Read the instructions prior to performing any task!

Yu 5 Industrial

Operating manual

Yu 5 Industrial robot

Agile Robots

Hardware version 1.3

Agile Robots SE
Plinganserstraße 134
81369 Munich
GERMANY
Telephone: +49 89 277814-101
Email: welcome@agile-robots.com
Internet: www.agile-robots.com

Translation of the original

About this manual

This manual enables safe and efficient use of the robot Yu 5 Industrial (hereinafter also referred to as the “robot”). This manual is part of the scope of delivery of the robot and must be kept in the immediate vicinity of the robot where it is accessible to personnel at all times.

Personnel must have read this manual carefully and have understood it before starting any work with the robot. A basic prerequisite for safe working is compliance with all safety instructions and handling instructions included in this manual.

Furthermore, the local occupational health and safety regulations and general safety regulations for the area in which the robot is used are also applicable.

Illustrations in this manual are for basic understanding and may differ from the actual execution.

Other applicable documents

This manual contains information on the design and function of the robot, as well as instructions for mechanical and electrical installation of the robot.

In addition to these instructions, the following documents also apply:

- *“Robot Yu 5 Industrial” software manual*
- Declaration of incorporation in accordance with Machinery Directive 2006/42/EC

Limitation of liability

All information and instructions in this manual were compiled taking into account the valid standards and regulations, the state of the art, and our many years of knowledge and experience.

The manufacturer accepts no liability for damage in the following cases:

- Failure to comply with this manual
- Use deviating from the intended use
- Deployment of insufficiently qualified personnel
- Unauthorised modifications
- Technical changes
- Use of unauthorised spare parts

The obligations agreed in the contract documents, the general terms and conditions, and the delivery conditions of Agile Robots SE and the legal regulations valid at the time of conclusion of the contract apply.

Copyright

Naming groups of individuals

For reasons of legibility, the masculine form is sometimes used in this manual; this is intended to refer to persons of both genders.

Customer service

Our customer service is at your disposal for technical information and if you require repairs or experience malfunctions:

Address	Agile Robots SE Am Bleichanger 48c 87600 Kaufbeuren GERMANY
Phone	■ Customer service in German: +49 89 277814-800 ■ Customer service in English: +49 89 277814-810
Email	service@agile-robots.com

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1 Notes and markings in this manual

Safety instructions

Safety instructions in this manual are indicated with symbols. Safety instructions are introduced by signal words which explain in words the extent of the hazard.

DANGER

This combination of symbol and signal word indicates an imminently dangerous situation that will result in death or severe injuries if it is not avoided.

WARNING

This combination of symbol and signal word indicates a potentially dangerous situation that can result in death or severe injuries if it is not avoided.

CAUTION

This combination of symbol and signal word indicates a potentially dangerous situation that can result in minor or slight injuries if it is not avoided.

NOTICE

This combination of symbol and signal word indicates a potentially dangerous situation that can result in material damages if it is not avoided.

UMWELTSCHUTZ!

This combination of symbol and signal word indicates potential dangers to the environment.

Tips and recommendations

This symbol emphasizes useful tips and recommendations, as well as information for efficient and trouble-free operation.

Safety instructions within general instructions

Safety instructions can refer to specific, general instructions. These safety instructions are embedded in the general instruction so that they do not interrupt the flow of reading during the execution of the action. The signal words described above are used.

Example:

01. Loosen screw.
02. ⚠ **CAUTION! Danger of pinching on the lid!**

    Close the lid carefully.
03. Tighten the screw.

Other markings

In order to highlight instructions, results, lists, references and other elements, the following markings are used in this manual:

Label	Explanation
→	Step-by-step instructions
▶	Results of actions
⇳	References to sections of this manual and to other applicable documents
■	Lists without a fixed order
[Button]	Operating elements (e.g. buttons, switches), display elements (e.g. signal lights)
'Display'	Screen elements (e.g. buttons, assignment of function keys)

2 Your robot at a glance

2.1 How collaborative robots work

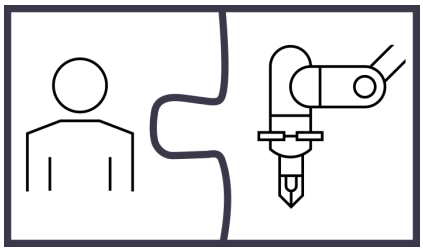

Fig. 1 Human-machine interaction

Collaborative robots are robots that are designed to interact directly with humans. This allows people to work side by side with robots in a common work process. An essential goal of this collaboration is to combine the individual skills of humans with the endurance and accuracy of robots Fig. 1.

Unlike conventional industrial robots, collaborative robotics enables collaboration between humans and robots without spatial separation. This immediate spatial proximity results in new safety requirements to protect the operator from collision forces at all times. In the case of the Yu 5 Industrial robot, the robot is safeguarded on the basis of ongoing monitoring of the following variables:

- Speed
- Position
- Torques
- Mechanical performance

The robot's sensory capabilities, combined with intuitive manual guidance, allow the operator to perform versatile applications in various collaborative scenarios that require frequent adjustment and flexibility.

2.2 The robot and its components

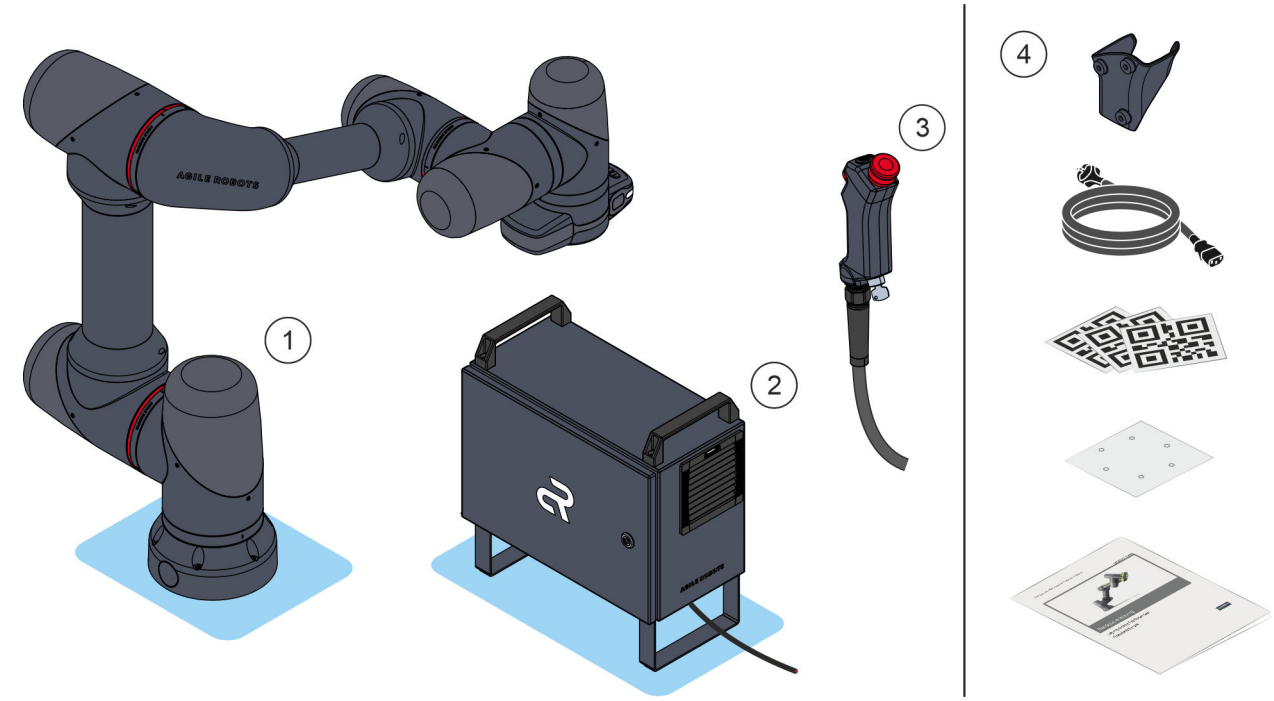

Fig. 2 The robot and its components

① Robot arm
② Robot controller
③ Handheld controller
④ Accessories and user documentation

The Yu 5 Industrial robot consists of the main components (①–③) shown in Fig. 2. The design and function of these main components are described in detail in the following sections.

Additional information on the scope of delivery

In addition to the robot unit, the scope of delivery includes the accessories shown in Fig. 2 and the user documentation.

A detailed overview of all parts included in the scope of delivery can be found in *Chapter 4.1 'Delivery and scope of delivery' on page 99*.

2.2.1 Robot

Design of robot

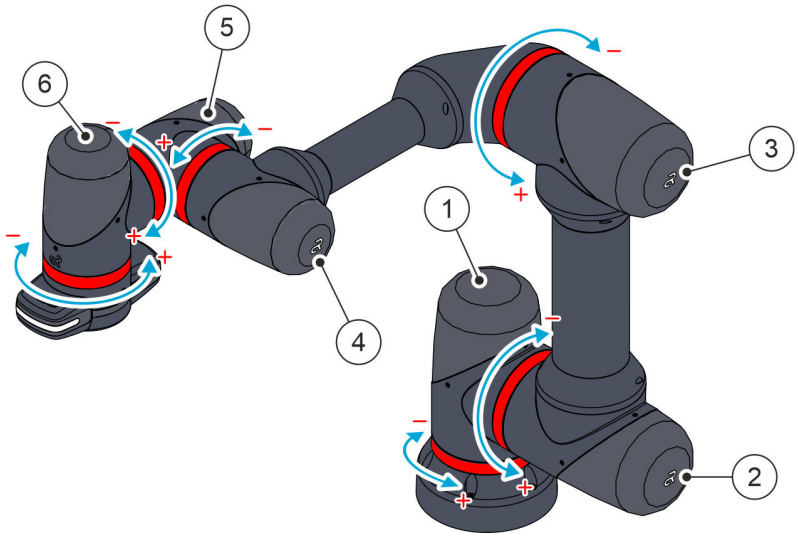

Fig. 3 Overview of robot axes

- Rotation direction of axes
- Joints
- ① Axis 1
- ② Axis 2
- ③ Axis 3
- ④ Axis 4
- ⑤ Axis 5
- ⑥ Axis 6

The robot has a total of six axes Fig. 3/①–⑥, which are connected to each other in a kinematic chain.

The movements of the robot take place along the joints on the robot axes.

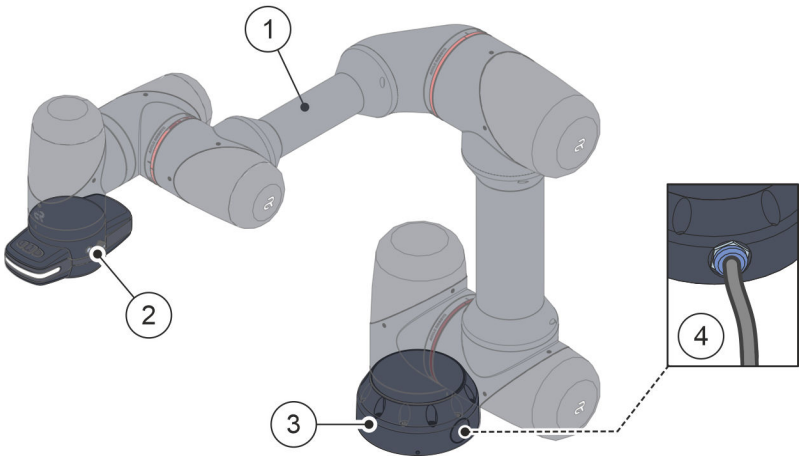

Fig. 4 Media flange and robot base

① Robot arm
② Media flange
③ Robot base
④ Connecting cable (robot – robot controller)

The robot on the robot base Fig. 4/③ is bolted to the mounting surface. The connecting cable Fig. 4/④ for connecting the robot and the robot controller is firmly connected to the robot base.

Tools or other devices can be connected to the robot via the media flange Fig. 4/②.

Design of media flange

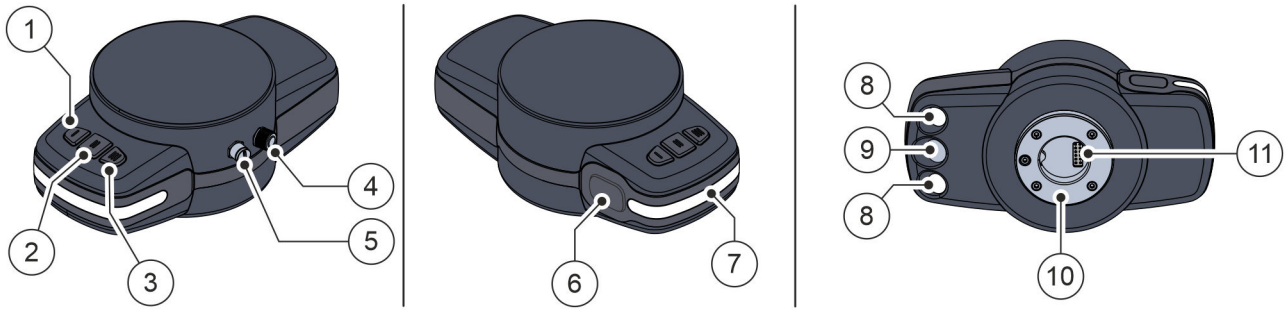

Fig. 5 Design of media flange

① Function key *[1]*
② Function key *[2]*
③ Function key *[3]*
④ External 8-pin electrical interface
⑤ External 6-pin electrical interface
⑥ Manual guidance button
⑦ Status LED
⑧ Camera LED
⑨ Camera
⑩ Tool connecting flange
⑪ Internal 12-pin electrical interface

On the top of the media flange there are three function buttons Fig. 5/① –③ with the following functions:

- Function key *[1]* ➔ Set waypoint for a path command (PTP movement)
- Function key *[2]* ➔ Open/close gripper
- Function key *[3]* ➔ Set waypoint for a path command (linear movement)

A tool can be connected to the robot via the connecting flange Fig. 5/⑩ and the associated electrical interface Fig. 5/⑪. By default, the connecting flange can hold all tool types that meet the requirements of ISO 9409-1-50-4-M6 without additional installation work. For tools that require additional electrical signals to be processed, two additional external interfaces Fig. 5/④ + ⑤ are available (↯ *Chapter 2.2.5 'Interfaces' on page 23*).

When the manual guidance button Fig. 5/⑥ is pressed, the robot arm can be moved and aligned by hand in manual mode. The robot's brakes are released and if the operator touches the robot, a collision stop is not triggered.

Manual guidance button

The manual guidance button is **not** designed as a three-stage button and may be operated with a maximum force of 5 N.

The camera Fig. 5/⑨ on the underside of the media flange enables the robot to be used for variable automation processes that require optical detection of objects and positions (e.g. using AgileTags executed as 2D codes). Thanks to the two camera LEDs Fig. 5/⑧, the camera can also function in darker surroundings.

The following applies to activation of the camera LEDs:

- The camera LEDs can be configured in the user interface to automatically turn on when the camera is capturing an image, i.e. for a few seconds.
- The illumination intensity of the camera LEDs can be set in stages (0–100%) in the user interface.

Status LED overview

The status LED on the media flange indicates the current operating status of the robot according to the following assignment:

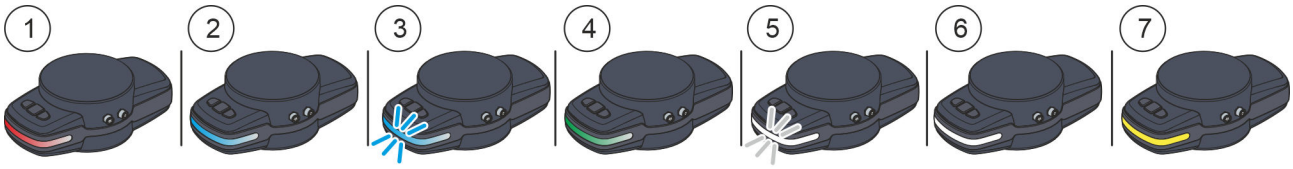

Fig. 6 Robot operating states

No.	Status LED colour	Operating status
Fig. 6/①	Red	**Safety stop** The robot is currently subject to an emergency stop or safety stop: ■ Robot controllers are inactive ■ Brakes are active (*'Safety stop' on page 47*)
Fig. 6/②	Blue	**Manual guidance button** ■ Manual guidance button is actuated ■ Manual guidance of the robot is active
Fig. 6/③	Flashing blue	**Collision stop** ■ Robot is currently subject to a collision stop ■ Drives are still active ■ Brakes are inactive ■ The robot can be moved with little effort even without activating the manual guidance button
Fig. 6/④	Green	**Operational readiness** ■ Robot is ready to start ■ Robot controllers are active ■ Brakes are inactive
Fig. 6/⑤	Flashing white	**Booting procedure** ■ Robot controllers are inactive ■ Brakes are active ■ Robot axes and media flange are powered (24 V) ■ Robot is booting

No.	Status LED colour	Operating status
Fig. 6/⑥	White	**Standby** ■ Booting procedure is complete ■ Robot controllers are inactive ■ Brakes are active
Fig. 6/⑦	Yellow	**Warning** ■ Fieldbus connection is inactive ■ Robot controllers are inactive ■ Brakes are active

2.2.2 Handheld controller

Design of handheld controller

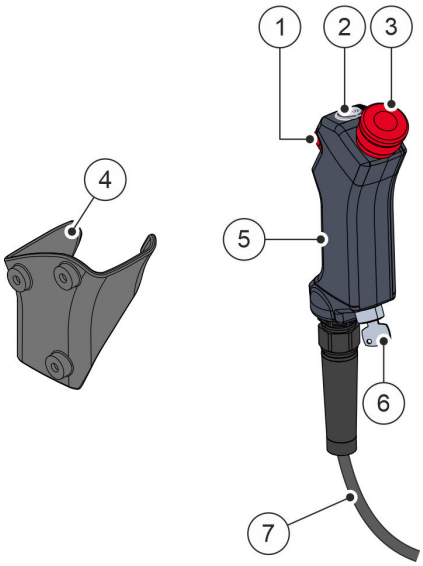

Fig. 7 Handheld controller overview

① Enabling button
② On/off button
③ Emergency stop button
④ Bracket
⑤ Handle
⑥ Mode selector switch
⑦ Connecting cable to the robot controller

The operating elements shown in Fig. 7 can be found on the handheld controller.

The enabling button is used to move the robot using the user interface or with the manual guidance button in manual mode.

Enabling button

It is not possible to use more than one enabling button at the same time.

The enabling button Fig. 7/① must be pressed for each robot movement.

The enabling button is designed as a three-stage button. Robot movements can only be carried out when the enabling button is actively pressed and held in the second stage (middle position) (*page 74*).

Switching off the enabling button's enabling function

The enabling function of the enabling button can be switched off in the safety settings on the user interface.

As a prerequisite for this, the system integrator or the responsible safety engineer must first ensure that the values of the safety configuration are parameterised in the safe range, i.e. the robot is in a collaborative state.

The operating mode of the robot is set using the mode selector switch Fig. 7/⑥. Only authorised operating personnel are allowed to set the operating mode, and they are also responsible for the key (*Chapter 3.9 'Personnel requirements' on page 67*).

The robot can be switched on and off with the on/off button Fig. 7/②. The on/off button has an LED ring that lights up green when the robot is switched on.

Pressing the emergency stop button Fig. 7/③ triggers an emergency stop, which immediately stops all robot movements (*page 73*).
The robot's brakes are applied and the robot can no longer be moved manually by pressing the manual guidance button. To restart the robot, the emergency stop button must be unlocked and the robot must be reset on the user interface (*page 132*).

The handheld controller can be suspended from the bracket Fig. 7/④ close to the robot at a suitable working height. The bracket must be mounted so that when the handheld controller is suspended from it, it is out of the robot's range.

The handheld controller is already connected to the robot controller's connections on delivery.

Disconnection of handheld controller

If the handheld controller becomes disconnected from the robot controller due to cable breakage in the handheld controller cable, a safety stop is automatically triggered.

The stop category of the safety stop depends on which safety device connection is interrupted, e.g. stop category 1 if the emergency stop button cable is interrupted.

2.2.3 Robot controller

Design of robot controller

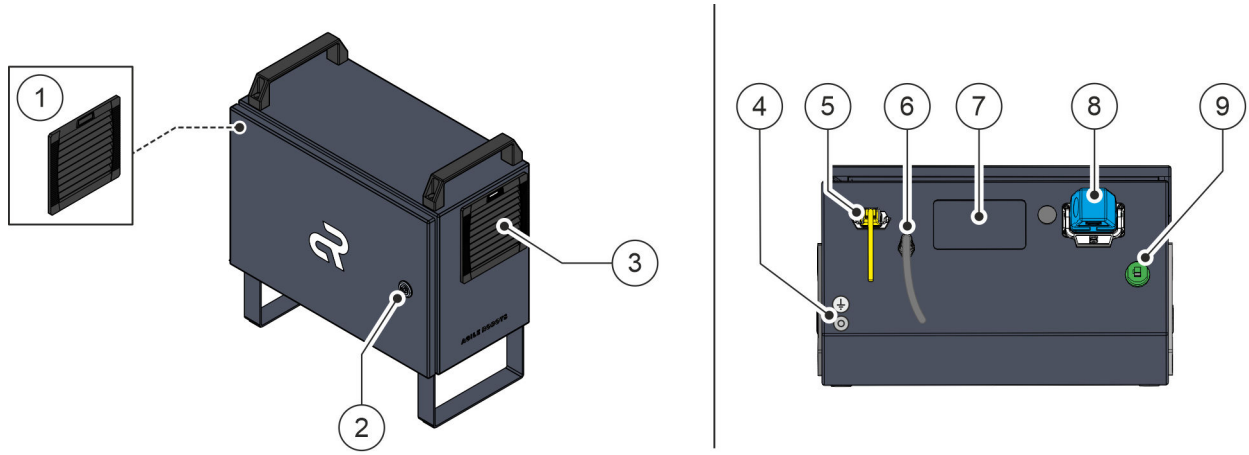

Fig. 8 Overview of robot controller (left), underside of robot controller with connections (right)

① Outlet filter of the fan unit
② Lock
③ Filter fan of the fan unit
④ Connection for local equipotential bonding
⑤ Mains plug power supply (can be unplugged)
⑥ Connecting cable for handheld controller (cannot be unplugged)
⑦ Cable bushing for external devices
⑧ Connecting cable for robot (can be unplugged)
⑨ Ethernet port

In the robot controller Fig. 8, the electrical equipment is protected against external influences. The robot controller contains the interfaces for connecting the robot to external machines and safety devices provided by the owner.

Only the system integrator or a qualified electrician may open the robot controller Fig. 8/②.

The connecting cables for the robot, the handheld controller and the power supply are connected to the bottom of the robot controller Fig. 8/⑧ + ⑥ + ⑤. The mains connection features the following:

- Earthing connection
- Connection fuse

WARNING
Electrical hazards due to residual currents!

The mains connection for the robot is **not equipped** with a residual current circuit breaker.

- Ensure that the mains connection is equipped with a residual current circuit breaker provided by the owner before the robot is put into operation.

Master switch to be retrofitted

We recommend that the owner install a master switch upstream of the mains connection.

The robot is operated with the help of a user interface that can be accessed on a laptop or a tablet. The Ethernet port Fig. 8/⑧ for connecting to the laptop or tablet is also located on the bottom of the robot controller.

IP classification

If IP54 protection is required for the Ethernet port, the owner must fit a plug connection such as **CONEC 17-150254** or **17-150264** to the Ethernet cable.

The robot controller is equipped with a fan unit Fig. 8/① + ③ for cooling.

2.2.4 Accessories and documentation

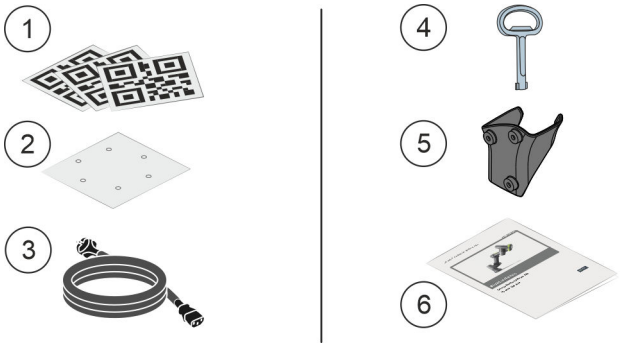

Fig. 9 Accessories and documentation

① AgileTags
② Drilling template
③ Power cable
④ Robot controller key
⑤ Handheld controller bracket
⑥ Operating manual

2.2.5 Interfaces

Cable specification

For additional information on the type and length of cables that may be used for connecting the robot interfaces, see *Chapter 10 'Technical data' on page 169*.

2.2.5.1 Mechanical interface on the media flange

Mechanical interface for tools

Tools can be attached to the media flange via a mechanical interface as specified by ISO 9409-1-50-4-M6.

The specifications in Fig. 10 and Fig. 11 apply to the dimensions of the mechanical interface.

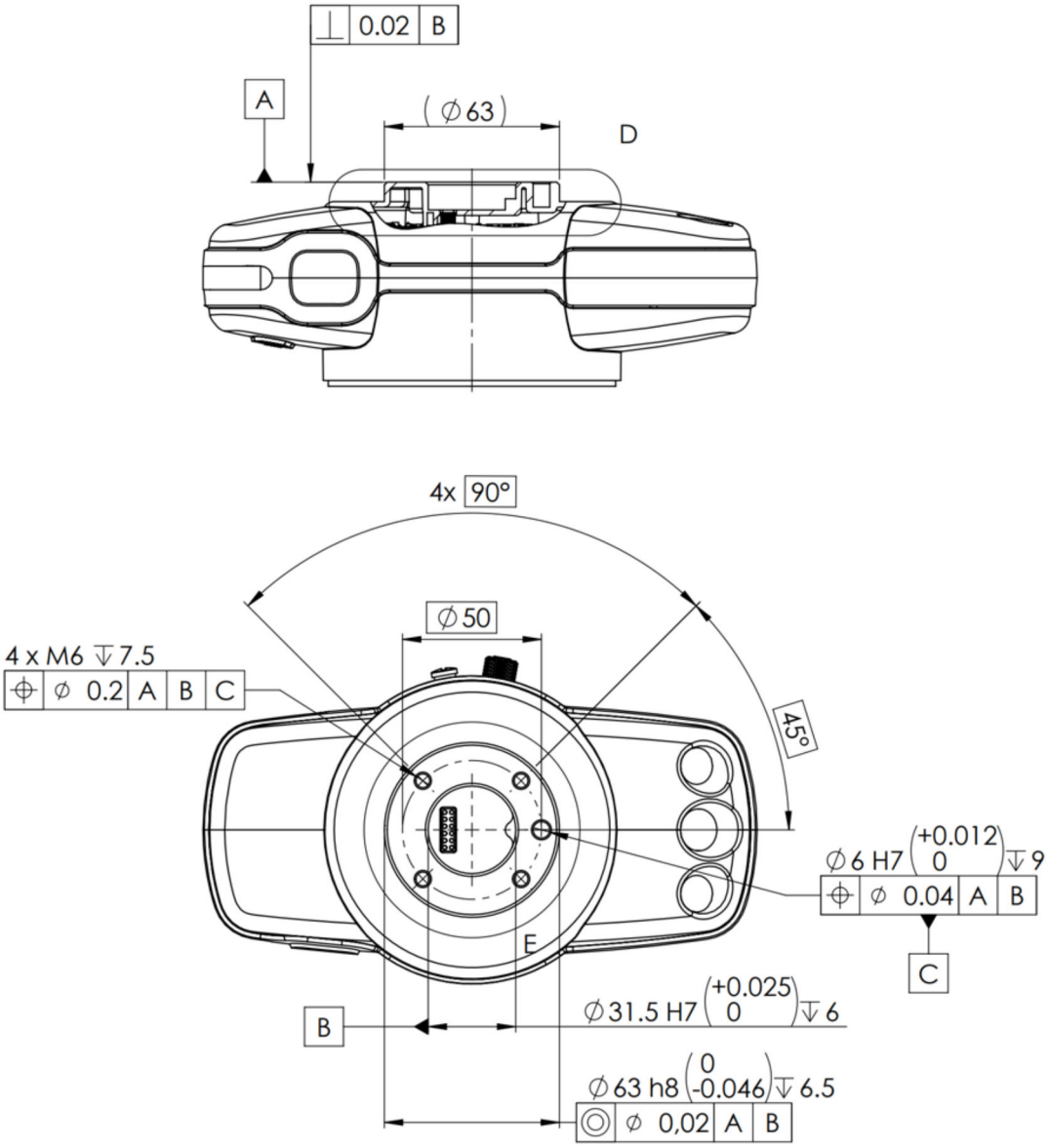

Fig. 10 Dimensions of mechanical interface on the media flange, view 1 (dimensions in mm)

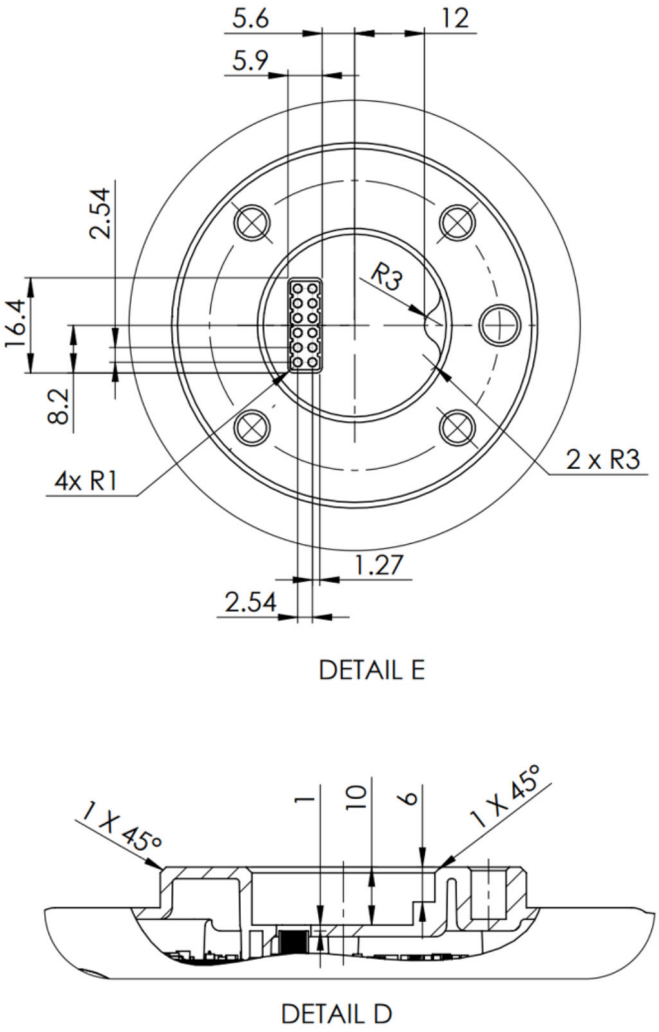

Fig. 11 Dimensions of mechanical interface on the media flange, view 2 (dimensions in mm)

2.2.5.2 Electrical interfaces on the media flange

NOTICE
Risk of robot damage due to overvoltage!

When the robot is connected to external voltage sources, there is a risk of robot damage due to overvoltage if the permissible voltage limit is exceeded.

- Ensure that only systems with low voltage are connected to the robot's external interfaces.

Overview of electrical interfaces on the media flange

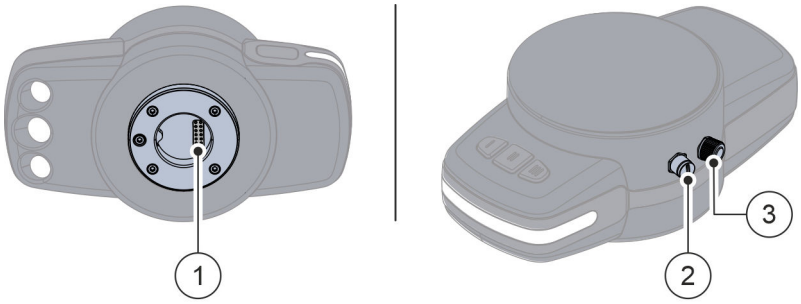

Fig. 12 Media flange with electrical interfaces

① Internal 12-pin electrical interface
② External 6-pin electrical interface
③ External 8-pin electrical interface

The media flange has three electrical interfaces Fig. 12 for supplying and controlling the tools. Internal spring contacts on the connecting flange enable a wireless connection to the tools Fig. 12/①.

Two other interfaces in the form of M8 circular connectors are located on the sides of the media flange Fig. 12/② + ③. The interfaces can be operated individually or, in the case of a multi-tool, simultaneously. The electrical interfaces (I/O interfaces) include digital inputs and outputs as well as analogue inputs. The following sections contain a detailed description of the interfaces.

The power supply for the tools and the logic levels for the digital interfaces are set to 24 VDC with 2 A (max. 48 W).

Internal 12-pin electrical interface

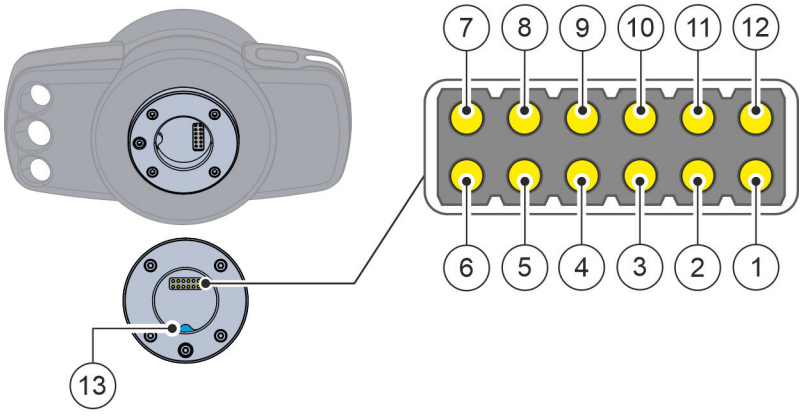

Fig. 13 Layout of 12-pin interface

① GND (earthing connection)
② Analogue input 1 (AI 1)
③ +24 V (max. 48 W), PELV
④ Digital input 1 (DI 1)

⑤ Digital output 1 (DO 1)
⑥ Digital output 3 (DO 3)
⑦ Digital output 4 (DO 4)
⑧ Digital output 2 (DO 2)
⑨ Digital input 2 (DI 2)
⑩ +24 V (max. 48 W), PELV
⑪ Analogue input 2 (AI 2)
⑫ GND (earthing connection)
⑬ Anti-twist protection

Tools can be connected to the media flange via the internal 12-pin interface according to the pin assignment shown in Fig. 13.

The interface consists of 12 spring contacts in two rows with a spacing of 2.54 mm, which are supplied with protective extra-low voltage (PELV).

NOTICE
Risk of damage to property if a tool is used without anti-twist protection!

If a tool is used without anti-twist protection, the robot may be damaged due to a short circuit.

- Ensure that only tools with anti-twist protection are connected to the robot's connecting flange.

PRECI-DIP connector

We recommend the PRECI-DIP connector **813-S1-012-10-014101** for the interface.

The electrical specifications for the 12-pin interface are shown in the following table:

Interface	Parameter	Min	Type	Max	Unit
24 V power supply					
+24 V – GND	Voltage	22	24	26	V
+24 V – GND	Current	0	-	2	A
Digital outputs					

Interface	Parameter	Min	Type	Max	Unit
DO_x/pin 8 (**D**igital **O**ut)	Current	0	-	0.5/0.3	A
DO_x/pin 8	Voltage drop	0	-	0.5/1.75	V
DO_x/pin 8	Leakage current	0	-	0.1/0.002	mA
DO_x/pin 8	Function	-	PNP	-	Type
Digital inputs					
DI_x (**D**igital **I**n)	Voltage	-3	-	30	V
DI_x	OFF range	-3	-	5	V
DI_x	ON range	11	-	30	V
DI_x	Current (11–30 V)	1	-	3	mA
DI_x	Input resistance	-	10	-	kΩ

Interface	Parameter	Min	Type	Max	Unit
Analogue inputs in current mode					
AI_x (**A**nalogue **I**n)	Current	4	-	20	mA
AI_x	Resistance	-	20	-	Ω
AI_x	Resolution	-	12	-	Bit
Analogue inputs in voltage mode					
AI_x	Voltage	0	-	10	V
AI_x	Resistance	-	10	-	kΩ
AI_x	Resolution	-	12	-	Bit

NOTICE
Damage due to lack of protection against overvoltage!

The analogue inputs are not protected against overvoltage in current mode.

Exceeding the limit value specified in the electrical specifications may result in permanent damage to the input.

- Ensure that only systems with low voltage are connected to the robot's external interfaces (see electrical specifications above).

External 8-pin electrical interface (main peripheral)

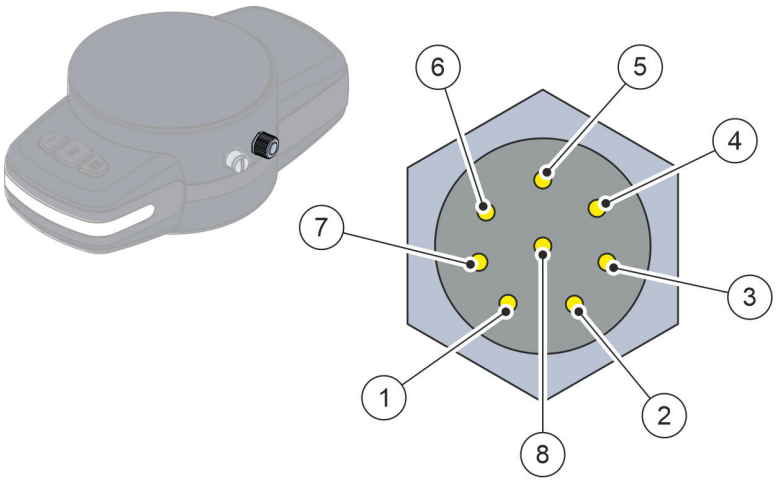

Fig. 14 Layout of 8-pin interface

① Analogue input 3 (AI 3)
② Analogue input 4 (AI 4)
③ Digital input 5 (DI 5)
④ Digital input 4 (DI 4)
⑤ +24 V (24 W), PELV
⑥ Digital output 6 (DO 6)
⑦ Digital output 5 (DO 5)
⑧ GND (earthing connection)

For tools that require additional electrical signals to be processed, an external 8-pin interface is available with a pin assignment as shown in Fig. 14.

The interface allows the tool to be controlled via digital and analogue interfaces. The 8-pin socket provides a supply of 24 V Fig. 14/⑤. The functions of the individual pins and the outputs can be configured in the user interface.

The electrical specifications for the 8-pin interface are shown in the following table:

Interface	Parameter	Min	Type	Max	Unit
24 V power supply					
+24 V – GND	Voltage	22	24	26	V
+24 V – GND	Current	0	-	1	A
Digital outputs					
DO_x/pin 7 (**D**igital **O**ut)	Current	0	-	0.5/0.3	A
DO_x/pin 7	Voltage drop	0	-	0.5/1.75	V
DO_x/pin 7	Leakage current	0	-	0.1/0.002	mA
DO_x/pin 7	Function	-	PNP	-	Type
Digital inputs					
DI_x (**D**igital **I**n)	Voltage	-3	-	30	V
DI_x	OFF range	-3	-	5	V
DI_x	ON range	11	-	30	V
DI_x	Current (11–30 V)	1	-	3	mA
DI_x	Input resistance	-	10	-	kΩ
Analogue inputs in current mode					
AI_x (**A**nalogue **I**n)	Current	4	-	20	mA
AI_x	Resistance	-	20	-	Ω
AI_x	Resolution	-	12	-	Bit
Analogue inputs in voltage mode					
AI_x	Voltage	0	-	10	V
AI_x	Resistance	-	10	-	kΩ
AI_x	Resolution	-	12	-	Bit

NOTICE
Damage due to lack of protection against overvoltage!

The analogue inputs are not protected against overvoltage in current mode.

Exceeding the limit value specified in the electrical specifications may result in permanent damage to the input.

- Ensure that only systems with low voltage are connected to the robot's external interfaces (see electrical specifications above).

External 6-pin electrical interface (M8 connector)

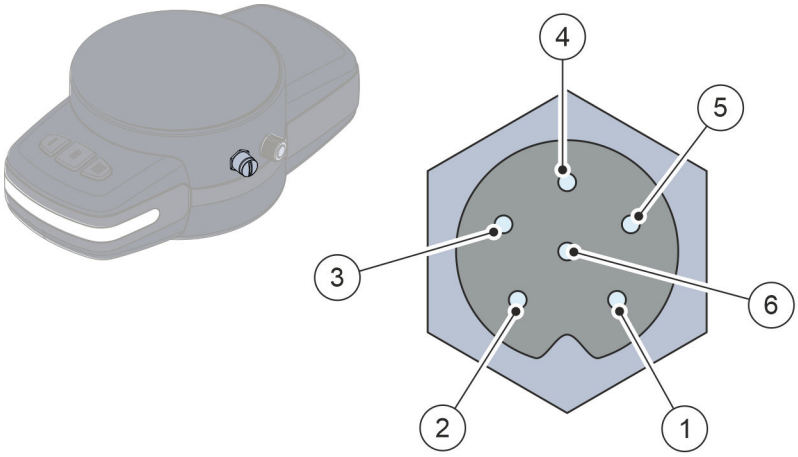

Fig. 15 Layout of 6-pin interface

① Function not yet available
② Function not yet available
③ Function not yet available
④ +24 V (24 W), PELV
⑤ Function not yet available
⑥ GND (earthing connection)

For tools that require additional electrical signals to be processed, an external 6-pin interface is available with a pin assignment as shown in Fig. 15.

The 6-pin socket provides a power supply of over 24 V Fig. 15/④.

The electrical specifications for the 6-pin interface are shown in the following table:

Interface	Parameter	Min	Type	Max	Unit
24 V power supply					
+24 V – GND	Voltage	22	24	26	V
+24 V – GND	Current	0	-	1	A

2.2.5.3 Electrical interfaces in the robot controller

WARNING
Electrical hazards due to dismantling of the covers inside the robot controller!

Dismantling the covers inside the robot controller is not permitted, as there is a danger of fatal electric shock.

- Ensure that the covers within the robot controller are never dismantled.
- Ensure that no unauthorised persons gain access to the robot controller.

NOTICE
Risk of robot damage due to overvoltage!

When the robot is connected to external voltage sources, there is a risk of robot damage due to overvoltage if the permissible voltage limit is exceeded.

- Ensure that only systems with low voltage are connected to the robot's external interfaces.

Maximum pulse cycle for OSSD pulses

The following specification applies to the connection of external electrical devices to the robot's secure digital inputs:

The devices may emit OSSD pulses with a maximum pulse cycle of 950 µs. Otherwise, a safety stop of the robot is triggered.

Access to robot controller

Only the responsible system integrator or a qualified electrician may open the robot controller and connect it to devices provided by the owner.

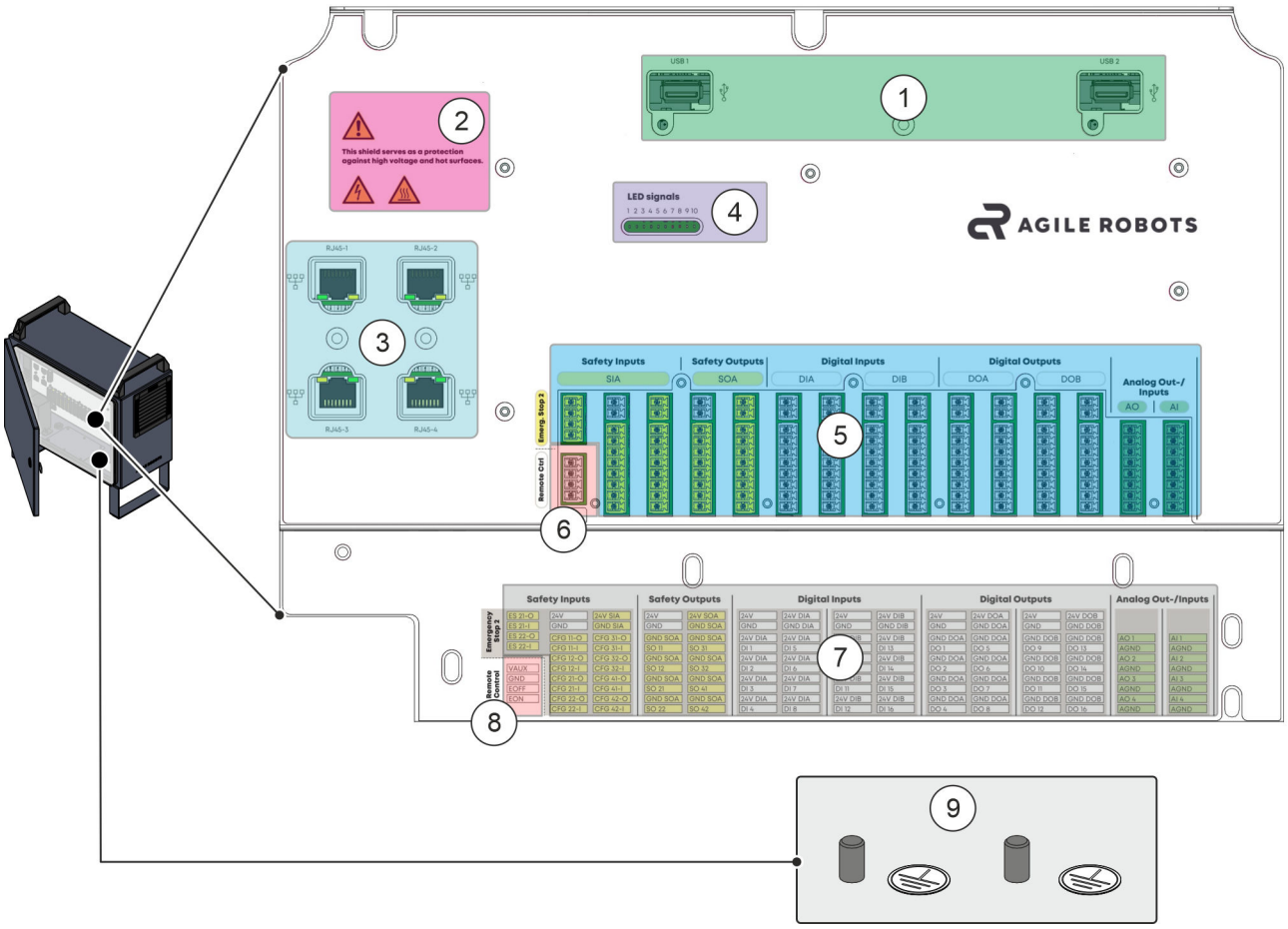

Fig. 16 Overview of open robot controller

① USB ports
② Warning signs
③ Ethernet ports
④ LED signal lights
⑤ I/O interfaces
⑥ Remote control interface
⑦ Labelling of the I/O interfaces
⑧ Labelling of the remote control interface
⑨ Protective conductor connection points

Opening the door on the robot controller gives the system integrator or the electrician access to the electrical input and output interfaces (hereinafter: I/O interfaces) of the robot unit Fig. 16/⑤.

The I/O interfaces are used to transmit digital control signals from or to an electrical device provided by the owner. The following sections describe the individual interface groups in detail. The connection of equipment provided by the owner is described in *Chapter 6.4 'Connecting the robot to the owner's components' on page 137*.

In addition to the I/O interfaces, the robot controller includes other ports such as USB and Ethernet ports Fig. 16/① + ③ that allow additional connections to external devices.

Warning signs Fig. 16/② and LED signal lights are also installed on the robot controller Fig. 16/④.

USB ports

Fig. 17 USB ports

The two USB ports on the robot controller Fig. 17 provide additional connection options between the robot and external devices. Both USB ports are designed as USB 3.0 type A.

The following maximum values apply to the power supply for the connections:

- I_{max} = 0.9 A
- P_{max} = 4.5 W

Ethernet ports

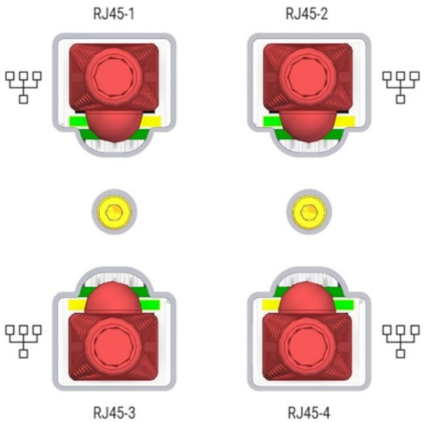

Fig. 18 Ethernet ports RJ45-1/2/3/4

The four Ethernet ports RJ45-1/2/3/4 for the robot controller Fig. 18 are used to exchange data between the robot and external devices. A DHCP client is active; this allows access to the internet, for example.

LED signal lights

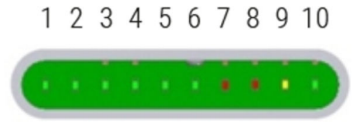

Fig. 19 LED signal lights

The LED signal lights Fig. 19 indicate the system state of the robot controller's components. If the robot does not start properly, the LED signal lights can be used, for example, to perform a fault analysis using the boot procedure.

Remote control interface

Fig. 20 Remote control interface

An external remote control Fig. 20 can be connected to the robot via the remote control interface. A PLC (programmable logic controller) can be connected to provide an external control system, for example.

The interface is supplied with **p**rotective **e**xtra-**l**ow **v**oltage (PELV).

The following pin assignment applies:

- Pin *[VAUX]* ➔ 12 V
- Pin *[GND]* ➔ GND (earthing connection)
- Pin *[EOFF]* ➔ remote control inactive
- Pin *[EON]* ➔ remote control active

Protective conductor connection points

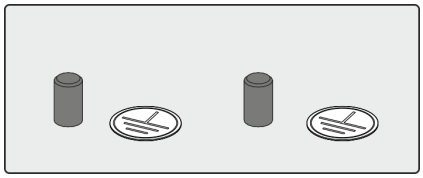

Fig. 21 Protective conductor connection points

There are two protective conductor connection points in the robot controller for discharging electrical currents Fig. 21.

The protective conductor connection points can be reached via the cable bushing on the underside of the robot controller.

I/O interfaces

Fig. 22 Overview of I/O interfaces

① I/O interfaces
② Labelling of the I/O interfaces

I/O interfaces are used to transmit digital control signals from or to external devices provided by the owner according to the arrangement in Fig. 22.

Analogue outputs

The terminals for the analogue outputs are intended for future connection options for the robot Fig. 22.

All I/O interfaces are supplied with PELV (**p**rotective **e**xtra-**l**ow **v**oltage). The I/O interfaces may only be connected on the owner's side to PELV circuits.

The following devices, among others, can be connected to the I/O interfaces:

- Sensors/actuators
- Programmable logic controllers (PLC)
- Emergency stop buttons (only via the safety I/O interfaces)

The following colour scheme applies to the I/O interfaces:

Colour scheme	Meaning
Yellow with black lettering	Safety I/O interfaces (digital I/O interfaces that can be configured exclusively for safety devices and functions)
White with black lettering	General purpose digital I/O interfaces
Green with black lettering	General purpose analogue I/O interfaces

Common specifications for all digital I/O interfaces

This section defines the electrical specifications for the following 24 V digital I/O interfaces of the robot controller:

- Safety I/O interfaces (not configured and configured)
- Configurable digital I/O interfaces

External power supply

If the owner desires, an external power supply can be connected. Observe the procedure described in *Chapter 6.4.1 'Connecting the external power supply' on page 139*.

The following values apply to the electrical specifications for the internal and external power supply:

Terminals	Parameter	Min	Type	Max	Unit
Internal 24 V power supply					
[24 V – GND]	Voltage	20.4	24	27.6	V
[24 V – GND]	Current	0	-	4	A
External 24 V input requirements					

Terminals	Parameter	Min	Type	Max	Unit
[24 V DI(A/B)/ DO(A/B) – GND DI(A/B)/ DO(A/B)]	Voltage	19.2	24	30	V
[24 V DI(A/B)/ DO(A/B) – GND DI(A/B)/ DO(A/B)]	Current	0	-	4	A

The digital I/O interfaces meet the requirements of the IEC 61131-2 standard.

The associated electrical specifications are shown in the following table:

Terminals	Parameter	Min	Type	Max	Unit
Digital outputs					
[CFGx-O/SOx/Ex-O/ OMx-O/DOx]	Current	0	-	Maximum 0.5 per output	A
[CFGx-O/SOx/Ex-O/ OMx-O/DOx]	Maximum voltage drop	0	-	0.5	V
[CFGx-O/SOx/Ex-O/ OMx-O/DOx]	Leakage current	0	-	0.1	mA
[CFGx-O/SOx/Ex-O/ OMx-O/DOx]	Function	-	PNP	-	Type
[CFGx-O/SOx/Ex-O/ OMx-O/DOx]	IEC 61131-2	-	1A	-	Type
Digital inputs					
[CFGx-I/Ex-I/OMx-I/ DIx]	Voltage	-3	-	30	V
[CFGx-I/Ex-I/OMx-I/ DIx]	OFF range	-3	-	5	V
[CFGx-I/Ex-I/OMx-I/ DIx]	ON range	11	-	30	V

Terminals	Parameter	Min	Type	Max	Unit
[CFGx-I/Ex-I/OMx-I/DIx]	Current (11–30 V)	2	-	15	mA
[CFGx-I/Ex-I/OMx-I/DIx]	Function	-	PNP	-	Type
[CFGx-I/Ex-I/OMx-I/DIx]	IEC 61131-2	-	3	-	Type

Safety I/O interfaces

This section describes the special safety inputs (yellow terminals with black lettering) and configurable I/O interfaces that are configured as safety I/O interfaces.

The electrical specifications defined on *page 37* apply to the safety I/O interfaces.

All safety I/O interfaces are arranged in pairs (redundant) and must be maintained as two separate instances. This way, a single malfunction will not result in the loss of the safety function.

The emergency stop function (only for emergency stop devices according to EN 60947-5-5) is designed as a permanent safety input.

The following assignment applies to the emergency stop function:

Specification	Value
Robot movement stops	✓
Program execution	Stopped
Robot current* (48 VDC)	Off
Reset	Manual
Frequency of use	Not often
Requires acknowledgement in the user interface	✓
Stop category (DIN EN 60204-1:2019-06)	SS1

* Sensors are still supplied with power

The configurable I/O interfaces can be used to set up additional safety I/O interfaces such as an emergency shutdown output. The configurable I/O interfaces are set up on the user interface.

Safety I/O interfaces

Examples of connecting safety I/O interfaces are listed in *Chapter 6.4.2 'Connecting safety I/O interfaces' on page 141*.

Default safety configuration

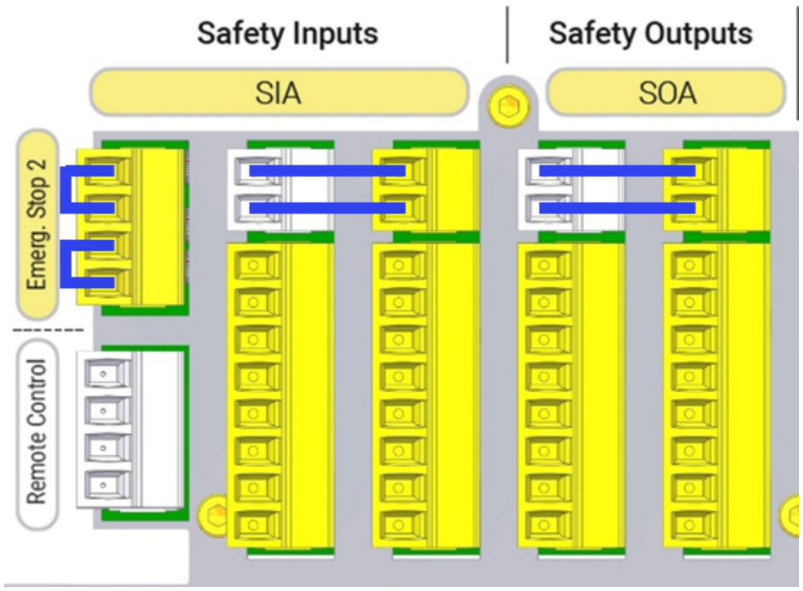

Fig. 23 Safety I/O interfaces reserved by default

— Jumpers

The safety I/O interfaces indicated in Fig. 23 have fixed jumpers when the robot is delivered.

General purpose digital I/O interfaces

The electrical specifications defined on *page 37* apply to the digital I/O interfaces.

The general digital I/O interfaces (grey terminals) can be used for direct control of external devices such as pneumatic relays or for communication with a PLC.

Digital I/O interfaces

Examples of connecting digital I/O interfaces are listed in *Chapter 6.4.3 'Connecting digital I/O interfaces' on page 143*.

General purpose analogue I/O interfaces

The analogue I/O interfaces (green terminals) can be used to record the voltage of devices provided by the owner.

Analogue outputs

The terminals for the analogue outputs are intended for future connection options for the robot.

The following values apply to the electrical specifications for the analogue I/O interfaces:

Terminals	Parameter	Min	Type	Max	Unit
Analogue input in voltage mode					
[AIx – AGND]	Voltage	0	-	10	V
[AIx – AGND]	Resistance	-	10	-	kΩ
[AIx – AGND]	Resolution	-	12	-	10
Analogue output in voltage mode					
[AOx – AGND]	Voltage	(0)*	-	(10)*	V
[AOx – AGND]	Current	(0)*	-	(20)*	mA
[AOx – AGND]	Resistance	-	(1)*	-	Ω
[AOx – AGND]	Resolution	-	(12)*	-	Bit

* Intended for future robot versions

Analogue I/O interfaces

Examples of connecting analogue I/O interfaces are listed in
Chapter 6.4.4 'Connecting analogue I/O interfaces' on page 144.

2.2.6 Operating modes and operating states of the robot

Automatic mode

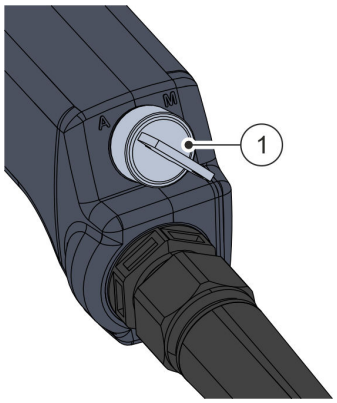

Fig. 24 Mode selector switch on the handheld controller (automatic mode)

Automatic mode Fig. 24/A is switched on at the mode selector switch Fig. 24/① on the handheld controller.

In automatic mode, the operator can load, start and stop programs.

Manual mode

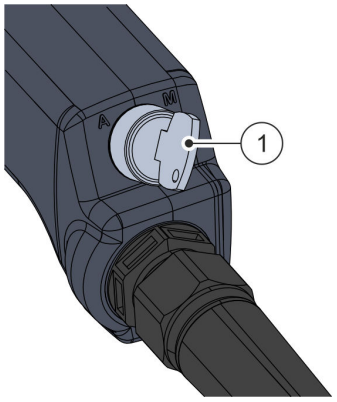

Fig. 25 Mode selector switch on the handheld controller (manual mode)

Manual mode Fig. 25/M is switched on at the mode selector switch Fig. 25/① on the handheld controller.

Manual mode is available to the following groups of operating personnel:

- Maintenance specialists
- Programmers
- Safety engineers
- System integrators

In manual mode, the robot can be moved manually by entering data into the user interface. To do so, press and hold the enabling button on the handheld controller in the middle position.

The speed of the robot is limited to 250 mm/s here. Faster movements of the robot can be enabled in the user interface by actively confirming this.

The different speeds are intended for the following robot applications:

- Speed ≤ 250 mm/s
  - Jogging
  - Creating and testing new programs
  - Teaching the robot
- Speed > 250 mm/s
  - Exclusively for verifying the correct program sequence when creating new programs

The system integrator or the responsible safety engineer can cancel the enabling function by actively confirming this in the safety configuration. To do so, the system integrator must have performed a risk assessment in advance to ensure that robot movements in the current environment and with the currently active safety configuration do not pose a danger to personnel.

If the enabling function is cancelled, the distinction mentioned above between reduced and increased speed no longer applies. In this case, the robot can be moved for all applications at the speed defined in the force and power limitation.

We recommend keeping all persons out of the robot's hazard area when working in manual mode.

NORMAL and reduced MODE

The forces used to move the robot are determined by the force and power limitation.

The system integrator or the responsible safety engineer can define the specific values of the force and power limitation using customised parameter sets for NORMAL mode and for REDUCED mode.

By default, the parameter set for NORMAL mode is active. This applies to automatic and manual operating modes.

The NORMAL and REDUCED parameter sets in detail

For further information on how to configure the two parameter sets, refer to *page 79*.

Rescue mode

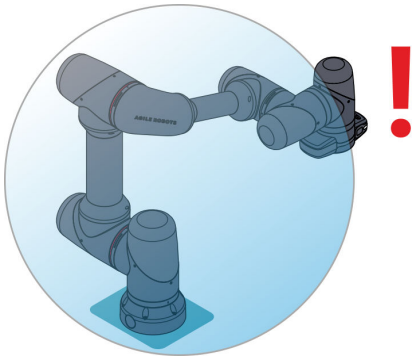

Fig. 26 Exceeding the robot's working space limits

Rescue mode can be activated by the system integrator or by one of the owner's authorised safety engineers on the user interface, in order to release the robot from an error position. To do this, the following conditions must be met:

- The robot is at a standstill.
- The robot is in manual mode.
  Chapter 6.3.3 'Switching the operating mode' on page 131
- Rescue mode is activated on the user interface.

Rescue mode is intended for the following error states:

- The robot's working space limits have been exceeded.
- The robot's axis limits have been exceeded.
- The robot has registered a self-collision.

Using rescue mode

Use of rescue mode outside the cases specified above may require additional safety measures on the part of the owner.

Note the dangers in rescue mode *Chapter 3.3.8 'Dangers in rescue mode' on page 60***.**

After rescue mode is activated, the robot can be moved manually from the error position using manual guidance or using jog mode in the user interface (recommended). To do this, the enabling button must be pressed and held in the middle position.

This also applies if the enabling button has been deactivated in the user interface. In rescue mode, the robot can be moved at a maximum Cartesian velocity of 250 mm/s.

The following restrictions also apply:

- The axis speed is significantly reduced.
- The robot performance is significantly reduced.
- The following safety functions are inactive:
  - Safely limited axis position
    (Safely Limited Drive Position (SLDP))
  - Safely limited Cartesian position
    (Safely Limited Cartesian Position (SLCP))
  - Safely limited Cartesian orientation
    (Safely Limited Cartesian Orientation (SLCO))
  - Safely limited Cartesian force
    (Safely Limited Cartesian Force (SLCF))

After rescue mode is deactivated, the safety functions are activated again. The enabling button's enabling function may be deactivated again, provided that the function was previously deactivated in the user interface.

Rescue mode

Rescue mode is **not** indicated by the status LED on the media flange.

Collision stop

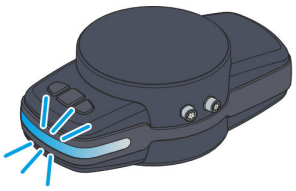

Fig. 27 Status LED for collision stop

The collision stop is triggered in automatic and manual modes by physical contact with the robot. This only applies if collision detection has not been disabled in the user interface.

All robot movements and the currently active program are stopped immediately in the event of a collision stop. The program can be restarted once the collision state no longer applies.

In the event of a collision stop, the status LED on the media flange flashes blue Fig. 27.

In this case, the robot can also be moved manually without pressing the manual guidance button. To put the robot back into operation, the manual guidance button must be pressed.

Alternatively, the robot can also be put into standby mode and then switched back to active mode.

Collision stop

The collision stop is **not** designed as a safety-related stop.

Collaborative and non-collaborative state

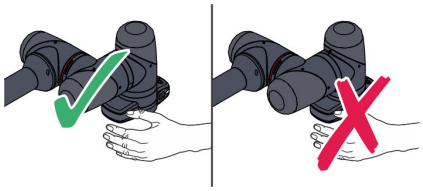

Fig. 28 Collaborative and non-collaborative state

Depending on the parameters in the safety configuration, the robot may be in either the collaborative or non-collaborative state.

In the collaborative state, humans and robots can share the same workspace because the robot moves at a reduced speed. To enable this, the system integrator or the responsible safety engineer must ensure that the permissible biomechanical limits for human-machine collisions are not exceeded in the event of physical contact with the robot (ISO/TS 15066) by setting the parameters for force and power limitation accordingly.

In the non-collaborative state, the operator must be protected from the robot's movements by protective measures provided by the owner (e.g. enclosures, light barriers). It is then not possible to work together in the same workspace.

Safety stop

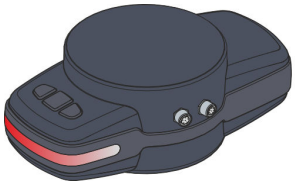

Fig. 29 Status LED for safety stop

In the event of a safety stop, all robot movements are immediately stopped by switching off the power electronics, and the robot's brakes are actuated. A safety stop is triggered in the following situations:

- When the emergency stop button on the handheld controller is pressed.
- If there is a fault in the safety controller.
- If the robot is in motion and the operating mode is changed on the mode selector switch.
- If the enabling button on the handheld controller is in the middle position and the operating mode is changed on the mode selector switch (in both automatic mode and in manual mode).
- If any of the robot's safety functions are triggered, e.g. because the maximum allowable speed is exceeded (↯ *page 76*).
- If an external safety device provided by the owner is connected to the safety I/O interfaces in the robot controller and this safety device is triggered.

After a safety stop, the robot cannot be moved with the manual guidance button even in manual mode. However, in order to be able to release the robot quickly in the event of entrapment, for example, it is possible to move the robot by exerting force even after a safety stop.

In the event of a safety stop, the status LED on the media flange lights up red Fig. 29.

Status LED

The status LED is not a certain indicator and may therefore be faulty.

The specific cause of a safety stop is displayed in the status display on the user interface.

In order to be able to put the robot back into operation after a safety stop, the event that triggered the safety stop must be corrected and a reset must be carried out in the user interface (↬ *page 132*).

3 For your safety

3.1 Scope of the manual

The information in this manual is intended to enable the owner to operate and maintain the robot properly. This does not include information on how a complete robot application can be developed, installed or operated by the responsible system integrator.

The system integrator must have understood the locally applicable safety regulations for automation processes and ensure compliance with the regulations for all robot applications and for the owner's overall system in which the robot is integrated.

The owner's responsible personnel must have read this manual carefully and have understood it before the robot is switched on for the first time.

3.2 Intended use

Use

The Yu 5 Industrial robot is intended exclusively for handling and transporting components or products using a tool or similar devices in an industrial environment.

Operating personnel working with or on the robot must have the qualifications specified in *Chapter 3.9 'Personnel requirements' on page 67*.

The robot can only be used under specific ambient conditions. The ambient conditions are listed in *Chapter 10 'Technical data' on page 169*.

The robot is designed for collaborative operation in close proximity to the operator. Collaborative operation of the robot is only intended for applications that have been subjected to a comprehensive risk assessment by the owner's responsible system integrator. The risk assessment must ensure that the entire application including the tools, workpiece and all possible collision and entrapment scenarios in the robot's working area are free of sources of danger for the operator.

For collaborative operation of the robot, the system integrator or the responsible safety engineer must first have parameterised the values of the safety configuration in a secure area. This means that robot does not exceed the permissible biomechanical limits for human-machine collisions.

When designing collaborative robot applications, the system integrator must also observe the requirements of EN ISO 10218-2 and ISO/TS 15066.

Intended use also includes compliance with all requirements in this manual.

Misuse

Any use going beyond the intended use counts as misuse of the robot:

- Use outside the specified operating limits (*Chapter 10 'Technical data' on page 169*)
- Use in a potentially explosive atmosphere
- Use in earthquake-prone areas
- Use in a vacuum

- Use in the non-industrial sector (definition of terms based on DIN EN ISO 10218-1:2012-01 Chap. 1, Note 1)

  Examples of non-industrial areas and applications:

  - Underwater, military and space robots
  - Remotely operated manipulators
  - Prosthestics and other aids for people with physical disabilities
  - Microrobot (travel less than 1 mm)
  - Surgery and health care
  - Service or consumer products
  - Schools and teaching facilities
- Use in medical, vital or life-sustaining applications
- Use without issuing a declaration of conformity in accordance with the Machinery Directive for the owner's overall system
- Use of unsuitable and untrained personnel
- Carrying out welding work with spark formation in the area of the robot (arc welding)
- Making changes:
  - to the robot
  - to its components
  - to the electrical installation
  - to the controller
- Use without protective enclosures or safety devices
- Use above the robot's maximum loading weight (*Chapter 10 'Technical data' on page 169*)
- Operation without a mains connection that can be locked in the disconnected state
- Use in the event of safety-related malfunctions or in a faulty state
- Failure to comply with the owner's safety requirements and accident prevention regulations as well as non-compliance with maintenance and inspection deadlines
- Use of operating materials and auxiliary materials that have not been agreed with the manufacturer or have not been approved in the operating manual
- Use of force and power limitation without correctly set parameters
- Loading of third-party programs or modification of programs by unauthorised persons

- Use if the safety configuration has been changed by the system integrator or the responsible safety engineer, but has not yet been approved by means of a risk assessment
- Use if the safety configuration has been changed by someone other than the system integrator or the responsible safety engineer

  If such a case nevertheless occurs, have the robot parameterised by the responsible system integrator or safety engineer before putting it back into operation.
- Use on mobile platforms or other moving components that are not designed and approved for it
- Use as a climbing aid
- Improper use of manual guidance

  If the robot is to be moved in non-collaborative operation using manual guidance:
  - The enabling button on the handheld controller and the manual guidance button on the media flange must be operated by the same person.

    Never allow a person to operate the enabling button while another person is guiding the robot by hand.
  - Ensure that during manual guidance by a person, no other person is in the vicinity of the mobile device that could make entries in the user interface. Data entry in the user interface poses a risk of injury to personnel guiding the robot manually due to unintentional robot movements.

    If possible, lock the mobile device before starting manual guidance.
- Use of spare parts not approved by the manufacturer

3.3 Residual hazards

The following section describes residual hazards associated with the robot even when it is used as intended.

3.3.1 Dangers due to electrical energy

Electrical voltage

DANGER
Danger to life due to voltage!

Contact with live parts poses an immediate danger to life due to electric shock. Damage to the insulation or to live components can be life-threatening.

- If the insulation is damaged, switch off the robot immediately and arrange for it to be repaired.

  To do this, contact Agile Robots SE customer service (*page 4*).
- Before carrying out any work on the electrical interfaces in the robot controller, always observe the following:
  - Only permit qualified electricians to work on the electrical system in the robot controller.
  - Voltage may also be present at the electrical interfaces even after the power supply has been disconnected.
- Only use the original cables provided with the robot.

  To replace the original cables, contact Agile Robots SE customer service (*page 4*).
- Keep liquids and chemical substances away from live components and all robot components.
- Ensure that the covers within the robot controller are never dismantled.
- Ensure that the mains disconnection device (mains plug) is always accessible to the operator.
- Ensure that a residual current circuit breaker is installed in the owner's electrical system.
- Never disconnect the robot cable from the robot controller during operation.

  Before putting the robot into operation, ensure that the bracket on the robot cable connector is locked onto the robot controller.
- Never disconnect the power cable from the robot controller or power supply during operation.

  This does not apply if the power supply to the robot needs to be disconnected as quickly as possible in an emergency.
- After disconnecting the robot cable from the robot controller and after disconnecting the power cable, do not touch the exposed contacts for at least five minutes.

Dangerous residual voltages may be present at the contacts.

- Ensure that cables are not kinked, pinched or stretched.
  Do not extend or modify cables.
- Ensure that an overvoltage protection device *'Overvoltage protection' on page 54* is installed in the robot controller.

Overvoltage protection

Overvoltage protection

An overvoltage protection device (type 3 charge eliminator with thermal monitoring and acoustic fault warning) is installed in the robot controller.

If the overvoltage protection device is overloaded, the internal protection circuit is disconnected from the mains. If the acoustic fault warning sounds, the robot controller must not be used.

For insulation resistance testing up to 500 VDC, the charge eliminator does not have to be disconnected.

For test voltages above 500 V, the charge eliminator must be disconnected. To do this, contact Agile Robots SE customer service (*page 4*).

3.3.2 Dangers if the robot's safety configuration is changed

Dangers if the robot's safety configuration is changed

WARNING
Risk of injury if the robot's safety configuration is changed!

If the robot's safety configuration is not properly parameterised, there is a risk of injury to the operator.

- The safety configuration can only be changed by the system integrator or by the responsible safety engineer.
- Ensure that the safety PIN is always protected against unauthorised access.
- Ensure that a risk assessment of the planned application is performed by the system integrator each time before a new robot application is set up. The risk assessment must show that all robot movements, including the tools or other devices connected to the media flange, do not constitute a source of danger for the operator.
- Before changing the current safety configuration, check the requirements that may arise, for example, if the tool is changed, if additional components are connected or if the work process or the robot environment change.
- Ensure that after each change to the safety configuration (i.e. the safety ID for the safety configuration also changes) the system integrator or the responsible safety engineer personally checks the safety parameters in a test operation for possible risks and functionality.

Setting the safety configuration parameters

For more information on parametrising the safety configuration and the safety ID, refer to the associated software manual:

↳ *"Robot Yu 5 Industrial" software manual*

3.3.3 Dangers due to movements of the robot

Dangers due to movements of the robot

WARNING
Risk of injury due to movements of the robot!

In order to keep the risk of injury to a minimum in all contact situations with the robot, always observe the following specifications, even in collaborative operation:

- When working with the robot, always wear close-fitting protective work clothing.

  Wear suitable hair protection for long hair.

  Chapter 3.10 'Personal protective equipment' on page 71
- Ensure that no objects such as jewellery that could be caught on the robot are worn on the body.
- Only connect tools and devices to the media flange that have been classified as safe by the system integrator as part of the risk assessment for the respective application.
- In collaborative operation, never use pointed or sharp-edged tools or devices on the robot and ensure that there are no sharp edges in the surroundings.
- Ensure that the robot's manual guidance is only used if the current application has been classified as safe by the safety integrator.
- Ensure that no people are in the hazard area before the robot is switched on.

  When it is switched on, the robot performs a self-test of the 48 V power supply. In the event of damage to or failure of the robot brakes, they may release and trigger uncontrolled movements of the robot.

  Operating personnel must always be informed of these risks during the starting process.
- When remote mode is active, the single point of control (SPoC) is no longer guaranteed and robot movements can be performed from a location other than the connected mobile device.

  Ensure that only authorised operating personnel activate and monitor remote mode.

Before activating remote mode, make sure that no unexpected movements that could startle personnel are triggered.

- When changing from the NORMAL parameter set (if configured for non-collaborative operation) to the REDUCED parameter set (if configured for collaborative operation):

  Make sure that the robot is in a collaborative state before a contact situation with people can arise.
- Make sure that only authorised operating personnel operate the robot using the handheld controller in manual mode.

  Note the following here:
  - Ensure that no hazards arise from the robot's movements during manual operation.
  - Ensure that there are no people in the robot's hazard area.
- Ensure that the operator is informed about the position and functioning of the safety devices.

3.3.4 Dangers due to falling objects

Dangers due to falling objects

WARNING
Dangers due to falling objects!

When an emergency stop or a safety stop of stop category 0 or 1 is triggered, the robot's 48 V power supply is shut down. As a result, the tool currently connected to the media flange is de-energised.

In the case of a gripper unit, there is a risk that the gripper unit will open and objects will fall from it. This risk also exists if the gripper unit is unintentionally opened due to operating errors on the user interface.

- When designing a robot application, ensure that the system integrator takes into account the risks arising from an object falling from the gripper unit.
- Ensure that personnel are informed of the risks of falling objects when an emergency stop or safety stop is triggered.
- If necessary, use a self-holding gripper as a tool.

3.3.5 Dangers when restarting the robot after a collision

Dangers when restarting the robot after a collision

WARNING
Dangers when restarting the robot after a collision!

Collisions between the robot with its surroundings can result in mechanical damage to robot components. Due to exposed parts, the operator may be harmed by electric shock or sharp edges.

- Before restarting the robot after a collision, check whether there is any damage to the robot and its components.

  In particular, check the plastic caps on the individual robot axes for damage.

  This also applies if the robot is put back into operation after vibrations caused by earthquake loads.
- If it is damaged, do not put the robot back into operation and contact Agile Robots SE customer service (*page 4*).

3.3.6 Dangers due to assembly and disassembly work

Dangers due to improper assembly and disassembly

WARNING
Dangers due to improper assembly and disassembly!

During assembly and disassembly work, there is a risk of injury due to crushing of body parts or falling components.

- Assembly and disassembly work may only be carried out by an installation specialist as specified in *Chapter 3.9 'Personnel requirements' on page 67*.
- Before starting assembly work, ensure that only suitable and properly functioning work equipment and devices are used.
- Before starting assembly work, ensure that the intended installation site has sufficient structural stability to support the weight of the robot.
- Always observe the specifications in *Chapter 5.1 'Safety during assembly' on page 103* and in *Chapter 9.1 'Safety during disassembly' on page 159*.

3.3.7 Dangers due to hot surfaces

Dangers due to hot surfaces

CAUTION
Dangers due to hot surfaces!

The surfaces of the robot and the robot controller can heat up during operation, especially during fast movements or when moving heavy loads.

In **collaborative** mode, elevated temperatures (up to 54°C) may occur on the surfaces of the robot at ambient temperatures above 35°C, depending on the load case and application.

Prolonged skin contact with hot surfaces can be painful for the operator.

- Before working on the robot and on the robot controller, ensure that all surfaces have cooled down to ambient temperature.

3.3.8 Dangers in rescue mode

Dangers in rescue mode

WARNING
Dangers in rescue mode!

In rescue mode, the robot can be moved manually out of error positions. The following safety functions are inactive during this process:

- Safely limited axis position
  (Safely Limited Drive Position (SLDP))
- Safely limited Cartesian position
  (Safely Limited Cartesian Position (SLCP))
- Safely limited Cartesian orientation
  (Safely Limited Cartesian Orientation (SLCO))
- Safely limited Cartesian force
  (Safely Limited Cartesian Force (SLCF))
- Safely limited axis torque
  (Safely Limited Drive Torque (SLDT))

Manual movement of the robot with partially inactive safety functions can lead to dangerous situations.

- Ensure that only the system integrator or an authorised safety engineer activates rescue mode.
- Ensure that the owner's personnel are aware of the risks that may arise from rescue mode.
  If necessary, take additional safety measures on the part of the owner.

3.3.9 Dangers due to photobiological exposure

Dangers due to photobiological exposure

CAUTION
Dangers due to photobiological exposure!

The light emitted by the two camera LEDs on the media flange can damage the eyes when viewed directly.

- Avoid direct eye contact with the camera LEDs when they are switched on.
- Maintain a sufficient distance from the camera LEDs when they are switched on.
- During programming and set-up work, ensure the following:
  - The switched-on camera LEDs are never aimed directly at bystanders.
  - The switched-on camera LEDs are never aimed directly at reflective surfaces that could dazzle bystanders.

3.3.10 Dangers due to electromagnetic fields

Dangers due to electromagnetic fields

WARNING
Dangers due to electromagnetic fields!

During operation, electromagnetic fields may build up near the robot.

- Persons with pacemakers or other metallic implants must not be in the robot's hazard area. Pacemakers could be impaired.

3.4 Safety during collaborative operation

Risk of injury during collaborative operation

WARNING
Risk of injury during collaborative operation!

There is a risk of injury due to improper behaviour during collaborative operation.

- Only use personnel authorised by the owner as described in *Chapter 3.9 'Personnel requirements' on page 67* for collaborative cooperation with the robot.
- Ensure that no pointed or sharp tools or tools with an increased risk of entrapment are used in collaborative operation.
- Make sure that there are no objects in the robot's working area that could lead to entrapment with the robot and the operator.
- Ensure that the requirements of **EN ISO 10218-2** and **ISO/TS 15066** are observed when designing collaborative robot applications.

3.5 Safety during non-collaborative operation

Risk of injury during non-collaborative operation

WARNING
Risk of injury during non-collaborative operation!

In non-collaborative operation, the robot is operated in a non-safe state, i.e. the parameters of the safety configuration are in a non-secure area.

If people are in the robot's hazard area during non-collaborative operation, there is a considerable risk of injury.

- Ensure that personnel are separated from the robot at all times by safety guards.

  The safety guards must ensure that all movements of the robot are stopped immediately when a person enters the hazard area.
- When switching between non-collaborative and collaborative areas in hybrid operation:

  Make sure that the robot is in the collaborative area before any contact with people can occur.

3.6 Safety during integrated operation in an overall system

Risk of injury during integrated operation in an overall system

WARNING
Risk of injury when integrated into an overall system!

There is a risk of injury if the robot is improperly integrated into an overall system.

- Ensure that a risk assessment of the entire application has been carried out on the part of the owner; an assessment that covers all movements of the components involved, including the robot and the tools used.
- Ensure that there is a safety concept provided by the owner that protects the operator from entering the hazard area.
- Ensure that the robot is integrated into the protective circuit provided by the owner for the overall system.
- Ensure that personnel are separated by safety guards from all components that are not in a collaborative operating state.
- Never connect safety devices provided by the owner to the robot's standard I/O interfaces.
  Connect safety devices exclusively to the safety I/O interfaces.

Risk of injury due to improper connection of the I/O interfaces

WARNING
Risk of injury due to improper connection of the I/O interfaces!

If the I/O interfaces are improperly connected to the owner's electrical components, there is a risk of injury due to inactive safety functions.

- Connect safety I/O interfaces in the robot controller exclusively to components provided by the owner that are suitable for safe operation.
- Always route signals from the safety I/O interfaces separately from the general digital I/O interfaces.
- Design all safety-relevant signals to be redundant (two independent channels).

  Always keep both channels separate so that a single malfunction cannot lead to the loss of the safety function.
- When configuring interfaces as safety I/O interfaces, always observe the information in *Chapter 2.2.5.3 'Electrical interfaces in the robot controller' on page 32*.

3.7 Robot's working area and hazard area

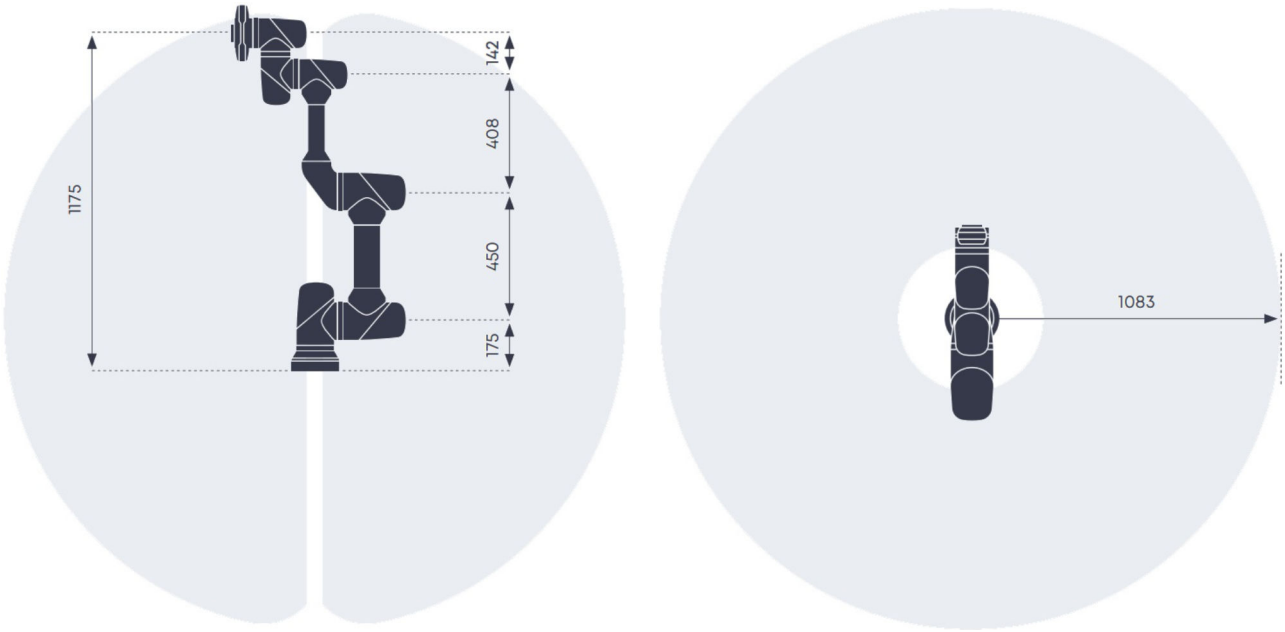

Fig. 30 Robot's working area and hazard area

The working and hazard area Fig. 30 is the area in which the robot arm can execute movements during a program sequence. Only authorised personnel are allowed into this area, even during safe collaborative operation.

The boundaries of the working and hazard area are parameterised by the system integrator or the responsible safety engineer in the safety configuration. For new applications, the working and hazard area must be checked again and, if necessary, the settings in the safety configuration must be adjusted.

If the robot's currently active limits are exceeded, the robot stops immediately.

In order to be able to move the robot manually from the error position, the system integrator or the responsible safety engineer must activate rescue mode in the user interface. To do this, the robot must be in manual mode.

In rescue mode, the robot can be moved back to a safe position in the working area by using manual guidance or by entering data in the user interface (*'Rescue mode' on page 45*).

We recommend keeping all persons out of the robot's hazard area when working in manual mode.

3.8 Owner's responsibility

Owner

The owner is the person who operates the robot for commercial or economic purposes or who entrusts it to a third-party for use and who bears the legal product responsibility during operation concerning protection of users, personnel and third-parties.

Owner's responsibility

The robot is used for industrial purposes. The owner of the robot is therefore subject to the legal obligations relating to safety in the workplace.

In addition to the safety instructions in this manual, the occupational health and safety regulations and environmental protection regulations that apply to the area in which the robot is used must be observed.

The following applies in particular:

- The owner must obtain information about the applicable occupational health and safety regulations and, in a risk assessment, must also determine additional hazards resulting from the specific working conditions at the location where the robot is used. These regulations must be implemented in the form of operating instructions for the use of the robot.
- The owner must, during the entire service life of the robot, monitor whether these operating instructions comply with the current state of the regulations and, if necessary, adjust them.
- The owner must clearly regulate and define the responsibilities for installation, operation, troubleshooting, maintenance and cleaning.
- The owner must ensure that all individuals handling the robot have read and understood this manual. In addition, personnel must be trained at regular intervals and be informed of the dangers that the robot can pose even when used as intended.
- The owner must provide personnel with the necessary protective equipment and instruct them on how to wear the necessary protective equipment.
- The owner must inform personnel if changes are made to the safety configuration.

Furthermore, the owner is responsible for ensuring that the robot is always in perfect technical condition. The following applies in particular:

- The owner must ensure that the maintenance intervals described in this manual are complied with (↯ *Chapter 7.3 'Maintenance schedule' on page 146*).
- The owner must have all safety devices and safety functions checked at regular intervals for functionality and completeness.
- Ensure that an overvoltage protection device ↯ *'Overvoltage protection' on page 54* is installed in the robot controller.
- We recommend that the owner install a master switch upstream of the mains connection.

Declaration of incorporation of incomplete machine

The robot is an incomplete machine within the meaning of the Machinery Directive and is therefore delivered with a declaration of incorporation. The declaration of incorporation states that the robot may only be put into operation if the owner properly integrates it into an overall application provided by the owner.

The owner's system integrator is also obliged to draw up a declaration of conformity in accordance with the Machinery Directive for the owner's overall application.

3.9 Personnel requirements

Insufficient qualification

WARNING
Risk of injury if personnel are not sufficiently qualified!

If unqualified personnel carry out work on or with the robot, hazards may arise which can lead to serious injuries and considerable property damage.

- All activities must be carried out by qualified personnel only.
- Keep unqualified personnel away from the robot's working area and hazard area.
- Always keep the login details for the user interface protected against unauthorised access.

Approved personnel

The various tasks described in this manual require different qualifications for the persons entrusted with these tasks.

Only persons who can be expected to carry out this work reliably are permitted to perform any work.

Persons whose responsiveness is affected, e.g. by drugs, alcohol or medication, are not permitted, and neither are children.

Personnel qualifications

This manual identifies the personnel qualifications listed below for the various tasks:

Owner

The owner must observe the occupational health and safety regulations concerning use of the robot. This includes the owner fulfilling his or her monitoring obligations and instructing the personnel listed in this section at specified intervals.

Operator

Operators have been instructed or trained by the owner about the tasks assigned to them and the possible dangers associated with improper conduct when handling the robot. In particular, operators have been informed about proper behaviour during collaborative operation and about how the safety devices function.

Operators are able to carry out basic operating activities in automatic mode, and are able to perform cleaning activities in a professional and safe manner. This includes:

- Selecting and loading programs
- Starting programs
- Stopping programs
- Cleaning robots and components

Maintenance specialist

Due to their technical training, knowledge and experience, as well as their knowledge of the relevant standards and regulations, maintenance specialists are able to carry out work on the robot's electrical and mechanical system and to independently recognise and avoid potential hazards – including when operating the robot.

Maintenance specialists are specially trained for the work environment in which they work and are familiar with the relevant standards and regulations in this area.

Installation specialist

Installation specialists have undergone technical training and are familiar with assembling and disassembling the robot. Due to their training, installation specialists are capable of selecting suitable tools and aids to properly assemble/disassemble the robot and to independently recognise and avoid potential hazards.

The installation process is managed by the owner or by a person commissioned by the owner who ensures that the installation work is carried out properly.

Programmer

Due to their professional training, knowledge and experience, programmers are able to carry out set-up work, and they have been informed about the specific hazards involved in operating the robot.

Programmers can create new programs for robot applications and have the necessary programming knowledge to ensure that no unexpected movements of the robot are executed at any time.

Safety engineer

Safety engineers are specialists appointed by the owner who, due to their professional training, knowledge and experience, are able to carry out set-up and operating activities on the robot – especially in safety-relevant situations. This includes:

- Parameterisation of the safety configuration in compliance with the system integrator's specifications
- Moving the robot in manual mode
- Moving the robot out of error positions in rescue mode
- Releasing the robot from entrapment situations
- Carrying out the torque sensor calibration
- Carrying out the brake test
- Carrying out position verification

System integrator

The system integrator is responsible for safe operation of the robot. Therefore, the system integrator must carry out a comprehensive risk assessment for each robotic application, taking into consideration all workflows, ambient conditions, and devices used on the media flange, such as tools.

The associated parameters such as the tool geometry or the definition of impermissible movement ranges are set by the system integrator in the safety configuration. For collaborative robot applications, the system integrator must ensure that the permissible limits for speeds and collision forces are not exceeded and that the robot poses no hazards to the operator.

If the robot is integrated into an overall system provided by the owner, the system integrator must take all measures to ensure safe operation of the robot in the production process. This includes, in particular, integrating the robot into the safety concept for the overall system, for example by connecting the robot to safety devices such as safety doors or light barriers.

The system integrator is personally appointed by the owner's business managers. The core tasks of the system integrator include the following work:

- Set-up and initial commissioning of the robot
- Creating risk assessments for the applications in which the robot is to be used

  This also includes taking into consideration the owner's overall system in which the robot is integrated.
- Creating new programs
- Editing existing programs
- Deleting programs
- Parametrising the safety configuration taking into account the safety-relevant factors from the risk assessment
- Operating the robot in manual mode
- Changing tools and devices on the media flange
- Opening the robot controller and establishing electrical connections with external components or machines in the owner's overall system, such as additional safety devices
- Ensuring that unauthorised personnel do not gain access to the robot's safety-related settings and cannot make any changes to the robot's tools and devices
- Equipping the robot and the components of the overall system with further safety markings, if the risk assessment so requires

- If necessary:

  Providing additional information for the operator to properly operate a robot application
- Joint storage of all documents required to operate the robot, including this manual

Transport personnel

For transport tasks, the owner must appoint an authorised person to supervise and coordinate all work on the robot. Only persons who are trained for the transport tasks and who are aware of the potential hazards during transport may be deployed as transport personnel.

Changing the operating mode

The following of the owner's personnel groups are authorised to use the key for the key switch and to select the robot's manual mode:

- System integrator
- Safety engineer
- Programmer
- Maintenance specialist

Changing the safety configuration

The robot's safety configuration is password-protected and may only be changed by the responsible system integrator and the responsible security engineer.

3.10 Personal protective equipment

Personal protective equipment is used to protect persons and avoid health and safety risks at work.

Personnel must wear protective equipment during various types of work near and on the robot. This equipment is specifically mentioned in the relevant individual sections of this manual.

Missing or incorrect protective equipment

WARNING
Risk of injury due to missing or incorrect protective equipment!

There is a risk of injury to personnel working on the robot due to missing or incorrect protective equipment.

- In addition to the protective equipment mentioned in this manual, always observe the local regulations concerning protective equipment that apply at the robot's installation site.
- Ensure that personnel have additional protective equipment prescribed by the owner and are informed of how and when to use it.

Description of the personal protective equipment

Industrial hard hat
Industrial hard hats protect the head against falling objects, swinging loads and impact with fixed objects.

Protective work clothing
Protective work clothing is close-fitting work clothing with a low tear resistance, close-fitting sleeves and without protruding parts.

Safety footwear
Safety footwear protects the feet against crushing, falling parts and slipping on slippery floors.

3.11 Safety devices

Risk of injury from non-functioning safety devices

WARNING
Risk of injury from non-functioning safety devices!

If the safety devices do not work or are deactivated, there is a risk of injury due to collisions with the robot.

- Never override or bypass safety devices.
  In particular, before switching on automatic mode, ensure that all safety devices are fitted and functional.
- Make sure that the safety devices are always accessible.

Safety devices for the robot

In order to minimise the risk of injury due to robot movements, the robot is equipped with the safety devices described below. The safety devices are triggered by active intervention on the part of the operator.

Emergency stop button

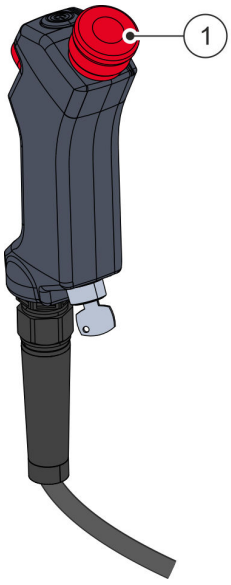

Fig. 31 Emergency stop button

Pressing the emergency stop button Fig. 31/① stops all the robot's movements (category 1 emergency stop according to DIN EN 60204-1:2019-06) and applies the robot brakes.

The power supply to the robot drives is interrupted and the controller remains in operation.

In order to be able to put the robot back into operation, the emergency stop button must first be unlocked by turning it and then the associated status message must be acknowledged in the user interface.

The function of the emergency stop button must be checked daily (*Chapter 7.5 'Checking safety devices' on page 150*).

Enabling button

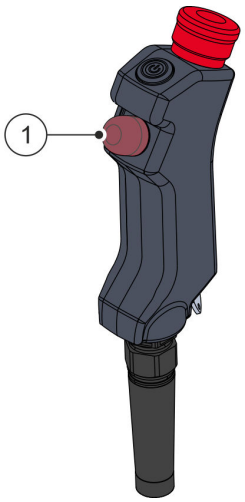

Fig. 32 Enabling button

To move the robot in manual mode from the user interface or with manual guidance, press and hold the enabling button Fig. 32/① on the handheld controller in the middle position.

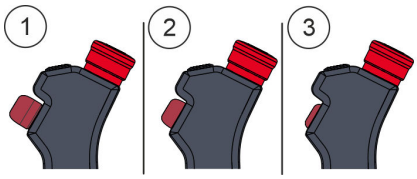

Fig. 33 Three stages of the enabling button

① Enabling function off
② Enabling function on
③ Enabling function off

The enabling button is designed as a three-stage button Fig. 33:

In the first stage, the enabling button is not pressed and the robot cannot be moved Fig. 33/①.

In the second stage, the enabling button is in the middle position and the enabling function is activated. The robot can now be moved from the user interface or using the manual guidance button Fig. 33/②. The speed of the robot in the area of the end effector is limited to 250 mm/s. Robot movements at higher speeds can be enabled in the user interface by active confirmation (see also *'Manual mode' on page 43*). Only the personnel groups system integrator, safety engineer and programmer can set the travel speed.

In the third stage, the enabling button is pushed all the way, which deactivates the enabling function and stops all robot movements Fig. 33/③. This ensures that no robot movements are possible when the button is released or pushed all the way when the operator is startled. The safety stop triggered in positions 1 and 3 is a category 2 stop (DIN EN 60204-1:2019-06). To put the robot back into operation after a safety stop has been triggered on the enabling button, the enabling button must first be completely released.

The set-up process for programs in manual mode can be carried out when the enabling device is disabled. To do this, the system integrator or the responsible safety engineer must enter the PIN to actively confirm the message in the user interface stating that the robot is to be moved without an activated enabling button. The prerequisite for this is that the system integrator has properly parameterised the robot's force and power limitation for safe collaborative operation (see also ISO/TS 15066). In this setting and in automatic mode, the enabling button is disabled.

Operating mode selection on the mode selector switch

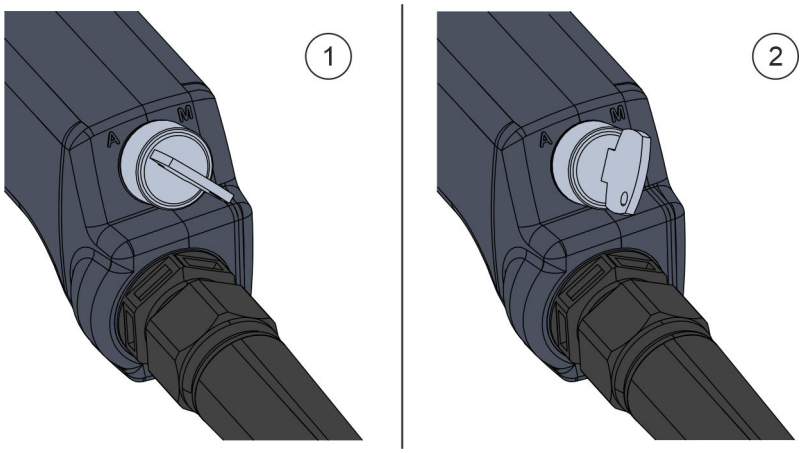

Fig. 34 Operating mode selection on the mode selector switch

① Mode selector switch position **Automatic mode**
② Mode selector switch position **Manual mode**

By turning the mode selector switch on the handheld controller, you can switch between automatic Fig. 34/① and manual Fig. 34/② modes.

If the mode is changed or the enabling button is pressed during a robot movement, a category 1 safety stop (DIN EN 60204-1:2019-06) is triggered.

3.12 Safety functions

Risk of injury due to inactive safety functions

WARNING
Risk of injury due to inactive safety functions!

If safety functions are inactive, there is a risk of injury due to collision with the robot.

- Never override safety functions.
- Ensure that the limits of the force and power limitation and the robot's range of movement are correctly parameterised.

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  For collaborative operation, this means that the biomechanical limits for human-machine collisions must be complied with (see also ISO/TS 15066).

Dangers if the robot's safety configuration is changed

WARNING
Risk of injury if the robot's safety configuration is changed!

If the robot's safety configuration is not properly parameterised, there is a risk of injury to the operator during collaborative operation.

- The safety configuration can only be changed by the system integrator or by the responsible safety engineer.
- Ensure that the safety PIN is always protected against unauthorised access.
- Ensure that the risk assessment for the respective robot application is taken into account when parametrising the safety configuration.
- Ensure that the requirements of **EN ISO 10218-2** and **ISO/TS 15066** are observed when designing collaborative robot applications.
- Ensure that after each change to the safety configuration (i.e. the safety ID* for the safety configuration also changes) the system integrator or the responsible safety engineer personally checks the safety parameters in a test operation for possible risks and functionality.

Selecting safety functions

When the robot is delivered, all safety functions are active. If necessary, the system integrator or the responsible safety engineer can manually deactivate individual safety functions in the safety configuration.

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The robot can only move if the enable signal is present in the robot controller for the safety functions selected by the system integrator or the safety engineer.

Safety functions of the robot

In order to minimise the risk of injury due to robot movements, the robot is equipped with the safety functions described below.

The safety functions continuously monitor operating parameters such as the robot’s force, power, speed, position and orientation, speed and torque.

As soon as a parameter is outside the permissible limits, all robot movements are automatically stopped.

Tool configuration

In order to ensure that the safety functions are effective, the system integrator or the responsible safety engineer must configure the tool that is to be used in the safety settings before it is used for the first time.

If a robot application allows changing between two tools during operation, the safety configuration must cover the geometric body resulting from the totality of both tool geometries.

The specific parameter settings result from the owner’s risk assessment of the robot application.

Probability of failure for safety functions

Safety function	PFH*	Diagnostic coverage DC	Performance level
SLCP	3.97×10^{-7}	≥ 97.5%	PL-d, cat 3
SLCO	3.97×10^{-7}	≥ 97.5%	PL-d, cat 3
SLCS	3.97×10^{-7}	≥ 97.5%	PL-d, cat 3
SLDT (axis 1–3)	4.57×10^{-7}	≥ 97.9%	PL-d, cat 3
SLDT (axis 4–6)	4.57×10^{-7}	≥ 97.9%	PL-d, cat 3
SLCF	4.57×10^{-7}	≥ 97.9%	PL-d, cat 3
SLDP	3.97×10^{-7}	≥ 97.5%	PL-d, cat 3
SLDS	3.97×10^{-7}	≥ 97.5%	PL-d, cat 3
SLRP	4.57×10^{-7}	≥ 97.9%	PL-d, cat 3
Emergency stop button, enabling button, mode selector switch	3.97×10^{-7}	≥ 92.7%	PL-d, cat 3
Secure digital inputs and outputs	3.97×10^{-7}	≥ 92.7%	PL-d, cat 3

* The PFH value indicates the average probability of a dangerous failure per hour (Probability of dangerous Failure per Hour).

For more information on the probability of failure, contact Agile Robots SE customer service (*page 4*).

Tolerances of the safety functions

The following values represent the detection tolerance for safety functions during quasi-static robot operation, e.g. at constant speed.

During dynamic operation of the robot, e.g. during high accelerations, the actual tolerances may deviate from the specified values.

The owner must put the safety functions into operation accordingly and ensure that the tolerances required for the application are complied with.

Safety function	Value
SLCP	30 mm
SLCO	1.6°
SLCS	11 mm/s
SLDT (axis 1–3)	9 Nm
SLDT (axis 4–6)	1 Nm
SLCF	35 N
SLDP	5°
SLDS	2.5°/s
SLRP	56 W

3.12.1 Force and power limiting

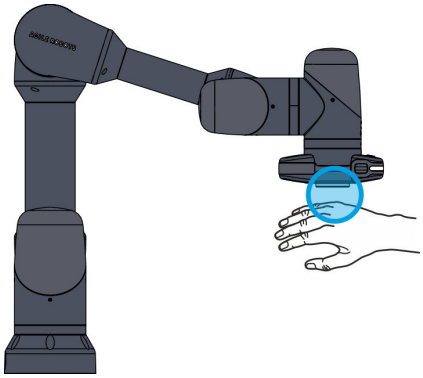


Fig. 35 Force and power limitation (example illustration)

In order to minimise the risk of injury due to robot movements, the robot is equipped with a force and power limitation (in the user interface: “Force and Power Limiting”) Fig. 35.

The force and power limitation is divided into five safety functions, which are described in the following sections.

- Safely limited axis speed
  (Safely Limited Drive Speed (SLDS))
- Safely limited Cartesian speed
  (Safely Limited Cartesian Speed (SLCS))
- Safely limited axis torque
  (Safely Limited Drive Torque (SLDT))
- Safely limited robot power
  (Safely Limited Robot Power (SLRP))
- Safely limited Cartesian force
  (Safely Limited Cartesian Force (SLCF))

The safety functions are parameterised via the safety settings in the user interface.

↳ *“Robot Yu 5 Industrial” software manual*

In order to be able to operate the robot in the collaborative state, the system integrator or the responsible safety engineer must ensure when parameterising the safety functions that the permissible biomechanical limit values for human-machine collisions are not exceeded. This minimises the risk of injury in the event of physical contact with the robot.

In rescue mode, the following safety features are automatically disabled:

- Safely limited axis position
  (Safely Limited Drive Position (SLDP))
- Safely limited Cartesian position
  (Safely Limited Cartesian Position (SLCP))
- Safely limited Cartesian orientation
  (Safely Limited Cartesian Orientation (SLCO))
- Safely limited axis torque*
  (Safely Limited Drive Torque (SLDT))
- Safely limited Cartesian force
  (Safely Limited Cartesian Force (SLCF))

* Safely Limited Drive Torque (SLDT)

SLDT is deactivated in rescue mode only if the torque of one of the drives exceeds the preset torque limits for the drive (e.g. if the robot is stuck at a table).

When the robot is released, SLDT is reactivated even if rescue mode is still active.

The values for force and power limitation can only be changed within the range of the preset limit values. When creating a new program for a robot application, the system integrator must consider all possible human-robot collision scenarios as part of a risk assessment.

Depending on the application, it may be necessary to re-parameterise the force and power limitation in order to avoid injury to the operator in certain situations with an increased risk of entrapment, for example.

The safety controller continuously monitors the force and power limitation on the basis of the torque and position values in each of the six robot axes.

Axis torques

The following prerequisites apply to correct monitoring of the axis torques:

- The zero point for all torque sensors is correctly calibrated.
- The tool is correctly mounted on the connecting flange and correctly parameterised.
- The parameterised mounting direction (gravitational vector) does not deviate from the robot's mounting direction.

Increase in interaction force

Depending on the robot speed, the braking distance following a safety stop can lead to a violation of the axis torques and thus to a further increase in the interaction force.

NORMAL and REDUCED parameter sets

The values of force and power limitation can be defined in two parameters sets, NORMAL and REDUCED. The values defined for the REDUCED parameter set must be less than or at most equal to the values for the NORMAL parameter set. By default, the NORMAL parameter set is active.

In principle, configurations that allow collaborative or non-collaborative operation of the robot are possible for both parameter sets. This means that the following modes of operation are available:

- Fully collaborative operation

  The NORMAL and REDUCED parameter sets are both in the collaborative range.
- Fully non-collaborative operation

  The NORMAL and REDUCED parameter sets are both in the non-collaborative range.
- Hybrid operation

  The REDUCED parameter set is in the collaborative range, while the NORMAL parameter set is in the non-collaborative range.

Hybrid operation is used in order to switch automatically between both sets of parameters while the robot is in operation. This switch can be triggered by an external or internal trigger as follows:

- Example of external trigger

  The robot is integrated into an application provided by the owner and is operated with the NORMAL parameter set (non-collaborative state).

  The robot's working area and hazard area is protected by a light curtain connected to the robot's safety I/O interfaces.

  When the operator enters the working and hazard area, the light curtain is triggered, which, if configured accordingly, automatically switches the robot to the REDUCED parameter set.

  The robot now operates at reduced speed, reduced force and/or reduced power in the collaborative state.
- Example of internal trigger

  The robot is operated with the NORMAL parameter set (non-collaborative state).

As soon as the robot exceeds a safety level within its working and hazard area, it automatically switches to the REDUCED parameter set and the robot moves at reduced speed, reduced force and/or reduced power (collaborative state).

After returning to the safety level, the robot automatically switches back to the NORMAL parameter set (non-collaborative state).

Changeover time between parameter sets

The changeover time between the NORMAL and REDUCED parameter sets is 200 ms by default and can be set by the system integrator or by the responsible safety engineer in the user interface.

If the robot leaves the safety area before the changeover time has elapsed, rescue mode will not be activated.

When designing a robot application for hybrid operation, the system integrator must ensure that the robot is in the collaborative area before a contact situation with humans can occur.

Safely limited axis speed (Safely Limited Drive Speed)

This safety function monitors the angular velocity of the robot's individual axis drives based on the position data for the respective drive.

If the maximum permissible speed of a drive is exceeded, a category 1 safety stop (see also DIN EN 60204-1:2019-06, Annex A) is triggered.

Safely limited Cartesian speed

This safety function monitors the Cartesian speed of the robot, taking into account the position data for the respective drive.

If the maximum permissible Cartesian speed of the end effector or the elbow joint on the robot is exceeded, a category 1 safety stop (DIN EN 60204-1:2019-06) is triggered.

Safely limited axis torque (Safely Limited Drive Torque)

This safety function monitors the external torque applied to an axis based on the torque sensor data for the respective drive.

If the maximum permissible externally acting axis torque of a drive is exceeded, a category 1 safety stop (DIN EN 60204-1:2019-06) is triggered.

The external axis torque can still increase considerably after the safety function is triggered and before the robot finally comes to a standstill.

This safety function can only monitor static torques that occur for longer than the tripping time tolerance. Transient contacts and resulting hazards must be mitigated by additional measures, e.g. limiting the kinetic energy of the robot by reducing the maximum speed to a suitable value.

The resulting static torque depends, among other things, on the following application-dependent factors:

- Initial speed/energy of the robot
- Payload
- Rigidity of the contact environment
- Clamping or free contact

Safely limited robot power

This safety function monitors the robot's mechanical power.

If the maximum permissible robot power is exceeded, a category 1 safety stop (DIN EN 60204-1:2019-06) is triggered.

Safely limited Cartesian force

This safety function monitors the externally applied Cartesian force at the end effector according to the quasi-static contact scenario pursuant to ISO/TS 15066.

If the maximum permissible Cartesian force is exceeded, a category 1 safety stop (DIN EN 60204-1:2019-06) is triggered.

This safety function restricts the robot's range of motion robot as described in *Appendix 'Singularities' on page 182*.

The minimum configurable force is 35 N.

The robot's safety controller does not monitor exceeding of the transient limit according to ISO/TS 15066. The owner must take this into account as part of the risk assessment for the respective robot application and when parametrising the safety configuration.

3.12.2 Safely limited range of robot motion (Motion Range Limiting)

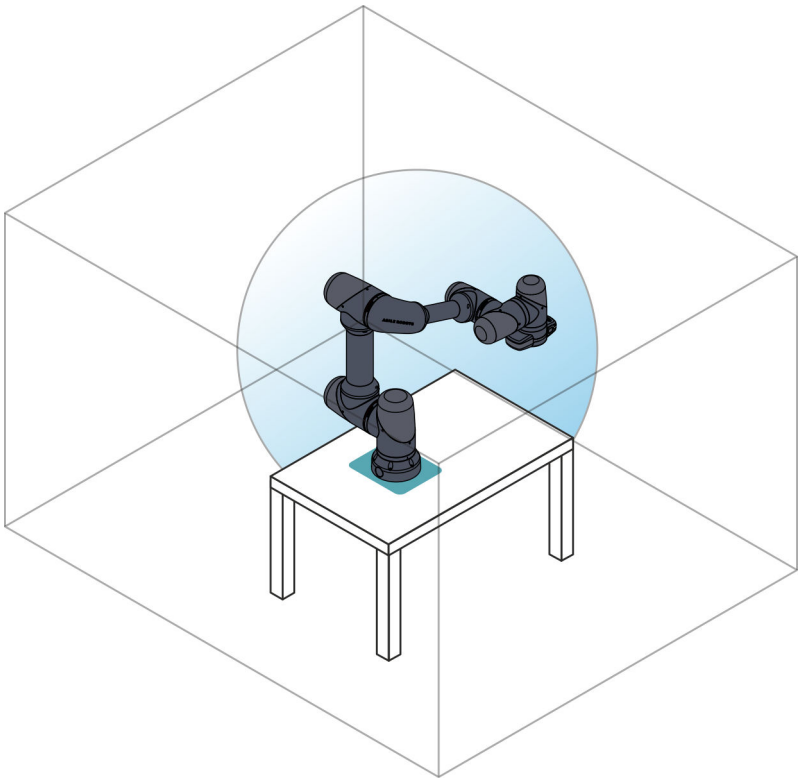


Fig. 36 Safely limited range of motion

In order to minimise the risk of injury as a result of collisions, the robot has a safely limited range of motion in addition to force and power limitation Fig. 36.

This is divided into three safety functions, which are described in the following sections:

- Safely limited axis position
  (Safely Limited Drive Position (SLDP))
- Safely limited Cartesian position
  (Safely Limited Cartesian Position (SLCP))
- Safely limited Cartesian orientation
  (Safely Limited Cartesian Orientation (SLCO))

These functions continuously monitor the movements of the robot and its position and orientation in Cartesian space, both in automatic mode and in manual mode.

If the robot has exceeded a permissible limit and has come to a standstill, the robot must be moved manually from the error position. To do this, the robot must be in manual mode and an authorised person must activate rescue mode in the user interface.

The robot can then be moved back to a safe position with predefined, reduced rescue parameters by pressing the enabling button.

Rescue mode

In rescue mode, the safety functions indicated above and the "Safely Limited Drive Torque" safety function are inactive, i.e. no position monitoring of the robot takes place in this case.

Safely limited axis position (Safely Limited Drive Position)

This safety function monitors the angle positions of the robot's individual axis drives based on the position data for the respective drive.

The safety function only monitors a range of ≤ 360° and is not effective if the range is configured to a value > 360°.

When leaving the permissible angular positions of a drive, a category 1 safety stop (DIN EN 60204-1:2019-06) is triggered.

Safely limited Cartesian position

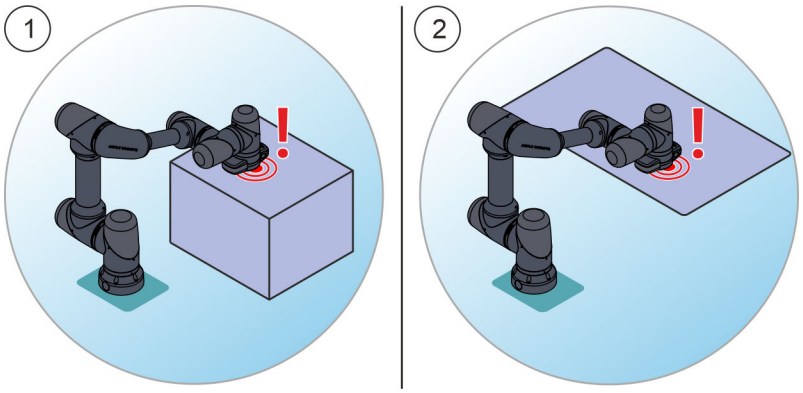


Fig. 37 Working area and hazard area with safety areas

① Safety cuboid
② Safety level

This safety function monitors the Cartesian position of the robot based on planes and cuboids defined in the Cartesian space.

If the end effector or the elbow joint on the robot enters a safety cuboid Fig. 37/① or a safety plane Fig. 37/②, the robot behaves as follows, depending on the safety configuration:

- A category 1 safety stop (DIN EN 60204-1:2019-06) is triggered.
- It switches to the REDUCED parameter set and the robot moves with reduced parameter values.

Safely limited Cartesian orientation

This safety function monitors the Cartesian orientation of the end effector on the robot, taking into account a safety cone in which the end effector orientation may deviate from the application-specific normal position. If the permissible Cartesian orientation of the end effector is exceeded, a category 1 safety stop (DIN EN 60204-1:2019-06) is triggered.

3.12.3 External safety stop

This safety function executes a safety stop of the robot on triggering of an external safety device provided by the owner that is connected to the safety I/O interfaces in the robot controller. Stop categories 1 and 2 (DIN EN 60204-1:2019-06) can be configured separately for the individual inputs.

Safety stops are configured via the safety I/O interface SI_{cfg}. A stop-reset input can also be configured via another SI_{cfg} interface; this input must be activated after a safety stop before the operator can acknowledge the error message.

In the event of a category 2 safety stop (DIN EN 60204-1:2019-06)

If no external reset signal is configured via the SI_{cfg} interface, the robot is put back into operation by enabling the safety stop signal.

If speed and distance monitoring is planned for the robot with the aid of an external safety device provided by the owner, at least one category 2 safety stop (DIN EN 60204-1:2019-06) must be configured for this purpose.

Three possible scenarios for the implementation of speed and distance monitoring must be taken into account:

- An external safety device is connected to the SI_{cfg} input. When the safety device is triggered, a category 2 safety stop (DIN EN 60204-1:2019-06) is performed.
- An external safety device is connected to the SI_{cfg} input. When the safety device is triggered, the robot switches to a reduced speed, e.g. from the NORMAL parameter set (if configured for non-collaborative operation) to the REDUCED parameter set (if configured for collaborative operation).
- An external safety device is connected to the SI_{cfg} input.
  - If a person approaches the robot and thus triggers the safety device, the robot switches to a reduced speed.
  - If a person approaches the robot even further and the permissible minimum distance is violated, a category 2 safety stop (DIN EN 60204-1:2019-06) is performed.

3.13 Configurable safety digital inputs and outputs

3.13.1 Configurable safety inputs

The robot has four configurable safety digital inputs that can be configured with the three functions described below.

Overview of interfaces

A detailed overview of the interfaces in the robot controller can be found in *Chapter 2.2.5.3 'Electrical interfaces in the robot controller' on page 32***.**

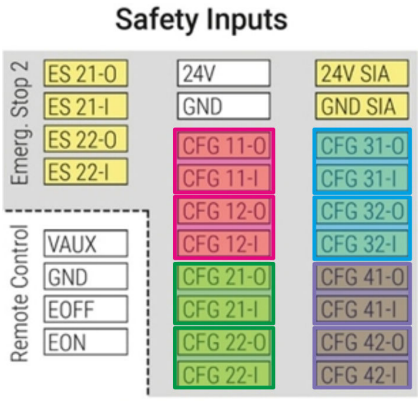


Fig. 38 Overview of "Safety Inputs"

The inputs marked in colour in Fig. 38 can be configured with the functions described in the following table. For safety reasons, the connections are redundant, i.e. two connections always make up one input.

Example

The connections **CFG 11** and **CFG 12** (red markings) make up one input.

All four inputs can be configured with one of the following functions.

Input	Function
Safety stop	Configurable digital input for a category 1 or 2 safety stop (DIN EN 60204-1:2019-06). The following configurations are possible: ■ Category 1 safety stop (DIN EN 60204-1:2019-06) ■ Category 2 safety stop (DIN EN 60204-1:2019-06) ■ Category 1 safety stop (DIN EN 60204-1:2019-06) only in automatic mode ■ Category 2 safety stop (DIN EN 60204-1:2019-06) only in automatic mode The input signal can only be processed if the input is configured. Assignment ■ *0/Low*: safety stop triggered ■ *1/High*: safety stop not triggered
Stop reset	Configurable digital input for resetting an emergency stop and a safety stop. Assignment ■ *0/Low* ➔ *1/High*: reset triggered ■ *Otherwise*: reset not triggered
REDUCED mode	Configurable digital input for switching to the REDUCED parameter set. The changeover time is 200 ms by default and can be set by the system integrator or the responsible safety engineer in the user interface. Assignment ■ *0/Low*: REDUCED parameter set active ■ *1/High*: NORMAL parameter set active

Self-tests of configurable inputs

The safety controller automatically performs self-tests of the configurable inputs.

After restarting the robot, ensure the following:

actuate the safety input for at least two seconds the first time it is used, i.e. pull it to the HIGH level.

After this initial actuation, a short actuation time of less than one second is sufficient.

Resetting a detected self-test fault of the safety inputs must not be used to ignore faults that occur during operation.

External safety digital inputs – self test

When external active devices are connected to the robot's safety inputs, the robot can check only its own input path by means of a self-test.

When external passive devices are connected to the safety inputs, self-tests cannot detect short circuits that bridge a normally closed contact.

The assumptions for error detection for external passive devices also only apply if the designated high-side connection is used.

The system integrator or operator must select measures to ensure that faults in the external wiring can be detected or ruled out, e.g.:

- Using active devices that check the wiring on their side (OSSD)
- Separate cable routing for outgoing and return conductors
- Separate shielding for outgoing and return conductors
- Cyclical manual check of the function

3.13.2 Configurable safety outputs

The robot has four configurable safety digital outputs that can be configured with the following four functions.

Overview of interfaces

A detailed overview of the interfaces in the robot controller can be found in *Chapter 2.2.5.3 'Electrical interfaces in the robot controller' on page 32*.

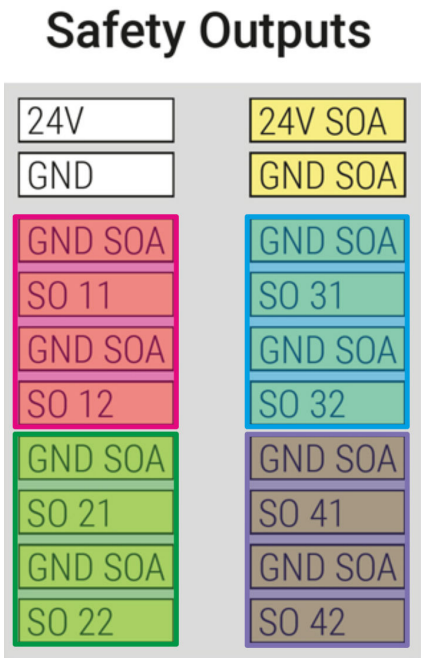


Fig. 39 Overview of "Safety Outputs"

The outputs marked in colour in Fig. 39 can be configured with the functions described in the following table. For safety reasons, the connections are redundant, i.e. two connections always make up one output.

Example

The connections SO 11 and SO 12 (red marking) make up one output.

All four outputs can be configured with one of the four functions.

Output	Function
Emergency stop	Digital output for signalling an emergency stop on the safety controller in the robot controller. The signal is triggered in the same way as the emergency stop signal at the SI_1 or SI_2 inputs. **Assignment** ■ *0/Low*: emergency stop active ■ *1/High*: emergency stop not active
Safety stop	Digital output for signalling a safety stop or hardware fault on the safety controller in the robot controller. The signal is triggered in the following cases: ■ If the SI_{cfg} input is configured for a safety stop: A safety stop is registered at the SI_{cfg} input. A distinction can be made between the following stop categories for a safety stop: • Stop category 1 (DIN EN 60204-1:2019-06) • Stop category 2 (DIN EN 60204-1:2019-06) • Stop category 1 (DIN EN 60204-1:2019-06) and stop category 2 (DIN EN 60204-1:2019-06) ■ If the SI_{cfg} input is configured for an emergency stop: An emergency stop is registered at the SI_{cfg} input. ■ A safety function of the robot is triggered and a safety stop is executed (↯ *Chapter 3.12 'Safety functions' on page 76*). **Assignment** ■ *0/Low*: safety stop active ■ *1/High*: safety stop not active
Robot movement	Digital output for signalling a robot movement. **Assignment** ■ *0/Low*: robot in motion ■ *1/High*: robot at standstill
REDUCED mode	Digital output for signalling REDUCED mode. **Assignment** ■ *0/Low*: robot is in NORMAL mode ■ *1/High*: robot is in REDUCED mode

Self-test pulses

If the self-test pulses are configured for a safety output, the operator is responsible for ensuring that errors such as getting stuck in high or a short circuit to another signal can be detected by suitable measures if the signal is to be further processed for safety-relevant applications.

3.14 What to do in the event of accidents

Preventive measures

- Always be prepared for accidents!
- Keep first aid equipment (first aid kit) and fire extinguishers in working order and close at hand.
- Familiarise personnel with accident reporting, first aid and rescue facilities.
- Check first aid and rescue facilities at regular intervals.

What to do in the event of an accident

- Immediately trigger the emergency stop by pressing the emergency stop button on the handheld controller.

  In the case of integrated operation of the robot in an overall system, trigger the emergency stop device provided by the owner, if necessary.
- Remove persons from the danger zone

  If a person is trapped by the robot:
  - Move the robot out of the entrapment position with manual force and free the person. The robot can be moved backwards with the physical force of two people.

    DGUV Information 208-053: Mensch und Arbeitsplatz – Physikalische Belastungen [People and Workplaces – Physical Strains] (September 2019)
  - When resolving the entrapment situation, note the following:

    If possible, move the robot's axes 1 and 2 in order to be able to apply the greatest possible leverage.
- Initiate first aid measures.
- Alert emergency services.
- Inform the person responsible at the place of use.

3.15 Environmental protection

UMWELTSCHUTZ!
Danger to the environment due to improper handling of environmentally hazardous substances!

Improper handling of environmentally hazardous substances, especially if disposed of incorrectly, can cause considerable damage to the environment.

- Always observe the information below on how to handle and dispose of environmentally hazardous substances.
- If environmentally hazardous substances accidentally escape into the environment, take appropriate measures immediately. If in doubt, inform the responsible local authority about the damage and ask for appropriate measures to be taken.

Disposal of the robot and its components

To protect the environment, the robot has been manufactured with limited use of hazardous substances pursuant to **RoHS Directive 2011/65/EU**.

The Agile Robots SE is registered with the Stiftung EAR foundation (waste electrical and electronic equipment register) and takes back Yu 5 Industrial brand robots that have been sold on the German market free of charge in order to dispose of them properly.

Importers in European countries that are subject to the **WEEE Directive 2012/19/EU** are responsible for registering with the national WEEE register in their country.

A list of national registers can be found here:

https://www.ewrn.org/national-registers

The following environmentally hazardous substances are used:

Electronic components

Electronic components may contain toxic substances. They must not enter the environment. They must be disposed of by a specialist disposal company.

Cross roller bearing

Cross roller bearings contain toxic substances. They are subject to special waste treatment and must be disposed of by a specialist waste disposal company.

3.16 Security of the IT environment

NOTICE
Risk of robot damage due to non-secure IT environment!

Operating the robot in a non-secure IT environment can cause damage and malfunction.

- Ensure that the robot is never operated in a non-secure network environment where it is endangered by malicious software.
- Ensure that protection measures provided by the owner such as firewalls, antivirus software or encrypted VPN connections are used.

  If possible, during operation disconnect the internet connection for the mobile device that is connected to the robot.
- Ensure that the mobile device connected to the robot is free of viruses and is used exclusively to operate the robot.

  The use of private hardware for robot operation is not permitted.
- Ensure that storage media connected to the robot, such as USB devices, are free of viruses and are only used for data exchange with the robot.

  The use of private storage media for data exchange is not permitted.
- Ensure that exported robot programs are protected against unauthorised access to prevent unauthorised manipulation of the programs.

  The system integrator is obliged to first test each imported program in manual mode before using it in automatic mode.
- Ensure that the system settings and the system status of the mobile device provided by the owner are checked regularly.
- Ensure that the robot is operated exclusively with an up-to-date software version.
- Ensure that no external remote access to the robot is possible from outside the internal company network.

Attacks or intrusion into the network

Agile Robots SE is not liable for damage caused by attacks or intrusion into the network aimed at changing the robot controller's software system or the safety configuration.

4 Delivery, packaging and storage

4.1 Delivery and scope of delivery

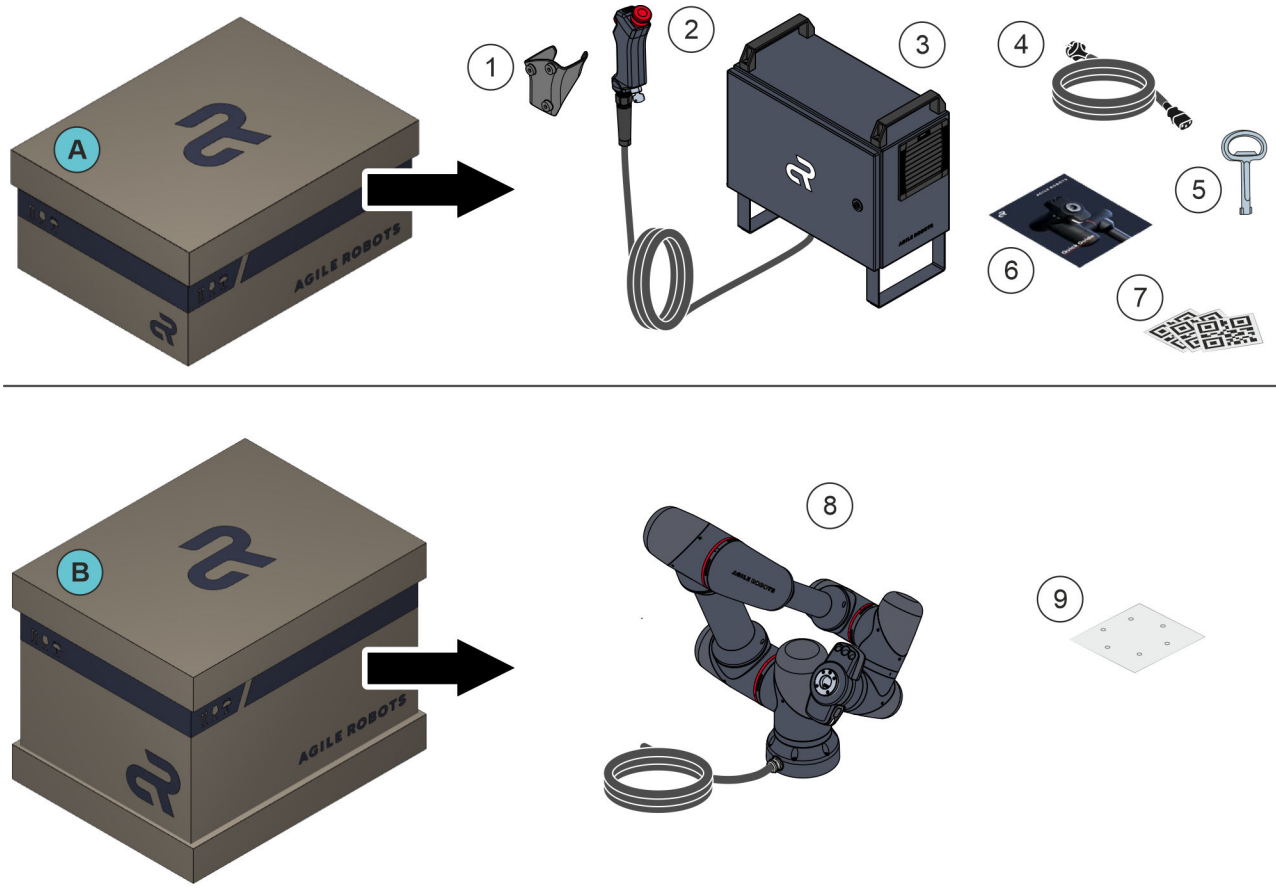


Fig. 40 Delivery condition and scope of delivery

- Ⓐ Robot controller + components box
- Ⓑ Robot + components box
- ① Handheld controller bracket
- ② Handheld controller, permanently connected to robot controller
- ③ Robot controller
- ④ 3 m power cable
- ⑤ Robot controller key
- ⑥ Quick guide
- ⑦ AgileTags
- ⑧ Robot with connecting cable to robot controller
- ⑨ Robot arm drilling template

The robot and its components are delivered in two boxes Fig. 40/Ⓐ + Ⓑ on a transport pallet. The two boxes contain the following components:

- Robot controller + accessories Fig. 40/①–⑦
- Robot + accessories Fig. 40/⑧–⑨

IP54 classification

When delivered and when fully connected, the robot system fulfils the IP54 classification.

The IP54 classification no longer applies as soon as one of the following cases occurs.

- The cable bushing on the underside of the robot controller has been disassembled.
- The twist cap on the RJ45 Ethernet port is open.
- The filter units in the robot controller's fan have been removed.
- The protective cap on the connecting flange has been removed.
- The protective caps on the external electrical interfaces on the media flange have been removed.
- The robot cable is disconnected from the robot controller.

4.2 Packing

NOTICE
Risk of robot damage due to lack of fixation!

Upon delivery, the robot is in the transport position. The robot is not stable in this position due to its eccentric centre of gravity. If the robot is not fixed in place by the packaging parts, there is a risk that it will tip over and components, in particular the torque sensors in the axes, will be damaged.

- Do **not** completely unpack the robot before starting assembly.
  Ensure that the foam packaging of the robot is removed according to the specifications in *Chapter 5.3 'Installing the robot and putting it into operation' on page 107*.

About the packaging

The individual packing units are protected from moisture with film. Only environmentally friendly materials have been used for the packaging. The packaging is intended to protect the individual components against damage during transport, against corrosion and other damage until they are installed.

Therefore, do not dispose of the packaging and do not remove it until shortly before assembling the robot.

Handling of packaging materials

Dispose of the outer packaging material in accordance with the applicable statutory provisions and local regulations.

Foam packaging

We recommend retaining the foam packaging to enable safe future transport of the robot and the control cabinet.

This also applies to the reusable transport straps for closing the robot box.

UMWELTSCHUTZ!
Danger to the environment due to improper disposal!

Packaging materials are valuable raw materials and can in many cases be re-used or usefully processed and recycled. Improper disposal of packaging materials can harm the environment.

- Dispose of packing materials in an environmentally sound manner.
- Observe local disposal regulations. Where appropriate, hire a specialist company to handle the disposal.

Information on the packing material

The packaging contains the following information:

- Address of the recipient
- Net weight of packing unit [kg]
- Total weight of packing unit [kg]
- Dimensions of the packing unit: width, depth, height [cm]

4.3 Storage

Storage of packing units

Store packing units under the following conditions:

- Do not keep outdoors.
- Store in a dry and dust-free place.
- Do not expose to aggressive media.
- Protect against sunlight.
- Avoid mechanical vibrations.

- Storage temperature: +5 to +25°C
- Relative humidity, max.: 70% at temperatures up to +31°C, decreasing linearly to 50% at +40°C

Storage for more than 3 months

If stored for more than three months, check the general condition of all parts and packaging at regular intervals. If necessary, refresh or renew the preservation.

5 Assembling the robot

5.1 Safety during assembly

Danger due to improper assembly

WARNING
Dangers due to improper assembly!

During assembly activities, there is a risk of injury due to crushing of body parts or falling components.

- Assembly activities must only be carried out by an installation specialist (*Chapter 3.9 'Personnel requirements' on page 67*).
- Before starting assembly work, ensure the following:
  - Make sure that two people are always available to install the robot.
  - Ensure that only suitable and properly functioning work equipment and devices are used.
  - Ensure that the intended installation site has sufficient structural stability to support the weight of the robot.
  - Ensure that the intended installation site has a rigid surface to support the robot.
  - Ensure that the intended installation site has sufficient space for the movements of the robot arm.
- Never mount robots on mobile platforms or other moving components that are not designed and approved for this purpose.
- Lay cables so that there is no risk of tripping and no tensile forces are applied to the cables.

  If necessary, use cable holders or cable ties to fix the cables.
- When establishing the Ethernet connection on the robot controller, ensure the following:

  When the twist cap on the RJ45 Ethernet port is opened, the robot controller loses its IP54 tightness. The system integrator must therefore re-evaluate the robot controller's IP class after the Ethernet cable is connected.

  The IP54 tightness can be restored, for example, in combination with the CONEC 17-150254 or 17-150264 connectors.

5.2 Preparing for assembly

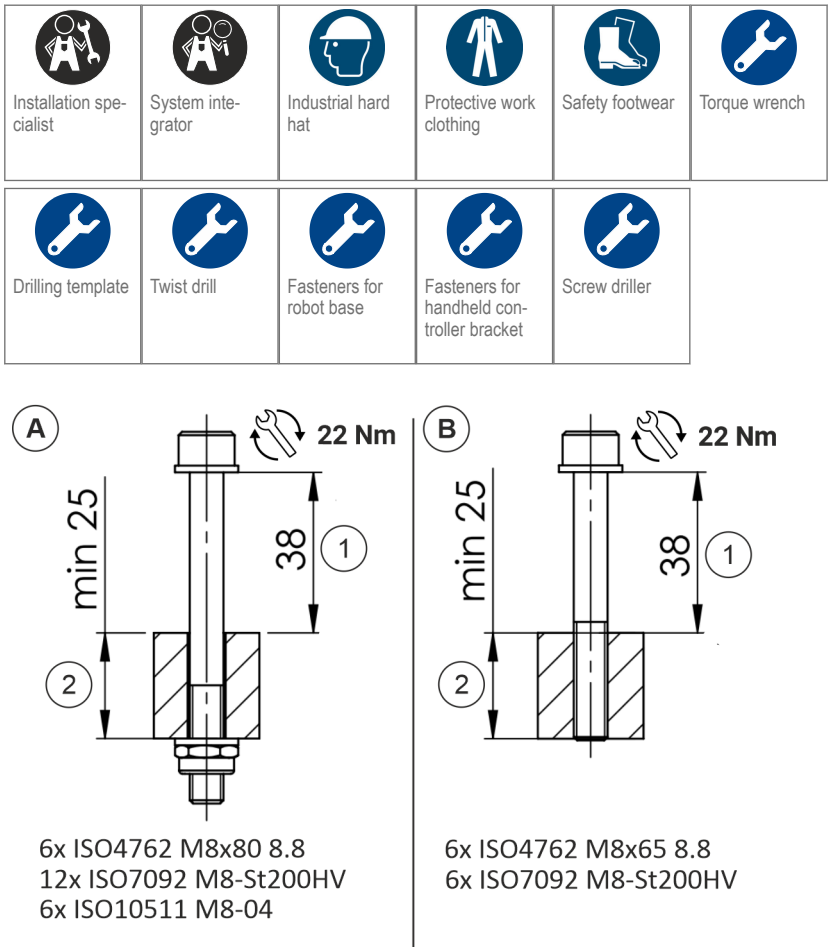


Fig. 41 Threaded connections for the robot base (fastening elements)

Ⓐ Assembly with through bores
Ⓑ Assembly with threaded bores
① Depth of hole on robot base
② Thick mounting plate

Prerequisites

- The stability of the owner's power supply is ensured at all times.
- Ensure order and cleanliness at the installation site.
- There is sufficient space for assembly before starting work.
- It is ensured that assembly takes place in a dry and well-lit environment.
- It is ensured that there are no strong magnetic fields in the area of the installation site.

- The installation site is selected so that the power cable and the socket of the owner's power supply are always accessible to the operator.
- It is ensured that the bolts for the threaded connections between the robot base and mounting plate meet the specifications in Fig. 41.
  - With regard to the bolt length, note that the robot base has a hole depth of **38 mm** Fig. 41/①.
  - Ensure that the bolts have a minimum strength class of **8.8** degrees.
  - Ensure that the bolts are tightened to a minimum tightening torque of **22 Nm**.
- The mobile device intended for operating the robot meets the following **minimum requirements**:
  - Display: 1280 x 768 pixels (recommended: touchscreen)
  - CPU: Intel Celeron® N4120
  - GPU: Intel® YHΔ graphics card 600
  - RAM: 4 GB
  - Operating system: Microsoft Windows®, Linux, Android® or Apple macOS®
  - Browser: Google Chrome® or Microsoft Edge® (version 79 or later)
- An Ethernet cable is available for connecting the robot controller and the mobile device.

Ethernet port

Only one mobile device may be connected to the robot controller via the Ethernet connection. Connecting to network devices such as routers or switches is not allowed.

Requirements for foundations (mounting plate)

The robot arm may only be mounted on horizontal foundations. Ceiling and wall mounting are not permitted.

For safety and performance reasons, the foundations for the robot arm must meet the following requirements:

Parameter	Value
Minimum yield strength of mounting plate	225 MPa
Natural frequency of foundation for best robot performance*	180 Hz
Thick mounting plate	≥ 25 mm

* The minimum natural frequency requires a frequency of the first oscillation level of 60 Hz.

Load calculation for foundations (mounting plate)

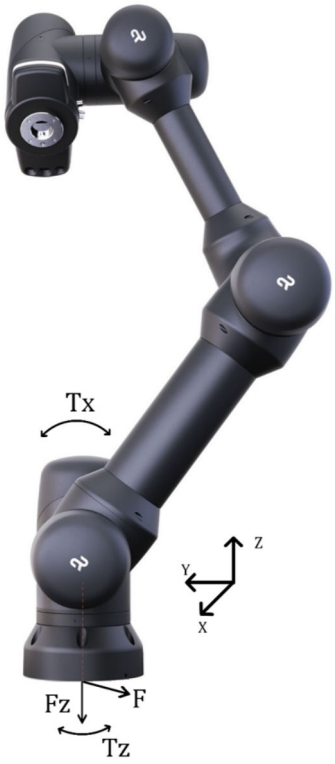


Fig. 42 Forces and torques of robot base

When calculating the natural frequencies of the foundation and the material stresses, take into account the following loads acting on the foundation:

Force/torque	Description	Value
F	Maximum lateral force	583 N
Fz	Tensile force in Z-direction	583 N
Tx	Maximum bending moment (torsional moment around the X-axis)	± 400 Nm
Tz	Torsional torque around the Z-axis	± 306 Nm
The stresses act at the same time!		

Total weight of the robot

When calculating the loads, use the total weight of the robot including the installed equipment (end effectors, cable guides etc.).

If you have questions about specific use cases and applications, contact Agile Robots SE customer service (*page 4*).

5.3 Installing the robot and putting it into operation

Risk of robot damage due to lack of fixation during assembly

NOTICE
Risk of robot damage due to lack of fixation during assembly!

Upon delivery, the robot is in the transport position. The robot is not stable in this position due to its eccentric centre of gravity. If the robot is not fixed in place by the packaging parts, there is a risk that it will tip over and components, in particular the torque sensors in the axes, will be damaged.

- Do **not** completely unpack the robot before starting assembly. Ensure that the robot's foam packaging is not completely removed until the robot base is fastened to the mounting surface with at least two bolts (see the following sequence of actions).

Mounting surface

In the following section, a table is used as an example of a mounting surface for the robot.

Foam packaging

We recommend retaining the foam packaging to enable safe future transport of the robot and the control cabinet.

This also applies to the reusable transport straps for closing the robot box.

Removing the outer packaging

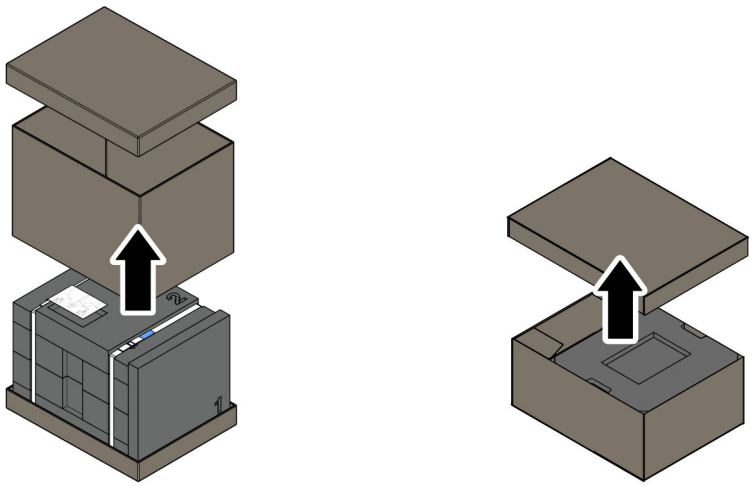


Fig. 43 Removing the outer packaging (example)

01. Remove the outer packaging of the boxes for the robot and for the robot controller Fig. 43.

02. Remove the foam packaging of the box for the robot controller and place the components on a level surface.

    Stability of the robot
    To prevent the robot from tipping over, ensure that the complete foam packaging and transport straps for the robot are **not** removed before step **13**.

03. Completely unwind the cable on the handheld controller.

04. Check that the contents of the box for the robot controller are complete and intact, in accordance with *Chapter 4.1 'Delivery and scope of delivery' on page 99*.

Checking the delivery
If there are any missing or damaged components, do not put the robot controller into operation.

Immediately contact the dealer who sold the robot or Agile Robots SE customer service (*page 4*).

Assembling the robot

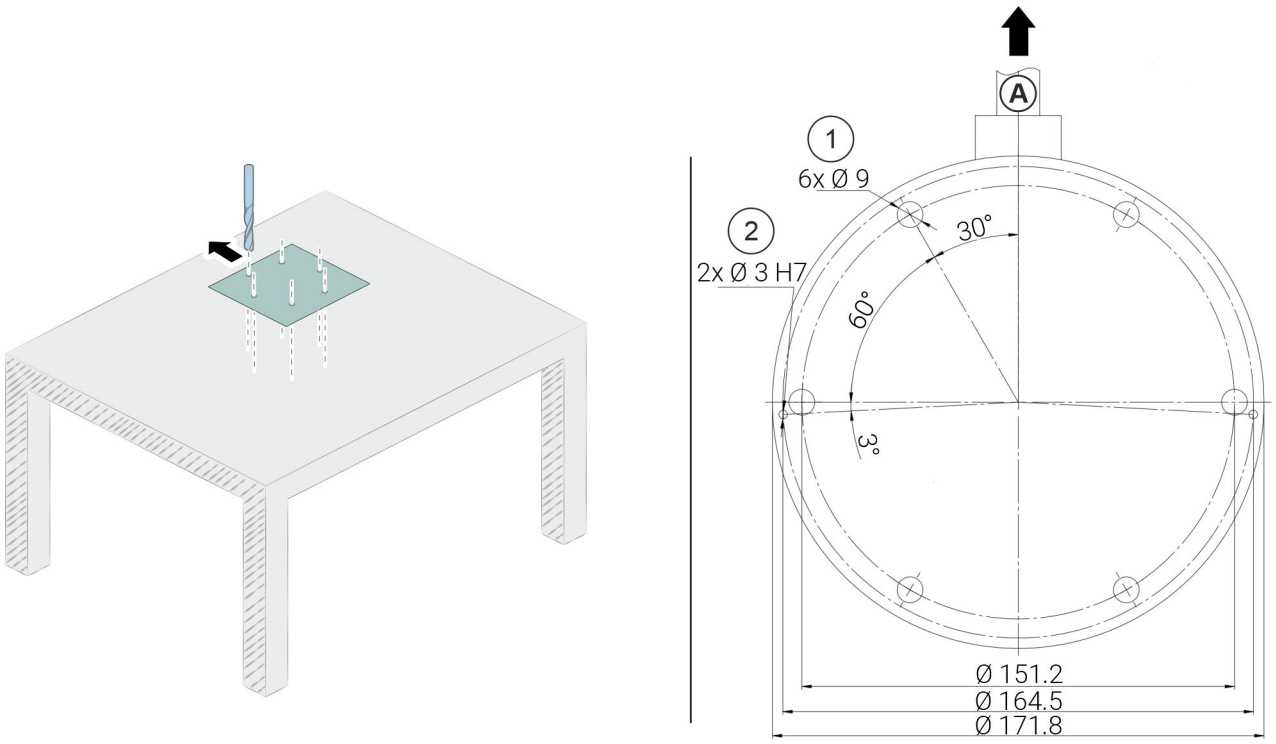


Fig. 44 Robot drilling template

Ⓐ Outgoing cable (back of robot)
① Holes for bolts
② Holes for dowel pins

05. Align the robot's drilling template on the edge of the table as shown in Fig. 44 and mark the six drill holes on the table plate.

Positioning of drilling template
In order to ensure sufficient space to assemble the robot, we recommend positioning the drilling template centrally on the table plate and not right at one of the table edges.

06. Using the twist drill according to the markings, drill six holes Fig. 44/①.

Threaded connections with lock nuts
Depending on the thickness of the table plate, we recommend drilling completely through the table plate and establishing the threaded connections for the robot using lock nuts.

07. **Dowel pins**
The robot can also be fixed in place with dowel pins in order to secure the precise position of the robot or to ensure repeat accuracy when installing the robot again.

If necessary, drill two holes with the twist drill according to the markings Fig. 44/②.

08. Remove packing part **1** of the robot box Fig. 45.

Labelling of packaging parts
All packaging parts of the robot are labelled with a number indicating the order in which they should be unpacked.

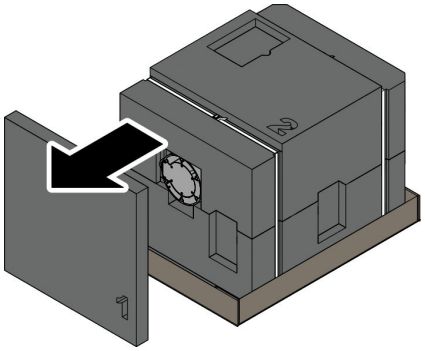


Fig. 45 Removing packaging part **1**

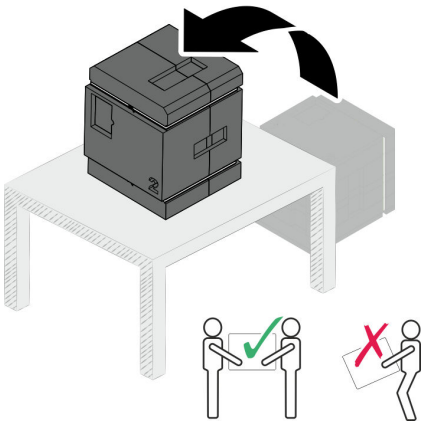


Fig. 46 Setting the robot box down

09. **WARNING! Risk of injury due to heavy load!**

Make sure that two people are available to carry the robot box.

10. Place the robot box on the table rotated by 90° as shown in Fig. 46.

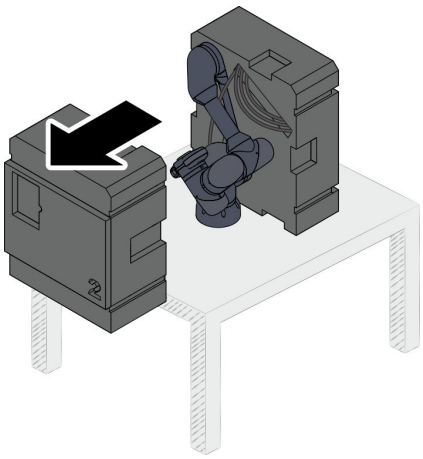


Fig. 47 Remove packaging part **2**

11. Remove the transport straps and remove packing part 2 Fig. 47.

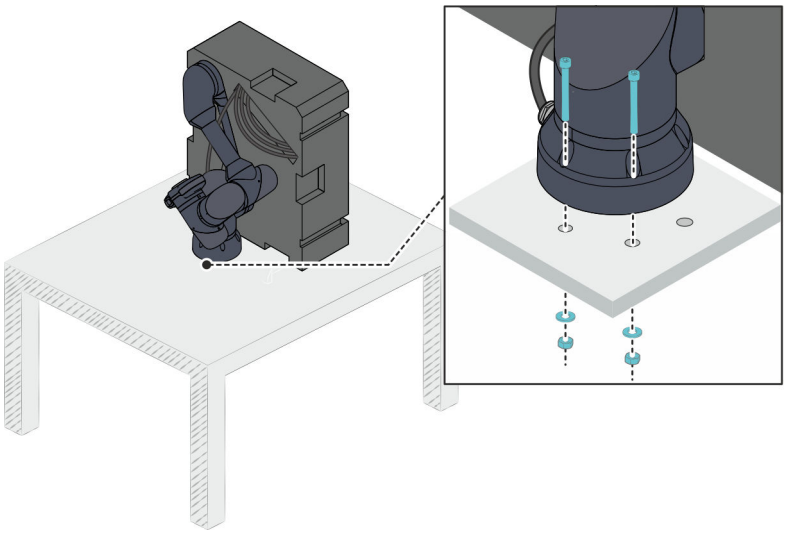


Fig. 48 Example: Assembly with through bores (part 1)

12. Align the robot with the packaging part 3 on the drill holes on the table plate Fig. 48.
13. Establish the threaded connections on the robot base as follows:

    Assembly with through bores:

    - Insert at least two bolts (M8) with washers (M8) through the openings on the free side of the robot base Fig. 48.
    - Place washers (M8) and lock nuts (M8) on the bolts and initially tighten lock nuts clockwise to a tightening torque of 13 Nm Fig. 48.

      The lock nuts are only tightened to the full tightening torque of 22 Nm after the robot has been fully screwed on (step 16).

    Assembly with threaded bores:

    - Insert at least two bolts (M8) with washers (M8) through the openings on the free side of the robot base Fig. 48.
    - Initially tighten the bolts clockwise to a tightening torque of 13 Nm Fig. 48.

      The bolts are only tightened to the full tightening torque of 22 Nm after the robot has been fully screwed on (step 16).

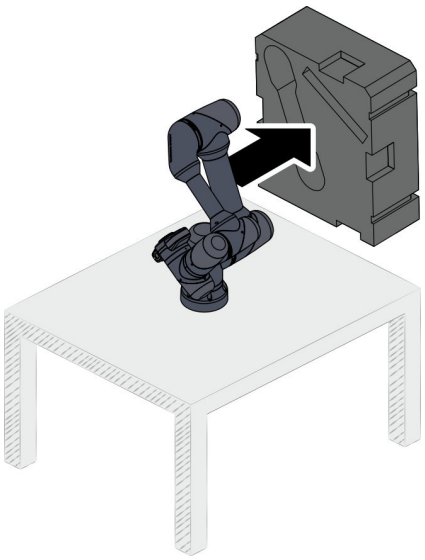


Fig. 49 Removing packaging part **3**

14. Remove packaging part **3** Fig. 49 and completely unwind the robot cable.
15. Check that the robot is intact.

    Checking the delivery
    If there are any missing or damaged components, do not put the robot and its components into operation.

    Immediately contact the dealer who sold the robot or Agile Robots SE customer service (*page 4*).

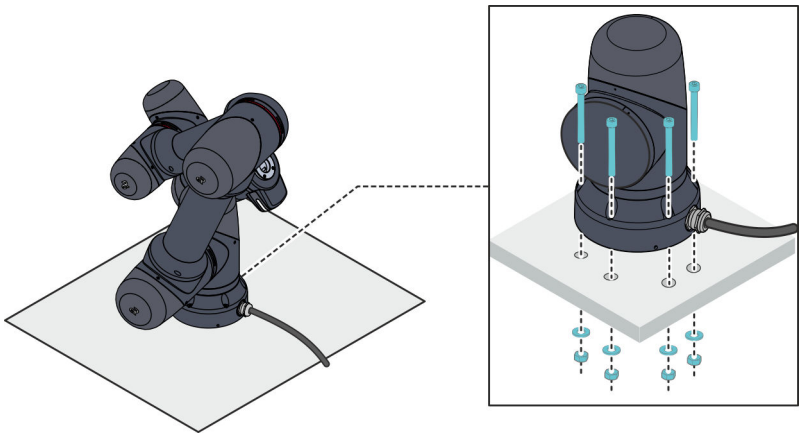


Fig. 50 Example: Assembly with through bores (part 2)

16. Initially tighten the threaded connections on the robot base for the remaining four holes to a tightening torque of 13 Nm Fig. 50.

17. Tighten all six bolts crosswise to the full tightening torque of 22 Nm.

Assembling the handheld controller bracket

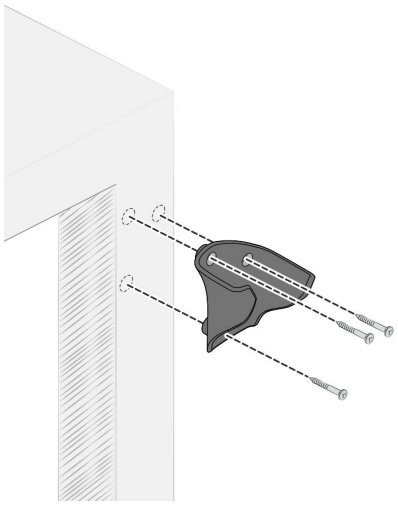


Fig. 51 Assembling the handheld controller bracket

18. Align the bracket for the handheld controller as shown in Fig. 51 on a flat surface outside the robot's working space.

    Fig. 51 shows assembly of the bracket on the table leg as an example.

19. Use the bracket to mark three holes on the table.

20. **Screws for handheld controller bracket**
    We recommend using cylinder head screws with a maximum diameter of 4 mm to mount the bracket.

    Establish the threaded connections for the bracket as follows:

    Use the screw driller to screw three screws through the openings in the bracket into the markings on the table Fig. 51.

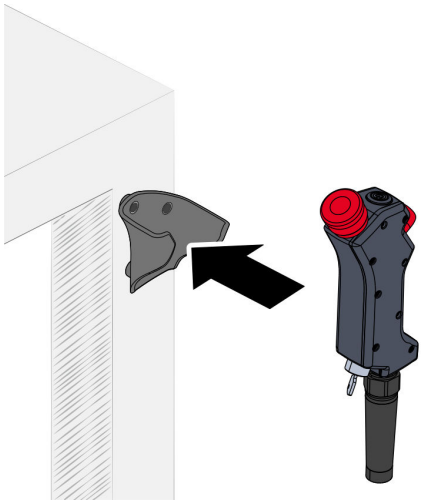


Fig. 52 Inserting the handheld controller

21. Insert the handheld controller into the bracket Fig. 52.

Connecting components

Fig. 53 Positioning the robot controller

22. **Positioning the robot controller**
Ensure that the robot controller is not on the table or at a higher level.

    Place the robot controller under the table near the robot on the floor Fig. 53.

23. **NOTICE! Material damage due to blocked fan outlets on the robot controller!**

    Ensure that the robot controller is at a minimum distance of 20 cm from surrounding walls or objects in the area of the fan outlets.

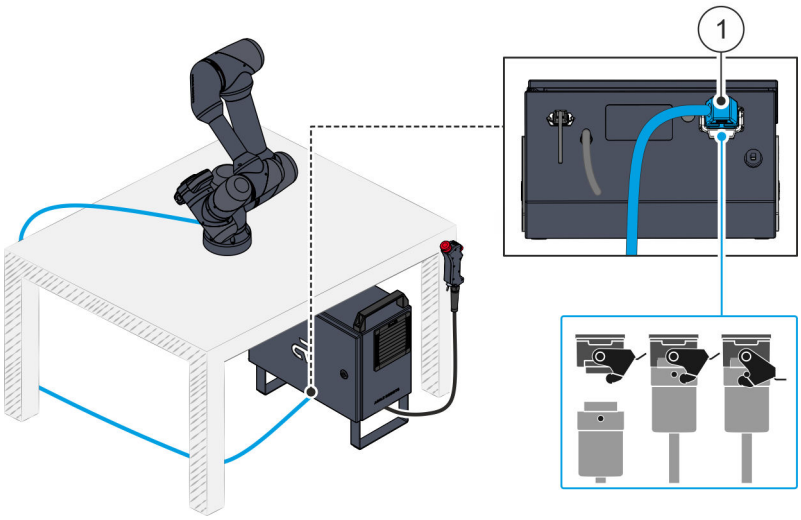


Fig. 54 Connecting the robot and robot controller

24. Plug the robot's connecting cable into the associated connection socket on the robot controller Fig. 54/①.

    When doing so, ensure that the cable plug is locked to the connection socket with the help of the bracket Fig. 54.

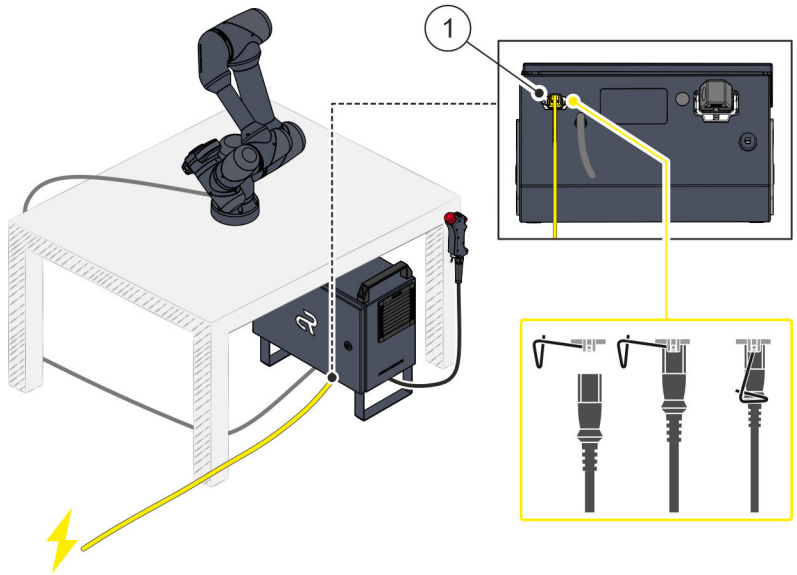


Fig. 55 Establishing the electrical connection

25. Plug the power cable into the associated connection socket on the underside of the robot controller Fig. 55/①.

    When doing so, ensure that the cable plug is locked to the connection socket with the help of the bracket Fig. 55.

26. Connect the contact pins on the other end of the power cable to the owner's power supply (230 V).

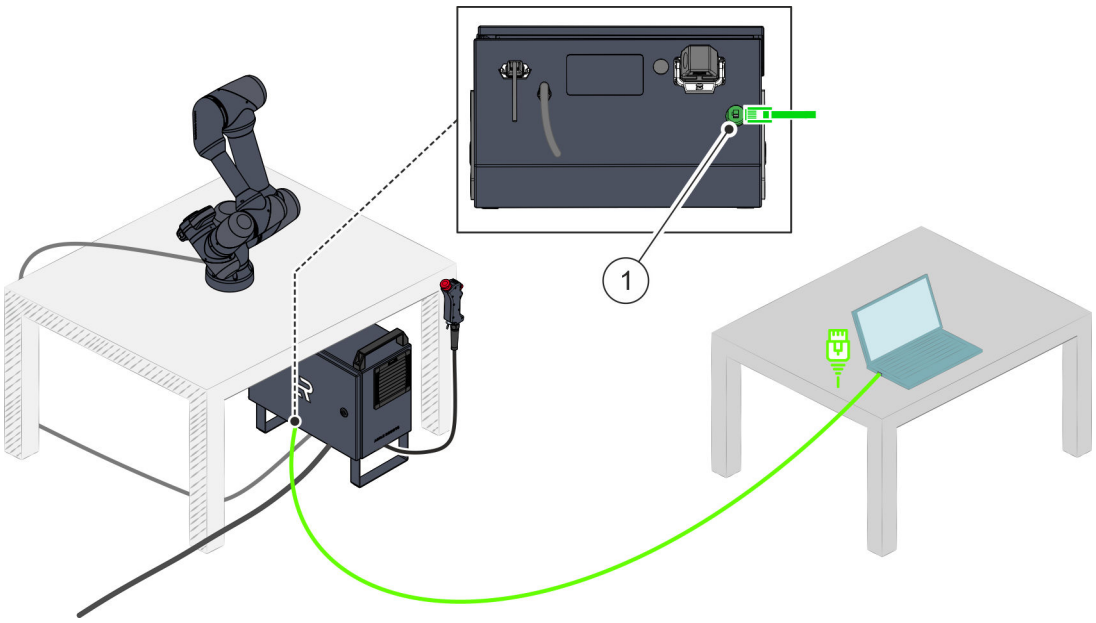


Fig. 56 Connecting to a laptop

27. Mobile devices

The maximum response time for data communication between the robot controller and a mobile device (to operate the HMI) complies with TCP/IP standards.

Fig. 56 shows an example of how to connect the laptop.

In addition, any Ethernet-enabled device on which the Google Chrome® browser is installed can be used to set up the user interface.

Connect one end of the Ethernet cable to the network port on the laptop Fig. 56.

Plug the other end of the Ethernet cable into the associated port on the underside of the robot controller Fig. 56/①.

Switching on the robot and accessing the user interface

NOTICE! Risk of property damage!
After unpacking for the first time or after storing the robot for a longer period of time, wait for the robot to reach the ambient temperature before switching it on.

- Ensure that any condensate that has formed due to the rapid temperature change between the storage and installation location has completely evaporated.

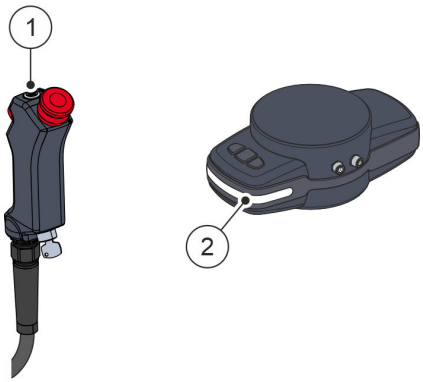


Fig. 57 Switching on the robot

28. WARNING! Risk of injury due to unintentional robot movements!

    Before switching the robot on, make sure there are no people in the robot's hazard area.

29. Press the on/off button Fig. 57/① on the handheld controller for about one second to switch on the robot.

    ▶ ▪ The outer ring of the on/off button lights up **green** Fig. 57/①.

    ▪ The status LED on the media flange initially flashes **white** and then lights up **white** continuously once the boot process is complete Fig. 57/②.

30. Switch the laptop on.

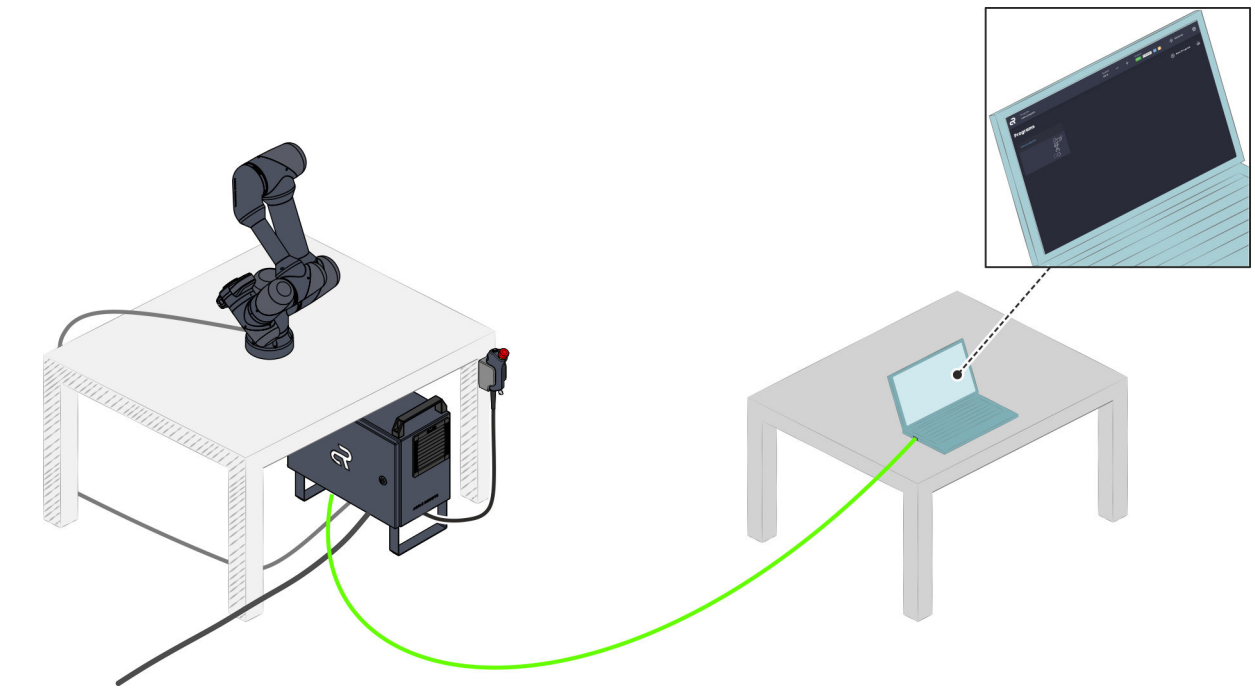


Fig. 58 Accessing the user interface

31. On your laptop, open the Google Chrome® browser.

32. Enter the following IP address in the browser's address bar and confirm with the Enter key:

    192.168.1.1

    ▶ ■ The robot controller's user interface opens Fig. 58.
    ■ The robot is ready for operation.

33. **NOTICE! Risk of property damage due to unauthorised data entry in the user interface!**

    Ensure that only the responsible system integrator makes settings in the user interface the first time that the robot is put into operation.

    For more information, see *Chapter 6.3.1 'Checking that the robot is functional before operation' on page 128*.

6 Operating the robot

About this chapter

This chapter contains information for mechanical operation of the robot.

For more information on programming the robot, refer to the relevant software manual:

"Robot Yu 5 Industrial" software manual

6.1 Operational safety

Improper operation

WARNING
Risk of injury due to improper operation!

Incorrect operation can result in injury and material damage.

- Complete all the operating steps in accordance with the specifications and instructions in this manual.
- Before starting work with the robot, ensure the following:
  - Ensure that the robot is securely assembled in accordance with *Chapter 5 'Assembling the robot' on page 103*.

    Only switch on the robot when the power cable is connected to the owner's power supply and the robot cable is connected to the robot controller.
  - Ensure that the system integrator or the responsible safety engineer has parameterised the safety configuration in accordance with the requirements of the risk assessment.
  - Ensure that all covers and safety devices are installed and functioning properly.
  - Ensure there are no unauthorised persons in the robot's working area and hazard area.
- Never operate the robot if components are damaged or only loosely attached or have been completely removed.

  Exposed parts can pose a danger for the operator due to electric shock or sharp edges.
- Before commissioning the robot after a collision:
  - Check all components of the robot for damage.
  - Check that safety devices are functioning.

  Do not start up the robot if safety devices are damaged or not functioning.
- Never override or bypass safety devices during operation.
- Ensure that only the following of the owner's personnel perform operating activities on the robot in manual mode:
  - System integrators
  - Safety engineers
  - Programmers
  - Maintenance specialists
- If the system integrator's risk assessment includes the following situation for a specific application:

Do not enter the robot's working area or touch the robot while it is in operation.

- Ensure that the operator has been informed about the functioning and possible risks of the owner's application.
- If the robot is to be moved in non-collaborative operation using manual guidance:
  - The enabling button on the handheld controller and the manual guidance button on the media flange must be operated by the same person.

    Never allow a person to operate the enabling button while another person is guiding the robot by hand.
  - Ensure that during manual guidance by a person, no other person is in the vicinity of the mobile device that could make entries in the user interface. Data entry in the user interface poses a risk of injury to personnel guiding the robot manually due to unintentional robot movements.

    If possible, lock the mobile device before starting manual guidance.
- Ensure that the total weight of the tool used and the payload to be moved do not exceed the maximum permissible load of 5 kg (movement radius: 1,000 mm):
- When connecting a tool provided by the owner, the cover on the media flange must be removed. This results in the robot losing its IP54 tightness. The system integrator must therefore re-evaluate the robot's IP class after a tool is connected for the first time.
- Never disconnect the robot cable from the robot controller during operation.

  Before putting the robot into operation, ensure that the bracket on the robot cable connector is locked onto the robot controller.
- Never disconnect the power cable from the robot controller or power supply during operation.

  This does not apply if the power supply to the robot needs to be disconnected as quickly as possible in an emergency.
- Ensure that the robot does not come into contact with moisture or chemicals.

Hot surfaces

CAUTION
Dangers due to hot surfaces!

The surfaces of the robot can heat up during operation, especially during fast movements or when moving heavy loads. Prolonged skin contact with hot surfaces (metal surfaces) can be painful for the operator.

- When guiding and operating the robot, only touch the caps and the media flange (touch points, Fig. 59).

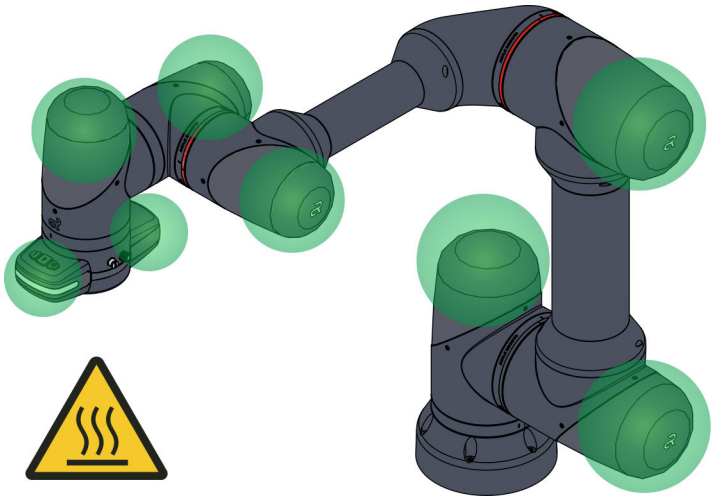


Fig. 59 Touch points ( ) on the robot

6.2 Connecting a tool provided by the owner

6.2.1 Connecting a tool to the connecting flange

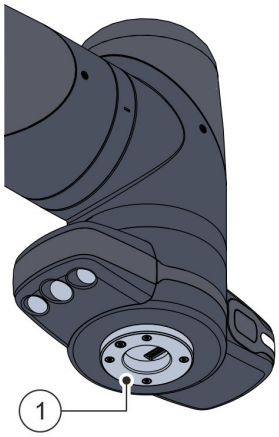


Fig. 60 Connecting flange

Depending on the robot application, various different owner tools can be connected to the media flange via the connecting flange Fig. 60/①.

Permitted tools

The tool to be connected must meet the requirements of **ISO 9409-1-50-4-M6**.

To ensure optimum performance, we recommend attaching the tool directly to the robot's media flange.

If you have questions about specific use cases and applications, contact Agile Robots SE customer service (↳ *page 4*).

System integrator	Torque wrench	Four M6 bolts	One dowel pin

Prerequisites

- The robot is switched off.
  ↳ *Chapter 6.3.2 'Switching the robot on or off' on page 129*
- The tool to be connected meets the requirements of ISO 9409-1-50-4-M6.
- The tool to be connected has anti-twist protection on the connection flange.
- The tool to be connected meets the electrical specifications of the internal 12-pin interface.
  ↳ *'Internal 12-pin electrical interface' on page 26*
- In a risk assessment for the robot application planned by the owner, the system integrator checked the tool that is to be connected and classified it as safe for the operator.

- The tool manufacturer's specifications concerning tool assembly have been properly implemented by the system integrator.
- The following specifications apply to the threaded connections:
  - Only M6 bolts with a metric thread may be used.
  - The bolts must have a strength class of at least 8.8 degrees.
  - The bolts must ensure a screw-in depth of at least 6 mm.
  - The maximum tightening torque is 5.5 Nm.

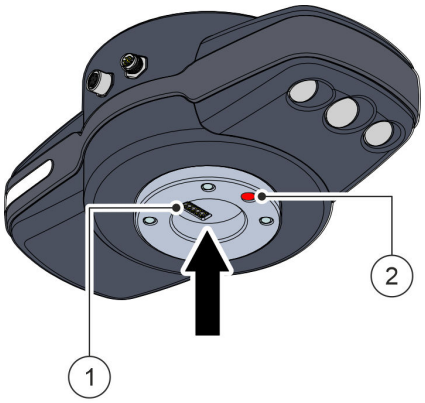


Fig. 61 Connecting the internal interface

01. Remove the protective cap from the connecting flange.

    IP54 tightness
    Removing the protective cap from the connecting flange results in the robot losing its IP54 tightness. To restore IP54 tightness by connecting a tool, ensure the following:

    - **The connection between the tool and the connecting flange is tightly closed.**
    - **The operator or system integrator must ensure that the connection between the tool and the connecting flange is sealed.**
    - **The tool has an IP54 tightness or higher.**

02. Align the tool correctly using the hole for the dowel pin Fig. 61/② and the internal 12-pin interface Fig. 61/①.

03. Place the tool on the connecting flange.

    In doing so, ensure that the electrical tool connection is correctly connected to the internal 12-pin interface Fig. 61/①.

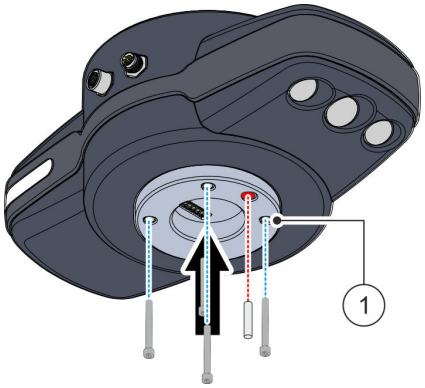


Fig. 62 Screwing the tool on tight

04. Attach the tool to the holes Fig. 62/① in the connecting flange with an optional dowel pin and four M6 bolts.

    Ensure that the maximum torque of 7.5 Nm is not exceeded.

6.2.2 Connecting other tool components

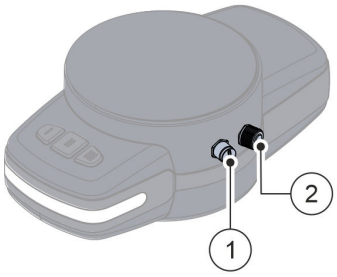


Fig. 63 External electrical interfaces on the media flange

① External 6-pin electrical interface
② External 8-pin electrical interface

Additional components such as grippers or sensors that are to be used together with a specific tool can be connected via the two electrical interfaces Fig. 63/① + ② on the media flange.

Connecting other components

The following sections describe by way of example how a signal lamp and an analogue sensor can be connected to the media flange via the electrical 8-pin interface Fig. 63/②.

System integrator

Prerequisites

- The robot is switched off.
  Chapter 6.3.2 'Switching the robot on or off' on page 129
- The tool is connected to the media flange.
  Chapter 6.2 'Connecting a tool provided by the owner' on page 123
- The components to be connected meet the electrical specifications of the external electrical interfaces.
  'External 8-pin electrical interface (main peripheral)' on page 29
  or
  'External 6-pin electrical interface (M8 connector)' on page 31

Example: Connecting a signal lamp via digital outputs

This example illustrates the activation of a signal lamp via the digital outputs of the 8-pin interface.

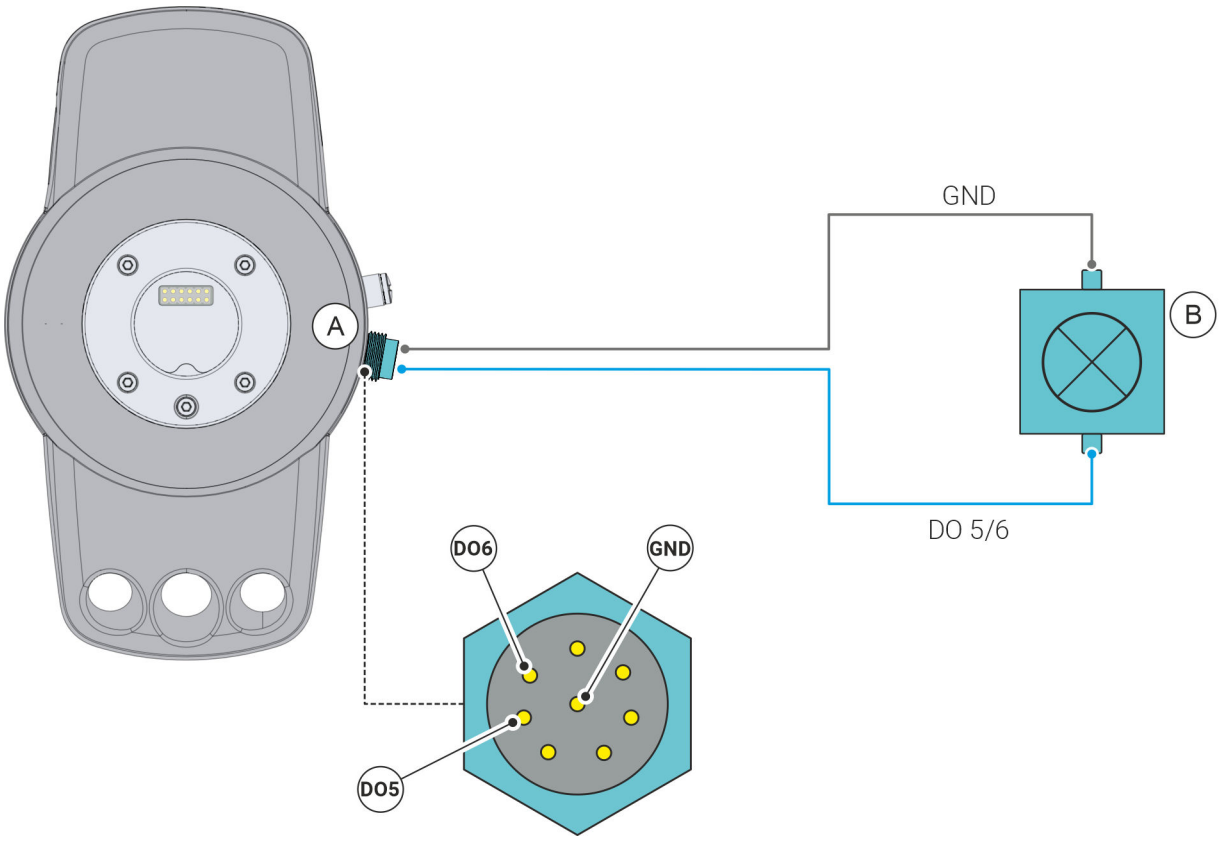


Fig. 64 Connecting a signal lamp via digital outputs

Ⓐ External 8-pin electrical interface
Ⓑ Signal lamp
GND Ground connection (GND)
DO5 Digital output 5
DO6 Digital output 6

01. Connect the signal lamp to the digital output **DO 5** or **DO 6** of the 8-pin interface Fig. 64.
02. Connect the signal lamp to the ground connection (GND) of the 8-pin interface Fig. 64.

Example: Connecting an analogue sensor via analogue inputs

In this example, an analogue sensor is connected via the analogue inputs of the 8-pin interface.

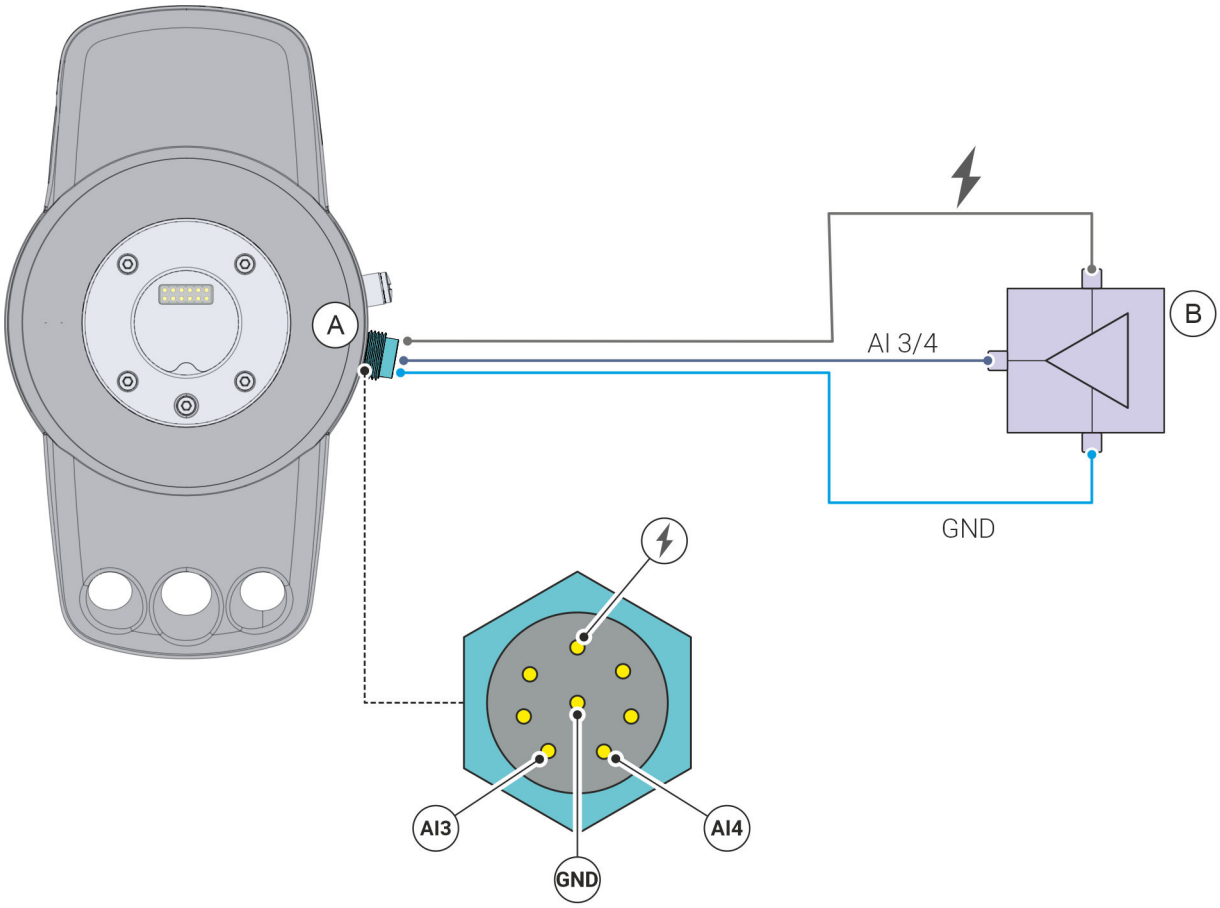


Fig. 65 Connecting an analogue sensor via analogue inputs

Ⓐ External 8-pin electrical interface
Ⓑ Analogue sensor
⚡ +24 V (24 W), PELV voltage
AI3 Analogue input 3
AI4 Analogue input 4
GND Ground connection (GND)

01. Connect the analogue sensor to the analogue input **AI 3** or **AI 4** of the 8-pin interface Fig. 65.
02. Connect the analogue sensor to the 24 V power supply of the 8-pin interface Fig. 65.
03. Connect the analogue sensor to the ground connection (GND) of the 8-pin interface Fig. 65.

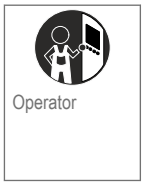
6.3 Operating robot functions

6.3.1 Checking that the robot is functional before operation

Before switching on the robot, the following tests must be carried out:

- Ensure that the robot is mounted and mechanically stable.
  ↯ *Chapter 5.3 'Installing the robot and putting it into operation' on page 107*.
- Ensure that the electrical connections are properly installed and that the power (voltage, frequency etc.) is within the specified limits.
  ↯ *Chapter 10.3 'Connected loads' on page 172*
- Ensure that the ambient conditions (temperature, humidity etc.) are within the specified limits.
  ↯ *Chapter 10.2 'Ambient conditions' on page 170*
- Make sure that the safety-relevant parts of the control system are properly installed.
  ↯ *Chapter 6.4 'Connecting the robot to the owner's components' on page 137*
- Ensure that the proper electrical grounding (equipotential bonding) is established.
- Ensure that all safety devices are functional.
  ↯ *Chapter 7.5 'Checking safety devices' on page 150*
- Ensure that all programs (normal control and safety-relevant programs) are installed in the current version.
  ↯ *"Robot Yu 5 Industrial" software manual*
- Ensure that test operation, including functional testing of the controller at reduced speed, has been carried out.
- Ensure that personnel are adequately protected during operation of the robot (e.g. by fences, light curtains).

6.3.2 Switching the robot on or off



Prerequisites

- The robot has been checked for proper functioning.
  Chapter 6.3.1 'Checking that the robot is functional before operation' on page 128

NOTICE! Risk of property damage!
After unpacking for the first time or after storing the robot for a longer period of time, wait for the robot to reach the ambient temperature before switching it on.

- Ensure that any condensate that has formed due to the rapid temperature change between the storage and installation location has completely evaporated.

01. WARNING! Risk of injury due to unintentional robot movements!

    Ensure that there are no people in the robot's hazard area.

02. Make sure that the robot is not in an inconsistent position.

    Inconsistent position
    An inconsistent position exists when the robot is not in the correct position (e.g. the robot has been moved when it was switched off). In this case, carefully check the position of the robot, i.e. the positions of all robot axes, and correct if necessary. If necessary, consult the safety engineer.

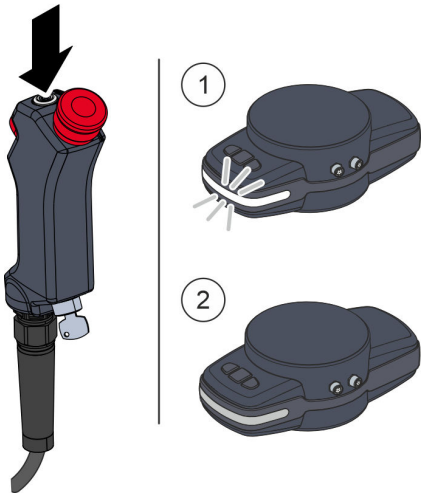


Fig. 66 Pressing the on/off button

03. Press the on/off button Fig. 66 on the handheld controller for about one second to switch the robot on or off.

▶ When switching on

- The on/off button on the handheld controller lights up green.
- During the booting process, the status LED on the media flange initially flashes white Fig. 66/①.
- Once the boot process is complete, the status LED lights up white.

▶ When switching off

- Before switching off, make sure that the robot is at a standstill.
- When the on/off button is pressed in the ON state, a pop-up window is displayed in the user interface.
  Confirm with *'OK'* to shut down the robot controller and switch off the robot.
- The status LED on the media flange Fig. 66/② goes out when the robot is switched off.

ⓘ Switching off

Alternatively, the robot can be switched off directly by pressing the on/off button for five seconds.

We do **not** recommend switching the robot off directly during regular operation as this can lead to malfunctions when it is switched on again.

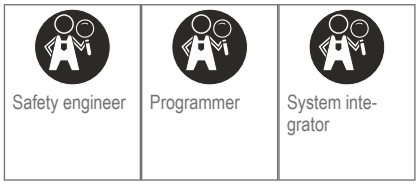
6.3.3 Switching the operating mode

WARNING
Risk of injury due to unauthorised data entry in manual mode!

After manual mode has been switched on at the mode selector switch, additional functions are available to authorised operating personnel in the user interface.

Unauthorised data entry in the user interface can cause dangerous robot movements such as manually moving the robot in a non-collaborative state.

- Ensure that only authorised operating personnel switch between operating modes (*Chapter 3.9 'Personnel requirements' on page 67*).
- Ensure that the robot and the user interface are protected against unauthorised access in manual mode.
- Ensure that the key for the mode selector switch is held exclusively by authorised operating personnel (*Chapter 3.9 'Personnel requirements' on page 67*).



Prerequisites

- The key is in the mode selector switch.
- All safety devices are installed and functional.

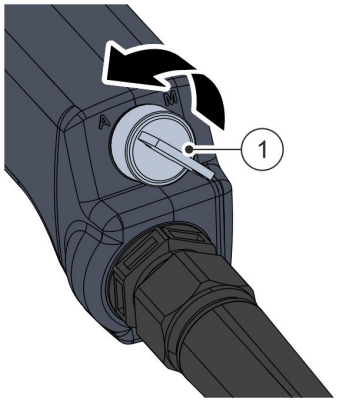


Fig. 67 Switching on automatic mode

Switching on automatic mode

01. Turn the mode selector switch Fig. 67/① on the handheld controller to position “A”.

▶ ■ Automatic mode is switched on.
■ In the status display of the user interface, the symbol for automatic mode is displayed.

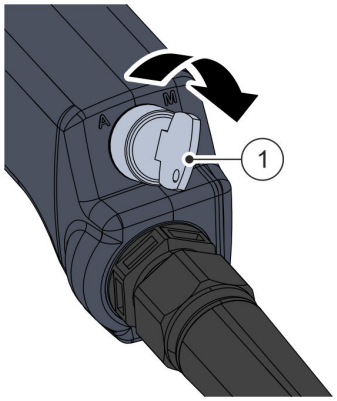


Fig. 68 Switching on manual mode

Switching on manual mode

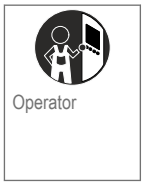
01. Turn the mode selector switch Fig. 68/① on the handheld controller to the “M” position.

▶ ■ Manual mode is switched on.
■ In the status display of the user interface, the symbol for manual mode is displayed.

6.3.4 Reset after a robot stop

The following section describes how to restart the robot after a stop or after a change of operating state:

Reset after a collision stop



A collision stop is triggered by physical contact with the robot. All robot movements are stopped immediately and a currently active program is interrupted. The program can be resumed after the robot is put back into operation.

01. To put the robot back into operation after a collision stop, press the manual guidance button on the media flange Fig. 69.

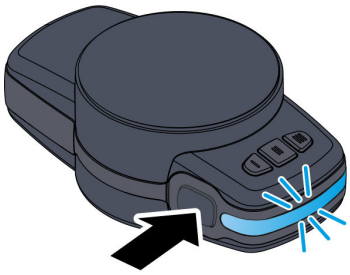


Fig. 69 Pressing the manual guidance button

Reset after an emergency stop

An emergency stop of the robot is triggered by pressing the emergency stop button on the handheld controller.

All robot movements are stopped immediately and the robot's brakes are active.

The robot controllers are switched off.

01. In order to put the robot back into operation after an emergency stop, make sure that there is no hazardous situation in the robot's working area.
02. Unlock the emergency stop button by turning it clockwise (Fig. 70).
03. Reset the robot in the user interface.

    ↳ *"Robot Yu 5 Industrial" software manual*

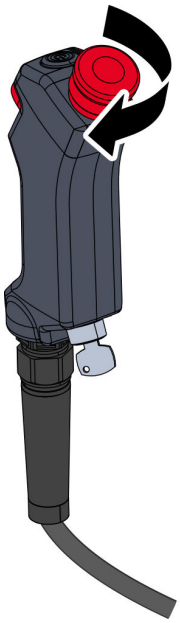


Fig. 70 Unlocking an emergency stop button

Reset after a safety stop

In the event of a safety stop, all robot movements are immediately stopped and the brakes of the robot are actuated. A safety stop is triggered in the following situations:

- When the emergency stop button on the handheld controller is pressed.
- If there is a fault in the safety controller.
- If the robot is in motion and the operating mode is changed on the mode selector switch.
- If the enabling button on the handheld controller is in the middle position and the operating mode is changed on the mode selector switch (in both automatic mode and in manual mode).

- If any of the robot's safety functions are triggered, e.g. because the maximum permissible speed is exceeded (*Chapter 3.12 'Safety functions' on page 76*).
- If an external safety device provided by the owner is connected to the safety I/O interfaces in the robot controller and this safety device is triggered.

Programmer	Safety engineer	System integrator

Prerequisites

- The robot is in manual mode.
  Chapter 6.3.3 'Switching the operating mode' on page 131

01. In order to put the robot back into operation after a safety stop, make sure that there is no hazardous situation in the robot's working area and that the event that triggered the safety stop has been corrected.
02. If the safety stop was triggered by pressing the emergency stop button:

    Unlock the emergency stop button by turning it clockwise Fig. 71.
03. Reset the robot in the user interface.

    "Robot Yu 5 Industrial" software manual

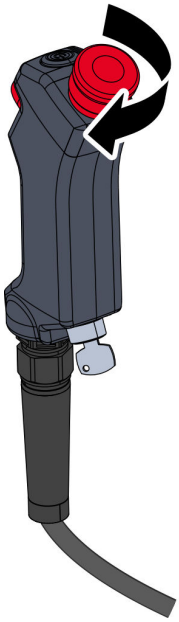


Fig. 71 Unlocking an emergency stop button

6.3.5 Setting the safety configuration parameters

Dangers if the robot's safety configuration is changed

WARNING
Risk of injury if the robot's safety configuration is changed!

If the robot's safety configuration is not properly parameterised, there is a risk of injury to the operator.

- The safety configuration can only be changed by the system integrator or by the responsible safety engineer.
- Ensure that the safety PIN is always protected against unauthorised access.
- Ensure that a risk assessment of the planned application is performed by the system integrator each time before a new robot application is set up. The risk assessment must show that all robot movements, including the tools or other devices connected to the media flange, do not constitute a source of danger for the operator.
- Before changing the current safety configuration, check the requirements that may arise, for example, if the tool is changed, if additional components are connected or if the work process or the robot environment change.
- Ensure that after each change to the safety configuration (i.e. the safety ID for the safety configuration also changes) the system integrator or the responsible safety engineer personally checks the safety parameters in a test operation for possible risks and functionality.

Setting the safety configuration parameters

For more information on parametrising the safety configuration and the safety ID, refer to the associated software manual:

"Robot Yu 5 Industrial" software manual

6.4 Connecting the robot to the owner's components

Risk of injury due to improper connection of the I/O interfaces

WARNING
Risk of injury due to improper connection of the I/O interfaces!

If the I/O interfaces are improperly connected to the owner's electrical components, there is a risk of injury due to inactive safety functions.

- Connect safety I/O interfaces in the robot controller exclusively to components provided by the owner that are suitable for safe operation.
- Always route signals from the safety I/O interfaces separately from the general digital I/O interfaces.
- Design all safety-relevant signals to be redundant (two independent channels).

  Always keep both channels separate so that a single malfunction cannot lead to the loss of the safety function.
- When configuring interfaces as safety I/O interfaces, always observe the information in *Chapter 2.2.5.3 'Electrical interfaces in the robot controller' on page 32*.

Risk of mixing up active and inactive components

WARNING
Risk of mixing up active and inactive components!

If components that were already connected to the robot controller on delivery, such as the handheld controller, are to be replaced by components provided by the owner, there is a risk of confusion between active and inactive components.

- Ensure that only service personnel from Agile Robots SE replace the handheld controller.
- If the handheld controller from Agile Robots SE is to be replaced with an enabling device provided by the owner:

  As soon as the handheld controller is disconnected from the robot controller, separate the handheld controller from the robot controller and keep it out of reach of the operator.

  This prevents the operator mistakenly using the inactive handheld controller.
- Ensure that only one handheld controller is used at a time.

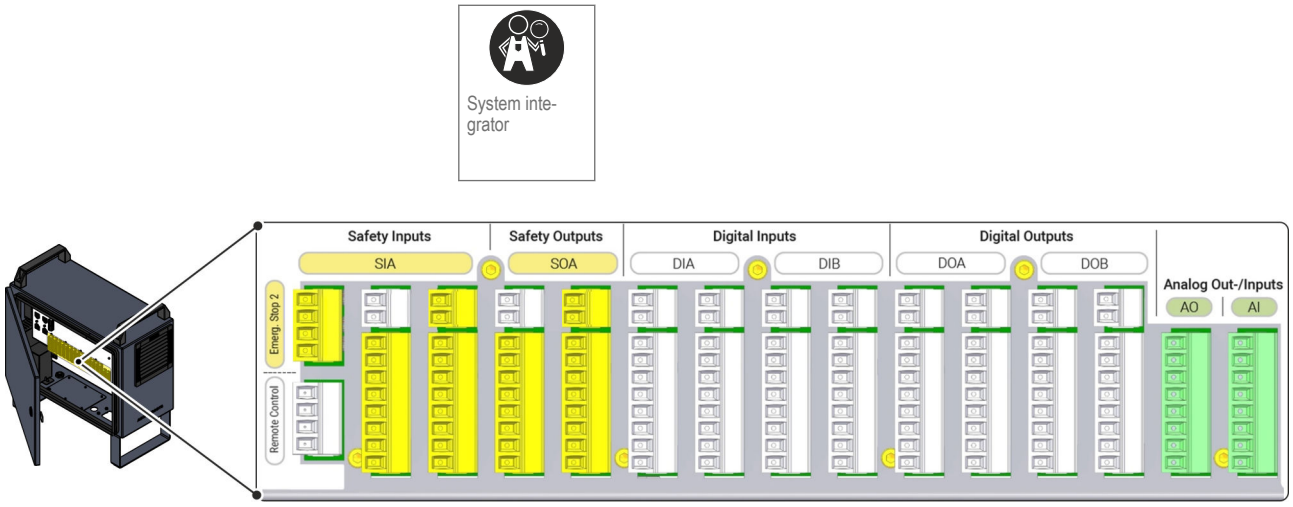


Fig. 72 I/O interfaces in the robot controller

Via the I/O interfaces in the robot controller Fig. 72, the robot can be connected to electrical equipment provided by the owner such as pneumatic relays or emergency stop switches.

The following sections illustrate some possible applications using practical examples.

Prerequisites

- The robot is switched off.

  ↳ *Chapter 6.3.2 'Switching the robot on or off' on page 129*

6.4.1 Connecting the external power supply

NOTICE
Risk of short-circuit due to lack of equipotential bonding!

When the robot is connected to an external power supply provided by the owner, there is a risk of short circuit due to a lack of equipotential bonding between the external and internal power supply.

- Always ensure that equipotential bonding is established between the robot's external and internal power supplies.

If the internal power supply is not sufficient to supply external components, a power supply provided by the owner can be connected.

PELV power pack

We recommend using a PELV power pack (**P**rotective **E**xtra **L**ow **V**oltage) with a rated voltage of 24 V and a safe disconnection function for the external power supply.

External power supply

Fig. 73 shows an example of the external power supply for the inputs of the digital I/O interfaces.

The other I/O interfaces in the robot controller can be connected to an external power supply in the same way.

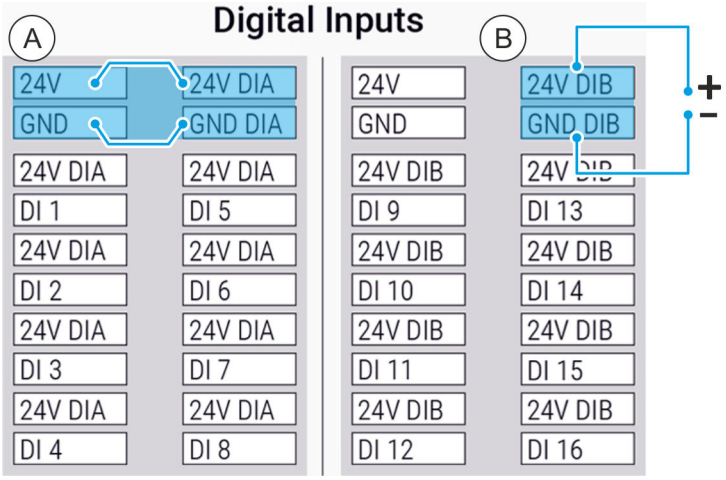


Fig. 73 Connecting the external power supply (example)

Ⓐ Internal power supply
Ⓑ External power supply

01. Connect the external power supply as shown in Fig. 73.

6.4.2 Connecting safety I/O interfaces

6.4.2.1 Connecting emergency stop switches

Integrating the robot into the owner's production process usually requires the use of additional emergency stop switches.

Fig. 74 Connecting emergency stop switches (example)

Ⓐ Emergency stop switch
Ⓑ Internal power supply

01. When connecting an external emergency stop switch, note the example configuration in Fig. 74.
02. Ensure that the internal power supply for the interfaces is guaranteed in accordance with Fig. 74.

    Otherwise, connect an external voltage source as described in *Chapter 6.4.1 'Connecting the external power supply' on page 139*.

6.4.2.2 Connecting a safety stop with reset button

If a safety input configured as a safety stop is connected to a light curtain, the application must be reset from outside the safety zone. The reset button required for this, like the light curtain, requires two channels.

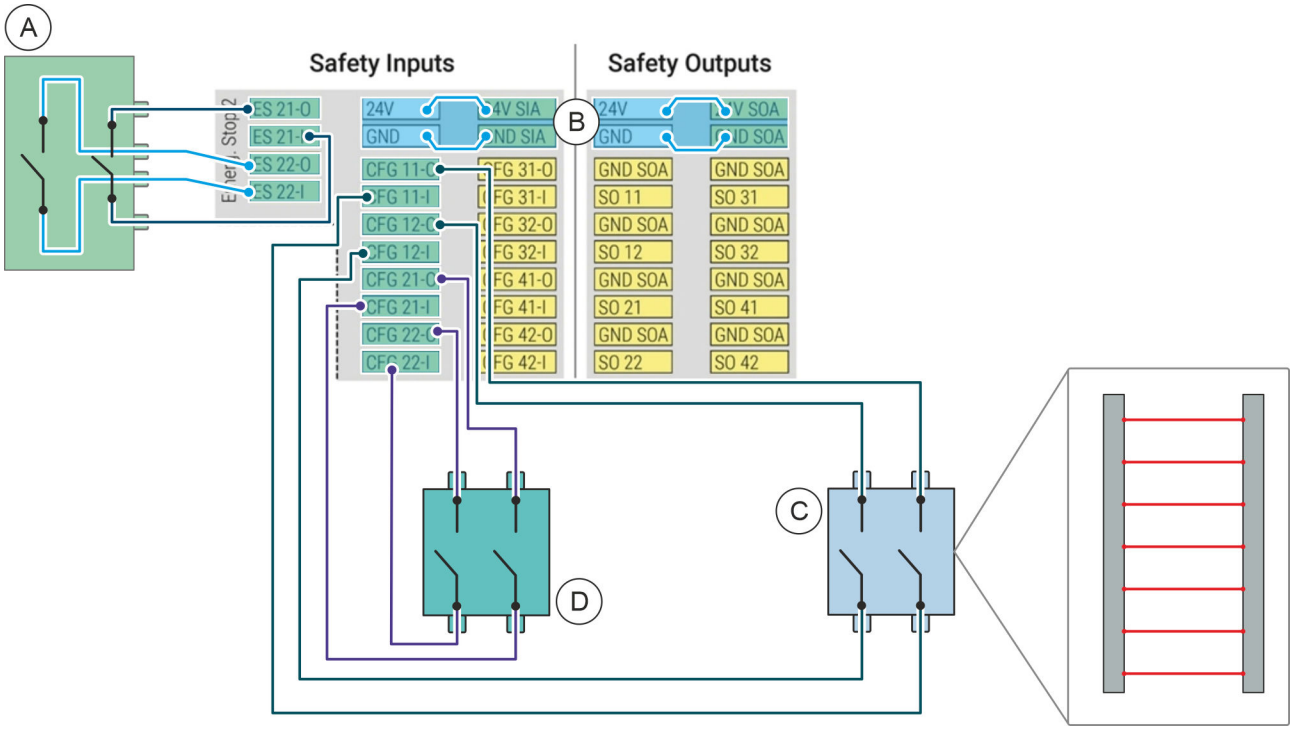


Fig. 75 Connecting a safety stop with reset button (example)

Ⓐ Emergency stop switch
Ⓑ Internal power supply
Ⓒ Light curtain
Ⓓ Reset button

01. When connecting a light curtain and a reset button, note the example configuration in Fig. 75.

02. Ensure that the internal power supply for the interfaces is guaranteed in accordance with Fig. 75.

    Otherwise, connect an external voltage source as described in *Chapter 6.4.1 'Connecting the external power supply' on page 139*.

6.4.3 Connecting digital I/O interfaces

6.4.3.1 Controlling an electronic load via digital outputs

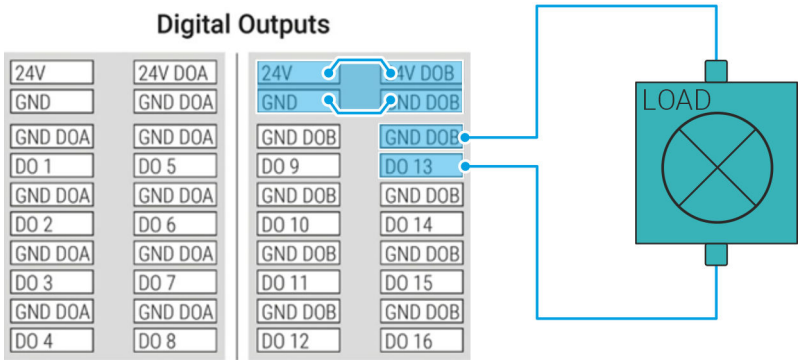


Fig. 76 Connecting an electronic load (example)

01. When connecting an electronic load via the digital output, note the example configuration in Fig. 76.

6.4.3.2 Connecting a button via digital inputs

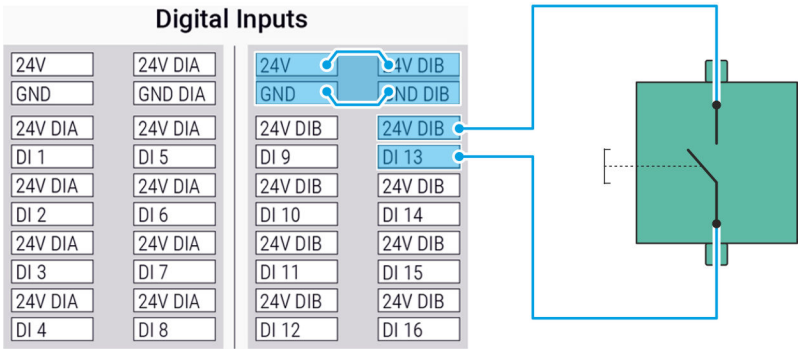


Fig. 77 Connecting a button (example)

01. When connecting a button via the digital input, note the example configuration in Fig. 77.

6.4.4 Connecting analogue I/O interfaces

Connecting an analogue sensor via analogue input

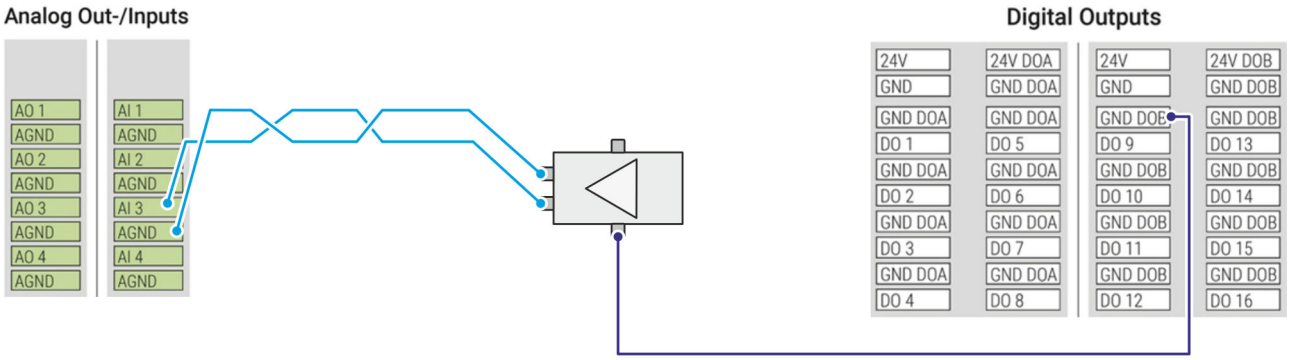


Fig. 78 Connecting an analogue sensor via analogue input (example)

01. When connecting an analogue sensor via the analogue input, note the example configuration in Fig. 78.

7 Cleaning and maintaining the robot

7.1 Safety during cleaning and maintenance work

Improper cleaning and maintenance

WARNING
Risk of injury due to improper cleaning and maintenance!

Incorrect cleaning and maintenance of the robot can result in injury and material damage.

- Carry out all cleaning and maintenance activities in accordance with the specifications and instructions in this manual.
- Before starting cleaning work, switch off the robot and secure it against being switched on again.
  ↳ *Chapter 7.4 'Securing against a restart' on page 147*
- If the robot is integrated in an overall system provided by the owner, ensure that work in the hazard area is only carried out when the overall system is switched off.
- Never make any changes to the robot or its components.
  For maintenance and repair work, send the robot to Agile Robots SE customer service (↳ *page 4*).

7.2 Spare parts

Incorrect spare parts

WARNING
Risk of injury due to the use of incorrect spare parts!

The use of incorrect or faulty spare parts can cause hazards for the operator as well as damage, malfunctions or a total failure of the robot.

- Only use original spare parts from Agile Robots SE or spare parts approved by Agile Robots SE.
  If you are unsure, always consult Agile Robots SE customer service (↳ *page 4*).

7.3 Maintenance schedule

If handled properly, the robot and its components can be operated without maintenance. In order to ensure the functionality of all components in the long term, we recommend cleaning the robot and its components and inspecting them visually at regular intervals according to the following overview.

If you have questions about maintenance work and intervals, contact Agile Robots SE customer service (↯ *page 4*).

Interval	Maintenance task	To be carried out by
Daily	Check safety devices. ↯ *Chapter 7.5 'Checking safety devices' on page 150*	System integrators Safety engineers
	Perform a visual inspection of the robot and its components, in particular the emergency stop button. ↯ *Chapter 7.6 'Performing a visual inspection of the robot and its components' on page 153*	Operator
	Perform a brake test. ↯ *"Robot Yu 5 Industrial" software manual*	Maintenance specialists Safety engineers
Once a month	Clean the robot and its components. ↯ *Chapter 7.8 'Cleaning the robot and its components' on page 155*	Operator
At least once a year	Restart the robot. ↯ *Chapter 6.3.2 'Switching the robot on or off' on page 129*	Operator

Interval	Maintenance task	To be carried out by
As needed	Perform a visual inspection of the robot controller's fan filter. If soiled, replace the filter unit. INFO: The maintenance interval depends on the cleanroom classification in which the robot is operated. ↳ *Chapter 7.7 'Performing a visual inspection of the fan filter and replacing the filter unit' on page 153*	Maintenance specialists
	Calibrate torque sensors. ↳ *"Robot Yu 5 Industrial" software manual*	Maintenance specialists Safety engineers

7.4 Securing against a restart

Risk of injury due to unauthorised or uncontrolled restarting

WARNING
Danger of injury due to switching on again without authorisation or without checking!

When work is carried out on the robot and its components, such as cleaning activities, there is a risk that the power supply will be switched on without authorisation and uncontrolled robot movements will be triggered.

- Always follow the procedure described below to secure against restarting.
- If a master switch is installed by the owner upstream of the mains connection:
  Ensure that once the master switch has been locked, only the responsible system integrator carries the associated key.

Securing against a restart

Fig. 79 Pressing the on/off button

01. Press the on/off button on the handheld controller for about one second Fig. 79.

02. In the pop-up window, choose *'OK'* to confirm and switch off the robot.

↳ *"Robot Yu 5 Industrial" software manual*

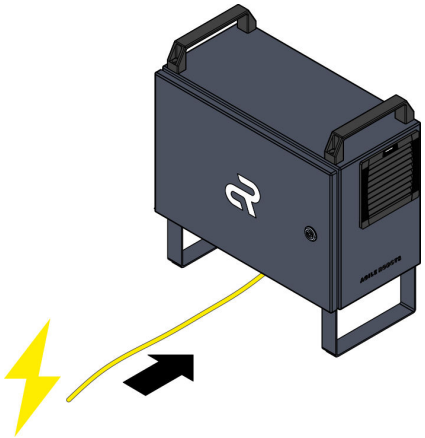


Fig. 80 Disconnecting the power supply

03. Disconnect the robot controller from the owner's power supply.

To do this, disconnect the power cable from the power outlet Fig. 80.

If a master switch is installed by the owner upstream of the mains connection:

Switch off the robot at the master switch and lock the master switch. The key must be kept by an authorised person until the robot is put back into operation.

Otherwise, attach a sign to the master switch warning against switching it back on: "Do not switch on! Work in the hazard area"

▶ The robot is secured against restart.

If maintenance work has to be carried out while the robot controller is switched on:

01. Activate the emergency stop button on the handheld controller .

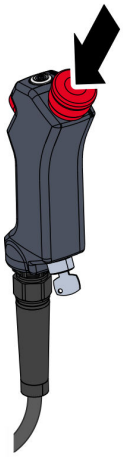


Fig. 81 Trigger the emergency stop button

02. Make sure that the status LED on the media flange lights up red .

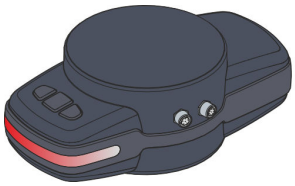


Fig. 82 Checking the status LED

▶ ■ The 48 V supply to the robot is stopped.

■ Maintenance personnel are protected from unexpected robot movements.

7.5 Checking safety devices

Checking the emergency stop button

System integrator	Safety engineer

Prerequisites

- The robot is switched on and is moving.
  Chapter 6.3.2 'Switching the robot on or off' on page 129

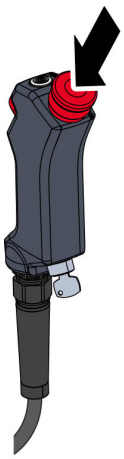


Fig. 83 Pressing the emergency stop button

01. Activate the emergency stop button on the handheld controller Fig. 83.
    ▶ - All movements of the robot immediately stop.
      - The status message for an emergency stop is displayed in the user interface.

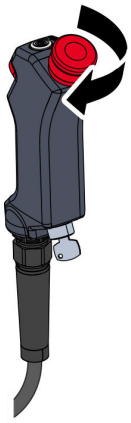
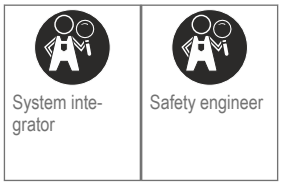


Fig. 84 Unlocking an emergency stop button

02. Unlock the emergency stop button by turning it clockwise Fig. 84.
03. Acknowledge the status message for the emergency stop in the user interface.
04. Switch the robot controller back on in the user interface.
    ▶ The robot is ready to operate again.
05. In case of component malfunctions:

    Do not put the robot back into operation and contact Agile Robots SE customer service (*page 4*).

Checking the enabling button



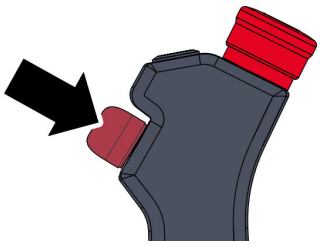


Fig. 85 Pressing the enabling button

Prerequisites

- The robot is switched on.

  ↳ *Chapter 6.3.2 'Switching the robot on or off' on page 129*

01. Press the enabling button on the handheld controller in the middle position and move the robot manually for a short distance Fig. 85.
02. Fully depress the enabling button during the robot movement.
    - ▶ All movements of the robot immediately stop.
    - The status message for a safety stop is displayed in the user interface.
    - The status LED on the media flange lights up red.
03. Acknowledge the safety stop by pressing the enabling button in the middle position.
    - ▶ The robot is ready to operate again.
04. In case of component malfunctions:

    Do not put the robot back into operation and contact Agile Robots SE customer service (↳ *page 4*).

Checking the mode selector switch

System integrator	Safety engineer

Prerequisites

- The robot is switched on and is moving.
  Chapter 6.3.2 'Switching the robot on or off' on page 129

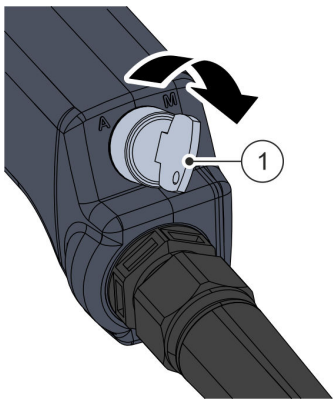


Fig. 86 Turning the mode selector switch (example)

01. Change the operating mode by turning the mode selector switch on the handheld controller Fig. 86.
    ▶ - All movements of the robot immediately stop.
      - The status message for a safety stop is displayed in the user interface.
02. Acknowledge the status message for the safety stop in the user interface.
03. Switch the robot controller back on in the user interface.
    ▶ The robot is ready to operate again.
04. In case of component malfunctions:

    Do not put the robot back into operation and contact Agile Robots SE customer service (*page 4*).

7.6 Performing a visual inspection of the robot and its components

Performing a visual inspection

Prerequisites

- The robot is switched off.

01. Visually inspect the robot and its components for damage, in particular the cable sheath Fig. 87/① in the area of the robot base and the robot plug, on a daily basis.
02. Ensure that the robot has no sharp edges.

If there is any damage, the robot must not be put into operation. Contact Agile Robots SE customer service (↳ *page 4*) to arrange for repairs.

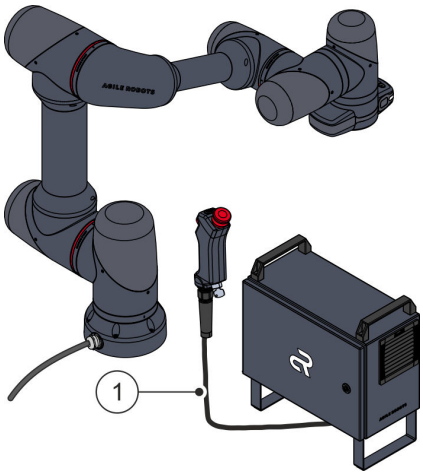


Fig. 87 Visual inspection of the robot components

7.7 Performing a visual inspection of the fan filter and replacing the filter unit

Prerequisites

- The robot is switched off.
  ↳ *Chapter 6.3.2 'Switching the robot on or off' on page 129*

Fan filter

The procedure for replacing the filter unit is identical for both fan filters.

The following intervals apply to the replacement of the filter unit:

Ambient conditions	Fleece filter	Folded filter
Coarse particles	Min. 2 times per year	Min. 1 time per year
Dusty/spray mist	Min. 6 times per year	Min. 3 times per year
Highly oily	Min. 1 time per week	Min. 2 times per month
Without relevant stresses	Min. 2 times per year	Min. 1 time per year

01. Carefully fold down the cover on the fan filter Fig. 88.

02. Check the filter unit for soiling Fig. 88/①.

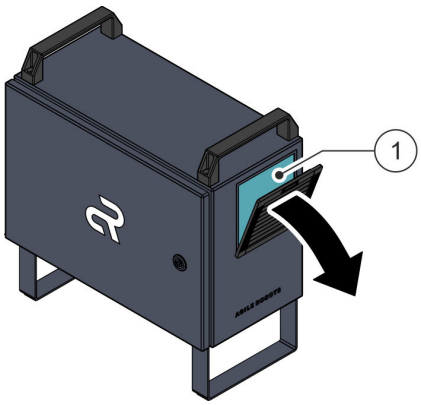


Fig. 88 Folding down the cover

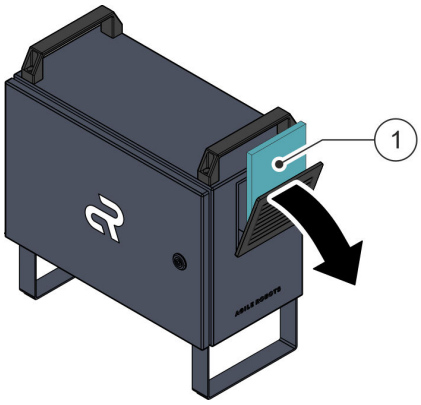


Fig. 89 Replacing the filter unit

03. If the filter unit is soiled or damaged:

    Remove the filter unit and insert a new filter unit from Pfannenberg (item number 18611600030) Fig. 89/①.

    Manufacturer's instructions
    Further information on the filter unit can be found in the relevant manufacturer's manual.

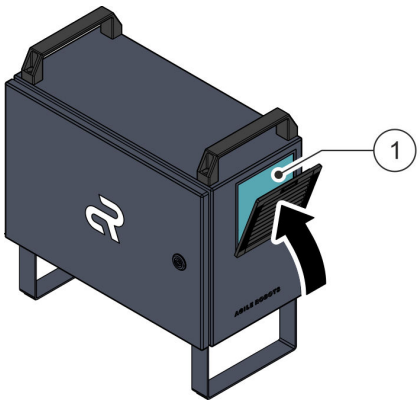


Fig. 90 Folding up the cover

04. Close the cover on the fan filter Fig. 90/①.

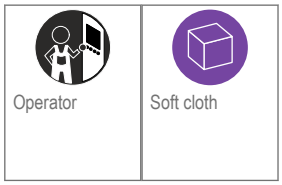
7.8 Cleaning the robot and its components

Damage due to improper cleaning

NOTICE
Damage due to improper cleaning!

Never clean robots with compressed air, steam or water jets.

Do not use chemical cleaning agents.



Prerequisites

- The robot is switched off.

  Chapter 6.3.2 'Switching the robot on or off' on page 129

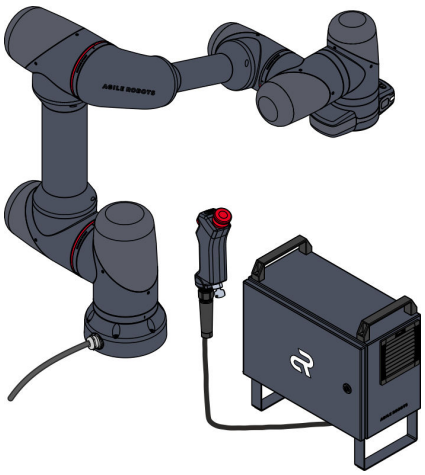


Fig. 91 Overview of the robot and components

01. Wipe the outer surfaces of the robot and its components with a soft cloth and warm water Fig. 91. In particular, keep the areas at the axis transitions free of dirt.

    Avoid the electrical interfaces during all cleaning work.

    Warning signs
    Make sure that the warning signs in the robot controller are easy to read at all times.

8 Troubleshooting

8.1 Safety during troubleshooting work

Improper troubleshooting

WARNING
Danger of injury due to improper troubleshooting!

Incorrect troubleshooting can result in injury and material damage.

- Carry out all troubleshooting tasks in accordance with the specifications and instructions in this manual.
- If troubleshooting requires work in the robot's or the robot controller's hazard area, switch off the robot and secure it against being switched on again before starting the work (*Chapter 7.4 'Securing against a restart' on page 147*).
- Never make changes to the robot and its components that go beyond connecting devices provided by the owner as described in *Chapter 6.4 'Connecting the robot to the owner's components' on page 137*.

  In the event of damage or defects in individual components, contact Agile Robots SE customer service (*page 4*).

8.2 What to do in the event of faults

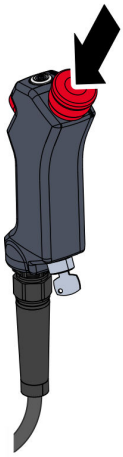


Fig. 92 Pressing the emergency stop button

Key information:

01. In the event of faults that pose an immediate danger to persons or property, initiate an emergency stop immediately Fig. 92.
02. If possible: identify the cause of the fault.
03. If troubleshooting requires work in the hazard area, switch off the robot and secure it against being switched on again (↳ *Chapter 7.4 'Securing against a restart' on page 147*).
04. Depending on the type of fault, have it rectified by the responsible system integrator or contact Agile Robots SE customer service (↳ *page 4*).

8.3 Starting up the robot after a fault has been rectified

01. If the robot has been disassembled for repair work:

    Ensure that the robot and its components are set up and fastened in accordance with the specifications in this manual.
02. Ensure that the robot's working area is free of objects.
03. Ensure that there are no foreign objects and no defective, loose or detached parts on the robot.
04. In the case of integrated operation in an overall system:

    Ensure that the application is ready for operation in accordance with the owner's specifications.
05. Ensure that all the safety devices for the robot and the owner's application are installed and functioning properly.
06. Put the robot back into operation according to the information in ↳ *Chapter 6 'Operating the robot' on page 119*.

9 Disassembly and disposal of robots

9.1 Safety during disassembly

Dangers due to improper disassembly

WARNING
Dangers due to improper disassembly!

During dismantling work, there is a risk of injury due to crushing of body parts or falling components.

- Dismantling work must only be carried out by professionally qualified personnel.
- Before starting dismantling work, ensure the following:
  - The robot is switched off and disconnected from the mains.
  - There are always two people available to disassemble the robot.
  - Only suitable and properly functioning work equipment and devices are used for disassembly.

9.2 Preparing for disassembly

Disposal of the robot and its components

To protect the environment, the robot has been manufactured with limited use of hazardous substances pursuant to **RoHS Directive 2011/65/EU**.

The Agile Robots SE is registered with the Stiftung EAR foundation (waste electrical and electronic equipment register) and takes back Yu 5 Industrial brand robots that have been sold on the German market free of charge in order to dispose of them properly.

Importers in European countries that are subject to the **WEEE Directive 2012/19/EU** are responsible for registering with the national WEEE register in their country.

A list of national registers can be found here:

https://www.ewrn.org/national-registers

Prerequisites

- Ensure order and cleanliness at the dismantling site.
- There is sufficient space for disassembly before starting work.
- It is ensured that dismantling takes place in a dry and well-lit environment.
- The foam packaging of the robot box and the associated transport straps are available.
- There are no tools on the robot's media flange.
- There are no loose parts on the robot.
- The robot is in the transport position.

  ↳ *"Robot Yu 5 Industrial" software manual*
- The robot is switched off.

  ↳ *Chapter 6.3.2 'Switching the robot on or off' on page 129*

9.3 Disassembling the robot

Undo the connecting cables for the components

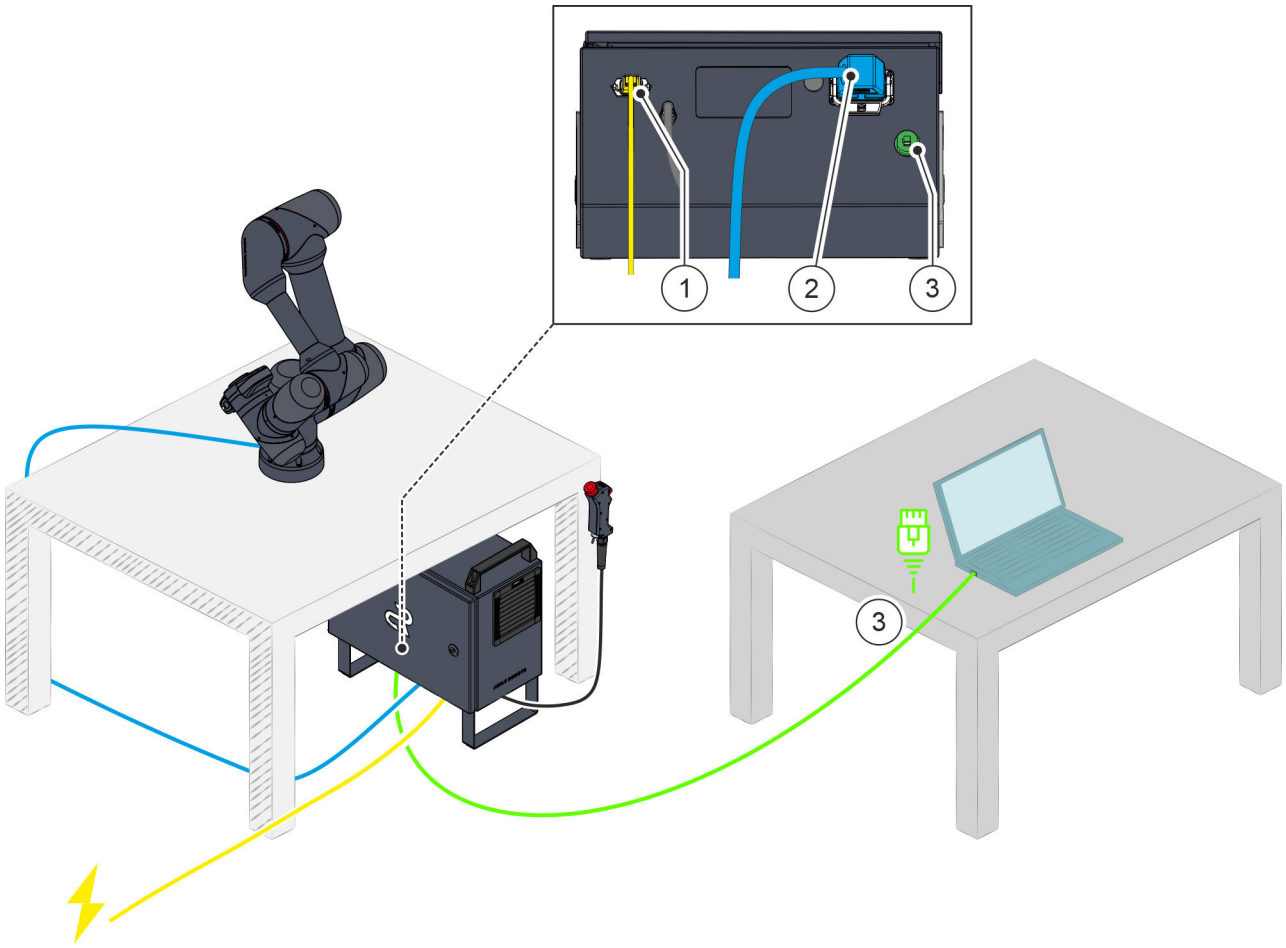


Fig. 93 Undoing the connecting cables

01. After switching off the robot, wait about 10 seconds.

02. ⚠ WARNING! Dangerous residual voltages on exposed plug contacts!

Disconnect the connecting cables as follows. When doing so, take care not to touch the exposed contacts.

- Disconnect the power cable and remove it from the connection to the robot controller Fig. 93/①.
- Disconnect the robot's connecting cable and remove it from the connection to the robot controller Fig. 93/②.
- Disconnect the Ethernet cable from the ports on the laptop and robot controller Fig. 93/③.

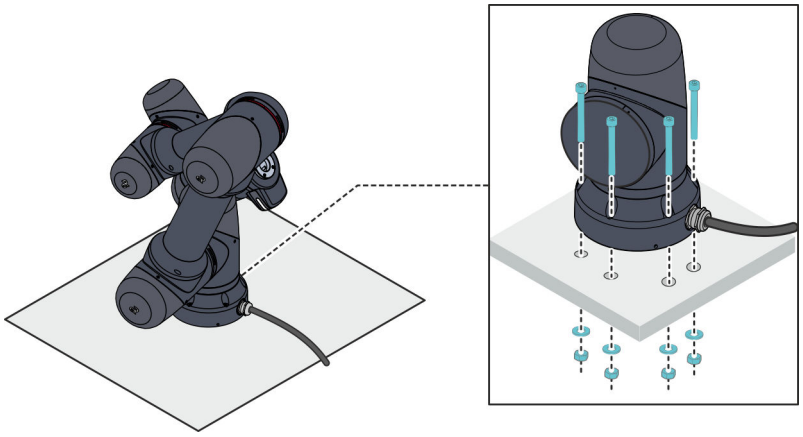


Fig. 94 Undoing the threaded connections (part 1)

03. ⚠ WARNING! Risk of tipping over due to the robot's lack of stability!

Use the socket wrench to loosen a maximum of four lock nuts (M8) on the underside of the table counter-clockwise Fig. 94.

Note the following here:

- Do not loosen the two remaining bolts before step 5 to ensure the robot remains stable.
- Ensure that exactly the bolts shown in Fig. 94 are loosened.

04. Remove the corresponding four washers and bolts from the robot base Fig. 94.

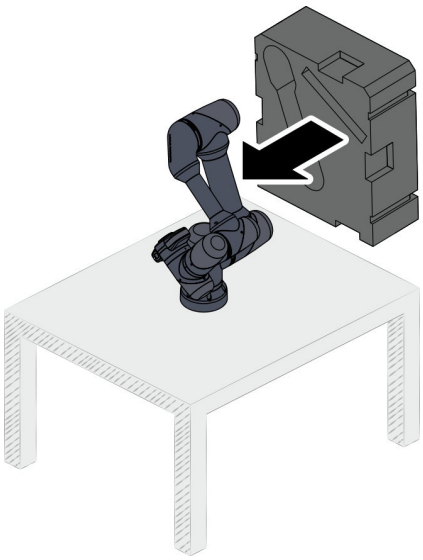


Fig. 95 Inserting packaging part **3**

05. Place packaging part 3 on the robot Fig. 95 and stow the rolled-up robot cable in the recess in the foam packaging.

    Ensure that the robot cable is not kinked.

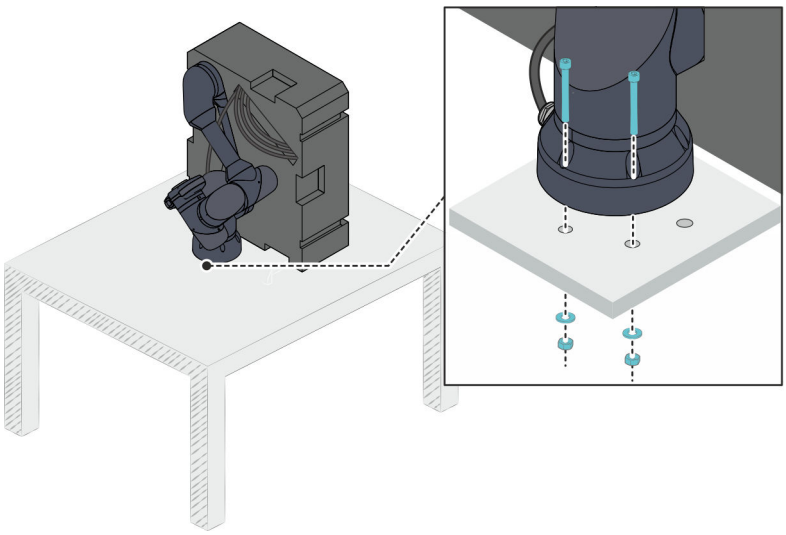


Fig. 96 Undoing the threaded connections (part 2)

06. Use the socket wrench to loosen the two remaining lock nuts (M8) on the underside of the table counter-clockwise Fig. 96.

07. Remove the corresponding two washers and bolts from the robot base Fig. 96.

08. Place packaging part 2 on the robot Fig. 97.

    In doing so, ensure that packaging parts 2 and 3 completely enclose the robot.

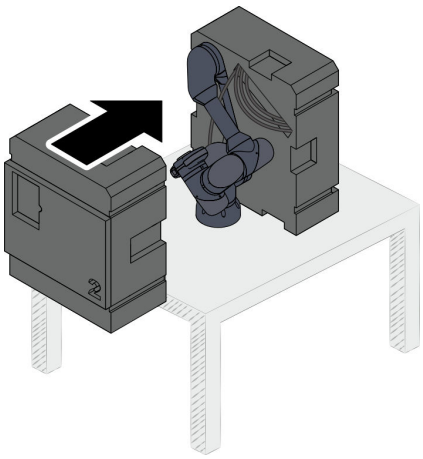


Fig. 97 Inserting packaging part **2**

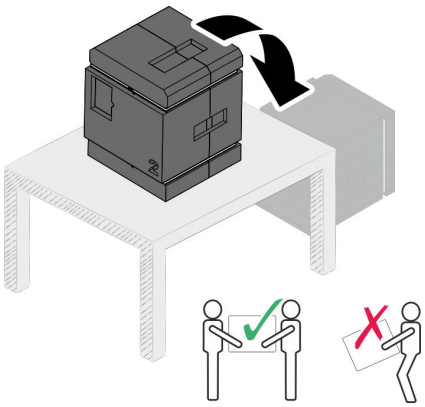


Fig. 98 Attaching the transport strap

09. ⚠ WARNING! Risk of injury due to heavy load!

    Make sure that two people are available to carry the robot box.

10. Attach the transport straps and lift the robot box off the table rotated by 90° as shown in Fig. 98.

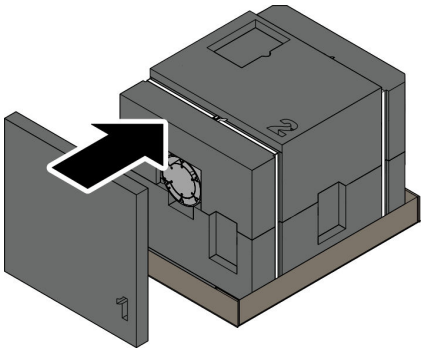


Fig. 99 Inserting packaging part **1**

11. Close the robot box with packaging part 1 Fig. 99.

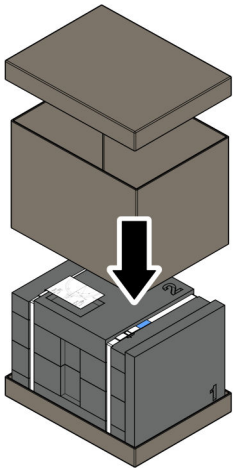


Fig. 100 Packing the robot box

12. Use the outer packaging to pack the robot box Fig. 100.

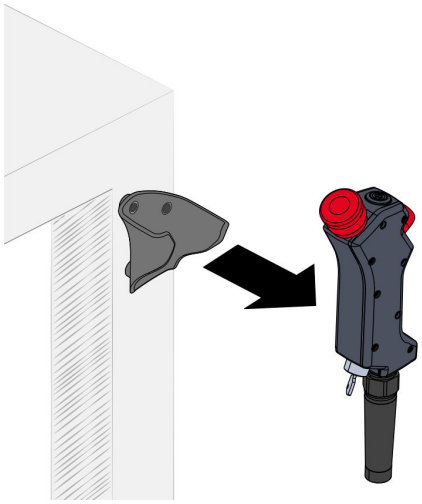


Fig. 101 Removing the handheld controller

13. Remove the handheld controller from the bracket on the table and place it near the robot controller Fig. 101.

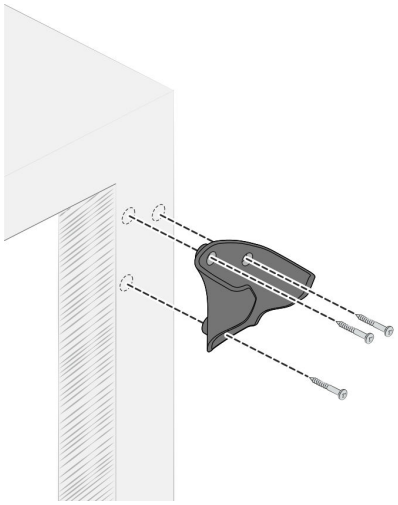


Fig. 102 Disassemble the handheld controller bracket

14. Loosen the three screws for the bracket counter-clockwise and remove the bracket from the table Fig. 102.

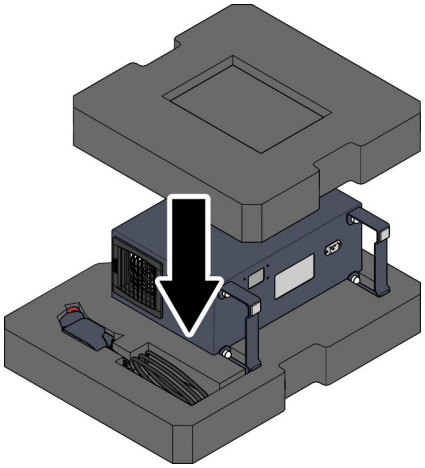


Fig. 103 Robot controller box

15. If all components are to be transported:

    Place the robot controller and handheld controller in the lower shell of the foam packaging and close the box with the upper part Fig. 103.

    Ensure that the handheld controller cable is not kinked.

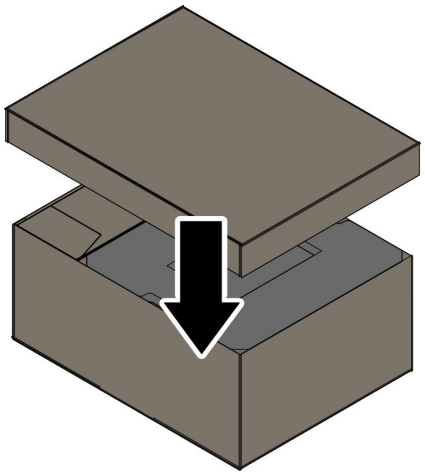


Fig. 104 Robot controller box

16. Pack the box for the robot controller with the outer packaging Fig. 104.

9.4 Disposing of robots and their components

Disposal information

UMWELTSCHUTZ!
Danger to the environment due to improper disposal!

Improper disposal can harm the environment.

- Have electronic waste, electronic components and auxiliary materials disposed of by approved specialist companies.
- If in doubt, obtain information on environmentally sound disposal of components and materials from your local municipal authority or specialised waste disposal companies.

If no take-back or disposal agreement has been agreed, recycle dismantled components:

- Have metals scrapped.
- Send plastic elements to recycling.
- Have electronic components disposed of by a specialist company.
- Have batteries disposed of in accordance with the regulations applicable at the place of use.
- Dispose of other components sorted according to material properties.

10 Technical data

10.1 Basic data

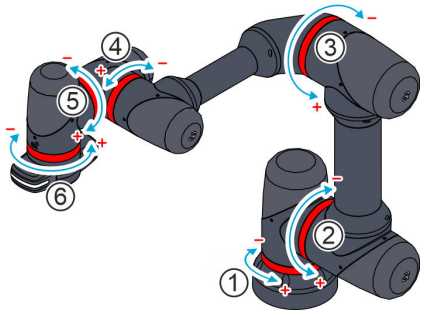


Fig. 105 Robot axes

Specification	Value
Maximum payload	5 kg
Maximum range	1,083 mm
Number of controllable axes	6
Position accuracy	± 0.05 mm
Maximum speed of the end effector (Tool Centre Point, TCP)	2 m/s
Axis limits	
Axis 1	-220°/+220°
Axis 2	-310°/+130°
Axis 3	-160°/+160°
Axis 4	-310°/+130°
Axis 5	-220°/+220°
Axis 6	-220°/+220°
Maximum axis speeds	
Axis 1	141°/s
Axis 2	141°/s
Axis 3	169°/s
Axis 4	180°/s
Axis 5	180°/s
Axis 6	180°/s
Weight of robot arm	31.5 kg
Weight of robot controller	17.1 kg
Dimensions of robot controller (H x W x L)	473 x 462 x 225 mm
Installation position	Floor

Specification	Value
IP classification (only in the fully connected state)	■ Robot arm: IP54 ■ Robot controller: IP54 ■ Handheld controller: IP54
Sound power level	65.3 dB
Operation	Browser-based user interface (Google Chrome®)

10.2 Ambient conditions

Operating conditions (robot and robot controller)

Specification	Value
Ambient temperature	+5 to +40°C*
Altitude	-300 to +1,000 m
Air pressure	90–106 kPa
Relative humidity, max.	70% at temperatures up to +31°C, decreasing linearly to 50% at +40°C
Relative humidity, min.	At least 45% for the specified temperature range. Non-condensing
Place of use	In enclosed spaces
Degree of pollution, max.	II as per EN 61010-1:2010
Environmental classes as per DIN IEC EN 60721-3-3:2020	3M10/3B1/3S6/3Z2
Corrosivity category as per ISO 9223	C1
Permissible earthquake loads	None

* At an ambient temperature of > 40°C and high humidity, the maximum payload of 5 kg cannot be guaranteed.

At an ambient temperature < 10°C, we recommend a 10-minute warm-up period for the robot. Otherwise, there is a risk that the robot will stop or can only be operated with lower power due to temperature-dependent lubricant viscosity.

Storage conditions (robot and robot controller)

Specification	Value
Ambient temperature	+5 to +40°C
Altitude	-300 to +1,000 m
Air pressure	90–106 kPa
Relative humidity, max.	70% at temperatures up to +31°C, decreasing linearly to 50% at +40°C
Relative humidity, min.	At least 45% for the specified temperature range. Non-condensing
Degree of pollution, max.	II as per EN 61010-1:2010
Environmental classes as per DIN EN IEC 60721-3-1:2018-12	1M11/1B1/1S11/1C1/1Z2

Transport conditions (robot and robot controller)

Specification	Value
Ambient temperature	-20 to +40°C
Altitude	-300 to +1,000 m
Air pressure	90–106 kPa
Relative humidity, max.	70% at temperatures up to +31°C, decreasing linearly to 50% at +40°C
Relative humidity, min.	At least 45% for the specified temperature range. Non-condensing
Degree of pollution, max.	II as per EN 61010-1:2010
Environmental classes as per DIN EN IEC 60721-3-2:2018-12	2M4/2B1/2S5/2C1

10.3 Connected loads

Specification	Value
Robot power supply	
Mains voltage	**Europe** 230 VAC **China** 220 VAC
Frequency	50–60 Hz
Performance, max.	1,200 W
Number of phases	1
Short-circuit current	100 A
Media flange power supply	
Voltage	24 VDC
Current	2 A
Protection class	
Protection class I in accordance with DIN EN 61800-5-1:2007	

Cable lengths (included in scope of delivery)

Cable	Cable length
Connecting cable for robot – robot controller	2.8 m
Connecting cable for handheld controller – robot controller	3 m
Power cable for robot controller, max.	3 m Cable cross-section: min. 1.5 mm²

Cable specification (not included in scope of delivery)

Interface	Max. cable length	Cable specification
Media flange		
8-pin interface	3 m	Shielded
12-pin interface	-	Shielded by tool

Interface	Max. cable length	Cable specification
Ethernet port	3 m	CAT 6
Robot controller		
Ethernet port	30 m	SFTP, CAT 6
Digital I/O interfaces	3 m	Not shielded
Analogue I/O interfaces	3 m	Shielded or twisted
USB port	3 m	USB 3.0, shielded
IEC connection	3 m	Not shielded

10.4 Interfaces

Electrical I/O interfaces

Internal 12-pin electrical interface (*page 26*)	External 6-pin electrical interface (*page 31*)	External 8-pin electrical interface (*page 29*)	Robot controller (*page 32*)
Digital In: 2	Digital In: -	Digital In: 2	Digital In: 16
Digital Out: 4	Digital Out: -	Digital Out: 2	Digital Out: 16
Analogue In: 2		Analogue In: 2	Analogue In: 4
			Analogue Out: intended for future robot version
Power supply: 24 V	Power supply: 24 V	Power supply: 24 V	Power supply: 24 V

Mechanical interfaces

Connecting flange for tools on the media flange	Standard robot flange as per ISO 9409-1-50-4-M6
Button on the media flange	■ 1 manual guidance button on the media flange ■ 3 function buttons on the media flange

Minimum requirements for mobile device

Display	1280 x 768 pixels (recommended: touchscreen)
CPU	Intel Celeron® N4120
GPU	Intel® YHΔ graphics card 600
RAM	4 GB
Operating system	Microsoft Windows®, Linux, Android® or Apple macOS®
Browser	Browser: Google Chrome® or Microsoft Edge® (version 79 or later)

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Appendix

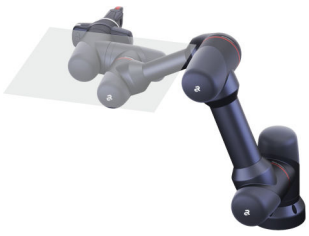
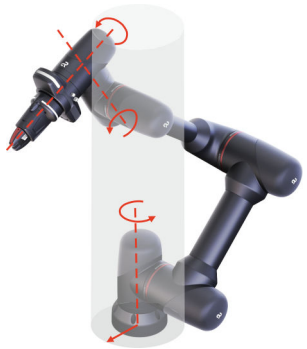
A Singularities

Overview

Singularities denote robot positions in which the movement of the robot is restricted in one or more directions. If the robot moves on a predetermined path geometry (e.g. linear, circular etc.) in the vicinity of a singularity, very high angular velocities and forces can occur.

The Yu 5 Industrial robot automatically detects when a movement near a singularity is planned and reduces the path speed if possible. Depending on the configuration, there may still be excessive speed, which triggers a safety stop. It is therefore necessary to know the different singularity configurations and to take them into account when programming applications.

The Yu 5 Industrial robot is a six-axis articulated robot with three different types of singular configurations, which are described in the following section.

Example illustration	Description
	**Elbow singularity** This singularity is present when the axis angle of axis 3 is 0° or 180°. Effects on the maximum speed and accuracy of the Cartesian force estimation are to be expected from a distance of 30° to the singular configuration. Unrestricted area: 30° to 150° and -30° to -150°
	**Wrist singularity** This singularity is present when the axial angle of axis 5 is 0° or ±180° and thus axes 4 and 6 are aligned parallel to one another. Effects on the maximum speed and accuracy of the Cartesian force estimation are to be expected from a distance of 20° to the singular configuration. Unrestricted area: 20° to 160° and -20° to -160°
	**Internal singularity** This singularity exists when the intersection of axis 5 and axis 6 lies on a cylinder with a radius of 138.2 mm around the robot base. Effects on the maximum speed and accuracy of the Cartesian force estimation are to be expected from a cylinder radius of 185 mm.

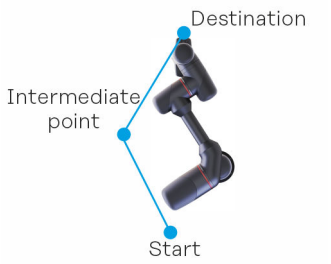
Dangers due to singularities

Example illustration	Description
	Interpolated movements in Cartesian space can lead to rapid and unexpected axial movements in the vicinity of singularities. **Example** Movements over axis 1 may result in extremely rapid movements around axis 1. We recommend avoiding such robot movements.

Dealing with singularities

Example illustration	Description
	■ The robot controller does not distinguish between the different types of singularity. ■ The speed of Cartesian jogging is automatically reduced (to a standstill) as the robot approaches a singularity. Jogging is accelerated again as soon as the robot moves away from the singularity. ■ Jogging in the joint CS is not affected. ■ Singularities have no effect on the path planning of PTP commands. **With regard to hazardous movements** ■ Rapid movements resulting from robot movements in the vicinity of singularities are possible, but are monitored and limited by the force and power limitation.

Recommendations for planning robot movements near singularities

Example illustration	Description
	■ If possible, move in JointCS (MovePTP). If necessary, modify existing MoveLinear commands to MovePTP. ■ If possible, do not move over axis 1 or along axis 1. ■ Bypass singularities with the help of additional intermediate points. A fast cycle time can still be achieved with the help of blending.

B Stopping time and distance

Diagrams of stopping time and stopping distance

The following section shows diagrams of the stopping times and distances as a function of the speed for various axes, payloads and extensions.

Worst-case scenario

The values indicated in the diagrams represent the worst case. The actual values will deviate from these values.

The results for the SS0 stops are shown in the following table:

Axis 1		Axis 2		Axis 3	
Distance [mm]	Time [ms]	Distance [mm]	Time [ms]	Distance [mm]	Time [ms]
343	226	396	366	201	206

The values specified here for the stopping time and stopping distance always apply when an SS1 stop is triggered (e.g. by virtual planes, cuboids, limits of the drive angle position, limits of the drive angle speed).

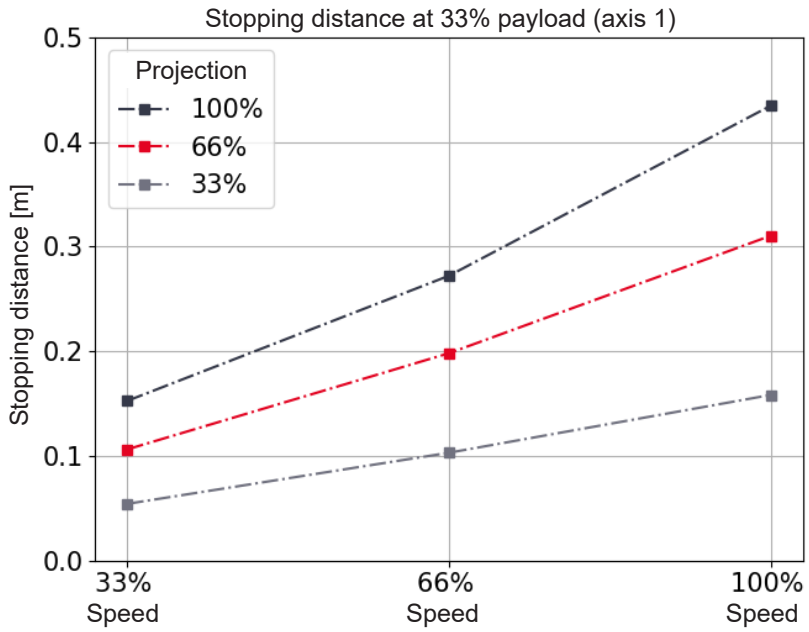
Safety functions ensure that limits are not exceeded, e.g. stopping times, stopping distances and tolerances. The system integrator is obliged to integrate the robot into a cell, for example. For this, the system integrator needs the values.

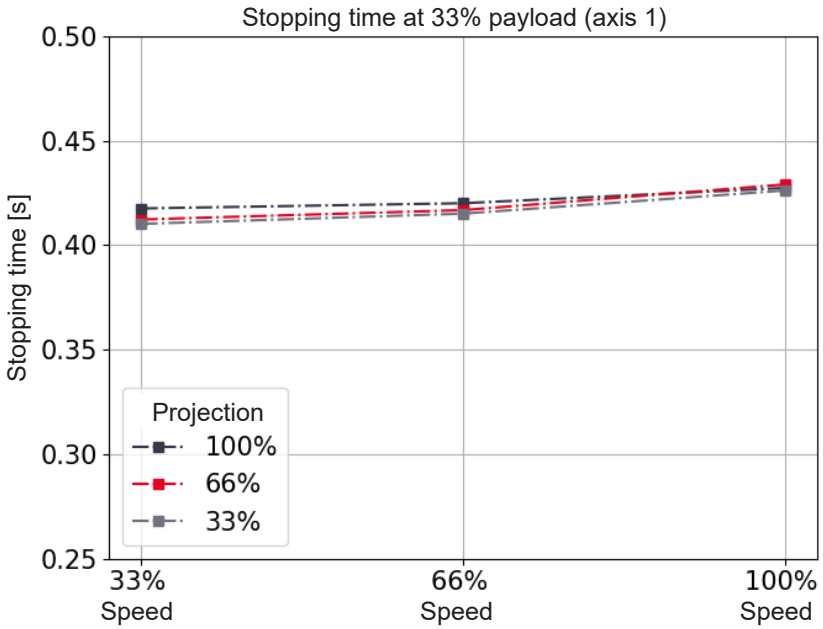
If you have questions about the robot's stopping times and stopping distances, contact Agile Robots SE customer service (*page 4*).

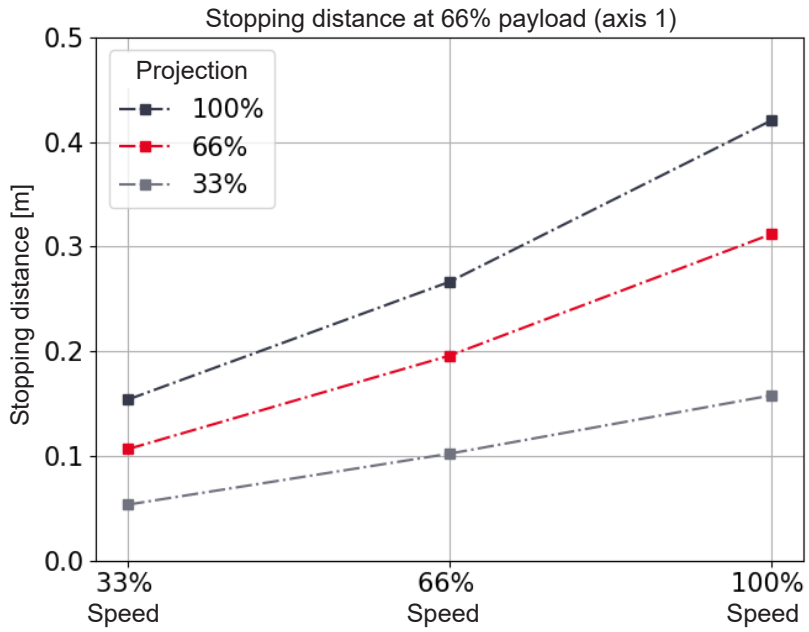
Process safety time

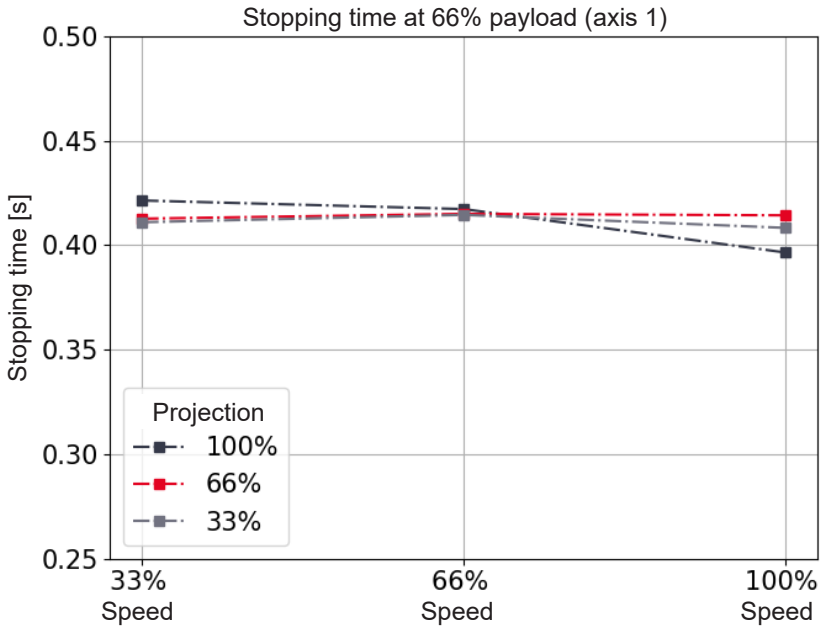
Observe the process safety time (e.g. when putting the robot into operation) for the respective stop category (DIN EN 60204-1:2019-06):

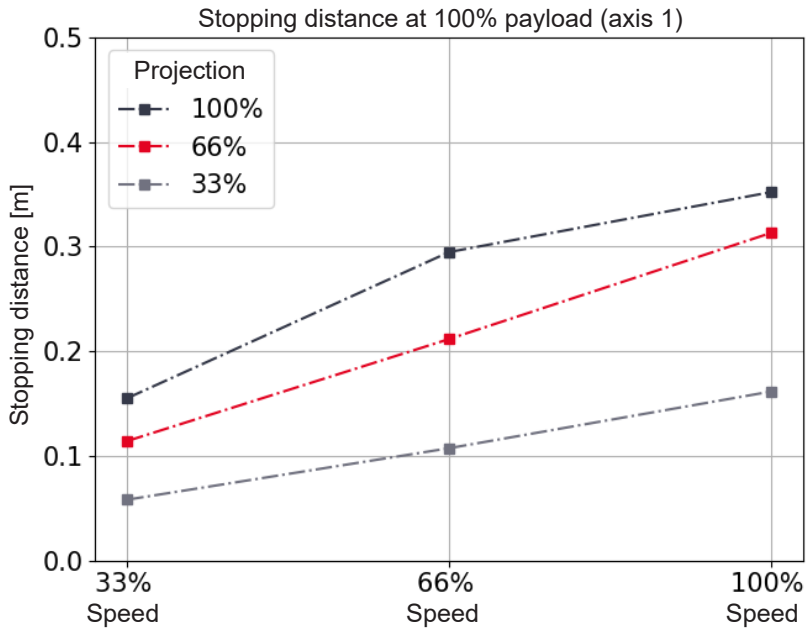
Stop category	Process safety time [ms]
SS0	1091
SS1	1014
SS2	10

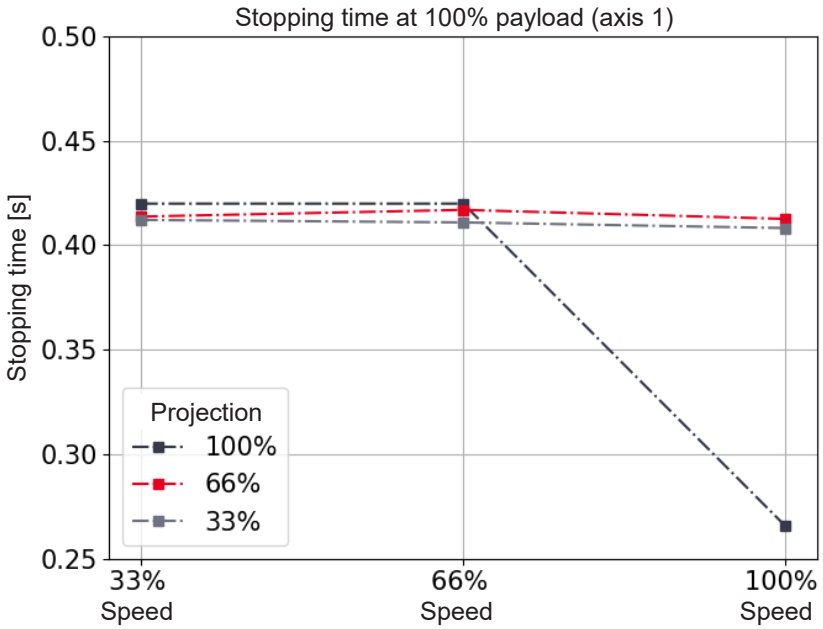

Stopping distance at 33% payload (axis 1)
Stopping distance [m]
0.5
0.4
0.3
0.2
0.1
0.0
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

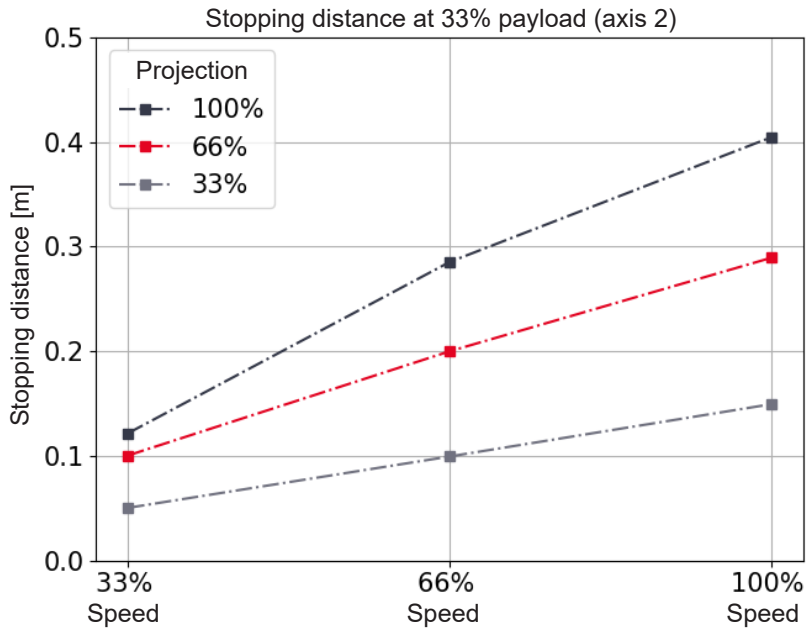

Stopping time at 33% payload (axis 1)
Stopping time [s]
0.50
0.45
0.40
0.35
0.30
0.25
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

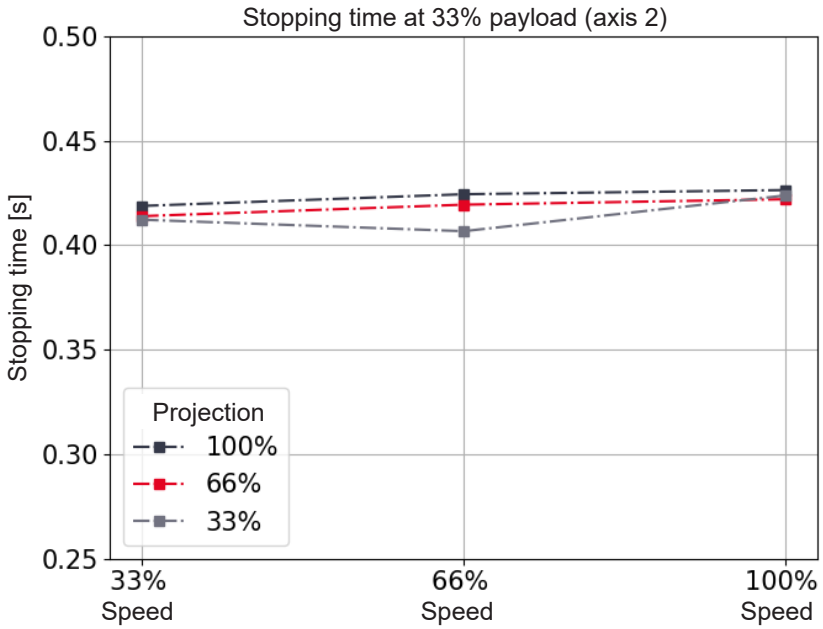

Stopping distance at 66% payload (axis 1)
Stopping distance [m]
0.5
0.4
0.3
0.2
0.1
0.0
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

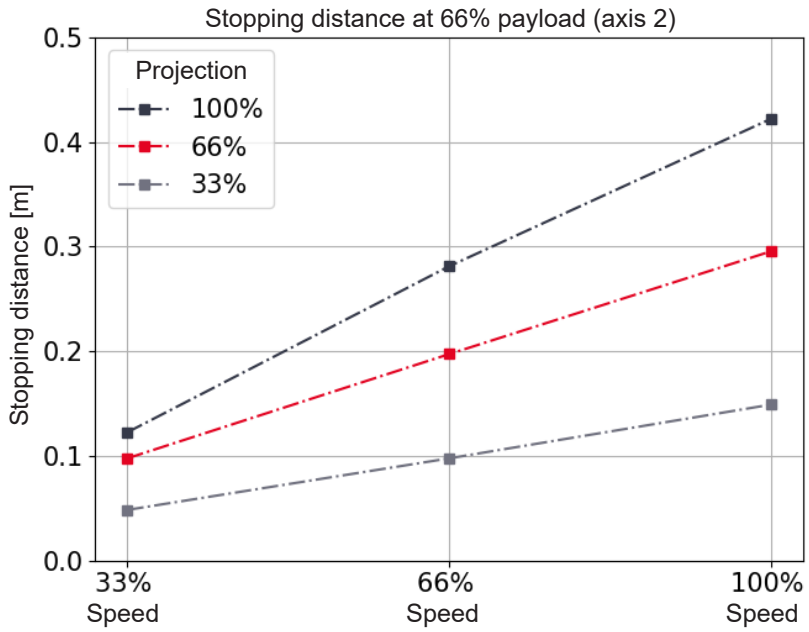

Stopping time at 66% payload (axis 1)
Stopping time [s]
0.50
0.45
0.40
0.35
0.30
0.25
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

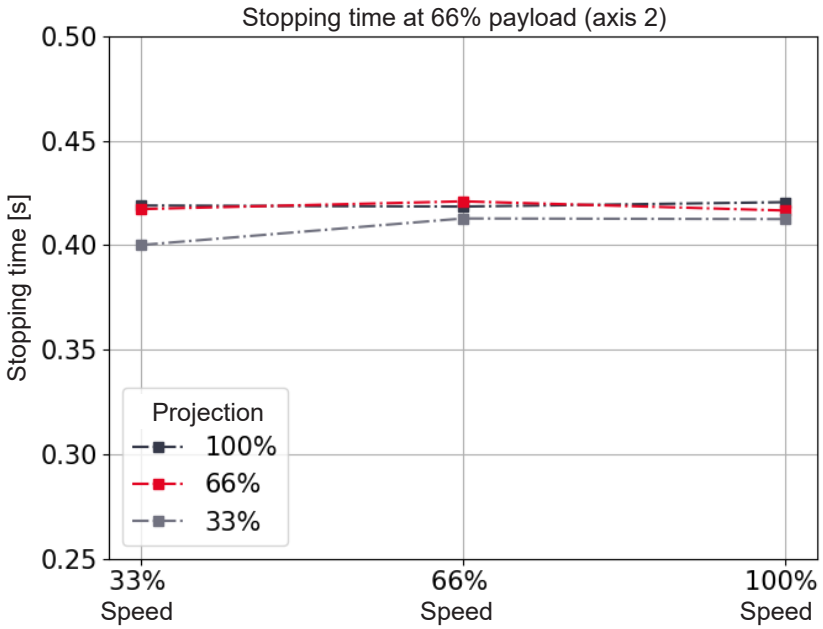

Stopping distance at 100% payload (axis 1)
Stopping distance [m]
0.5
0.4
0.3
0.2
0.1
0.0
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

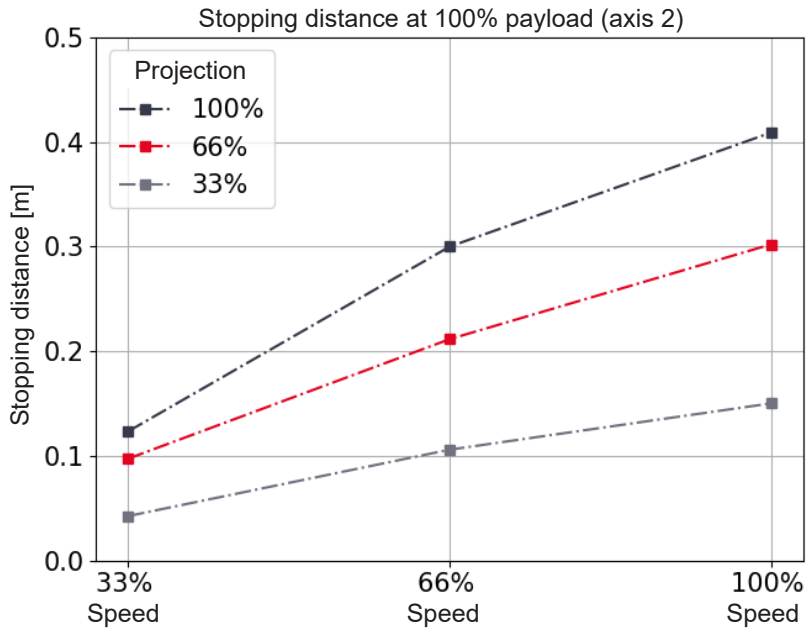

Stopping time at 100% payload (axis 1)
Stopping time [s]
0.50
0.45
0.40
0.35
0.30
0.25
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

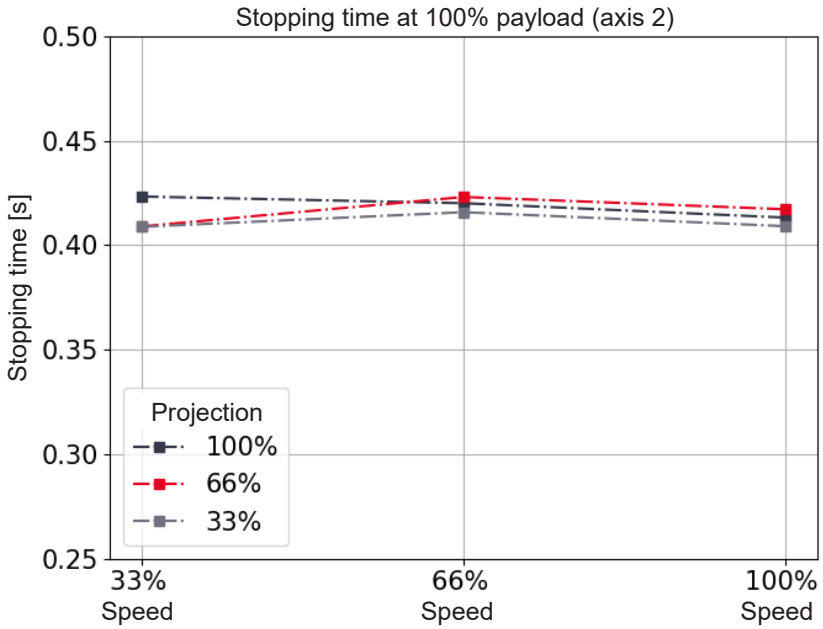

Stopping distance at 33% payload (axis 2)
Stopping distance [m]
0.5
0.4
0.3
0.2
0.1
0.0
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

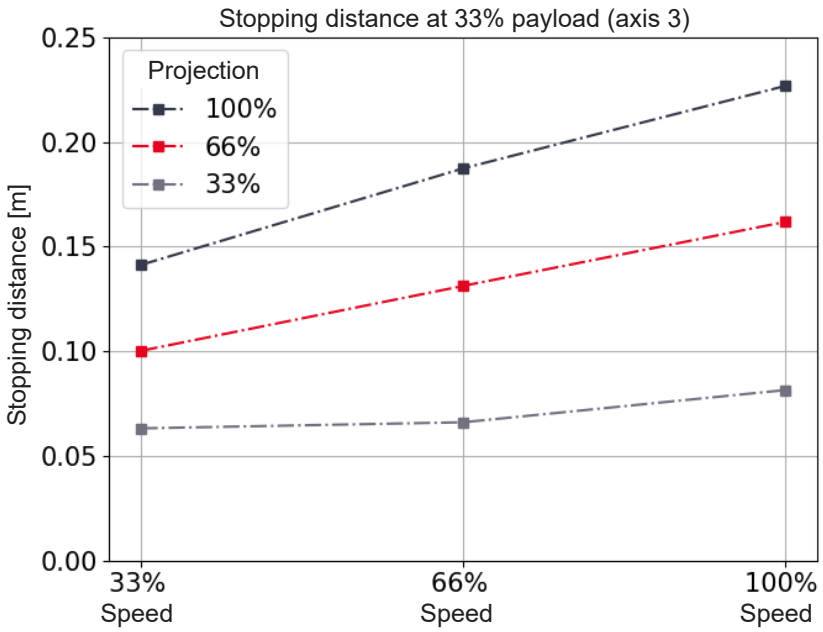

Stopping time at 33% payload (axis 2)
Stopping time [s]
0.50
0.45
0.40
0.35
0.30
0.25
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

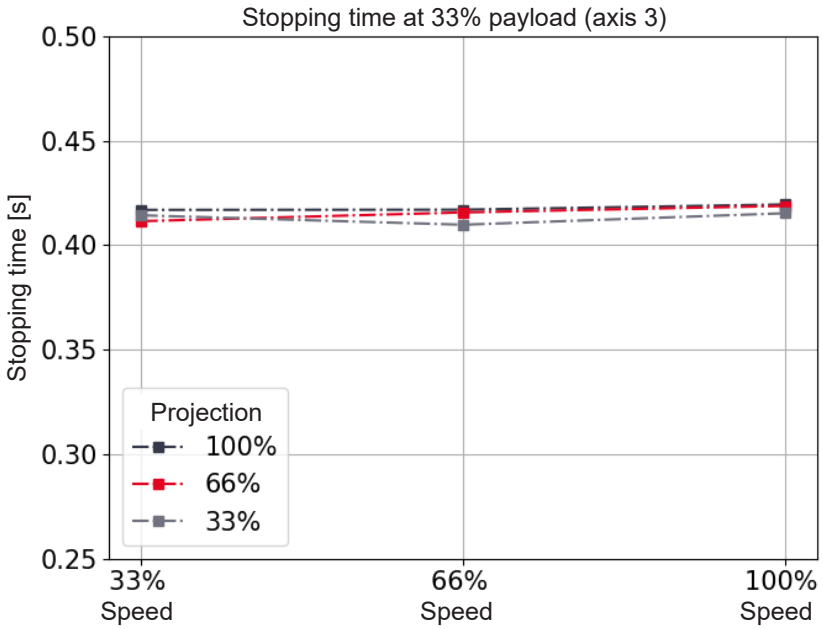

Stopping distance at 66% payload (axis 2)
Stopping distance [m]
0.5
0.4
0.3
0.2
0.1
0.0
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

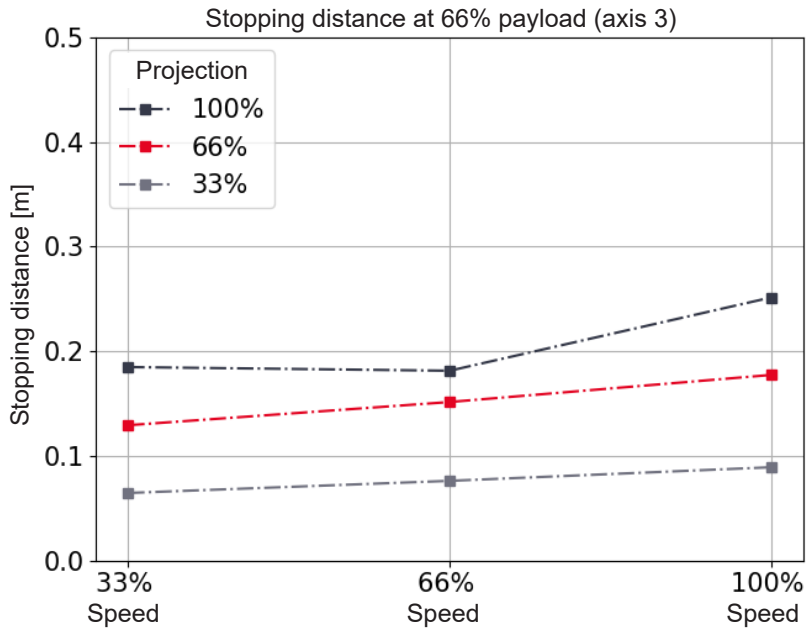

Stopping time at 66% payload (axis 2)
Stopping time [s]
0.50
0.45
0.40
0.35
0.30
0.25
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

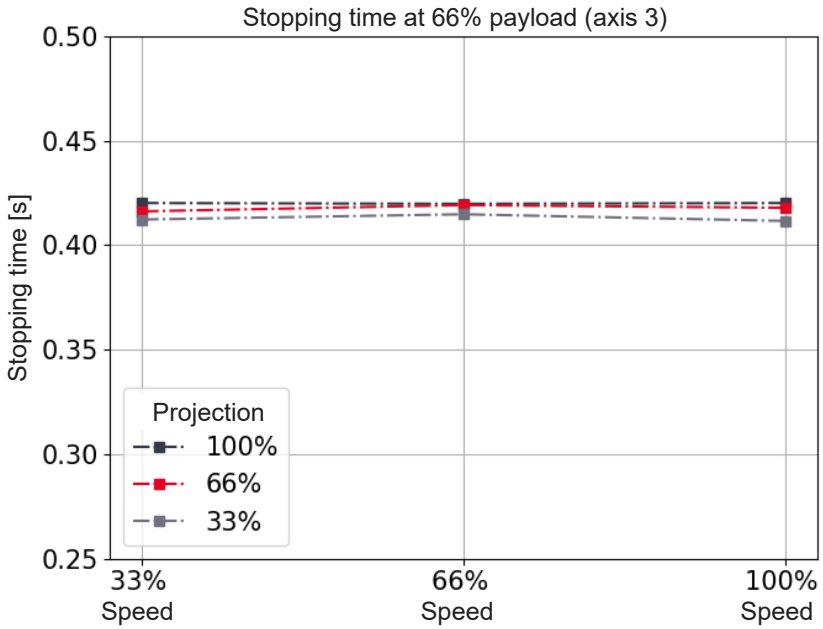

Stopping distance at 100% payload (axis 2)
Stopping distance [m]
0.5
0.4
0.3
0.2
0.1
0.0
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

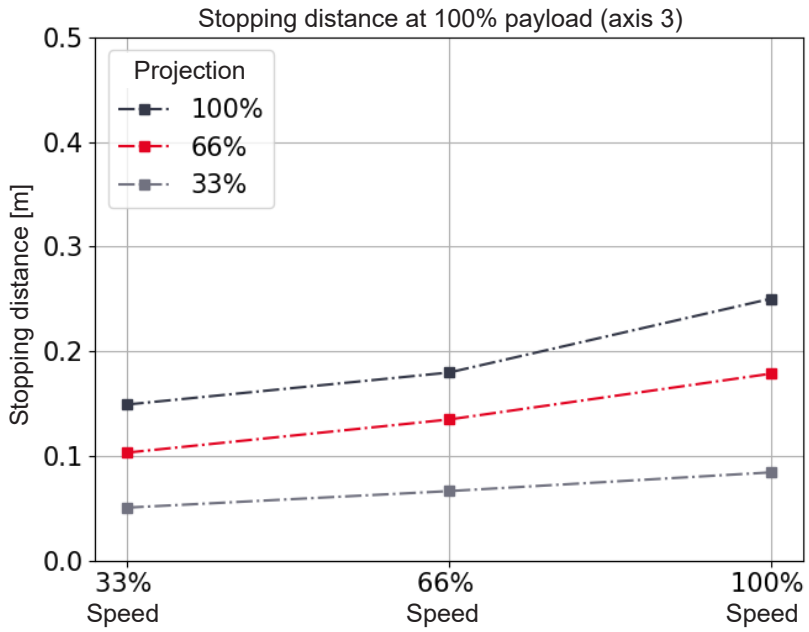

Stopping time at 100% payload (axis 2)
Stopping time [s]
0.50
0.45
0.40
0.35
0.30
0.25
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

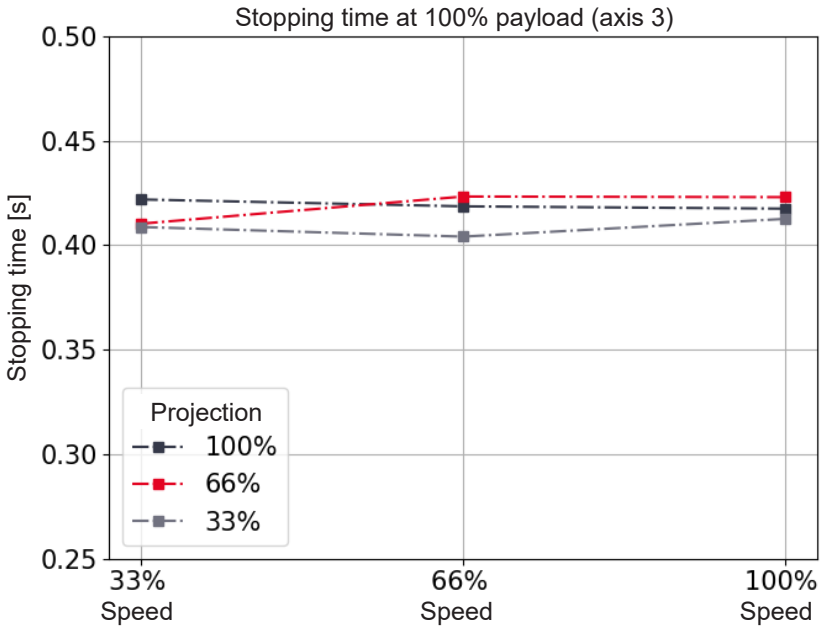

Stopping distance at 33% payload (axis 3)
Stopping distance [m]
0.25
0.20
0.15
0.10
0.05
0.00
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed


Stopping time at 33% payload (axis 3)
Stopping time [s]
0.50
0.45
0.40
0.35
0.30
0.25
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed


Stopping distance at 66% payload (axis 3)
Stopping distance [m]
0.5
0.4
0.3
0.2
0.1
0.0
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed


Stopping time at 66% payload (axis 3)
Stopping time [s]
0.50
0.45
0.40
0.35
0.30
0.25
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed


Stopping distance at 100% payload (axis 3)
Stopping distance [m]
0.5
0.4
0.3
0.2
0.1
0.0
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed


Stopping time at 100% payload (axis 3)
Stopping time [s]
0.50
0.45
0.40
0.35
0.30
0.25
Projection
100%
66%
33%
33%
Speed
66%
Speed
100%
Speed

C EtherCAT communication

Our product Yu 5 Industrial uses both EtherCAT and FSoE technology for **internal** communication and secure communication.

Fig. 106 “EtherCAT”* logo and “Safety over EtherCAT”* logo

* EtherCAT® and Safety over EtherCAT® are registered trademarks and patented technologies licensed by Beckhoff Automation GmbH, Germany.

D Declaration of incorporation

The declaration of incorporation can be found here:

www.agile-robots.com/en/robotic-solutions/hardware/yu-5-industrial

E Certificates

The certificates from TÜV SÜD Rail GmbH and TÜV SÜD Product Service GmbH and the EMC certificate can be found here:

www.agile-robots.com/en/robotic-solutions/hardware/yu-5-industrial