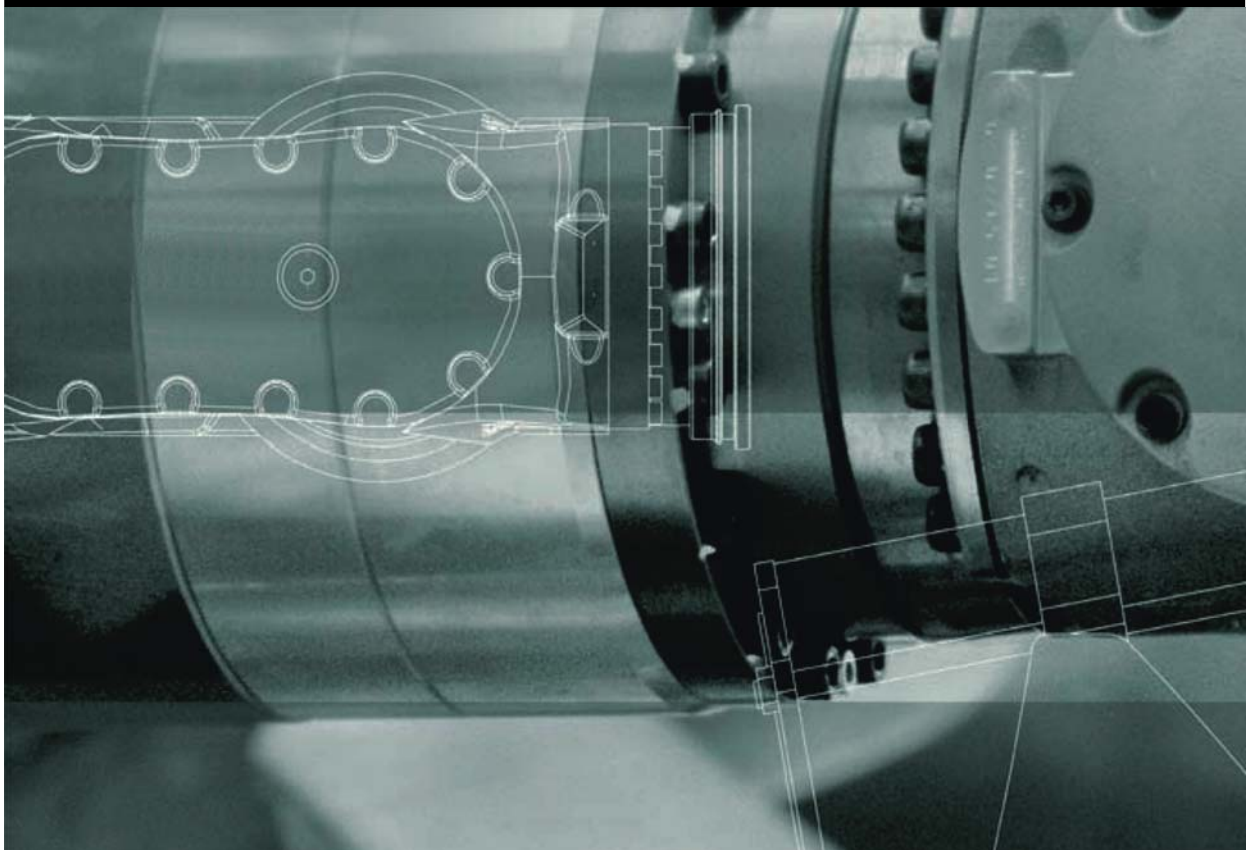


Lightweight Robot 4

Specification



Issued: 16.09.2009

Version: Spez LBR 4 V3 en



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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 operating instructions

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1 Product description

1.1 Description of the robot system

The robot system consists of the following components:

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

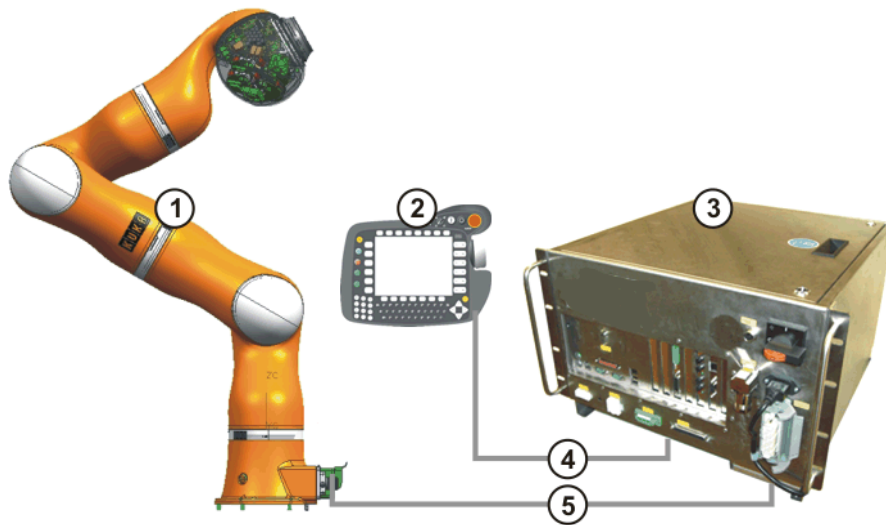


Fig. 1-1: Example of a robot system

- | | |
|--------------------|--------------------------|
| 1 Robot | 4 Connecting cable/KCP |
| 2 Teach pendant | 5 Connecting cable/robot |
| 3 Robot controller | |

1.2 LWR 4 robot

Overview

The robot is a 7-axis jointed-arm robot. All motor units and current-carrying cables are protected beneath screwed-on cover plates.

Each joint is equipped with a position sensor on the input side and position and torque sensors on the output side. The robot can thus be operated with position, velocity and torque control.

The robot consists of the following principal components:

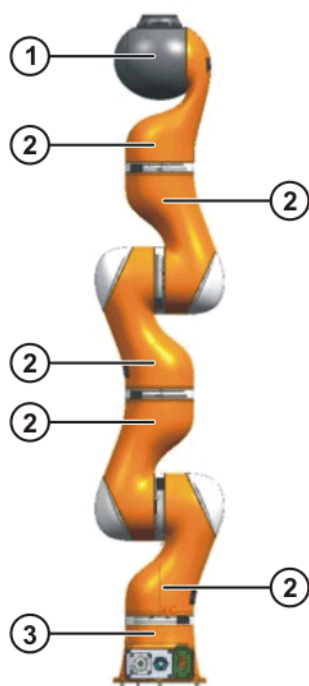


Fig. 1-2: Principal components

- 1 In-line wrist
- 2 Joint module
- 3 Base frame

In-line wrist

The robot is fitted with a 2-axis in-line wrist. The motors are located in axes A5 and A6. The mounting flange and power supply cables are situated on the output side of axis A6.

Joint module

The joint modules consist of a CRP structure. The drive units are situated inside these modules. In this way, the drive units are linked to one another via the CRP structures.

Base frame

The base frame is the base of the robot.

2 Technical data

2.1 Designated use of the robot system

The robot system is designed exclusively for the specified applications.



Further information is contained in the technical data of the operating instructions for the robot system and its options.

Using the system 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 robot system and its options within the limits of its designated use also involves continuous observance of the operating instructions with particular reference to the maintenance specifications.

Impermissible misuse

Any use or application deviating from the designated 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

2.2 Basic data

Basic data

Type	Lightweight Robot LWR 4
Number of axes	7
Volume of working envelope	1.84 m ³
Repeatability (ISO 9283)	±0.05 mm
Working envelope reference point	Intersection of axes A4 and A5
Weight	approx. 16 kg
Protection classification of the robot	IP 20 ready for operation, with connecting cables plugged in (according to EN 60529)
Protection classification of the in-line wrist	IP 20
Sound level	< 75 dB (A) outside the working envelope
Mounting position	any
Surface finish, paintwork	Aluminum: silver; paintwork: orange; base frame enclosure: orange

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 length: 7 m

The connecting cable incorporates the power supply/data cable. The following connector designations and connections are used:

Cable designation	Connector designation	Robot controller - Robot
Motor/data cable	X20 - X30	Harting connector - Harting connector

2.3 Axis data**Axis data**

Axis	Range of motion, software-limited	Velocity without payload
A1 (J1)	+/-170°	112.5 °/s
A2 (J2)	+/-120°	112.5 °/s
E1 (J3)	+/-170°	112.5 °/s
A3 (J4)	+/-120°	112.5 °/s
A4 (J5)	+/-170°	180.0 °/s
A5 (J6)	+/-120°	112.5 °/s
A6 (J7)	+/-170°	112.5 °/s

Maximum torques

Axis	Maximum torque
A1 (J1)	200 Nm
A2 (J2)	200 Nm
E1 (J3)	100 Nm
A3 (J4)	100 Nm
A4 (J5)	100 Nm

Axis	Maximum torque
A5 (J6)	30 Nm
A6 (J7)	30 Nm

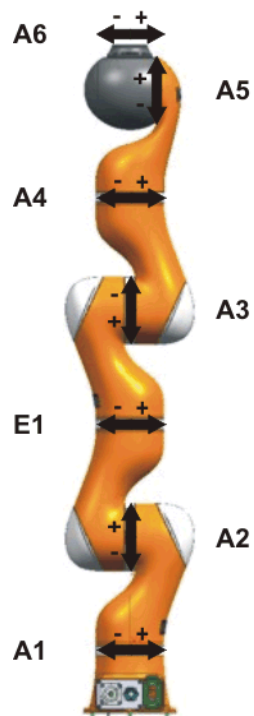


Fig. 2-1: Robot axes

Working envelope

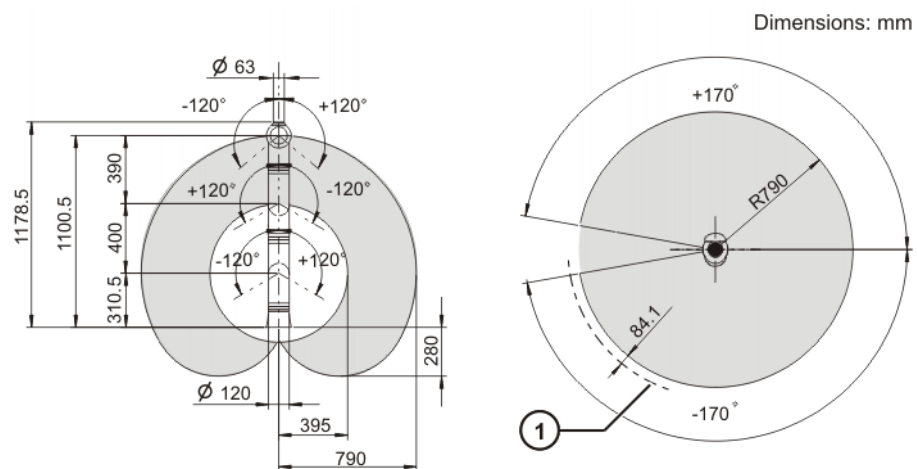


Fig. 2-2: Working envelope

1 Interference radius

2.4 Payloads

Payloads

Robot	LWR
In-line wrist	IW
Rated payload	7 kg
	Higher payloads only after consultation with KUKA Roboter GmbH

Distance of the load center of gravity L_x	20 mm
Distance of the load center of gravity L_y	0 mm
Distance of the load center of gravity L_z	100 mm

For all payloads, the load center of gravity refers to the distance from the face of the mounting flange on axis A6 (J7).



Once the tool has been mounted on the flange, the torque sensor of axis A6 (J7) must be recalibrated.

Payload diagram

Permissible mass inertia at the design point (L_x , L_y , L_z) is 0.21 kgm^2 .

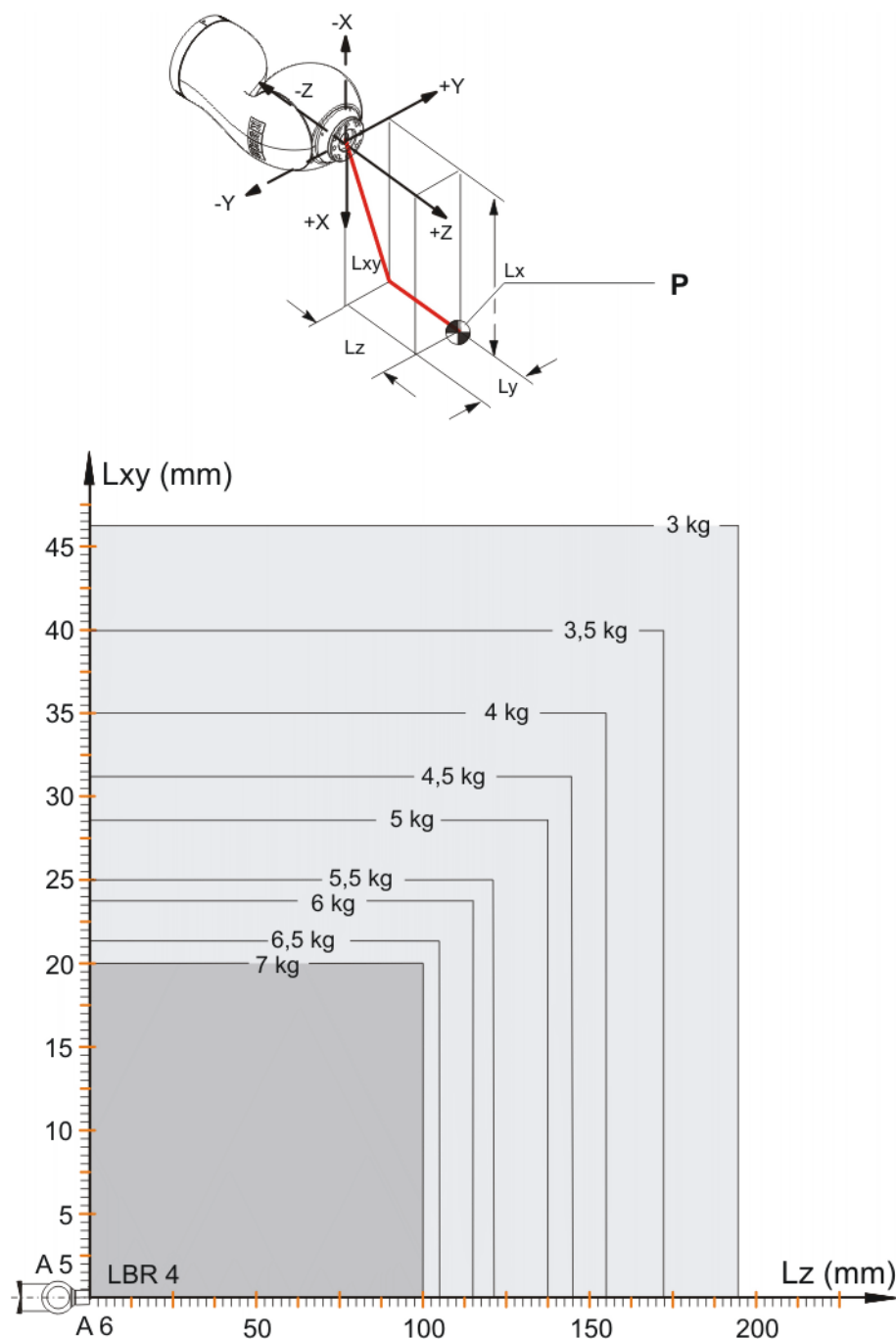
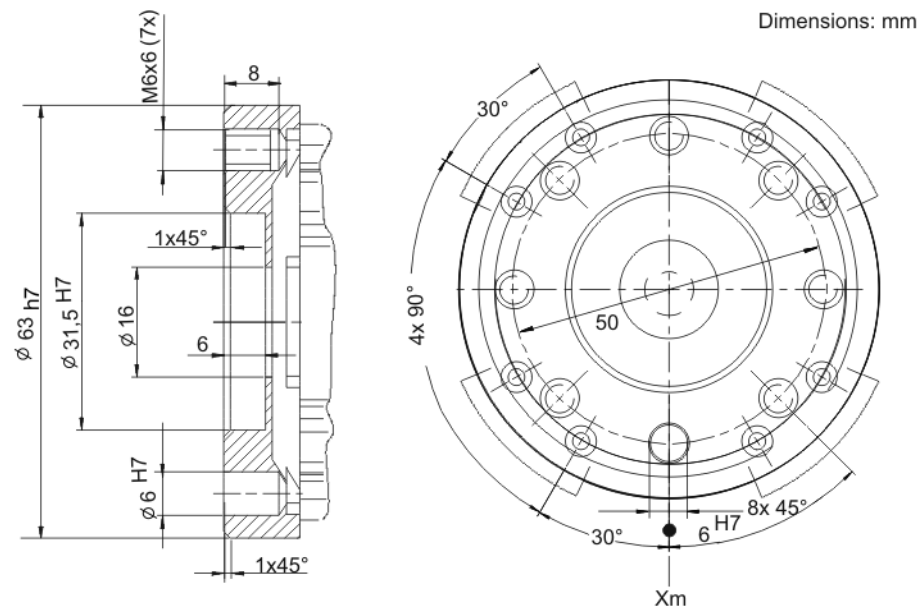


Fig. 2-3: Payload diagram



The mass inertia must be verified using KUKA.Load. It is imperative for the load data to be entered in the robot controller!

Mounting flange	DIN ISO 9409-1-A50
Strength class	10.9
Screw size	4 x DIN6912-M6
Depth of engagement	5 mm
Locating element	6 ^{H7}



The robot cannot carry supplementary loads.

2.5 Loads acting on the mounting base

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

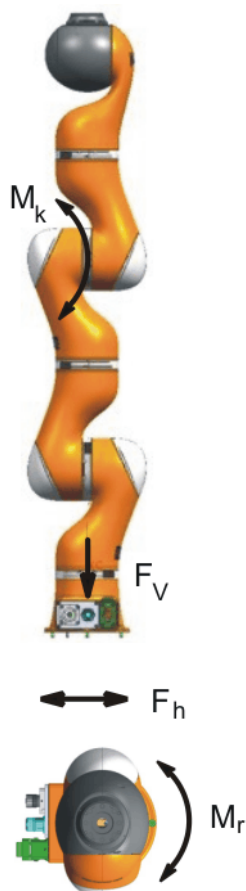


Fig. 2-5: Loads acting on the mounting base

Type of load	Force/torque/mass
F_v = vertical force	$F_{vmax} = 396 \text{ N}$
F_h = horizontal force	$F_{hmax} = 215 \text{ N}$
M_k = tilting moment	$M_{kmax} = 306 \text{ Nm}$
M_r = torque	$M_{rmax} = 204 \text{ Nm}$
Total mass for load acting on the mounting base	22 kg
Robot	approx. 16 kg
Total load (rated payload)	7 kg

3 Safety

3.1 General

3.1.1 Liability

The device described in these operating instructions is an industrial robot – called “robot system” in the following text – consisting of:

- Robot
- Connecting cables
- Robot controller
- Teach pendant

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

The robot system may only be used in perfect technical condition in accordance with its designated use and only by safety-conscious persons who are fully aware of the risks involved in its operation. Use of the robot system is subject to compliance with these operating instructions and with the declaration of incorporation supplied together with the robot system. Any functional disorders affecting the safety of the system 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 robot system will not cause personal injuries or material damage.

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

In addition to the Safety chapter, the operating instructions contain further safety instructions. These must be observed.

3.1.2 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.

3.1.3 Designated use of the robot system

The robot system is designed exclusively for the specified applications.



Further information is contained in the technical data of the operating instructions for the robot system and its options.

Using the system 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 robot system and its options within the limits of its designated use also involves continuous observance of the operating instructions with particular reference to the maintenance specifications.

Impermissible misuse

Any use or application deviating from the designated 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

3.1.4 EC declaration of conformity and declaration of incorporation

This robot system is a partial or incomplete machine as defined by the EC Machinery Directive. The robot system may only be put into operation if the following preconditions are met:

- The robot system is integrated into an overall system.
Or: The robot system, together with other machines, constitutes an overall system.
Or: All safety equipment and safeguards required for operation in the overall system as defined by the EC Machinery Directive have been added to the robot system.
- The overall 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 overall system in accordance with the Machinery Directive. The declaration of conformity forms the basis for the CE mark for the system. The robot system 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

A declaration of incorporation is provided for the robot system. This declaration of incorporation contains the stipulation that the robot system must not be commissioned until it complies with the provisions of the Machinery Directive.

3.1.5 Terms used

Term	Description
Axis range	Range of each axis, in degrees, within which it may move. The axis range must be defined for each axis that is to be monitored.
Stopping distance	- Stopping distance = reaction distance + braking distance - The stopping distance is part of the danger zone. - The braking distance is the distance covered by the robot and any optional external axes after the stop function has been triggered and before the robot comes to a standstill.
Workspace	The robot is allowed to move within its workspace. The workspace is derived from the individual axis ranges.
Operator (User)	The user of the robot system can be the management, employer or delegated person responsible for use of the robot system.
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 robot system.
Robot system	The robot system consists of the robot controller and robot, together with any options.
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 robot and any external axes (optional) perform path-oriented braking. Note: This stop category is called STOP 0 in this document.
Stop category 1	The robot and any external axes (optional) brake with 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 robot 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 robot system into a plant 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 robot but which is controlled using the robot controller, e.g. KUKA linear unit, two-axis positioner, Posiflex. In the LWR, axis 3 is defined as external axis E1.

3.2 Personnel

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

- User
- Personnel



All persons working with the robot system must have read and understood the robot system 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
 - Operator
 - Cleaning personnel



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

System integrator

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

The system integrator is responsible for the following tasks:

- Installing the robot system
- Connecting the robot system
- Performing risk assessment
- Operating the required safety equipment and safeguards
- Issuing the declaration of conformity
- Attaching the CE mark
- Creating the operating instructions for the overall system

Operator

The operator must meet the following preconditions:

- The operator must be trained for the work to be carried out.
- Work on the robot system 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 dangers.

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 robot		x	x
Configuration		x	x
Programming		x	x
Start-up			x
Maintenance			x

Tasks	Operator	Programmer	System integrator
Repair			x
Shutting down			x
Transportation			x



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

3.3 Safety equipment and safeguards in the robot system

3.3.1 Overview of the safety equipment and safeguards

The following safety equipment and safeguards are present in the robot system:

- Mode selector switch
(>>> 3.3.4 "Mode selector switch" page 18)
- Operator safety (= connection for interlocking fixed guards)
(>>> 3.3.7 "Operator safety" page 21)
- EMERGENCY STOP device
(>>> 3.3.8 "EMERGENCY STOP device" page 21)
- Enabling device
(>>> 3.3.9 "Enabling device" page 22)
(>>> 3.3.10 "Connection for external enabling device" page 23)
- Jog mode in the test modes
(>>> 3.3.11 "Jog mode" page 23)
- Labeling of danger areas in the robot system
(>>> 3.3.15 "Labeling on the robot system" page 25)

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



Danger!

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

3.3.2 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 robot system to a standstill.

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

The ESC safety logic monitors the following inputs:

- Operator safety
- Local EMERGENCY STOP (= EMERGENCY STOP button on the KCP)
- External EMERGENCY STOP

- Enabling device
- Drives OFF
- Drives ON
- Operating modes
- Qualifying inputs

3.3.3 Category for safety-related controller components

Safety-related controller components include:

- Local EMERGENCY STOP device (= EMERGENCY STOP button on the KCP)
- External EMERGENCY STOP device
- Enabling device
- External enabling device
- Operator safety
- Qualifying inputs
- Automatic mode
- Test mode

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

3.3.4 Mode selector switch

The robot system 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 robot and any external axes (optional) are stopped with a STOP 0.

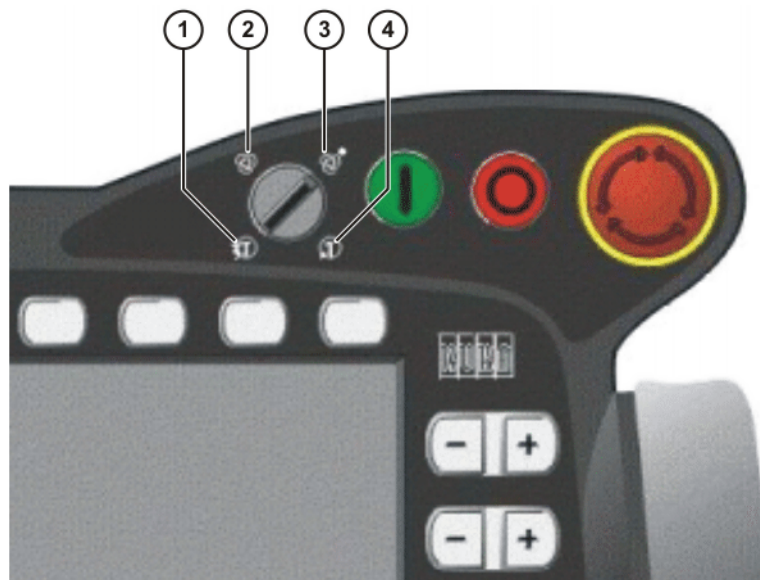


Fig. 3-1: Mode selector switch

- 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
AUT	For robot systems without higher-level controllers Only possible with a connected safety circuit	■ Program mode: Programmed velocity ■ Jog mode: not possible
AUT EXT	For robot systems with higher-level controllers, e.g. PLC Only possible with a connected safety circuit	■ Program mode: Programmed velocity ■ Jog mode: not possible

3.3.5 Stop reactions

Stop reactions of the robot system 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	-
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	STOP 0	
Power failure	STOP 0	

3.3.6 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. If a safeguard is triggered, the robot is braked and comes to a stop within the danger zone.

The danger zone consists of the workspace and the stopping distances of the robot. It must be safeguarded by means of physical safeguards to prevent danger to persons or the risk of material damage.

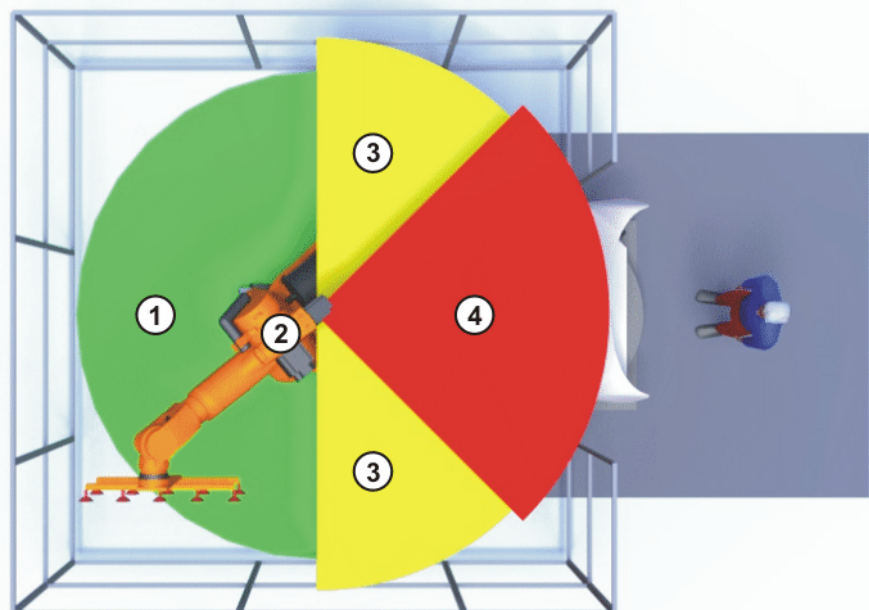


Fig. 3-2: Example of axis range A1

1	Workspace	3	Stopping distance
2	Robot	4	Safety zone

3.3.7 Operator safety

The operator safety input is used for interlocking fixed guards. 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 drives are deactivated after 1 s and the robot and any external axes (optional) are stopped with a STOP 1. When the signal is applied again at the input (e.g. safety gate closed), Automatic operation can be resumed once the corresponding message has been acknowledged.



The operator safety must be designed in such a way that it is only possible to acknowledge the message from outside.

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

3.3.8 EMERGENCY STOP device

The EMERGENCY STOP device for the robot system 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 robot system if the EMERGENCY STOP button is pressed:

- Manual Reduced Velocity (T1) and Manual High Velocity (T2) modes:
The drives are switched off immediately. The robot 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 robot 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. 3-3: EMERGENCY STOP button on the KCP

1 EMERGENCY STOP button



Warning!

Tools and other equipment connected to the robot 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.

3.3.9 Enabling device

The enabling devices of the robot system 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 T1 (Manual Reduced Velocity) and T2 (Manual High Velocity), the robot 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 robot 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. 3-4: Enabling switches on the KCP

1 - 3 Enabling switches

3.3.10 Connection for external enabling device

External enabling devices are required if there is more than one person in the danger zone of the robot system. They can be connected via the peripheral interface on the robot controller.

External enabling devices are not included in the scope of supply of the robot system.

3.3.11 Jog mode

In the operating modes T1 (Manual Reduced Velocity) and T2 (Manual High Velocity), the robot 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 robot and any external axes (optional) stop with a STOP 0.

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

3.3.12 Software limit switches

The axis ranges of all robot and positioner axes are limited by means of adjustable software limit switches. These software limit switches serve as machine protection and must be adjusted.

The software limit switches are set during commissioning of a robot system.



Further information is contained in the operating and programming instructions.

3.3.13 Overview of operating modes and safety measures

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

Safety measures	T1	T2	AUT	AUT EXT
Operator safety	-	-	active	active
EMERGENCY STOP device	active (STOP 0)	active (STOP 0)	active (STOP 1)	active (STOP 1)
Enabling device	active	active	-	-
Reduced velocity during program verification	active	-	-	-
Jog mode	active	active	-	-
Software limit switches	active	active	active	active

3.3.14 External safety equipment and safeguards

E-STOP

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 to the peripheral interface of the robot.

Safeguards

The access of persons to the danger zone of the robot 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 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 robot 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.

3.3.15 Labeling on the robot system

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

Labeling on the robot system consists of:

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



Further information can be found in the operating instructions of the robot, linear unit, positioner and robot controller.

3.4 Safety measures

3.4.1 General safety measures

The robot system may only be used in perfect technical condition in accordance with its designated 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 robot system 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 robot or external axes to sag. If work is to be carried out on a switched-off robot system, the robot 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 robot and external axes must be secured by appropriate means.



Danger!

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



Warning!

The motors reach temperatures during operation which can cause burns to the skin. Contact should be avoided if at all possible. If necessary, appropriate protective equipment must be used.

KCP

If more than one KCP is used in the overall system, it must be ensured that each KCP is unambiguously assigned to the corresponding robot system. There must be no possibility of mixing them up in an emergency situation.

**Warning!**

The operator must ensure that decoupled KCPs are immediately removed from the system and stored out of sight and reach of the robot system personnel. 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.

Faults

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

- 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 robot system, 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.

3.4.2 Transportation**Robot**

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

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 for the robot controller.

External axis (optional)

The prescribed transport position of the external axis (e.g. KUKA linear unit, two-axis positioner, etc.) must be observed. Transportation must be carried out in accordance with the operating instructions for the external axis.

3.4.3 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 robot system. If cables are interchanged, the robot 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 robot, always connect the connecting cables to the robots and their corresponding robot controllers.



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 robot system is correctly installed and fastened in accordance with the specifications in the documentation.
- There are no foreign bodies or loose parts on the robot system.
- All required safety equipment is correctly installed and operational.
- The power supply ratings of the robot system 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)

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

The velocity thus calculated must not exceed 250 mm/s.

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 ma-

chine data on the rating plate of the robot and the external axes (optional) must be entered during start-up.



Warning!

The 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.

3.4.4 Virus protection and network security

The user of the robot system 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.

3.4.5 Manual mode

Manual mode is the mode for setup work. Setup work is all the tasks that have to be carried out on the robot system 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 robot 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 robot, tooling or external axes (optional) must never touch or project beyond the safety fence.
- Components, tooling and other objects must not become jammed due to the motion of the robot system, 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 robot system.
 - 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.

3.4.6 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 (SSTEP T1). It may be necessary to modify the program.

3.4.7 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 production line.
- The defined working procedures are adhered to.

If the robot 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.

3.4.8 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 robot system:

- 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 robot controller 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 equipment 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.

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.

3.4.9 Decommissioning, storage and disposal

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

3.4.10 Safety measures for “single point of control”

Overview

If certain components in the robot system 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.

3.5 Applied norms and regulations

Name	Definition	Edition
2006/95/EC	Low Voltage Directive: Directive of the European Parliament and the Council of 12 December 2006 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits	2006
89/336/EEC	EMC Directive: Council Directive of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility	1993
97/23/EC	Pressure Equipment Directive: Directive 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

Name	Definition	Edition
98/37/EC	Machinery Directive: Directive of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery	1998
EN ISO 13850	Safety of machinery: E-STOP - Principles for design	2007
EN ISO 13732-1	Ergonomics of thermal environment: Methods for the assessment of human responses to contact with surfaces - Part 1: Hot surfaces	2006
EN 614-1	Safety of machinery: Ergonomic design principles – Part 1: Terms and general principles	2006
EN 954-1	Safety of machinery: Safety-related parts of control systems - Part 1: General principles for design	1997
EN 60204-1	Safety of machinery: Electrical equipment of machines - Part 1: General requirements	2007
EN 61000-6-2	Electromagnetic compatibility (EMC): Part 6-2: Generic standards; Immunity for industrial environments	2002
EN 61000-6-4	Electromagnetic compatibility (EMC): Part 6-4: Generic standards; Emission standard for industrial environments	2002
EN ISO 10218-1	Industrial robots: Safety	2006
EN ISO 12100-1	Safety of machinery: Basic concepts, general principles for design - Part 1: Basic terminology, methodology	2004
EN ISO 12100-2	Safety of machinery: Basic concepts, general principles for design - Part 2: Technical principles	2004

4 Planning

4.1 Mounting variants

The following mounting variants are available for installing the robot:

- Mounting base with centering
(>>> 4.1.1 "Mounting base" page 33)
- Mounting with adapter plate (optional)
(>>> 4.1.2 "Mounting with adapter plate (optional)" page 34)

The robot can be installed on the floor, the wall or the ceiling.



In the case of installation on the wall or ceiling, the gravitation vector must be adapted. Further information is contained in the operating and programming instructions.

4.1.1 Mounting base



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 made in the mounting base for mounting the robot:

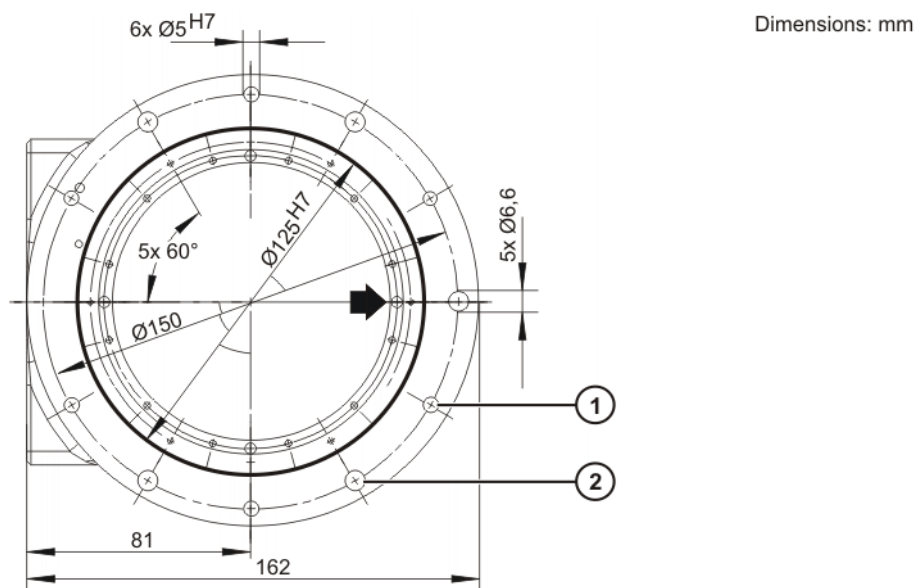


Fig. 4-1: Hole pattern for robot mounting base

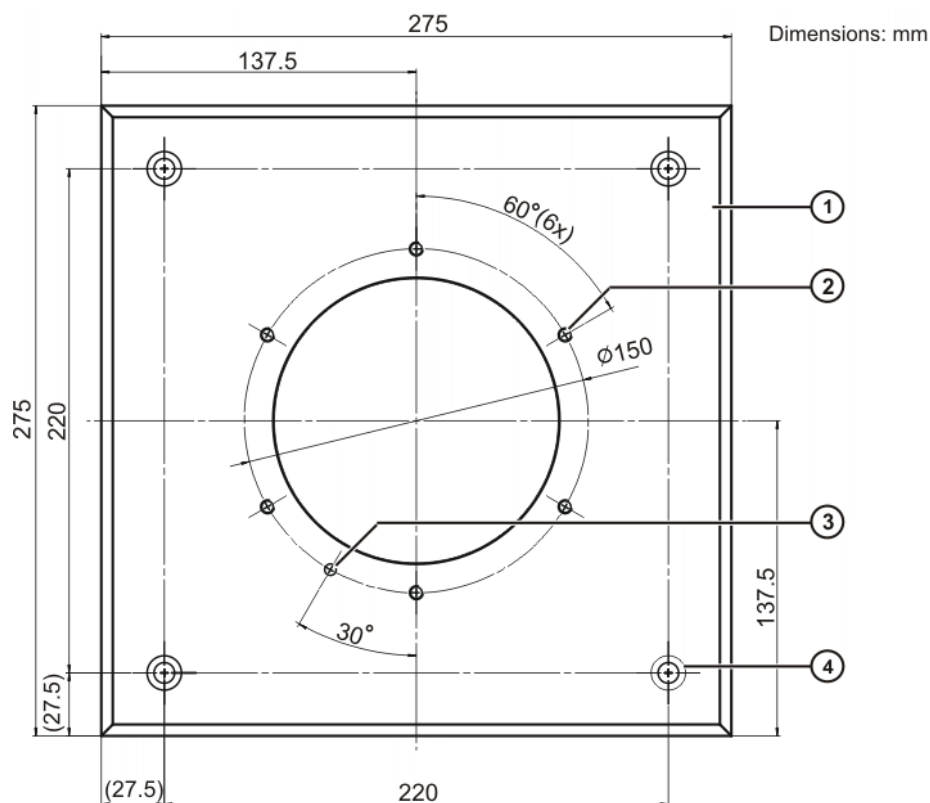
- 1 1x hole for locating pin
- 2 Allen screws

The LWR is fastened to the mounting base by means of 1 locating pin and 5 Allen screws. Only 1 hole needs to be drilled for the locating pin. For the Allen screws, 5 holes must be drilled in accordance with the hole pattern.



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.

The KUKA adapter plate has the following holes:



- 1 KUKA adapter plate
- 2 Allen screws
- 3 Locating pin
- 4 Fastening screws, min. M8x18

There are 6 holes for the Allen screws for fastening the robot. Depending on the alignment of the robot, one of these holes remains free.

Technical drawing of a shaft assembly with four callouts:

- Callout 1:** Points to the shaft diameter, labeled $\varnothing 125 f7$.
- Callout 2:** Points to the keyway, labeled $\varnothing 9 (4x)$ and $\varnothing 15 (4x)$.
- Callout 3:** Points to the key, labeled $M 6 (6x)$ and $\varnothing 0,15$.
- Callout 4:** Points to the shaft end, labeled $\varnothing 5 H7$ and $\varnothing 0,02$.

Additional dimensions and features include:

- Overall length: 19
- Keyway width: 9
- Keyway depth: 9
- Surface finish: $Rz10$
- Texture: 0,2
- Key: $\varnothing 9 (4x)$
- Key: $\varnothing 15 (4x)$
- Key: $M 6 (6x)$
- Key: $\varnothing 0,15$
- Key: $\varnothing 5 H7$
- Key: $\varnothing 0,02$
- Key: $Rz10$
- Key: $Rz25$
- Key: $5 \times 45^\circ$
- Key: $4 \begin{smallmatrix} 0 \\ -0,2 \end{smallmatrix}$
- Key: 1
- Key: $0,05 A$
- Key: $0,2$
- Key: A
- Key: a

- 1 Fastening screws, min. M8x18
- 2 Allen screws
- 3 KUKA adapter plate
- 4 Locating pin



The robot can also be installed using an adapter plate other than the KUKA adapter plate. In this case, it must be taken into consideration that the length of the fastening screws may differ.

5 Transportation

5.1 Transportation



The robot may only be transported in the transport position and in the transport container provided.

Transport position

Move the robot into the corresponding transport position each time it is transported. The robot is in the transport position when the axes are in the following positions:

A1 (J1)	A2 (J2)	E1 (J3)	A3 (J4)	A4 (J5)	A5 (J6)	A6 (J7)
0°	+90°	0°	0°	0°	0°	0°

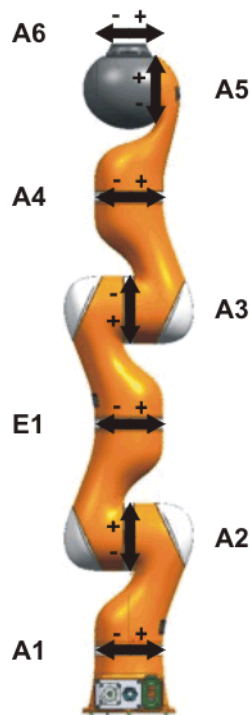


Fig. 5-1: Robot axes

Transport dimensions

Transport the robot in the transport container provided that has the following outer dimensions:

- Length: 1360 mm
- Width: 435 mm
- Height: 300 mm

The transport container is fitted with antistatic Ethafoam 220. This holds the robot in position and serves as shock-resistant and break-proof packing.

6 KUKA Service

6.1 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

6.2 KUKA Customer Support

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

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