Configurable Profinet or Modbus TCP/IP
Air Humidity	20 % to 80 % non-condensing
IP Classification	IP 20
Noise	Comparatively noiseless
Operation Temperature	0 to 45 °C
Storage Temperature	-10 to 60 °C
Altitude	Up to 1000m
Cabling	Between manipulator and control box: 3 m Between motion bar and control box: 7 m

A.4 Motion Bar

Specification	Value
Dimensions	175 mm x 55 mm x 40 mm
Weight	0.15 kg
Air Humidity	20 % to 80 % non-condensing
IP Classification	IP 40
Operation Temperature	0 to 45 °C
Storage Temperature	-10 to 60 °C
Altitude	Up to 1000m

If the product is taken from a colder place to a warm and humid place, or if any condensation is observed on the product, please wait at least 120 minutes before powering on the device to reduce the risk of circuit shorting due to potential water condensation inside the product.

Users must ensure that the robot is correctly grounded (a direct physical connection to the earth).

Users must ensure that the input current source of the control box is protected by the residual-current device (RCD).

A.5 Teach Pendant

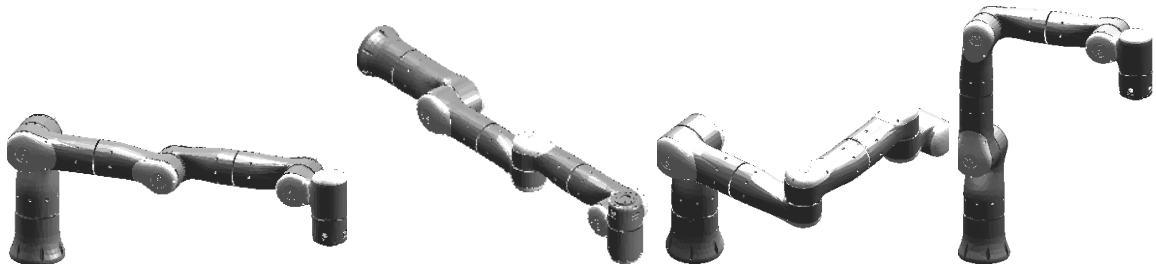
A lightweight computer or tablet computer can be connected to the Control Box via Ethernet Cable or Wi-Fi.
Teach Pendant will display a warning if the communication is interrupted for 2 seconds.

STOPPING DISTANCES AND TIMES

APPENDIX B

Table B.1 includes the stopping distances and times measured when the emergency stop switch is triggered as a category 1 stop. These measurements correspond to the following configuration of the robot:

- *Extension: 100% (the robotic manipulator is fully extended).*
- *Speed: 100% (The general speed of the robot is set to 100%).*
- *Payload: maximum payload attached to the TCP (4 kg).*



(a) Axis 1 (b) Axis 2 (c) Axis 3 (d) Axis 4

Figure B.1: 100% extension, Axis 1 - Axis 4

The data are given for axes A1, A2, A3, and A4. These axes are the axes that can result in large velocities at the TCP. Note that, during operation, synchronized movements of multiple

axes often occur and may result in longer stopping distances should they all run at peak velocities.

Axis	Stopping Distance	Stopping Time
A1 (Base)	36.67 deg	0.696s
A2 (Shoulder)	37.40 deg	0.593s
A3	33.98 deg	0.427s
A4 (Elbow)	31.47 deg	0.378s

Table B.1: Full Speed, 100% Extension, 4kg Payload.

DECLARATIONS AND CERTIFICATES

APPENDIX C

EC- Declaration of Conformity

Herewith we,	Foshan Flexiv Robotics Technology Co., Ltd, Room B409-27, 4th Floor, Building B, Information Avenue, Software Technology Park, Nanhai District, Foshan City, Guangdong Province, China, 528200

declare that the following Appliance complies with the appropriate basic safety and health requirements of the EC Directives (see item 4) based on its design and type, as brought into circulation by us.

This declaration relates exclusively to the machinery in the state in which it was placed on the market, and excludes components which are added and/or operations carried out subsequently by the final user.

1. Designation/ function: Adaptive Robot / Robot Controller

2. Type: Rizon 4 / Hesper

3. Serial number:	XXXXXXXXX
4. Applicable EC Directives:	- Machinery Directive 2006/42/EC
5. Used harmonized Standards:	- EN ISO 10218-1:2011 - EN 60204-1:2018 - EN ISO 12100:2010
6. Responsible for documentation:	Name of authorized representative in EU: Address of authorized representative in EU:
7. *Date /Place/Name/ Authorized Signature:*	*05-20-2021 / Cayman Island / Shiquan Wang*

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Test Verification of Conformity

Verification Number: 191202859SHA-V1

On the basis of the referenced test report(s), sample(s) tested of the below product have been found to comply with the standards harmonized with the directives listed on this verification at the time the tests were carried out. Other standards and Directives may be relevant to the product. This verification is part of the full test report(s) and should be read in conjunction with it <them>.

Once compliance with all product relevant CE mark directives are verified, including any relevant e.g. risk assessment and production control, the manufacturer may indicate compliance by signing a Declaration of Conformity themselves and applying the mark to products identical to the tested sample(s).

Applicant Name & Address:	Shanghai Flexiv Robotics Technology Co., Ltd. Room 1096, Building C, No. 555, Dongchuan Rd, Minhang District, Shanghai, China, 200241
Product Description:	Adaptive Robot
Ratings & Principle Characteristics:	100~240Vac, 50/60Hz, single phase, FLA:15A, SCCR:1500A, max. reach: 780mm, max. payload: 4kg
Models/Type References:	Hesper, Rizon 4
Brand Name:	Flexiv
Relevant Standards:	EN ISO 10218-1:2011 EN 60204-1:2018 EN ISO 12100:2010 EN ISO 13849-1:2015
Verification Issuing Office Name & Address:	Intertek Testing Services Shanghai Building No.86, 1198 Qinzhou Road (North), Shanghai 200233, China
Date of Tests:	September 17, 2021
Test Report Number(s):	191202859SHA-001, 191202859SHA-002, 191202859SHA-003, 210101451SHA-001

Signature

Name: Jonny Jing
Position: Operation Manager
Date: 2021-09-29

Test Verification of Conformity

Verification Number: 210401407SHA-V1

On the basis of the referenced test report(s), sample(s) tested of the below product have been found to comply with the standards harmonized with the directives listed on this verification at the time the tests were carried out. Other standards and Directives may be relevant to the product. This verification is part of the full test report(s) and should be read in conjunction with it <them>.

Once compliance with all product relevant CE mark directives are verified, including any relevant e.g. risk assessment and production control, the manufacturer may indicate compliance by signing a Declaration of Conformity themselves and applying the mark to products identical to the tested sample(s).

Applicant Name & Address:	Shanghai Flexiv Robotics Technology Co., Ltd. Room 1096, Building C, No.555, Dongchuan Rd, Minhang District, Shanghai, 200241
Product Description:	Adaptive Robot
Ratings & Principle Characteristics:	100-240Vac, single phase, 60Hz, FLA: 7.5A, SCCR: 1500A, max.reach:780mm, max.payload:4kg
Models/Type References:	Hesper, Rizon 4
Brand Name(s):	Flexiv
Verification Issuing Office Name & Address:	Intertek Testing Services Shanghai Building No.86, 1198 Qinzhou Road (North), Caohejing Development Zone, Shanghai 200233, China
Date of test:	May 20, 2021

Additional information in Appendix.

Signature

Name: Jonny Jing
Position: Operation Director
Date: Sep 30, 2021

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APPENDIX: Test Verification of Conformity

This is an Appendix to Test Verification of Conformity Number: 210401407SHA-V1

Frequency Range:	2412-2472 MHz
Output Power:	<20dBm
Antenna:	Dipole, 2.0dBi Gain
Network Interface:	WIFI
Duty Cycle:	≤ 100%
Applied Directive:	Radio Equipment Directive (2014/53/EU)

Applied Standards & Test Report Number(s):

Article of RED	Standard	Test Report No.
Article 3.1 a): Safety	EN ISO 10218-1:2011 EN 60204-1:2018 EN ISO 12100:2010 EN ISO 13849-1	191202859SHA-001 191202859SHA-002 191202859SHA-003 210101451SHA-001
Article 3.1 a): Health	EN IEC 62311:2020	210401407SHA-003
Article 3.1 b): EMC	ETSI EN 301 489-1 V2.2.3 ETSI EN 301 489-17 V3.2.4 EN 55032:2015/A11:2020 EN 55035:2017/A11:2020 EN IEC 61000-3-2:2019 EN 61000-3-3:2013+A1:2019	210401407SHA-001 210401407SHA-002
Article 3.2: Radio Spectrum	EN 300 328 V2.2.2	RSC200326001-22B

Signature

Name: Jonny Jing
Position: Operation Director
Date:Sep 30, 2021

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Test Verification of Conformity

Verification Number: 210402468SHA-001

On the basis of the referenced test report(s), sample(s) tested of the below product have been found to comply with the standards harmonized with the directives listed on this verification at the time the tests were carried out. Other standards and Directives may be relevant to the product. This verification is part of the full test report(s) and should be read in conjunction with it <them>.

Once compliance with all product relevant CE mark directives are verified, including any relevant e.g. risk assessment and production control, the manufacturer may indicate compliance by signing a Declaration of Conformity themselves and applying the mark to products identical to the tested sample(s).

Applicant Name & Address:	Shanghai Flexiv Robotics Technology Co., Ltd. Room 1096, Building C, No.555,Dongchuan Rd, Min hang District, Shanghai
Product Description:	Adaptive Robot Control Box Motion Bar
Models/Type References:	Rizon 4 Hesper Motion Bar
Standard(s)/Directive(s):	RoHS Directive 2011/65/EU and (EU)2015/863 of the European Parliament and of the Council with regard to the restriction of the use of certain hazardous substances in electrical and electronic equipment.
Verification Issuing Office Name & Address:	Intertek Testing Services Shanghai Building No.86, 1198 Qinzhou Road (North), Shanghai 200233, China
Test Report Number(s):	210402468SHA-001

Signature

Name:
Position: Operation Director
Date: 29 September 2021

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AUTHORIZATION TO MARK

This authorizes the application of the Certification Mark(s) shown below to the models described in the Product(s) Covered section when made in accordance with the conditions set forth in the Certification Agreement and Listing Report. This authorization also applies to multiple listee model(s) identified on the correlation page of the Listing Report.

This document is the property of Intertek Testing Services and is not transferable. The certification mark(s) may be applied only at the location of the Party Authorized To Apply Mark.

Applicant:	Shanghai Flexiv Robotics Technology Co., Ltd.	**Manufacturer:**	Foshan Flexiv Robotics Technology Co., Ltd.
Address:	Room 1096, Building C, No.555, Dongchuan Rd, Minhang District, Shanghai, 200241	**Address:**	Room B409-27, 4th Floor, Building B, Information Avenue, Software Technology Park, Nanhai District, Foshan City, Guangdong Province
Country:	China	**Country:**	China
Contact:	Mr. Xiaoping Hu	**Contact:**	Mr. Zhuanglin Yang
Phone:	86-15510115783	**Phone:**	86-13148801580
FAX:	/	**FAX:**	/
Email:	xiaoping.hu@flexiv.com	**Email:**	zhuanglin.yang@flexiv.com

Party Authorized To Apply Mark: Same as Applicant
Report Issuing Office: Intertek Testing Services Shanghai Limited

Control Number: *5020526* **Authorized by:** _____
for L. Matthew Snyder, Certification Manager

C ETL LISTED US
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This document supersedes all previous Authorizations to Mark for the noted Report Number.

Intertek Testing Services NA Inc.
545 East Algonquin Road, Arlington Heights, IL 60005
Telephone 800-345-3851 or 847-439-5667 Fax 312-283-1672

Standard(s):	Industrial Robots and Robotic Equipment [UL 1740:2018 Ed.4+R:17Nov2020] Industrial Robots and Robot Systems (R2019) [CAN/CSA Z434:2014 Ed.3+U1]
Product:	Adaptive Robot
Brand Name:	Flexiv
Models:	Hesper, Rizon 4

Test Verification of Conformity

Verification Number: 210401406SHA-V1

On the basis of the tests undertaken, the sample<s> of the below product have been found to comply with the requirements of the referenced specification<s>/standard<s> at the time the tests were carried out. This verification is part of the full test report<s> and should be read in conjunction with it <them>.

Applicant Name & Address:	Shanghai Flexiv Robotics Technology Co., Ltd. Room 1096, Building C, No.555, Dongchuan Rd, Minhang District, Shanghai, 200241
Manufacturer site Name & Address:	Foshan Flexiv Robotics Technology Co., Ltd. Room B409-27, 4th Floor, Building B, Information Avenue, Software Technology Park, Nanhai District, Foshan City, Guangdong Province
Product Description:	Adaptive Robot
Ratings & Principle Characteristics:	100-120Vac, single phase, 60Hz, FLA: 7.5A, SCCR: 1500A, max.reach:780mm, max.payload:4kg
Models/Type References:	Hesper, Rizon 4
Brand Name<s>:	Flexiv
Specification<s>/Standard<s>:	47CFR Part 15 (2019) ANSI C63.4 (2014)
Date of Test:	May 26, 2020
Verification Issuing Office Name & Address:	Intertek Testing Services Shanghai Building No.86, 1198 Qinzhou Road (North), Caohejing Development Zone, Shanghai 200233, China
Test Report Number<s>:	210401406SHA-001

Signature

Name: Jonny Jing
Position: Operation Director
Date: Sep 30, 2021

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Attestation of Conformity

Certificate Number: FS-CRT-0010

Intertek Testing Services NA hereby confirms the below listed collaborative robot on satisfactory evaluation has been deemed to meet the claimed Functional Safety Performance Levels.

Product： Adaptive Robot

Model: Hesper, Rizon 4

Manufacturer: Shanghai Flexiv Robotics Technology Co., Ltd.
Room 1096, Building C, No.555, Dongchuan Rd, Minhang District, Shanghai 200241

The above listed Collaborative robot with seven joints has been evaluated in accordance to below listed Standards and deemed to provide a Performance Level (PL) PL d (Cat. 3)

Standard:	Title:
EN ISO 13849-1:2015	Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design

The decision to award this Attestation is based on satisfactory Certification Review of the following reports:

Report Number:	Issuing Body:
210901954SHA-001	Intertek Testing Services Ltd. Shanghai

Safety Function:

No.	Safety function	External Connection Port (if any)	Performance level (Cat. 3, DC low, CCF score >65, MTTFD>100 years)
SF0	Emergency Stop (Cat. 0 stop)		PL=d
SF1	Emergency Stop (Cat. 1 stop)	DI2a_I0H, DI2b_I0H	PL=d
SF2	Safeguard Stop	DI2a_I3H, DI2b_I3H	PL=d
SF3	Joint Position Limit		PL=d
SF4	Joint Speed Limit		PL=d
SF5	Joint Torque Limit		PL=d
SF6	TCP Position Limit		PL=d
SF7	TCP Speed Limit		PL=d
SF8	TCP Force Limit		PL=d
SF9	Momentum Limit		PL=d
SF10	Power Limit		PL=d
SF11	Safeguard Reset Input	DI2a_I2H, DI2b_I2H	PL=d
SF12	Reduced State Input	DI2a_I1H, DI2b_I1H	PL=d
SF13	Emergency Stop Output	DO2a_OUT0, DO2b_ OUT0	PL=d
SF14	Robot Moving Output	DO2a_OUT1, DO2b_ OUT1	PL=d
SF15	Robot Not Stopping Output	DO2a_OUT2, DO2b_ OUT2	PL=d
SF16	Robot Reduced State Output	DO2a_OUT3, DO2b_ OUT3	PL=d
SF17	Robot Not Reduced State Output	DO2a_OUT4, DO2b_ OUT4	PL=d

ABOUT FLEXIV

Flexiv Ltd. is a global leading general-purpose robotics company, focusing on developing and manufacturing adaptive robots which integrate industrial-grade force control, computer vision and AI technologies. Flexiv provides innovative turnkey solutions and services based on Flexiv robotic systems to customers in multi-industries. The company started in 2016, with core founding team from robotics and AI laboratories at Stanford University. Today, Flexiv has established offices in Santa Clara, Shanghai, Beijing, Shenzhen, Foshan, Taiwan and Singapore.

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