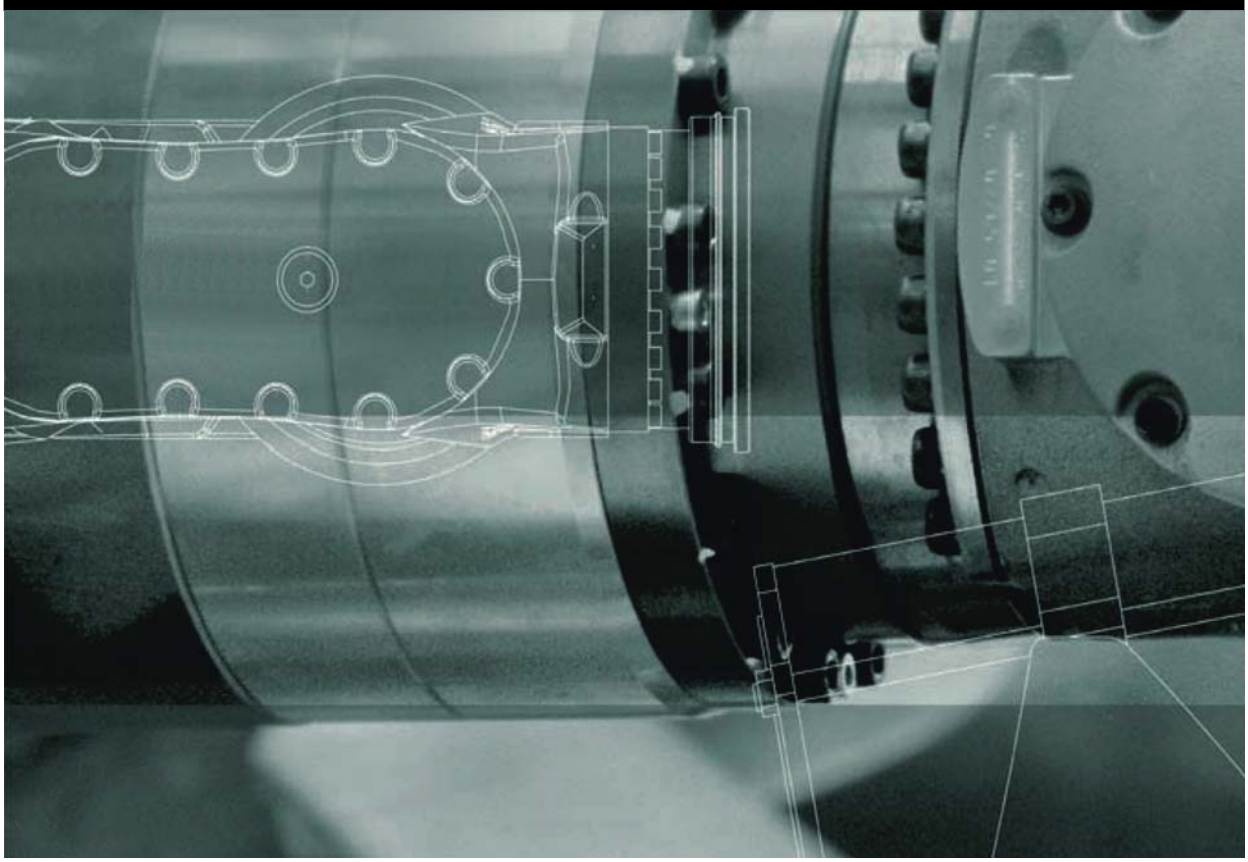
KUKA

Controller

KUKA Roboter GmbH

KR C2 edition2005

Specification



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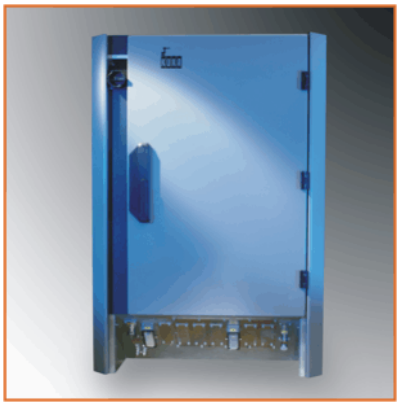

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Contents

1 Product description

1.1 Overview of the industrial robot

The industrial robot consists of the following components:

- Manipulator
- Robot controller
- Teach pendant
- Connecting cables
- Software
- Options, accessories

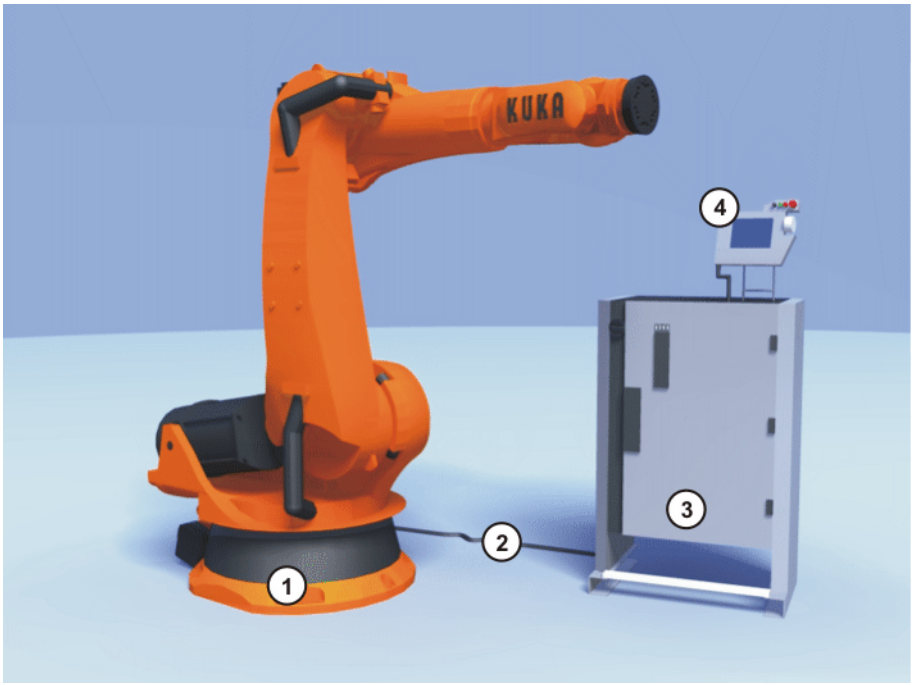

Fig. 1-1: Example of an industrial robot

1	Manipulator	3	Robot controller
2	Connecting cables	4	Teach pendant

1.2 Overview of the robot controller

The robot controller consists of the following components:

- Control PC
- Power unit
- KCP teach pendant
- Safety logic ESC
- KCP coupler (optional)
- Service socket (optional)
- Connection panel

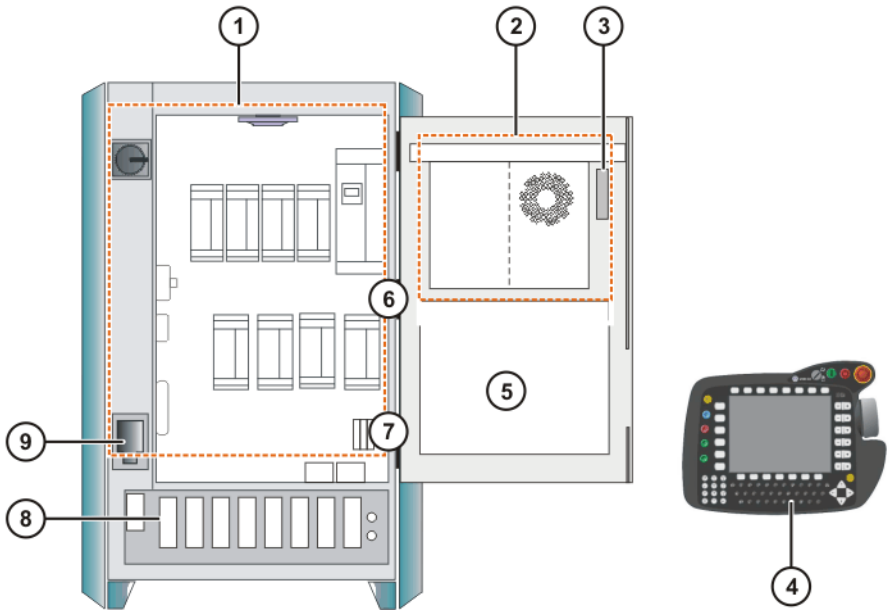

Fig. 1-2: Overview of the robot controller

1	Power unit	6	Safety logic (ESC)
2	Control PC	7	KCP coupler card (optional)
3	KCP coupler control and indicator elements (optional)	8	Connection panel
4	KCP	9	Service socket (optional)
5	Mounting plate for customer components		

1.3 Description of the control PC

Functions

With its fitted components, the PC performs all the functions of the robot controller.

- Windows user interface with visual display and input
- Program creation, correction, archiving, and maintenance
- Sequence control
- Path planning
- Control of the drive circuit
- Monitoring
- Parts of the ESC safety circuit
- Communication with external periphery (other controllers, host computers, PCs, network)

Overview

The control PC includes the following components:

- Motherboard with interfaces
- Processor and main memory
- Hard drive
- MFC3
- KVGA
- DSE-IBS-C33
- RDC
- Batteries
- Optional modules, e.g. field bus cards

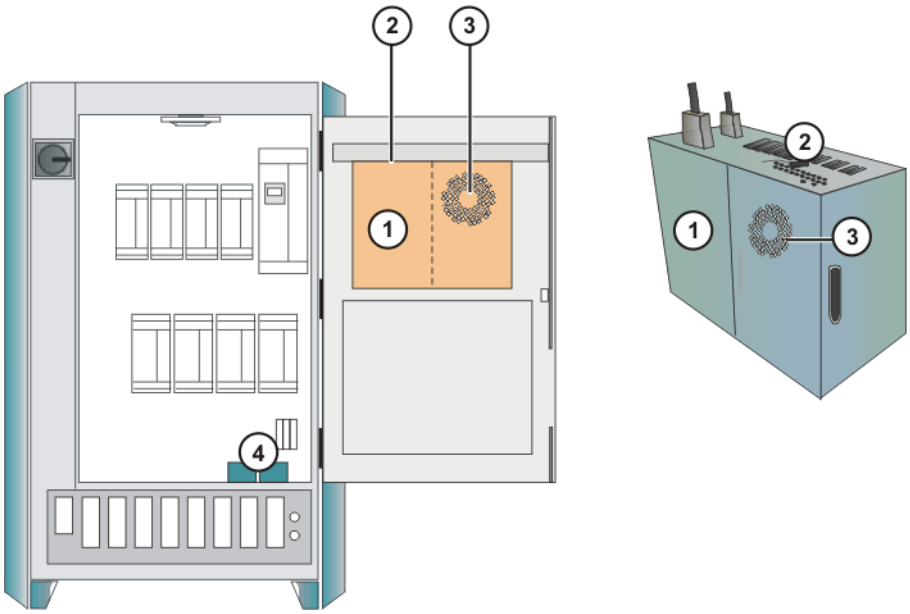

Fig. 1-3: Overview of the control PC

1	PC	3	PC fan
2	PC interfaces	4	Batteries

1.3.1 Control PC interfaces

Overview

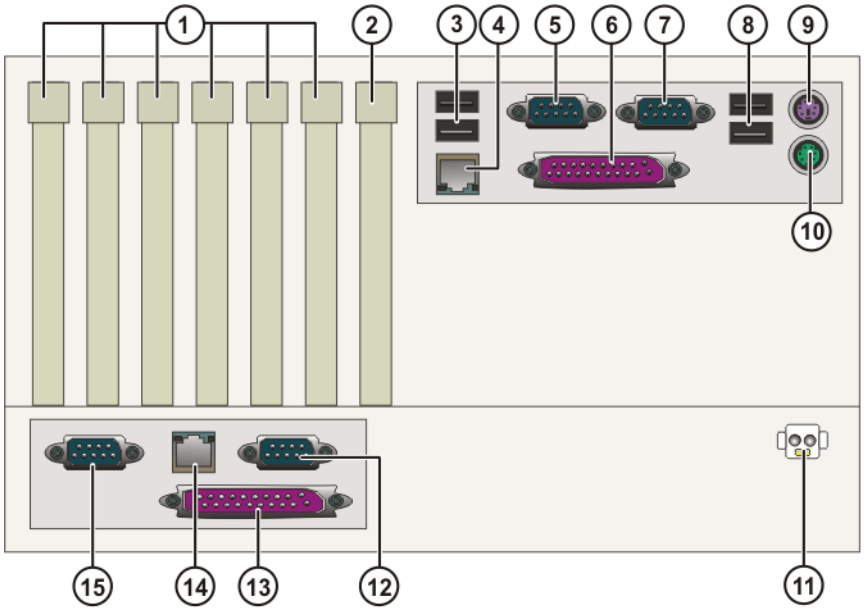

Fig. 1-4: Control PC interfaces

Item	Interface	Item	Interface
1	PCI slots 1 to 6 (>>> 1.3.2 "PCI slot assignment" Page 10)	9	Keyboard connection
2	AGP PRO slot	10	Mouse connection
3	USB (2x)	11	X961 power supply DC 24 V
4	X804 Ethernet	12	ST5 serial real-time interface COM 3

Item	Interface	Item	Interface
5	COM 1 serial interface	13	ST6 ESC/KCP etc.
6	LPT1 parallel interface	14	ST3 drive bus to KPS600
7	COM 2 serial interface	15	ST4 serial RDC interface X21
8	USB (2x)		

1.3.2 PCI slot assignment

Overview

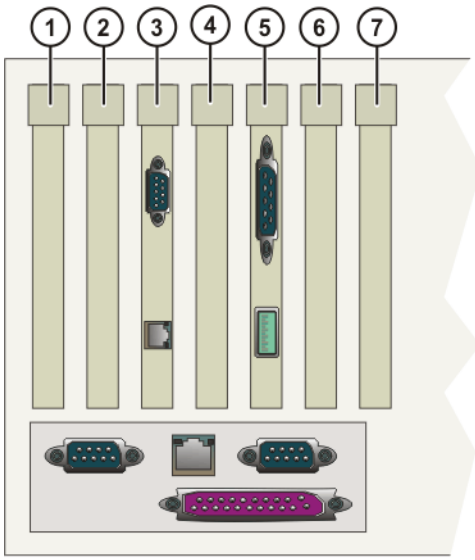

Fig. 1-5: PCI slots

The PC slots can be fitted with the following plug-in cards:

Slot	Plug-in card
1	■ Interbus card (FOC) (optional) ■ Interbus card (copper) (optional) ■ LPDN scanner card (optional) ■ Profibus master/slave card (optional) ■ CN_EthernetIP card (optional)
2	LPDN scanner card (optional)
3	KVGA card
4	DSE-IBS-C33 AUX card (optional)
5	MFC3 card
6	■ Network card (optional) ■ LPDN scanner card (optional) ■ Profibus master/slave card (optional) ■ LIBO-2PCI card (optional) ■ KUKA modem card (optional)
7	free

1.4 Description of the KUKA Control Panel (KCP)

Function

The KCP (KUKA Control Panel) is the teach pendant for the robot system. The KCP has all the control and display functions required for operating and programming the robot system.

1.4.1 Front view

Overview

Fig. 1-6: Front view of KCP

1	Mode selector switch	10	Numeric keypad
2	Drives ON	11	Softkeys
3	Drives OFF / SSB GUI	12	Start backwards key
4	EMERGENCY STOP button	13	Start key
5	Space Mouse	14	STOP key
6	Right-hand status keys	15	Window selection key
7	Enter key	16	ESC key
8	Arrow keys	17	Left-hand status keys
9	Keypad	18	Menu keys

1.4.2 Rear view

Overview

Fig. 1-7: Rear view of KCP

1	Rating plate	4	Enabling switch
2	Start key	5	Enabling switch
3	Enabling switch		

Description

Element	Description
Rating plate	KCP rating plate
Start key	The Start key is used to start a program.
Enabling switch	The enabling switch has 3 positions: ■ Not pressed ■ Center position ■ Panic position The enabling switch must be held in the **center position** in operating modes T1 and T2 in order to be able to jog the robot. In the operating modes Automatic and Automatic External, the enabling switch has no function.

1.5 Electronic Safety Circuit (ESC) safety logic

Overview

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 system consists of the following components:

- CI3 board
- KCP (master)

- KPS600
- MFC (passive node)

The ESC system with its node periphery replaces all the interfaces of a conventional safety system.

The ESC safety logic monitors the following inputs:

- Local EMERGENCY STOP
- External EMERGENCY STOP
- Operator safety
- Enabling
- Drives OFF
- Drives ON
- Operating modes
- Qualifying inputs

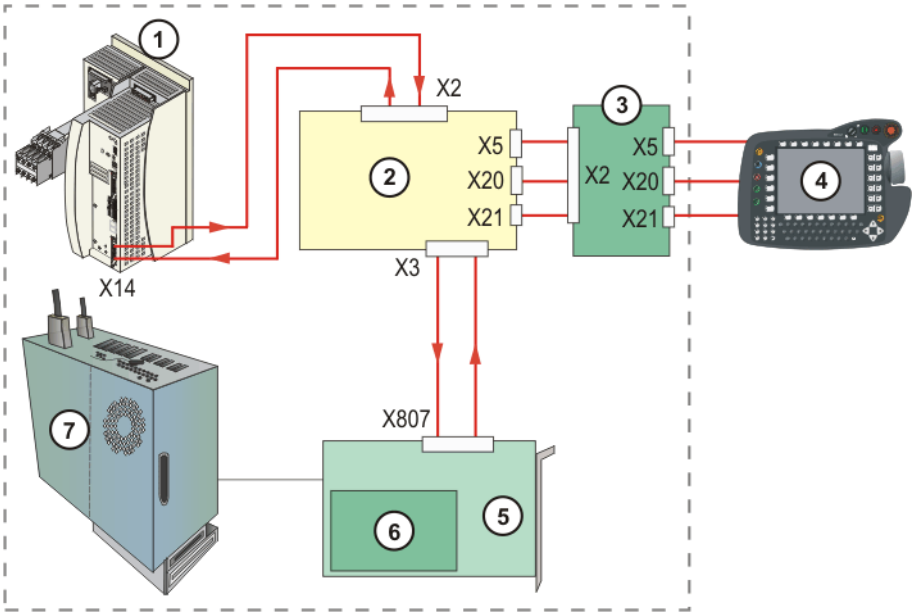

Fig. 1-8: Structure of the ESC circuit

1	KPS600	5	MFC3
2	CI3 board	6	DSE
3	KCP coupler (optional)	7	PC
4	KCP		

Node in the KCP

The node in the KCP is the master and is initialized from here.

The node receives dual-channel signals from:

- EMERGENCY STOP pushbutton
- Enabling switches

The node receives single-channel signals from:

- Drives ON
- AUTO mode, TEST mode

If no KCP coupler is used, the ESC circuit will only function with the KCP connected. If the KCP is unplugged during operation without a KCP coupler, the drives are immediately switched off.

Node in the KPS In the KPS there is an ESC node which switches off the drives contactor in the case of a fault.

Node on the MFC3 On the MFC3 board is a passive ESC node which monitors the information on the ESC circuit and then passes it on to the controller.

1.5.1 Overview of CI3 boards

Description The CI3 board links the individual nodes of the ESC system with the customer interface being used.

Various different boards are used in the robot controller according to the specific customer requirements:

Board	Own node	Description
CI3 Standard	No	Indicates the following states: ■ Local E-STOP
CI3 Extended	Yes	Indicates the following states: ■ Operating modes ■ Local E-STOP ■ Drives ON
CI3 Bus	No	Connecting board between the ESC circuit and the SafetyBUS p from PILZ
CI3 Tech	Yes	This board is required for the following components: ■ KUKA.RoboTeam ■ KUKA.SafeRobot ■ SafetyBUS Gateway ■ Output to the top-mounted cabinet (external axes) ■ Power supply to a 2nd RDC via X19A Indicates the following states: ■ Operating modes ■ Local E-STOP ■ Drives ON

1.6 Description of the power unit

Overview The power unit includes the following components:

- Power supply units
- Servo drive modules (KSD)
- Fuse elements
- Fans
- Main switch
- Mains filter

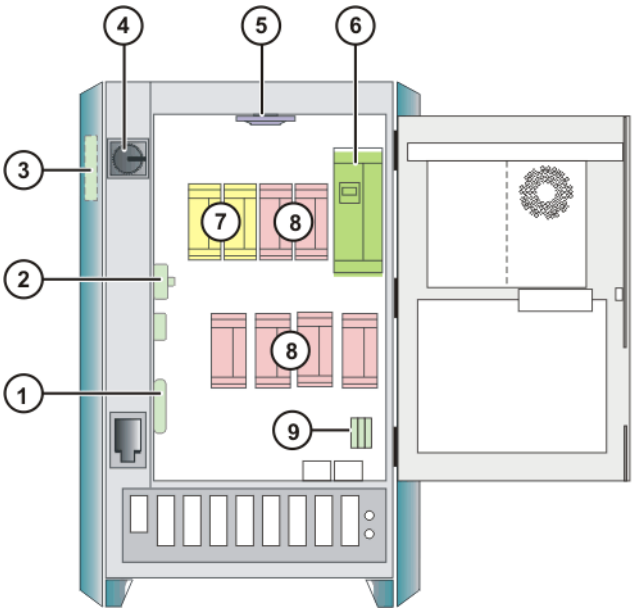

Fig. 1-9: Power unit

1	Low-voltage power supply KPS-27
2	Fuse elements (24 V without battery back-up)
3	Mains filter
4	Main switch (EU version)
5	Fan for inner cooling circuit
6	Power supply unit KPS600
7	KSDs for 2 external axes (option)
8	KSDs for 6 robot axes
9	Fuse elements (24 V with battery back-up)

1.7 Description of interfaces

Overview

The connection panel of the control cabinet consists as standard of connections for the following cables:

- Power cable / infeed
- Motor cables to the robot
- Control cables to the robot
- KCP connection

The configuration of the connection panel varies according to the customer-specific version and the options required.

Connection panel

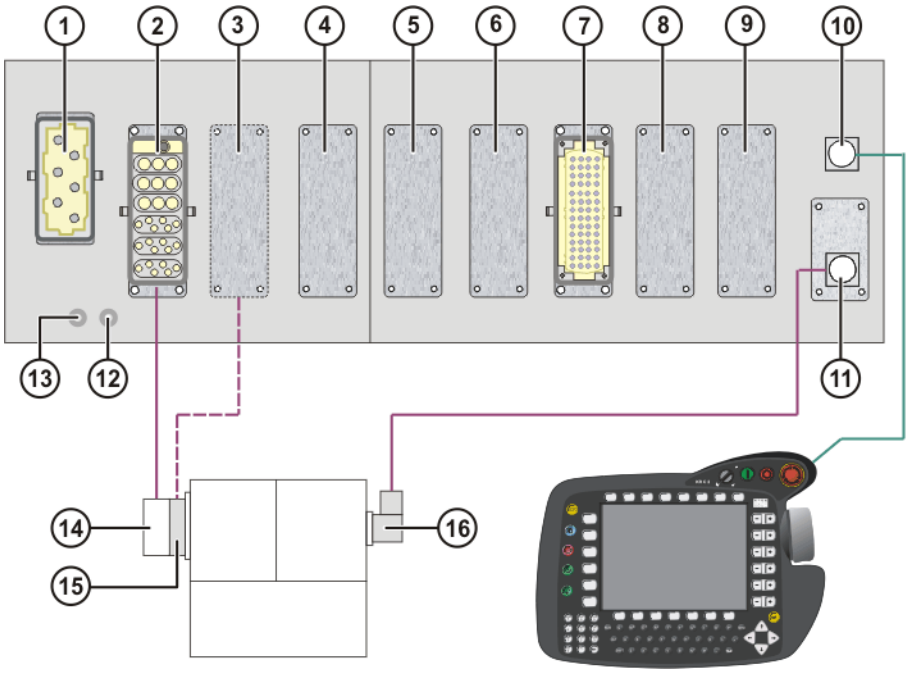

Fig. 1-10: KR C2 edition2005 connection panel

1	X1/XS1 power supply connection	9	Optional
2	X20 motor connection	10	X19 KCP connection
3	X7 motor connection	11	X21 RDC connection
4	Optional	12	PE1 ground conductor to the robot
5	Optional	13	PE2 main infeed ground conductor
6	Optional	14	X30 motor connection on the robot base
7	X11 customer interface	15	X30.2 motor connection on the robot base
8	Optional	16	X31 RDC connection on the robot base

The motor connection X7 is used for:

- Heavy-duty robots
- Robots with high payloads

All contactor, relay and valve coils that are connected to the robot controller by the user must be equipped with suitable suppressor diodes. RC elements and VCR resistors are not suitable.

1.7.1 Power supply connection X1/XS1

Description

The robot controller can be connected to the mains via the following connections:

- X1 Harting connector on the connection panel
- XS1 CEE connector; the cable is led out of the robot controller (optional)

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

Overview

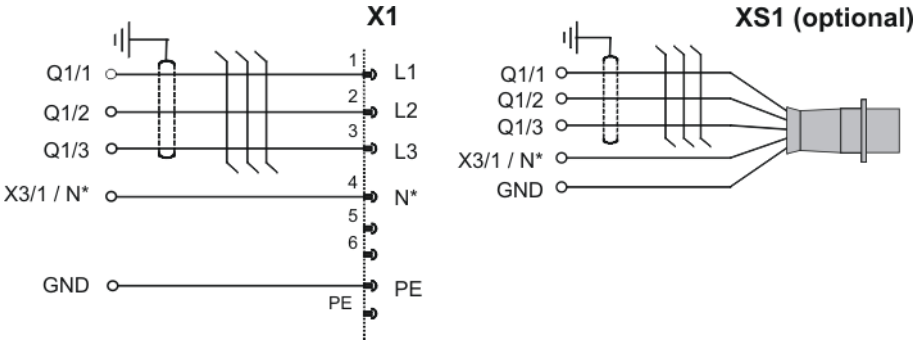

Fig. 1-11: Power supply connection

* The N-conductor is only necessary for the service socket option with a 400 V power supply.

The robot controller must only be connected to a power system with a clockwise rotating field. Only then is the correct direction of rotation of the fan motors ensured.

1.7.2 KCP connector X19

Connector pin allocation

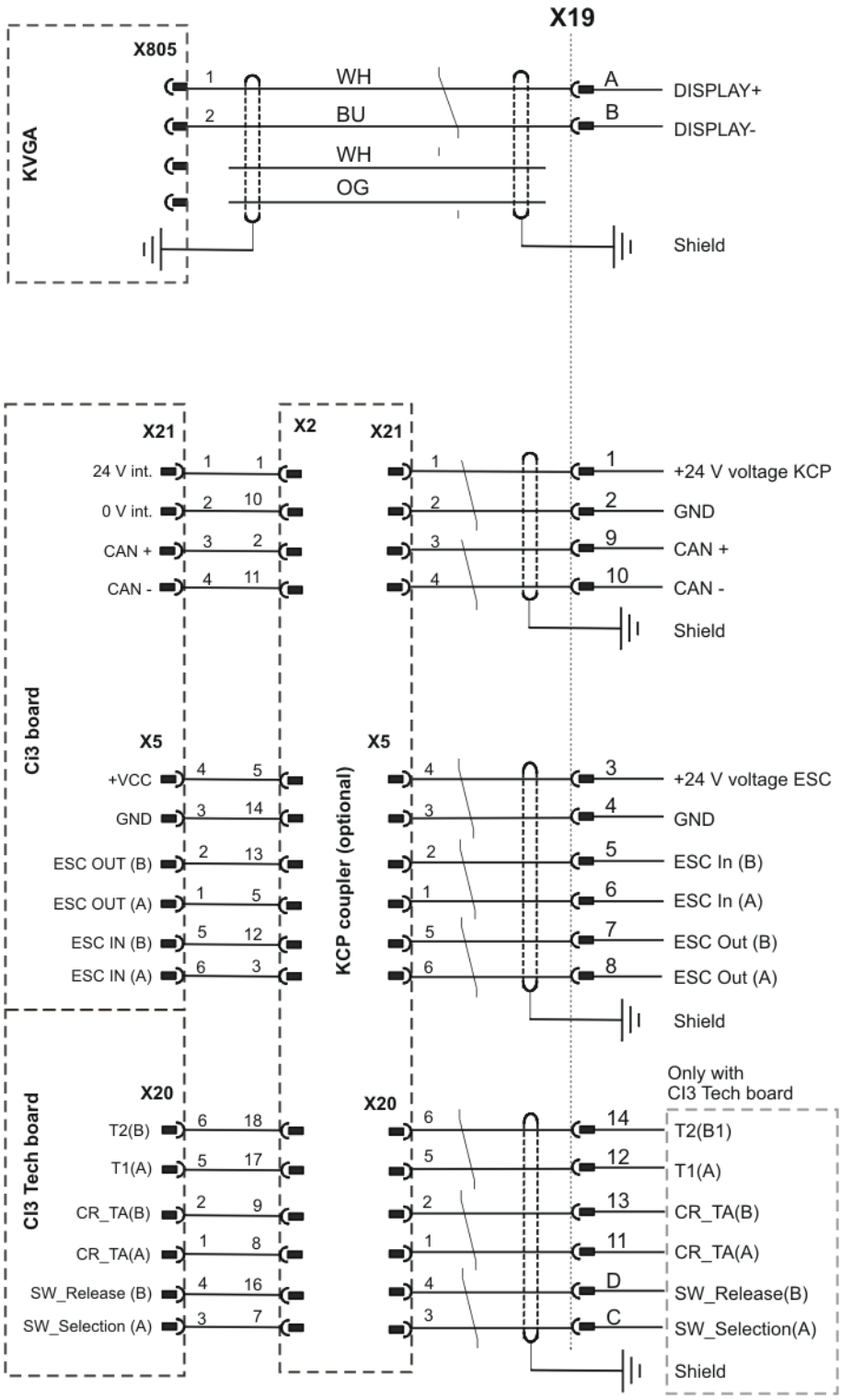

Fig. 1-12

1.7.3 Motor connector X20, axes 1 to 6

Connector pin allocation

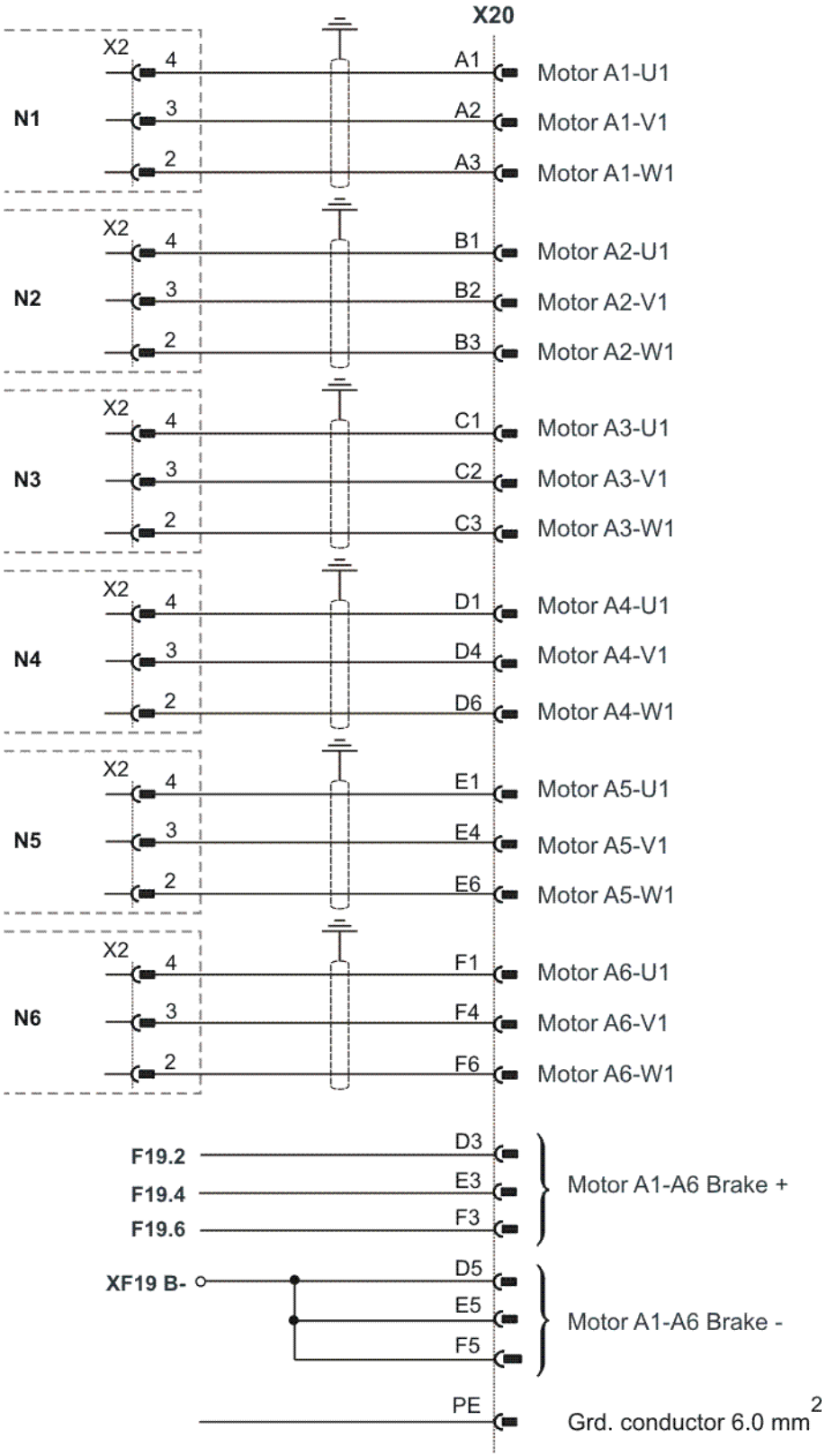

Fig. 1-13: Multiple connector X20: standard brakes

1.7.4 Motor connector X7 (optional)

Connector pin allocation

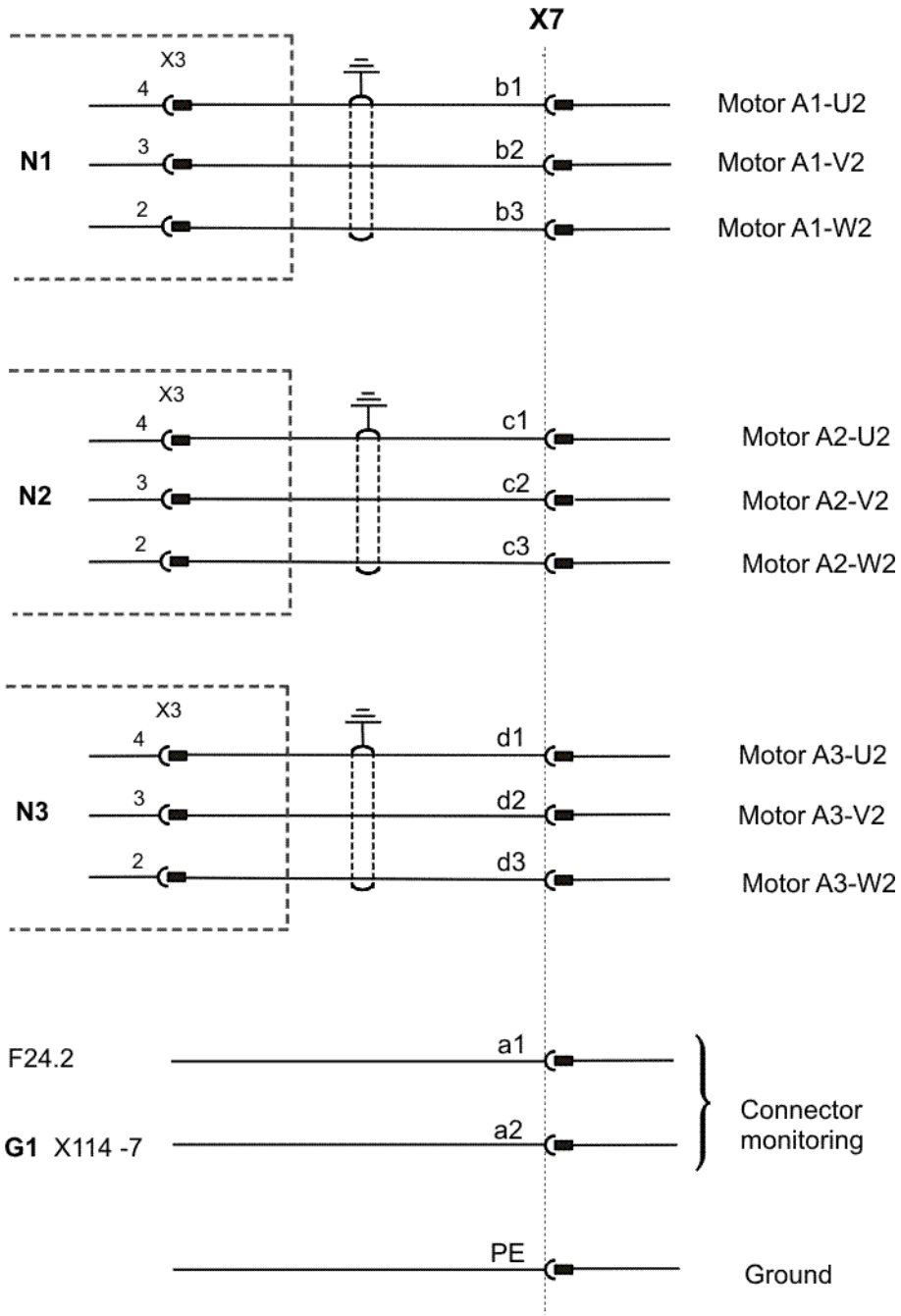

Fig. 1-14

1.7.5 Data cable X21, axes 1 to 8

Connector pin allocation

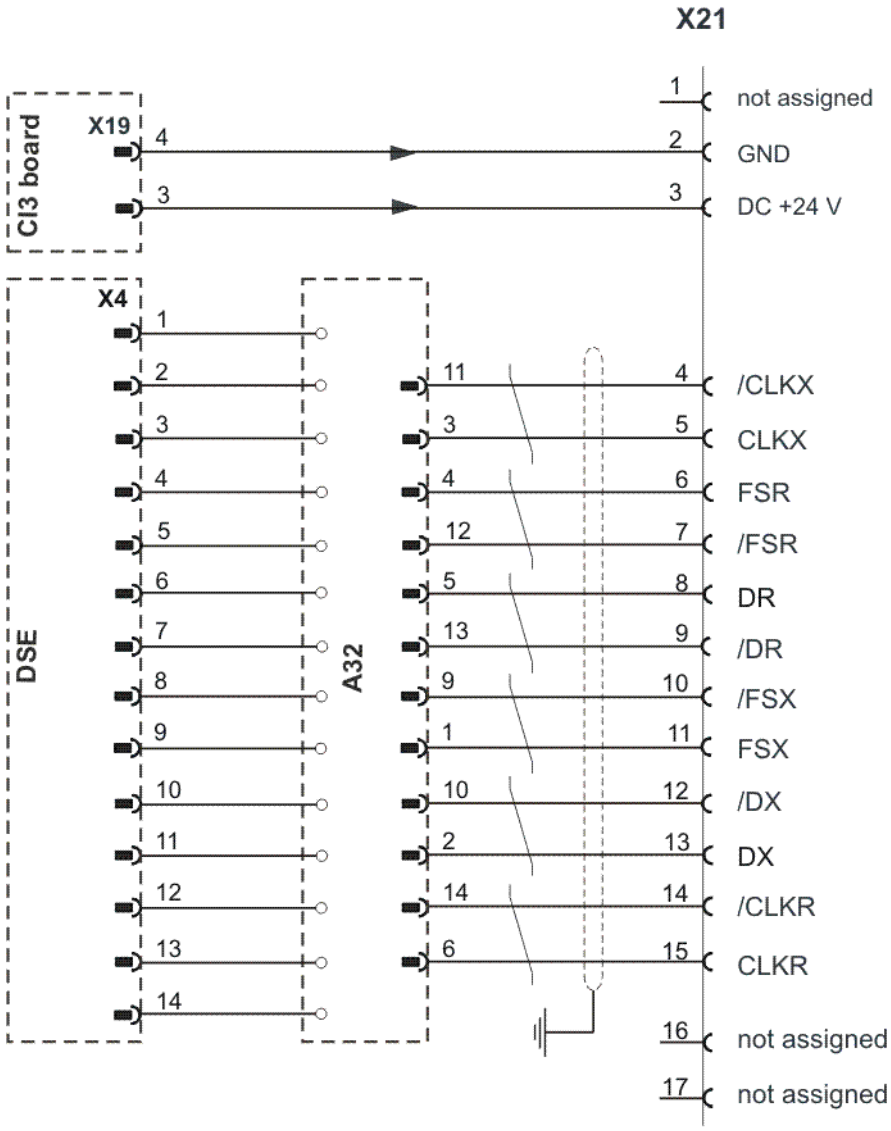

Fig. 1-15: Connector pin allocation for X21

1.8 Description of the mounting plate for customer components (optional)

Overview

The mounting plate for customer components is a mounting plate on the inside of the door which can be fitted as an option for integrating external customer equipment.

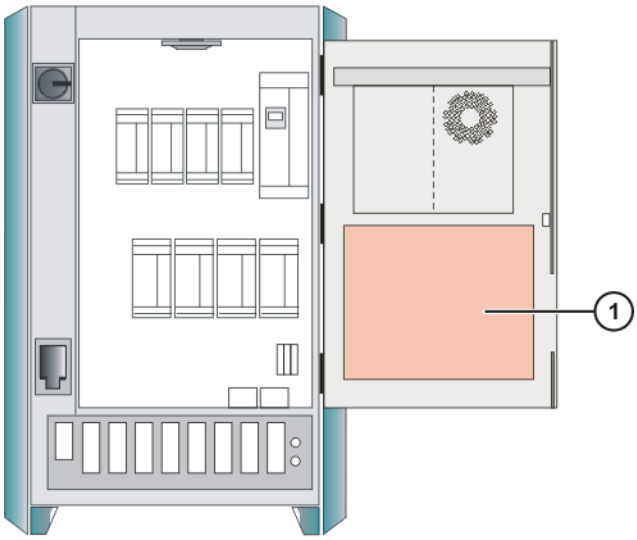

Fig. 1-16: Mounting plate for customer components

1 Mounting plate for customer components

Technical data

Designation	Values
Weight of installed components	max. 5 kg
Power dissipation of installed components	max. 20 W
Depth of installed components	180 mm
Width of mounting plate	400 mm
Height of mounting plate	340 mm

2 Technical data

2.1 Robot controller

Basic data

Control cabinet type	KR C2 edition2005
Color	See delivery note
Number of axes	Max. 8
Weight	See identification plate
Protection classification	IP 54
Sound level according to DIN 45635-1	Average: 67 dB (A)
Installation with other cabinets (with/without cooling unit)	Side-by-side, clearance 50 mm
Load on cabinet roof with even distribution	1000 N

Power supply connection

Rated supply voltage	AC 3x400 V ... AC 3x415 V
Permissible tolerance of rated voltage	400 V -10% ... 415 V +10%
Mains frequency	49 ... 61 Hz
System impedance up to the connection point of the robot controller	≤ 300 mΩ
Rated power input ▪ Standard	7.3 kVA, see rating plate
Rated power input ▪ Heavy-duty robot ▪ Palletizing robot ▪ Press-to-press robot	13.5 kVA, see rating plate
Mains-side fusing	min. 3x25 A slow-blowing, max. 3x32 A slow-blowing, see rating plate
If an RCCB is used: trip current difference	300 mA per robot controller, universal-current sensitive
Equipotential bonding	The common neutral point for the equipotential bonding conductors and all protective ground conductors is the reference bus of the power unit.

Brake control

Output voltage	25-26 V DC
Output current, brake	Max. 6 A
Monitoring	Open circuit and short circuit

Service socket (optional)

Output current	Max. 4 A
Use	The service socket may only be used for test and diagnosis equipment.

Environmental conditions

Ambient temperature during operation without cooling unit	+5 ... 45 °C (278 to 318 K)
Ambient temperature during operation with cooling unit	+5 ... 55 °C (278 to 328 K)
Ambient temperature during storage/transportation with batteries	-25 ... +40 °C (248 to 313 K)
Ambient temperature during storage/transportation without batteries	-25 ... +70 °C (248 to 343 K)
Temperature change	max. 1.1 K/min
Humidity class	3k3 acc. to DIN EN 60721-3-3; 1995
Altitude	■ up to 1000 m above mean sea level with no reduction in power ■ 1000 to 4000 m above mean sea level with a reduction in power of 5%/1000 m

Caution!
To prevent exhaustive discharge and thus destruction of the batteries, the batteries must be recharged at regular intervals according to the storage temperature.
If the storage temperature is +20 °C or lower, the batteries must be recharged every 9 months.
If the storage temperature is between +20 °C and +30 °C, the batteries must be recharged every 6 months.
If the storage temperature is between +30 °C and +40 °C, the batteries must be recharged every 3 months.

Vibration resistance

Type of loading	During transportation	During continuous operation
r.m.s. acceleration (sustained oscillation)	0.37 g	0.1 g
Frequency range (sustained oscillation)	4 - 120 Hz	
Acceleration (shock in X/Y/Z direction)	10 g	2.5 g
Waveform/duration (shock in X/Y/Z direction)	Half-sine/11 ms	

If more severe mechanical stress is expected, the controller must be installed on anti-vibration components.

Control unit

Supply voltage	25.8 to 27.3 V DC

Control PC

Main processor	See shipping version
DIMM memory modules	at least 512 MB
Hard drive	See shipping version

KUKA Control Panel

Supply voltage	25.8 to 27.3 V DC
Dimensions (WxHxD)	Approx. 33x26x8 cm^3
VGA display resolution	640x480 pixels
VGA display size	8"
Protection classification	Top of KCP IP54 Underside of KCP IP23
Weight	1.4 kg

Cable lengths

The designations and standard and optional lengths may be noted from the following table.

Cable	Standard length in m	Optional length in m
Motor cable	7	15 / 25 / 35 / 50
Data cable	7	15 / 25 /35 / 50
Power cable with XS1 (optional)	3	-

Cable	Standard length in m	Extension in m
KCP cable	10	10 / 20 / 30/ 40

When using KCP cable extensions only **one** may be employed at a time, and a total cable length of 60 m must not be exceeded.

2.2 Dimensions of robot controller

The dimensions of the robot controller are indicated in the diagram (>>> Fig. 2-1).

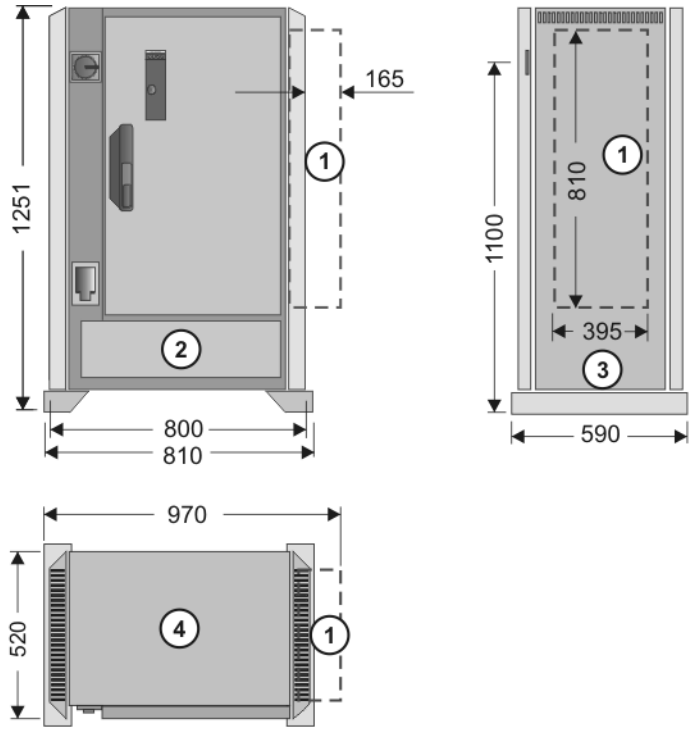

Fig. 2-1: Dimensions (in mm)

1	Cooling unit (optional)	3	Side view
2	Front view	4	Top view

2.3 Minimum clearances, robot controller

The minimum clearances that must be maintained for the robot controller are indicated in the diagram (>>> Fig. 2-2).

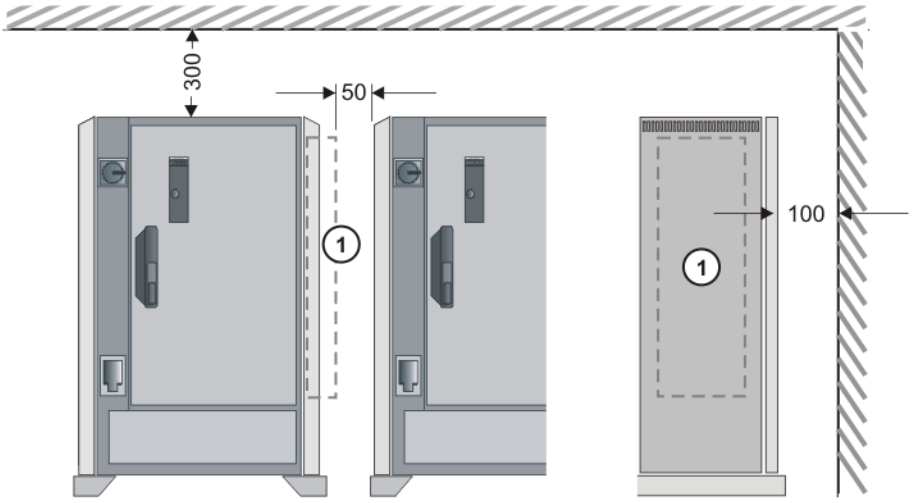

Fig. 2-2: Minimum clearances (dimensions in mm)

1 Cooling unit (optional)

Warning!
If the minimum clearances are not maintained, this can result in damage to the robot controller. The specified minimum clearances must always be observed.

Certain maintenance and repair tasks on the robot controller must be carried out from the side or from the rear. The robot controller must be accessible for this. If the side or rear panels are not accessible, it must be possible to move the robot controller into a position in which the work can be carried out.

2.4 Minimum clearances, top-mounted / technology cabinet

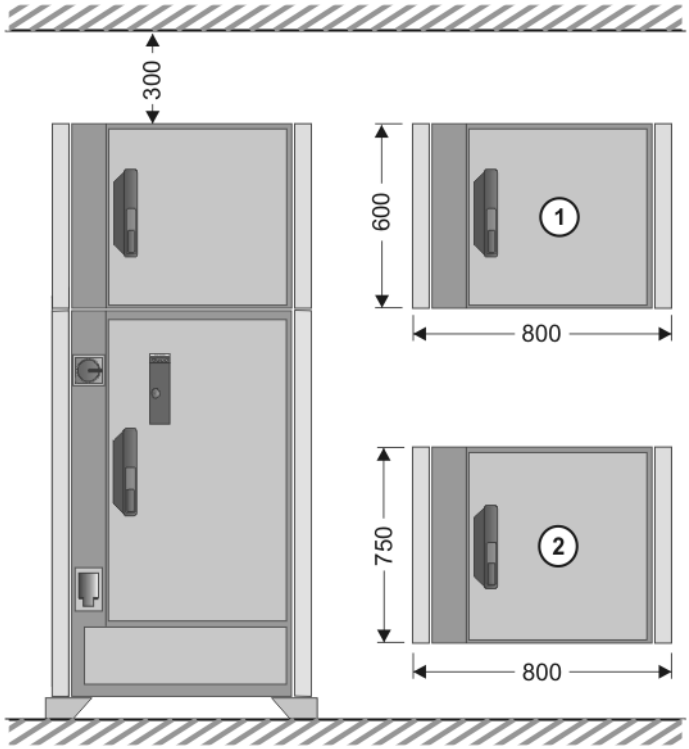

Fig. 2-3: Minimum clearances with top-mounted / technology cabinet

1 Top-mounted cabinet (optional)
2 Technology cabinet (optional)

2.5 Dimensions of boreholes for floor mounting

The dimensions of the boreholes for floor mounting are indicated in the diagram (>>> Fig. 2-4).

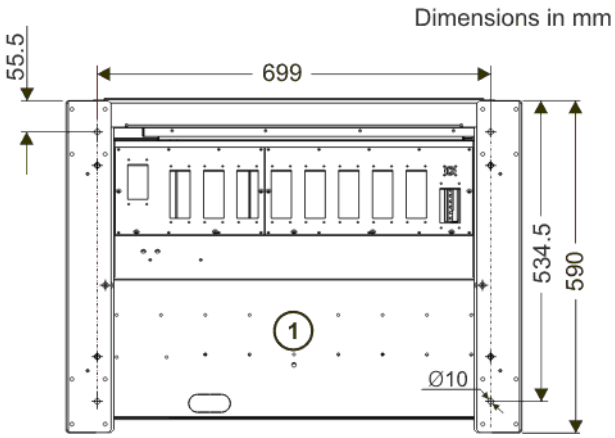

Fig. 2-4: Boreholes for floor mounting

1 View from below

2.6 Swing range for cabinet door

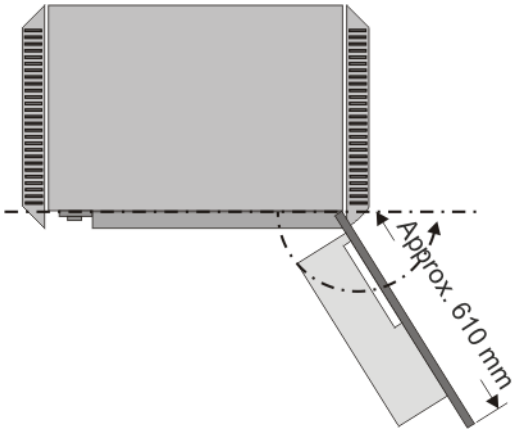

Fig. 2-5: Swing range for cabinet door

Swing range, standalone cabinet:

- Door with computer frame approx. 180°

Swing range, butt-mounted cabinets:

- Door approx. 155°

3 Safety

3.1 General

3.1.1 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.

3.1.2 Intended use of the industrial robot

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

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

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

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

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

Misuse

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

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

3.1.3 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.

3.1.4 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.

3.2 Personnel

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

- User
- Personnel

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

User

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

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

Personnel

Personnel must be instructed, before any work is commenced, in the type of work involved and what exactly it entails as well as any hazards which may 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

Tasks	Operator	Programmer	System integrator
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.

3.3 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.

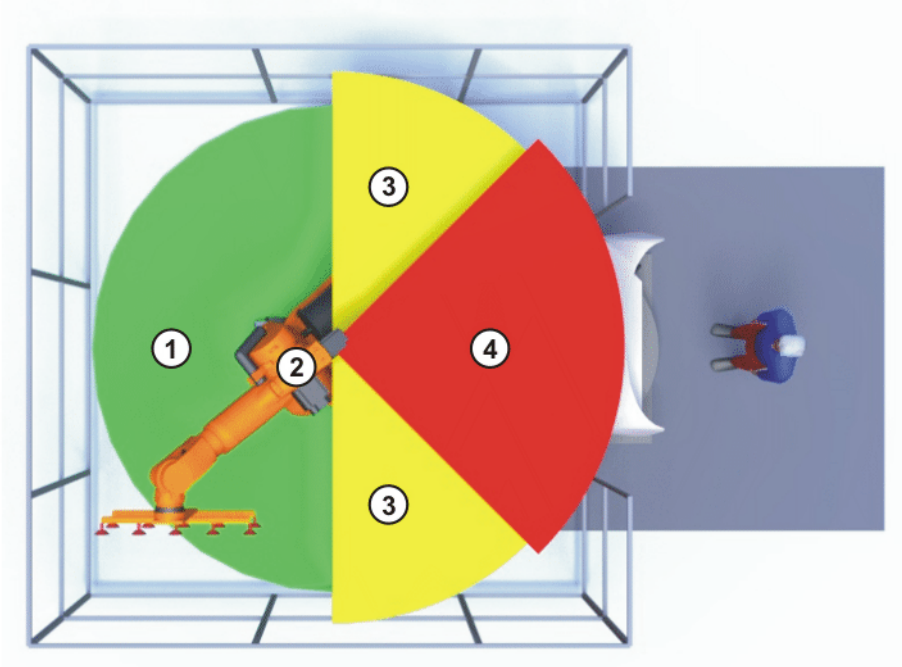

Fig. 3-1: Example of axis range A1

1	Workspace	3	Stopping distance
2	Manipulator	4	Safety zone

3.4 Triggers for stop reactions

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

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

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

3.5 Safety functions

3.5.1 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
- External enabling device
- Local safety stop via qualifying input
- RoboTeam: disabling of robots that have not been selected

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

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

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

3.5.2 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
- External enabling device
- Drives OFF
- Drives ON
- Operating modes
- Qualifying inputs

The ESC safety logic monitors the following outputs:

- Operating mode
- Drives ON
- Local E-STOP

3.5.3 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.

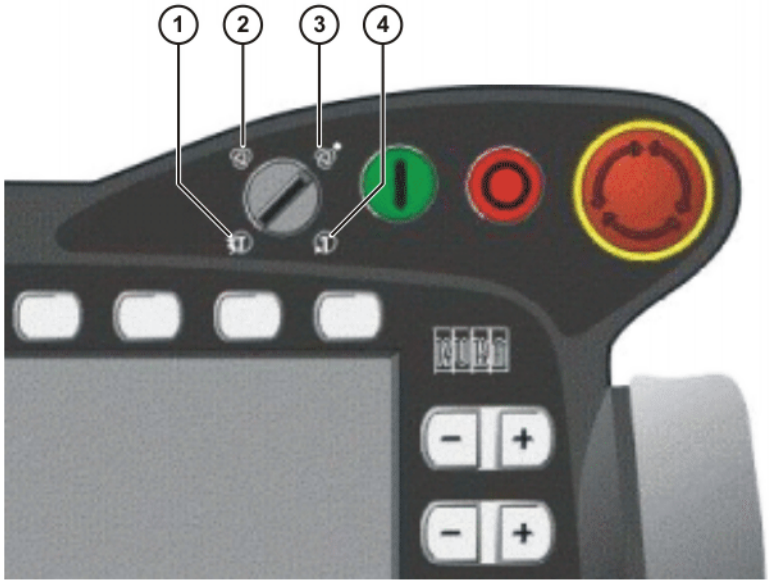

Fig. 3-2: Mode selector switch

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

3.5.4 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 possi-

ble. 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.

3.5.5 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. 3-3: 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.

3.5.6 External EMERGENCY STOP device

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

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

3.5.7 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. 3-4: Enabling switches on the KCP

1 - 3 Enabling switches

3.5.8 External enabling device

External enabling devices are required if it is necessary for more than one person to be in the danger zone of the industrial robot. 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 industrial robot.

3.6 Additional protective equipment

3.6.1 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.

3.6.2 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.

3.6.3 Mechanical end stops

The axis ranges of main axes A1 to A3 and wrist axis A5 of the manipulator are limited by means of mechanical end stops with buffers.

Additional mechanical end stops can be installed on the external axes.

Warning!
If the manipulator or an external axis hits an obstruction or a buffer on the mechanical end stop or axis range limitation, this can result in material damage to the industrial robot. KUKA Roboter GmbH must be consulted before the industrial robot is put back into operation (>>> 7 "KUKA Service" Page 79). The affected buffer must be replaced with a new one before operation of the industrial robot is resumed. If a manipulator (or external axis) collides with a buffer at more than 250 mm/s, the manipulator (or external axis) must be exchanged or recommissioning must be carried out by KUKA Roboter GmbH.

3.6.4 Mechanical axis range limitation (optional)

Some manipulators can be fitted with mechanical axis range limitation in axes A 1 to A 3. The adjustable axis range limitation systems restrict the working range to the required minimum. This increases personal safety and protection of the system.

In the case of manipulators that are not designed to be fitted with mechanical axis range limitation, the workspace must be laid out in such a way that there is no danger to persons or material property, even in the absence of mechanical axis range limitation.

If this is not possible, the workspace must be limited by means of photoelectric barriers, photoelectric curtains or obstacles on the system side. There must be no shearing or crushing hazards at the loading and transfer areas.

This option is not available for all robot models. Information on specific robot models can be obtained from KUKA Roboter GmbH.

3.6.5 Axis range monitoring (optional)

Some manipulators can be fitted with dual-channel axis range monitoring systems in main axes A1 to A3. The positioner axes may be fitted with additional axis range monitoring systems. The safety zone for an axis can be adjusted and monitored using an axis range monitoring system. This increases personal safety and protection of the system.

This option is not available for all robot models. Information on specific robot models can be obtained from KUKA Roboter GmbH.

3.6.6 Release device (optional)

Description

The release device can be used to move the manipulator manually after an accident or malfunction. The release device can be used for the main axis drive motors and, depending on the robot variant, also for the wrist axis drive motors. It is only for use in exceptional circumstances and emergencies (e.g. for freeing people).

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

Procedure

1. Switch off the robot controller and secure it (e.g. with a padlock) to prevent unauthorized persons from switching it on again.
2. Remove the protective cap from the motor.
3. Push the release device onto the corresponding motor and move the axis in the desired direction.

   The directions are indicated with arrows on the motors. It is necessary to overcome the resistance of the mechanical motor brake and any other loads acting on the axis.

Warning!
Moving an axis with the release device can damage the motor brake. This can result in personal injury and material damage. After using the release device, the affected motor must be exchanged.

3.6.7 KCP coupler (optional)

The KCP coupler allows the KCP to be connected and disconnected with the robot controller running.

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.

Further information is contained in the operating instructions or installation instructions for the robot controller.

3.6.8 Labeling on the industrial robot

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

Labeling on the industrial robot consists of:

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

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

3.6.9 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.

3.7 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

3.8 Safety measures

3.8.1 General safety measures

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

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

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

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

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

KCP

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

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

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

External keyboard, external mouse

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

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

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

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

Faults

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

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

Modifications

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

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

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

3.8.2 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:

- E-STOP pushbutton, mode selector switch

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

  If relays are switched on at an output, they must be switched off at least once every 6 months in order to detect any malfunction.

Additional checks are required during start-up and recommissioning.

(>>> 3.8.4 "Start-up and recommissioning" Page 45)

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.

3.8.3 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.

3.8.4 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.

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

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

Interruptions/ cross-connections

Interruptions or cross-connections affecting safety functions and not detected by the robot controller or SafeRDC must either be precluded (e.g. by the construction) or detected by the customer (e.g. by means of a PLC or by testing the outputs).

Recommendation: design the construction in such a way as to preclude cross-connections. For this, observe the remarks in EN ISO 13849-2, tables D.5, D.6 and D.7.

Overview: possible cross-connections that are not detected by the robot controller or SafeRDC

Cross-connection	Possible in the case of …
Cross-connection to 0 V	■ ESC output Drives ON ■ ESC output E-STOP
Cross-connection to 24 V	■ ESC output Drives ON ■ ESC output E-STOP ■ ESC output Operating Mode ■ SafeRDC inputs
Cross-connection between the contacts of an output	■ ESC output Drives ON ■ ESC output E-STOP ■ ESC output Operating Mode
Cross-connection between the contacts of different outputs	
Cross-connection of an ESC output with an ESC input	
Cross-connection between the channels of different ESC inputs	ESC inputs
Cross-connection between 2 SafeRDC inputs	SafeRDC inputs
Cross-connection of a SafeRDC output with a SafeRDC input	SafeRDC outputs, SafeRDC inputs

Function test

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

General test:

It must be ensured that:

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

Test of safety-oriented circuits:

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

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

Test of reduced velocity control:

This test is to be carried out as follows:

1. Program a straight path with the maximum possible velocity.

2. Calculate the length of the path.
3. Execute the path in T1 mode with the override set to 100% and time the motion with a stopwatch.

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

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

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

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

Machine data

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

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

3.8.5 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.

3.8.6 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.

3.8.7 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.

3.8.8 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.

3.8.9 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 operation-

al state. Repair work includes troubleshooting in addition to the actual repair itself.

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

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

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

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

Robot controller

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

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

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

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

Counterbalancing system

Some robot variants are equipped with a hydropneumatic, spring or gas cylinder counterbalancing system.

The hydropneumatic and gas cylinder counterbalancing systems are pressure equipment and, as such, are subject to obligatory equipment monitoring. Depending on the robot variant, the counterbalancing systems correspond to category 0, II or III, fluid group 2, of the Pressure Equipment Directive.

The user must comply with the applicable national laws, regulations and standards pertaining to pressure equipment.

Inspection intervals in Germany in accordance with Industrial Safety Order, Sections 14 and 15. Inspection by the user before commissioning at the installation site.

The following safety measures must be carried out when working on the counterbalancing system:

- The manipulator assemblies supported by the counterbalancing systems must be secured.
- Work on the counterbalancing systems must only be carried out by qualified personnel.

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.

3.8.10 Decommissioning, storage and disposal

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

3.8.11 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.

3.9 Applied norms and regulations

Name	Definition	Edition
2006/42/EC	Machinery Directive: Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)	2006
2004/108/EC	EMC Directive: Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC.	2004
97/23/EC	Pressure Equipment Directive: Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment	1997
EN ISO 13850	Safety of machinery: Emergency stop - Principles for design	2008
EN ISO 13849-1	Safety of machinery: Safety-related parts of control systems - Part 1: General principles for 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
EN ISO 10218-1	Industrial robots: Safety	2008
EN 614-1	Safety of machinery: Ergonomic design principles - Part 1: Terminology and general principles	2006

Name	Definition	Edition
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

4 Planning

4.1 Electromagnetic compatibility (EMC)

Description

If connecting cables (e.g. field buses, etc.) are routed to the control PC from outside, only shielded cables with an adequate degree of shielding may be used. The cable shield must be connected with maximum surface area to the PE rail in the cabinet using shield terminals (screw-type, no clamps).

The robot controller may only be operated in an **industrial environment**.

4.2 Installation conditions

Dimensions

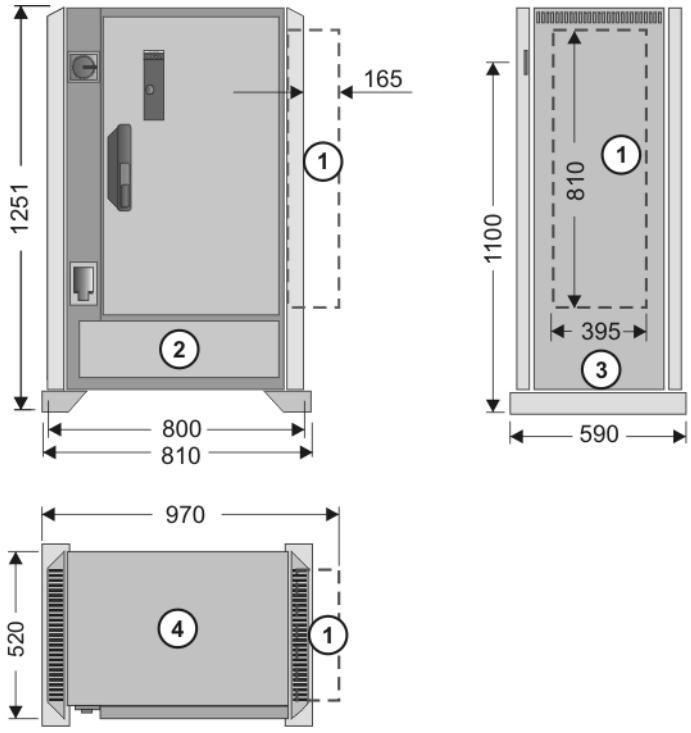

Fig. 4-1: Dimensions (in mm)

1	Cooling unit (optional)	3	Side view
2	Front view	4	Top view

The minimum clearances that must be maintained for the robot controller are indicated in the diagram (>>> Fig. 4-2).

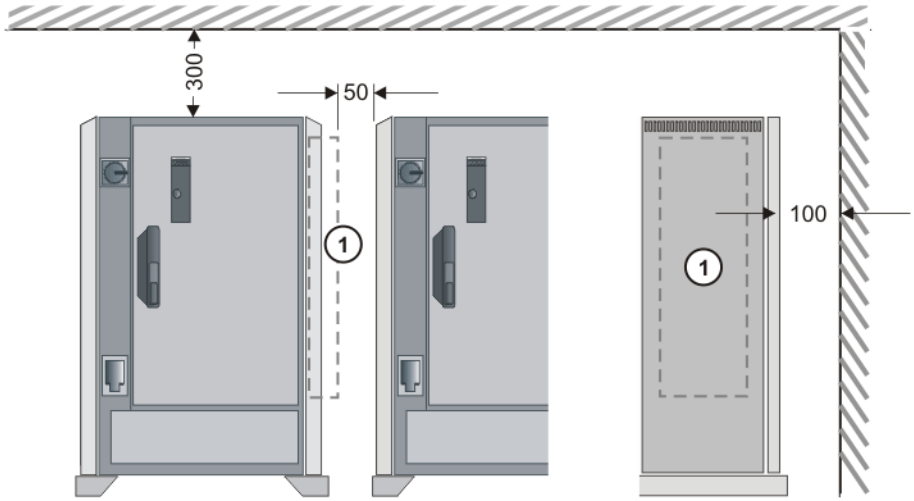

Fig. 4-2: Minimum clearances (dimensions in mm)

1 Cooling unit (optional)

Warning!
If the minimum clearances are not maintained, this can result in damage to the robot controller. The specified minimum clearances must always be observed.

Certain maintenance and repair tasks on the robot controller must be carried out from the side or from the rear. The robot controller must be accessible for this. If the side or rear panels are not accessible, it must be possible to move the robot controller into a position in which the work can be carried out.

Minimum clearances with top-mounted cabinet

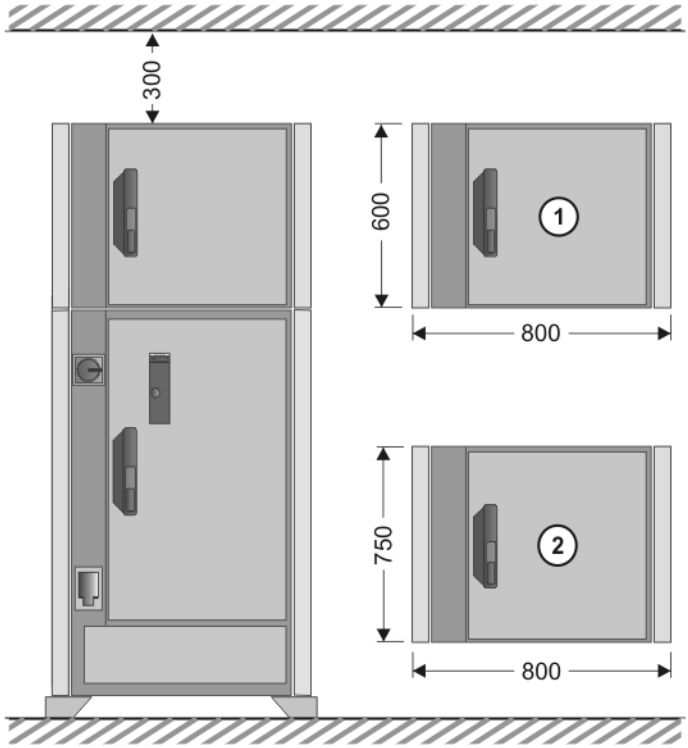

Fig. 4-3: Minimum clearances with top-mounted / technology cabinet

1 Top-mounted cabinet 2 Technology cabinet

Swing range for door

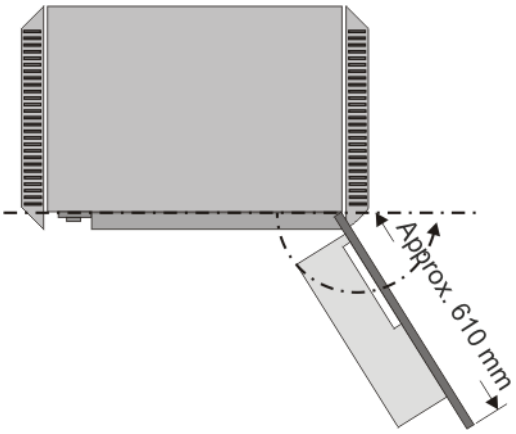

Fig. 4-4: Swing range for cabinet door

Swing range, standalone cabinet:

- Door with computer frame approx. 180°

Swing range, butt-mounted cabinets:

- Door approx. 155°

Boreholes

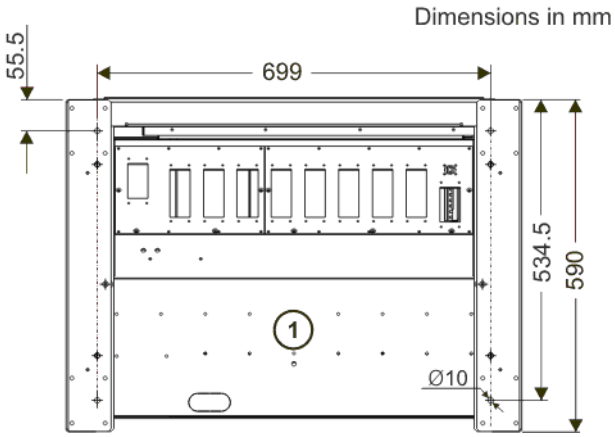

Fig. 4-5: Boreholes for floor mounting

1 Top view
2 View from below

4.3 Connection conditions

Power supply connection

Rated supply voltage	AC 3x400 V ... AC 3x415 V
Permissible tolerance of rated voltage	400 V -10% ... 415 V +10%
Mains frequency	49 ... 61 Hz
System impedance up to the connection point of the robot controller	≤ 300 mΩ
Rated power input ■ Standard	7.3 kVA, see rating plate

Rated power input ■ Heavy-duty robot ■ Palletizing robot ■ Press-to-press robot	13.5 kVA, see rating plate
Mains-side fusing	min. 3x25 A slow-blowing, max. 3x32 A slow-blowing, see rating plate
If an RCCB is used: trip current difference	300 mA per robot controller, universal-current sensitive
Equipotential bonding	The common neutral point for the equipotential bonding conductors and all protective ground conductors is the reference bus of the power unit.

Caution!
If the system impedance of 300 mΩ is exceeded, it is possible that, in unfavorable circumstances, the power fuse of the servo drives cannot be triggered or can only be triggered after a long delay in the event of ground faults. The system impedance up to the connection point of the robot controller must be ≤ 300 mΩ.

Caution!
If the robot controller is operated with a supply voltage other than that specified on the rating plate, this may cause malfunctions in the robot controller and material damage to the power supply units. The robot controller may only be operated with the supply voltage specified on the rating plate.

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

This device meets the requirements of EN55011 Class A and may be operated in power supply systems with their own low-voltage power supply (transformer station, power plant). The device may be operated in public power supply systems subject to prior approval by the power utility concerned.

Cable lengths

The designations and standard and optional lengths may be noted from the following table.

Cable	Standard length in m	Optional length in m
Motor cable	7	15 / 25 / 35 / 50
Data cable	7	15 / 25 /35 / 50
Power cable with XS1 (optional)	3	-

Cable	Standard length in m	Extension in m
KCP cable	10	10 / 20 / 30/ 40

When using KCP cable extensions only **one** may be employed at a time, and a total cable length of 60 m must not be exceeded.

4.4 Power supply connection

Description

The robot controller can be connected to the mains via the following connections:

- X1 Harting connector on the connection panel
- XS1 CEE connector; the cable is led out of the robot controller (optional)

Overview

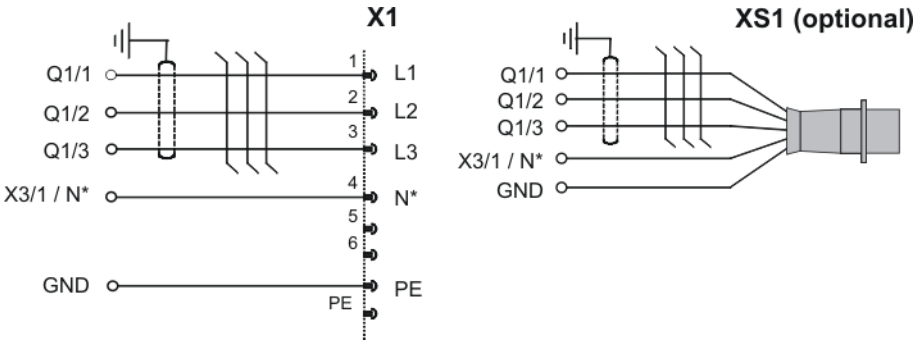

Fig. 4-6: Power supply connection

* The N-conductor is only necessary for the service socket option with a 400 V power supply.

The robot controller must only be connected to a power system with a clockwise rotating field. Only then is the correct direction of rotation of the fan motors ensured.

4.4.1 Power supply connection via X1 Harting connector

Description

A Harting connector bypack is supplied with the robot controller. The customer can connect the robot controller to the power supply via connector X1.

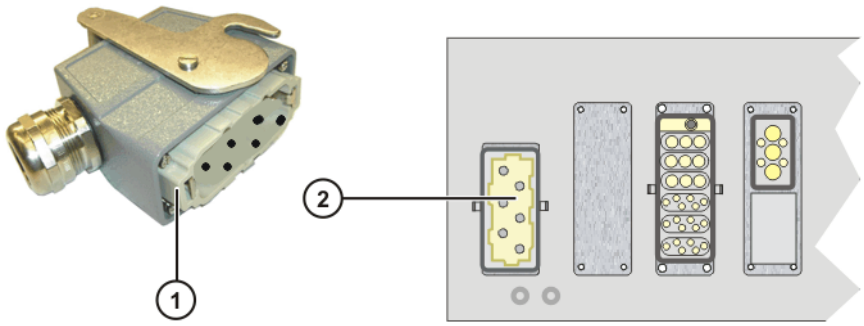

Fig. 4-7: Power supply connection X1

1 Harting connector bypack (optional)
2 Power supply connection X1

4.4.2 Power supply connection via CEE connector XS1

Description

With this option, the robot controller is connected to the power supply via a CEE connector. The cable is approx. 3 m long and is routed to the main switch via a cable gland.

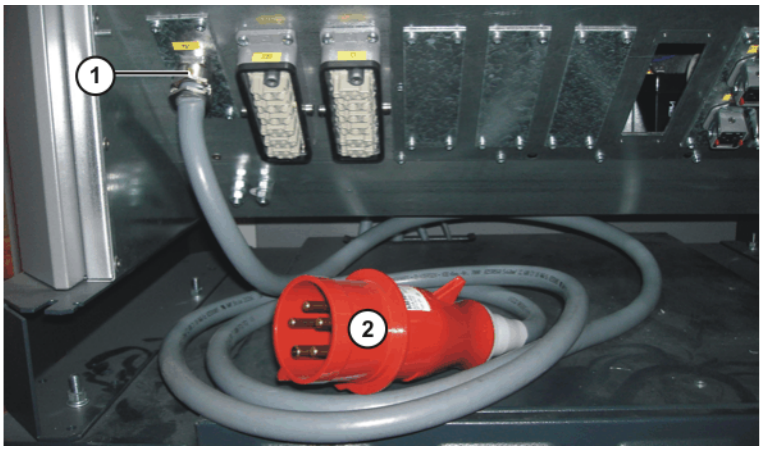

Fig. 4-8: Power supply connection XS1

1 Cable gland
2 CEE connector

4.5 EMERGENCY STOP circuit and safeguard

The following examples show how the EMERGENCY STOP circuit and safeguard of the robot system can be connected to the periphery.

Example

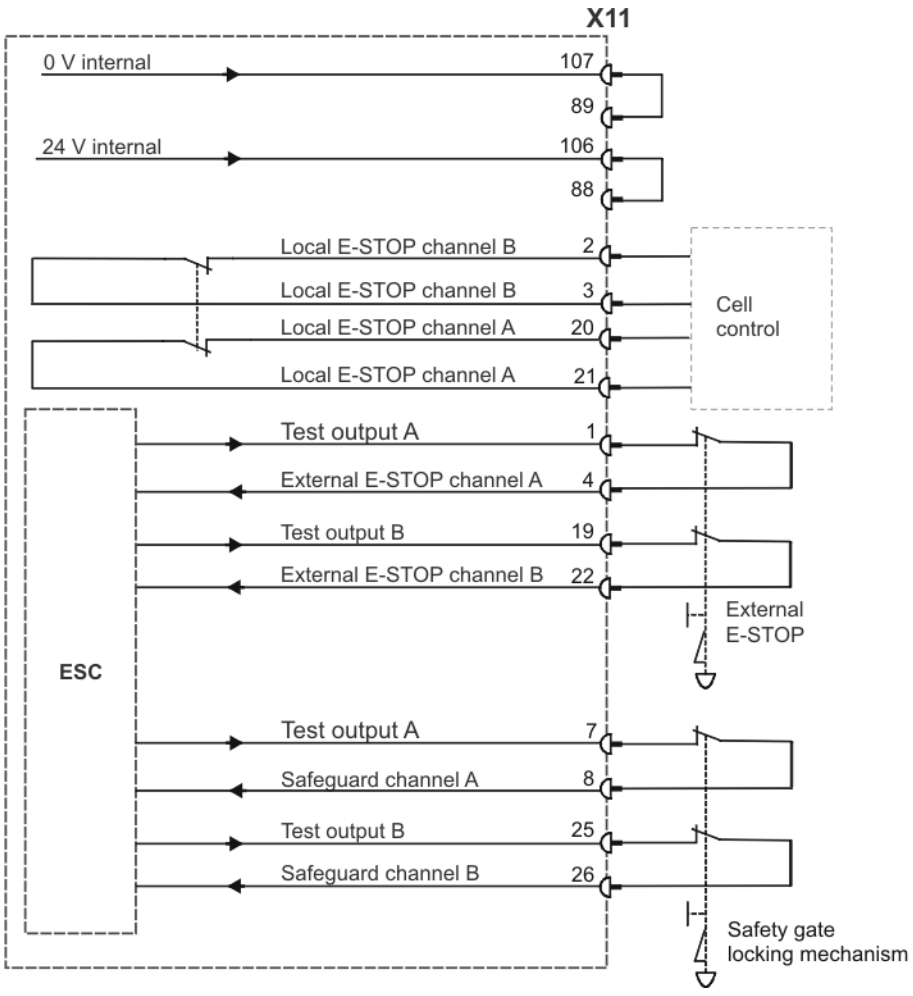

Fig. 4-9: Robot with periphery

Example

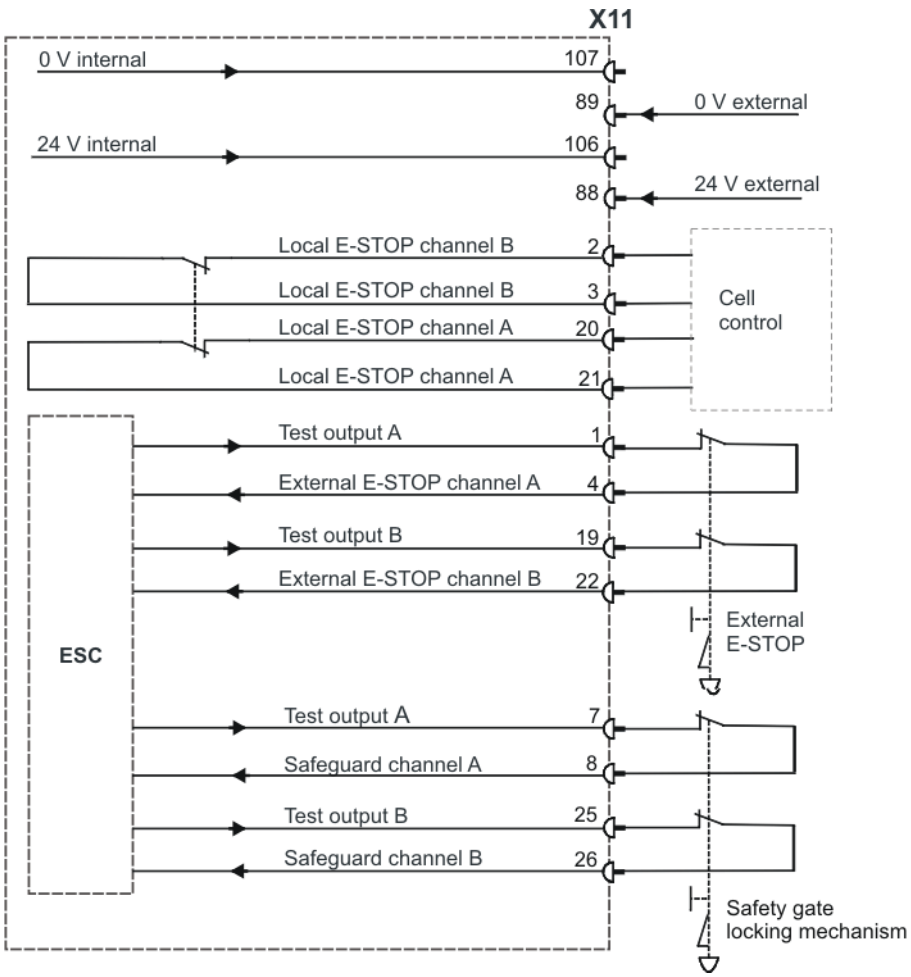

Fig. 4-10: Robot with periphery and external power supply

Example

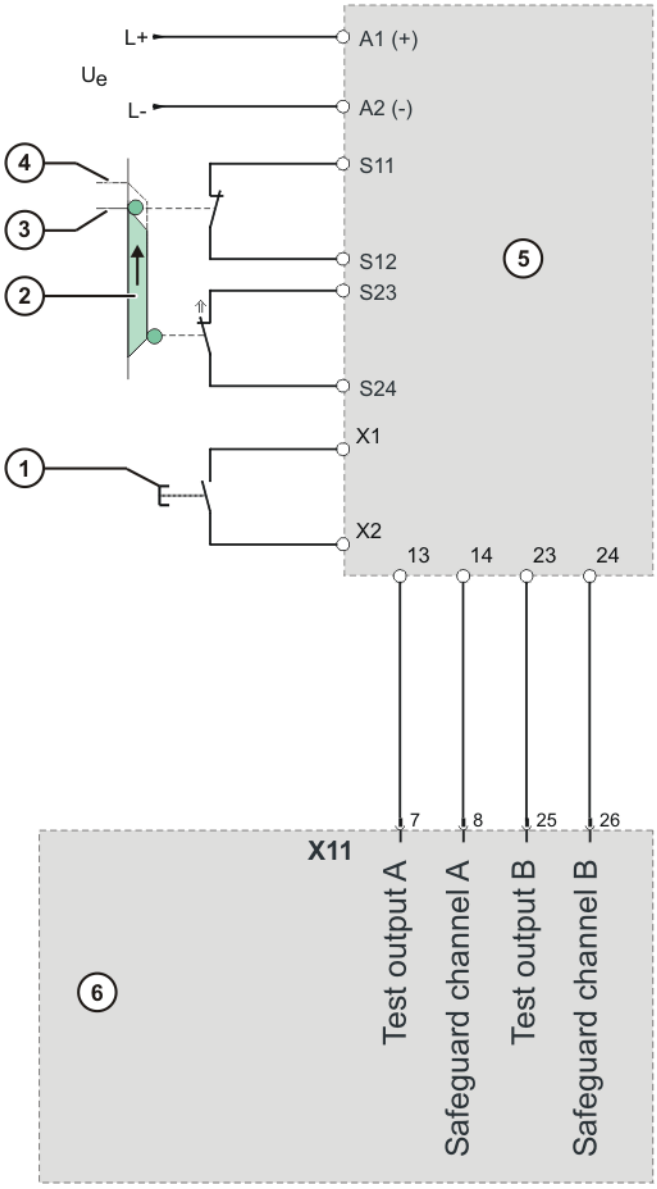

Fig. 4-11: Safety gate monitor

Item	Element	Description
1	Enabling pushbutton with safety gate closed	The pushbutton must be installed outside the safe-guarded zone.
2	Gate position switches	-
3	Gate position switch, safety gate closed	-
4	Gate position switch, safety gate open	-
5	Safety gate monitor	e.g. PST3 manufactured by Pilz
6	Interface X11	-

4.6 Interface X11

Description EMERGENCY STOP devices must be connected via interface X11 or linked together by means of higher-level controllers (e.g. PLC).

Wiring

Take the following points into consideration when wiring interface X11:

- System concept
- Safety concept

Various signals and functions are available, depending on the specific CI3 board. (>>> 1.5.1 "Overview of CI3 boards" Page 14)

Detailed information about integration into higher-level controllers is contained in the Operating and Programming Instructions for System Integrators, in the chapter “Automatic External signal diagrams”.

Connector pin allocation

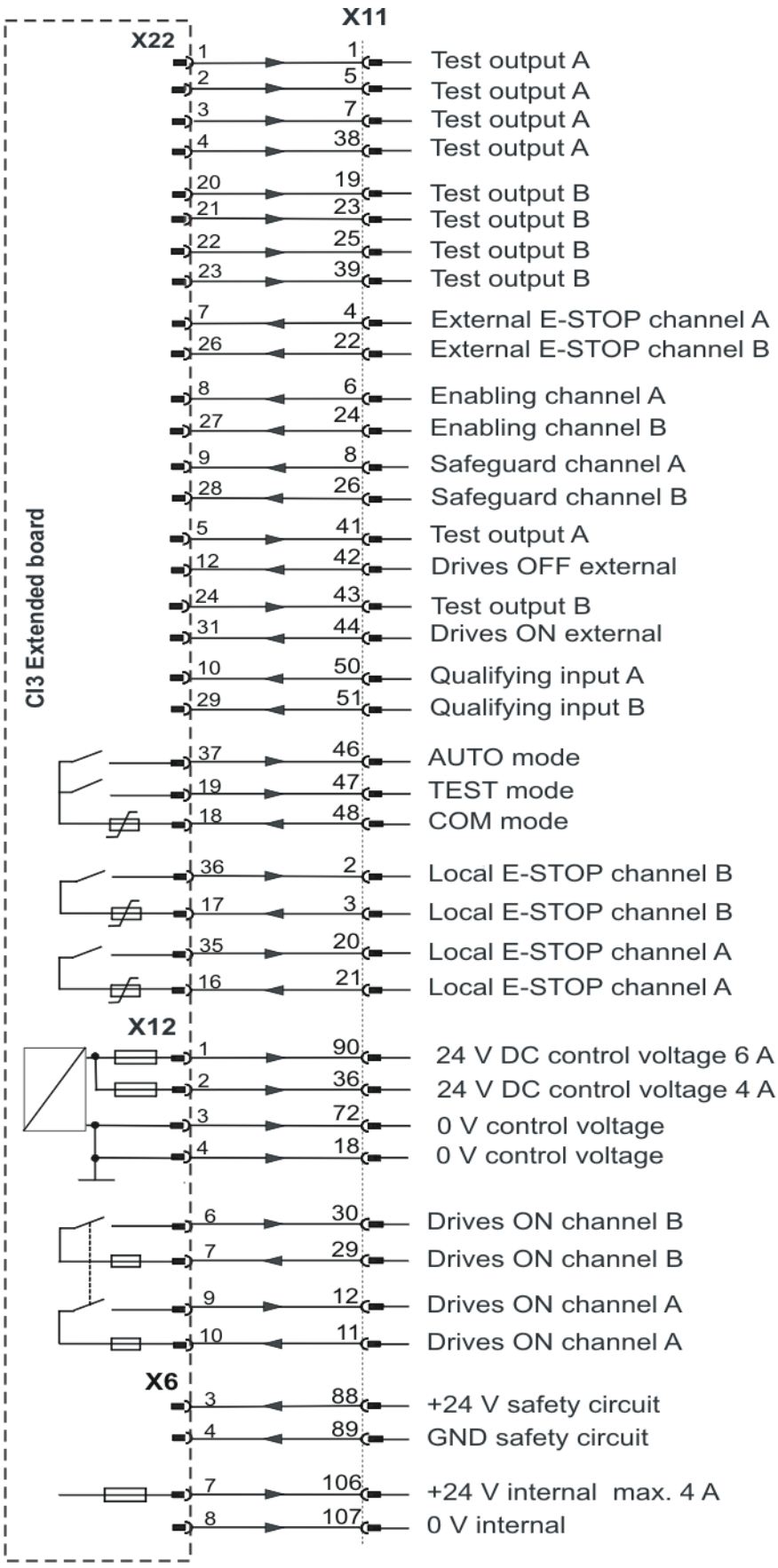

Fig. 4-12

Signal	Pin	Description	Comments
+24 V internal 0 V internal	106 107	ESC power supply max. 2 A	
24 V external 0 V external	88 89	In the absence of an external power supply, 24 V / 0 V must be jumpered internally.	An external power supply is recommended for interlinked systems.
+24 V 0 V	36 18	24 V control voltage for supply to external devices, max. 4 A.	Optional
+24 V 0 V	90 72	24 V control voltage for supply to external devices, max. 6 A.	Optional
Test output A (test signal)	1 5 7 38 41	Makes the pulsed voltage available for the individual interface inputs of channel A.	Connection example: enabling switch is connected under channel A to pin 1 (TA_A) and pin 6.
Test output B (test signal)	19 23 25 39 43	Makes the pulsed voltage available for the individual interface inputs of channel B.	Connection example: safety gate locking mechanism is connected under channel B to pin 19 (TA_B) and pin 26.
Local E-STOP channel A	20 / 21	Output, floating contacts from internal E-STOP, max. 24 V, 600 mA	In the non-activated state, the contacts are closed.
Local E-STOP channel B	2 / 3		
External E-STOP channel A	4	E-STOP, dual-channel input, max. 24 V, 10 mA.	
External E-STOP channel B	22		
Enabling channel A	6	For connection of an external dual-channel enabling switch with floating contacts max. 24 V, 10 mA	If no enabling switch is connected, pins 5 and 6 and pins 23 and 24 must be jumpered. Only effective in TEST mode.
Enabling channel B	24		
Safeguard channel A	8	For dual-channel connection of a safety gate locking mechanism, max. 24 V, 10 mA	Only effective in AUTOMATIC mode.
Safeguard channel B	26		
Drives OFF external, channel A (single-channel)	42	A floating contact (break contact) can be connected to this input. If the contact opens, the drives are switched off, max. 24 V, 10 mA.	If this input is not used, pins 41/42 must be jumpered.
Drives ON external, channel B (single-channel)	44	For connection of a floating contact.	Pulse > 200 ms switches the drives on. Signal must not be permanently active.
Drives ON channel B	29 / 30	Floating contacts (max. 7.5 A) signal “Drives ON”. These contacts are only available if a CI3 Extended or CI3 Tech board is used.	Is closed if the “Drives ON” contactor is energized.

Signal	Pin	Description	Comments
Drives ON channel A	11 / 12	Floating contacts (max. 2 A) signal “Drives ON”. These contacts are only available if a CI3 Extended or CI3 Tech board is used.	Is closed if the “Drives ON” contactor is energized.
Operating mode group Automatic	48 / 46	Floating contacts of the safety circuit signal the operating mode. These contacts are only available if a CI3 Extended or CI3 Tech board is used.	Automatic contact 48 / 46 is closed if Automatic or External is selected on the KCP.
Operating mode group Test	48 / 47		Test contact 48 / 47 is closed if Test 1 or Test 2 is selected on the KCP.
Qualifying input, channel A	50	0 signal causes a category 0 STOP in all operating modes.	If these inputs are not used, pin 50 must be jumpered to test output 38, and pin 51 to test output 39.
Qualifying input, channel B	51		

The counterpart to interface X11 is a 108-contact Harting connector with a male insert, type Han 108DD, housing size 24B.

I/Os

I/Os can be configured using the following components:

- DeviceNet (master) via MFC
- Optional field bus cards
  - Interbus
  - Profibus
  - DeviceNet
- ProfiNet
- Specific customer interfaces

4.6.1 Wiring example X11

Connector X11 is a Harting connector with a male insert, type Han 108DD, housing size 24B.

Connector pin allocation

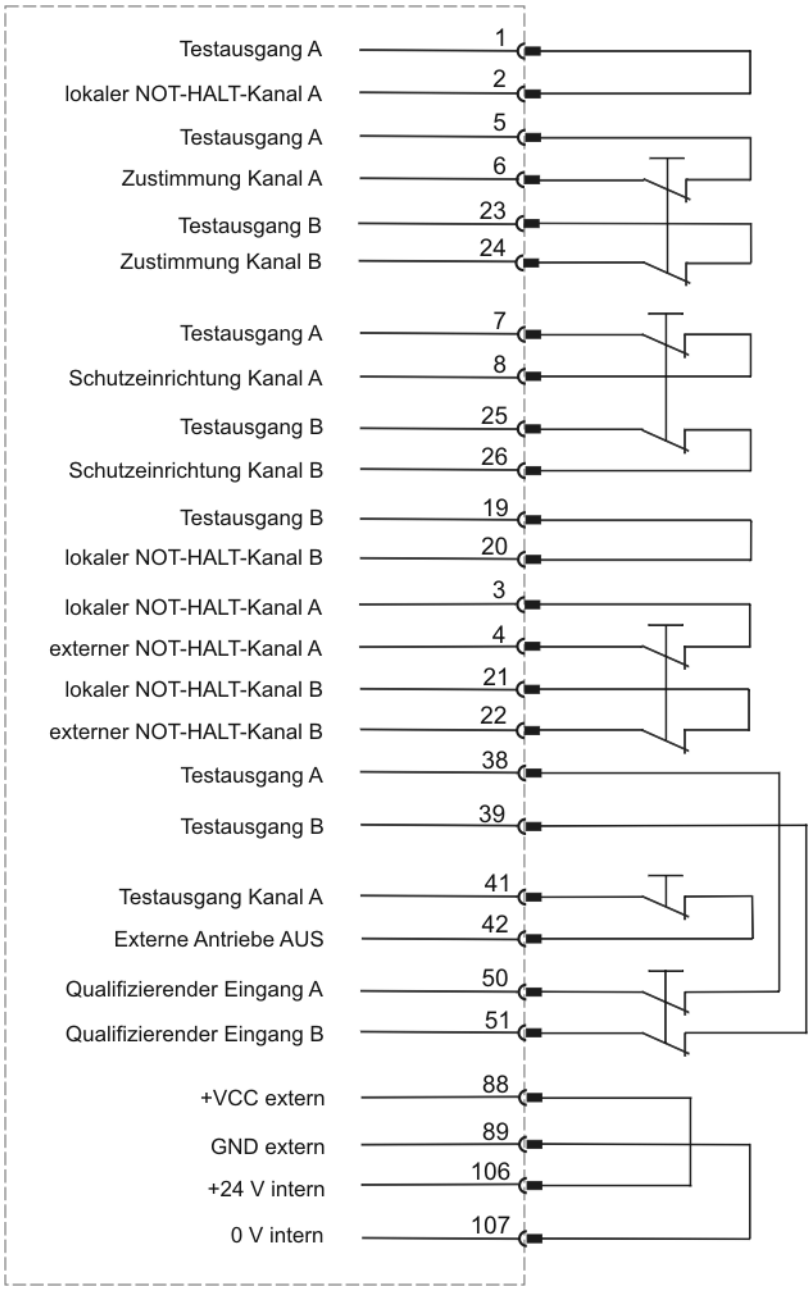

Fig. 4-13: Wiring example X11

Caution!
If wiring example X11 is used for start-up or troubleshooting, the connected safety components of the robot system are disabled.

4.7 PE equipotential bonding

Description

The following cables must be connected before start-up:

- A 16 mm^2 cable as equipotential bonding between the robot and the robot controller.
- An additional PE conductor between the central PE rail of the supply cabinet and the PE bolt of the robot controller.

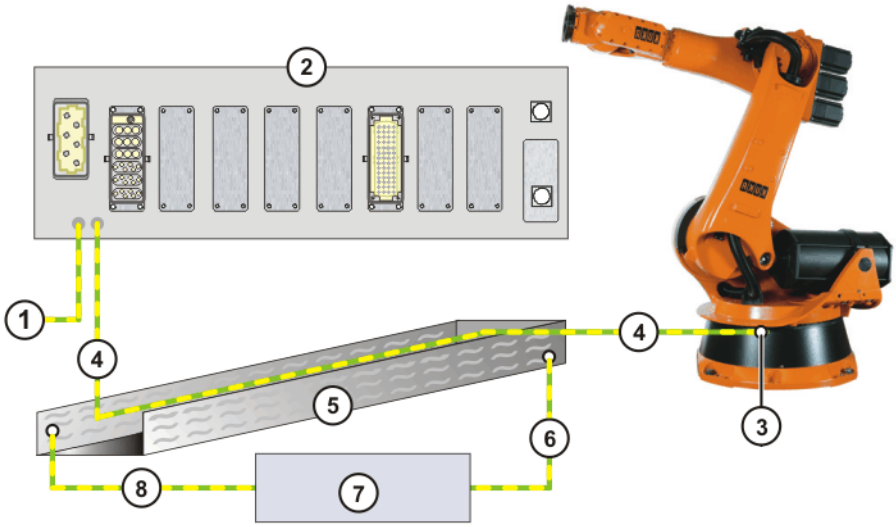

Fig. 4-14: Equipotential bonding, from robot controller to robot, with cable duct

1 PE to central PE rail of the supply cabinet
2 Connection panel on robot controller
3 Equipotential bonding connection on the robot
4 Equipotential bonding from the robot controller to the robot
5 Cable duct
6 Equipotential bonding from the start of the cable duct to the main equipotential bonding
7 Main equipotential bonding
8 Equipotential bonding from the end of the cable duct to the main equipotential bonding

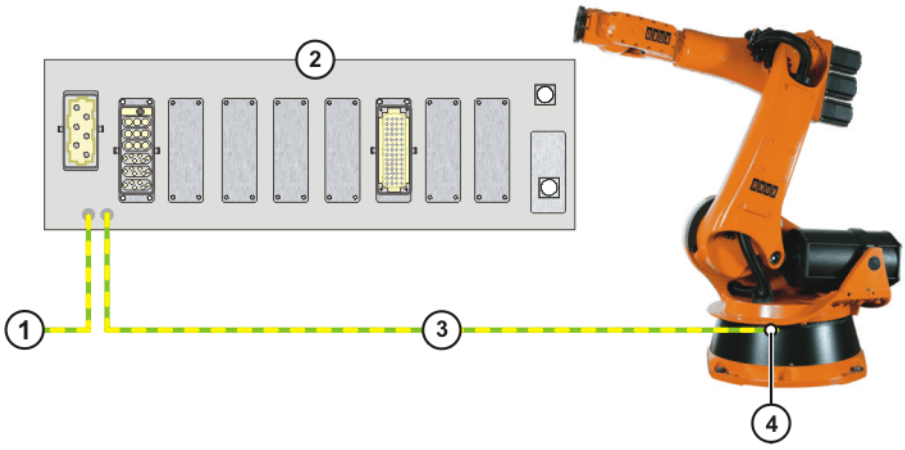

Fig. 4-15: Equipotential bonding, robot controller - robot

1 PE to central PE rail of the supply cabinet
2 Connection panel on robot controller
3 Equipotential bonding from the robot controller to the robot
4 Equipotential bonding connection on the robot

4.8 Visualization of the KCP coupler (option)

Description

If the robot controller is operated with a detachable KCP, the following system variables must be visualized:

- $T1 (T1 mode)
- $T2 (T2 mode)
- $EXT (External mode)
- $AUT (Automatic mode)
- $ALARM_STOP
- $PRO_ACT (program active)

The display can be configured using I/Os or a PLC. The system variables can be configured in the file: STEU/$MACHINE.DAT.

Warning!
If the KCP is disconnected, the system can no longer be deactivated by means of the EMERGENCY STOP button on the KCP. An external E-STOP must be connected to interface X11 to prevent personal injury and material damage.

4.9 Performance level

The safety functions of the robot controller conform to category 3 and Performance Level d according to EN ISO 13849-1.

4.9.1 PFH values of the safety functions

The safety values are based on a service life of 20 years.

The PFH value classification of the controller is only valid if the test cycles for E-STOP buttons and mode selector switches and the switching frequency of the contactors are observed. E-STOP buttons and mode selector switches must be actuated at least once every 6 months. The switching frequency of the contactors in the disconnection path must be at least twice per year and no more than 100 times per day.

When evaluating system safety functions, it must be remembered that the PFH values for a combination of multiple controllers may have to be taken into consideration more than once. This is the case for RoboTeam systems or higher-level hazard areas. The PFH value determined for the safety function at system level must not exceed the limit for PL d.

The PFH values relate to the specific safety functions of the different controller variants.

Safety function groups:

- Standard safety functions (ESC)
  - EMERGENCY STOP device (KCP, cabinet, customer interface)
  - Operator safety (customer interface)
  - Enabling (KCP, customer interface)
  - Operating mode (KCP, customer interface)
  - Safety stop (customer interface)
- Safety functions of KUKA.SafeOperation (option)
  - Monitoring of axis spaces
  - Monitoring of Cartesian spaces
  - Monitoring of axis velocity
  - Monitoring of Cartesian velocity

- Monitoring of axis acceleration
- Standstill monitoring
- Tool monitoring

Overview of controller variant PFH values:

Robot controller variant	PFH value
(V)KR C2 (edition2005)	1×10^{-7}
(V)KR C2 (edition2005) and 1 top-mounted cabinet	1×10^{-7}
(V)KR C2 (edition2005) with 2 top-mounted cabinets	1×10^{-7}
(V)KR C2 (edition2005) with KCP coupler	1×10^{-7}
(V)KR C2 edition2005 with KUKA.SafeOperation	1×10^{-7}
(V)KR C2 (edition2005) with 2 top-mounted cabinets and KUKA.SafeOperation	1×10^{-7}
KR C2 edition2005 titan	1×10^{-7}
KR C2 edition2005 titan with top-mounted cabinet	1×10^{-7}
KR C2 edition2005 titan with KCP coupler	1×10^{-7}
KR C2 edition2005 titan with KUKA.SafeOperation	1×10^{-7}
(V)KR C2 (edition2005) RoboTeam (standard) with 5 slaves	3×10^{-7}
(V)KR C2 (edition2005) with SafetyBUS Gateway	3×10^{-7}
(V)KR C2 (edition2005) with SafetyBUS Gateway and KCP coupler	3×10^{-7}
(V)KR C2 (edition2005) with KCP coupler, SafetyBUS Gateway and KUKA.SafeOperation with I/O connection via optocoupler and top-mounted cabinet	3×10^{-7}
(V)KR C2 (edition2005) RoboTeam (with KCP coupler, SafetyBUS Gateway) with 2 slaves, each with 2 top-mounted cabinets and KUKA.SafeOperation	3×10^{-7}
(V)KR C2 (edition2005) RoboTeam (standard) with 5 slaves and KUKA.SafeOperation	3×10^{-7}
KR C2 edition2005 titan with SafetyBUS Gateway	3×10^{-7}
KR C2 edition2005 titan with SafetyBUS Gateway and KCP coupler	3×10^{-7}

For controller variants that are not listed here, please contact KUKA Roboter GmbH.

5 Transportation

5.1 Transportation using lifting tackle

Preconditions

- The robot controller must be switched off.
- No cables may be connected to the robot controller.
- The door of the robot controller must be closed.
- The robot controller must be upright.
- The anti-toppling bracket must be fastened to the robot controller.

Necessary equipment

- Lifting tackle with or without lifting frame

Procedure

1. Attach the lifting tackle with or without a lifting frame to all 4 transport eyebolts on the robot controller.

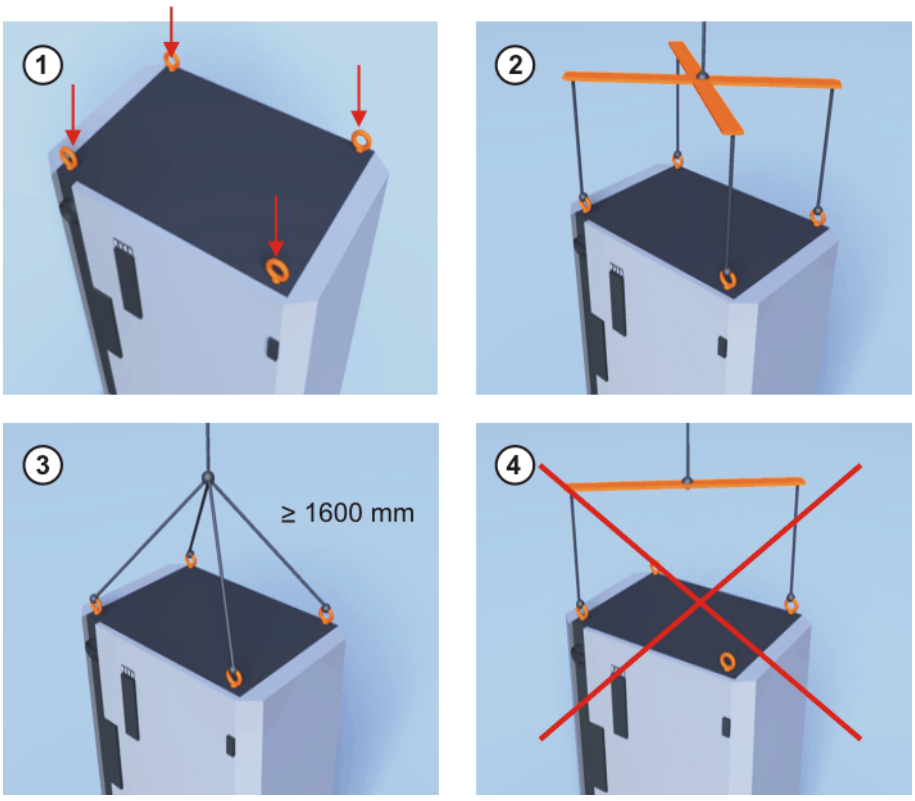

Fig. 5-1: Transportation using lifting tackle

1	Transport eyebolts on the robot controller
2	Correctly attached lifting tackle
3	Correctly attached lifting tackle
4	Incorrectly attached lifting tackle

2. Attach the lifting tackle to the crane.

Danger!
If the suspended robot controller is transported too quickly, it may swing and cause injury or damage. Transport the robot controller slowly.

3. Slowly lift and transport the robot controller.
4. Slowly lower the robot controller at its destination.
5. Unhook lifting tackle on the robot controller.

5.2 Transportation by pallet truck

Preconditions

- The robot controller must be switched off.
- No cables may be connected to the robot controller.
- The door of the robot controller must be closed.
- The robot controller must be upright.
- The anti-toppling bracket must be fastened to the robot controller.

Procedure

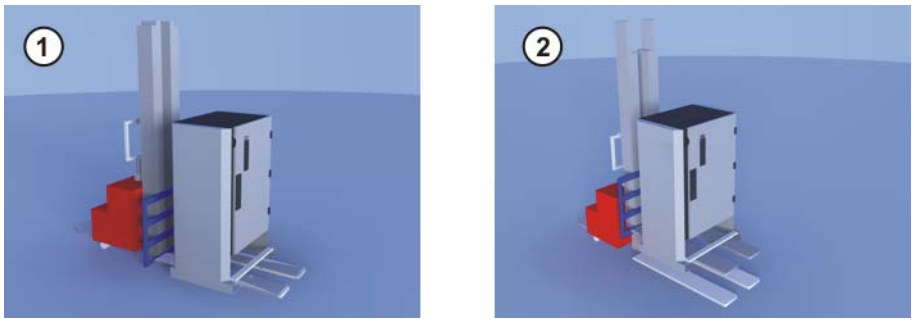

Fig. 5-2: Transportation by pallet truck

1 Control cabinet with anti-toppling bracket
2 Robot controller in raised position

5.3 Transportation by fork lift truck

Preconditions

- The robot controller must be switched off.
- No cables may be connected to the robot controller.
- The door of the robot controller must be closed.
- The robot controller must be upright.
- The anti-toppling bracket must be fastened to the robot controller.

Procedure

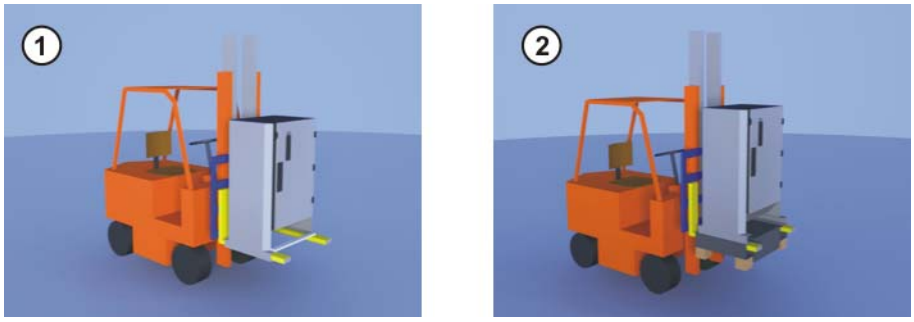

Fig. 5-3: Transportation by fork lift truck

1 Robot controller with fork slots
2 Robot controller with transformer installation kit

5.4 Transportation with the set of rollers (optional)

The robot controller rollers may only be used to roll the cabinet into and out of a row of cabinets – not to transport the cabinet over longer distances.

Fig. 5-4: Transportation on rollers

Warning!
If the robot controller is towed by a vehicle (fork lift truck, electrical vehicle), this can result in damage to the rollers and to the robot controller. The robot controller must not be hitched to a vehicle and transported using its rollers.

6 Start-up and recommissioning

6.1 Start-up overview

This is an overview of the most important steps during start-up. The precise sequence depends on the application, the manipulator type, the technology packages used and other customer-specific circumstances.
For this reason, the overview does not claim to be comprehensive.

This overview refers to the start-up of the industrial robot. The start-up of the overall system is not within the scope of this documentation.

Robot

Step	Description	Information
1	Carry out a visual inspection of the robot.	Detailed information is contained in the operating or assembly instructions for the robot, in the chapter “Start-up and recommissioning”.
2	Install the robot mounting base (mounting base, machine frame mounting or booster frame).	
3	Install the robot.	

Electrical system

Step	Description	Information
4	Carry out a visual inspection of the robot controller.	-
5	Make sure that no condensation has formed in the robot controller.	-
6	Install the robot controller.	(>>> 6.2 "Installing the robot controller" Page 75)
7	Connect the connecting cables.	(>>> 6.3 "Connecting the connecting cables" Page 75)
8	Connect the KCP.	(>>> 6.4 "Connecting the KCP" Page 76)
9	Establish the equipotential bonding between the robot and the robot controller.	(>>> 6.5 "Connecting the PE equipotential bonding" Page 76)
10	Connect the robot controller to the power supply.	(>>> 1.7.1 "Power supply connection X1/XS1" Page 16)
11	Reverse the battery discharge protection measures.	(>>> 6.7 "Reversing the battery discharge protection measures" Page 76)
12	Configure and connect interface X11. **Note:** If interface X11 has not been wired, the robot cannot be jogged.	(>>> 6.9 "Configuring and connecting connector X11" Page 77)
13	Switch on the robot controller.	(>>> 6.10 "Switching on the robot controller" Page 77)
14	Check the direction of rotation of the fans.	(>>> 6.11 "Checking the direction of rotation of the external fan" Page 77)

Step	Description	Information
15	Check the safety equipment.	Detailed information is contained in the operating instructions for the robot controller, in the chapter “Safety”.
16	Configure the inputs/outputs between the robot controller and the periphery.	Detailed information can be found in the field bus documentation.

Software

Step	Description	Information
17	Check the machine data.	Detailed information is contained in the operating and programming instructions.
18	Transfer data from the RDC to the hard drive.	Detailed information is contained in the Operating and Programming Instructions for System Integrators.
19	Master the robot without a load.	Detailed information is contained in the operating and programming instructions.
20	Only for palletizing robots with 6 axes: Activate palletizing mode.	Detailed information is contained in the Operating and Programming Instructions for System Integrators.
21	Mount the tool and master the robot with a load.	Detailed information is contained in the operating and programming instructions.
22	Check the software limit switches and adapt them if required.	
23	Calibrate tool. In the case of a fixed tool: calibrate external TCP.	Detailed information is contained in the operating and programming instructions.
24	Enter load data.	
25	Calibrate base (optional). In the case of a fixed tool: calibrate workpiece (optional).	
26	If the robot is to be controlled from a higher-level controller: configure Automatic External interface.	Detailed information is contained in the Operating and Programming Instructions for System Integrators.

Accessories

Precondition: the robot is ready to move, i.e. the software start-up has been carried out up to and including the item “Master the robot without load”.

Description	Information
Optional: install axis range limitation systems. Adapt software limit switches.	Detailed information can be found in the axis range limitation documentation.
Optional: install and adjust axis range monitoring, taking the programming into consideration.	Detailed information can be found in the axis range monitoring documentation.
Optional: install and adjust external energy supply system, taking the programming into consideration.	Detailed information can be found in the energy supply system documentation.
Positionally accurate robot option: check data.	

6.2 Installing the robot controller

Procedure

1. Install the robot controller. The minimum clearances to walls, other cabinets, etc. must be observed. (>>> 4.2 "Installation conditions" Page 53)
2. Check the robot controller for any damage caused during transportation.
3. Check that fuses, contactors and boards are fitted securely.
4. Secure any modules that have come loose.
5. Check that all screwed and clamped connections are securely fastened.
6. The operator must cover the warning label **Read manual** with a label in the relevant local language.

6.3 Connecting the connecting cables

Overview

A cable set is supplied with the robot system. In the standard version this consists of:

- Motor cables to the robot
- Control cables to the robot

  The following cables may be provided for additional applications:
- Motor cables for external axes
- Peripheral cables

Danger!
The robot controller is preconfigured for the specific industrial robot. 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.

Preconditions

- Compliance with the connection conditions concerning: (>>> 4.3 "Connection conditions" Page 55)
  - Cable cross-section
  - Fusing
  - Electric potential difference
  - Mains frequency
- Compliance with the safety regulations

Procedure

1. Route the motor cables to the manipulator junction box separately from the control cable. Plug in connector X20.
2. Route the control cables to the manipulator junction box separately from the motor cable. Plug in connector X21.
3. Connect the peripheral cables.

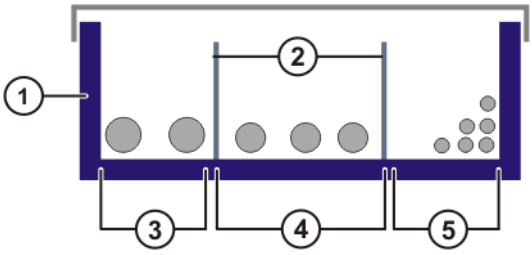

Fig. 6-1: Example: Installing the cables in the cable duct

1 Cable duct
2 Separating webs
3 Welding cables
4 Motor cables
5 Control cables

6.4 Connecting the KCP

Procedure

- Connect the KCP to X19 on the robot controller.

6.5 Connecting the PE equipotential bonding

Procedure

1. Connect an additional PE conductor between the central PE rail of the supply cabinet and the PE bolt of the robot controller.
2. Connect a 16 mm^2 cable as equipotential bonding between the robot and the robot controller.
   (>>> 4.7 "PE equipotential bonding" Page 65)
3. Carry out a ground conductor check for the entire robot system in accordance with DIN EN 60204-1.

6.6 Connecting the robot controller to the power supply

Procedure

- Connect the robot controller to the power supply via X1, XS1 or directly at the main switch. (>>> 4.4.1 "Power supply connection via X1 Harting connector" Page 57) (>>> 4.4.2 "Power supply connection via CEE connector XS1" Page 57)

6.7 Reversing the battery discharge protection measures

Description

To prevent the batteries from discharging before the controller has been started up for the first time, the robot controller is supplied with connector X7 disconnected from the KPS600.

Procedure

- Plug connector X7 (1) into the KPS600.

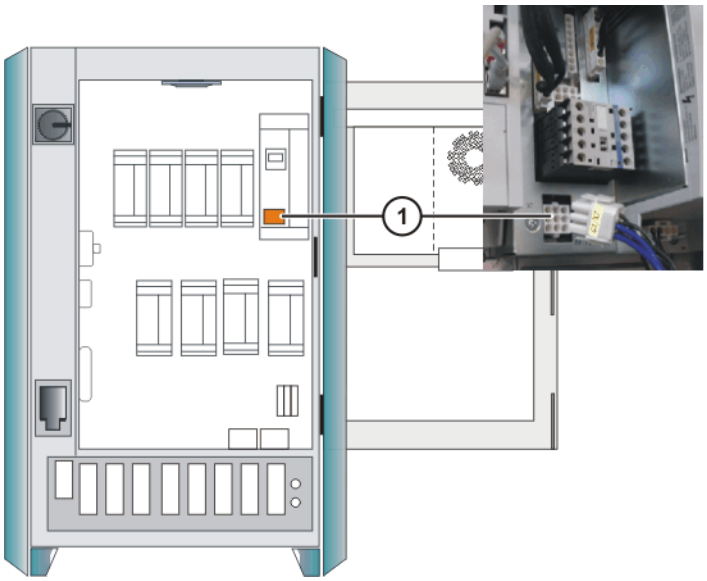

Fig. 6-2: Reversing the battery discharge protection measures

6.8 Connecting the EMERGENCY STOP circuit and safeguard

Procedure

1. Connect the EMERGENCY STOP circuit and safeguard (operator safety) to interface X11. (>>> 4.5 "EMERGENCY STOP circuit and safeguard" Page 58)

6.9 Configuring and connecting connector X11

Procedure

1. Configure connector X11 in accordance with the system and safety concepts. (>>> 4.6 "Interface X11" Page 60)
2. Connect interface connector X11 to the robot controller.

6.10 Switching on the robot controller

Preconditions

- The door of the robot controller is closed.
- All electrical connections are correct and the energy levels are within the specified limits.
- It must be ensured that no persons or objects are present within the danger zone of the robot.
- All safety devices and protective measures are complete and fully functional.
- The internal temperature of the cabinet must have adapted to the ambient temperature.

Procedure

1. Switch on the mains power to the robot controller.
2. Unlock the EMERGENCY STOP button on the KCP.
3. Switch on the main switch. The control PC begins to run up the operating system and the control software.

Information about operator control of the robot using the KCP can be found in the operating and programming instructions for the KUKA System Software (KSS).

6.11 Checking the direction of rotation of the external fan

Procedure

- Check outlet (2) on the rear of the robot controller.

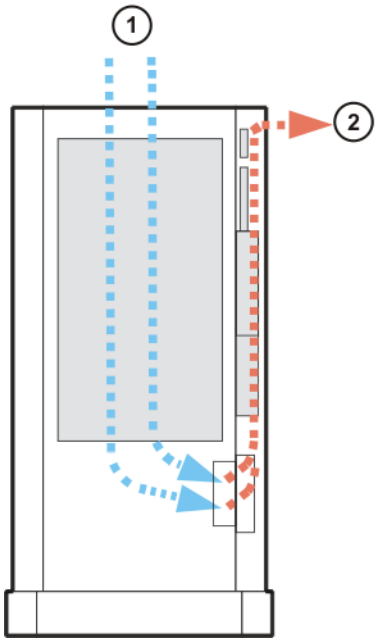

Fig. 6-3: Checking the direction of rotation of the fan

1 Air inlet 2 Air outlet

7 KUKA Service

7.1 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

7.2 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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