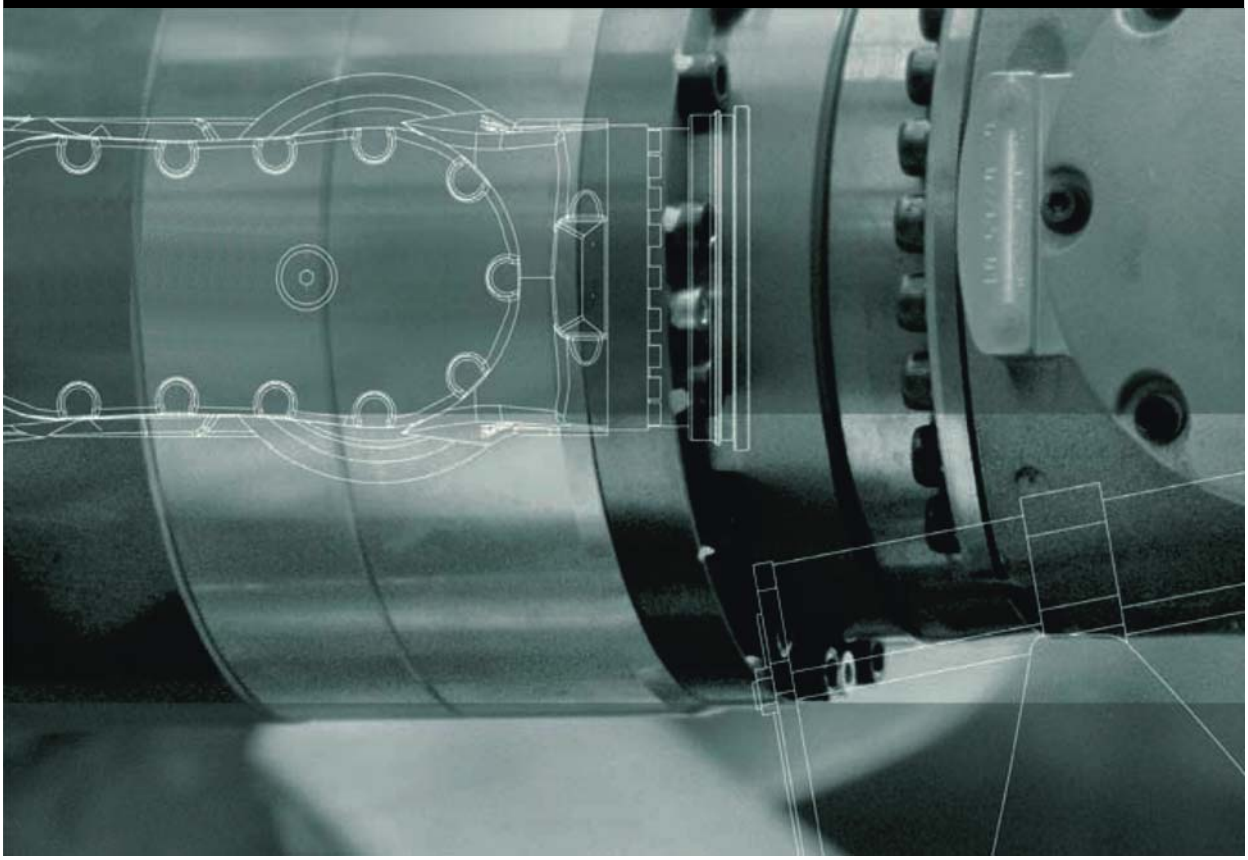
KUKA

Robots

KUKA Roboter GmbH

KR 5 sixx R650, R850

Operating Instructions



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Other functions not described in this documentation may be operable in the controller. The user has no claims to these functions, however, in the case of a replacement or service work.

We have checked the content of this documentation for conformity with the hardware and software described. Nevertheless, discrepancies cannot be precluded, for which reason we are not able to guarantee total conformity. The information in this documentation is checked on a regular basis, however, and necessary corrections will be incorporated in the subsequent edition.

Subject to technical alterations without an effect on the function.

Translation of the original documentation

KIM-PS5-DOC

Publication: Pub BA KR 5 sixx en
Book structure: BA KR 5 sixx V7.1
Label: BA KR 5 sixx V5

Contents

1 Introduction

1.1 Industrial robot documentation

The industrial robot documentation consists of the following parts:

- Documentation for the manipulator
- Documentation for the robot controller
- Operating and programming instructions for the KUKA System Software
- Documentation relating to options and accessories
- Parts catalog on storage medium

Each of these sets of instructions is a separate document.

1.2 Representation of warnings and notes

Safety

Warnings marked with this pictogram are relevant to safety and **must** be observed.

Danger!
This warning means that death, severe physical injury or substantial material damage **will** occur, if no precautions are taken.

Warning!
This warning means that death, severe physical injury or substantial material damage **may** occur, if no precautions are taken.

Caution!
This warning means that minor physical injuries or minor material damage **may** occur, if no precautions are taken.

Notes

Notes marked with this pictogram contain tips to make your work easier or references to further information.

Tips to make your work easier or references to further information.

2 Purpose

2.1 Target group

This documentation is aimed at users with the following knowledge and skills:

- Advanced knowledge of mechanical engineering
- Advanced knowledge of electrical and electronic systems
- Knowledge of the robot controller system

For optimal use of our products, we recommend that our customers take part in a course of training at KUKA College. Information about the training program can be found at www.kuka.com or can be obtained directly from our subsidiaries.

2.2 Intended use

Use

- Handling and machining workpieces in dry rooms.

If the robot environment has an increased dust content or is subject to abnormal temperatures, KUKA must be consulted!

Misuse

Any use or application deviating from the intended use is deemed to be impermissible misuse; examples of such misuse include:

- Transportation of persons and animals
- Use as a climbing aid
- Operation outside the permissible operating parameters
- Use in potentially explosive environments

The robot system is an integral part of a complete system and may only be operated in a CE-compliant system.

3 Product description

3.1 Overview of the robot system

The robot system consists of the following components:

- Robot
- Robot controller
- KCP teach pendant
- Connecting cables
- Software
- Options, accessories

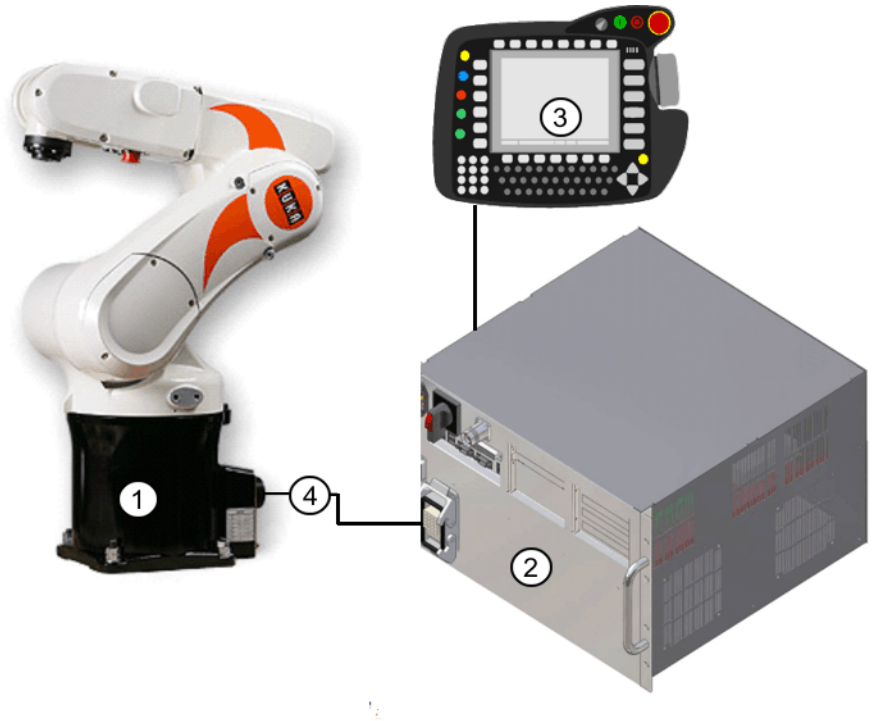


Fig. 3-1: Example of a robot system

1	Robot	3	Teach pendant (KCP)
2	Robot controller	4	Connecting cables

3.2 Description of the KR 5 sixx robot

Overview

The robot is a 6-axis jointed-arm robot made of cast light alloy. All motor units and current-carrying cables are protected against dirt and moisture beneath screwed-on cover plates.

The robot consists of the following principal components:

- In-line wrist
- Arm
- Link arm
- Rotating column
- Base frame
- Electrical installations

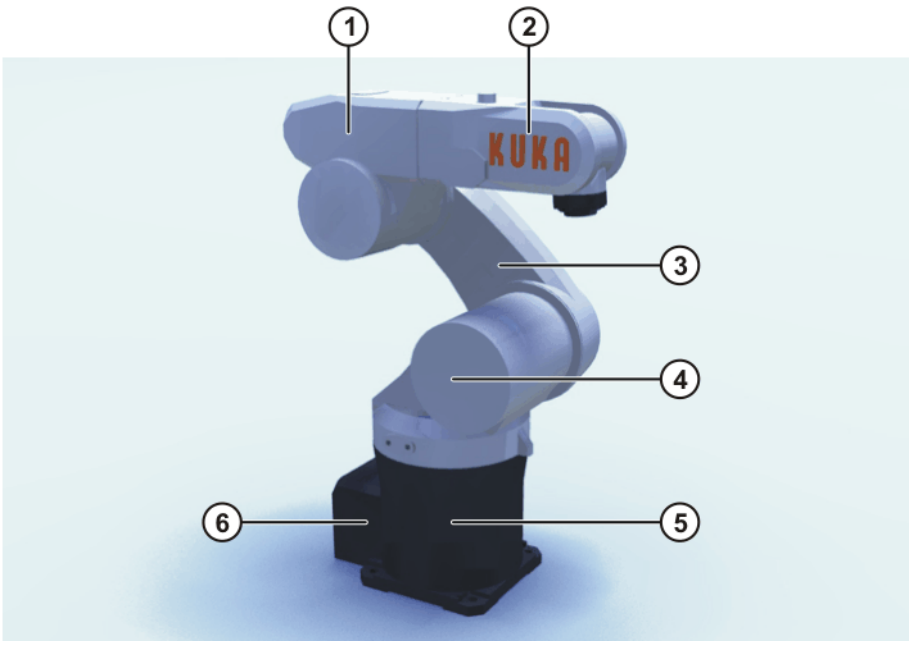


Fig. 3-2: Principal components

1	Arm	4	Rotating column
2	In-line wrist	5	Base frame
3	Link arm	6	Electrical installations

In-line wrist

The robot is fitted with a 3-axis in-line wrist. It is driven by the motors in the arm (axis 4) and in-line wrist. The motor of axis 4 drives the gear unit directly, while axes 5 and 6 are additionally driven by means of a toothed belt. The in-line wrist performs the motions about axes 4, 5 and 6.

There are three 5/2 pulse valves in the in-line wrist that can be used for controlling tools. The description and the data of the valve group are given in the section "Technical data" (>>> 4.6 "Valve assembly" page 21).

The in-line wrist also accommodates the 10-contact circular connector of the wrist I/O cable.

Arm

The arm is the link between the in-line wrist and the link arm. It houses the motor of wrist axis 4. There are 2 variants of arm available.

Link arm

The link arm is installed between the arm and the rotating column. It houses the motors and gear units of axes 2 and 3. The supply lines of the energy supply system and cable harness for axes 2 to 6 are routed through the link arm. There are 2 variants of link arm available.

Rotating column

The rotational motions of axis 1 are performed by the rotating column. This is screwed to the base frame via the gear unit of axis 1 and is driven by a motor in the base frame. The rotating column houses the backup batteries for backing up the axis data of the position sensing system.

Base frame

The base frame is the base of the robot. It constitutes the interface for the connecting cables between the robot, the controller and the energy supply system. All connecting cables are accommodated at the rear of the base frame.

4 Technical data

4.1 Basic data

Basic data

Type	KR 5 sixx R650, KR 5 sixx R850
Number of axes	6
Volume of working envelope	KR 5 sixx R650 1.0 m^3 KR 5 sixx R850 2.3 m^3
Repeatability (ISO 9283)	KR 5 sixx R650 ±0.02 mm KR 5 sixx R850 ±0.03 mm
Working envelope reference point	Intersection of axes 4 and 5
Weight	KR 5 sixx R650 approx. 28 kg KR 5 sixx R850 approx. 29 kg
Principal dynamic loads	See Loads acting on the mounting base
Protection classification of the robot	IP 40, ready for operation, with connecting cables plugged in (according to EN 60529)
Protection classification of the in-line wrist	IP 65
Sound level	< 75 dB (A) outside the working envelope
Mounting position	Floor or ceiling
Surface finish, paintwork	Plastic: white, paintwork: white, base frame: black

Vibration stress

Operation	No permanent vibration stress permissible Brief, one-off: 0.5 g
Storage and transportation	Brief, one-off: 3 g

Ambient temperature

Operation	0 °C to +40 °C (273 K to 313 K) Relative air humidity ≤ 90% No condensation permissible.
Storage and transportation	-10 °C to +60 °C (263 K to 333 K) Relative air humidity ≤ 75% No condensation permissible.

Ambient conditions

Operation	■ Free from inflammable dust, gases and liquids ■ Free from aggressive and corrosive gases and liquids ■ Free from flying parts ■ Free from spraying liquids ■ Free from electromagnetic loads, e.g. from welding equipment or high-frequency converters

Connecting cables

Cable lengths: 4 m, 6 m, 12 m

The connecting cables consist of the motor/data cable and the wrist I/O cable. The following connector designations and connections are used:

Cable designation	Connector designation	Robot controller - Robot
Motor/data cable	X20 - CN22	Harting circular connector
Wrist I/O cable	X32 - CN20	D-Sub circular connector
Ground conductor	PE	M5 cable lug at each end

For detailed specifications of the connecting cables, see (>>> 12.3 "Description of the connecting cables" page 90)

4.2 Axis data

The data are valid for floor-mounted R650 and R850 robots.

Axis data

Axis	Range of motion, software-limited	Speed with rated payload 5 kg
1	+/-170°	375 °/s with R650 250 °/s with R850
2	+45° to -190°	300 °/s with R650 250 °/s with R850
3	+165° to -119°	375 °/s with R650 250 °/s with R850
4	+/-190°	410 °/s
5	+/-120°	410 °/s
6	+/-358 °	660 °/s

The direction of motion and the arrangement of the individual axes may be noted from the following diagram.

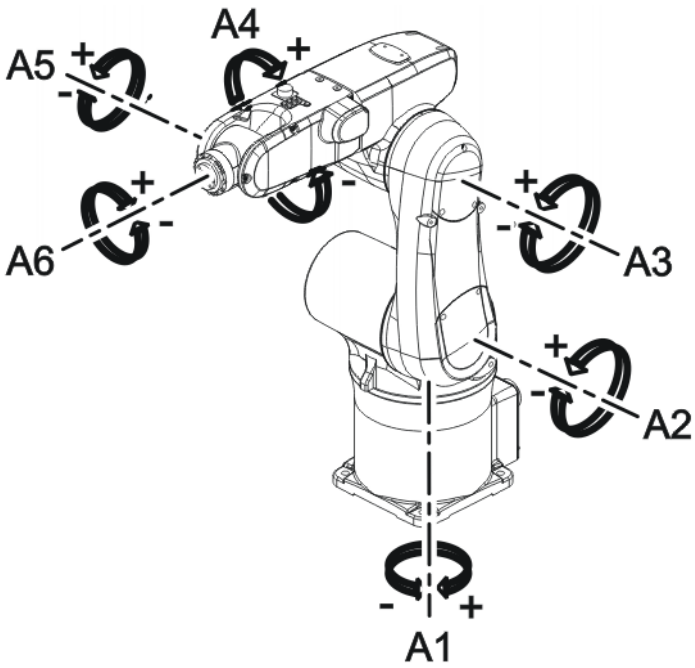


Fig. 4-1: Robot axes

Working envelope

The following diagram shows the shape and size of the working envelope.

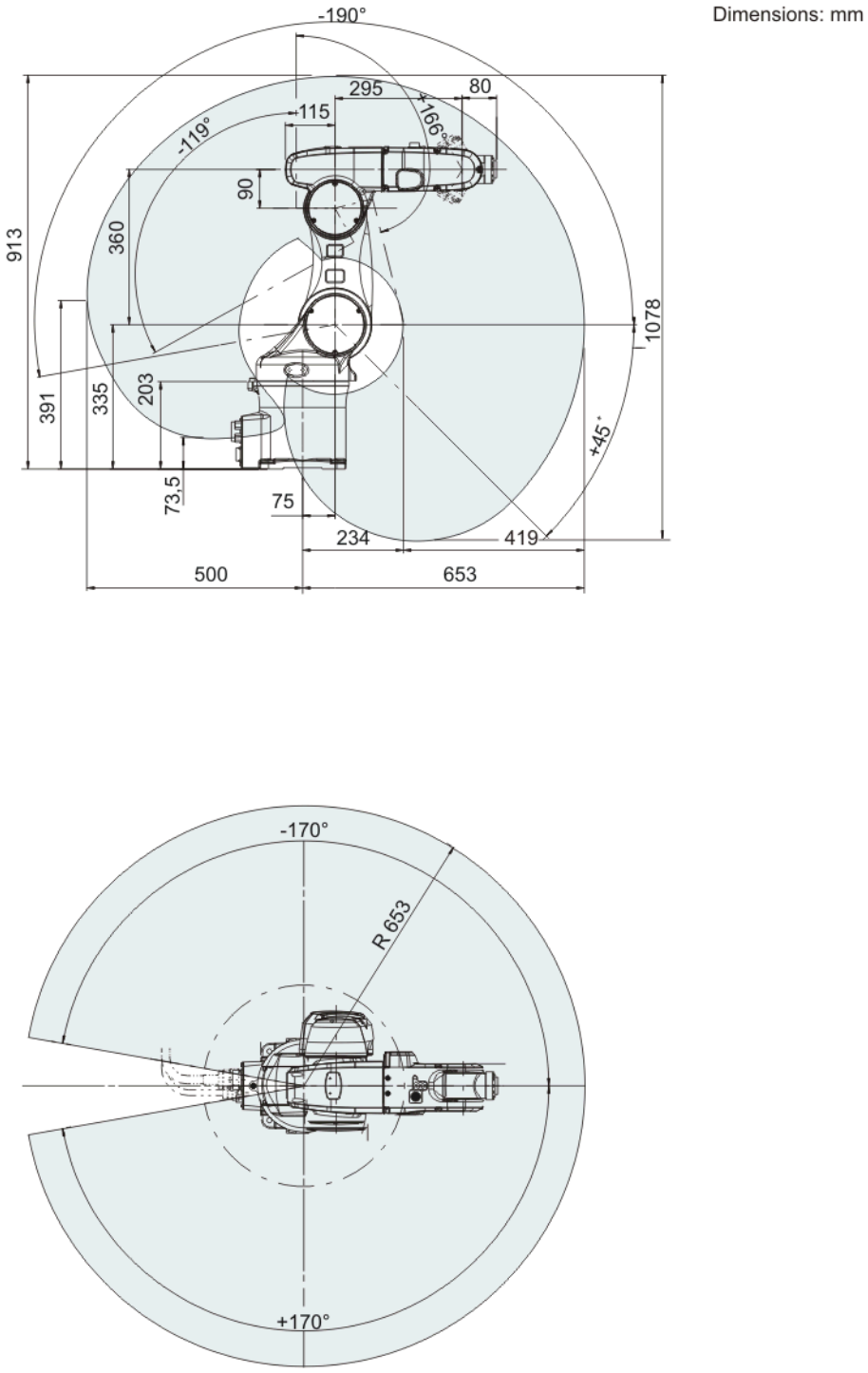


Fig. 4-2: Working envelope R650

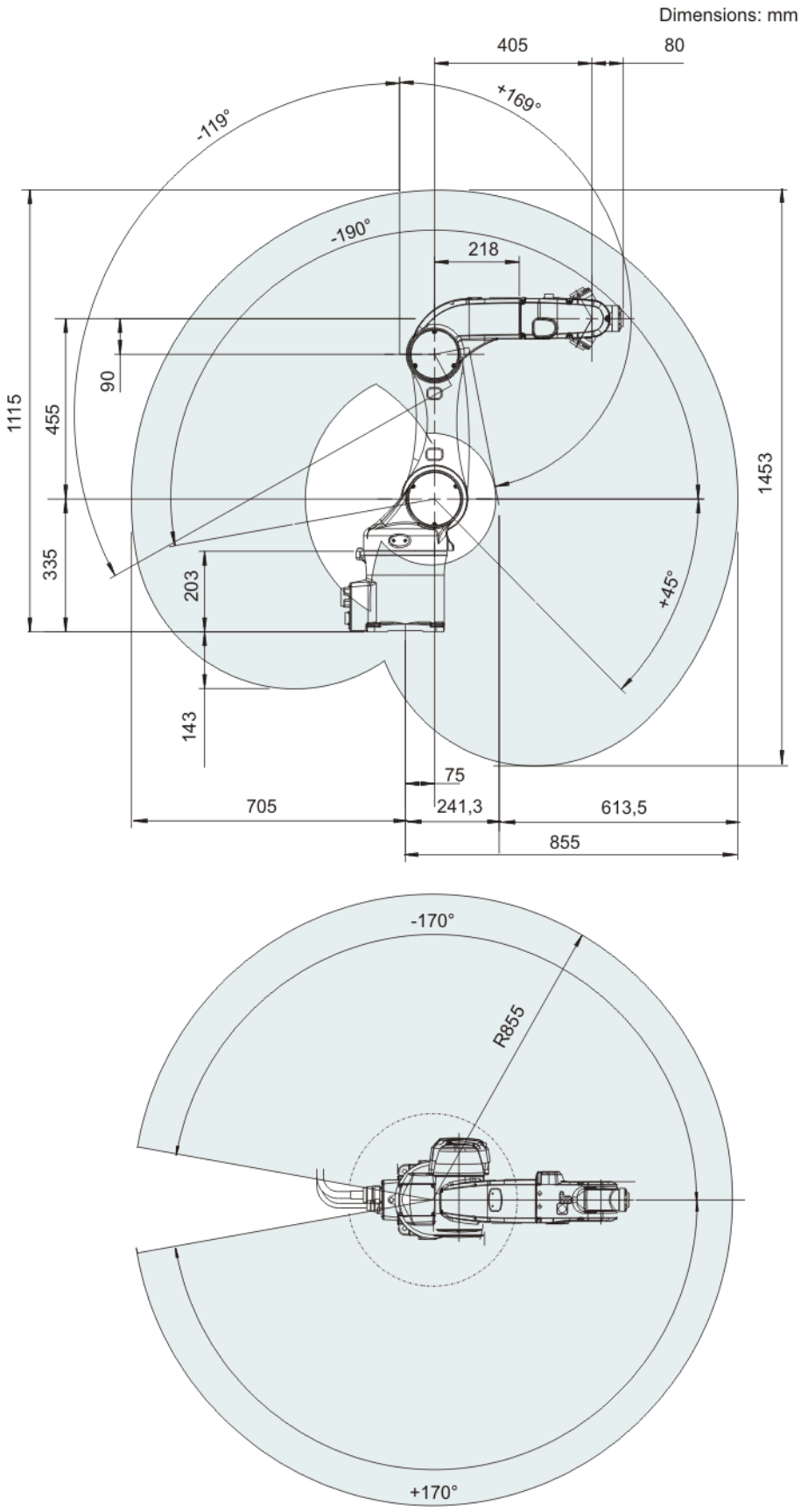


Fig. 4-3: Working envelope R850

4.3 Payloads

Payloads

Robot	KR 5 sixx
In-line wrist	IW 5
Rated payload	5 kg
Distance of the load center of gravity L_x	80 mm
Distance of the load center of gravity L_y	0 mm
Distance of the load center of gravity L_z	150 mm
Max. total load	5 kg

Load center of gravity P

For all payloads, the load center of gravity refers to the distance from the face of the mounting flange on axis 6. Refer to the payload diagram for the nominal distance.

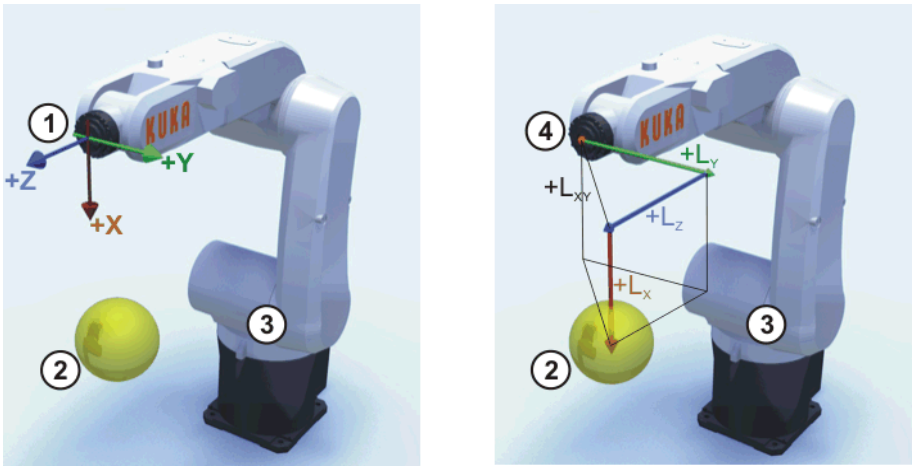


Fig. 4-4: Payload on the robot

1 FLANGE coordinate system
2 Load center of gravity
3 Robot
4 Distances L_X, L_Y, L_Z of the load center of gravity

Payload diagram Permissible mass inertia at the design point (L_x, L_y, L_z) is 0.045 kgm².

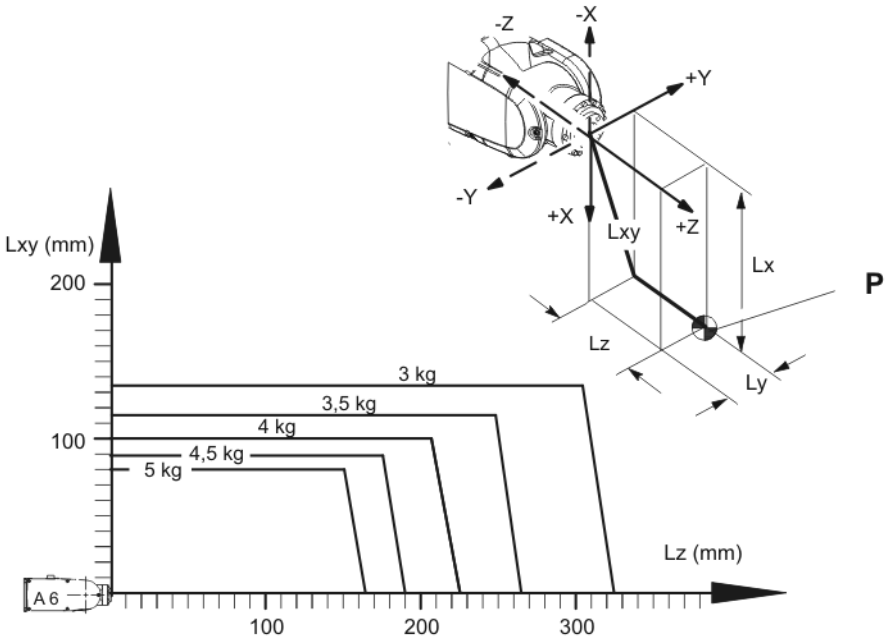


Fig. 4-5: Payload diagram

This loading curve corresponds to the maximum load capacity. Both values (payload and principal moment of inertia) must be checked in all cases. Exceeding this capacity will reduce the service life of the robot and overload the motors and the gears; in any such case the KUKA Robot GmbH must be consulted beforehand.
The values determined here are necessary for planning the robot application. For commissioning the robot, additional input data are required in accordance with operating and programming instructions of the KUKA System Software.
The mass inertia must be verified using KUKA.Load. It is imperative for the load data to be entered in the robot controller!

Supplementary load The robot cannot carry supplementary loads.

4.3.1 Mounting flange

The mounting flange is included in the scope of supply of the robot.

Mounting flange	DIN/ISO 9409-1-A31,5
Strength class	10.9
Screw size	M5
Grip length	1.5 x nominal diameter
Depth of engagement	min. 6 mm, max. 8 mm
Locating element	5 ^{H7}

The mounting flange is depicted (>>> Fig. 4-6) with axes 4 and 5 in the zero position. The symbol X_m indicates the position of the locating element (bushing) in the zero position.

Dimensions: mm

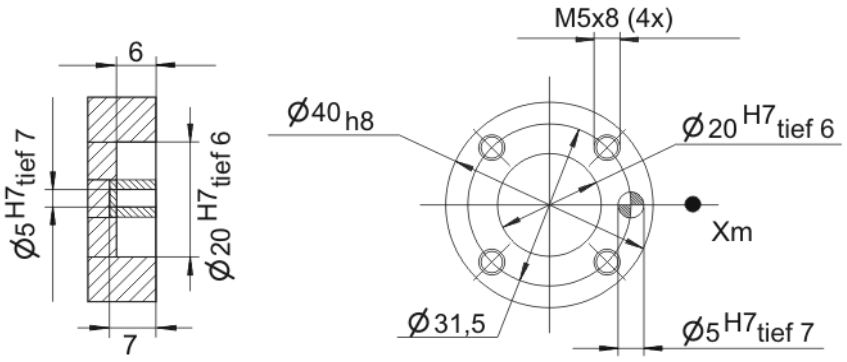


Fig. 4-6: Mounting flange

4.4 Loads acting on the foundation

Loads acting on the foundation

The specified forces and moments already include the payload and the inertia force (weight) of the robot.

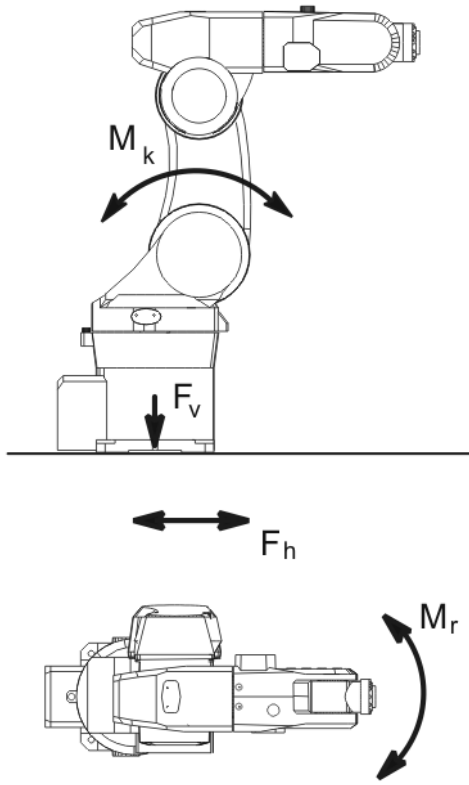


Fig. 4-7: Loads acting on the mounting base

Type of load	Force/torque/mass
F_v = vertical force	F_{vmax} = 1,000 N
F_h = horizontal force	F_{hmax} = 1,050 N with R650 F_{hmax} = 850 N with R850
M_k = tilting moment	M_{kmax} = 1,000 Nm with R650 M_{kmax} = 1,100 Nm with R850
M_r = torque	M_{rmax} = 1,100 Nm

Type of load	Force/torque/mass
Total mass for load acting on the mounting base	33 kg with R650 34 kg with R850
Robot	28 kg with R650 29 kg with R850
Total load (suppl. load on arm + rated payload)	5 kg

4.5 Additional data

Accessories

Only accessories authorized and offered by KUKA may be used for this robot. All items of equipment must possess the appropriate certification and declarations of conformity.

Fastening threads

The fastening holes serve for fastening the covers, axis range limitations or cable harnesses.

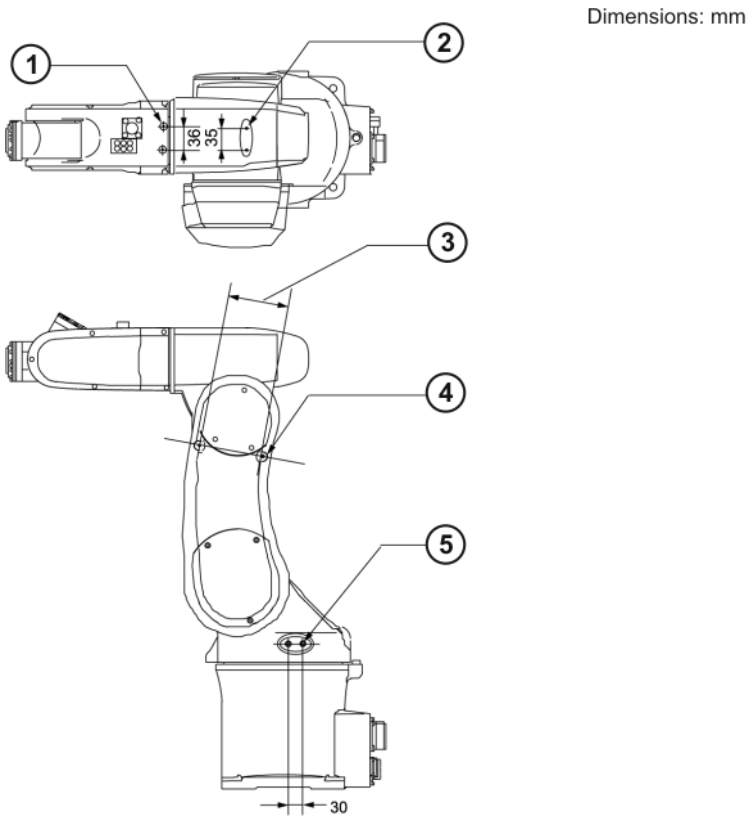


Fig. 4-8: Fastening threads

1 2 holes, M3, 7 mm deep
2 2 holes, M4, 16 mm deep
3 2 holes, M3, 7 mm deep; distance 104.5 mm
4 2 holes, M5, 12 mm deep
5 2 holes, M8, 25 mm deep (transportation)

4.6 Valve assembly

The robot has three 5/2-way valves integrated into the in-line wrist. The valve assembly is activated via the internal energy supply system.

Designation	Limit values
Valve type	5/2 pulse valve
Operating pressure, infeed	0.1 to 0.39 MPa
Max. pressure	0.49 MPa
Switching frequency	10 Hz
Operating temperature	-5 °C to 50 °C (268 K to 323 K) condensation-free
Threaded union	M5 PT1/4
Medium	Air, oil-free
Operating voltage	24 V ±10%
Current	0.5 W, 21 mA

Recommendation:
The operating pressure should preferably be 0.39 MPa.

For the valve assembly with the corresponding threaded union PT1/4 or PT1/8, a universal plug-in connection with the designation KQ is required. This is supplied exclusively by SMC.

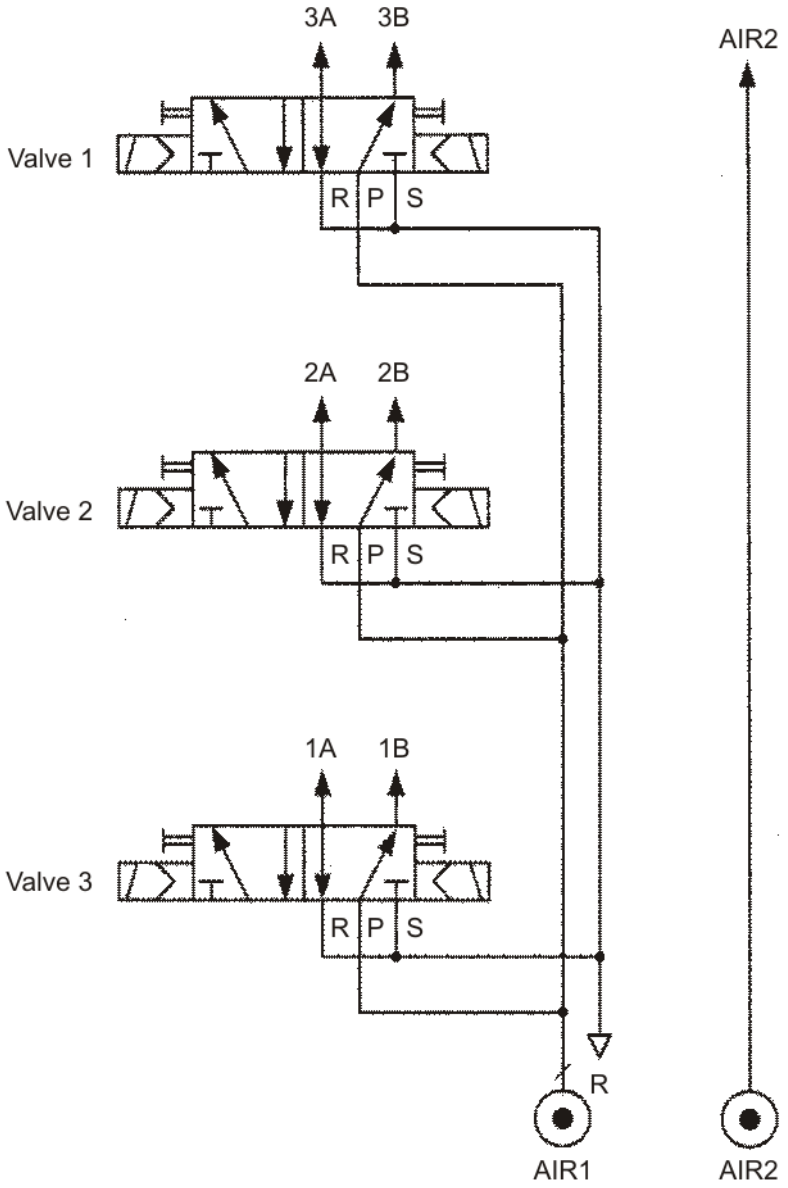


Fig. 4-9: Valve diagram

Signal	Connector X32	Connector CN20	Valve connector	Description
N. C.	Pin 8	Pin 12	Pin 1	0 V internal
$OUT9	Pin 1	Pin 13	Pin 2	Valve 1 - position A
$OUT10	Pin 14	Pin 17	Pin 6	Valve 3 - position A
$OUT11	Pin 2	Pin 14	Pin 3	Valve 1 - position B
$OUT12	Pin 15	Pin 18	Pin 7	Valve 3 - position B
$OUT13	Pin 3	Pin 15	Pin 4	Valve 2 - position A
$OUT15	Pin 4	Pin 16	Pin 5	Valve 2 - position B

4.7 Plates and labels

Plates and labels

The following plates, labels and signs are attached to the robot. They must not be removed or rendered illegible. Illegible plates, labels and signs must be replaced.

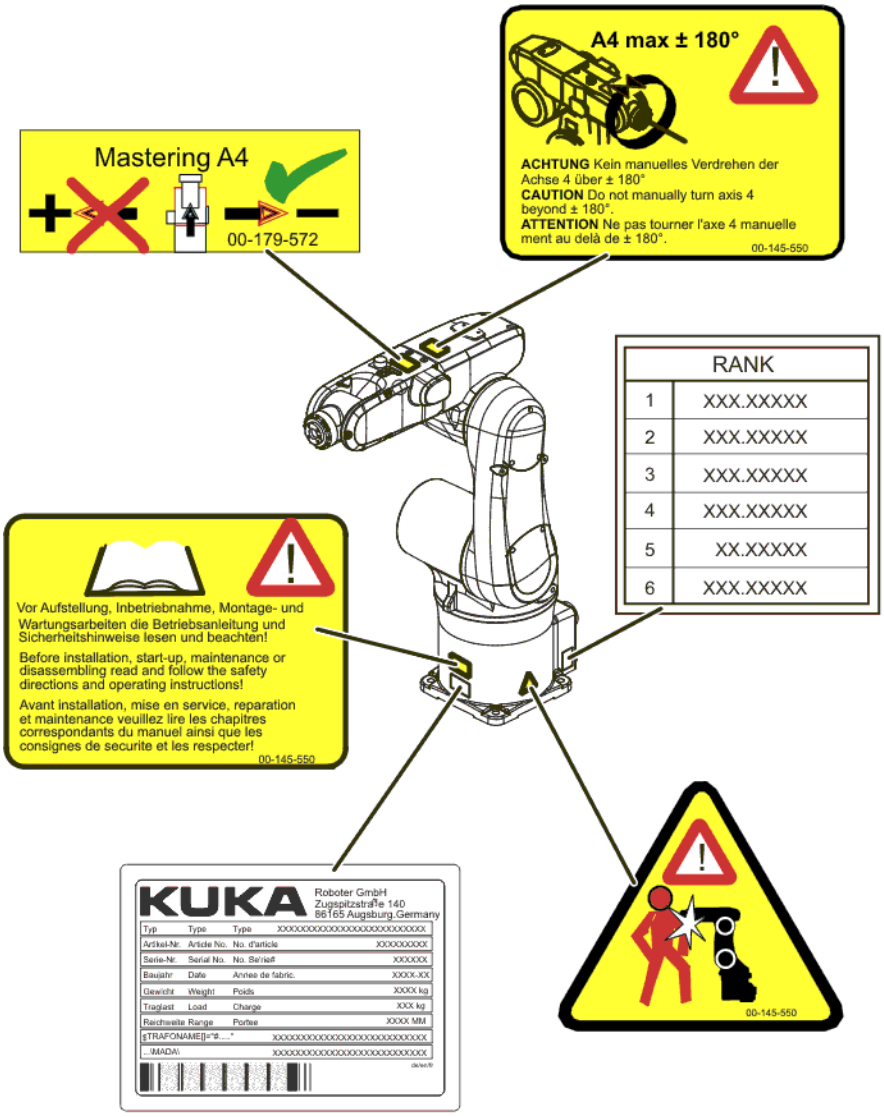


Fig. 4-10: Plates and labels

5 Safety

5.1 General

5.1.1 Liability

The device described in this document is either an industrial robot or a component thereof.

Components of the industrial robot:

- Manipulator
- Robot controller
- Teach pendant
- Connecting cables
- External axes (optional)
  e.g. linear unit, turn-tilt table, positioner
- Software
- Options, accessories

The industrial robot is built using state-of-the-art technology and in accordance with the recognized safety rules. Nevertheless, misuse of the industrial robot may constitute a risk to life and limb or cause damage to the industrial robot and to other material property.

The industrial robot may only be used in perfect technical condition in accordance with its intended use and only by safety-conscious persons who are fully aware of the risks involved in its operation. Use of the industrial robot is subject to compliance with this document and with the declaration of incorporation supplied together with the industrial robot. Any functional disorders affecting the safety of the industrial robot must be rectified immediately.

Safety information

Safety information cannot be held against KUKA Roboter GmbH. Even if all safety instructions are followed, this is not a guarantee that the industrial robot will not cause personal injuries or material damage.

No modifications may be carried out to the industrial robot without the authorization of KUKA Roboter GmbH. Additional components (tools, software, etc.), not supplied by KUKA Roboter GmbH, may be integrated into the industrial robot. The user is liable for any damage these components may cause to the industrial robot or to other material property.

In addition to the Safety chapter, this document contains further safety instructions. These must also be observed.

5.1.2 Intended use of the industrial robot

The industrial robot is intended exclusively for the use designated in the “Purpose” chapter of the operating instructions or assembly instructions.

Further information is contained in the “Purpose” chapter of the operating instructions or assembly instructions of the component.

Using the industrial robot for any other or additional purpose is considered impermissible misuse. The manufacturer cannot be held liable for any damage resulting from such use. The risk lies entirely with the user.

Operating the industrial robot and its options within the limits of its intended use also involves observance of the operating and assembly instructions for

the individual components, with particular reference to the maintenance specifications.

Misuse

Any use or application deviating from the intended use is deemed to be impermissible misuse. This includes e.g.:

- Transportation of persons and animals
- Use as a climbing aid
- Operation outside the permissible operating parameters
- Use in potentially explosive environments
- Operation without additional safeguards
- Outdoor operation

5.1.3 EC declaration of conformity and declaration of incorporation

This industrial robot constitutes partly completed machinery as defined by the EC Machinery Directive. The industrial robot may only be put into operation if the following preconditions are met:

- The industrial robot is integrated into a complete system.

  Or: The industrial robot, together with other machinery, constitutes a complete system.

  Or: All safety functions and safeguards required for operation in the complete machine as defined by the EC Machinery Directive have been added to the industrial robot.
- The complete system complies with the EC Machinery Directive. This has been confirmed by means of an assessment of conformity.

Declaration of conformity

The system integrator must issue a declaration of conformity for the complete system in accordance with the Machinery Directive. The declaration of conformity forms the basis for the CE mark for the system. The industrial robot must be operated in accordance with the applicable national laws, regulations and standards.

The robot controller is CE certified under the EMC Directive and the Low Voltage Directive.

Declaration of incorporation

The industrial robot as partly completed machinery is supplied with a declaration of incorporation in accordance with Annex II B of the EC Machinery Directive 2006/42/EC. The assembly instructions and a list of essential requirements complied with in accordance with Annex I are integral parts of this declaration of incorporation.

The declaration of incorporation declares that the start-up of the partly completed machinery remains impermissible until the partly completed machinery has been incorporated into machinery, or has been assembled with other parts to form machinery, and this machinery complies with the terms of the EC Machinery Directive, and the EC declaration of conformity is present in accordance with Annex II A.

The declaration of incorporation, together with its annexes, remains with the system integrator as an integral part of the technical documentation of the complete machinery.

5.1.4 Terms used

Term	Description
Axis range	Range of each axis, in degrees or millimeters, within which it may move. The axis range must be defined for each axis.
Stopping distance	Stopping distance = reaction distance + braking distance The stopping distance is part of the danger zone.
Workspace	The manipulator is allowed to move within its workspace. The workspace is derived from the individual axis ranges.
Operator (User)	The user of the industrial robot can be the management, employer or delegated person responsible for use of the industrial robot.
Danger zone	The danger zone consists of the workspace and the stopping distances.
KCP	The KCP (KUKA Control Panel) teach pendant has all the operator control and display functions required for operating and programming the industrial robot.
Manipulator	The robot arm and the associated electrical installations
Safety zone	The safety zone is situated outside the danger zone.
Stop category 0	The drives are deactivated immediately and the brakes are applied. The manipulator and any external axes (optional) perform path-oriented braking. **Note:** This stop category is called STOP 0 in this document.
Stop category 1	The manipulator and any external axes (optional) perform path-maintaining braking. The drives are deactivated after 1 s and the brakes are applied. **Note:** This stop category is called STOP 1 in this document.
Stop category 2	The drives are not deactivated and the brakes are not applied. The manipulator and any external axes (optional) are braked with a normal braking ramp. **Note:** This stop category is called STOP 2 in this document.
System integrator (plant integrator)	System integrators are people who safely integrate the industrial robot into a complete system and commission it.
T1	Test mode, Manual Reduced Velocity (<= 250 mm/s)
T2	Test mode, Manual High Velocity (> 250 mm/s permissible)
External axis	Motion axis which is not part of the manipulator but which is controlled using the robot controller, e.g. KUKA linear unit, turn-tilt table, Posiflex.

5.2 Personnel

The following persons or groups of persons are defined for the industrial robot:

- User
- Personnel

All persons working with the industrial robot must have read and understood the industrial robot documentation, including the safety chapter.

User

The user must observe the labor laws and regulations. This includes e.g.:

- The user must comply with his monitoring obligations.
- The user must carry out instruction at defined intervals.

Personnel

Personnel must be instructed, before any work is commenced, in the type of work involved and what exactly it entails as well as any hazards which may exist. Instruction must be carried out regularly. Instruction is also required after particular incidents or technical modifications.

Personnel includes:

- System integrator
- Operators, subdivided into:
  - Start-up, maintenance and service personnel
  - Operating personnel
  - Cleaning personnel

Installation, exchange, adjustment, operation, maintenance and repair must be performed only as specified in the operating or assembly instructions for the relevant component of the industrial robot and only by personnel specially trained for this purpose.

System integrator

The industrial robot is safely integrated into a complete system by the system integrator.

The system integrator is responsible for the following tasks:

- Installing the industrial robot
- Connecting the industrial robot
- Performing risk assessment
- Implementing the required safety functions and safeguards
- Issuing the declaration of conformity
- Attaching the CE mark
- Creating the operating instructions for the complete system

Operator

The operator must meet the following preconditions:

- The operator must be trained for the work to be carried out.
- Work on the industrial robot must only be carried out by qualified personnel. These are people who, due to their specialist training, knowledge and experience, and their familiarization with the relevant standards, are able to assess the work to be carried out and detect any potential hazards.

Example

The tasks can be distributed as shown in the following table.

Tasks	Operator	Programmer	System integrator
Switch robot controller on/off	x	x	x
Start program	x	x	x
Select program	x	x	x
Select operating mode	x	x	x
Calibration (tool, base)		x	x
Master the manipulator		x	x
Configuration		x	x
Programming		x	x
Start-up			x
Maintenance			x
Repair			x
Decommissioning			x
Transportation			x

Work on the electrical and mechanical equipment of the industrial robot may only be carried out by specially trained personnel.

5.3 Workspace, safety zone and danger zone

Workspaces are to be restricted to the necessary minimum size. A workspace must be safeguarded using appropriate safeguards.

The safeguards (e.g. safety gate) must be situated inside the safety zone. In the case of a stop, the manipulator and external axes (optional) are braked and come to a stop within the danger zone.

The danger zone consists of the workspace and the stopping distances of the manipulator and external axes (optional). It must be safeguarded by means of physical safeguards to prevent danger to persons or the risk of material damage.

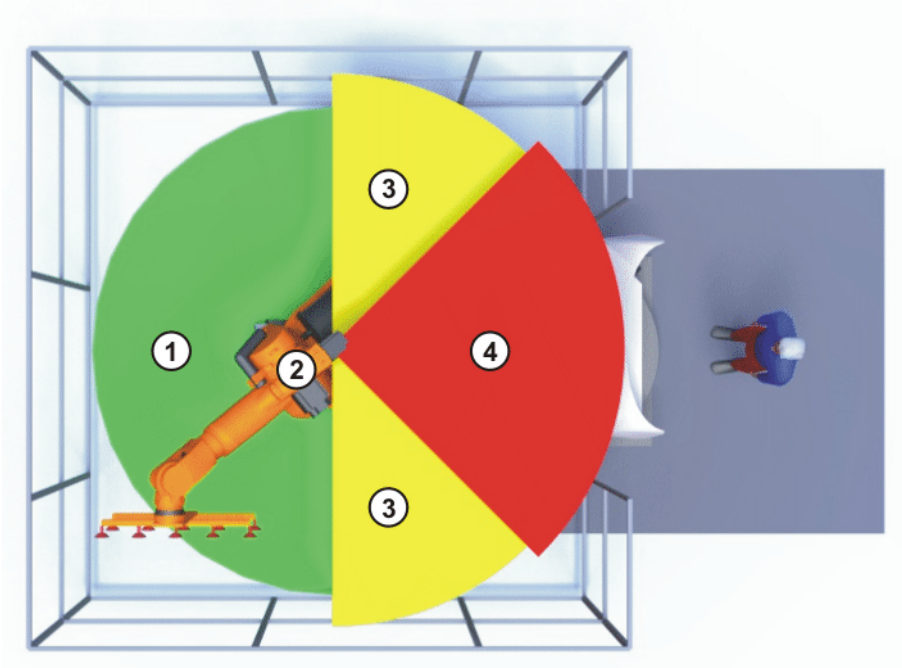


Fig. 5-1: Example of axis range A1

1	Workspace	3	Stopping distance
2	Manipulator	4	Safety zone

5.4 Triggers for stop reactions

Stop reactions of the industrial robot are triggered in response to operator actions or as a reaction to monitoring functions and error messages. The following table shows the different stop reactions according to the operating mode that has been set.

STOP 0, STOP 1 and STOP 2 are the stop definitions according to DIN EN 60204-1:2006.

Trigger	T1, T2	AUT, AUT EXT
Safety gate opened	-	STOP 1
EMERGENCY STOP pressed	STOP 0	STOP 1
Enabling withdrawn	STOP 0	-

Trigger	T1, T2	AUT, AUT EXT
Start key released	STOP 2	-
“Drives OFF” key pressed	STOP 0	
STOP key pressed	STOP 2	
Operating mode changed	STOP 0	
Encoder error (DSE-RDC connection broken)	STOP 0	
Motion enable canceled	STOP 2	
Robot controller switched off Power failure	STOP 0	

5.5 Safety functions

5.5.1 Overview of safety functions

Safety functions:

- Mode selection
- Operator safety (= connection for the guard interlock)
- Local EMERGENCY STOP device (= EMERGENCY STOP button on the KCP)
- External EMERGENCY STOP device
- Enabling device

These circuits conform to the requirements of category 3 according to EN 954-1.

Danger!
In the absence of functional safety functions and safeguards, the industrial robot can cause personal injury or material damage. If safety functions or safeguards are dismantled or deactivated, the industrial robot may not be operated.

5.5.2 ESC safety logic

The function and triggering of the electronic safety functions are monitored by the ESC safety logic.

The ESC (Electronic Safety Circuit) safety logic is a dual-channel computer-aided safety system. It permanently monitors all connected safety-relevant components. In the event of a fault or interruption in the safety circuit, the power supply to the drives is shut off, thus bringing the industrial robot to a standstill.

The ESC safety logic triggers different stop reactions, depending on the operating mode of the industrial robot.

The ESC safety logic monitors the following inputs:

- Operator safety
- Local EMERGENCY STOP (= EMERGENCY STOP button on the KCP)
- External EMERGENCY STOP
- Enabling device
- Operating modes
- Qualifying inputs

5.5.3 Mode selector switch

The industrial robot can be operated in the following modes:

- Manual Reduced Velocity (T1)
- Manual High Velocity (T2)
- Automatic (AUT)
- Automatic External (AUT EXT)

The operating mode is selected using the mode selector switch on the KCP. The switch is activated by means of a key which can be removed. If the key is removed, the switch is locked and the operating mode can no longer be changed.

If the operating mode is changed during operation, the drives are immediately switched off. The manipulator and any external axes (optional) are stopped with a STOP 0.

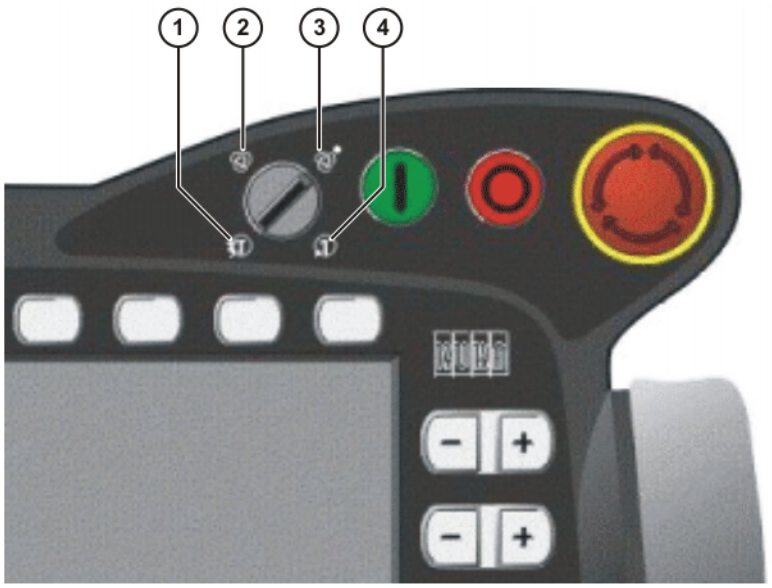


Fig. 5-2: Mode selector switch

1	T2 (Manual High Velocity)
2	AUT (Automatic)
3	AUT EXT (Automatic External)
4	T1 (Manual Reduced Velocity)

Operating mode	Use	Velocities
T1	For test operation, programming and teaching	■ Program verification: Programmed velocity, maximum 250 mm/s ■ Jog mode: Jog velocity, maximum 250 mm/s
T2	For test operation	■ Program verification: Programmed velocity

Operating mode	Use	Velocities
AUT	For industrial robots without higher-level controllers Only possible with a connected safety circuit	■ Program mode: Programmed velocity ■ Jog mode: Not possible
AUT EXT	For industrial robots with higher-level controllers, e.g. PLC Only possible with a connected safety circuit	■ Program mode: Programmed velocity ■ Jog mode: Not possible

5.5.4 Operator safety

The operator safety input is used for interlocking physical safeguards. Safety equipment, such as safety gates, can be connected to the dual-channel input. If nothing is connected to this input, operation in Automatic mode is not possible. Operator safety is not active in the test modes T1 (Manual Reduced Velocity) and T2 (Manual High Velocity).

In the event of a loss of signal during Automatic operation (e.g. safety gate is opened), the manipulator and the external axes (optional) stop with a STOP 1. Once the signal is active at the input again, automatic operation can be resumed.

Operator safety can be connected via the peripheral interface on the robot controller.

Warning!
It must be ensured that the operator safety signal is not automatically reset when the safeguard (e.g. safety gate) is closed, but only after an additional manual acknowledgement signal has been given. Only in this way can it be ensured that automatic operation is not resumed inadvertently while there are still persons in the danger zone, e.g. due to the safety gate closing accidentally.
Failure to observe this precaution may result in death, severe physical injuries or considerable damage to property.

5.5.5 EMERGENCY STOP device

The EMERGENCY STOP device for the industrial robot is the EMERGENCY STOP button on the KCP. The button must be pressed in the event of a hazardous situation or emergency.

Reactions of the industrial robot if the EMERGENCY STOP button is pressed:

- Manual Reduced Velocity (T1) and Manual High Velocity (T2) modes:
  The drives are switched off immediately. The manipulator and any external axes (optional) are stopped with a STOP 0.
- Automatic modes (AUT and AUT EXT):
  The drives are switched off after 1 second. The manipulator and any external axes (optional) are stopped with a STOP 1.

Before operation can be resumed, the EMERGENCY STOP button must be turned to release it and the stop message must be acknowledged.

Fig. 5-3: EMERGENCY STOP button on the KCP

1 EMERGENCY STOP button

Warning!
Tools and other equipment connected to the manipulator must be integrated into the EMERGENCY STOP circuit on the system side if they could constitute a potential hazard.
Failure to observe this precaution may result in death, severe physical injuries or considerable damage to property.

5.5.6 External EMERGENCY STOP device

There must be EMERGENCY STOP devices on every operator panel and anywhere else it may be necessary to trigger an EMERGENCY STOP. The system integrator is responsible for ensuring this. External EMERGENCY STOP devices are connected via the customer interface.

External EMERGENCY STOP devices are not included in the scope of supply of the industrial robot.

5.5.7 Enabling device

The enabling devices of the industrial robot are the enabling switches on the KCP.

There are 3 enabling switches installed on the KCP. The enabling switches have 3 positions:

- Not pressed
- Center position
- Panic position

In the test modes, the manipulator can only be moved if one of the enabling switches is held in the central position. If the enabling switch is released or pressed fully down (panic position), the drives are deactivated immediately and the manipulator stops with a STOP 0.

Warning!
The enabling switches must not be held down by adhesive tape or other means or manipulated in any other way.
Death, serious physical injuries or major damage to property may result.

Fig. 5-4: Enabling switches on the KCP

1 - 3 Enabling switches

5.6 Additional protective equipment

5.6.1 Jog mode

In the operating modes T1 (Manual Reduced Velocity) and T2 (Manual High Velocity), the robot controller can only execute programs in jog mode. This means that it is necessary to hold down an enabling switch and the Start key in order to execute a program.

If the enabling switch is released or pressed fully down (panic position), the drives are deactivated immediately and the manipulator and any external axes (optional) stop with a STOP 0.

Releasing only the Start key causes the industrial robot to be stopped with a STOP 2.

5.6.2 Software limit switches

The axis ranges of all manipulator and positioner axes are limited by means of adjustable software limit switches. These software limit switches only serve as machine protection and must be adjusted in such a way that the manipulator/positioner cannot hit the mechanical end stops.

The software limit switches are set during commissioning of an industrial robot.

Further information is contained in the operating and programming instructions.

5.6.3 Labeling on the industrial robot

All plates, labels, symbols and marks constitute safety-relevant parts of the industrial robot. They must not be modified or removed.

Labeling on the industrial robot consists of:

- Rating plates
- Warning labels
- Safety symbols
- Designation labels
- Cable markings
- Identification plates

Further information is contained in the technical data of the operating instructions or assembly instructions of the components of the industrial robot.

5.6.4 External safeguards

Safeguards

The access of persons to the danger zone of the manipulator must be prevented by means of safeguards.

Physical safeguards must meet the following requirements:

- They meet the requirements of EN 953.
- They prevent access of persons to the danger zone and cannot be easily circumvented.
- They are sufficiently fastened and can withstand all forces that are likely to occur in the course of operation, whether from inside or outside the enclosure.
- They do not, themselves, represent a hazard or potential hazard.
- The prescribed minimum clearance from the danger zone is maintained.

Safety gates (maintenance gates) must meet the following requirements:

- They are reduced to an absolute minimum.
- The interlocks (e.g. safety gate switches) are linked to the operator safety input of the robot controller via safety gate switching devices or safety PLC.
- Switching devices, switches and the type of switching conform to the requirements of category 3 according to EN 954-1.
- Depending on the risk situation: the safety gate is additionally safeguarded by means of a locking mechanism that only allows the gate to be opened if the manipulator is safely at a standstill.
- The button for acknowledging the safety gate is located outside the space limited by the safeguards.

Further information is contained in the corresponding standards and regulations. These also include EN 953.

Other safety equipment

Other safety equipment must be integrated into the system in accordance with the corresponding standards and regulations.

5.7 Overview of operating modes and safety functions

The following table indicates the operating modes in which the safety functions are active.

Safety functions	T1	T2	AUT	AUT EXT
Operator safety	-	-	active	active
EMERGENCY STOP device	active	active	active	active
Enabling device	active	active	-	-
Reduced velocity during program verification	active	-	-	-
Jog mode	active	active	-	-
Software limit switches	active	active	active	active

5.8 Safety measures

5.8.1 General safety measures

The industrial robot may only be used in perfect technical condition in accordance with its intended use and only by safety-conscious persons. Operator errors can result in personal injury and damage to property.

It is important to be prepared for possible movements of the industrial robot even after the robot controller has been switched off and locked. Incorrect installation (e.g. overload) or mechanical defects (e.g. brake defect) can cause the manipulator or external axes to sag. If work is to be carried out on a switched-off industrial robot, the manipulator and external axes must first be moved into a position in which they are unable to move on their own, whether the payload is mounted or not. If this is not possible, the manipulator and external axes must be secured by appropriate means.

Danger!
In the absence of operational safety functions and safeguards, the industrial robot can cause personal injury or material damage. If safety functions or safeguards are dismantled or deactivated, the industrial robot may not be operated.

Warning!
Standing underneath the robot arm can cause death or serious physical injuries. For this reason, standing underneath the robot arm is prohibited!

Warning!
The motors reach temperatures during operation which can cause burns to the skin. Contact should be avoided. Appropriate safety precautions must be taken, e.g. protective gloves must be worn.

KCP

The user must ensure that the industrial robot is only operated with the KCP by authorized persons.

If more than one KCP is used in the overall system, it must be ensured that each KCP is unambiguously assigned to the corresponding industrial robot. They must not be interchanged.

Warning!
The operator must ensure that decoupled KCPs are immediately removed from the system and stored out of sight and reach of personnel working on the industrial robot. This serves to prevent operational and non-operational EMERGENCY STOP facilities from becoming interchanged.
Failure to observe this precaution may result in death, severe physical injuries or considerable damage to property.

External keyboard, external mouse

An external keyboard and/or external mouse may only be used if the following conditions are met:

- Start-up or maintenance work is being carried out.
- The drives are switched off.
- There are no persons in the danger zone.

The KCP must not be used as long as an external keyboard and/or external mouse are connected.

The external keyboard and/or external mouse must be removed as soon as the start-up or maintenance work is completed or the KCP is connected.

Faults

The following tasks must be carried out in the case of faults in the industrial robot:

- Switch off the robot controller and secure it (e.g. with a padlock) to prevent unauthorized persons from switching it on again.
- Indicate the fault by means of a label with a corresponding warning (tag-out).
- Keep a record of the faults.
- Eliminate the fault and carry out a function test.

Modifications

After modifications to the industrial robot, checks must be carried out to ensure the required safety level. The valid national or regional work safety regulations must be observed for this check. The correct functioning of all safety circuits must also be tested.

New or modified programs must always be tested first in Manual Reduced Velocity mode (T1).

After modifications to the industrial robot, existing programs must always be tested first in Manual Reduced Velocity mode (T1). This applies to all components of the industrial robot and includes modifications to the software and configuration settings.

5.8.2 Transportation

Manipulator

The prescribed transport position of the manipulator must be observed. Transportation must be carried out in accordance with the operating instructions or assembly instructions of the manipulator.

Robot controller

The robot controller must be transported and installed in an upright position. Avoid vibrations and impacts during transportation in order to prevent damage to the robot controller.

Transportation must be carried out in accordance with the operating instructions or assembly instructions of the robot controller.

External axis (optional)

The prescribed transport position of the external axis (e.g. KUKA linear unit, turn-tilt table, etc.) must be observed. Transportation must be carried out in accordance with the operating instructions or assembly instructions of the external axis.

5.8.3 Start-up and recommissioning

Before starting up systems and devices for the first time, a check must be carried out to ensure that the systems and devices are complete and operational, that they can be operated safely and that any damage is detected.

The valid national or regional work safety regulations must be observed for this check. The correct functioning of all safety circuits must also be tested.

The passwords for logging onto the KUKA System Software as “Expert” and “Administrator” must be changed before start-up and must only be communicated to authorized personnel.

Danger!
The robot controller is preconfigured for the specific industrial robot. If cables are interchanged, the manipulator and the external axes (optional) may receive incorrect data and can thus cause personal injury or material damage. If a system consists of more than one manipulator, always connect the connecting cables to the manipulators and their corresponding robot controllers.

Warning!
If additional components (e.g. cables), that are not part of the scope of supply of KUKA Roboter GmbH, are integrated into the industrial robot, the user is responsible for ensuring that these components do not adversely affect or disable safety functions.

Caution!
If the internal cabinet temperature of the robot controller differs greatly from the ambient temperature, condensation can form, which may cause damage to the electrical components. Do not put the robot controller into operation until the internal temperature of the cabinet has adjusted to the ambient temperature.

Function test

The following tests must be carried out before start-up and recommissioning:

General test:

It must be ensured that:

- The industrial robot is correctly installed and fastened in accordance with the specifications in the documentation.
- There are no foreign bodies or loose parts on the industrial robot.
- All required safety equipment is correctly installed and operational.
- The power supply ratings of the industrial robot correspond to the local supply voltage and mains type.
- The ground conductor and the equipotential bonding cable are sufficiently rated and correctly connected.
- The connecting cables are correctly connected and the connectors are locked.

Test of safety-oriented circuits:

A function test must be carried out for the following safety-oriented circuits to ensure that they are functioning correctly:

- Local EMERGENCY STOP device (= EMERGENCY STOP button on the KCP)
- External EMERGENCY STOP device (input and output)
- Enabling device (in the test modes)
- Operator safety (in the automatic modes)
- Qualifying inputs (if connected)

- All other safety-relevant inputs and outputs used

Test of reduced velocity control:

This test is to be carried out as follows:

1. Program a straight path with the maximum possible velocity.
2. Calculate the length of the path.
3. Execute the path in T1 mode with the override set to 100% and time the motion with a stopwatch.

Warning!
It must be ensured that no persons are present within the danger zone during path execution.

4. Calculate the velocity from the length of the path and the time measured for execution of the motion.

Control of reduced velocity is functioning correctly if the following results are achieved:

- The calculated velocity does not exceed 250 mm/s.
- The robot executes the path as programmed (i.e. in a straight line, without deviations).

Machine data

It must be ensured that the rating plate on the robot controller has the same machine data as those entered in the declaration of incorporation. The machine data on the rating plate of the manipulator and the external axes (optional) must be entered during start-up.

Warning!
The industrial robot must not be moved if incorrect machine data are loaded. Death, severe physical injuries or considerable damage to property may otherwise result. The correct machine data must be loaded.

5.8.4 Virus protection and network security

The user of the industrial robot is responsible for ensuring that the software is always safeguarded with the latest virus protection. If the robot controller is integrated into a network that is connected to the company network or to the Internet, it is advisable to protect this robot network against external risks by means of a firewall.

For optimal use of our products, we recommend that our customers carry out a regular virus scan. Information about security updates can be found at www.kuka.com.

5.8.5 Manual mode

Manual mode is the mode for setup work. Setup work is all the tasks that have to be carried out on the industrial robot to enable automatic operation. Setup work includes:

- Jog mode
- Teaching
- Programming
- Program verification

The following must be taken into consideration in manual mode:

- If the drives are not required, they must be switched off to prevent the manipulator or the external axes (optional) from being moved unintentionally.

  New or modified programs must always be tested first in Manual Reduced Velocity mode (T1).
- The manipulator, tooling or external axes (optional) must never touch or project beyond the safety fence.
- Components, tooling and other objects must not become jammed as a result of the industrial robot motion, nor must they lead to short-circuits or be liable to fall off.
- All setup work must be carried out, where possible, from outside the safeguarded area.

If the setup work has to be carried out inside the safeguarded area, the following must be taken into consideration:

In **Manual Reduced Velocity mode (T1)**:

- If it can be avoided, there must be no other persons inside the safeguarded area.

  If it is necessary for there to be several persons inside the safeguarded area, the following must be observed:
  - Each person must have an enabling device.
  - All persons must have an unimpeded view of the industrial robot.
  - Eye-contact between all persons must be possible at all times.
- The operator must be so positioned that he can see into the danger area and get out of harm's way.

In **Manual High Velocity mode (T2)**:

- This mode may only be used if the application requires a test at a velocity higher than Manual Reduced Velocity.
- Teaching and programming are not permissible in this operating mode.
- Before commencing the test, the operator must ensure that the enabling devices are operational.
- The operator must be positioned outside the danger zone.
- There must be no other persons inside the safeguarded area. it is the responsibility of the operator to ensure this.

5.8.6 Simulation

Simulation programs do not correspond exactly to reality. Robot programs created in simulation programs must be tested in the system in **Manual Reduced Velocity mode (T1)**. It may be necessary to modify the program.

5.8.7 Automatic mode

Automatic mode is only permissible in compliance with the following safety measures:

- All safety equipment and safeguards are present and operational.
- There are no persons in the system.
- The defined working procedures are adhered to.

If the manipulator or an external axis (optional) comes to a standstill for no apparent reason, the danger zone must not be entered until an EMERGENCY STOP has been triggered.

5.8.8 Maintenance and repair

After maintenance and repair work, checks must be carried out to ensure the required safety level. The valid national or regional work safety regulations must be observed for this check. The correct functioning of all safety circuits must also be tested.

The purpose of maintenance and repair work is to ensure that the system is kept operational or, in the event of a fault, to return the system to an operational state. Repair work includes troubleshooting in addition to the actual repair itself.

The following safety measures must be carried out when working on the industrial robot:

- Carry out work outside the danger zone. If work inside the danger zone is necessary, the user must define additional safety measures to ensure the safe protection of personnel.
- Switch off the industrial robot and secure it (e.g. with a padlock) to prevent unauthorized persons from switching it on again. If it is necessary to carry out work with the robot controller switched on, the user must define additional safety measures to ensure the safe protection of personnel.
- If it is necessary to carry out work with the robot controller switched on, this may only be done in operating mode T1.
- Label the system with a sign indicating that work is in progress. This sign must remain in place, even during temporary interruptions to the work.
- The EMERGENCY STOP systems must remain active. If safety functions or safeguards are deactivated during maintenance or repair work, they must be reactivated immediately after the work is completed.

Faulty components must be replaced using new components with the same article numbers or equivalent components approved by KUKA Roboter GmbH for this purpose.

Cleaning and preventive maintenance work is to be carried out in accordance with the operating instructions.

Robot controller

Even when the robot controller is switched off, parts connected to peripheral devices may still carry voltage. The external power sources must therefore be switched off if work is to be carried out on the robot controller.

The ESD regulations must be adhered to when working on components in the robot controller.

Voltages in excess of 50 V (up to 600 V) can be present in various components for several minutes after the robot controller has been switched off! To prevent life-threatening injuries, no work may be carried out on the industrial robot in this time.

Water and dust must be prevented from entering the robot controller.

Hazardous substances

The following safety measures must be carried out when handling hazardous substances:

- Avoid prolonged and repeated intensive contact with the skin.
- Avoid breathing in oil spray or vapors.
- Clean skin and apply skin cream.

To ensure safe use of our products, we recommend that our customers regularly request up-to-date safety data sheets from the manufacturers of hazardous substances.

5.8.9 Decommissioning, storage and disposal

The industrial robot must be decommissioned, stored and disposed of in accordance with the applicable national laws, regulations and standards.

5.8.10 Safety measures for “single point of control”

Overview

If certain components in the industrial robot are operated, safety measures must be taken to ensure complete implementation of the principle of “single point of control”.

Components:

- Submit interpreter
- PLC
- OPC Server
- Remote control tools
- External keyboard/mouse

The implementation of additional safety measures may be required. This must be clarified for each specific application; this is the responsibility of the system integrator, programmer or user of the system.

Since only the system integrator knows the safe states of actuators in the periphery of the robot controller, it is his task to set these actuators to a safe state, e.g. in the event of an EMERGENCY STOP.

Submit interpreter, PLC

If motions, (e.g. drives or grippers) are controlled with the Submit interpreter or the PLC via the I/O system, and if they are not safeguarded by other means, then this control will take effect even in T1 and T2 modes or while an EMERGENCY STOP is active.

If variables that affect the robot motion (e.g. override) are modified with the Submit interpreter or the PLC, this takes effect even in T1 and T2 modes or while an EMERGENCY STOP is active.

Safety measures:

- Do not modify safety-relevant signals and variables (e.g. operating mode, EMERGENCY STOP, safety gate contact) via the Submit interpreter or PLC.
- If modifications are nonetheless required, all safety-relevant signals and variables must be linked in such a way that they cannot be set to a dangerous state by the Submit interpreter or PLC.

OPC server, remote control tools

These components can be used with write access to modify programs, outputs or other parameters of the robot controller, without this being noticed by any persons located inside the system.

Safety measures:

- KUKA stipulates that these components are to be used exclusively for diagnosis and visualization.

  Programs, outputs or other parameters of the robot controller must not be modified using these components.

External keyboard/mouse

These components can be used to modify programs, outputs or other parameters of the robot controller, without this being noticed by any persons located inside the system.

Safety measures:

- Only use one operator console at each robot controller.

- If the KCP is being used for work inside the system, remove any keyboard and mouse from the robot controller beforehand.

5.9 Applied norms and regulations

Name	Definition	Edition
2006/42/EC	Machinery Directive: Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)	2006
2004/108/EC	EMC Directive: Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC.	2004
97/23/EC	Pressure Equipment Directive: Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment	1997
EN ISO 13850	Safety of machinery: Emergency stop - Principles for design	2008
EN ISO 12100-1	Safety of machinery: Basic concepts, general principles for design - Part 1: Basic terminology, methodology	2003
EN ISO 12100-2	Safety of machinery: Basic concepts, general principles for design - Part 2: Technical principles	2003
EN ISO 10218-1	Industrial robots: Safety	2008
EN 954-1	Safety of machinery: Safety-related parts of control systems - Part 1: General principles for design	1997
EN 614-1	Safety of machinery: Ergonomic design principles - Part 1: Terminology and general principles	2006
EN 61000-6-2	Electromagnetic compatibility (EMC): Part 6-2: Generic standards; Immunity for industrial environments	2005
EN 61000-6-4	Electromagnetic compatibility (EMC): Part 6-4: Generic standards; Emission standard for industrial environments	2007
EN 60204-1	Safety of machinery: Electrical equipment of machines - Part 1: General requirements	2006

6 Planning

6.1 Mounting base

Description

The robot is fastened directly to the mounting base with 4 bolts. A suitable steel construction can be used as the mounting base. The mounting surface must be at least 20 mm thick. It must be ensured that the steel structure is able to withstand safely and permanently the dynamic loads (>>> 4.4 "Loads acting on the foundation" page 20) to which it is subjected.

In order to fasten the robot to a concrete foundation, a suitable steel plate must be prepared and fastened to the concrete foundation.

The connecting cables to the robot controller must be installed in a cable duct. If required, additional measures must be taken to ensure electromagnetic compatibility (EMC).

Caution!
Installation, connection and start-up of the robot must be carried out in accordance with the applicable national laws and regulations.
The robot may only be started up if the applicable regulations have been observed.

Hole pattern

The following holes must be used for mounting the robot.

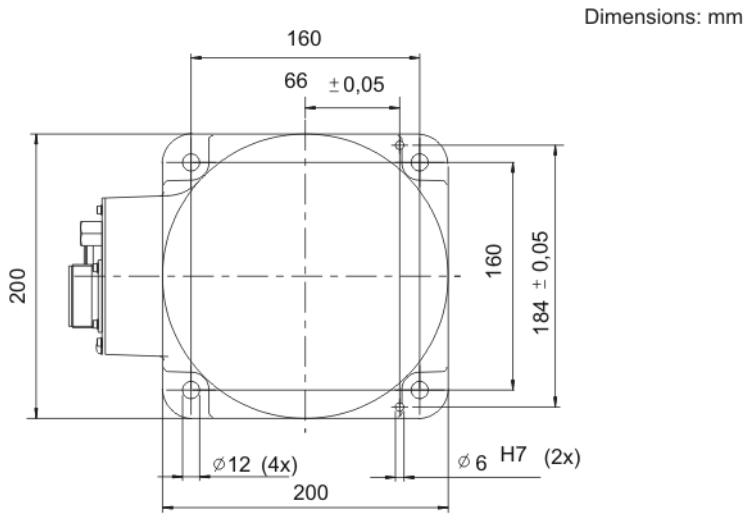


Fig. 6-1: Hole pattern

6.2 Instructions for mechanical axis range limitation

Description

The robot's working envelope can be reduced to the required minimum in axes 1 to 3 using mechanical axis range limitation systems.

Warning!
If the mechanical axis range limits are changed, the robot could collide with its end stops, resulting in damage to the robot and its tooling. The software limit switches must be set to a position at least 2 to 3° in front of the axis range limits.

In order to be able to use the mechanical axis range limitations, it is necessary to construct it. Instructions are supplied.

Axis	Mechanical axis range limitation
1	Plate with fastening blocks and 2 stops (>>> 6.2.1 "Instructions for mechanical axis range limitation on axis 1" page 46)
2	Stop (>>> 6.2.2 "Instructions for mechanical axis range limitation on axis 2" page 47)
3	Stop with holder (>>> 6.2.3 "KR 5 sixx R650: instructions mechanical axis range limitation on axis 3" page 47) (>>> 6.2.4 "KR 5 sixx R850: instructions mechanical axis range limitation on axis 3" page 48)

6.2.1 Instructions for mechanical axis range limitation on axis 1

Description

Two stops are used to limit the axis range for axis 1.

Axis range limitation	Description
Plate	Material: S45C
2 fastening blocks A	Material: S45C M8x16-12.9 Allen screws Tightening torque M_A = 36 ±7.2 Nm
2 stops	Material: A2017 M8x16-12.9 Allen screws Tightening torque M_A = 20 ±4 Nm
Fastening block B	Material: S45C M8x16-12.9 Allen screws Tightening torque M_A = 36 ±7.2 Nm

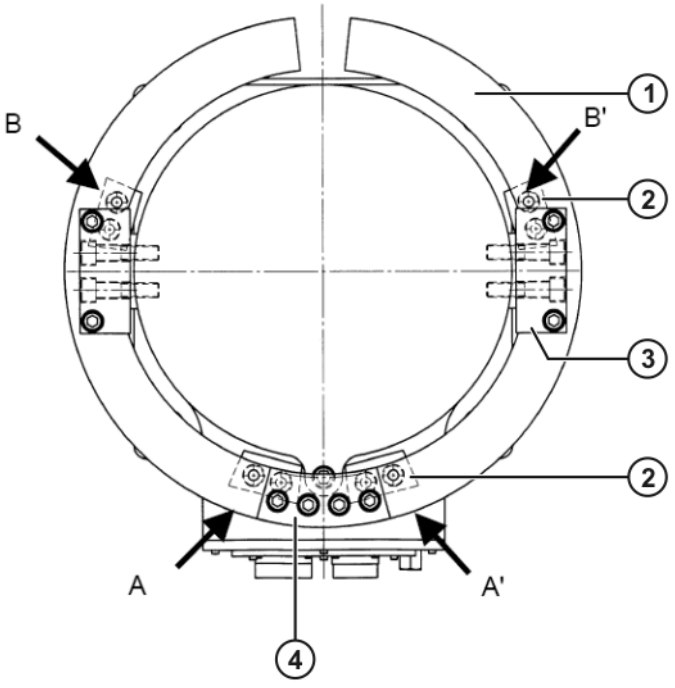


Fig. 6-2: Mechanical axis range limitation, axis 1

1 Plate
2 Stop
3 Fastening block A
4 Fastening block B

Item	Axis limit +	Axis limit -
O	5°	28°45'
A´	-28°45'	-5°
B	95°	118°45'
B´	-118°45'	-95°

Warning!
Axis 1 must not be moved between positions A and A´ to avoid damage to the energy supply system. Do not remove the screw at position 1.

For detailed specifications of the mechanical axis range limitation for axis 1, see (>>> 14.1 "Mechanical axis range limitation on axis 1, dimensioned drawings" page 103).

6.2.2 Instructions for mechanical axis range limitation on axis 2

Description A stop is used to limit the axis range for axis 2.

Axis range limitation	Description
Stop	Material: A2017-T4 M8x25 Allen screws Tightening torque M_A = 19.6 ±3.9 Nm

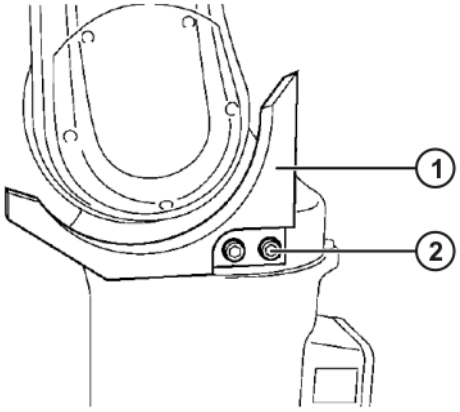


Fig. 6-3: Mechanical axis range limitation, axis 2

1 Mechanical axis range limitation, axis 2
2 Allen screw

For detailed specifications of the mechanical axis range limitation for axis 2, see (>>> 14.2 "Mechanical axis range limitation on axis 2, dimensioned drawings" page 104).

6.2.3 KR 5 sixx R650: instructions mechanical axis range limitation on axis 3

Description A stop is used to limit the axis range for axis 3.

Axis range limitation	Description
Stop	Material: A2017-T4 M6x20 Allen screws Tightening torque M_A = 9.8 ±2 Nm
Holder for the stop	Material: A2017-T4 M5x35 Allen screws Tightening torque M_A = 5.9 ±1.2 Nm M8x35 Allen screw with nut, thread length: 32 mm Tightening torque M_A = 10 ±2 Nm
Spacer	Material: S45C

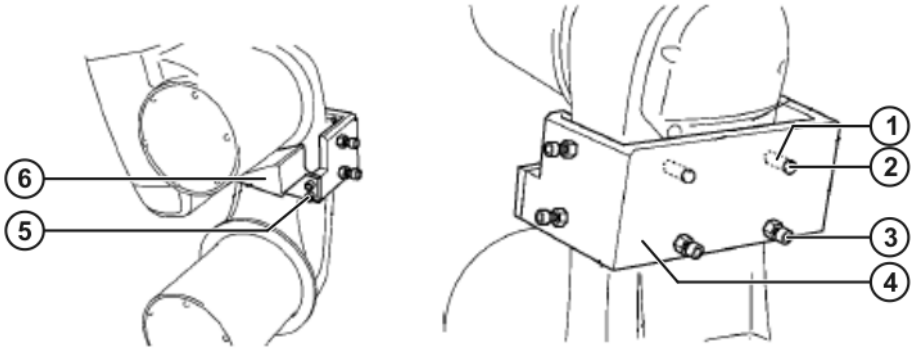


Fig. 6-4: Mechanical axis range limitation, axis 3

1	Spacer	4	Holder for the stop
2	M5x35 screw	5	Allen screw
3	M8x35 Allen screw with nut	6	Mechanical stop

For detailed specifications of the mechanical axis range limitation for axis 3, see (>>> 14.3 "KR 5 sixx R650: mechanical axis range limitation on axis 3, dimensioned drawings" page 105).

6.2.4 KR 5 sixx R850: instructions mechanical axis range limitation on axis 3

Description A stop is used to limit the axis range for axis 3.

Axis range limitation	Description
Stop	Material: A5083P-H32 M6x20 Allen screws Tightening torque M_A = 9.8 ±2 Nm
Holder for the stop	Material: A2017-T4 M5x35 Allen screws Tightening torque M_A = 5.9 ±1.2 Nm M8x35 Allen screw with nut, thread length: 32 mm Tightening torque M_A = 10 ±2 Nm
Spacer	Material: S45C

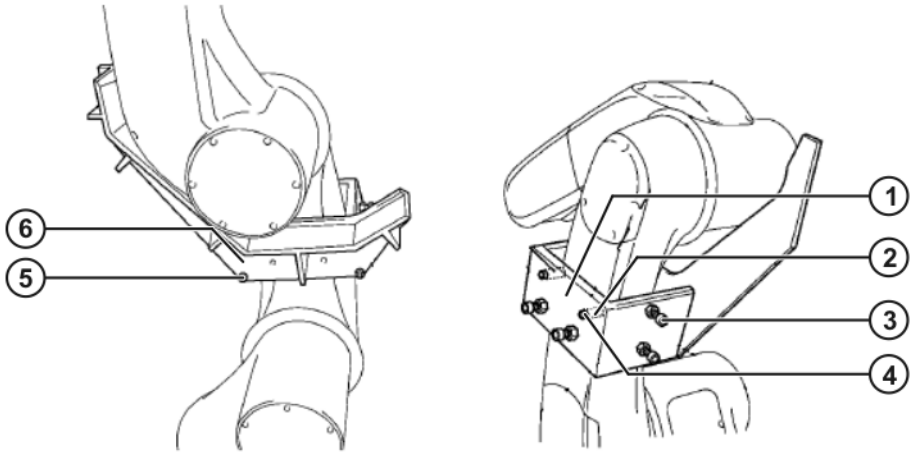


Fig. 6-5: Mechanical axis range limitation, axis 3

1	Holder for the stop	4	Allen screw
2	Screw	5	Mechanical stop
3	Spacer	6	Allen screw

For detailed specifications of the mechanical axis range limitation for axis 3, see (>>> 14.4 "KR 5 sixx R850: mechanical axis range limitation on axis 3, dimensioned drawings" page 107).

7 Transportation

7.1 Transporting the robot

It must be ensured that the robot is stable while it is being transported. The robot must remain in its transport position until it has been fastened in position. Before the robot is lifted it must be ensured that it is free from obstructions. Remove all transport safeguards, such as nails and screws, in advance. First remove any rust or glue on contact surfaces.

Transport position

The robot must be in the transport position (>>> Fig. 7-1) before it can be transported. The robot is in the transport position when the axes are in the following positions:

Type	A1 [°]	A2 [°]	A3 [°]	A4 [°]	A5 [°]	A6 [°]
KR 5 sixx	0	-145	+163	+90	+90	0

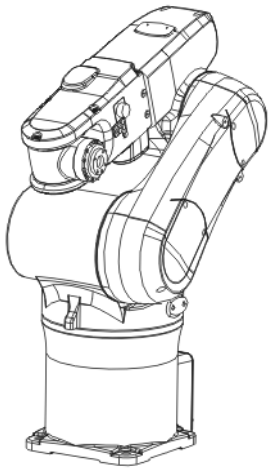


Fig. 7-1: Transport position

Transport dimensions

The dimensions for the robot transport can be noted from the following figure. The position of the center of mass and the weight vary according to the specific configuration. The specified dimensions refer to the robot without equipment.

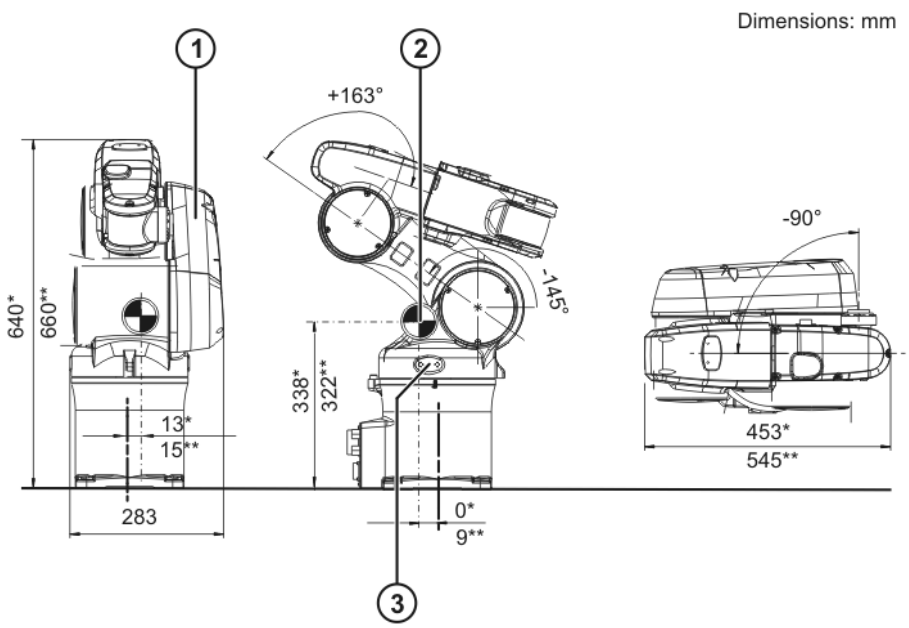


Fig. 7-2: Transport dimensions

1	Robot	*	KR 5 sixx R650
2	Center of gravity	**	KR 5 sixx R850
3	Eyebolt		

Transportation

The robot can be transported by fork lift truck or using lifting tackle. Ceiling-mounted robots are brought to the installation site already in the correct installation position.

Caution!
Use of unsuitable handling equipment may result in damage to the robot. Only use handling equipment with a sufficient load-bearing capacity. Only transport the robot in the manner specified here.

Transportation by fork lift truck

For transport by fork lift truck, the robot must be screwed to a pallet using 4 bolts. A Euro pallet or the pallet used for delivery is suitable for this purpose.

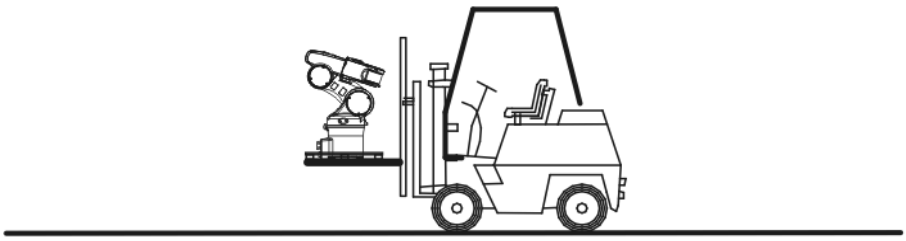


Fig. 7-3: Transport by fork lift truck

Transportation using lifting tackle

A floor-mounted robot can also be transported using lifting tackle. The robot must be in the transport position (>>> Fig. 7-1). The lifting tackle (>>> Fig. 7-4) is attached to 2 eyebolts screwed into the base frame.

Warning!
The robot may tip during transportation. Risk of injury and damage to property.
If the robot is being transported using lifting tackle, special care must be exercised to prevent it from tipping. Additional safeguarding measures must be taken. It is forbidden to pick up the robot in any other way using a crane!

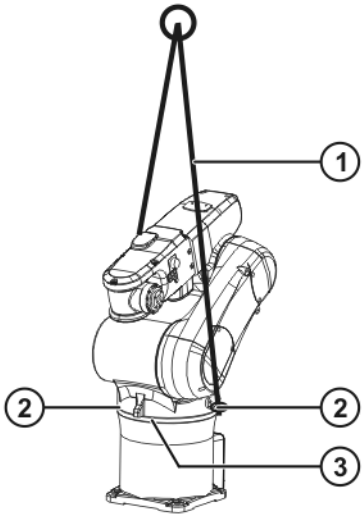


Fig. 7-4: Lifting tackle

1 Lifting tackle
2 Eyebolts
3 Rotating column

8 Start-up and recommissioning

8.1 Installing a floor-mounted robot

Description

This description is valid for the installation of floor-mounted robots. The installation and start-up of the robot controller is described in the robot controller operating instructions.

Preconditions

- Holes must be drilled in the mounting base in accordance with the hole pattern.
- Locating pins must be used.
- Connecting cables must be installed and routed in the system.
- The installation site must be free from obstacles and accessible for a crane.

Procedure

1. Check that both locating pins (>>> Fig. 8-1) are undamaged and fitted securely.
2. Clean the mounting surface.
3. Move the robot into its transport position (>>> Fig. 7-1).
4. Screw 2 eyebolts (>>> Fig. 8-1) into the base frame and insert the lifting tackle.

   The lifting tackle must not damage the robot.
5. Move the robot to the installation site.
6. Lower the robot vertically onto the mounting base. Ensure that an entirely vertical position is maintained in order to prevent damage to the two locating pins.
7. Remove the lifting tackle.
8. Unscrew the 2 eyebolts.
9. Insert 4 M10x30-12.9 hexagon bolts and conical spring washers and tighten using a torque wrench. Increase the tightening torque in several stages to M_A = 70 ±14 Nm.

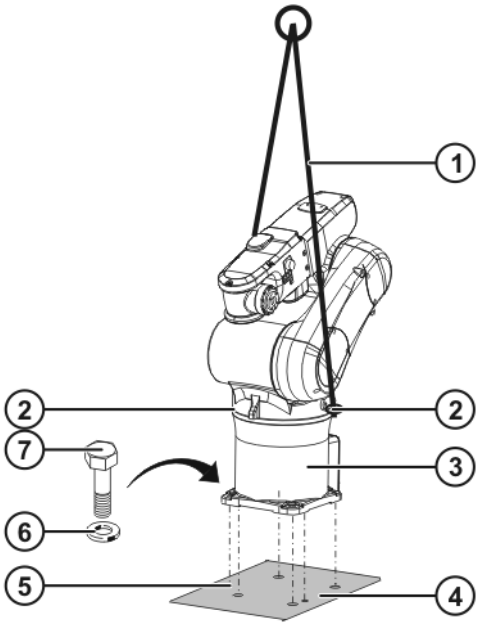


Fig. 8-1: Installing a floor-mounted robot

1	Lifting tackle	5	Locating pin
2	Eyebolt	6	Conical spring washer

3	Base frame	7	Hexagon bolt
4	Mounting surface		

10. Connect the ground conductor (>>> Fig. 8-2) using M5 hexagon nuts, washers and a lock washer.
11. Connect the compressed air lines.
12. Connect the motor/data cable X22 - CN22.
13. Connect the wrist I/O cable X32 - CN20.
14. Check the position of all cables. They must not be under mechanical strain nor be able to chafe against other components.
15. Adjust the pressure on the pressure regulator if necessary.

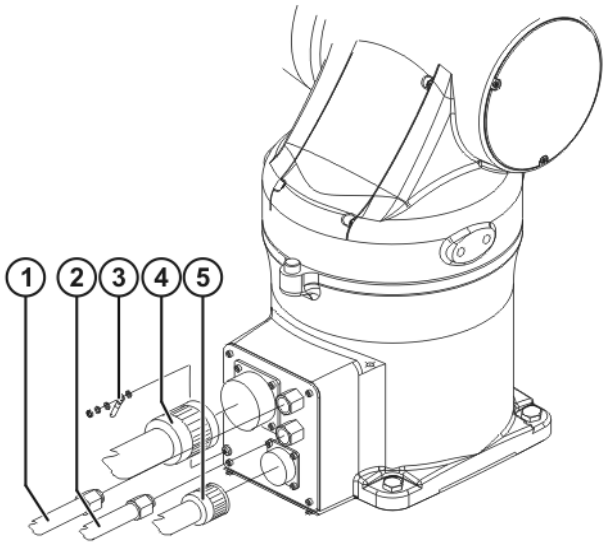


Fig. 8-2: Connecting a floor-mounted robot

1	Compressed air line	4	Motor/data cable
2	Compressed air line	5	Wrist I/O cable
3	Grd. conductor		

16. Mount the tool.

Further information is contained in the operating and programming instructions.

9 Maintenance

9.1 Maintenance table

Description

The maintenance intervals given in the tables are valid for the operating conditions specified in the technical data (>>> 4 "Technical data" page 13). In case of variations from normal conditions (e.g. increased dust or water content in the environment of the robot, abnormal temperatures), KUKA must be consulted.

If the robot is fitted with a KUKA energy supply system (optional), additional maintenance work must be carried out.

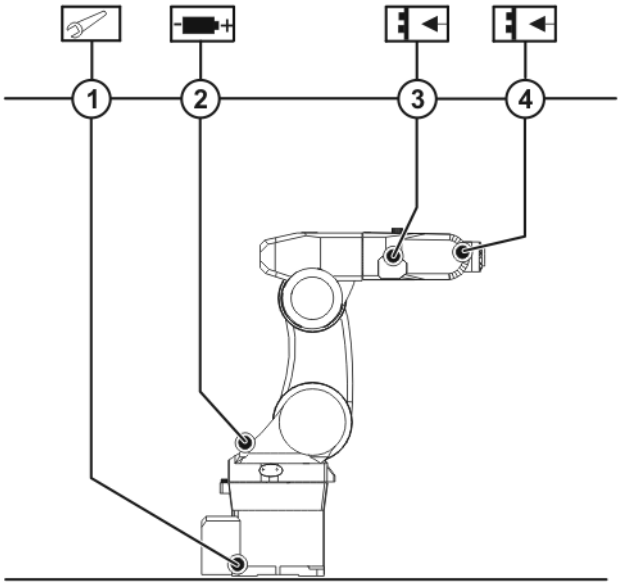


Fig. 9-1: Maintenance work

Maintenance table

The table provides an overview of the maintenance work applying to this robot.

Item	Maintenance interval	Activity
1	100 h, thereafter at least once a year	Check the tightening torque of the holding-down bolts on the mounting base. Tightening torque M_A = 70 ±14 Nm
2	24 months	Exchange the encoder battery. (>>> 9.2 "Exchanging the batteries" page 58)
3	24 months	Check the toothed belt tension on axis 5. (>>> 10.1.1 "Measuring the toothed belt tension for KR 5 sixx A5" page 61) On this robot, the toothed belts must be exchanged every 5 years.
4	24 months	Check the toothed belt tension on axis 6. (>>> 10.1.3 "Measuring the toothed belt tension for KR 5 sixx A6" page 64) On this robot, the toothed belts must be exchanged every 5 years.

9.2 Exchanging the batteries

Description

The encoder data of the robot are backed up using batteries. The batteries are installed in the rotating column and must be exchanged after 2 years, in accordance with maintenance schedule, or following a corresponding error message. If the power supply is interrupted for more than 2 minutes when the batteries are exchanged, the data are lost and all axes of the robot must be remastered (>>> 10.2 "Mastering the KR 5 sixx R650" page 68), (>>> 10.3 "Mastering the KR 5 sixx R850" page 76).

The batteries can also be exchanged with the robot controller switched on; in this case, however, the robot must be secured.

Warning!
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP button.
Warn all persons concerned before starting to put it back into operation.

Preconditions

- The correct batteries (set) must be to hand.
- The permissible battery storage period must not be exceeded.

  Equipotential bonding between the operator and the robot must be ensured.

Procedure

1. Shut down the robot and lock it.
2. Remove 4 screws (>>> Fig. 9-2) and take off the cover.

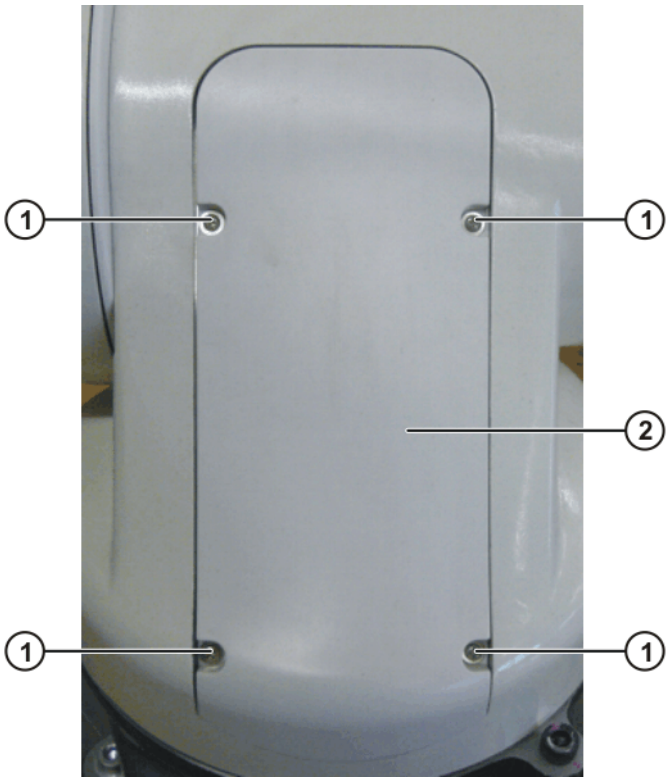


Fig. 9-2: Rotating column cover

1 Screw
2 Cover

3. Remove the battery (>>> Fig. 9-3) from the holder.
4. Release and unplug connector J3; plug in the connector of the new battery.

5. Insert the new batteries into the holders.
6. Exchange the batteries in the same manner.
7. Check once again that the plug-in connectors of all batteries are connected securely.

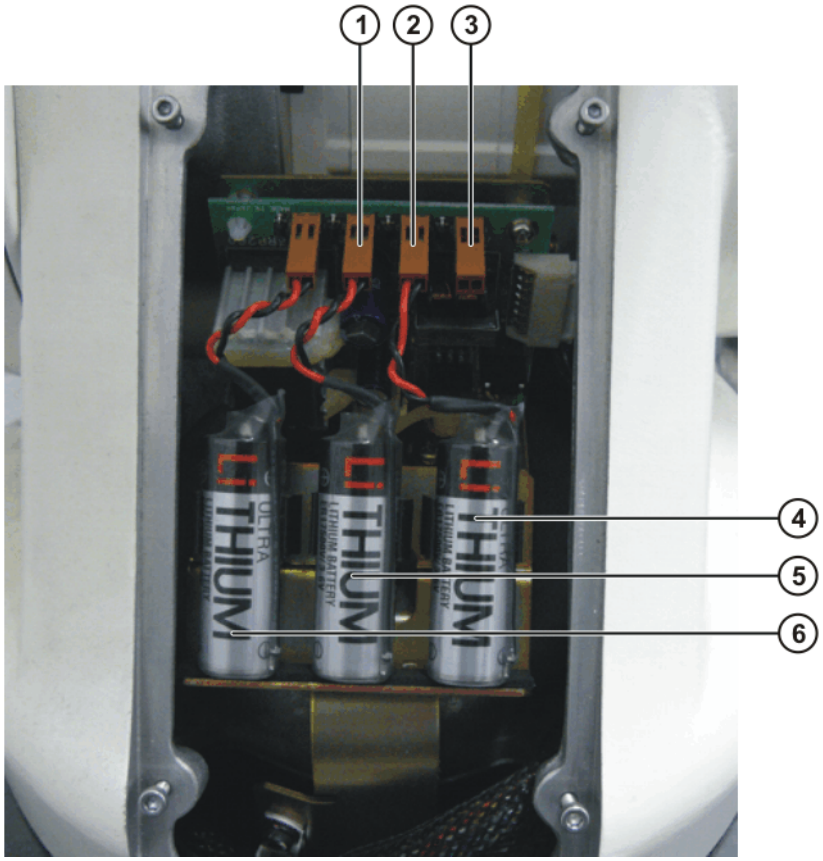


Fig. 9-3: Battery

1	Connector J3	4	Battery
2	Connector J2	5	Battery
3	Connector J1	6	Battery

8. Mount the cover (>>> Fig. 9-2).
9. Insert 4 screws and tighten them; tightening torque M_A = 0.59 ±0.1 Nm.

9.3 Cleaning the robot

Description

The robot must be cleaned in compliance with the instructions given here in order to prevent damage. These instructions only refer to the robot. System components, tools and the robot controller must be cleaned in accordance with the cleaning instructions relevant to them.

The following must be taken into consideration when using cleaning agents and carrying out cleaning work:

- Only use solvent-free, water-soluble cleaning agents.
- Do not use flammable cleaning agents.
- Do not use aggressive cleaning agents.
- Do not use steam or refrigerants for cleaning.
- Do not use pressure equipment or compressed fluids for cleaning.
- It must be ensured that no cleaning agent enters electrical or mechanical system components.

- Personnel protection measures must be taken.

Warning!
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP button.
Warn all persons concerned before starting to put it back into operation.

Procedure

1. Shut down the robot.
2. If necessary, stop adjacent system components and lock them.
3. Remove enclosures if this is necessary in order to carry out the cleaning work.
4. Clean the robot.
5. Fully remove all cleaning agents from the robot.
6. Clean any areas of corrosion and reapply corrosion protection.
7. Remove cleaning agents and equipment from the workspace of the robot.
8. Dispose of cleaning agents properly.
9. Install any safety equipment that has been removed and check that it is functioning correctly.
10. Replace any damaged or illegible plates and covers.
11. Put back in place any enclosures that have been removed.
12. Only put fully functional robots and systems back into operation.

10 Adjustment

10.1 Adjusting toothed belts

Description

The toothed belts are located in the in-line wrist and are only accessible if the cover is removed. They must only be adjusted in accordance with the maintenance intervals or after a toothed belt has been exchanged. When toothed belts are exchanged, the tension must be measured again after 100 hours of operation, as the toothed belts stretch during operation, causing the belt tension to change. If necessary, the toothed belt tension must be adjusted again.

Preconditions

The following preconditions must be met for adjusting the toothed belts:

- Axes A5 and A6 must be free from mechanical stress.
- The motors must be installed.
- A belt tension meter must be available.
- The robot must be secured.

Warning!
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP button.
Warn all persons concerned before starting to put it back into operation.

Warning!
If the toothed belt tension is measured and adjusted immediately after the robot has stopped operating, surface temperatures are likely to be high and could result in burn injuries. Protective gloves must be worn.

Special tools

Unitta sonic belt tension meter, KUKA art. no. 00-164-359

10.1.1 Measuring the toothed belt tension for KR 5 sixx A5

The information in section (>>> 10.1 "Adjusting toothed belts" page 61) must be observed before commencing work.

Procedure

1. Remove 5 screws (>>> Fig. 10-1) from the arm.

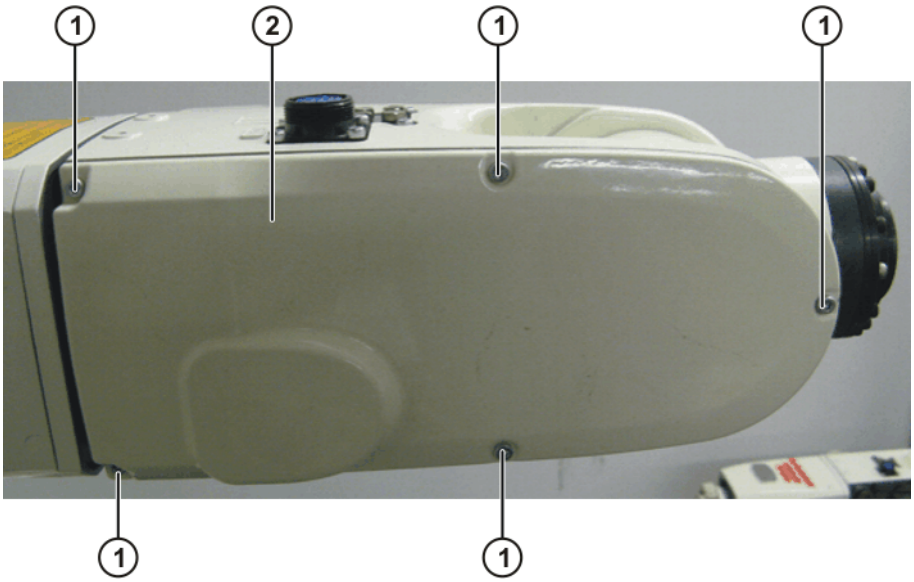


Fig. 10-1: Cover A5

1 Screw
2 Arm cover

2. Take off cover A5.
3. Switch on the belt tension meter.

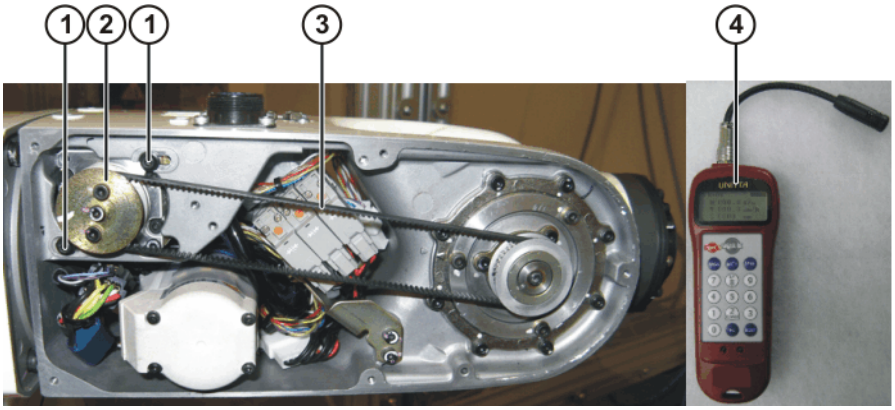


Fig. 10-2: Measuring the toothed belt tension on A5

1 Screw
2 Motor A5
3 Toothed belt
4 Belt tension meter

During measurement, ensure that the ambient noise level is kept low. If there is a high level of noise, the belt tension meter displays **ERROR**.

4. Measure at the middle of the free length of the toothed belt.
5. Pluck the toothed belt and hold the sensor at a distance of 5 mm from the vibrating belt. Read the measurement on the belt tension meter.
6. Repeat the measurement three times and calculate the mean value.
   The mean value must lie within the tolerance. If the tolerances are met, the robot can be re-assembled.

	Axis	Frequency
New toothed belt	A5	180-215 Hz
Used toothed belt	A5	127-152 Hz

7. Mount the cover (>>> Fig. 10-1).
8. Insert the 5 screws into the cover and tighten them; tightening torque M_A = 0.59 ±0.1 Nm.

Caution!
If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

10.1.2 Adjusting the toothed belt tension for KR 5 sixx A5

The information in section (>>> 10.1 "Adjusting toothed belts" page 61) must be observed before commencing work.

Procedure

1. Remove 5 screws (>>> Fig. 10-3) from the arm.

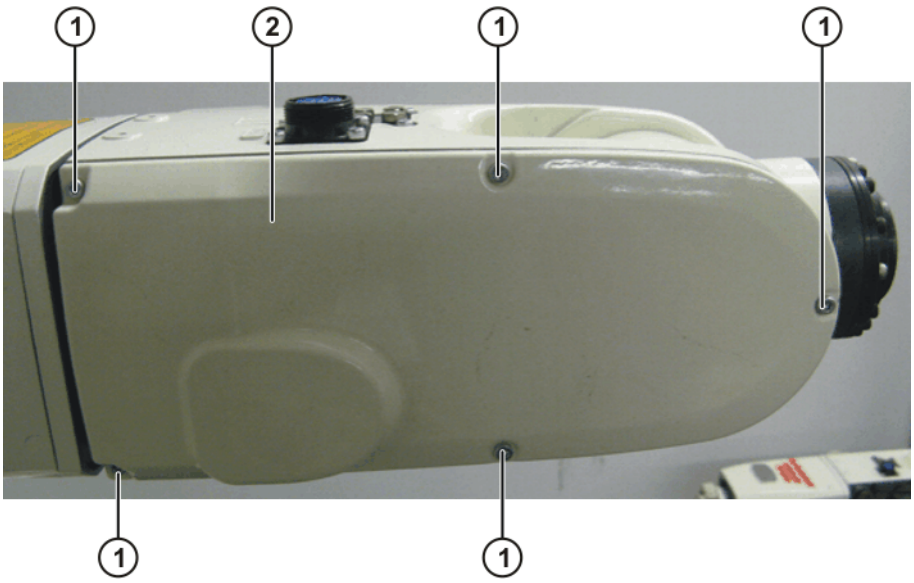


Fig. 10-3: Cover A5

1	Screw
2	Arm cover

2. Take off cover A5.
3. Switch on the belt tension meter.

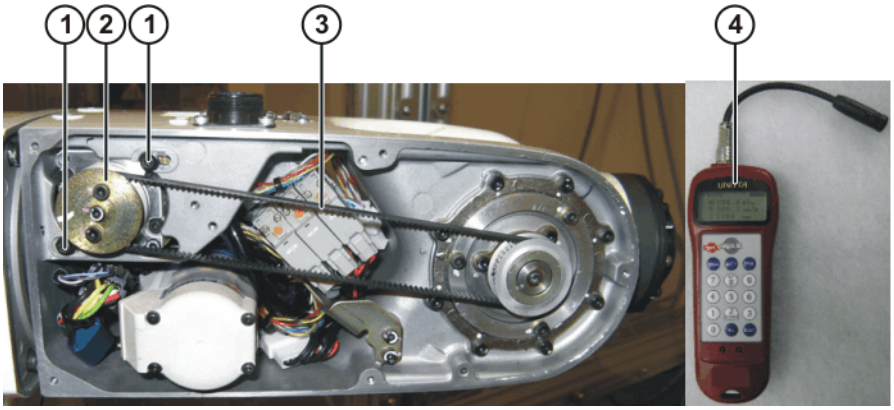


Fig. 10-4: Measuring the toothed belt tension on A5

1	Screw	3	Toothed belt
2	Motor A5	4	Belt tension meter

During measurement, ensure that the ambient noise level is kept low. If there is a high level of noise, the belt tension meter displays **ERROR**.

4. Measure at the middle of the free length of the toothed belt.
5. Pluck the toothed belt and hold the sensor at a distance of 5 mm from the vibrating belt. Read the measurement on the belt tension meter.
6. Repeat the measurement three times and calculate the mean value.

   The mean value must lie within the tolerance. If the tolerances are exceeded, the toothed belt tension must be adjusted according to the following procedure.

	Axis	Frequency
New toothed belt	A5	180-215 Hz
Used toothed belt	A5	127-152 Hz

7. Slightly slacken the 2 screws (>>> Fig. 10-4) on motor A5 until it is just possible to shift the motor.
8. Insert a slotted screwdriver as shown and exert light pressure in the direction of the arrow while tightening the 2 screws at the same time; tightening torque M_A = 2.0 ±0.2 Nm.

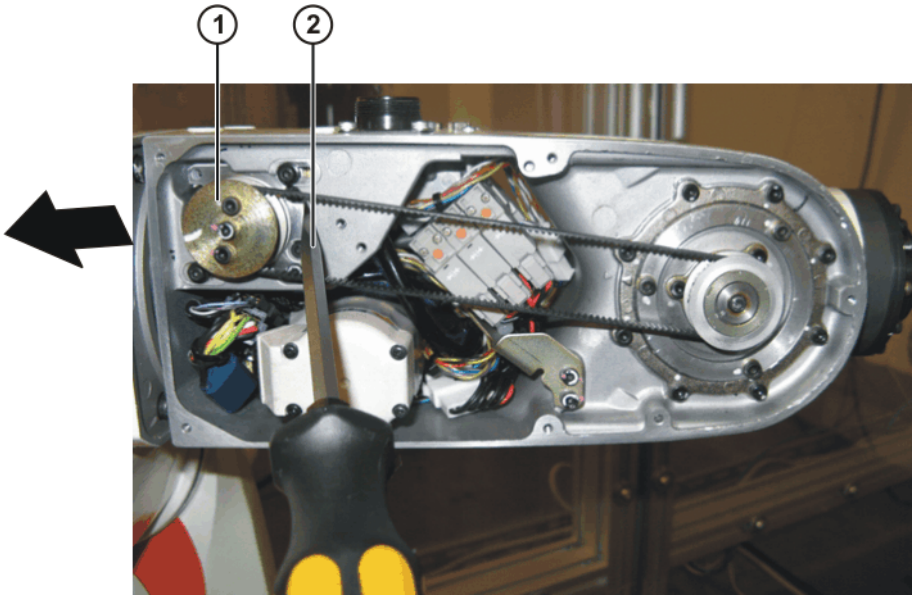


Fig. 10-5: Adjusting the toothed belt tension on A5

1 Motor A5
2 Slotted screwdriver

9. Measure the toothed belt tension again as described in steps 3 to 6. If necessary, adjust the toothed belt tension again.
10. Mount the cover (>>> Fig. 10-3).
11. Insert the 5 screws into the cover and tighten them; tightening torque M_A = 0.59 ±0.1 Nm.

If it is necessary to adjust the toothed belt tension, mastering must be carried out after completion of the adjustment work. The same applies if it is necessary to exchange the toothed belt.

Caution!
If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

10.1.3 Measuring the toothed belt tension for KR 5 sixx A6

The information in section (>>> 10.1 "Adjusting toothed belts" page 61) must be observed before commencing work.

Procedure

1. Remove 5 screws (>>> Fig. 10-6) from the arm.

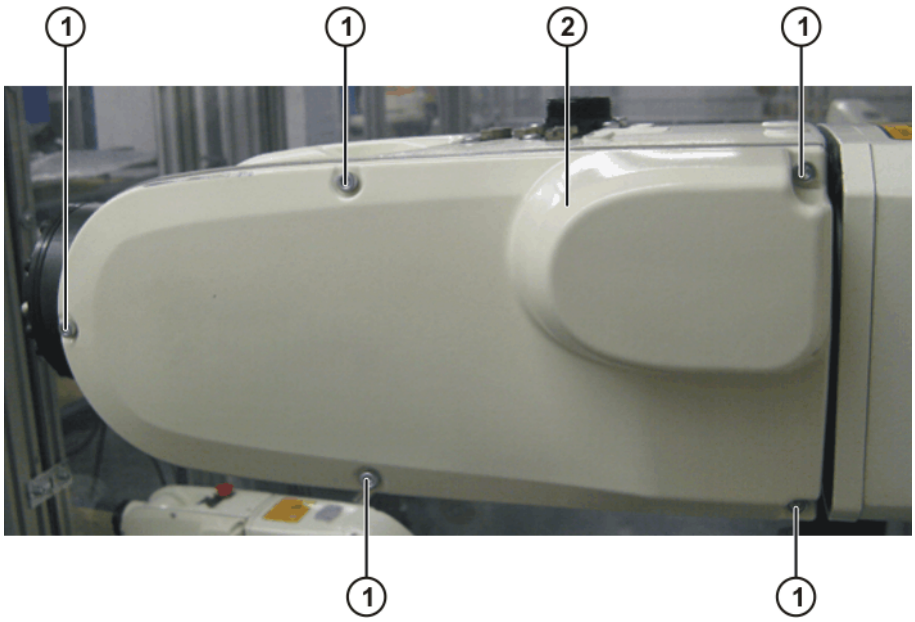


Fig. 10-6: Cover A6

1	Screw
2	Arm cover

2. Take off cover A6.
3. Switch on the belt tension meter.

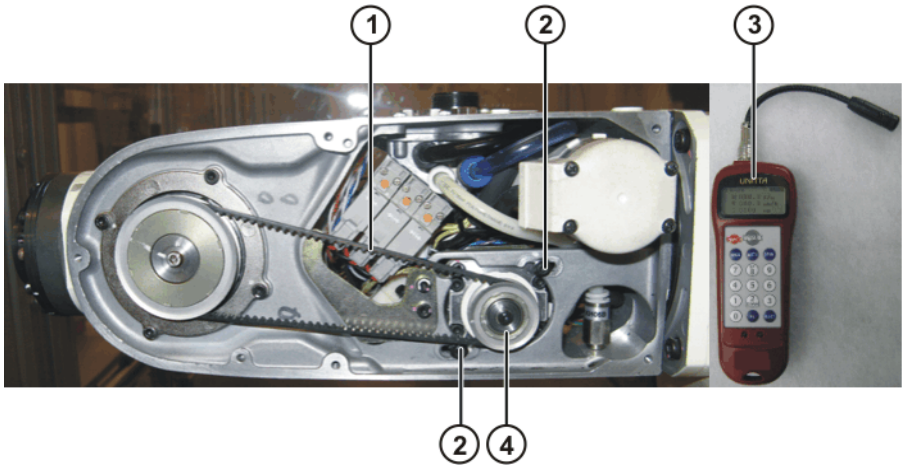


Fig. 10-7: Measuring the toothed belt tension on A6

1	Toothed belt	3	Belt tension meter
2	Screw	4	Motor A6

During measurement, ensure that the ambient noise level is kept low. If there is a high level of noise, the belt tension meter displays **ERROR**.

4. Measure at the middle of the free length of the toothed belt.
5. Pluck the toothed belt and hold the sensor at a distance of 5 mm from the vibrating belt. Read the measurement on the belt tension meter.
6. Repeat the measurement three times and calculate the mean value.

   The mean value must lie within the tolerance. If the tolerances are met, the robot can be re-assembled.

	Axis	Frequency
New toothed belt	A6	215-265 Hz
Used toothed belt	A6	152-187 Hz

7. Mount the cover (>>> Fig. 10-6).
8. Insert the 5 screws into the cover and tighten them; tightening torque M_A = 0.59 ±0.1 Nm.

Caution!
If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

10.1.4 Adjusting the toothed belt tension for KR 5 sixx A6

The information in section (>>> 10.1 "Adjusting toothed belts" page 61) must be observed before commencing work.

Procedure

1. Remove 5 screws (>>> Fig. 10-8) from the arm.

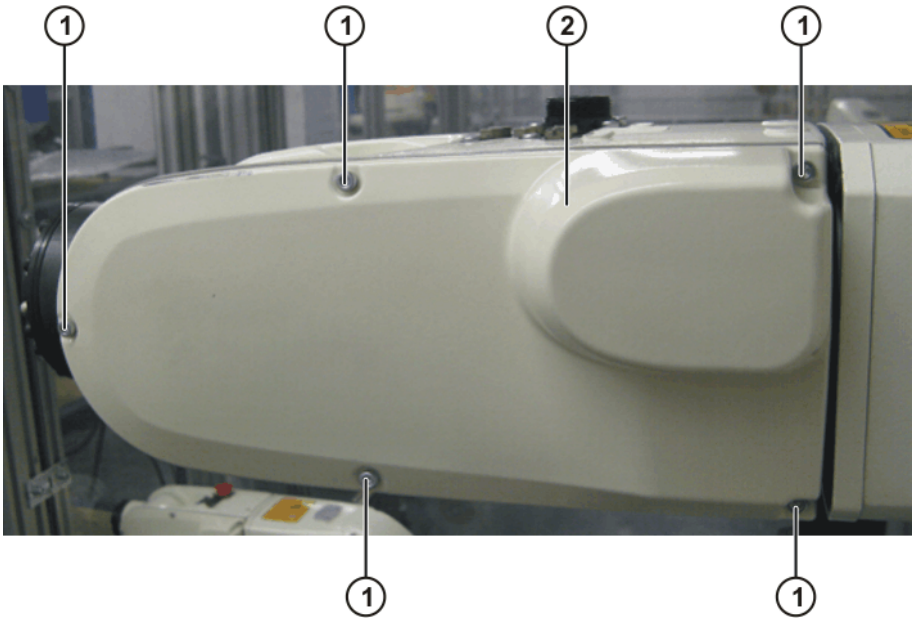


Fig. 10-8: Cover A6

1 Screw
2 Arm cover

2. Take off cover A6.
3. Switch on the belt tension meter.

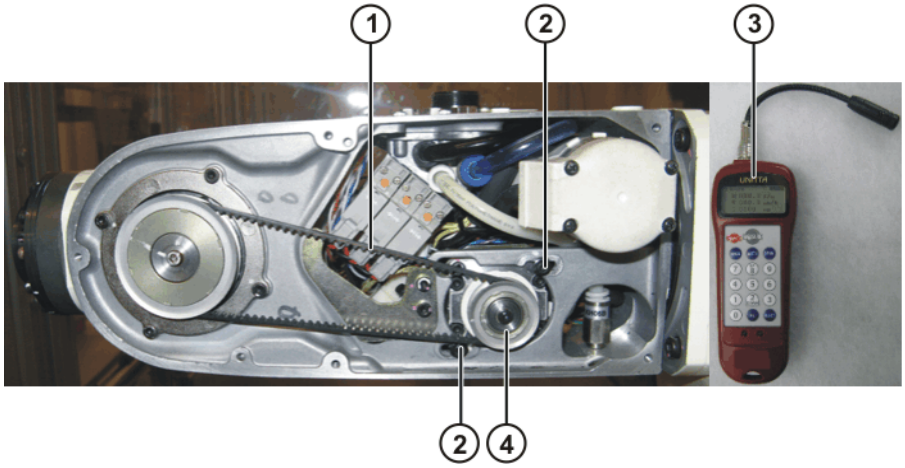


Fig. 10-9: Measuring the toothed belt tension on A6

1	Toothed belt	3	Belt tension meter
2	Screw	4	Motor A6

During measurement, ensure that the ambient noise level is kept low. If there is a high level of noise, the belt tension meter displays **ERROR**.

4. Measure at the middle of the free length of the toothed belt.
5. Pluck the toothed belt and hold the sensor at a distance of 5 mm from the vibrating belt. Read the measurement on the belt tension meter.
6. Repeat the measurement three times and calculate the mean value.

   The mean value must lie within the tolerance. If the tolerances are exceeded, the toothed belt tension must be adjusted according to the following procedure.

	Axis	Frequency
New toothed belt	A6	215-265 Hz
Used toothed belt	A6	152-187 Hz

7. Slightly slacken the 2 screws (>>> Fig. 10-9) on motor A6 until it is just possible to shift the motor.
8. Insert a slotted screwdriver as shown and exert light pressure in the direction of the arrow while tightening the 2 screws at the same time; tightening torque M_A = 2.0 ±0.2 Nm.

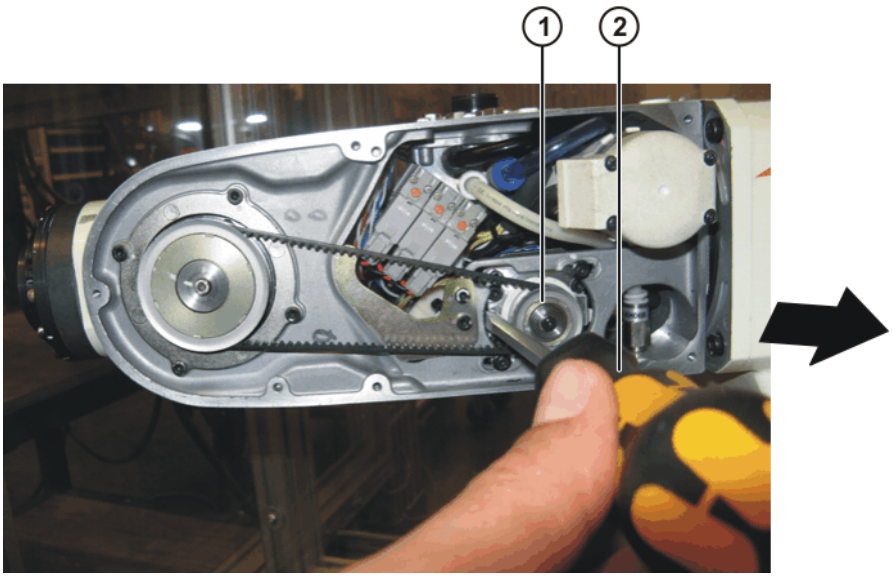


Fig. 10-10: Adjusting the toothed belt tension on A6

1 Motor A6
2 Slotted screwdriver

9. Measure the toothed belt tension again as described in steps 3 to 6. If necessary, adjust the toothed belt tension again.
10. Mount the cover (>>> Fig. 10-8).
11. Insert the 5 screws into the cover and tighten them; tightening torque M_A = 0.59 ±0.1 Nm.

If it is necessary to adjust the toothed belt tension, mastering must be carried out after completion of the adjustment work. The same applies if it is necessary to exchange the toothed belt.

Caution!
If a new toothed belt is installed, the belt tension must be rechecked after approximately 100 hours of operation and readjusted if necessary.

10.2 Mastering the KR 5 sixx R650

Description

During mastering, the robot is moved to a reference position, and the MAMES values for each axis are set relative to the zero position.

Only a mastered robot can move to programmed positions and be moved using Cartesian coordinates.

The robot must be mastered in the following cases:

- After repairs, e.g. after exchanging a motor.
- If the robot issues a message indicating that mastering is necessary. This applies, for example, if the robot's batteries are depleted.
- After exchanging a gear unit.
- After exchanging a toothed belt.
- After a collision, e.g. an impact with an end stop at more than 250 mm/s.

Overview

Mastering consists of the following steps:

Step	Description
1.	If the robot controller or the robot has been exchanged: Enter the robot-specific mastering values in the robot controller. (>>> 10.2.1 "Entering the MAMES values" page 69)
2.	Move the axes to be mastered into the pre-mastering position. (>>> 10.2.2 "Moving the axes to the pre-mastering position for KR 5 sixx R650" page 70)
3.	Master the axes. (>>> 10.2.3 "Mastering the axes for KR 5 sixx" page 75)

10.2.1 Entering the MAMES values

Description

The MAMES values must be entered in the robot controller before mastering is performed if the robot or the robot controller has been exchanged. Values already entered must be compared with the rank values given on the robot base.

MAMES values are robot-specific reference values. When the robot has reached its mastering position, it can use the MAMES value for this axis to identify its position relative to the zero position.

The MAMES values are given in a table on the base frame.

RANK	
1	173.23022
2	-103.07044
3	171.33120
4	182.13793
5	124.08612
6	95.21334

Precondition

- Expert user group

Procedure

1. Select the menu sequence **Setup** > **Master** > **Set mastering**.

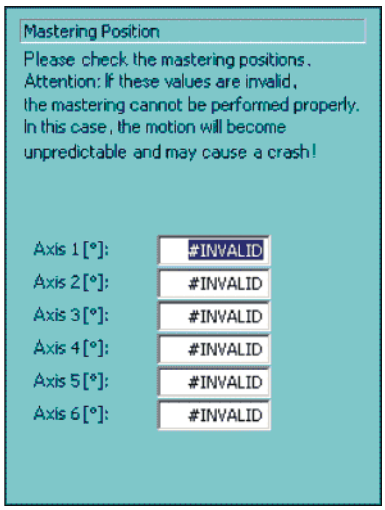


Fig. 10-11: Entering the MAMES values

2. Enter the MAMES values.

The values must be entered with all 5 decimal places.

The axes can now be mastered.

10.2.2 Moving the axes to the pre-mastering position for KR 5 sixx R650

Description

If only individual axes are to be mastered, it is only necessary to move these axes into the pre-mastering position.

Exception: A5 and A6 must always be mastered together and are therefore moved together into the pre-mastering position.

Necessary equipment

- 3 mm Allen key
- 4 mm Allen key
- Mastering plate, KUKA Art. no. 00-145-156
- Scale

Preparation

1. Operating mode T1
2. Select the jog mode "Jog keys" in the left-hand status key bar on the KCP:

3. Select axis-specific jogging in the right-hand status key bar:

4. Hold down the enabling switch.

   Axes 1 to 6 are displayed in the right-hand status key bar. Press the Plus or Minus status key to move an axis in the positive or negative direction.

Caution!
When moving to the pre-mastering positions, ensure that the axes do not impact with the limit stops. Material damage to the robot may result.

Pre-mastering position A1

- Move A1 to approx. 5 mm before the limit stop (>>> Fig. 10-12).

Fig. 10-12: Pre-mastering position A1

Pre-mastering position A2

- Move A2 into the following position: the distance (measured vertically) between the center of the screw and the lower edge of the base must be **263 mm** (>>> Fig. 10-13).

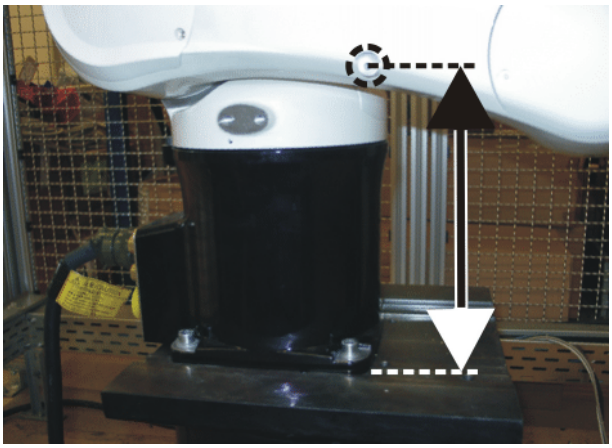


Fig. 10-13: Pre-mastering position A2

Pre-mastering position A4

A4 must be moved to the pre-mastering position before A3.

1. Remove the round motor cover on A3. Remove the screw shown (3 mm Allen key). (>>> Fig. 10-14)
   Do not reinstall the motor cover.

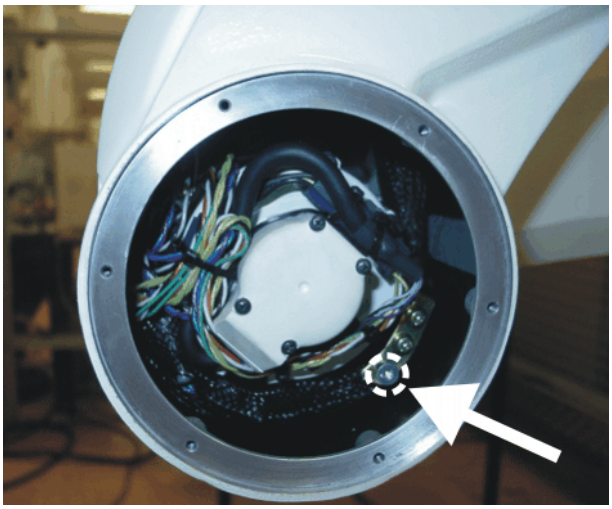
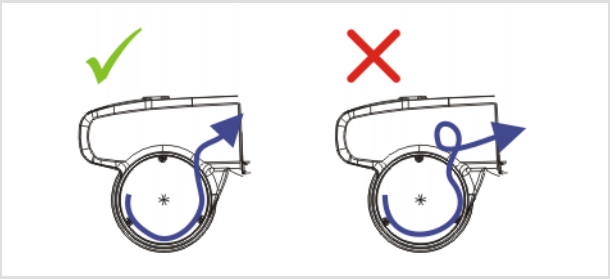


Fig. 10-14: Screw on A3

2. Move A4 so that the connections are on top as shown (>>> Fig. 10-15). Only from this position can A4 be correctly moved into the pre-mastering position.

Danger!
Move A4 slowly into the required position, observing the position of the cable in the open A3. The thick, black cable, leading from A3 into the robot arm, must not become wound up by the motions of the robot arm, as this would tear out the cable.
If necessary, move to the position from the other direction.



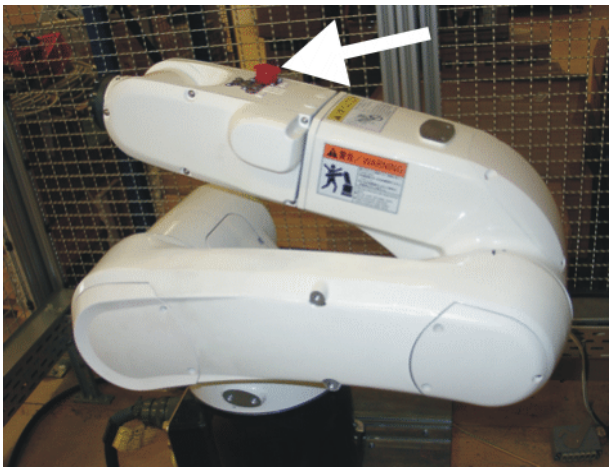


Fig. 10-15: Starting position A4

3. Move A4 in the minus direction until the place marked in the figure becomes accessible. Screw in the screw here (>>> Fig. 10-17).

Warning!
A4 must only be moved in the minus direction here. Otherwise the cables in the robot could break.
Observe the “Mastering A4” label on the in-line wrist.

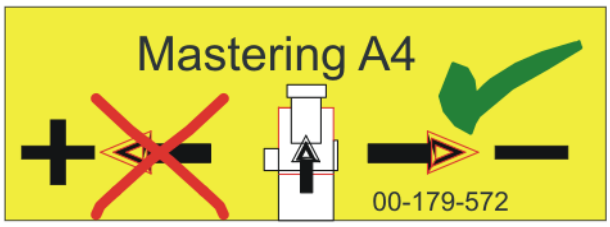


Fig. 10-16: “Mastering A4” label

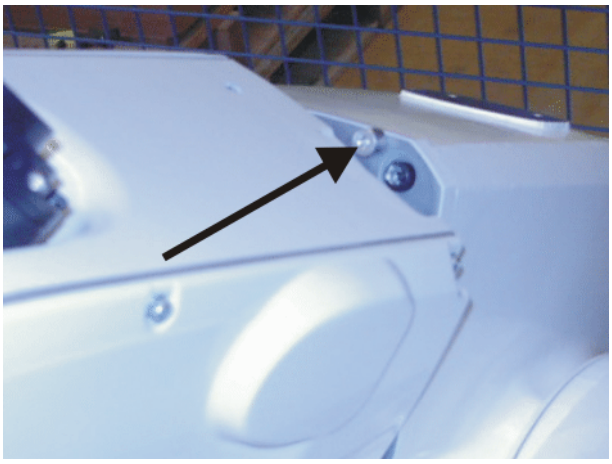


Fig. 10-17: Insert screw for mastering A4 here

4. Move A4 in the minus direction until the robot wrist is flush with the arm at the top (>>> Fig. 10-19).

Warning!
A4 must only be moved in the minus direction here. Otherwise the cables in the robot could break.
Observe the “Mastering A4” label on the in-line wrist.

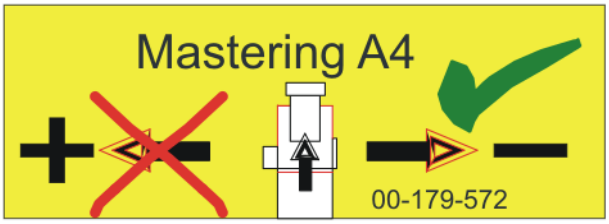


Fig. 10-18: “Mastering A4” label

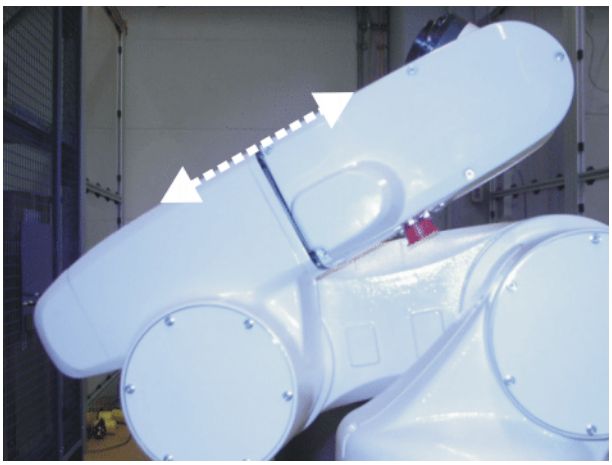


Fig. 10-19: Pre-mastering position A4

The robot wrist must not touch the screw inserted in step 2. There must be a gap of approx. 2 mm below and to the side.

Pre-mastering position A3

Requirement for A3: A4 must be in the pre-mastering position. Only then can A3 be moved correctly to the pre-mastering position.

- Move A3 into the following position: the distance (measured vertically) between the center of the screw and the highest point on A2 must be **105 mm** (>>> Fig. 10-20).

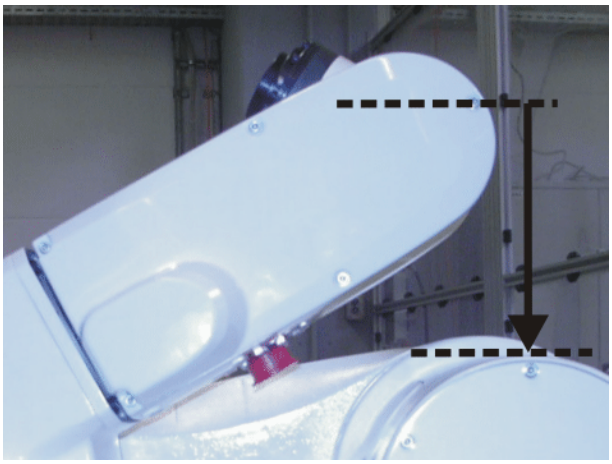


Fig. 10-20: Pre-mastering position A3

Pre-mastering position A5 + A6

1. Move A5 so that the tool flange is approx. 5 mm from the **top side** of the robot wrist (>>> Fig. 10-22).
   The **underside** of the robot wrist is the side on which the connections are found (>>> Fig. 10-21).

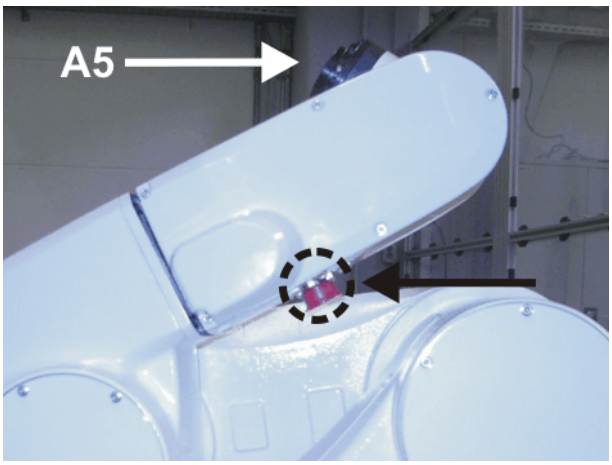


Fig. 10-21: A5 on the correct side of the robot wrist

2. Move A6 so that the screws are lined up as shown in the figure (>>> Fig. 10-22).

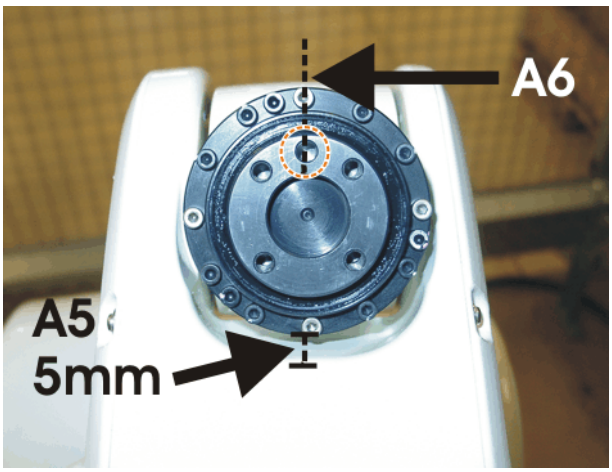


Fig. 10-22: Pre-mastering position A5 and A6

3. Screw the mastering plate to the tool flange (4 mm Allen key) (>>> Fig. 10-23).

Fig. 10-23: Mastering plate on the tool flange

The mastering plate is correctly mounted if the pin on the plate is positioned between the screws as shown (>>> Fig. 10-24).

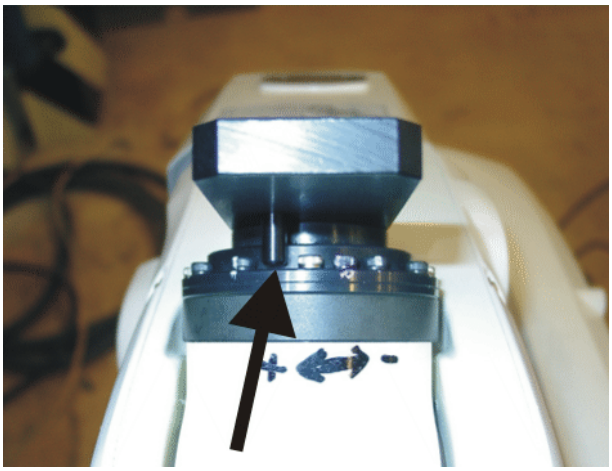


Fig. 10-24: Mastering plate correctly mounted

10.2.3 Mastering the axes for KR 5 sixx

The axes can be mastered individually.
Exceptions: A5 and A6 must always be mastered together.

Precondition

- If the robot controller or the robot has been exchanged:
  Enter the robot-specific mastering values in the robot controller.
- All axes to be mastered are in the pre-mastering position.
- There is no load on the robot; i.e. there is no tool or workpiece mounted.
- No program is selected.
- Operating mode T1

Procedure

1. Select the menu sequence **Setup** > **Master** > **Set mastering**.
   A window opens. All axes to be mastered are displayed. The axis that must be mastered first is selected.
2. Press the **Master** softkey.
3. Press an enabling switch and the Start key.

The robot stops automatically when it reaches the mastering position (= limit stop). In the case of A1, A2, A3 and A5, a message is displayed stating that the software limit switch was reached.

Caution!
If mastering fails, move to the pre-mastering position and perform the procedure again from the beginning.

4. Repeat steps 2 to 3 for all axes to be mastered.
   When all the axes have been mastered, message 1349 "Robot mastered" is displayed.
5. If A3 or A4 has been mastered: remove the screw from A4 and screw it back in place under the round motor cover of A3. Reinstall the round motor cover on A3.
   If A6 has been mastered: remove the mastering plate from the tool flange.

10.2.4 Unmastering axes on KR 5 sixx

Description

The mastering values of the individual axes can be deleted. The axes do not move during unmastering.

If the values for A5 are deleted, the values for A6 are also deleted automatically. This is because A5 is mechanically coupled to A6 in the robot model KR 5 sixx.

Warning!
The software limit switches of an unmastered robot are deactivated. The robot is able to hit the end stops, which can result in damage. An unmastered robot must not be jogged, if at all avoidable. If it must be jogged, the jog override must be reduced as far as possible.

Precondition

- No program is selected.

Procedure

1. Select the menu sequence **Setup** > **Unmaster**. A window opens.
2. Select the axis to be unmastered.
3. Press **UnMaster**. The mastering data of the axis are deleted.
4. Exit the window by means of **Close**.

10.3 Mastering the KR 5 sixx R850

Description

During mastering, the robot is moved to a reference position, and the MAMES values for each axis are set relative to the zero position.

Only a mastered robot can move to programmed positions and be moved using Cartesian coordinates.

The robot must be mastered in the following cases:

- After repairs, e.g. after exchanging a motor.
- If the robot issues a message indicating that mastering is necessary. This applies, for example, if the robot's batteries are depleted.
- After exchanging a gear unit.
- After exchanging a toothed belt.
- After a collision, e.g. an impact with an end stop at more than 250 mm/s.

Overview

Mastering consists of the following steps:

Step	Description
1	If the robot controller or the robot has been exchanged: Enter the robot-specific mastering values in the robot controller. (>>> 10.3.1 "Entering the MAMES values" page 77)
2	Move the axes to be mastered into the pre-mastering position. (>>> 10.3.2 "Moving the axes to the pre-mastering position for KR 5 sixx R850" page 78)
3	Master the axes. (>>> 10.3.3 "Mastering the axes for KR 5 sixx" page 84)

10.3.1 Entering the MAMES values

Description

The MAMES values must be entered in the robot controller before mastering is performed if the robot or the robot controller has been exchanged. Values already entered must be compared with the rank values given on the robot base.

MAMES values are robot-specific reference values. When the robot has reached its mastering position, it can use the MAMES value for this axis to identify its position relative to the zero position.

The MAMES values are given in a table on the base frame.

RANK	
1	173.23022
2	-103.07044
3	171.33120
4	182.13793
5	124.08612
6	95.21334

Precondition

- Expert user group

Procedure

1. Select the menu sequence **Setup** > **Master** > **Set mastering**.

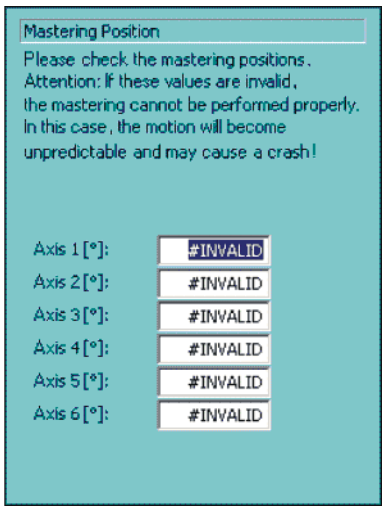


Fig. 10-25: Entering the MAMES values

2. Enter the MAMES values.

The values must be entered with all 5 decimal places.

The axes can now be mastered.

10.3.2 Moving the axes to the pre-mastering position for KR 5 sixx R850

Description

If only individual axes are to be mastered, it is only necessary to move these axes into the pre-mastering position.

Exception: A5 and A6 must always be mastered together and are therefore moved together into the pre-mastering position.

Necessary equipment

- 3 mm Allen key
- 4 mm Allen key
- Mastering plate, KUKA Art. no. 00-145-156
- Scale

Preparation

1. Operating mode T1
2. Select the jog mode "Jog keys" in the left-hand status key bar on the KCP:

3. Select axis-specific jogging in the right-hand status key bar:

4. Hold down the enabling switch.

   Axes 1 to 6 are displayed in the right-hand status key bar. Press the Plus or Minus status key to move an axis in the positive or negative direction.

Caution!
When moving to the pre-mastering positions, ensure that the axes do not impact with the limit stops. Material damage to the robot may result.

Pre-mastering position A1

- Move A1 to approx. 5 mm before the limit stop (>>> Fig. 10-26).

Fig. 10-26: Pre-mastering position A1

Pre-mastering position A2

- Move A2 into the following position: the distance (measured vertically) between the center of the screw and the lower edge of the base must be **270 mm** (>>> Fig. 10-27).

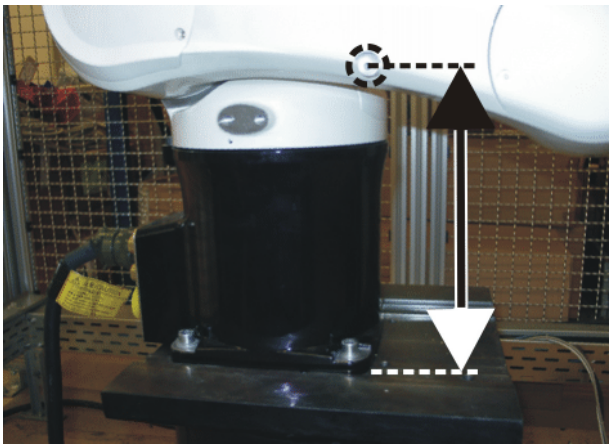


Fig. 10-27: Pre-mastering position A2

Pre-mastering position A4

A4 must be moved to the pre-mastering position before A3.

1. Remove the round motor cover on A3. Remove the screw shown (3 mm Allen key). (>>> Fig. 10-28)
   Do not reinstall the motor cover.

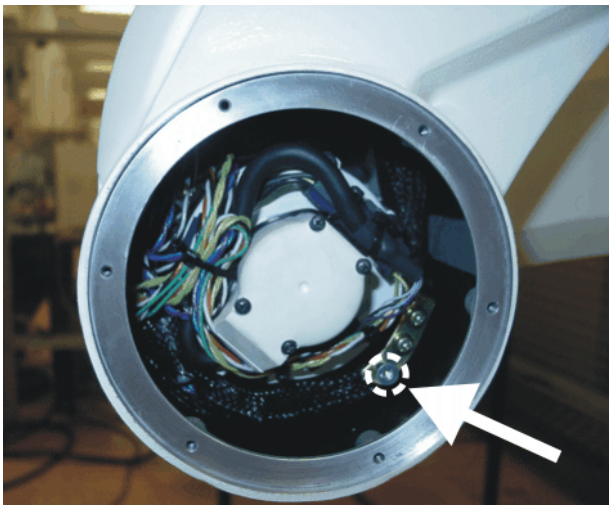
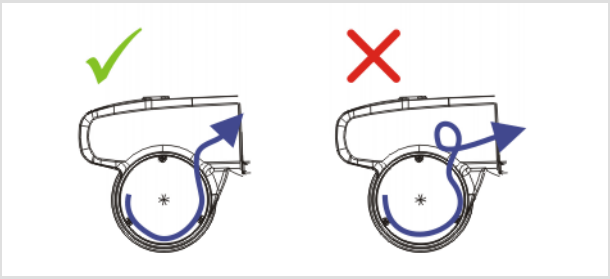


Fig. 10-28: Screw on A3

2. Move A4 so that the connections are on top as shown (>>> Fig. 10-29). Only from this position can A4 be correctly moved into the pre-mastering position.

Danger!
Move A4 slowly into the required position, observing the position of the cable in the open A3. The thick, black cable, leading from A3 into the robot arm, must not become wound up by the motions of the robot arm, as this would tear out the cable.
If necessary, move to the position from the other direction.



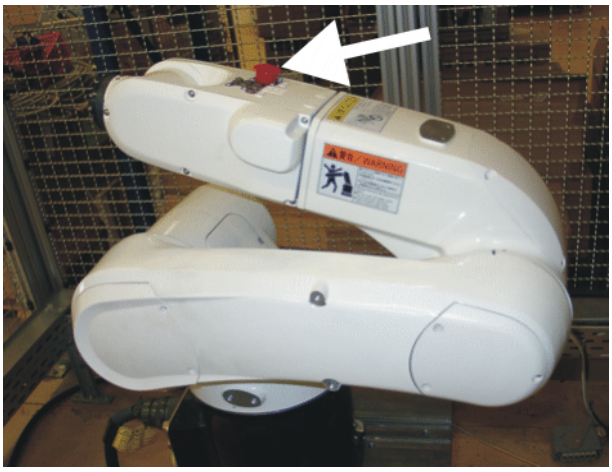


Fig. 10-29: Starting position A4

3. Move A4 in the minus direction until the place marked in the figure becomes accessible. Screw in the screw here (>>> Fig. 10-31).

Warning!
A4 must only be moved in the minus direction here. Otherwise the cables in the robot could break.
Observe the “Mastering A4” label on the in-line wrist.

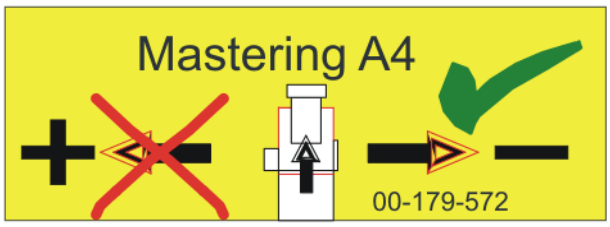


Fig. 10-30: “Mastering A4” label

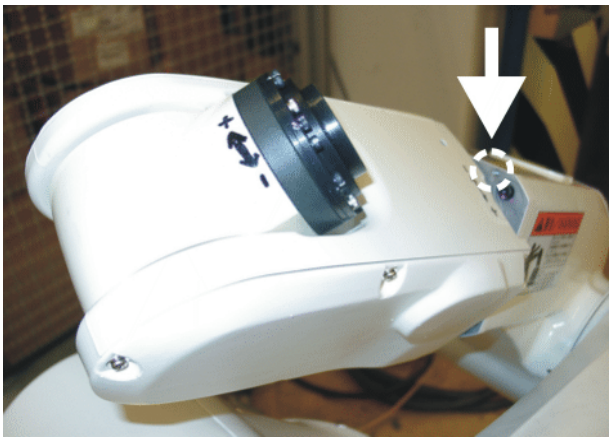


Fig. 10-31: Insert screw for mastering A4 here

4. Move A4 in the minus direction until the robot wrist is flush with the arm at the top (>>> Fig. 10-33).

Warning!
A4 must only be moved in the minus direction here. Otherwise the cables in the robot could break.
Observe the “Mastering A4” label on the in-line wrist.

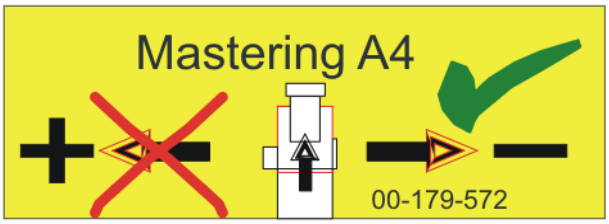


Fig. 10-32: “Mastering A4” label

Fig. 10-33: Pre-mastering position A4

The robot wrist must not touch the screw inserted in step 2. There must be a gap of approx. 2 mm below and to the side.

Fig. 10-34: Do not touch screw

Pre-mastering position A3

Requirement for A3: A4 must be in the pre-mastering position. Only then can A3 be moved correctly to the pre-mastering position.

- Move A3 into the following position: the distance (measured vertically) between the center of the screw and the highest point on A2 must be **135 mm** (>>> Fig. 10-35).

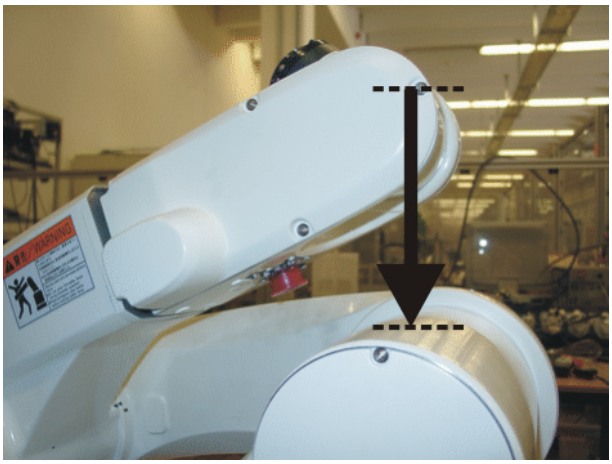


Fig. 10-35: Pre-mastering position A3

Pre-mastering position A5 + A6

1. Move A5 so that the tool flange is approx. 5 mm from the **top side** of the robot wrist (>>> Fig. 10-37).
   The **underside** of the robot wrist is the side on which the connections are found (>>> Fig. 10-36).

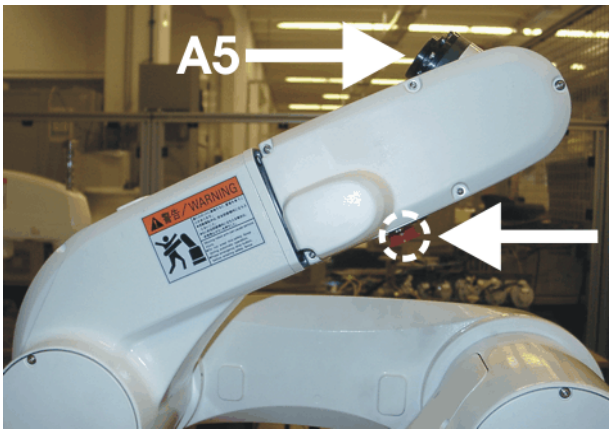


Fig. 10-36: A5 on the correct side of the robot wrist

2. Move A6 so that the screws are lined up as shown in the figure (>>> Fig. 10-37).

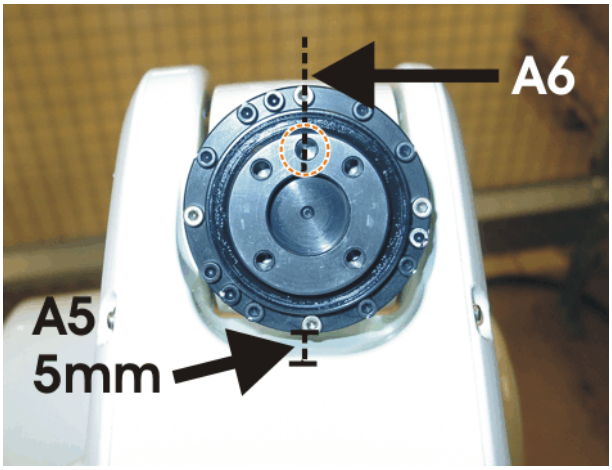


Fig. 10-37: Pre-mastering position A5 and A6

3. Screw the mastering plate to the tool flange (4 mm Allen key) (>>> Fig. 10-38).

Fig. 10-38: Mastering plate on the tool flange

The mastering plate is correctly mounted if the pin on the plate is positioned between the screws as shown (>>> Fig. 10-39).

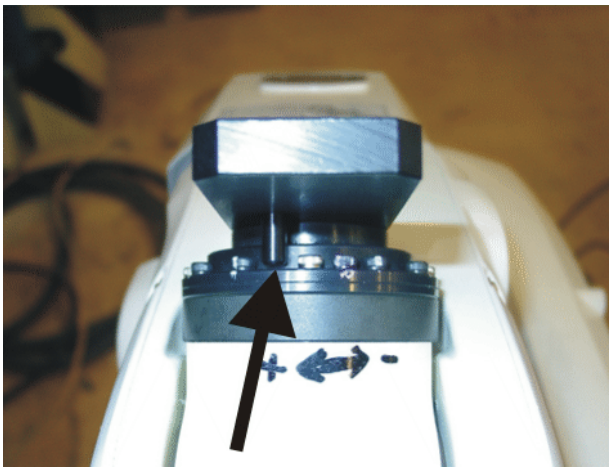


Fig. 10-39: Mastering plate correctly mounted

10.3.3 Mastering the axes for KR 5 sixx

The axes can be mastered individually.
Exceptions: A5 and A6 must always be mastered together.

Precondition

- If the robot controller or the robot has been exchanged:
  Enter the robot-specific mastering values in the robot controller.
- All axes to be mastered are in the pre-mastering position.
- There is no load on the robot; i.e. there is no tool or workpiece mounted.
- No program is selected.
- Operating mode T1

Procedure

1. Select the menu sequence **Setup** > **Master** > **Set mastering**.
   A window opens. All axes to be mastered are displayed. The axis that must be mastered first is selected.
2. Press the **Master** softkey.
3. Press an enabling switch and the Start key.
   The robot stops automatically when it reaches the mastering position (= limit stop). In the case of A1, A2, A3 and A5, a message is displayed stating that the software limit switch was reached.

Caution!
If mastering fails, move to the pre-mastering position and perform the procedure again from the beginning.

4. Repeat steps 2 to 3 for all axes to be mastered.
   When all the axes have been mastered, message 1349 "Robot mastered" is displayed.
5. If A3 or A4 has been mastered: remove the screw from A4 and screw it back in place under the round motor cover of A3. Reinstall the round motor cover on A3.
   If A6 has been mastered: remove the mastering plate from the tool flange.

10.3.4 Unmastering axes on KR 5 sixx

Description

The mastering values of the individual axes can be deleted. The axes do not move during unmastering.

If the values for A5 are deleted, the values for A6 are also deleted automatically. This is because A5 is mechanically coupled to A6 in the robot model KR 5 sixx.

Warning!
The software limit switches of an unmastered robot are deactivated. The robot is able to hit the end stops, which can result in damage. An unmastered robot must not be jogged, if at all avoidable. If it must be jogged, the jog override must be reduced as far as possible.

Precondition

- No program is selected.

Procedure

1. Select the menu sequence **Setup** > **Unmaster**. A window opens.
2. Select the axis to be unmastered.
3. Press **UnMaster**. The mastering data of the axis are deleted.
4. Exit the window by means of **Close**.

11 Repair

No repair work is planned for the robot. For further information, please contact your local KUKA Roboter Group subsidiary.

(>>> 15 "KUKA Service" page 109)

The motors may only be removed and installed from the robots after appropriate training at KUKA College.

The toothed belts may only be removed and installed from the robots after appropriate training at KUKA College.

12 Electrical installations

12.1 Description of the electrical installations (robot)

Overview

The electrical installations of the robot consist of:

- Cable harness
- Interface A1

Description

The electrical installations include all the supply and control cables for the motors of axes 1 to 6. All the connections on the motors are plug-and-socket connections. All the cabling is routed internally in the robot in such a way as to minimize wear on the cables. The cable harness is fitted, in places, with flexible tubes.

The connecting cable and the lines of the energy supply system are connected to the robot via the A1 interface on the base frame.

12.2 Overview of connecting cables and interfaces

Description

The connecting cables comprise all the cables for transferring energy and signals between the robot and the robot controller. A control cable and 2 compressed air lines are also provided for the internal energy supply system.

The robot is connected to the overall ground conductor system via its own ground conductor.

Interface A1

The illustration shows the connecting cable interface on the robot and the connections for the energy supply system.

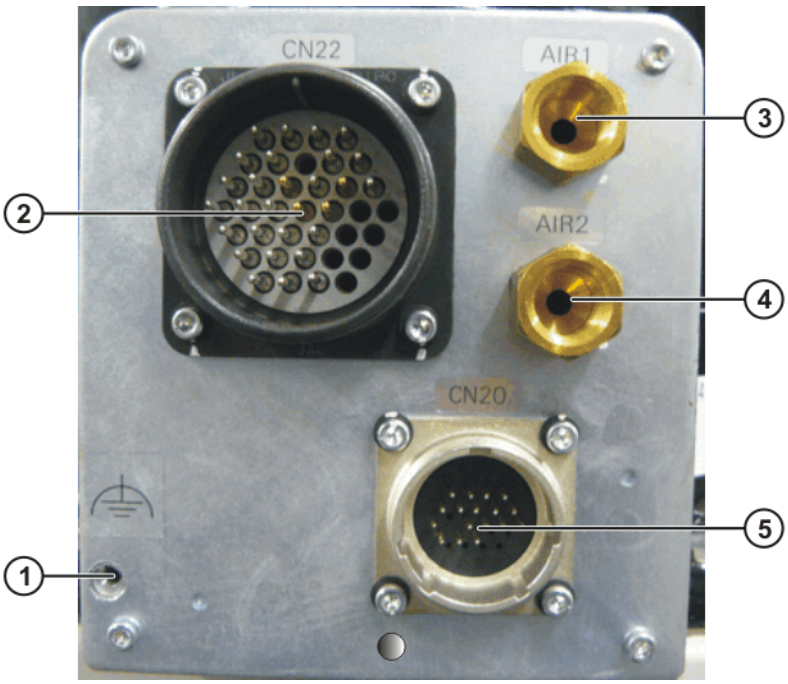


Fig. 12-1: Interface A1

1 Ground conductor connection M5
2 Motor/data cable CN22
3 Compressed air connection AIR1, PT1/4
4 Compressed air connection AIR2, PT1/4
5 Wrist I/O cable CN20

For the valve assembly with the corresponding threaded union PT1/4 or PT1/8, a universal plug-in connection with the designation KQ is required. This is supplied exclusively by SMC.

In-line wrist interface

The illustration shows the interface on the in-line wrist.

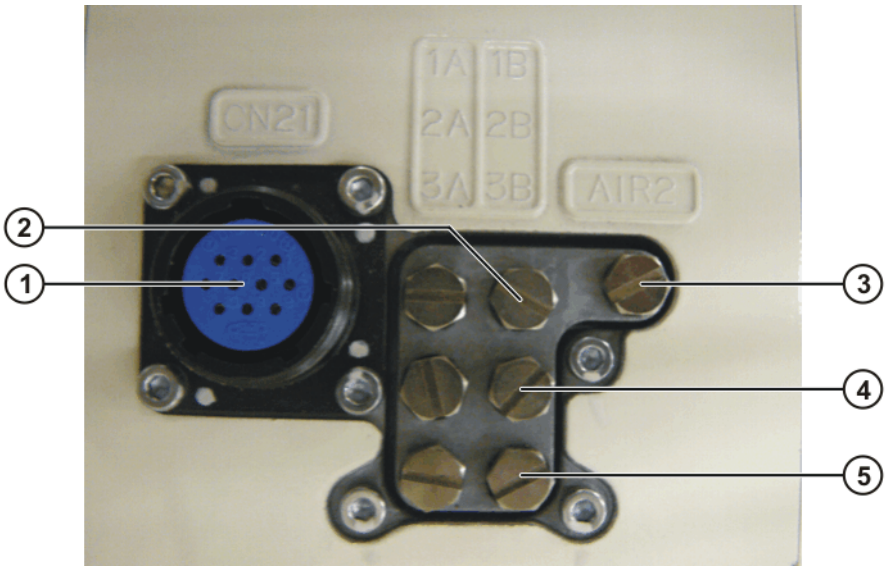


Fig. 12-2: In-line wrist interface

1	Wrist I/O cable, connector CN21	4	Valve 2, M5
2	Valve 1, M5	5	Valve 3, M5
3	Compressed air connection AIR2, M5		

For the valve assembly with the corresponding threaded union PT1/4 or PT1/8, a universal plug-in connection with the designation KQ is required. This is supplied exclusively by SMC.

The angled connectors can break off if subjected to excessive strain. It is recommended that the angled connectors are fastened to a strain relief device.

12.3 Description of the connecting cables

Configuration

The connecting cables are used to transfer power and signals between the robot controller and the robot.

The connecting cables include:

- Motor/data cable
- Wrist I/O cable (optional)

The motor and data cables have a single shared connector at each end, which is connected to the A1 interface of the robot and to the robot controller. The wrist I/O cable also has plug-in connectors. All connecting cables are available in the lengths: 4 m, 6 m and 12 m.

Cable designation

The following connecting cables are available:

Cable designation	Connector designation: robot controller - robot	KUKA art. no.
Motor/data cable	X20 - CN22	00-141-794 (4 m) 00-141-800 (6 m) 00-141-801 (12 m)
Wrist I/O cable (optional)	X32 - CN20	00-145-545 (4 m) 00-145-546 (6 m) 00-145-548 (12 m)

The ground conductor is not included in the scope of supply of the robot. The ground conductor is connected via a cable lug (2.5) to the A1 interface.

Bypack connector

The bypack connector serves as an adapter for the interface on the arm. Using the bypack connector, the energy supply system can be connected to the connection bracket.

Connector designation	KUKA art. no.
CN21	00-144-904

The bypack connector is included in the scope of supply of the robot.

12.4 Connector pin allocation

Connector pin allocation: motor/ data cable

The following tables show the connector pin allocation of the motor/data cable with connector X20 on the robot controller and connector CN22 on the robot.

Only those pins actually connected according to the wiring diagram (>>> Fig. 12-5) are assigned.

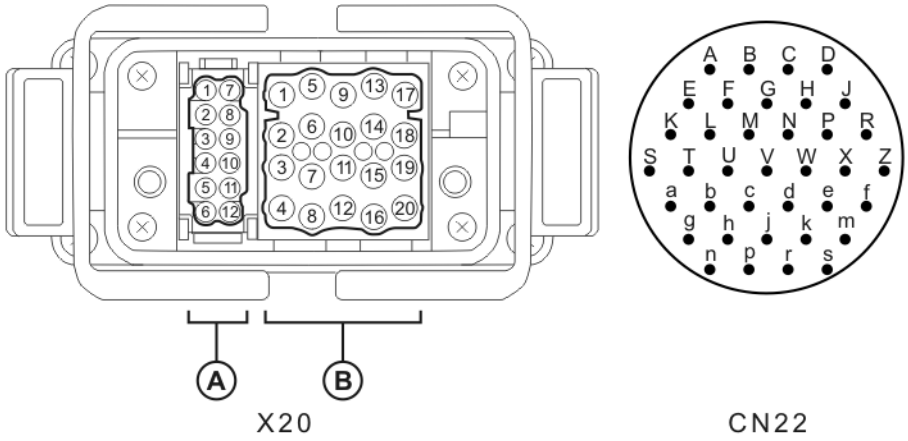


Fig. 12-3: Connector X20 - CN22

Connector X20 A	Connector CN22	Signal	Description
Pin 1	Pin P	+24 V	24 V DC
Pin 2	Pin W	0V_24	0 V
Pin 3	Pin U	DNC-B3	Brake 3
Pin 4	Pin b	DNC-B4	Brake 4
Pin 5	Pin F	DNC-B5	Brake 5
Pin 6	Pin L	DNC-B3	Brake 6
Pin 7	Pin M	DN-ENCRX	Encoder (RX)
Pin 8	Pin V	DN-ENCRXR	Encoder (RXR)

Connector X20 A	Connector CN22	Signal	Description
Pin 9	Pin e	LED_H	Spare
Pin 10	Pin f	LED_R	Spare
Pin 11	Pin c	DNC-B1	Brake 1
Pin 12	Pin d	DNC-B2	Brake 2
Overall shield at both ends on connector housing		- - - -	- - - -

Connector X20 B	Connector CN22	Signal	Description
Pin 1	Pin j	1U	Motor A1 U
Pin 2	Pin h	2U	Motor A2 U
Pin 3	Pin H	6U	Motor A6 U
Pin 4	Pin N	DNB-GND	GND brake
Pin 5	Pin r	1V	Motor A1 V
Pin 6	Pin n	2V	Motor A2 V
Pin 7	Pin J	6V	Motor A6 V
Pin 8	Pin G	DNC-B_EMG	Spare
Pin 9	Pin p	1W	Motor A1 W
Pin 10	Pin g	2W	Motor A2 W
Pin 11	Pin R	6W	Motor A6 W
Pin 12	Pin a	3U	Motor A3 U
Pin 13	Pin K	4U	Motor A4 U
Pin 14	Pin E	4V	Motor A4 V
Pin 15	Pin B	5U	Motor A5 U
Pin 16	Pin S	3V	Motor A3 V
Pin 17	Pin A	4W	Motor A4 W
Pin 18	Pin C	5 V	Motor A5 V
Pin 19	Pin D	5W	Motor A5 W
Pin 20	Pin T	3W	Motor A3 W
- - - -	Pin s	Ground conductor	Module frame
Overall shield at both ends on connector housing		- - - -	- - - -

Connector pin allocation, wrist I/O cable

The following table represents the connector pin allocation of the wrist I/O cable with connector X32 on the robot controller and connector CN20 on the robot.

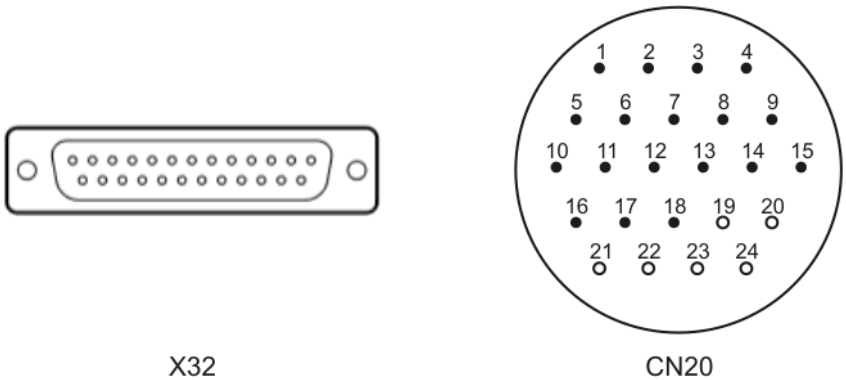


Fig. 12-4: Connector X32 - CN20

Connector X32	Connector CN20	Signal
Pin 1	Pin 13	$OUT9
Pin 2	Pin 14	$OUT11
Pin 3	Pin 15	$OUT13
Pin 4	Pin 16	$OUT15
Pin 5	Pin 3	$IN9
Pin 6	Pin 4	$IN11
Pin 7	Pin 5	$IN13
Pin 8	Pin 12	0 V internal
Pin 9	Pin 2	0 V internal
Pin 10	Pin 11	Spare
Pin 11	N. C.	N. C.
Pin 12	N. C.	N. C.
Pin 13	N. C.	N. C.
Pin 14	Pin 17	$OUT10
Pin 15	Pin 18	$OUT12
Pin 16	Pin 6	$OUT14
Pin 17	Pin 7	$OUT16
Pin 18	Pin 8	$IN10
Pin 19	Pin 9	$IN12
Pin 20	Pin 10	$IN14
Pin 21	Pin 1	24 V internal
Pin 22	Pin 19	24 V internal
Pin 23	Pin 20	Spare
Pin 24	N. C.	N. C.
Pin 25	N. C.	N. C.

Assignment of the I/O signals in the IOSYS.INI file:

```
[SRIO]
INB0=0    ;$IN[1...8]
OUTB0=0   ;$OUT[1...7]
INB0=1    ;$IN[9...14]
OUTB0=1   ;$OUT[9...16]
```

12.5 Wiring diagrams

Wiring diagram, motor cable

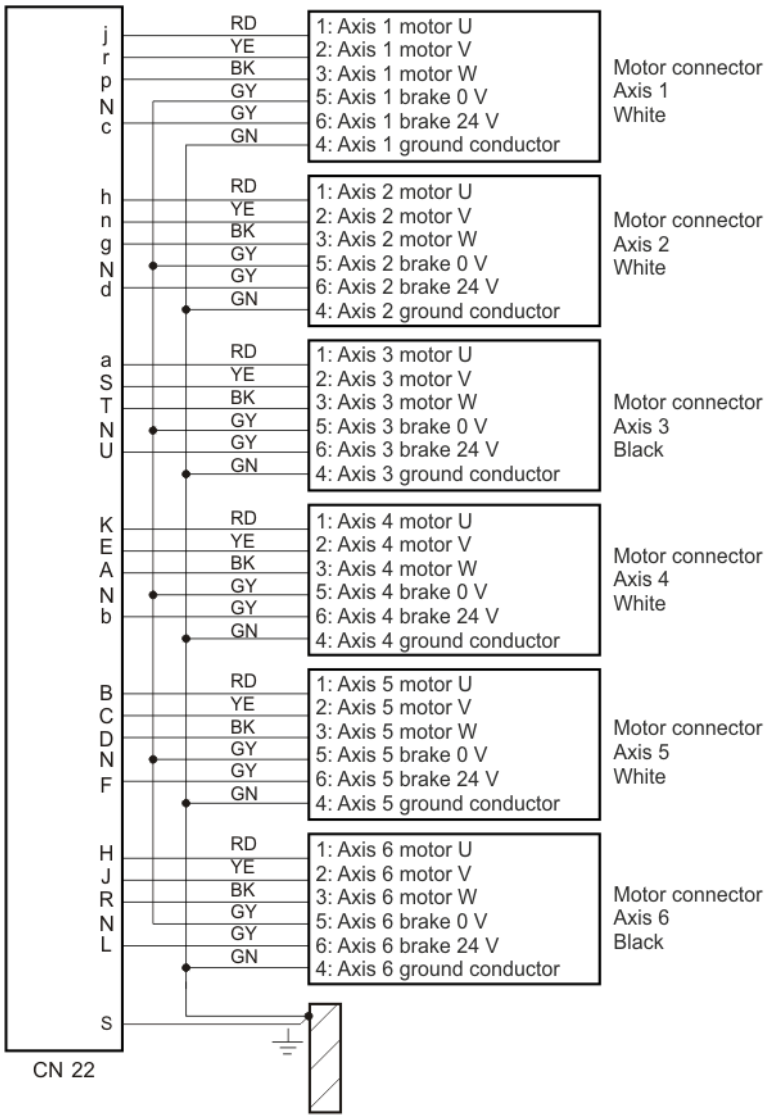


Fig. 12-5: Electrical installations: motor cable

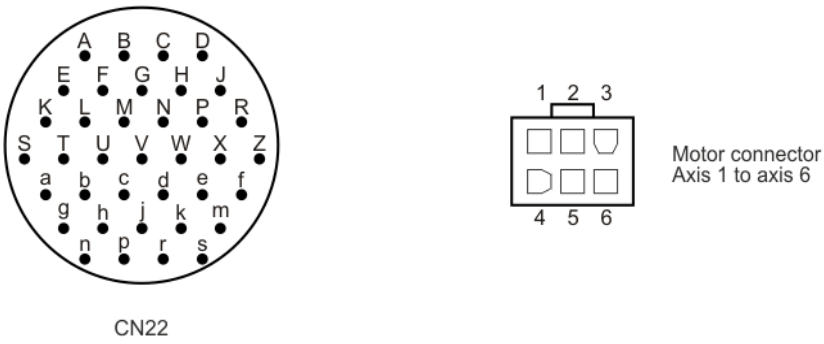


Fig. 12-6: Connector for motor cable

No brake is provided for the axis 1 motor.

Wiring diagram, data cable

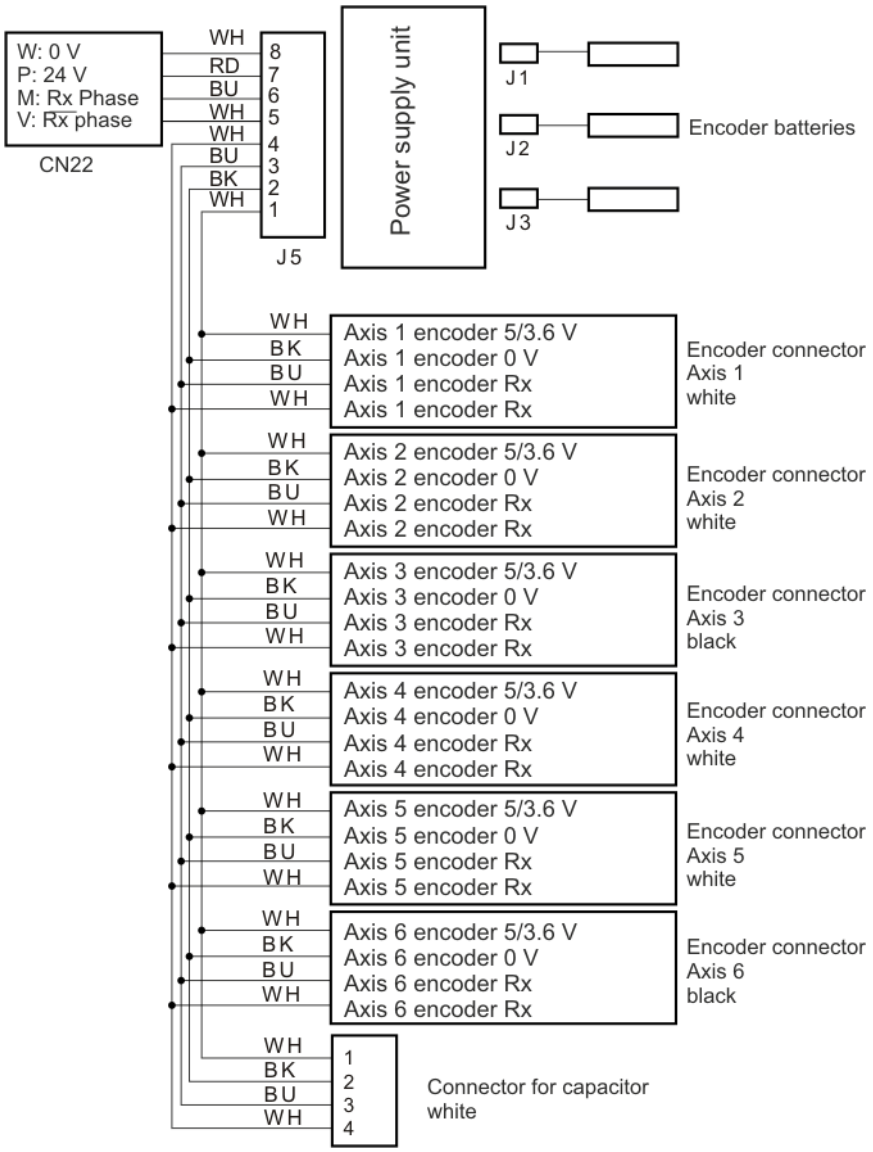


Fig. 12-7: Electrical installations: data cable

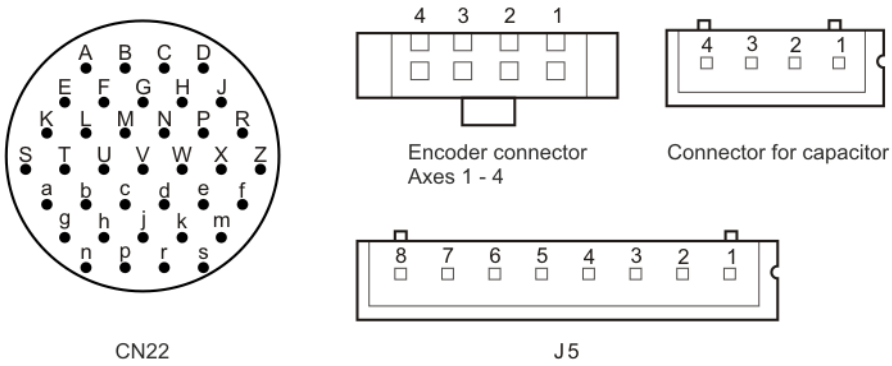


Fig. 12-8: Connectors: data cable

Wiring diagram, wrist I/O cable

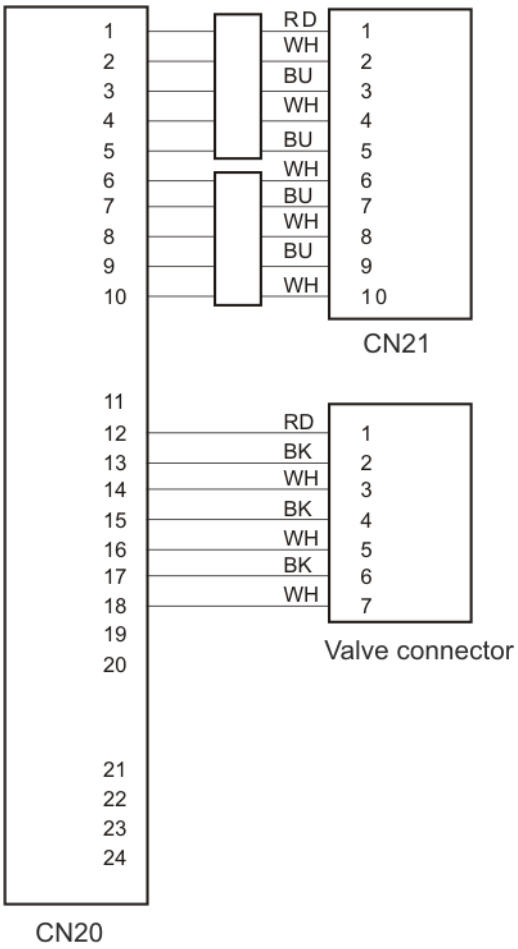


Fig. 12-9: Electrical installations: wrist I/O cable

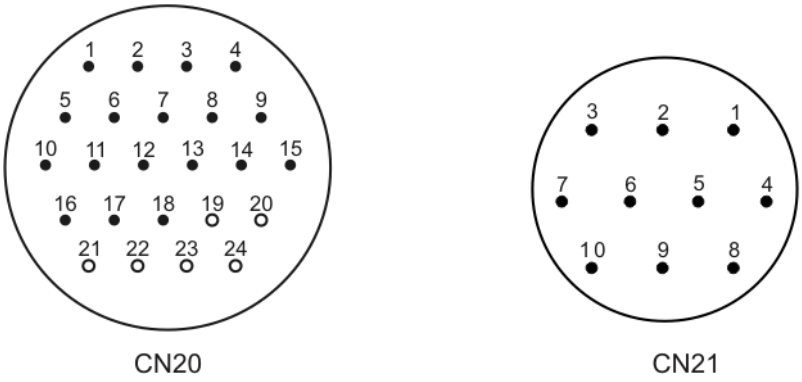


Fig. 12-10: Wrist I/O cable connectors: CN20 - CN21

Connector CN20	Connector CN21	Signal
Pin 1	Pin 1	24 V internal
Pin 2	Pin 2	0 V internal
Pin 3	Pin 3	$IN9
Pin 4	Pin 4	$IN11
Pin 5	Pin 5	$IN13
Pin 6	Pin 6	$OUT14
Pin 7	Pin 7	$OUT16
Pin 8	Pin 8	$IN10
Pin 9	Pin 9	$IN12
Pin 10	Pin 10	$IN14
Pin 11	N. C.	N. C.

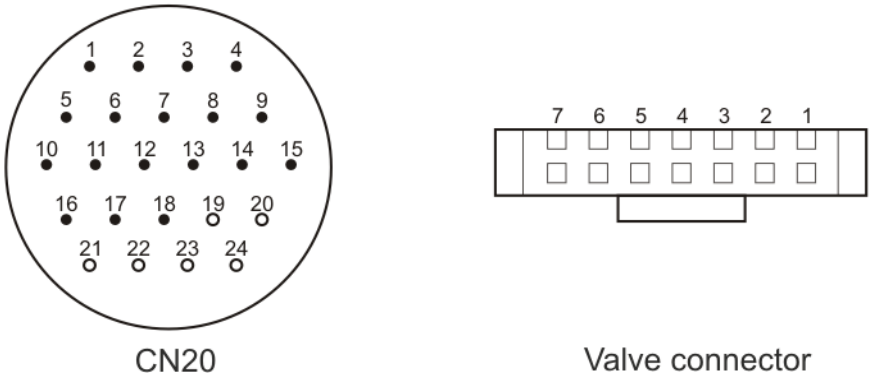


Fig. 12-11: Wrist I/O cable connectors: CN20 - valve connector

Connector CN20	Valve connector	Signal	Description
Pin 12	Pin 1	0 V internal	0 V internal
Pin 13	Pin 2	$OUT9	Valve 1 - position A
Pin 14	Pin 3	$OUT11	Valve 1 - position B
Pin 15	Pin 4	$OUT13	Valve 2 - position A
Pin 16	Pin 5	$OUT15	Valve 2 - position B
Pin 17	Pin 6	$OUT10	Valve 3 - position A
Pin 18	Pin 7	$OUT12	Valve 3 - position B

13 Decommissioning, storage and disposal

13.1 Decommissioning

Description

This section describes all the work required for decommissioning the robot if the robot is to be removed from the system. After decommissioning, it is prepared for storage or for transportation to a different location.

Procedure

1. Secure the robot.

Warning!
Unintentional robot motions can cause injuries and damage to property. If work is carried out on an operational robot, the robot must be secured by activating the EMERGENCY STOP button.
Warn all persons concerned before starting to put it back into operation.

2. Remove tools and equipment.
3. Put the robot into operation and move it into the transport position (>>> Fig. 7-1).
4. Secure the robot again.
5. Switch the robot controller off.
6. Cut off the compressed air supply to the robot.
7. Release and unplug the motor/data cable connector CN22 (>>> Fig. 13-1).
8. Release and unplug the wrist I/O cable connector CN20.
9. Release and unplug compressed air lines.
10. Unscrew the hexagon nuts.
11. Pull off the washers, lock washers and ground conductors.
12. Seal all cable and hose connections.
13. Protect the connectors and hose lines against fouling.
14. Screw eyebolts into both sides of the base frame.
15. Remove 4 hexagon bolts together with conical spring washers.

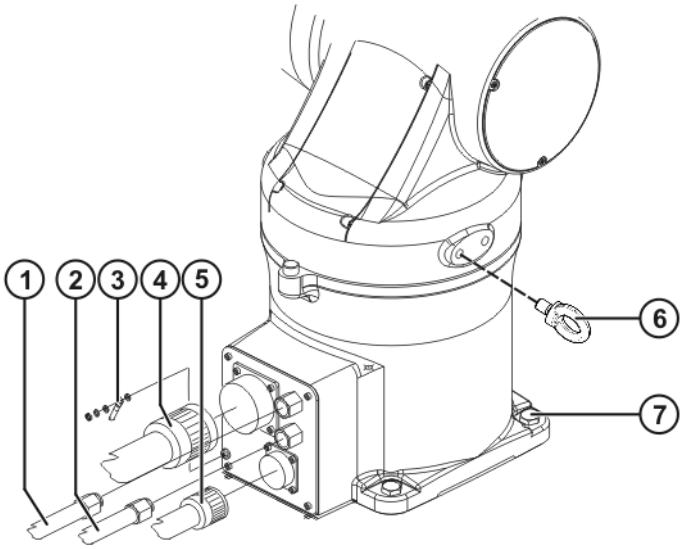


Fig. 13-1: Interface, axis 1, floor

1	Compressed air line	5	Wrist I/O cable
2	Compressed air line	6	Eyebolt

3	Grd. conductor	7	Hexagon bolt
4	Motor/data cable		

16. Attach the lifting tackle (>>> Fig. 13-2).
17. Lift the robot using a crane and transport it away.

Caution!
If the robot is caught on the mounting surface, it may come free abruptly, endangering persons and property.
The robot must stand loosely on the mounting surface; completely remove all fastening materials and any adhesives.

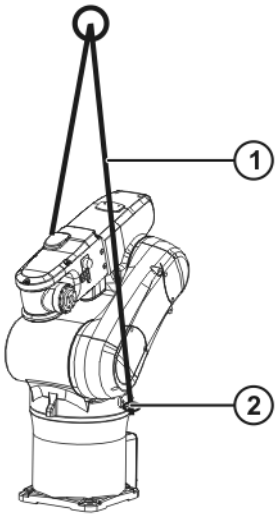


Fig. 13-2: Transporting the robot

1	Lifting tackle
2	Eyebolt

18. Prepare the robot for storage (>>> 13.2 "Storage" page 100). If the robot is placed on a pallet for onward transportation, secure the robot to the pallet with 4 M10 screws.

13.2 Storage

Description

If the robot is to be put into long-term storage, the following points must be observed:

- The place of storage must be as dry and dust-free as possible.
- Avoid temperature fluctuations.
- Avoid wind and drafts.
- Avoid condensation.
- Use appropriate coverings that cannot detach themselves and which can withstand the expected environmental conditions.
- Do not leave any loose parts on the robot, especially ones that might knock against other parts.
- Do not leave the robot exposed to direct sunlight while in storage.
- Observe and comply with the permissible temperature ranges for storage.
- Select a storage location in which the packaging materials cannot be damaged.

Procedure

1. Remove the robot.
2. Remove tools and equipment.

3. Clean and dry the robot. No dirt or cleaning agents may remain on or in the robot.
4. Inspect the robot, both internally and externally.
5. Remove any foreign bodies.
6. Remove any corrosion.
7. Attach all covers to the robot and check that the seals are correctly in place.
8. Seal off electrical connections with suitable covers.
9. Seal hose connections by suitable means.
10. Cover the robot with plastic film and seal it at the base frame against dust.
    If necessary, add a desiccant beneath the film.

13.3 Disposal

When the robot reaches the end of its useful life, it can be removed from the system and dismantled, and the materials can be disposed of properly by type.

The following table provides an overview of the materials used in the robot. All plastic components are marked with a material designation and must be disposed of accordingly.

Material, designation	Subassembly, component	Note
Cast aluminum	Rotating column, arm, link arm, wrist	
Cast steel	Base frame	
ABS	Panels, covers	
Steel	Gear units, screws and washers	
	Motors	Dispose of motors without dismantling them.
PUR	Cable sheaths	
ETFE	Flexible tube	
Copper	Cables, wires	
PU	Hoses	
Cable grease	Cabling	See safety data sheet, consumables
Gear grease, oil	Gear unit	See safety data sheet, consumables
PA	Hinged clamps	
NBR	O-rings, shaft seals	
Lithium battery	Back-up batteries	Must be disposed of as hazardous waste.

14 Appendix

14.1 Mechanical axis range limitation on axis 1, dimensioned drawings

Plate

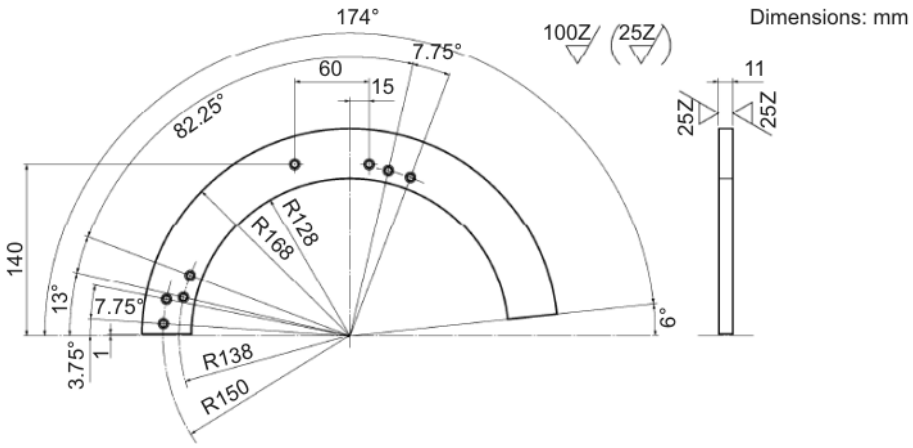


Fig. 14-1: Plate, dimensioned drawing

Fastening block A

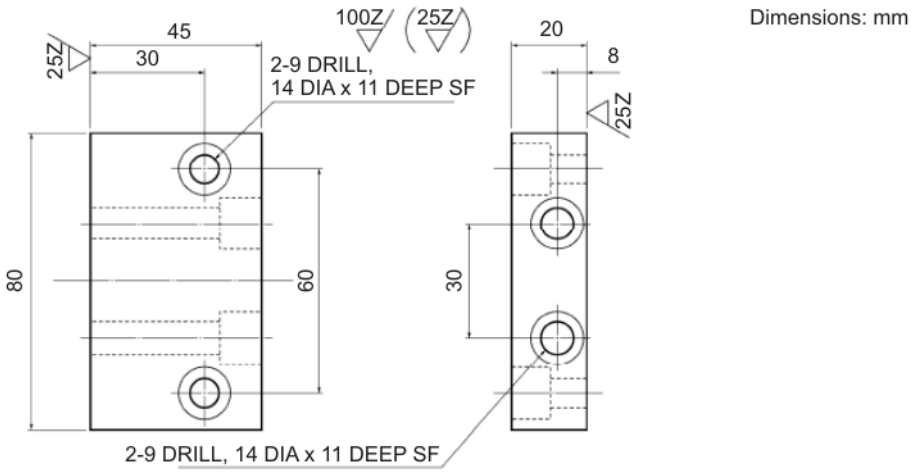


Fig. 14-2: Fastening block A, dimensioned drawing

Fastening block B

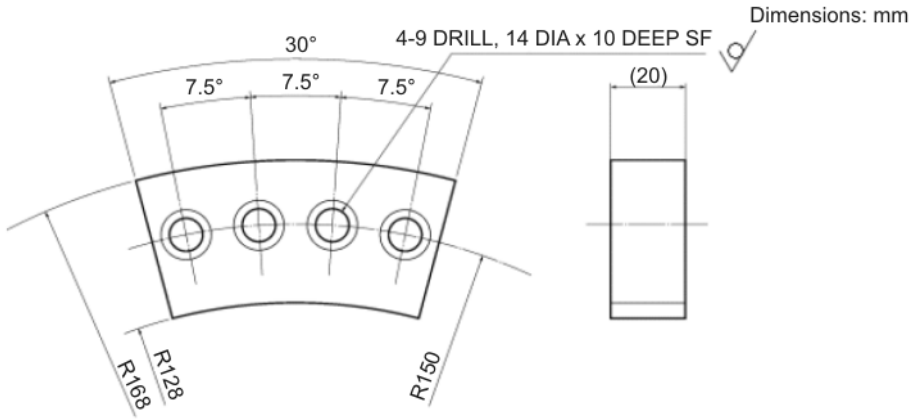


Fig. 14-3: Fastening block B, dimensioned drawing

Stop

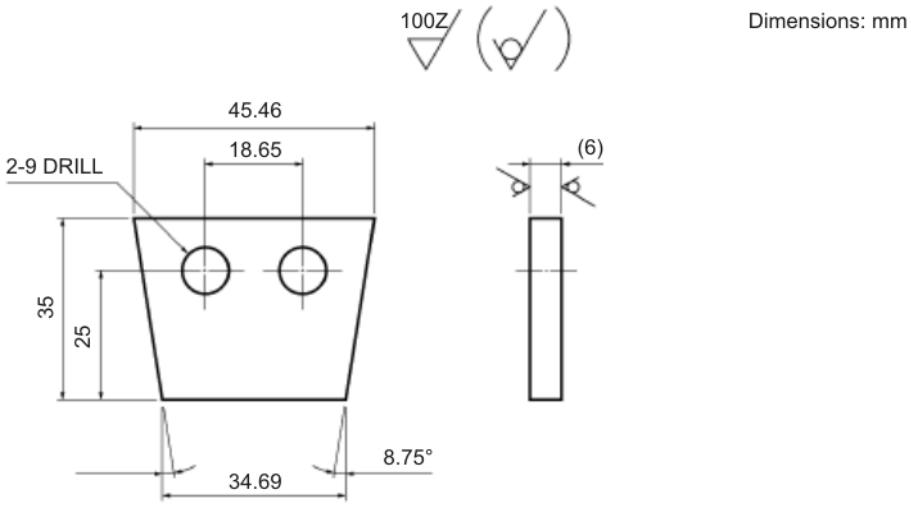


Fig. 14-4: Mechanical stop, dimensioned drawing

14.2 Mechanical axis range limitation on axis 2, dimensioned drawings

Stop

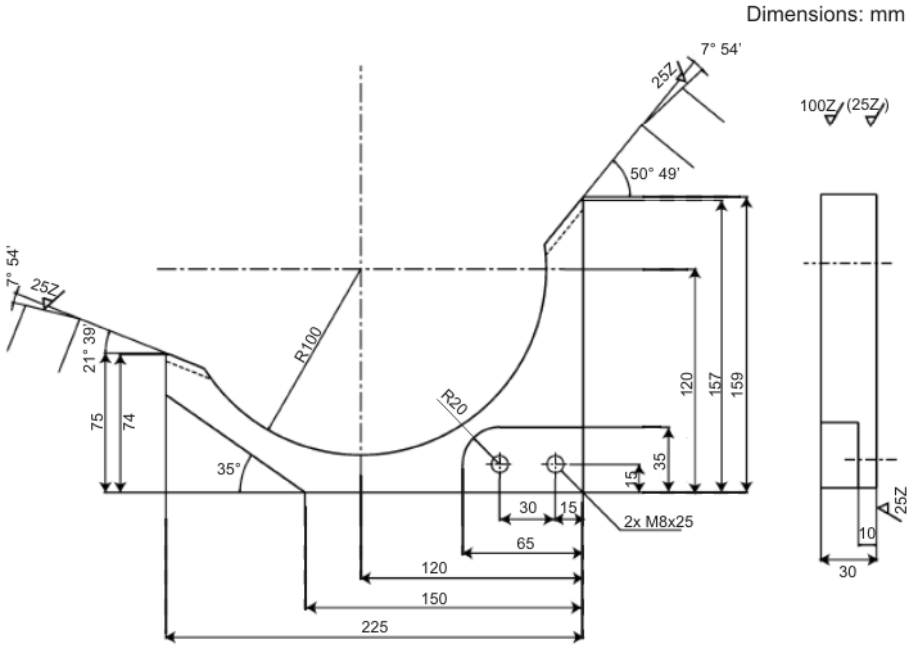


Fig. 14-5: Mechanical stop, dimensioned drawing

14.3 KR 5 sixx R650: mechanical axis range limitation on axis 3, dimensioned drawings

Stop

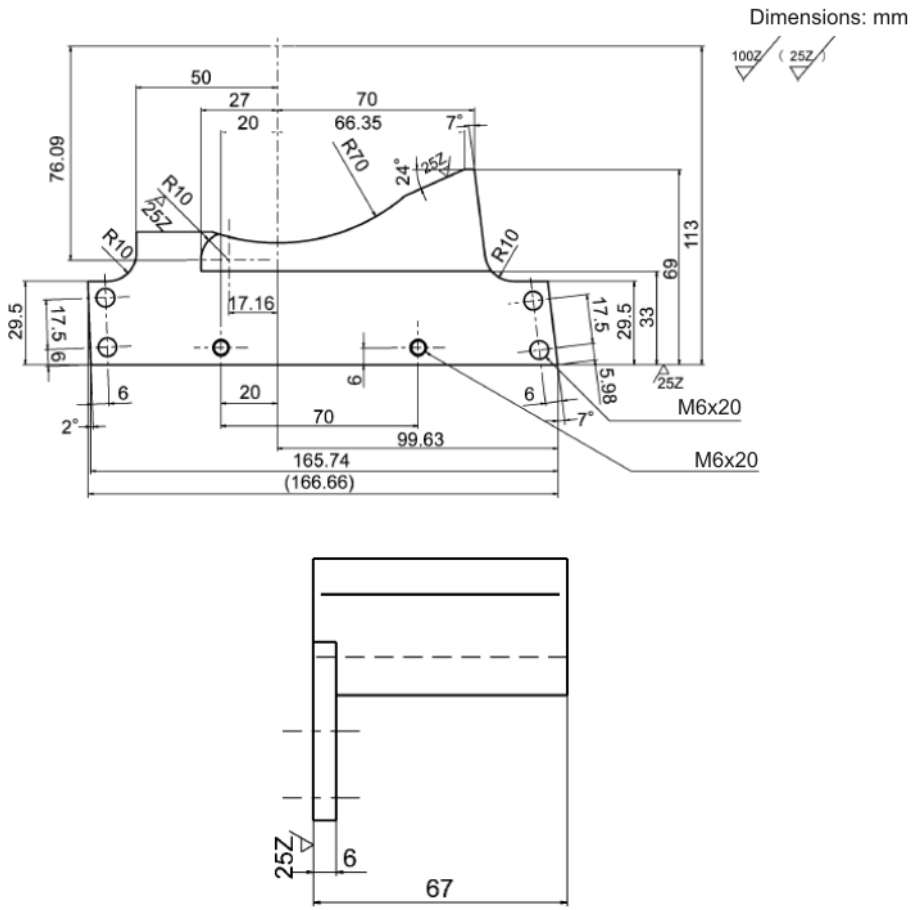


Fig. 14-6: Mechanical stop, dimensioned drawing

Spacer

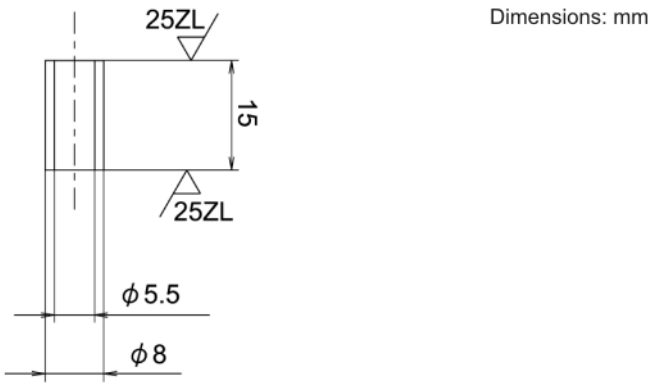


Fig. 14-7: Spacer, dimensioned drawing

Holder for stop

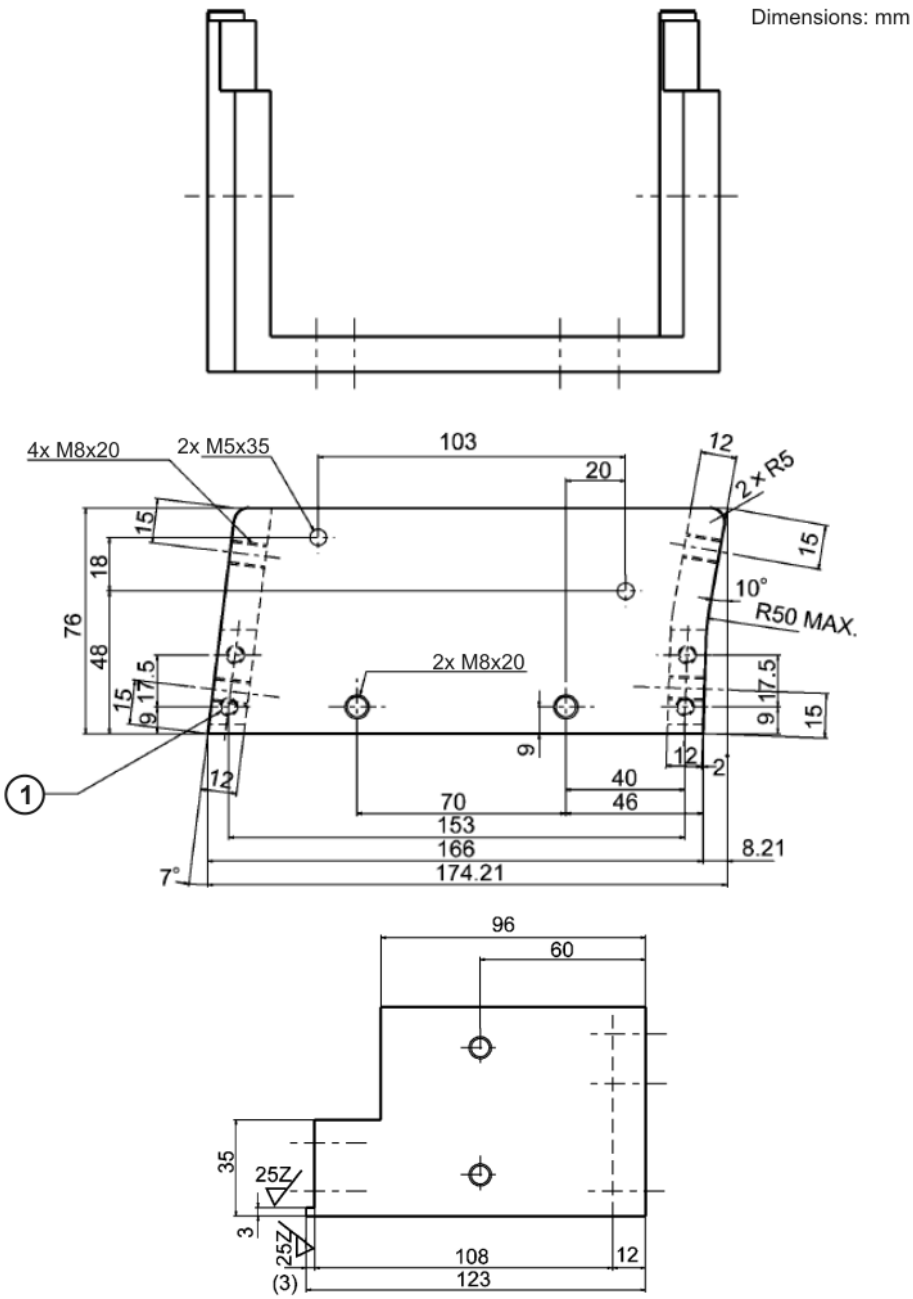


Fig. 14-8: Holder for stop, dimensioned drawing

14.4 KR 5 sixx R850: mechanical axis range limitation on axis 3, dimensioned drawings

Stop

Dimensions: mm

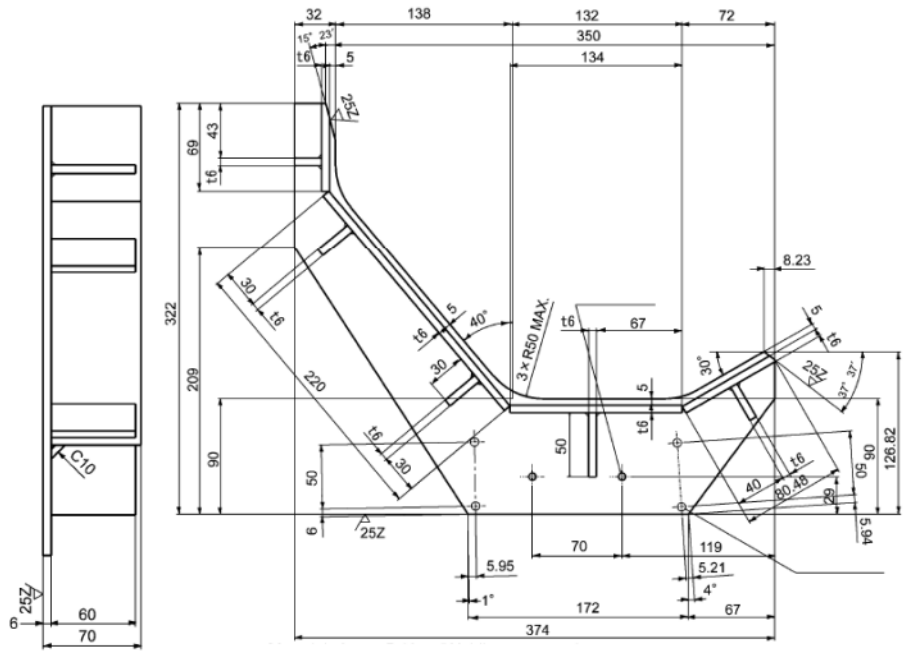


Fig. 14-9: Mechanical stop, dimensioned drawing

Spacer

Dimensions: mm

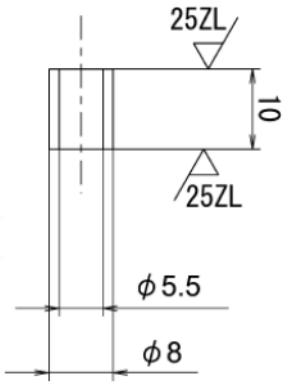


Fig. 14-10: Spacer, dimensioned drawing

Holder for stop

Dimensions: mm

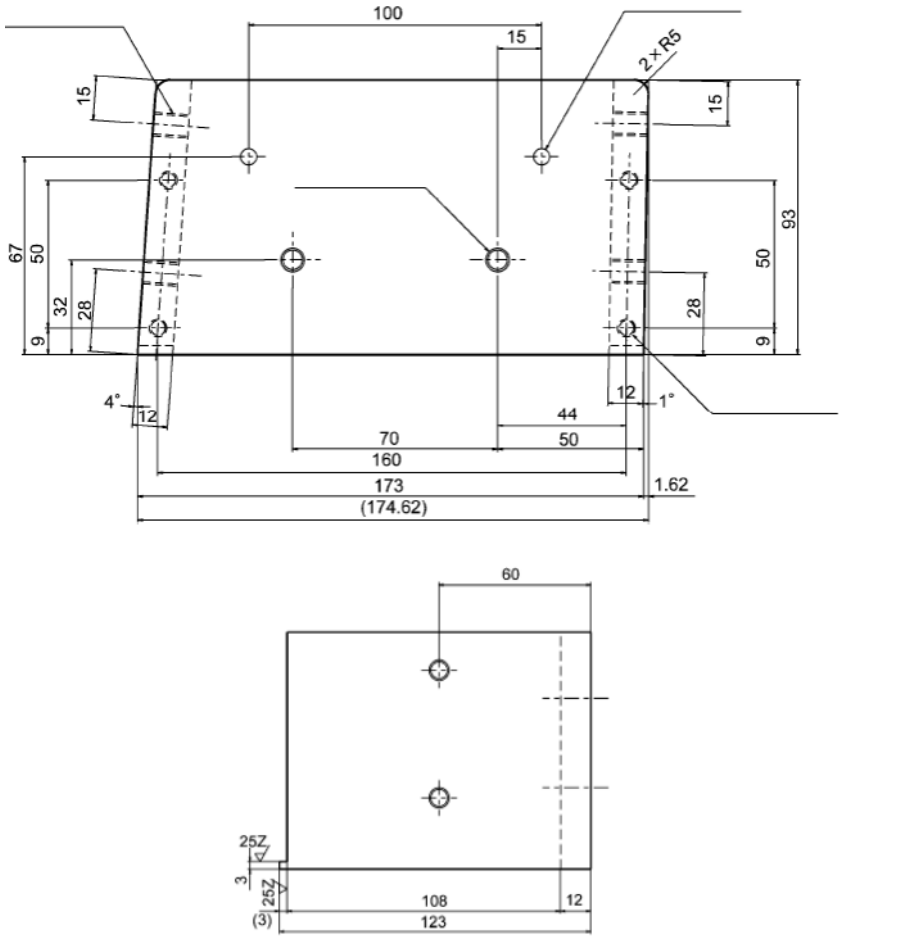


Fig. 14-11: Holder for stop, dimensioned drawing

15 KUKA Service

15.1 Requesting support

Introduction

The KUKA Roboter GmbH documentation offers information on operation and provides assistance with troubleshooting. For further assistance, please contact your local KUKA subsidiary.

Faults leading to production downtime should be reported to the local KUKA subsidiary within one hour of their occurrence.

Information

The following information is required for processing a support request:

- Model and serial number of the robot
- Model and serial number of the controller
- Model and serial number of the linear unit (if applicable)
- Version of the KUKA System Software
- Optional software or modifications
- Archive of the software
- Application used
- Any external axes used
- Description of the problem, duration and frequency of the fault

15.2 KUKA Customer Support

Availability

KUKA Customer Support is available in many countries. Please do not hesitate to contact us if you have any questions.

Argentina

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