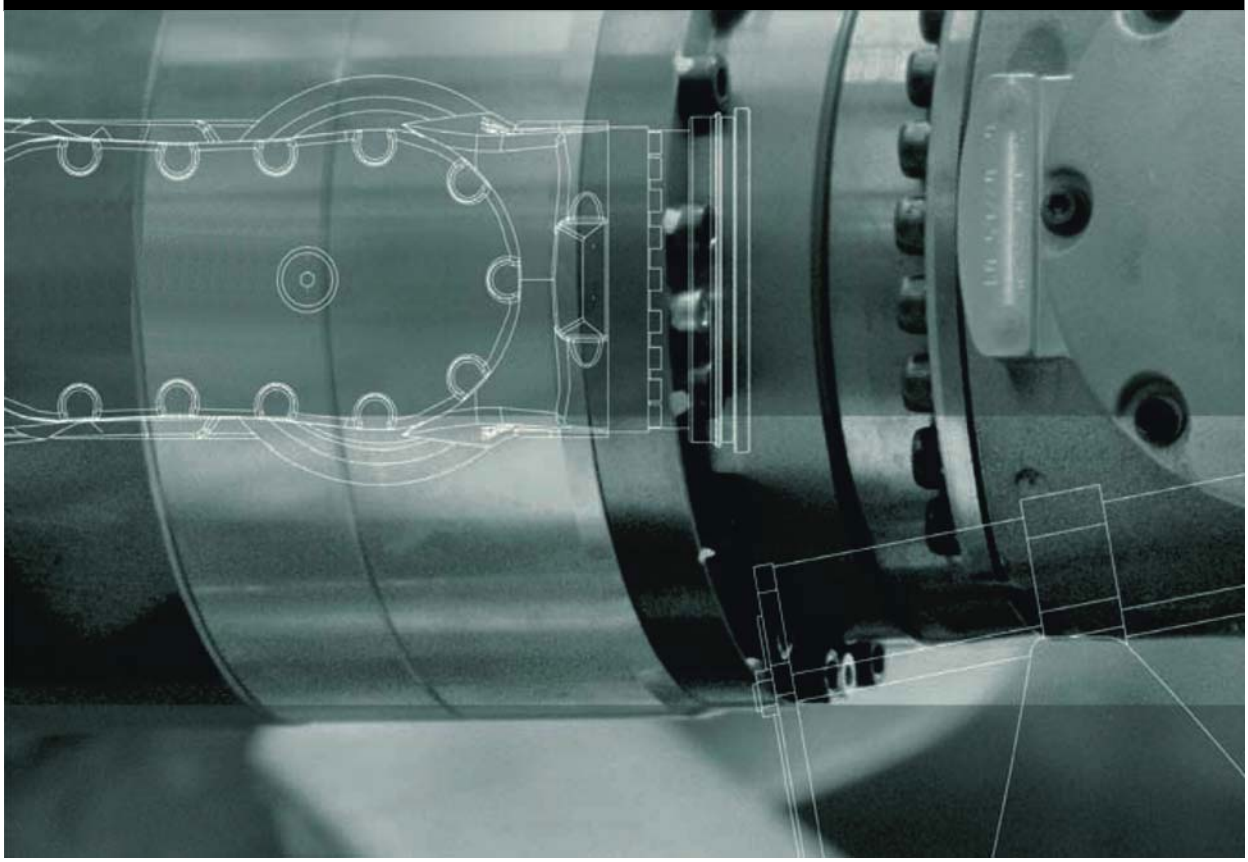
KUKA

Robots

KUKA Roboter GmbH

Lightweight Robot 4+

Operating Instructions



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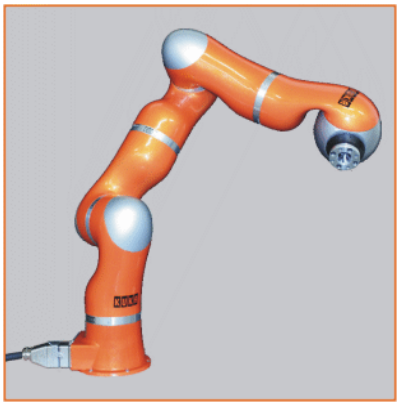

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Other functions not described in this documentation may be operable in the controller. The user has no claims to these functions, however, in the case of a replacement or service work.

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

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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

These warnings are relevant to safety and **must** be observed.

DANGER These warnings mean that it is certain or highly probable that death or severe physical injury **will** occur, if no precautions are taken.

WARNING These warnings mean that death or severe physical injury **may** occur, if no precautions are taken.

CAUTION These warnings mean that minor physical injuries **may** occur, if no precautions are taken.

NOTICE These warnings mean that damage to property **may** occur, if no precautions are taken.

These warnings contain references to safety-relevant information or general safety measures. These warnings do not refer to individual hazards or individual precautionary measures.

Notes

These hints serve to make your work easier or contain references to further information.

Tip to make your work easier or reference to further information.

1.3 Terms used

Term/Abbreviation	Meaning
KCP	KUKA Control Panel (teach pendant)
LWR	Lightweight robot

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 of tools or fixtures for processing or transferring components or products. Use is only permitted under the specified environmental conditions.

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
- Operation without additional safeguards
- Outdoor operation
- Leaning on the robot arm

NOTICE Changing the structure of the manipulator, e.g. by drilling holes, etc., can result in damage to the components. This is considered improper use and leads to loss of guarantee and liability entitlements.

3 Product description

3.1 Description of the industrial robot

The industrial robot consists of the following components:

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

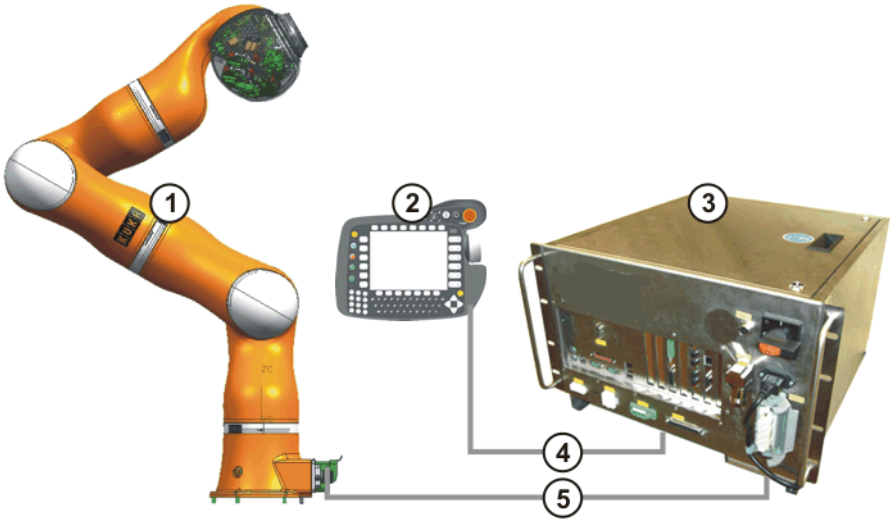

Fig. 3-1: Example of an industrial robot

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

3.2 Lightweight robot (LWR)

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:

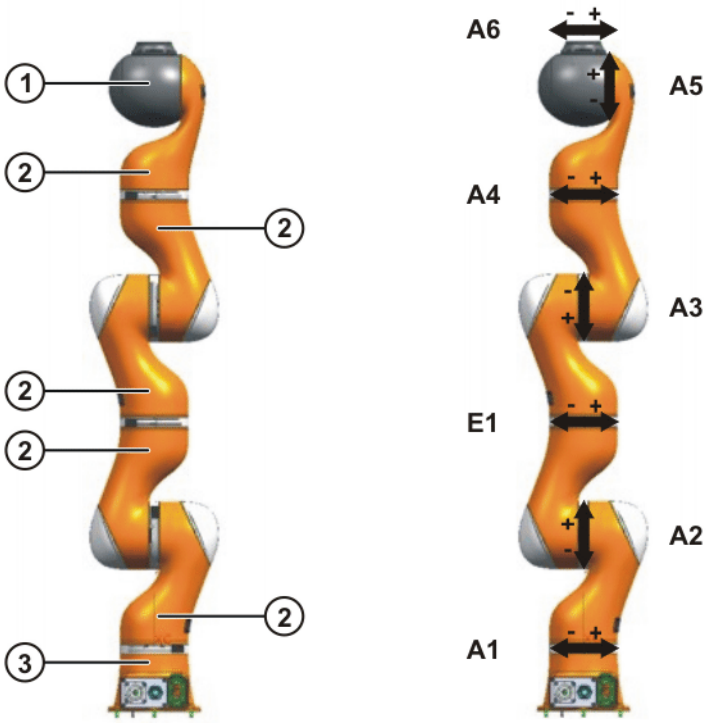

Fig. 3-2: Main assemblies and robot axes

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 an aluminum structure. The drive units are situated inside these modules. In this way, the drive units are linked to one another via the aluminum structures.

Base frame The base frame is the base of the robot.

4 Technical data

4.1 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	Floor, ceiling, wall
Surface finish, paintwork	Aluminum: silver; paintwork: orange; base frame: 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 +30 °C (273 K to 303 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

4.2 Axis data

Axis data

Axis	Range of motion, software-limited	Velocity without payload
A1 (J1)	+/-170°	110.0 °/s
A2 (J2)	+/-120°	110.0 °/s
E1 (J3)	+/-170°	128.0 °/s
A3 (J4)	+/-120°	128.0 °/s
A4 (J5)	+/-170°	204.0 °/s
A5 (J6)	+/-120°	184.0 °/s
A6 (J7)	+/-170°	184.0 °/s

Maximum torques

Axis	Maximum torque
A1 (J1)	176 Nm
A2 (J2)	176 Nm
E1 (J3)	100 Nm
A3 (J4)	100 Nm
A4 (J5)	100 Nm
A5 (J6)	38 Nm
A6 (J7)	38 Nm

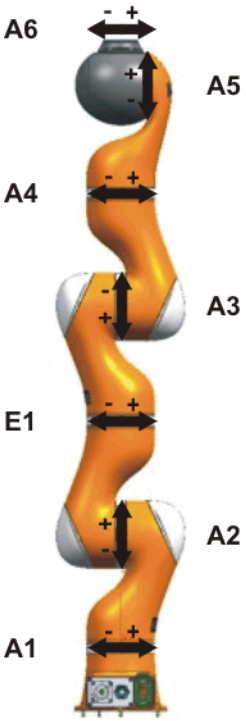

Fig. 4-1: Robot axes

Working envelope

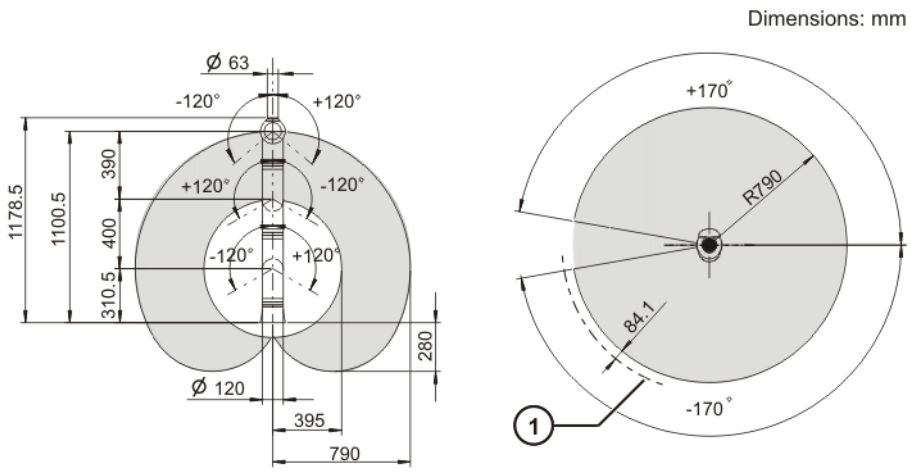

Fig. 4-2: Working envelope

1 Interference radius

4.3 Payloads

Payloads

Robot	LWR 4+
In-line wrist	IW
Rated payload	7 kg
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).

NOTICE 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.

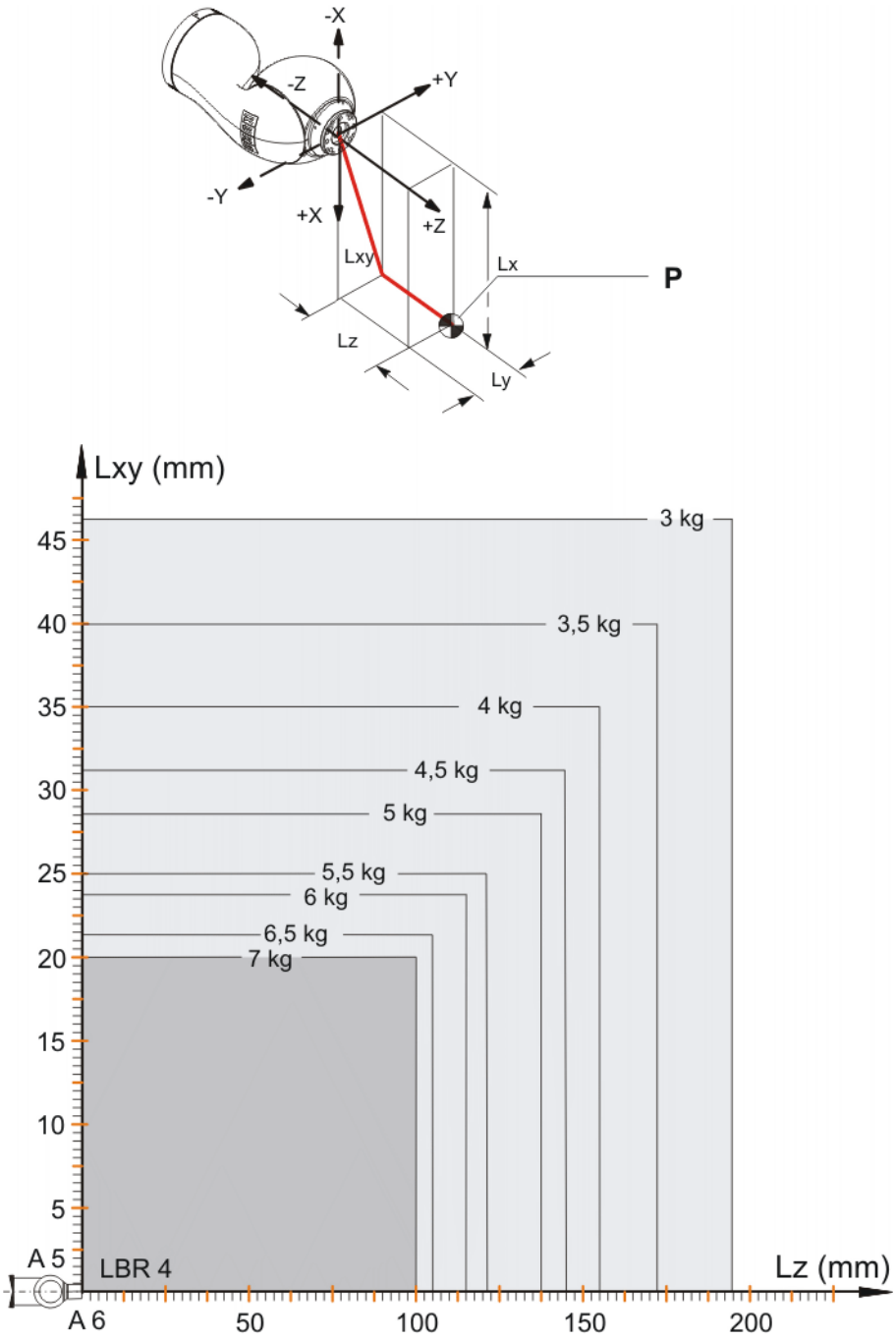

Fig. 4-3: Payload diagram

NOTICE This loading curve corresponds to the maximum load capacity. Both values (payload and mass 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 Roboter 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!

Mounting flange

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}

X_m = position of the locating element (bushing)

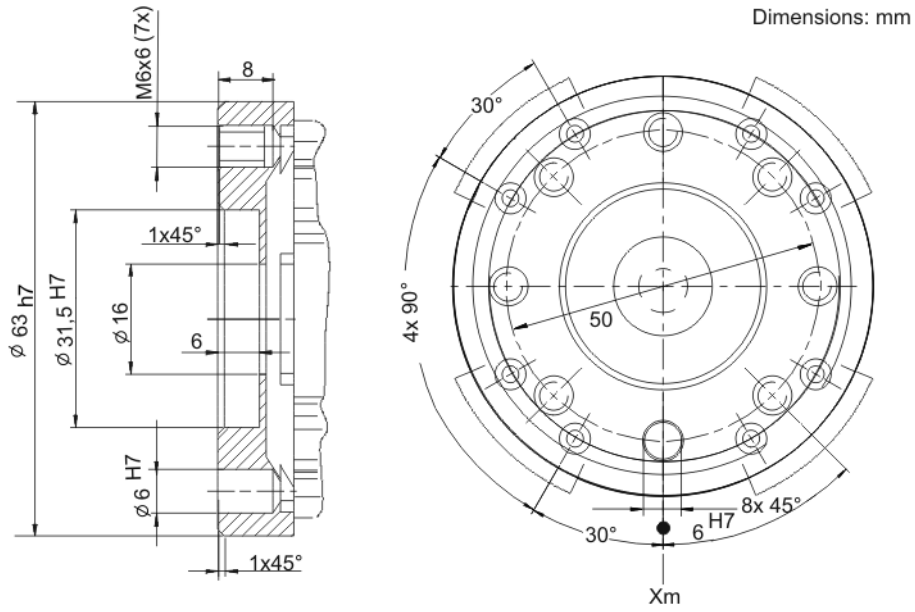

Fig. 4-4: Mounting flange

Supplementary load The robot cannot carry supplementary loads.

4.4 Loads acting on the mounting base

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

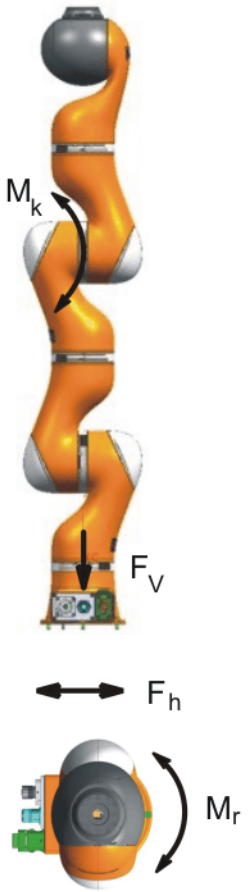

Fig. 4-5: Loads acting on the mounting base

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

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 industrial robot.

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 instructions 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 ex-

ist. 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.

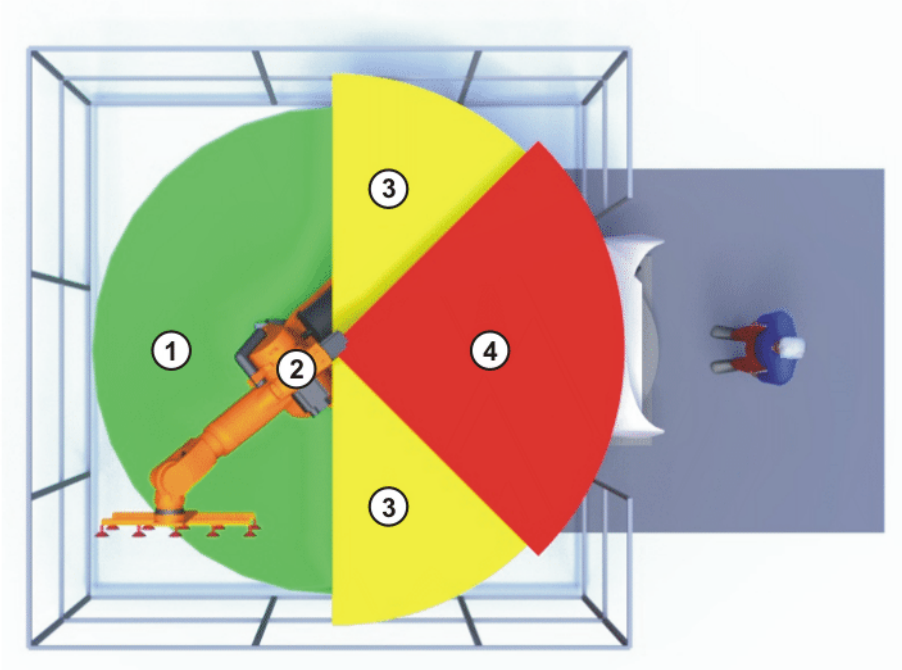

Fig. 5-1: Example of axis range A1

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

Trigger	T1, T2	AUT, AUT EXT
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 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 Performance Level d and category 3 according to EN ISO 13849-1. This only applies under the following conditions, however:

- The EMERGENCY STOP is not triggered more than once a day on average.
- The operating mode is not changed more than 10 times a day on average.
- Number of switching cycles of the main contactors:
  - Max. 100 per day
  - At least once every 6 months

If these conditions are not met, KUKA Roboter GmbH must be contacted.

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.

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

The ESC safety logic monitors the following outputs:

- Operating mode
- Local E-STOP

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.

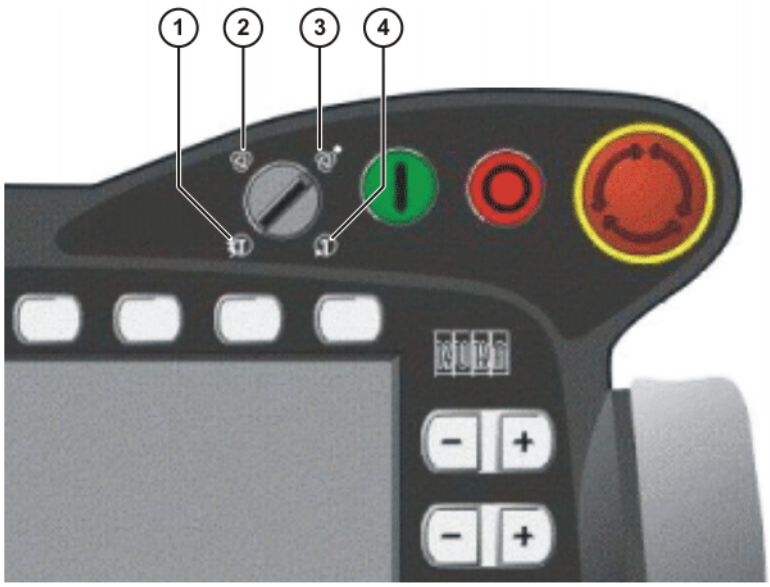

Fig. 5-2: Mode selector switch

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
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 available at every operator station that can initiate a robot motion or other potentially hazardous situation. The system integrator is responsible for ensuring this.

There must always be at least one external EMERGENCY STOP device installed. This ensures that an EMERGENCY STOP device is available even when the KCP is disconnected.

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:

- Identification plates
- Warning labels
- Safety symbols
- Designation labels
- Cable markings
- Rating 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 Performance Level d and category 3 according to EN ISO 13849-1.

- 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!

CAUTION The motors reach temperatures during operation which can cause burns to the skin. Contact must 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 Testing safety-related controller components

All safety-related controller components are rated for a service life of 20 years (with the exception of the input/output terminals for safe bus systems). The controller components must nonetheless be tested regularly to ensure that they are still functional.

Check:

The E-STOP pushbutton and the mode selector switch must be actuated at least once every 6 months in order to detect any malfunction.

Additional checks are required during start-up and recommissioning.

⚠ WARNING If input/output terminals are used in the robot controller for safe bus systems, these must be exchanged after 10 years at the latest. If this is not done, the integrity of the safety functions is not assured. This can result in death, physical injuries and damage to property.

5.8.3 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.

5.8.4 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.

⚠ If additional components (e.g. cables), which 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.

NOTICE 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. Death or severe physical injuries may result.

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.

⚠ DANGER 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.

5.8.5 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.

5.8.6 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.
- Workpieces, 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.

5.8.7 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.

5.8.8 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.

5.8.9 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 it from being switched 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.

5.8.10 Decommissioning, storage and disposal

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

5.8.11 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
EN ISO 13850	Safety of machinery: Emergency stop - Principles for design	2008
EN ISO 13849-1	Safety of machinery: Safety-related parts of control systems - Part 1: General principles of design	2008
EN ISO 13849-2	Safety of machinery: Safety-related parts of control systems - Part 2: Validation	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

Name	Definition	Edition
EN ISO 10218-1	Industrial robots: Safety	2008
EN 614-1	Safety of machinery: Ergonomic design principles - Part 1: Terms 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 variants

The following mounting variants are available for installing the robot:

- Mounting base with centering
  (>>> 6.1.1 "Mounting base" Page 39)
- Mounting with adapter plate (optional)
  (>>> 6.1.2 "Mounting with adapter plate (optional)" Page 40)

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 of the KUKA System Software (KSS) for the lightweight robot.

6.1.1 Mounting base

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:

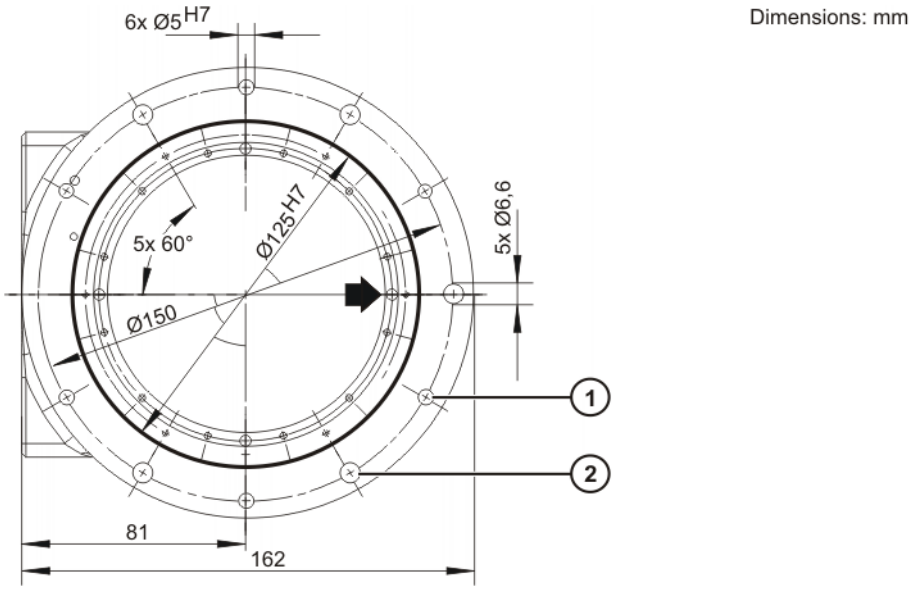

Fig. 6-1: Hole pattern for robot mounting base

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.

6.1.2 Mounting with adapter plate (optional)

> 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.

For simplified mounting, the robot can be installed using a KUKA adapter plate (Art. no.: 00-159-998).

Hole pattern

The KUKA adapter plate has the following holes:

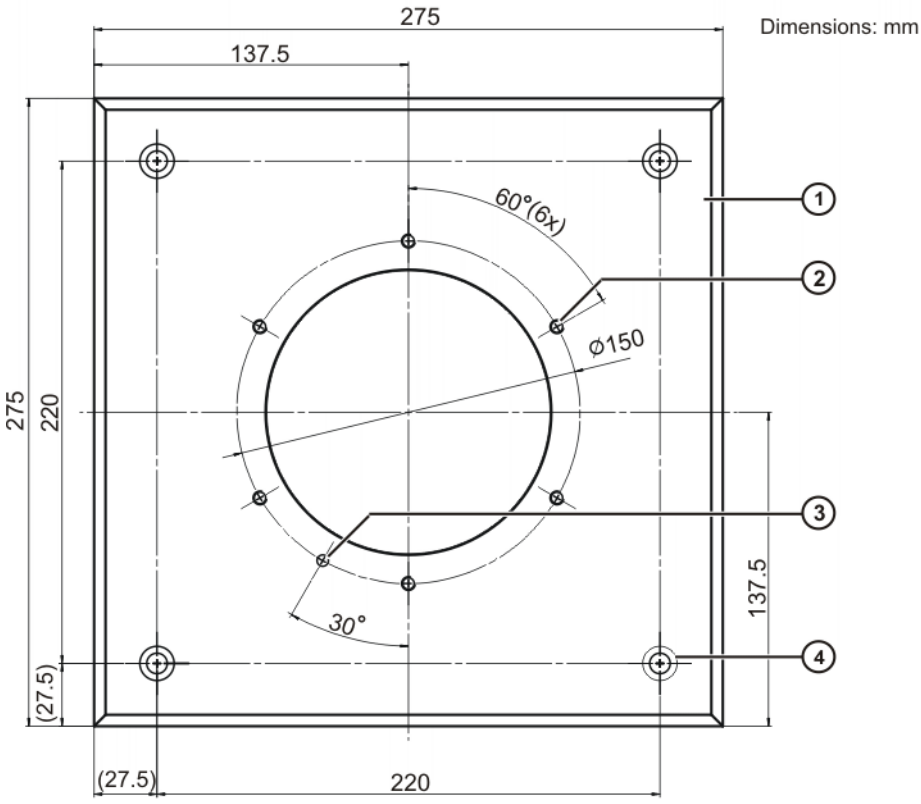

Fig. 6-2: Hole pattern for fastening the robot with the KUKA adapter plate

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.

Dimensions: mm

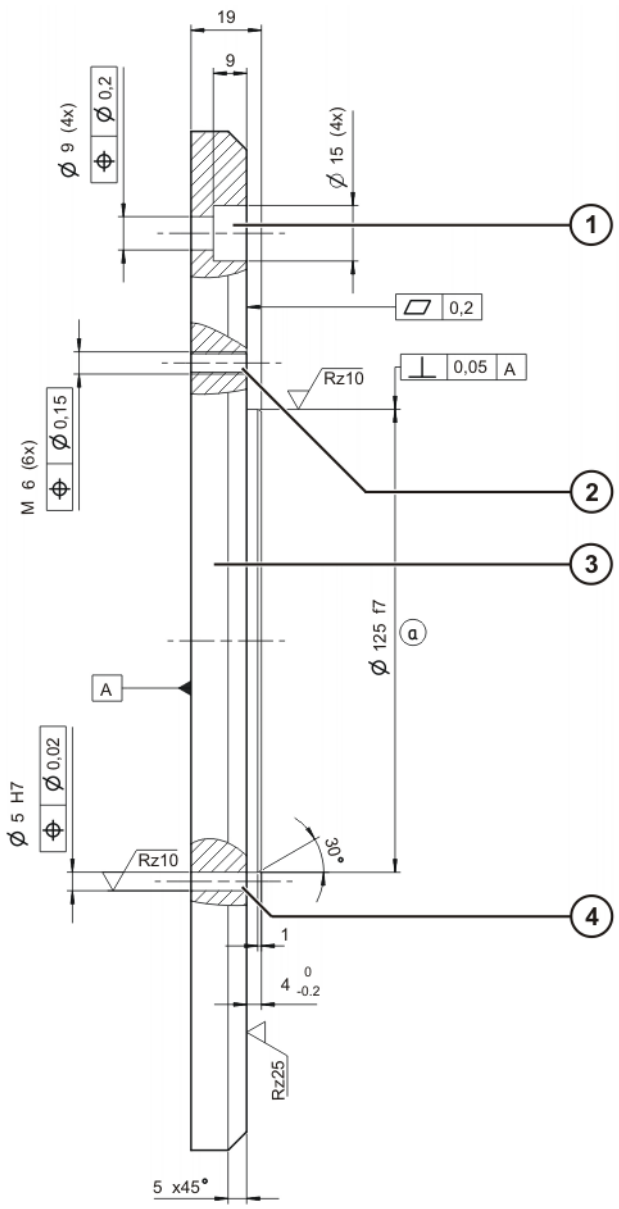

Fig. 6-3: Cross-section of the KUKA adapter plate

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

⚠ CAUTION 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.

7 Transportation

7.1 Transportation

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 transported, the tooling must be dismounted and the connecting cables must be unplugged. Remove all transport safeguards, such as nails and screws, in advance. First remove any rust or glue on contact surfaces.

NOTICE 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°

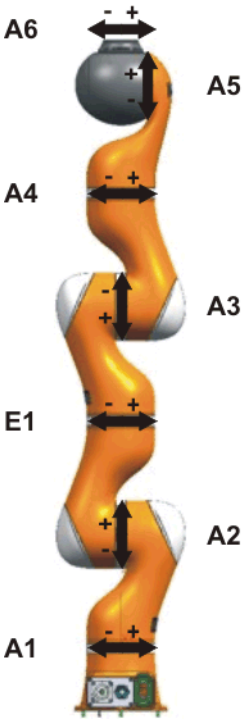

Fig. 7-1: Robot axes

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.

8 Start-up and recommissioning

8.1 Installing a floor-mounted robot

Description

This description is valid for the installation of floor-mounted robots with the mounting variant “mounting base with centering”. (>>> 6.1.1 "Mounting base" Page 39)

The installation and start-up of the robot controller, the tools mounted and the applications are not described.

Preconditions

- Holes must be drilled in the mounting base in accordance with the hole pattern.
  (>>> 6.1.1 "Mounting base" Page 39)
- The connecting cables must be installed on the system side.

Procedure

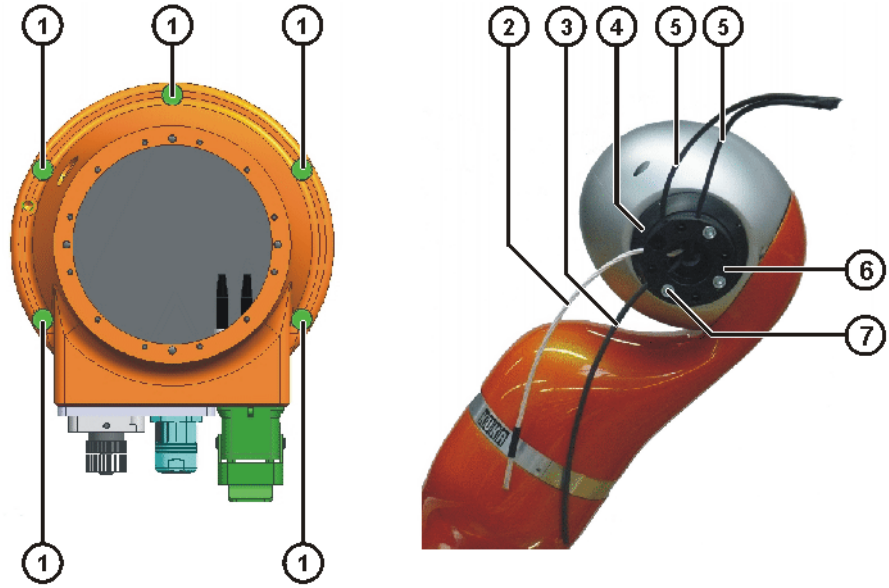

Fig. 8-1: Robot installation position/flange connection example

1 Allen screw
2 Cable of type 16/07 (4x0.5 mm^2 twisted as a bundle)
3 Round torsion cable 20xAWG30
4 Mounting flange
5 Ethernet cable 1x2x0.25 mm^2 (2x)
6 Cable adapter flange (transport safeguard)
7 Allen screw

The connections depend on the specific energy supply system.
(>>> 9.2 "Overview of connecting cables and interfaces" Page 51)

1. Move the robot to the installation site.
2. Insert 1 D5x16 locating pin into the locating hole on the mounting base.
3. Lower the robot vertically onto the holes and locating pin. Ensure that an entirely horizontal position is maintained in order to prevent damage to the locating pin.
4. Insert 5 M6x12-10.9 Allen screws into the base frame and tighten with a torque wrench in diagonally opposite sequence. Increase the tightening torque in several stages to M_A = 12.5 Nm.

5. Remove 3 Allen screws from the cable adapter flange and remove the cable adapter flange.
6. Check the position of all cables. They must not be under mechanical strain nor be able to chafe against other components.
7. If required, mount the tool and connect the energy supply systems.

8.2 Installing a wall-mounted robot

Description

This description is valid for the installation of wall-mounted robots with the mounting variant “mounting base with centering”. (>>> 6.1.1 "Mounting base" Page 39)

The installation and start-up of the robot controller, the tools mounted and the applications are not described.

Preconditions

- Holes must be drilled in the mounting base in accordance with the hole pattern.
  (>>> 6.1.1 "Mounting base" Page 39)
- The connecting cables must be installed on the system side.

Procedure

NOTICE Installation of the robot with this mounting variant must be carried out by at least 2 persons.

1. Move the robot to the installation site and into the transport position.
2. Fasten 1 locating pin to the base frame.
3. Place the robot horizontally onto the mounting base at an angle of 90 degrees. Ensure that an entirely horizontal position is maintained in order to prevent damage to the locating pin (>>> Fig. 8-2).
4. Insert 5 M6x12-10.9 Allen screws and tighten with a torque wrench in diagonally opposite sequence. Increase the tightening torque in several stages to M_A = 12.5 Nm.

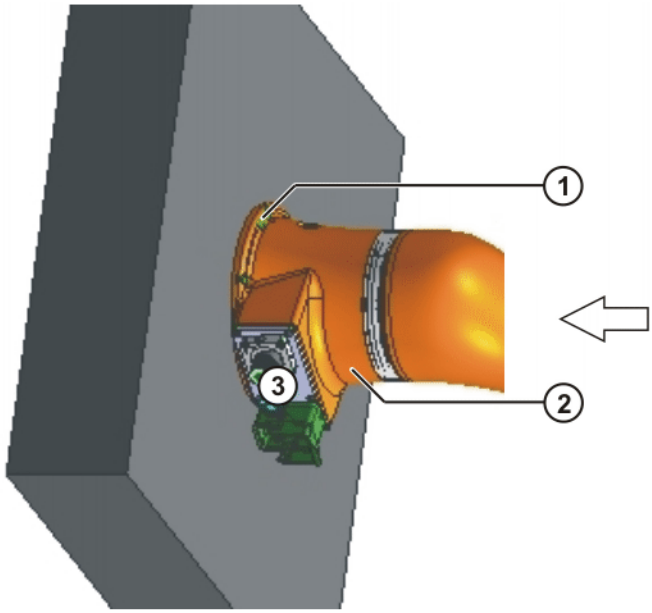

Fig. 8-2: Installation on the wall

1	Allen screws	3	Connector panel
2	Base frame		

5. Remove 3 Allen screws from the cable adapter flange and remove the cable adapter flange (>>> Fig. 8-3).

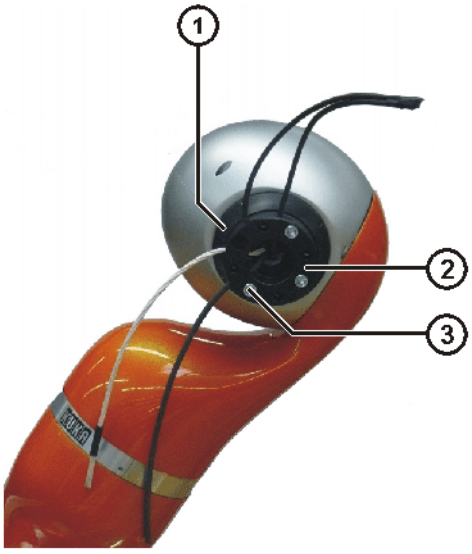

Fig. 8-3: Removing the cable adapter flange

1 Mounting flange
2 Cable adapter flange (transport safeguard)
3 Allen screw

6. Check the position of all cables. They must not be under mechanical strain nor be able to chafe against other components.
7. If required, mount the tool and connect the energy supply systems.

8.3 Installing a ceiling-mounted robot

Description

This description is valid for the installation of ceiling-mounted robots with the mounting variant “mounting base with centering”. (>>> 6.1.1 "Mounting base" Page 39)

The installation and start-up of the robot controller, the tools mounted and the applications are not described.

Preconditions

- Holes must be drilled in the mounting base in accordance with the hole pattern.
  (>>> 6.1.1 "Mounting base" Page 39)
- The connecting cables must be installed on the system side.

Procedure

NOTICE Installation of the robot with this mounting variant must be carried out by at least 2 persons.

1. Move the robot to the installation site and into the transport position.
2. Fasten 1 locating pin to the base frame.
3. Raise the robot vertically onto the mounting base from below. Ensure that an entirely vertical position is maintained in order to prevent damage to the centering pin (>>> Fig. 8-4).
4. Insert 5 M6x12-10.9 Allen screws and tighten with a torque wrench in diagonally opposite sequence. Increase the tightening torque in several stages to M_A = 12.5 Nm.

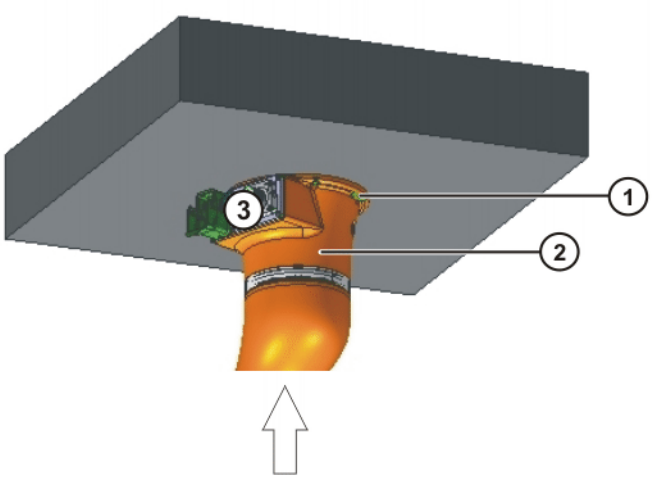

Fig. 8-4: Installation on the ceiling

1	Allen screws	3	Connector panel
2	Base frame		

5. Remove 3 Allen screws from the cable adapter flange and remove the cable adapter flange (>>> Fig. 8-5).

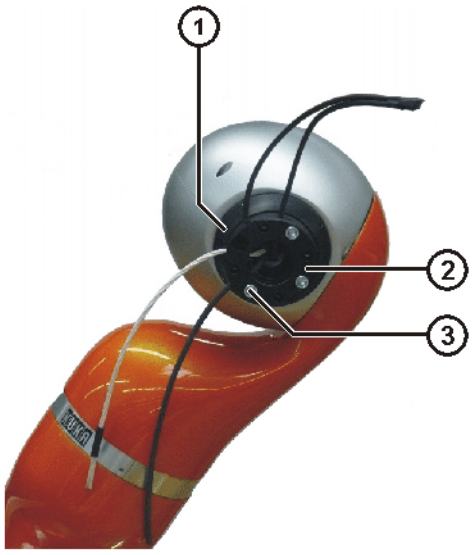

Fig. 8-5: Removing the cable adapter flange

1	Mounting flange
2	Cable adapter flange (transport safeguard)
3	Allen screw

6. Check the position of all cables. They must not be under mechanical strain nor be able to chafe against other components.
7. If required, mount the tool and connect the energy supply systems.

8.4 Installation with adapter plate (optional)

Description

This description is valid for the installation of robots with a KUKA adapter plate. The installation and start-up of the robot controller, the tools mounted and the applications are not described.

Preconditions

- KUKA adapter plate (Art. no.: 00-159-998) present.

- Holes for the fastening screws must be drilled in the mounting base.
  (>>> 6.1.2 "Mounting with adapter plate (optional)" Page 40)
- The connecting cables must be installed on the system side.

Procedure

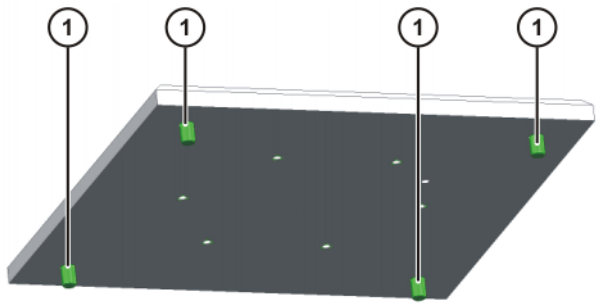

Fig. 8-6: KUKA adapter plate

1 M8x18 fastening screws

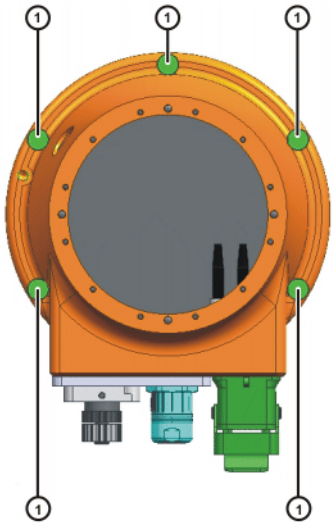

Fig. 8-7: Mounting position

1 Allen screw

1. Move the robot to the installation site and into the transport position.
2. Fasten KUKA adapter plate with 4 M8x18 fastening screws.
   (>>> Fig. 8-6)
3. Insert 1 D5x16 locating pin into the locating hole on the KUKA adapter plate. Take the intended installation position of the robot into consideration, i.e. the correct orientation in relation to the working envelope.
4. Lower the robot vertically onto the holes and locating pin. Ensure that an entirely vertical position is maintained in order to prevent damage to the centering pin.
5. Insert 5 M6x12-10.9 Allen screws into the base frame and tighten with a torque wrench in diagonally opposite sequence. Increase the tightening torque in several stages to M_A = 12.5 Nm.
6. Check the position of all cables. They must not be under mechanical strain nor be able to chafe against other components.
7. If required, mount the tool and connect the energy supply systems.

8.5 Mastering

Further information is contained in the operating and programming instructions of the KUKA System Software (KSS) for the lightweight robot.

8.6 Enabling axes

Further information is contained in the operating and programming instructions of the KUKA System Software (KSS) for the lightweight robot.

9 Electrical installations

9.1 Description of the electrical installations (robot)

Description

The electrical installations include all the supply and control cables for the motors of axes A1 (J1) to A6 (J7). 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 cables are connected to the robot controller. The energy supply system cables are connected to the periphery.

9.2 Overview of connecting cables and interfaces

Configuration

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

The robot can be equipped with one of the following energy supply systems:

- Pneumatic energy supply system
  KUKA art. no.: 00-164-750
- Electrical/pneumatic energy supply system
  KUKA art. no.: 00-172-158
- Electrical energy supply system
  KUKA art. no.: 00-169-837

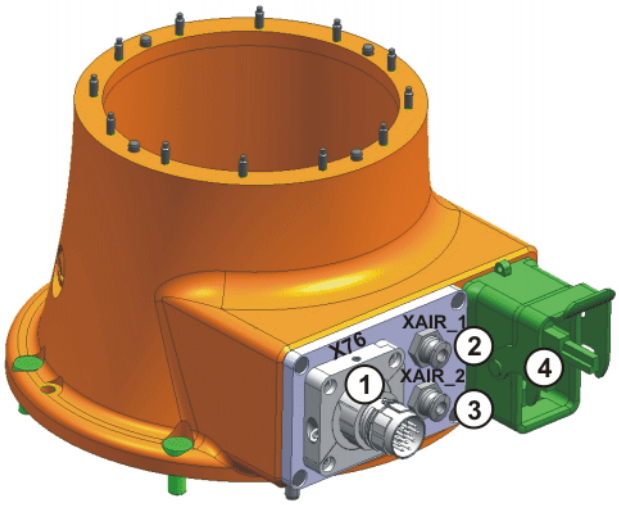

Fig. 9-1: Connection for pneumatic energy supply system

1 Control cable connection X76 (M17, 12-pole)
2 Pneumatic connection XAIR_1
3 Pneumatic connection XAIR_2
4 Robot controller connection X30

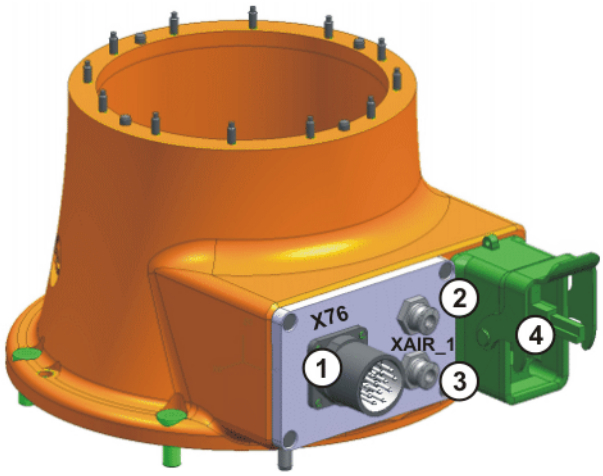

Fig. 9-2: Connection for electrical/pneumatic energy supply system

1 Control cable connection X76 (M23, 17-pole)
2 Blanking plug
3 Pneumatic connection XAIR_1
4 Robot controller connection X30

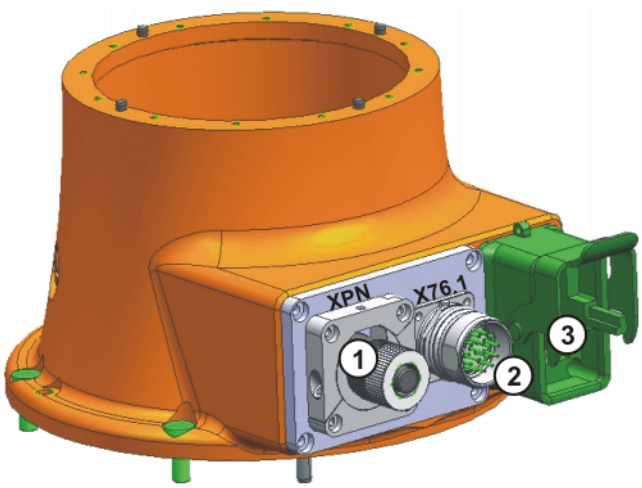

Fig. 9-3: Connection for electrical energy supply system

1 Ethernet connection XPN1 (4-pole, C-coded)
2 Control cable connection X76 (M23, 17-pole)
3 Robot controller connection X30

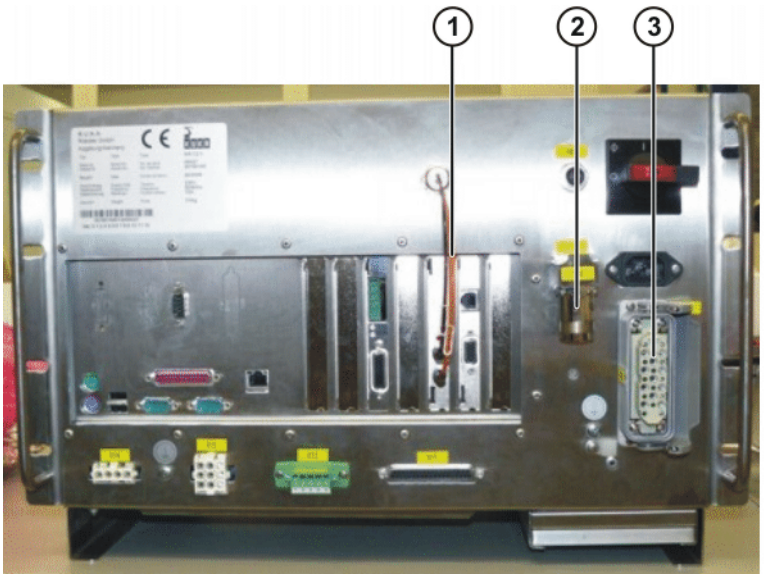

Fig. 9-4: Connecting cable from the robot to the robot controller

1 Control cable (designed as 2 fiber-optic cables)
2 KCP connection
3 Robot connection

Interface

Connection of the connecting cables to the robot controller:

Cable	Robot controller	Connection
LWR connecting cable	X20	Han 25 D

Bypack connector

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

Bypack connector for the pneumatic energy supply system:

Connector designation	KUKA art. no.
M17 (X76)	00-169-843

Bypack connector for the electrical/pneumatic energy supply system:

Connector designation	KUKA art. no.
M23 (X76)	00-169-840

Bypack connector for the electrical energy supply system:

Connector designation	KUKA art. no.
XPN1 (M12, 4-pole, C-coded)	00-158-798
M23 (X76)	00-169-840

The bypack connector must be ordered separately for the specific energy supply system.

9.3 Pneumatic energy supply system (Art. no.: 00-164-750)

9.3.1 Wiring diagram, control cable for pneumatic energy supply system

The control cable for the pneumatic energy supply system has the following characteristics:

Characteristic	Description
Operating voltage	60 V AC/DC
Current	EN 60204-1 (Derating factors must be taken into account)

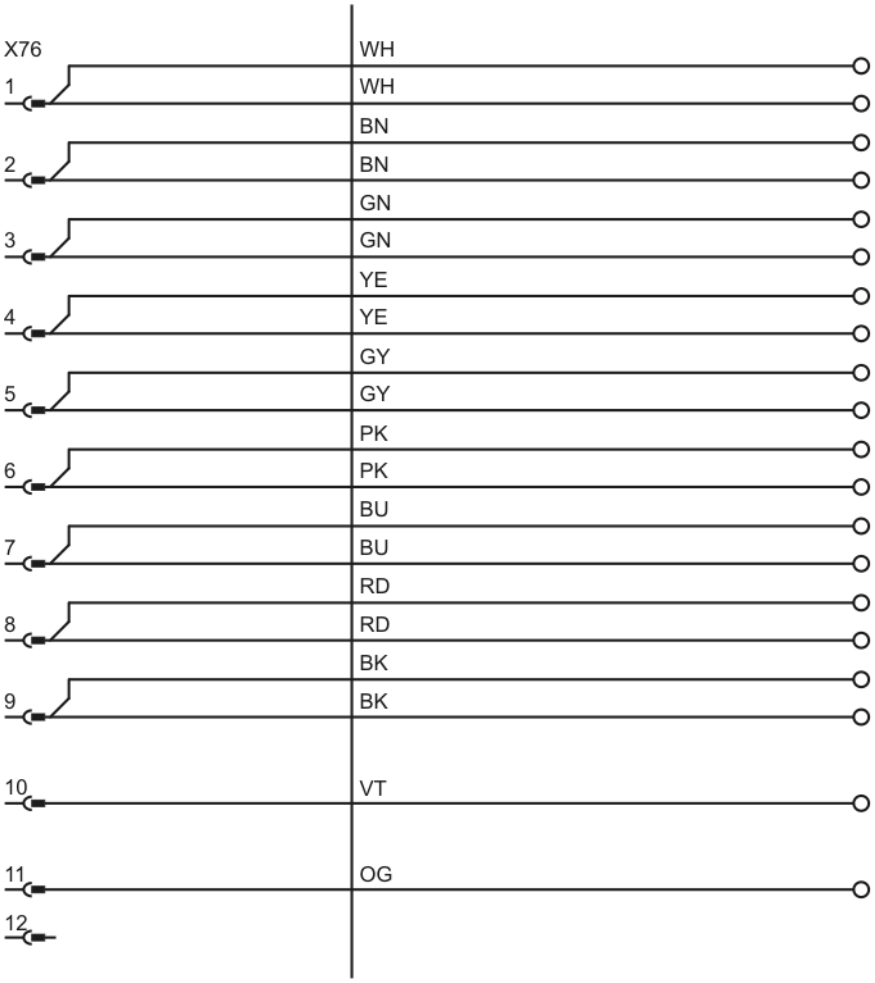

Fig. 9-5: Wiring diagram, energy supply system, control cable with AWG30

Bypack connector

The following connector shows the connector pin allocation for the pneumatic energy supply system on the robot.

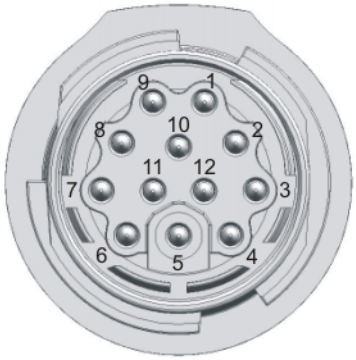

Fig. 9-6: M17 connector, 12-pole, view from contact side

9.3.2 Pneumatic hose dimensions

The pneumatic hoses have the following dimensions:

Dimensions	
Outside diameter	4.3 mm
Inside diameter	3 mm
Wall thickness	0.65 mm

The pneumatic hoses have the following characteristics:

Characteristic	Description
Permissible pressure	At 20 °C: 15 bar
	The permissible pressure is dependent on the temperature: At 50 °C: 70% of the operating pressure At 70 °C: 50% of the operating pressure At 80 °C: 45% of the operating pressure
Minimum bending radius	20 mm

9.4 Electrical/pneumatic energy supply system (Art. no.: 00-172-158)

9.4.1 Wiring diagram, control cable for electrical/pneumatic energy supply system

The control cable for the electrical/pneumatic energy supply system has the following characteristics:

Characteristic	Description
Operating voltage	60 V AC/DC
Current	EN 60204-1 (Derating factors must be taken into account)

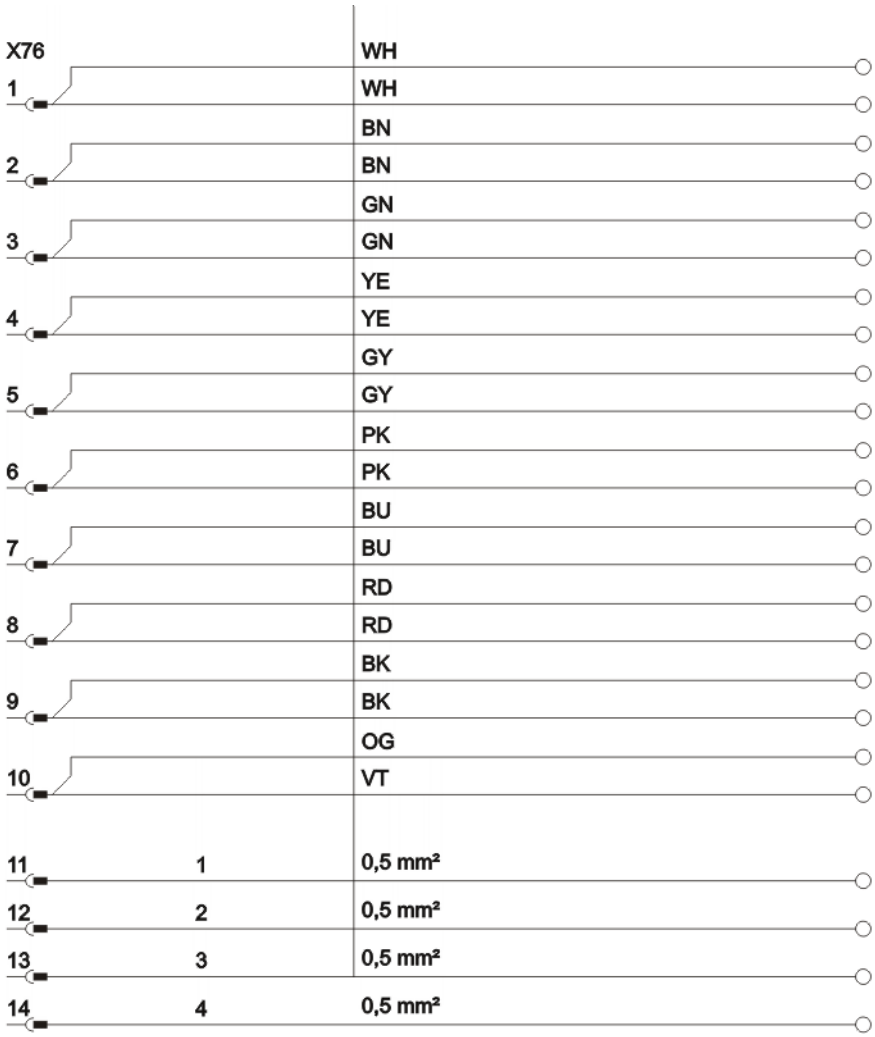

Fig. 9-7: Wiring diagram, energy supply system, control cable with AWG30

Bypack connector

The following connector shows the connector pin allocation for the electrical/ pneumatic energy supply system on the robot.

Fig. 9-8: M23 connector, 17-pole, view from contact side

9.4.2 Pneumatic hose dimensions

The pneumatic hoses have the following dimensions:

Dimensions	
Outside diameter	4.3 mm
Inside diameter	3 mm
Wall thickness	0.65 mm

The pneumatic hoses have the following characteristics:

Characteristic	Description
Permissible pressure	At 20 ºC: 15 bar
	The permissible pressure is dependent on the temperature: At 50 ºC: 70% of the operating pressure At 70 ºC: 50% of the operating pressure At 80 ºC: 45% of the operating pressure
Minimum bending radius	20 mm

9.5 Electrical energy supply system (Art. no.: 00-169-837)

9.5.1 Wiring diagram, control cable for electrical energy supply system

The control cable for the electrical energy supply system has the following characteristics:

Characteristic	Description
Operating voltage	60 V AC/DC
Current	EN 60204-1 (Derating factors must be taken into account)

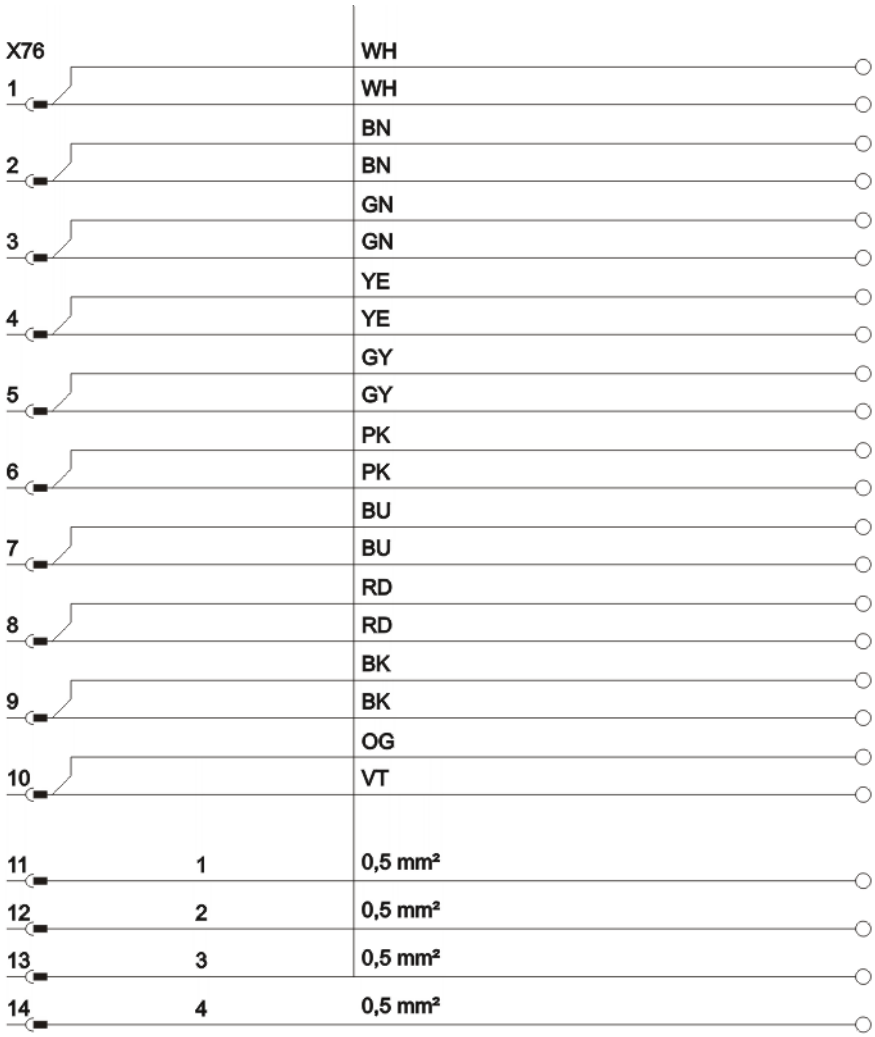

Fig. 9-9: Wiring diagram, energy supply system, control cable with AWG30

Bypack connector

The following connector shows the connector pin allocation for the electrical energy supply system on the robot.

Fig. 9-10: M23 connector, 17-pole, view from contact side

9.5.2 Wiring diagram for Ethernet cable

The characteristic impedance, attenuation and crosstalk of the cable conform to DIN EN 50288-2-2.

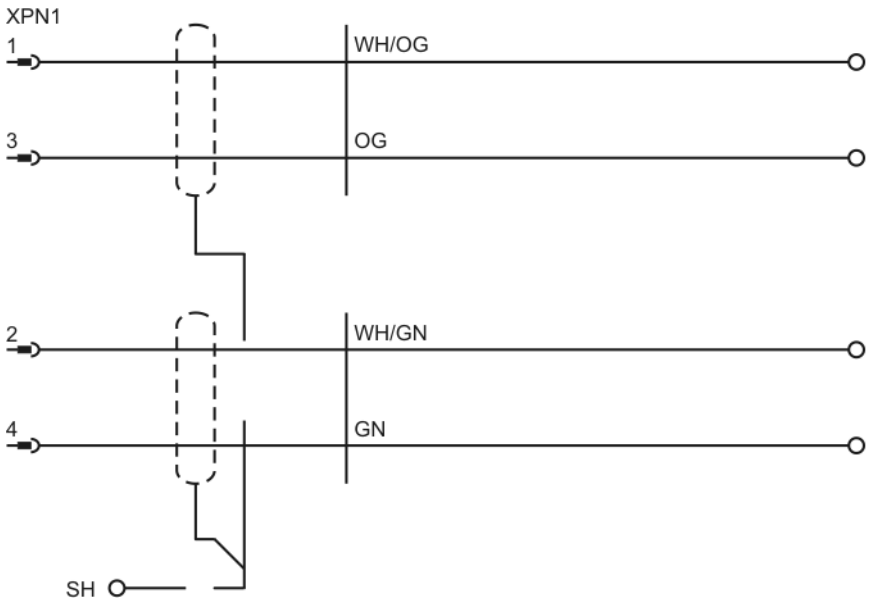

Fig. 9-11: Wiring diagram for Ethernet cable

10 Maintenance

10.1 Maintenance

No maintenance required if used for designated purpose.

10.2 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 high-pressure cleaners.
- 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.

11 Repair

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

12 Decommissioning, storage and disposal

12.1 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.
4. Secure the robot again.
5. Switch the robot controller off.
6. Release and unplug the connecting cables.
7. Remove Allen screws and locating pin.
8. Protect the connectors and hose lines against fouling.
9. Lift the robot and place it in the transport container.
10. Prepare the robot for storage (>>> 12.2 "Storage" Page 65).

12.2 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. Move robot into its transport position and remove it.
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. Place the robot in the transport container.

12.3 Disposal

When the robot reaches the end of its useful life, it can be removed 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.

Material, designation	Subassembly, component	Note
Aluminum	Load-bearing structures	Contains paint.
Aluminum	Robot base	
Copper	Cables	
Steel	Screws, locating pin	
PUR	Cable sheaths	
	Joint module	Dispose of joint module without dismantling it.
	Electronic components	Dispose of electronic components without dismantling them.

13 KUKA Service

13.1 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.

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

13.2 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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