KUKA

Controller

KUKA Roboter GmbH

KR C2 sr

Specification
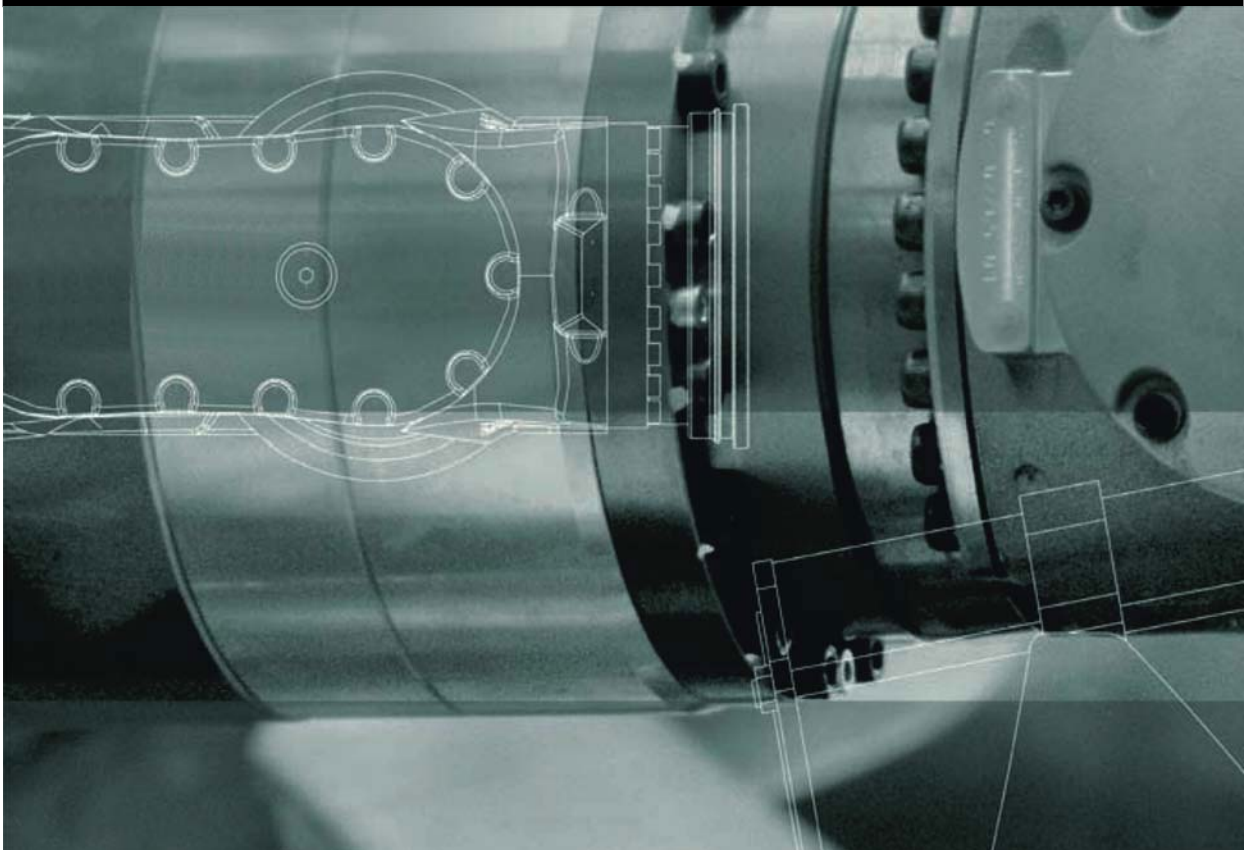
Issued: 21.12.2011

Version: Spez KR C2 sr V4 en

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	Teach pendant
2	Robot controller	4	Connecting cables

1.2 Overview of the robot controller

The robot controller is used for controlling the following systems:

- KUKA robots

The robot controller consists of the following components:

- Control PC
- Power unit
- KCP teach pendant
- Safety logic
- KCP coupler (optional)
- Connection panel
- Riser Cage with Ether CAT

The robot controller can be installed in a 19" rack.
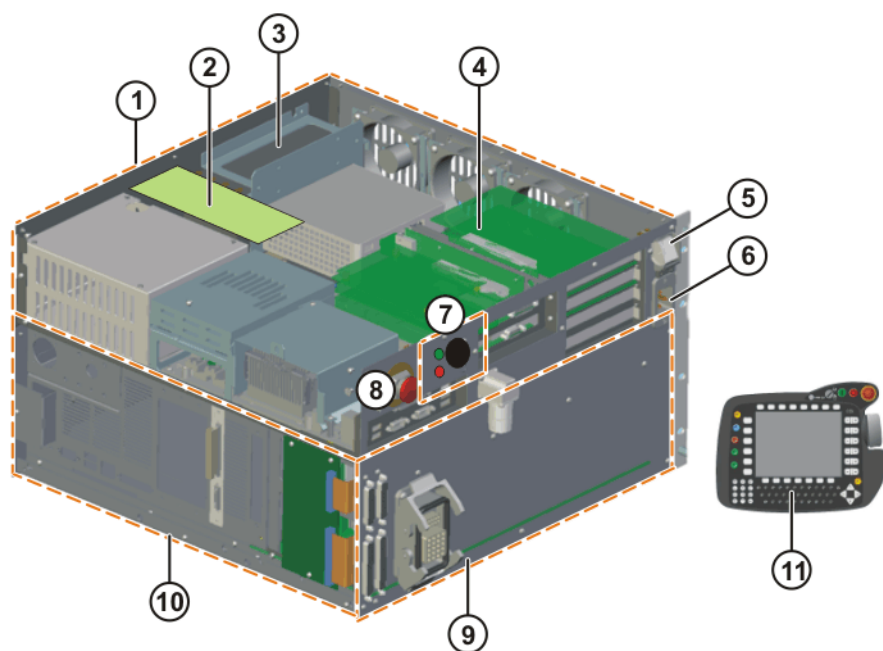
Fig. 1-2: Overview of the robot controller

1	Control PC	7	KCP coupler control and indicator elements (optional)
2	KCP coupler card (optional)	8	EMERGENCY STOP push-button
3	Batteries	9	Connection panel
4	Riser Cage	10	Power unit
5	Main switch	11	KCP
6	Power supply connection		

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
- Transmission of the axis data to the Small Robot
- 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 Tech
- KVGA
- UPS module with batteries

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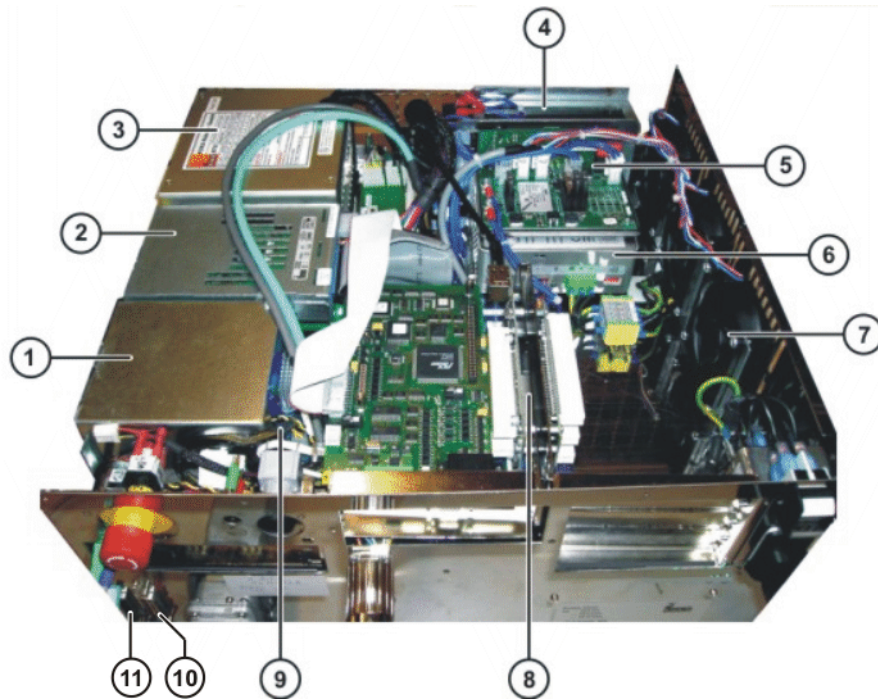
Fig. 1-3: Overview of the control PC

1	Processor	7	PC fan
2	Hard drive	8	Riser Cage
3	PC power supply	9	Motherboard
4	Batteries	10	Interface X12
5	UPS module	11	Interface X11
6	24 V DC power supply		

> **NOTICE** Connectors X11 and X12 must only be connected and disconnected with the controller switched off.

1.3.1 Riser Cage

Description The Riser Cage provides space for 5 PCI plug-in cards. The integrated network card forms the interface between the control unit and the power unit.

The following PC cards are plugged into the left-hand side of the Riser Cage:

- KVGA
- MFC3 Tech card

On the right-hand side of the Riser Cage are 3 PCI slots. The following PC cards can optionally be plugged in:

- Interbus PCI master
- Profibus PCI
- 3COM network card (Ethernet)
- DeviceNet card
- LPDN scanner card
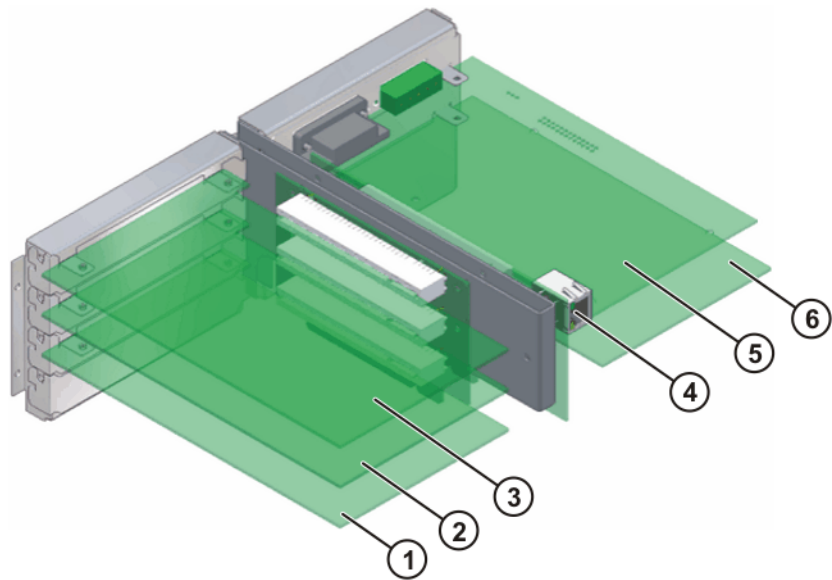
Fig. 1-4: Riser Cage configuration

Slots

Item	Interface	Item	Interface
1	Interbus Master/Slave card (optional)	4	Internal communications interface
2	Real-time or Windows network card (optional)	5	MFC3 Tech card
3	■ Profibus card (optional) ■ Windows network card (optional) ■ DeviceNet card (optional) ■ LPDN scanner card	6	KVGA

1.4   Description of the power unit

Overview   The power unit includes the following components:

- Power supply unit
- IPM boards
- Mini I/O board
- ESC Safety I/O sr
- Fans (2 units at bottom)
- Motherboard
- Mains filter
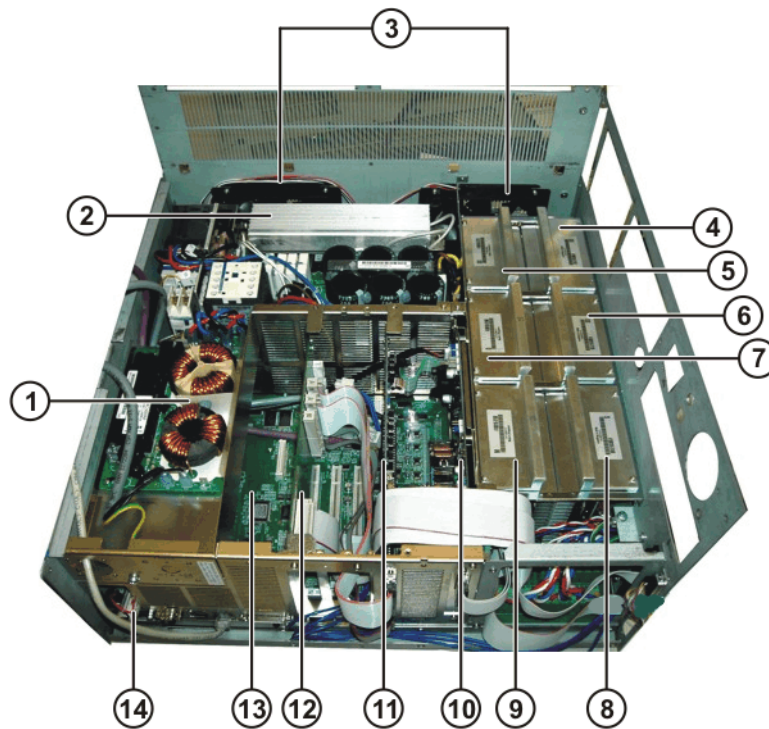
Fig. 1-5: KR C2 sr power unit

1	Mains filter	8	IPM board 2
2	Power supply unit	9	IPM board 1
3	Fans	10	ESC Safety I/O sr
4	IPM board 6	11	Mini I/O board
5	IPM board 5	12	Connector Print CP3
6	IPM board 4	13	Motherboard for the drives
7	IPM board 3	14	Memory backup battery

1.5 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.

1.5.1 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

1.5.2 Rear view

Overview

Fig. 1-7: Rear view of KCP

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

Description

Element	Description
Identification 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.

1.6 KCP coupler (optional)

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

Overview
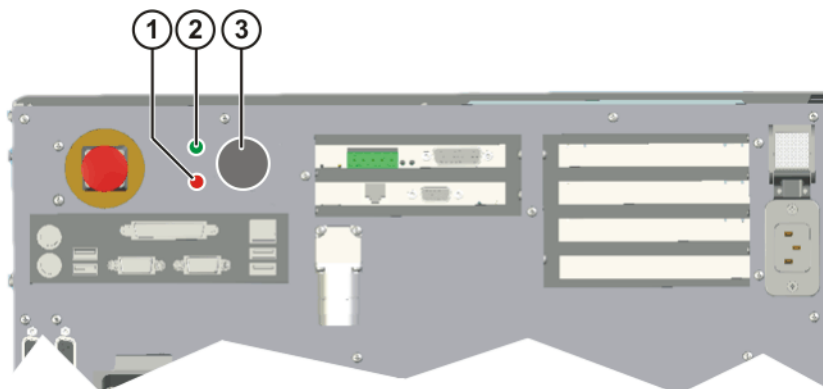
Fig. 1-8: KCP coupler LEDs and request button

1   Fault LED (red), KCP coupler
2   Request LED (green)
3   Request button

KCP coupler card
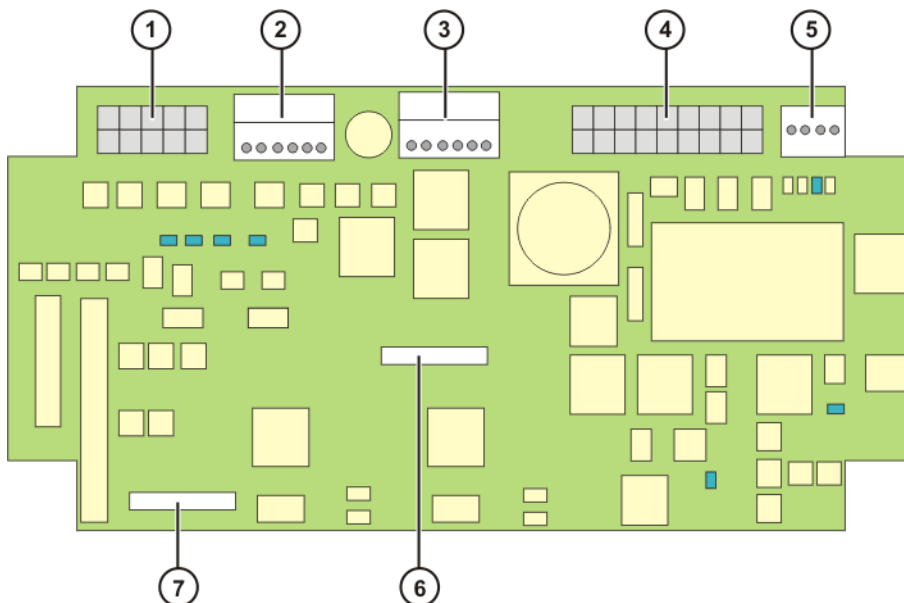
Fig. 1-9: KCP coupler card

Connections

Item	Connector	Description
1	X7	Request button LED connection
2	X5	ESC to the KCP
3	X20	SafeRobot to the KCP
4	X2	CI3 connection
5	X21	CAN bus to the KCP
6	X3	Debug connector B
7	X4	Debug connector A

The LEDs on the door and on the KCP coupler card indicate the operating status.

1.7 Description of interfaces

Overview

The connection panel of the robot controller consists as standard of connections for the following cables:

- Power supply cable
- Motor/data cable
- Wrist I/O cable
- KCP cable
- Ground conductor

The configuration of the connection panel varies according to the specific options required.

Connection panel
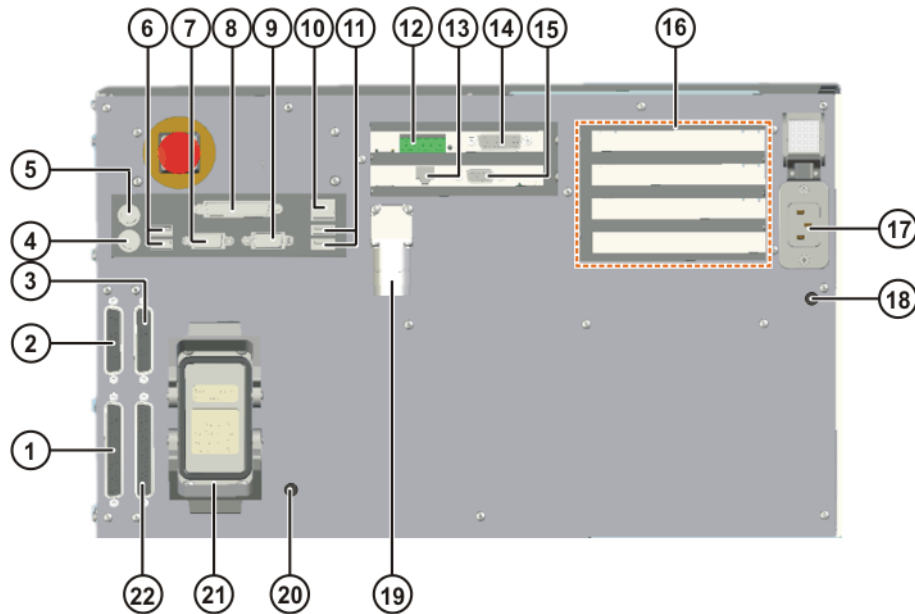
Fig. 1-10: Interfaces

Item	Interface	Item	Interface
1	X11 interface, 37-pin SUB-D contact strip	12	X801 from MFC, DeviceNet bus
2	X31 conveyor interface (option), 25-contact SUB-D female socket	13	X805 from KVGA, not used.
3	X32 wrist I/O interface, 25-pin SUB-D contact strip	14	X2 from MFC, not used.
4	Mouse connection	15	X821 external monitor (KVGA)
5	Keyboard connection	16	Slots for options
6	2x USB	17	X1 power supply connection
7	COM2 serial interface	18	M5 ground conductor connection
8	LPT1 parallel interface	19	X19 KCP connection
9	COM1 serial interface	20	M5 ground conductor connection
10	X804 Ethernet (Windows)	21	X20 motor/data connector
11	2x USB	22	X12 mini I/O interface, 37-contact SUB-D female socket

	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   Conveyor interface X31 (optional)

Connector pin allocation
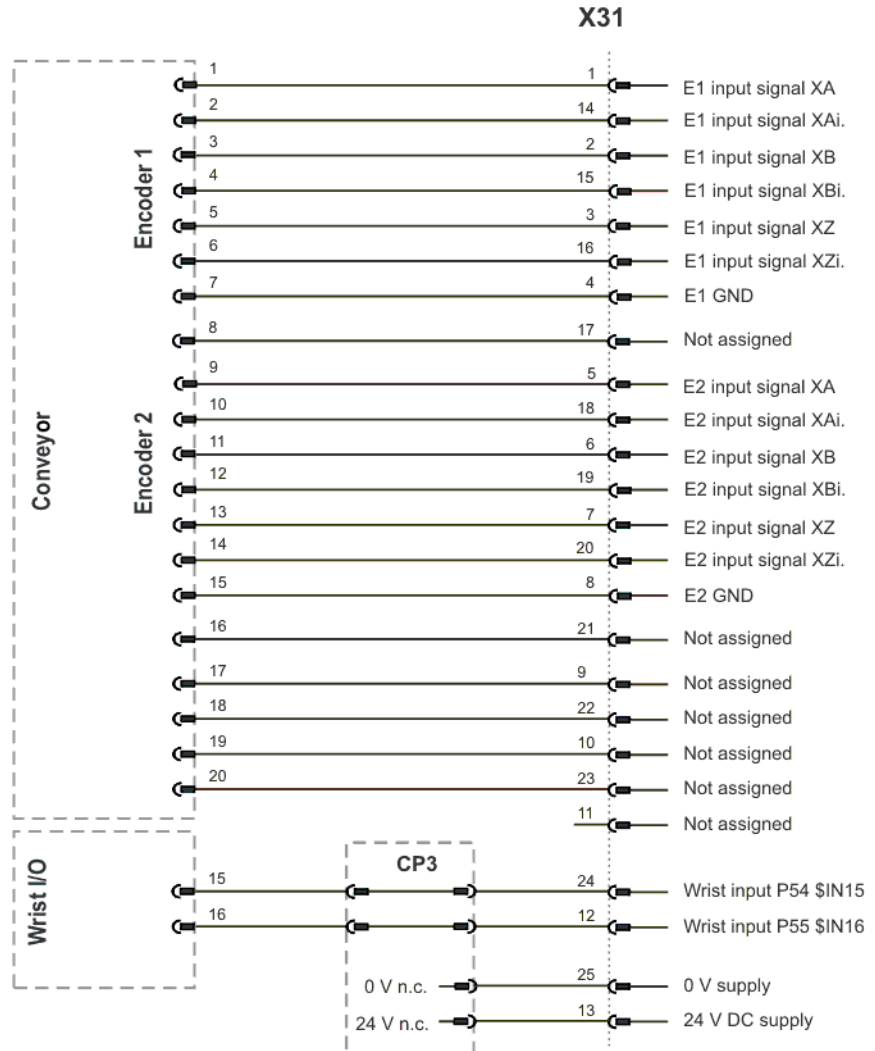
Fig. 1-11: Connector pin allocation KR C2 sr X31

Fast Measurement

Pins 24 ($IN15) and 12 ($IN16) are Fast Measurement inputs with a response time of 125 µs.

1.7.2   Wiring example X11

	Connector X11 is a 37-contact SUB-D female socket.

Connector pin allocation
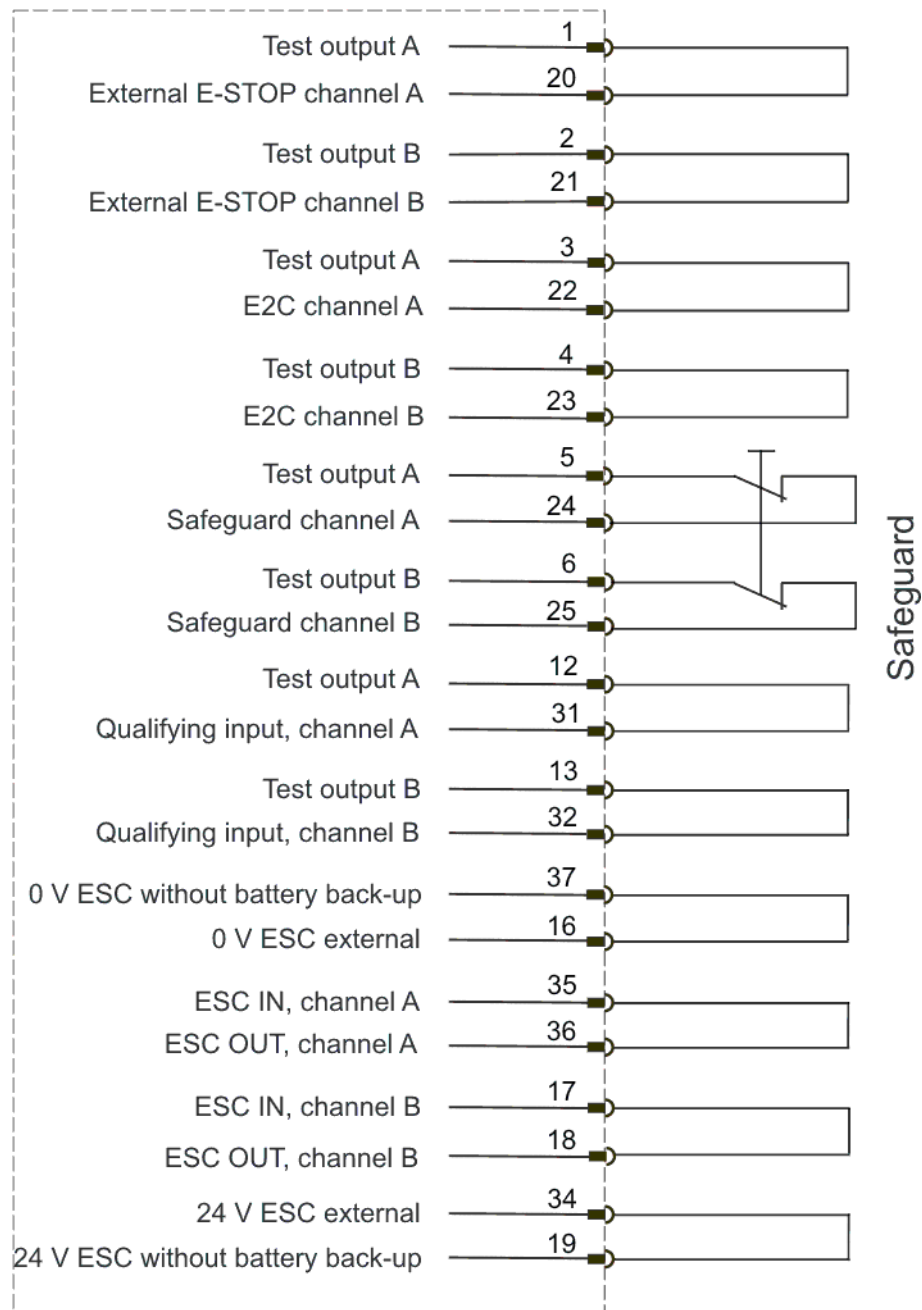
Fig. 1-12: KR C2 sr wiring example

⚠ **WARNING** — If wiring example X11 is used for start-up or trouble-shooting, the connected safety components of the robot system are disabled.

1.8 Category of the safety-oriented circuits

The following circuits correspond to Category 3 in accordance with EN 954-1:

- EMERGENCY STOP systems
- Enabling switches
- Operator safety
- Operating modes
- Qualifying inputs

2 Technical data

Basic data

Control cabinet type	KR C2 sr
Housing material	Stainless steel
Number of axes	max. 6
Weight	approx. 34 kg
Protection classification	IP 20
Max. power dissipation	350 W
Power consumption without a load and with the robot brakes applied	380 W

Power supply connection

Rated supply voltage	230 V AC, single-phase
Permissible tolerance of rated voltage	230 V +/- 10 %
Mains frequency	49...61 Hz
Rated power input	2.35 kVA
Mains-side fusing	2x 16 A slow-blowing, type C
Equipotential bonding	The housing is the reference point for the equipotential bonding conductors and all protective ground conductors.

Single-phase transformer

If there is no 230 V power supply available, a single-phase transformer with the following data can be used:

Input voltage	Dependent on the country of use
Regulations	
Protection classification	
Rated output power	2.75 kVA
Output voltage	230 V
Output current	12 A
Mains frequency	50 to 60Hz
Impedance drop	approx. 4%

Power dissipation

KR 5 sixx	2.1 kVA
KR 5 scara	2.05 kVA
KR 10 scara	2.7 kVA

Environmental conditions

Ambient temperature during operation	+10 °C to +40 °C (283 K to 313 K)
Ambient temperature during storage/transportation (without battery)	-10 °C to +60 °C (263 K to 333 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

Vibration resistance

Vibration resistance according to:	ASTM D4728-91
Shock resistance according to:	EN 60068-2-27

KUKA Control Panel

Dimensions W x H x D	approx. 33x26x8 cm^3
VGA display resolution	640x480 pixels
VGA display size	8"
Weight	1.4 kg

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

Cable	Standard length	Optional length
Power supply cable	3 m	-
Motor/data cable	4 m	6/12 m
KCP cable	10 m	20 m
Wrist I/O cable (optional)	4 m	6/12 m

2.1   Dimensions

Robot controller

Dimensions in mm
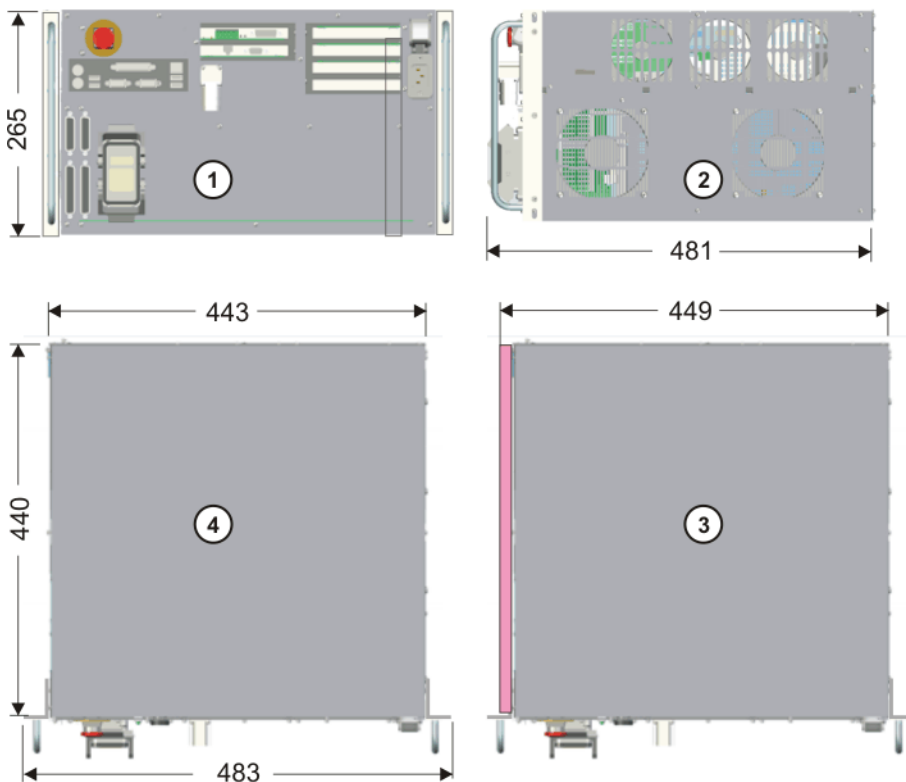
Fig. 2-1: Dimensions

1	Front view	3	Top view with filter mat
2	Side view	4	Top view

Fixing bracket
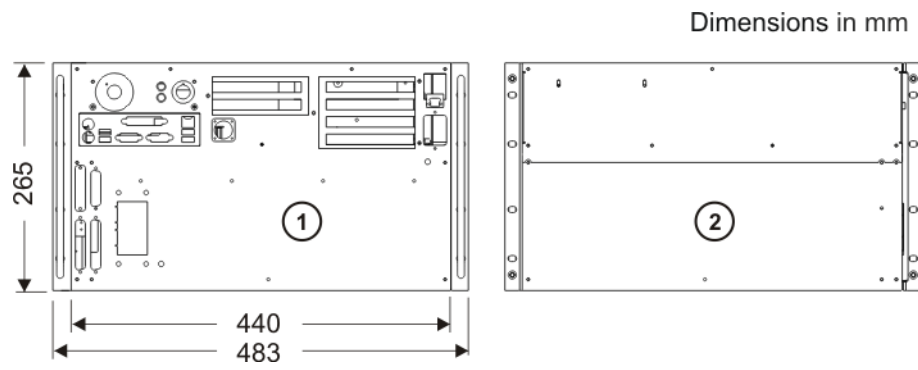
Dimensions in mm

Fig. 2-2: Dimensions of fixing bracket

1   Front view

2   Rear view

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 instructions at defined intervals.

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

ist. Instruction must be carried out regularly. Instruction is also required after particular incidents or technical modifications.

Personnel includes:

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

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

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

The system integrator is responsible for the following tasks:

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

Operator   The operator must meet the following preconditions:

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

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

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

ℹ️ 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.
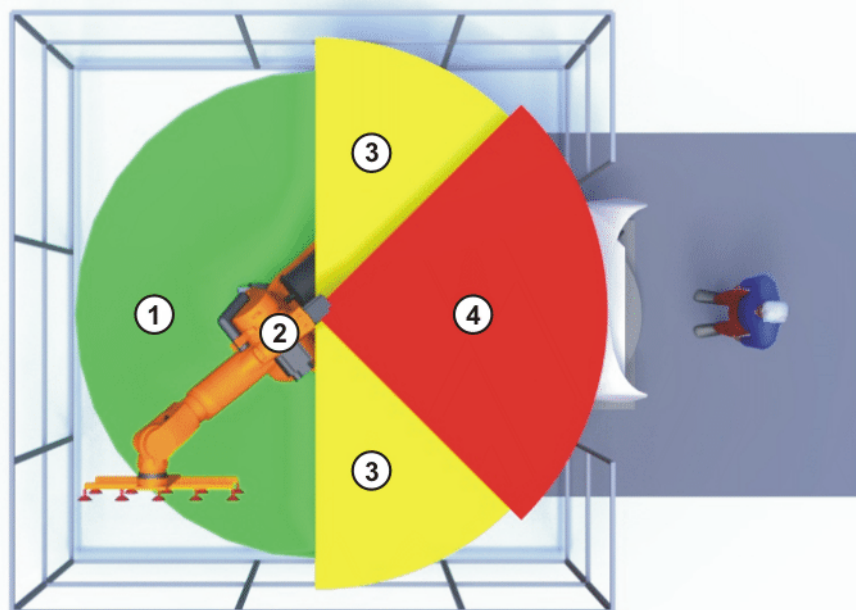
Fig. 3-1: Example of axis range A1

1	Workspace	3	Stopping distance
2	Manipulator	4	Safety zone

3.4 Triggers for stop reactions

Triggers for stop reactions

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

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

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

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

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

These circuits conform to the requirements of Performance Level d and category 3 according to EN ISO 13849-1. This only applies under the following conditions, however:

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

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

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

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.

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

The ESC safety logic monitors the following inputs:

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

The ESC safety logic monitors the following outputs:

- Operating mode
- Local E-STOP

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.
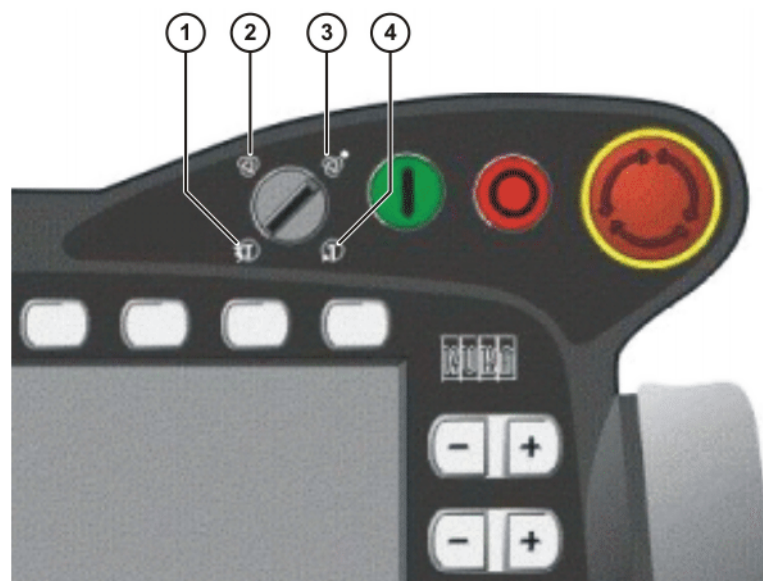

Fig. 3-2: Mode selector switch

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 possible. Operator safety is not active in the test modes T1 (Manual Reduced Velocity) and T2 (Manual High Velocity).

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

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

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

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

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

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

External EMERGENCY STOP devices are connected via the customer interface. External EMERGENCY STOP devices are not included in the scope of supply of the industrial robot.

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

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.

KUKA

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 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.

3.6.4 External safeguards

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

Physical safeguards must meet the following requirements:

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

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

- They are reduced to an absolute minimum.
- The interlocks (e.g. safety gate switches) are linked to the operator safety input of the robot controller via safety gate switching devices or safety PLC.

- Switching devices, switches and the type of switching conform to the requirements of category 3 according to EN 954-1.
- Depending on the risk situation: the safety gate is additionally safeguarded by means of a locking mechanism that only allows the gate to be opened if the manipulator is safely at a standstill.
- The button for acknowledging the safety gate is located outside the space limited by the safeguards.

> **i** 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 must be avoided. Appropriate safety precautions must be taken, e.g. protective gloves must be worn.

KCP

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

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

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

External keyboard, external mouse

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

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

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

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

Faults

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

- Switch off the robot controller and secure it (e.g. with a padlock) to prevent unauthorized persons from switching it on again.
- Indicate the fault by means of a label with a corresponding warning (tagout).
- 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 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.

3.8.3 Start-up and recommissioning

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

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

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

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

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

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

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

General test:

It must be ensured that:

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

Test of safety-oriented circuits:

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

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

Test of reduced velocity control:

This test is to be carried out as follows:

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

> ⚠ **WARNING** It must be ensured that no persons are present within the danger zone during path execution. Death or severe physical injuries may result.

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

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

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

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

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

3.8.4 Virus protection and network security

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

> ℹ 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.

3.8.5 Manual mode

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

- Jog mode
- Teaching
- Programming
- Program verification

The following must be taken into consideration in manual mode:

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

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

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

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

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

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

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

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

3.8.6 Simulation

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

3.8.7 Automatic mode

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

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

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

3.8.8 Maintenance and repair

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

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

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

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

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

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

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

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

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

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

Hazardous substances

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

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

> **i** 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.

3.8.9 Decommissioning, storage and disposal

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

3.8.10 Safety measures for "single point of control"

Overview

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

Components:

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

> **i** 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 12100-1	Safety of machinery: Basic concepts, general principles for design - Part 1: Basic terminology, methodology	2003
EN ISO 12100-2	Safety of machinery: Basic concepts, general principles for design - Part 2: Technical principles	2003
EN ISO 10218-1	Industrial robots: Safety	2008
EN 954-1	Safety of machinery: Safety-related parts of control systems - Part 1: General principles of design	1997
EN 614-1	Safety of machinery: Ergonomic design principles - Part 1: Terms and general principles	2006
EN 61000-6-2	Electromagnetic compatibility (EMC): Part 6-2: Generic standards; Immunity for industrial environments	2005

Name	Definition	Edition
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 Installation conditions

The robot controller can be installed in a 19" rack or as a standalone device. If the robot controller is to be installed in a 19" rack, the depth must be at least 800 mm.

> **i** If the robot controller is to be installed in a 19" rack, it must be fastened in the rack by appropriate means (preferably angle plates) along the entire side edge in order to prevent distortion of the housing.

Both sides of the robot controller must be accessible to the cooling air. Clearance of 70 mm on each side.

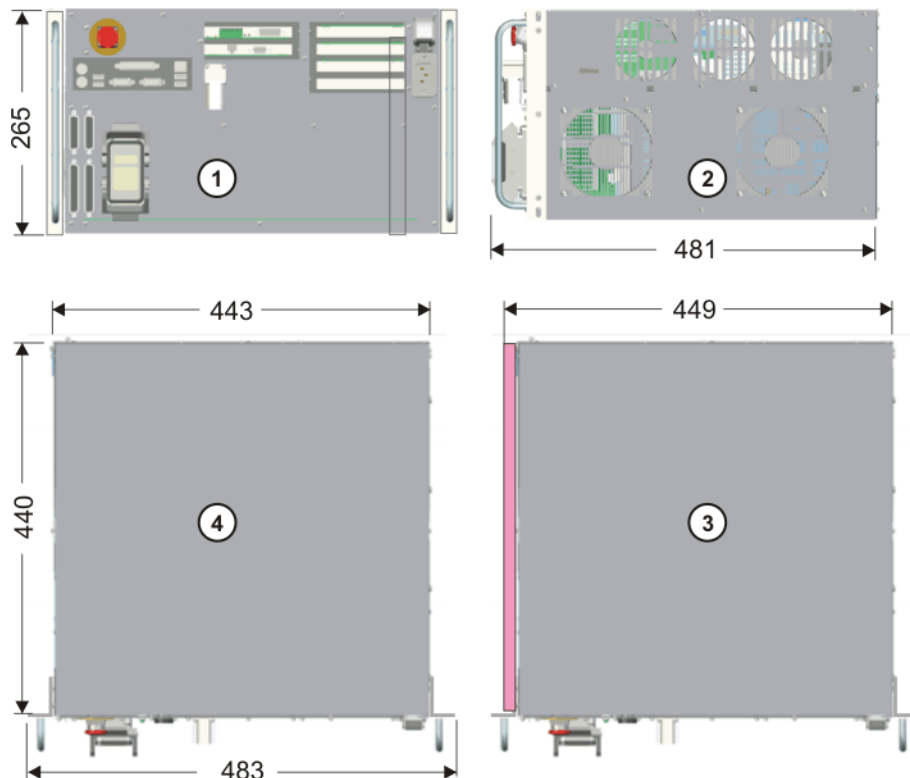**Fig. 4-1: KR C2 sr installation position**

Dimensions

Dimensions in mm

Fig. 4-2: Dimensions

1	Front view	3	Side view
2	Top view	4	Top view with filter mat

4.2 Connection conditions

Power supply connection

Rated supply voltage	230 V AC, single-phase
Permissible tolerance of rated voltage	230 V +/- 10 %
Mains frequency	49...61 Hz
Rated power input	2.35 kVA
Mains-side fusing	2x 16 A slow-blowing, type C
Equipotential bonding	The housing is the reference point for the equipotential bonding conductors and all protective ground conductors.

Cable lengths

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

Cable	Standard length	Optional length
Power supply cable	3 m	-
Motor/data cable	4 m	6/12 m
KCP cable	10 m	20 m
Wrist I/O cable (optional)	4 m	6/12 m

4.3   Power supply connection

Description   The robot controller is connected to the mains via a power plug.

Fig. 4-3: Power supply connection

1   Power supply connection on the robot controller
2   Plug-in connection to the robot controller
3   Power plug

4.4   EMERGENCY STOP circuit and safeguard

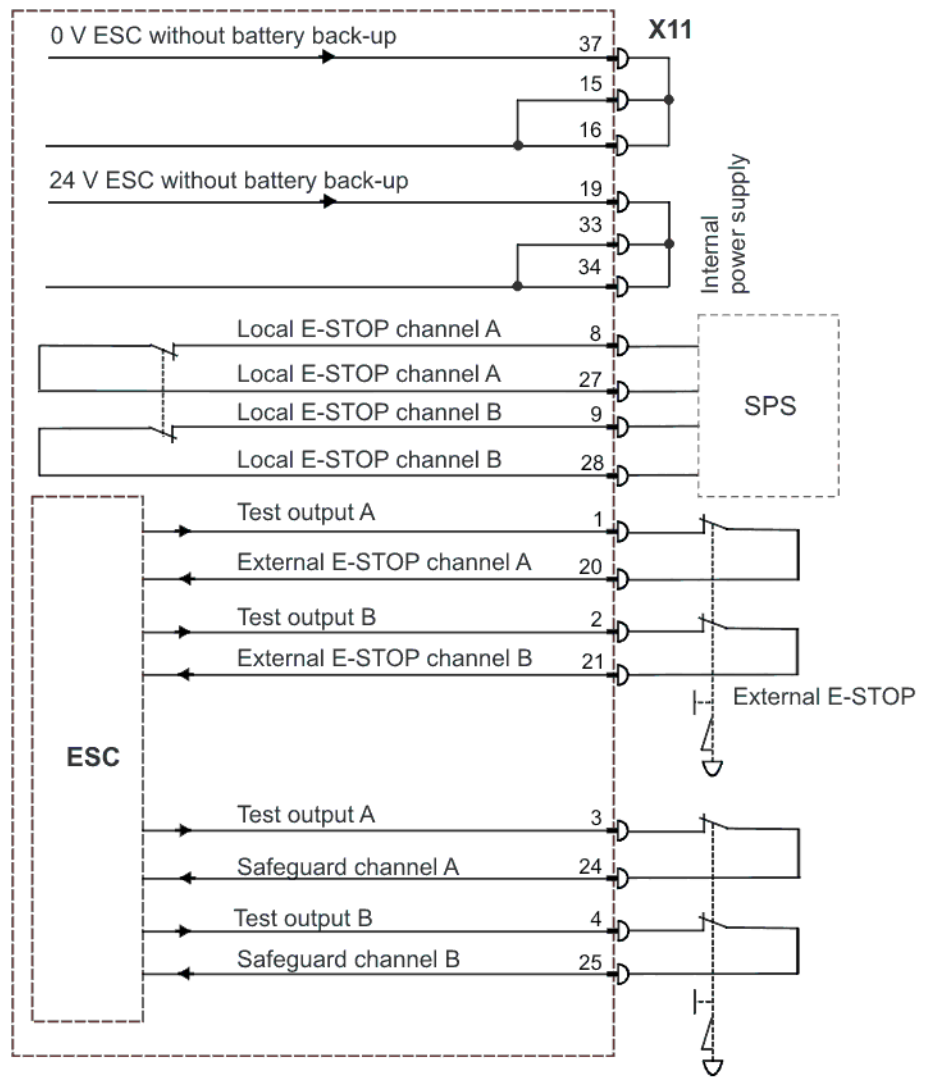The following examples show how the EMERGENCY STOP circuit and safeguard of the robot system can be connected to other robot systems or the periphery.

Example

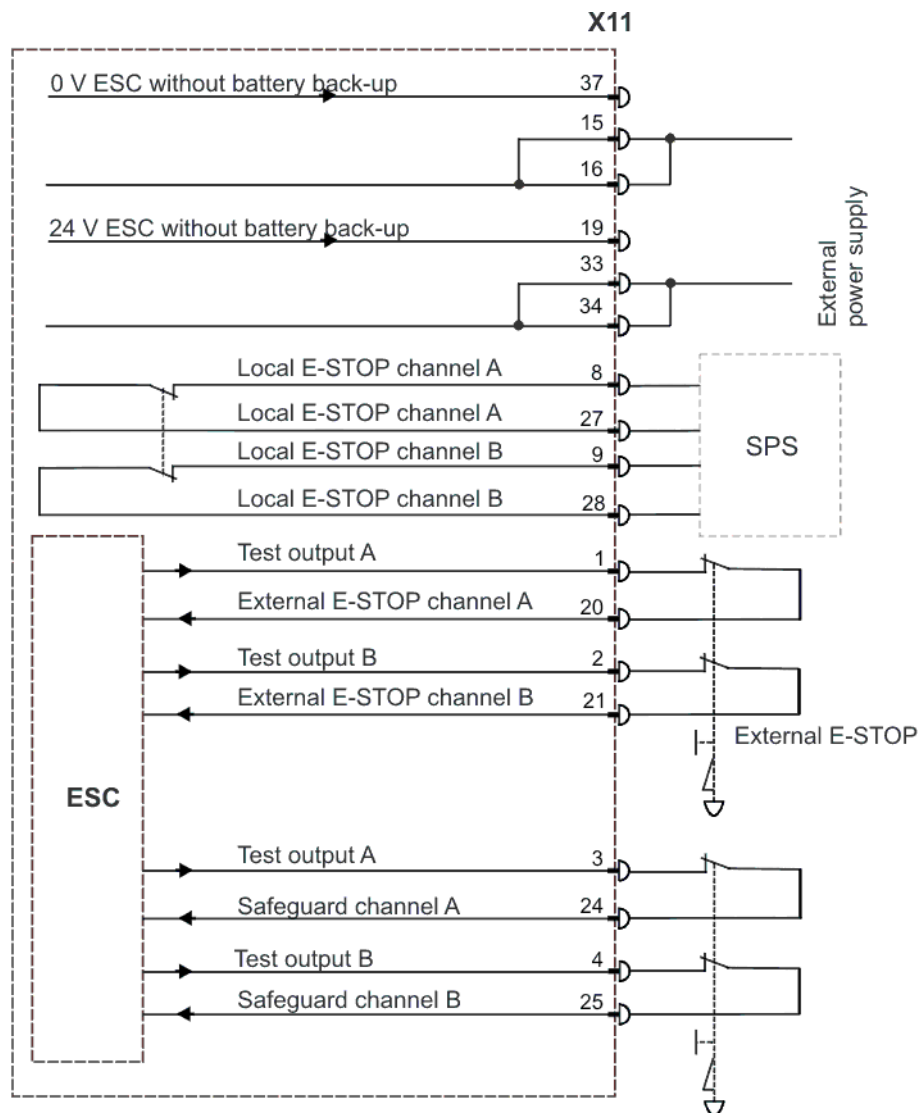
Fig. 4-4: Robot with periphery and internal power supply

Example

Fig. 4-5: Robot with periphery and external power supply

4.5   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

> **i** 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".
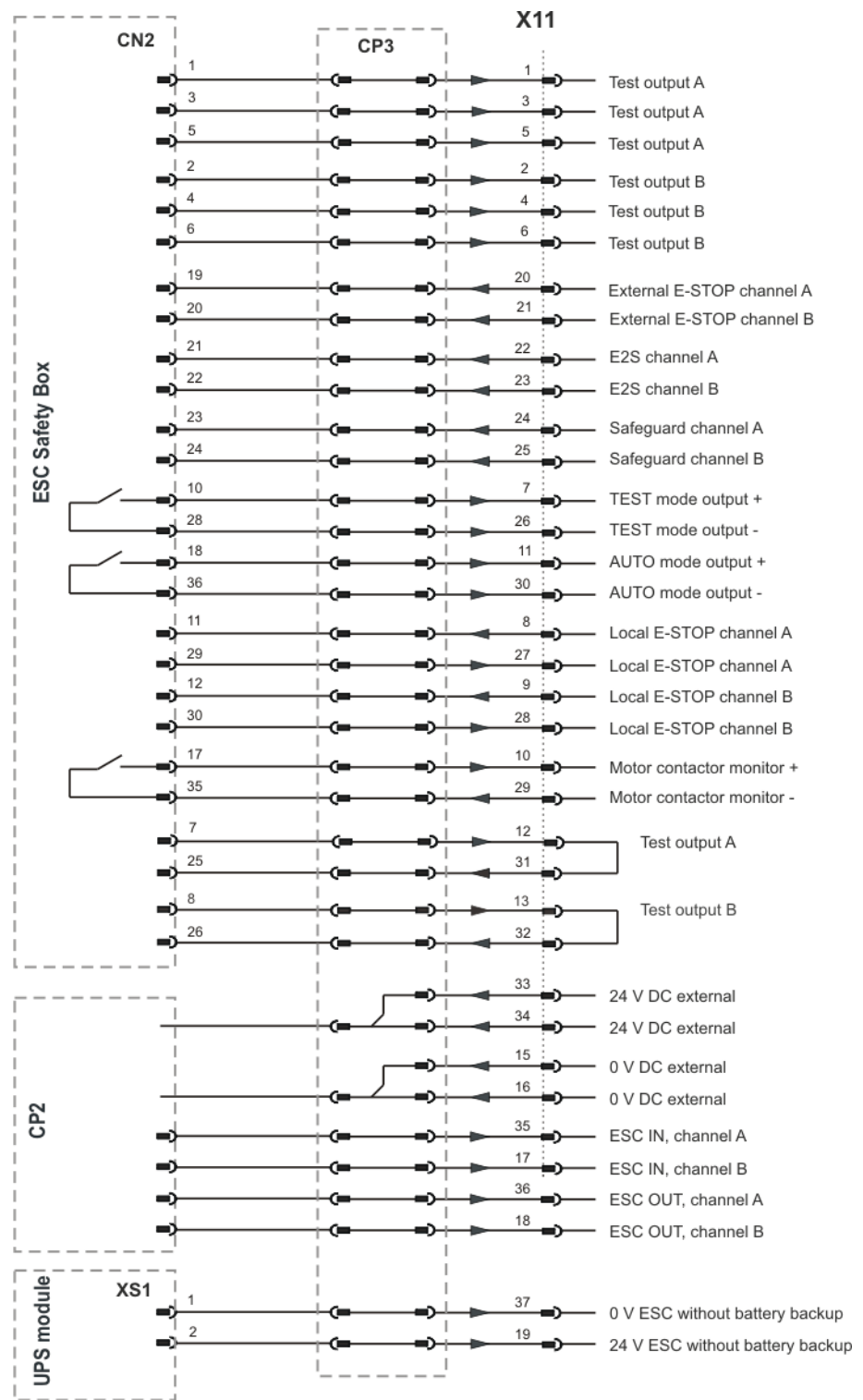
Connector pin allocation

Fig. 4-6

Signal	Pin	Description	Comments
+24 V ESC without battery back-up 0 V ESC without battery back-up	19 37	ESC power supply, max. 1.3 A	-
24 V external 0 V external	33 / 34 15 / 16	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.

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Signal	Pin	Description	Comments
Test output A (test signal)	1 3 5 12	Makes the pulsed voltage available for the individual interface inputs of channel A.	Connection example: safety gate locking mechanism is connected under channel A to pin 3 (TA_A) and pin 24.
Test output B (test signal)	2 4 6 13	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 4 (TA_B) and pin 25.
Local E-STOP, channel A	8 / 27	Output, floating contacts from internal E-STOP, max. 0.15 A / 24 V.	In the non-activated state, the contacts are closed.
Local E-STOP, channel B	9 / 28		
External E-STOP, channel A	20	E-STOP, dual-channel input, max. 24 V.	-
External E-STOP, channel B	21		
Safeguard channel A	24	For dual-channel connection of a safety gate locking mechanism, max. 24 V.	Only effective in the AUTOMATIC modes.
Safeguard channel B	25		
Motor contactor monitor	29 / 10	Floating contact signals "Drives ON", max. 0.15 A at 24 V.	Is closed if the "Drives ON" contactor is energized. **This contact is not safety-oriented.**
Operating mode group Automatic	11 / 30	Floating contacts signal the operating mode.	-
Operating mode group Test	7 / 26		
E2S channel A	22	E2 keyswitch, dual-channel, max. 24 V.	The input is at 0 V if keyswitch off. If the E2 keyswitch is not used, pin 22 must be jumpered to test output 3, and pin 23 to test output 4.
E2S channel B	23		
Qualifying input, channel A	31	These inputs have no function.	Pin 31 must be jumpered to test output 12, and pin 32 to test output 13.
Qualifying input, channel B	32		
ESC IN, channel A	35	--	If there are no other ESC circuit nodes present, the following pins must be jumpered:
ESC IN, channel B	17	-	■ Pin 35 / 36
ESC OUT, channel A	36	-	■ Pin 17 / 18
ESC OUT, channel B	18	-	

⚠ In the cabling for the input signals and test signals in the system, suitable measures must be taken to prevent a cross-connection between the voltages (e.g. separate cabling of input signals and test signals).

	In the cabling for the output signals and test signals in the system, suitable measures must be taken to prevent a cross-connection between the output signals of a channel (e.g. separate cabling).

I/Os   I/Os can be configured using the following components:

- DeviceNet (master) via MFC
- Optional field bus cards
    - Interbus
    - PROFIBUS
    - DeviceNet
- Specific customer interfaces
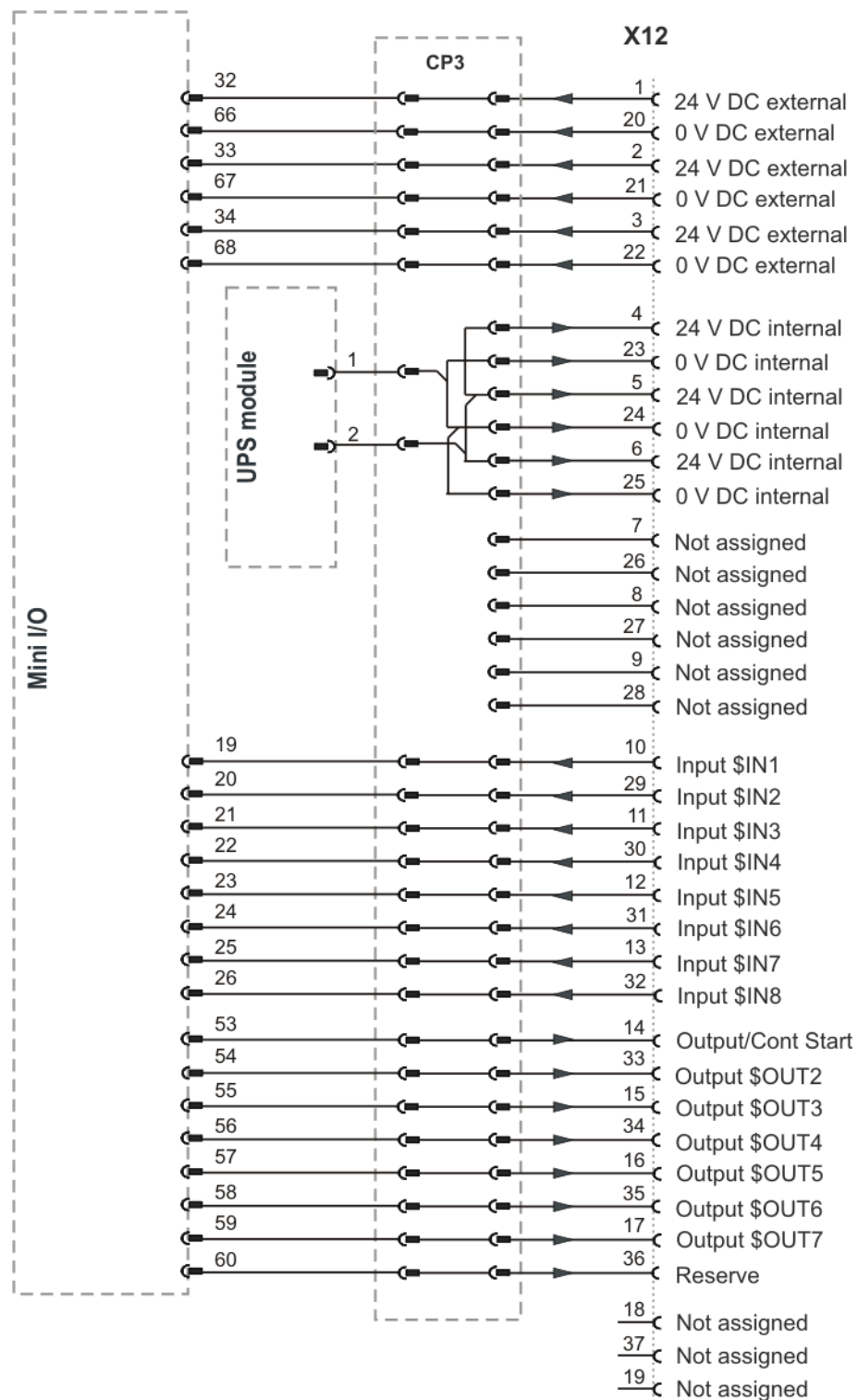
4.6 Configuring mini I/O X12

Connector pin allocation

Fig. 4-7: Mini I/O connector pin allocation X12

> ℹ The outputs of the mini I/O interface X12 each have a maximum capacity of 70 mA (24 V).

Internal power supply

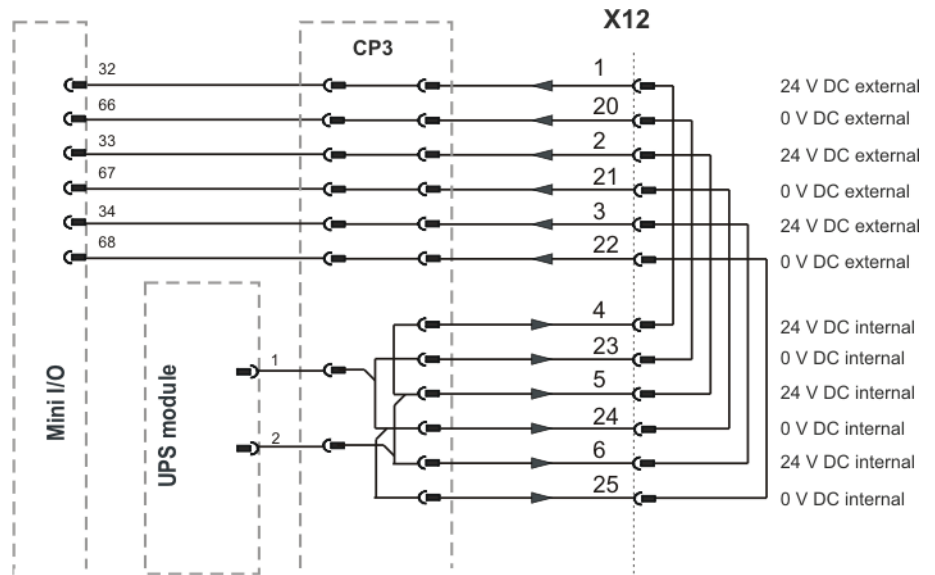If an internal power supply is used, the following jumpers must be connected:

X12

32	1	24 V DC external
66	20	0 V DC external
33	2	24 V DC external
67	21	0 V DC external
34	3	24 V DC external
68	22	0 V DC external
	4	24 V DC internal
	23	0 V DC internal
1	5	24 V DC internal
	24	0 V DC internal
2	6	24 V DC internal
	25	0 V DC internal

CP3

Mini I/O

UPS module

Fig. 4-8: X12 jumpers In the case of internal power supply

Circuit example
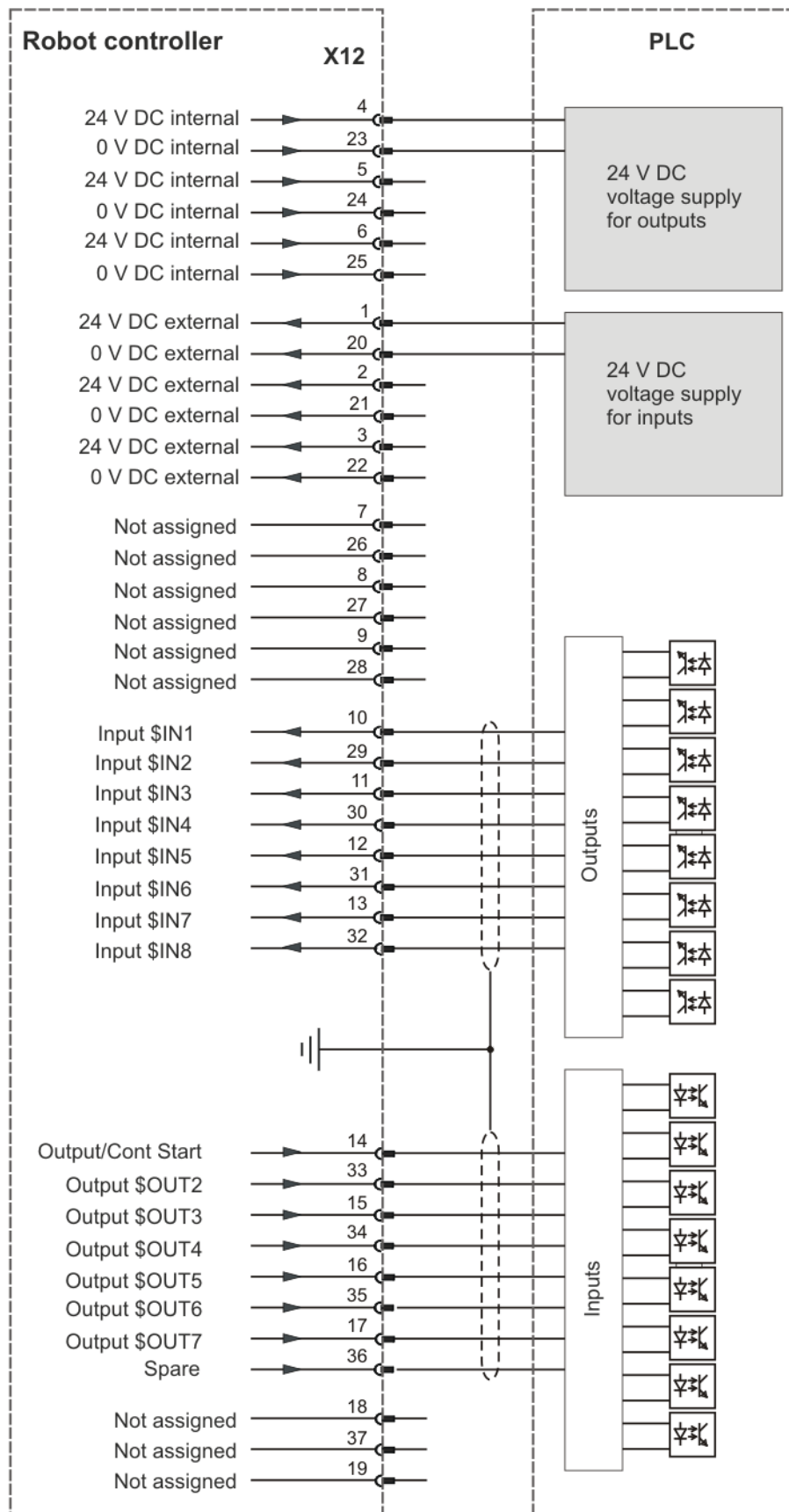
Fig. 4-9: KR C2 sr X12 wiring

4.7 Configuring wrist I/O X32

Connector pin allocation
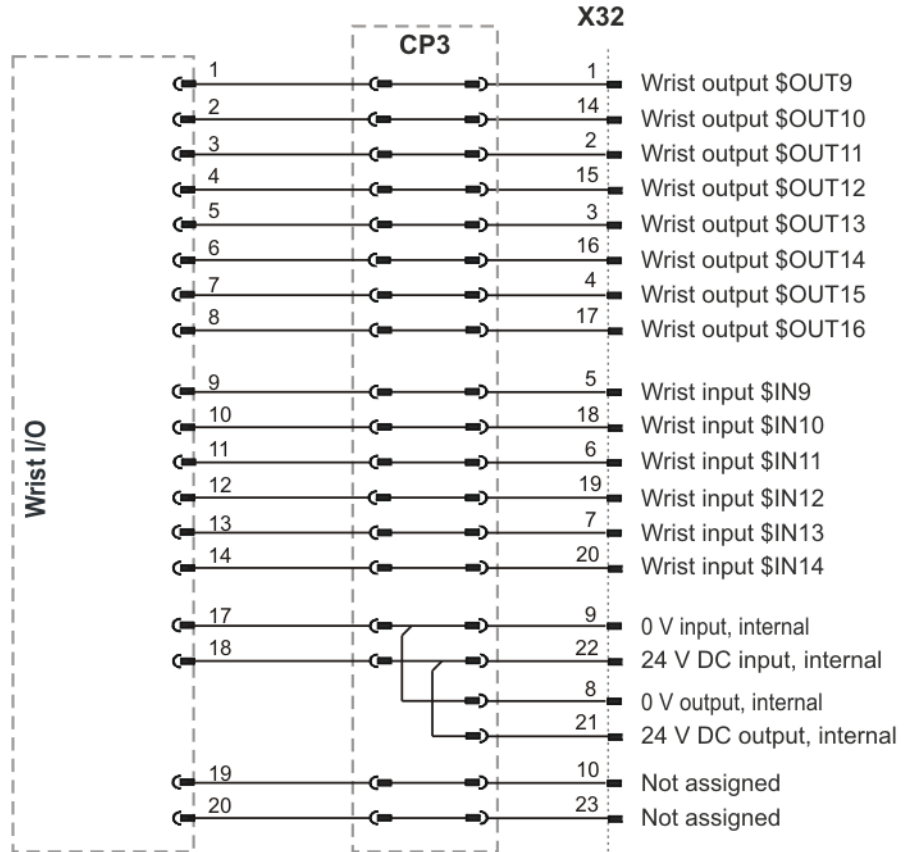
Fig. 4-10: Wrist I/O connector pin allocation X32

> **i** The outputs of the wrist I/O interface X32 each have a maximum capacity of 70 mA (24 V).

4.8 PE equipotential bonding

Description   A cable with a cross-section of at least 4 mm^2 must be used as equipotential bonding between the robot and the robot controller.
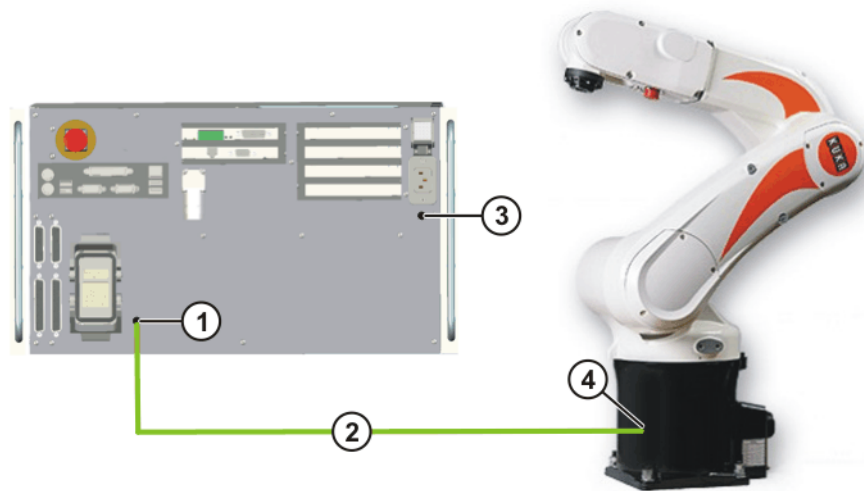
Fig. 4-11: Equipotential bonding between the robot and the robot controller

1	M5 bolt, equipotential bonding to the robot	3	M5 bolt, ground conductor connection of the robot controller
2	Equipotential bonding, min. 4 mm^2	4	Equipotential bonding connection on the robot

4.9 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.

4.10 Performance level

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

4.10.1 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 E-STOP button is tested at least once every 6 months

- the number of switching cycles of the main contactors does not exceed 100 per day
- the main contactors are switched at least twice a year

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. 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
  - Operating mode selection
  - Operator safety
  - EMERGENCY STOP device
  - Enabling device
  - External safe operational stop
  - External safety stop 1
  - External safety stop 2
  - Velocity monitoring in T1

Overview of controller variant PFH values:

Robot controller variant	PFH value
KR C2 sr	$< 1 \times 10^{-7}$

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

5 Transportation

5.1 Transporting the robot controller

Preconditions
- The housing of the robot controller must be closed.
- No cables may be connected to the robot controller.
- The robot controller must be transported in a horizontal position.

Procedure
- Transport the robot controller using a pallet truck or a fork lift truck. The robot controller must be laid on a pallet.
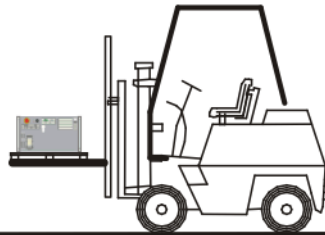

Fig. 5-1: Transport by fork lift truck

> **i** If the robot controller is installed in an electrical enclosure during transportation, this may result in vibrations (oscillations). Such vibrations can cause contact problems on the PC plug-in cards.

6 Start-up and recommissioning

6.1 Start-up overview

> **i** 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.

> **i** 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 robot operating instructions, in the chapter "Start-up".
2	Install the robot.	

Electrical system

Step	Description	Information
3	Carry out a visual inspection of the robot controller.	-
4	Install the robot controller.	(>>> 6.2 "Installing the robot controller" Page 58)
5	Connect the connecting cables.	(>>> 6.3 "Connecting the connecting cables" Page 58)
6	Connect the KCP.	(>>> 6.4 "Connecting the KCP" Page 59)
7	Establish the equipotential bonding between the robot and the robot controller.	(>>> 6.5 "Connecting the PE equipotential bonding" Page 59)
8	Connect the robot controller to the power supply.	(>>> 6.6 "Connecting the robot controller to the power supply" Page 59)
9	Configure and connect interface X11.\n\n**Note:** If interface X11 has not been wired, the robot cannot be jogged.	(>>> 4.5 "Interface X11" Page 45)
10	Configure and connect mini I/O interface X12.	(>>> 4.6 "Configuring mini I/O X12" Page 49)
11	Configure and connect wrist I/O interface X32.	(>>> 6.9 "Configuring and connecting wrist I/O connector X32" Page 60)\n\nDetailed information is contained in the robot operating instructions, in the chapter "Description of the electrical installations (robot)".
12	Switch on the robot controller.	

Step	Description	Information
13	Check the safety equipment.	Detailed information is contained in the operating instructions for the robot controller, in the chapter "Safety".
14	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
15	Check the machine data.	Detailed information is contained in the operating and programming instructions
16	Mount the tool.	
17	Check the software limit switches and adapt them if required.	
18	Calibrate the tool. In the case of a fixed tool: calibrate external TCP.	
19	Enter the load data.	
20	Calibrate the base (optional). In the case of a fixed tool: calibrate workpiece (optional).	
21	If the robot is to be controlled from a host computer or PLC: configure Automatic External interface.	Detailed information is contained in the Operating and Programming Instructions for System Integrators.

> **i** Long text names of inputs/outputs, flags, etc., can be saved in a text file and imported after a reinstallation. In this way, the long texts do not need to be re-entered manually for each manipulator. Furthermore, the long text names can be updated in application programs.

6.2 Installing the robot controller

Procedure

1. Install the robot controller horizontally. The minimum clearances to walls, other controllers, etc. must be observed. (>>> 4.1 "Installation conditions" Page 41)
2. Check the robot controller for any damage caused during transportation.
3. Check that components are fitted securely.
4. Secure any modules that have come loose.

6.3 Connecting the connecting cables

Overview

A cable set is supplied with the robot system. The basic version consists of:

- Motor/data cable
- Wrist I/O cable (optional)
  The following cables may be provided for additional applications:
- Peripheral cables

⚠ **WARNING** 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.

Procedure
1. Route motor/data cable from X20 on the robot controller to the robot junction box and plug in connector CN22.
2. Route I/O cable from X32 on the robot controller to the robot junction box and plug in connector CN20 (optional).
3. Connect the peripheral 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. Route and connect a 4 mm^2 cable as equipotential bonding between the robot and the robot controller at the installation site. (>>> 4.8 "PE equipotential bonding" Page 52)

   Route the equipotential bonding by the shortest route from the robot controller to the robot.
2. Ground the robot controller at the installation site.
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 mains via power plug X1.
   (>>> 4.3 "Power supply connection" Page 43)

6.7 Configuring and connecting connector X11

Preconditions
■ The robot controller must be switched off.

⚠ **WARNING** If connector X11 is connected or disconnected with the robot controller switched on, the UPS module may be destroyed. Connector X11 must only be connected or disconnected with the robot controller switched off.

Procedure
1. Configure connector X11 in accordance with the system and safety concepts. (>>> 4.5 "Interface X11" Page 45)
2. Connect interface connector X11 to the robot controller.

6.8 Configuring and connecting mini I/O connector X12

Procedure
1. Configure connector X12 in accordance with the system and safety concepts. (>>> 4.6 "Configuring mini I/O X12" Page 49)
2. Connect interface connector X12 to the robot controller.

6.9   Configuring and connecting wrist I/O connector X32

Procedure   1. Configure connector X32 in accordance with the system and safety con-
             cepts. (>>> 4.7 "Configuring wrist I/O X32" Page 52)

         2. Connect interface connector X32 to the robot controller.

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.

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.

Argentina Ruben Costantini S.A. (Agency)
Luis Angel Huergo 13 20
Parque Industrial
2400 San Francisco (CBA)
Argentina
Tel. +54 3564 421033
Fax +54 3564 428877
ventas@costantini-sa.com

Australia Marand Precision Engineering Pty. Ltd. (Agency)
153 Keys Road
Moorabbin
Victoria 31 89
Australia
Tel. +61 3 8552-0600
Fax +61 3 8552-0605
robotics@marand.com.au

Belgium KUKA Automatisering + Robots N.V.
Centrum Zuid 1031
3530 Houthalen
Belgium
Tel. +32 11 516160
Fax +32 11 526794
info@kuka.be
www.kuka.be

Brazil   KUKA Roboter do Brasil Ltda.

                    Avenida Franz Liszt, 80

                    Parque Novo Mundo

                    Jd. Guançã

                    CEP 02151 900 São Paulo

                    SP Brazil

                    Tel. +55 11 69844900

                    Fax +55 11 62017883

                    info@kuka-roboter.com.br

Chile   Robotec S.A. (Agency)

                    Santiago de Chile

                    Chile

                    Tel. +56 2 331-5951

                    Fax +56 2 331-5952

                    robotec@robotec.cl

                    www.robotec.cl

China   KUKA Flexible Manufacturing Equipment (Shanghai) Co., Ltd.

                    Shanghai Qingpu Industrial Zone

                    No. 502 Tianying Rd.

                    201712 Shanghai

                    P.R. China

                    Tel. +86 21 5922-8652

                    Fax +86 21 5922-8538

                    Franz.Poeckl@kuka-sha.com.cn

                    www.kuka.cn

Germany   KUKA Roboter GmbH

                    Zugspitzstr. 140

                    86165 Augsburg

                    Germany

                    Tel. +49 821 797-4000

                    Fax +49 821 797-1616

                    info@kuka-roboter.de

                    www.kuka-roboter.de

France   KUKA Automatisme + Robotique SAS

                    Techvallée

                    6, Avenue du Parc

                    91140 Villebon S/Yvette

                    France

                    Tel. +33 1 6931660-0

                    Fax +33 1 6931660-1

                    commercial@kuka.fr

                    www.kuka.fr

India	KUKA Robotics, Private Limited
	621 Galleria Towers
	DLF Phase IV
	122 002 Gurgaon
	Haryana
	India
	Tel. +91 124 4148574
	info@kuka.in
	www.kuka.in

Italy	KUKA Roboter Italia S.p.A.
	Via Pavia 9/a - int.6
	10098 Rivoli (TO)
	Italy
	Tel. +39 011 959-5013
	Fax +39 011 959-5141
	kuka@kuka.it
	www.kuka.it

Japan	KUKA Robotics Japan K.K.
	Daiba Garden City Building 1F
	2-3-5 Daiba, Minato-ku
	Tokyo
	135-0091
	Japan
	Tel. +81 3 6380-7311
	Fax +81 3 6380-7312
	info@kuka.co.jp

Korea	KUKA Robot Automation Korea Co. Ltd.
	4 Ba 806 Sihwa Ind. Complex
	Sung-Gok Dong, Ansan City
	Kyunggi Do
	425-110
	Korea
	Tel. +82 31 496-9937 or -9938
	Fax +82 31 496-9939
	info@kukakorea.com

Malaysia	KUKA Robot Automation Sdn Bhd
	South East Asia Regional Office
	No. 24, Jalan TPP 1/10
	Taman Industri Puchong
	47100 Puchong
	Selangor
	Malaysia
	Tel. +60 3 8061-0613 or -0614
	Fax +60 3 8061-7386
	info@kuka.com.my

Mexico   KUKA de Mexico S. de R.L. de C.V.
Rio San Joaquin #339, Local 5
Colonia Pensil Sur
C.P. 11490 Mexico D.F.
Mexico
Tel. +52 55 5203-8407
Fax +52 55 5203-8148
info@kuka.com.mx

Norway   KUKA Sveiseanlegg + Roboter
Bryggeveien 9
2821 Gjövik
Norway
Tel. +47 61 133422
Fax +47 61 186200
geir.ulsrud@kuka.no

Austria   KUKA Roboter Austria GmbH
Vertriebsbüro Österreich
Regensburger Strasse 9/1
4020 Linz
Austria
Tel. +43 732 784752
Fax +43 732 793880
office@kuka-roboter.at
www.kuka-roboter.at

Poland   KUKA Roboter Austria GmbH
Spółka z ograniczoną odpowiedzialnością
Oddział w Polsce
Ul. Porcelanowa 10
40-246 Katowice
Poland
Tel. +48 327 30 32 13 or -14
Fax +48 327 30 32 26
ServicePL@kuka-roboter.de

Portugal   KUKA Sistemas de Automatización S.A.
Rua do Alto da Guerra n° 50
Armazém 04
2910 011 Setúbal
Portugal
Tel. +351 265 729780
Fax +351 265 729782
kuka@mail.telepac.pt

Russia	OOO KUKA Robotics Rus
	Webnaja ul. 8A
	107143 Moskau
	Russia
	Tel. +7 495 781-31-20
	Fax +7 495 781-31-19
	kuka-robotics.ru

Sweden	KUKA Svetsanläggningar + Robotar AB
	A. Odhners gata 15
	421 30 Västra Frölunda
	Sweden
	Tel. +46 31 7266-200
	Fax +46 31 7266-201
	info@kuka.se

Switzerland	KUKA Roboter Schweiz AG
	Riedstr. 7
	8953 Dietikon
	Switzerland
	Tel. +41 44 74490-90
	Fax +41 44 74490-91
	info@kuka-roboter.ch
	www.kuka-roboter.ch

Spain	KUKA Robots IBÉRICA, S.A.
	Pol. Industrial
	Torrent de la Pastera
	Carrer del Bages s/n
	08800 Vilanova i la Geltrú (Barcelona)
	Spain
	Tel. +34 93 8142-353
	Fax +34 93 8142-950
	Comercial@kuka-e.com
	www.kuka-e.com

South Africa	Jendamark Automation LTD (Agency)
	76a York Road
	North End
	6000 Port Elizabeth
	South Africa
	Tel. +27 41 391 4700
	Fax +27 41 373 3869
	www.jendamark.co.za

Taiwan	KUKA Robot Automation Taiwan Co. Ltd.
	136, Section 2, Huanjung E. Road
	Jungli City, Taoyuan
	Taiwan 320
	Tel. +886 3 4371902
	Fax +886 3 2830023
	info@kuka.com.tw
	www.kuka.com.tw
Thailand	KUKA Robot Automation (M)SdnBhd
	Thailand Office
	c/o Maccall System Co. Ltd.
	49/9-10 Soi Kingkaew 30 Kingkaew Road
	Tt. Rachatheva, A. Bangpli
	Samutprakarn
	10540 Thailand
	Tel. +66 2 7502737
	Fax +66 2 6612355
	atika@ji-net.com
	www.kuka-roboter.de
Czech Republic	KUKA Roboter Austria GmbH
	Organisation Tschechien und Slowakei
	Sezemická 2757/2
	193 00 Praha
	Horní Počernice
	Czech Republic
	Tel. +420 22 62 12 27 2
	Fax +420 22 62 12 27 0
	support@kuka.cz
Hungary	KUKA Robotics Hungaria Kft.
	Fö út 140
	2335 Taksony
	Hungary
	Tel. +36 24 501609
	Fax +36 24 477031
	info@kuka-robotics.hu
USA	KUKA Robotics Corp.
	22500 Key Drive
	Clinton Township
	48036
	Michigan
	USA
	Tel. +1 866 8735852
	Fax +1 586 5692087
	info@kukarobotics.com
	www.kukarobotics.com

UK   KUKA Automation + Robotics

Hereward Rise

Halesowen

B62 8AN

UK

Tel. +44 121 585-0800

Fax +44 121 585-0900

sales@kuka.co.uk

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