KUKA Roboter GmbH

KUKA youBot

Assembly and Operating Instructions

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Translation of the original documentation

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Contents

1 Introduction

1.1 KUKA youBot documentation

The KUKA youBot documentation consists of the following parts:

- KUKA youBot Operating and Assembly Instructions
- Operating and programming instructions: Trinamic ETHERCAT™ MANUAL for axis controller TMCM-1632 (youBot platform) and TMCM-KR-841/ TMCM-1610-KR (youBot arm)
- Operating and programming instructions: Trinamic FIRMWARE MANUAL for gripper controller TMCM-KR-842
- Advantech user manual AIMB-212D-S6A1E for youBot PC
- Data sheet for power supply unit
- Data sheet for battery

Each of these sets of instructions is a separate document.

1.2 Representation of warnings and notes

Safety

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

DANGER	These warnings mean that it is certain or highly probable that death or severe injuries **will** occur, if no precautions are taken.
WARNING	These warnings mean that death or severe injuries **may** occur, if no precautions are taken.
CAUTION	These warnings mean that minor injuries **may** occur, if no precautions are taken.
NOTICE	These warnings mean that damage to property **may** occur, if no precautions are taken.
⚠	These warnings contain references to safety-relevant information or general safety measures. These warnings do not refer to individual hazards or individual precautionary measures.

This warning draws attention to procedures which serve to prevent or remedy emergencies or malfunctions:

SAFETY INSTRUCTIONS	Procedures marked with this warning **must** be followed exactly.

Hints

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

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

1.3 Terms used

Term	Description
User	The user of the youBot can be the management, employer or delegated person (e.g. system integrator) responsible for use of the youBot. Under certain circumstances, the user and the system integrator can be one and the same (legal or natural) person.
EMC	Electromagnetic compatibility, Directive 2004/108/EC
Device	See definition in EMC Directive 2004/108/EC.
ESHRs	Essential Health and Safety Requirements; Annex 1 to the Machinery Directive (Directive 2006/42/EC).
Home position	Defined basic position, e.g. of the youBot arm.
Jumper	Small plug-in jumper (short-circuit connector) that is plugged onto the contacts of contact strips.
Manipulator	The robot arm and the associated electrical installations.
Machine	See definition in Machinery Directive 2006/42/EC.
EC Machinery Directive	Machinery Directive 2006/42/EC.
EMERGENCY STOP	The EMERGENCY OFF shuts off the power to all motors of the youBot platform and/or youBot arm; the motors can move freely.
EMERGENCY STOP	The EMERGENCY STOP interrupts the EtherCAT communication. Each individual controller detects an interruption in the communication and attempts to stop the assigned motor by means of position control.
PELV	Protective Extra Low Voltage.
System integrator	The task of the system integrator is to commission the youBot system safely. Under certain circumstances, the user and the system integrator can be one and the same (legal or natural) person.
youBot arm	5-axis manipulator
youBot platform	Omnidirectionally movable transport system
youBot system	The device described in this documentation is a youBot system consisting of a youBot platform with one or two arms.
youBot 1-arm system	youBot platform with one youBot arm
youBot 2-arm system	youBot platform with two youBot arms

2 Purpose

2.1 Target group

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

- Basic knowledge of robotics
- Advanced knowledge of electrical engineering, mechanical engineering and/or mechatronics
- Knowledge of the robot controller system
- Basic knowledge of information technology

2.2 Intended use

The youBot system is an open, expandable, modular robot system that has been specially developed for research purposes with an emphasis on robotics. The youBot system may only be used by laboratory and research personnel for the performance of special experiments and research tasks.

Creation of the control software for the youBot system is part of the research project and is the responsibility of the user/system integrator.

Misuse

Any use or application deviating from the intended use is deemed to be misuse and is not allowed. This includes e.g.:

- Operation outside the permissible operating parameters
- Operation outdoors
- Operation in industry, small enterprises and commercial settings (production, manufacturing, etc.)
- Operation in residential and business environments
- Operation in potentially explosive environments
- Operation for military purposes
- Use in underground mining
- Operation without external safety equipment
- Operation as a means of transport for passengers
- Operation as a means of transport for liquids

Misuse of the youBot system applies analogously to the youBot platform and the youBot arm.

For the attachment of additional sensors, adapter plates, etc., only use the holes provided.
Modification of the components of the youBot, e.g. by drilling holes, etc., can result in damage to the components of the youBot. This is considered misuse and leads to loss of guarantee and liability entitlements.

Due to the open source character of the product, it is not possible for KUKA to prevent motions of the robot which could result in the destruction of the product.

No warranty can be offered for wear or damage to the mechanical components of the youBot arm if the youBot arm hits its mechanical end stops as a result of programming or motion execution, or for damage resulting from interaction with the environment (e.g. collisions). An exception is made here for motions that are required for calibrating the robot axes. In this case, the robot may be moved against its mechanical end stops in accordance with the instructions (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41).

No warranty can be offered for wear or damage to the mechanical components of the youBot platform caused by the programming or operator control and resulting from interaction with the environment (e.g. unsuitable floor surface, collisions). In conjunction with this, no warranty is offered for damage to objects, e.g. installed sensors, floor coating, etc.

3 Product description

3.1 Overview of the youBot system

The youBot system consists of the following hardware components:

Hardware component	Description
Arm (5-axis robot arm)	(>>> 3.1.1 "Description of the youBot arm" Page 10)
Platform (omnidirectional mobile platform)	(>>> 3.1.2 "Description of the youBot platform" Page 12)
Gripper module (two-finger gripper) (optional)	(>>> 3.1.3 "Description of the youBot gripper module (optional)" Page 15)
Loading area (optional)	A loading area can optionally be mounted on the platform.

Fig. 3-1: Overview of youBot system

1	Gripper (optional)	3	Platform
2	Arm	4	Loading area (optional)

The components arm and platform can be operated separately or as a group (system). Systems are available with either one or two arms.

The components arm and platform can be operated together or separately. The platform is operated with a battery. The arm can be supplied with power either via the platform or separately using the power supply unit.

The drives of the platform and the arm have an EtherCAT interface whose protocol is described in the supplier documentation from Trinamic. Both components can be controlled by a PC integrated into the platform or by an external PC (not included in the scope of supply) using EtherCAT telegrams.

The software required for controlling the system is not part of the scope of supply and is either created in the context of research projects or can be obtained

from publicly accessible Internet sites (e.g. www.kuka-youBot.com or www.kuka-labs-forum.com).

Within a research project, further components can be added by the system integrator. These may include, for example:

- Teach pendants
- Sensors (camera, laser scanner)
- Multi-finger hands
- Lifting systems
- Swivel and tilt modules
- Software modules

youBot enables the performance of a range of challenging research tasks, such as:

- Integration of planning and control
- Cognitively plausible, efficient and natural motion choreography
- Modification and adaptation of task and motion planning
- Integration of 3D perception, mapping and modeling
- Resource management (use of sensors for motion or manipulation)
- Software engineering for robotics (component models, model-based engineering)
- Robot control architectures
- Self-perception, self-modeling
- Non-functional aspects: robustness and reliability, openness, reusability

3.1.1 Description of the youBot arm

Overview

The arm is designed as a 5-axis jointed-arm kinematic system and driven by electric motors. The motors do not have mechanical brakes. An optional gripper module with two jaws is available for the arm (>>> 3.1.2 "Description of the youBot platform" Page 12).

The arm consists of the following principal components:

- Base frame
- Rotating column
- Link arm
- Arm
- Wrist
- Flange

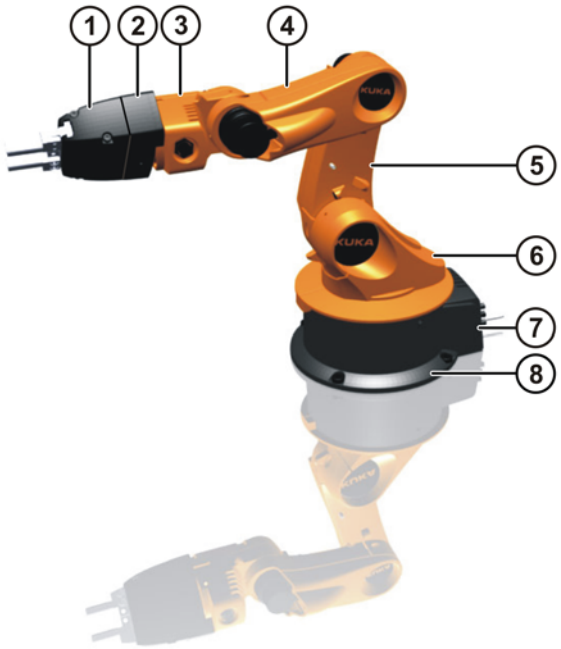


Fig. 3-2: youBot arm

1 Gripper module
2 Flange
3 Wrist
4 Arm
5 Link arm
6 Rotating column
7 Connections, power supply unit/EtherCAT, LED ON/OFF button (>>> Fig. 7-2)
8 Base frame

Base frame The base frame is the base of the arm. It contains a connection plate for the power supply connection (24 V) and the data communication (2x RJ45 connector). The base frame is screwed to a substructure (e.g. platform).

Rotating column The rotating column (axis 1) is screwed to the base frame; drive M1.

Link arm The link arm (axis 2) is the link between the arm and the rotating column; drive M2.

Arm The arm (axis 3) is the link between the wrist and the link arm; drive M3.

There is a master board installed in the arm. It performs the following tasks:

- Data conversion between EtherCAT and the internal E-bus of the arm
- Limitation of the electrical power to 80 W in non-safe design

The arm must not be opened. Opening it is considered misuse and leads to loss of guarantee and liability entitlements.

Wrist The wrist (axis 4) serves as a mount for the flange; drive M4.

Flange The flange (axis 5) serves as a mount for a tool (e.g. gripper, sensors); drive M5.

Gripper module (optional) The gripper module is a two-finger gripper and is mounted on the flange. The jaws of the gripper module are driven by 2 spindle motors.

3.1.2 Description of the youBot platform

The omnidirectional technology of the omniWheels means that the platform can be moved in any direction and positioned with great precision. The electric motors do not have mechanical brakes. The platform has a swing axle to compensate for slight unevenness in the floor. A raised loading area can optionally be mounted on the platform.

Overview

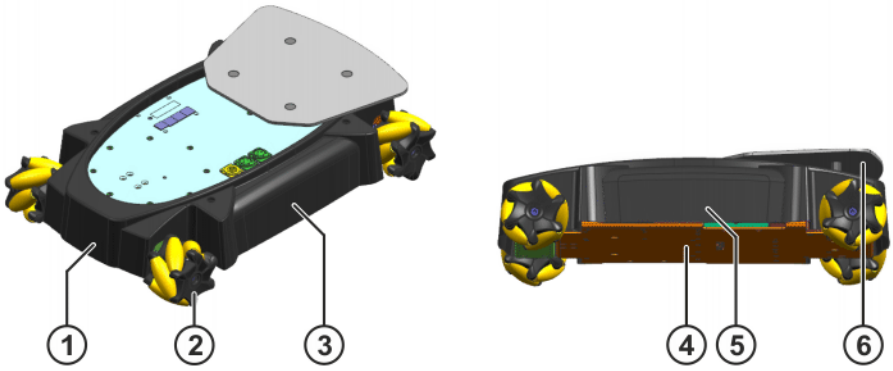


Fig. 3-3: Platform

1 Cover
2 omniWheel (4x)
3 Side cover, battery (removable)
4 Chassis
5 Side cover, PC (removable)
6 Loading area (optional)

The platform consists of the following principal components:

- Chassis with 4 KUKA omniWheels

  The omniWheel consists of convex, non-driven rollers, which are mounted between 2 rims at an angle of approximately 45°. The rollers are arranged in such a way that they replicate a circle. The wheels do not have a steering mechanism. Translational and rotational velocity and the center of rotation of the vehicle are essentially determined by the direction of rotation of the wheels relative to one another.
- Cover
- Loading area (optional)

  A loading area can optionally be mounted on the platform using studs. For this purpose, there are two hole circles marked on the upper side of the platform, indicating the available installation positions.

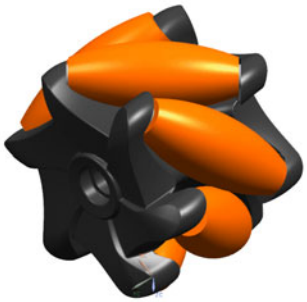


Fig. 3-4: omniWheel roller arrangement

Electrical system

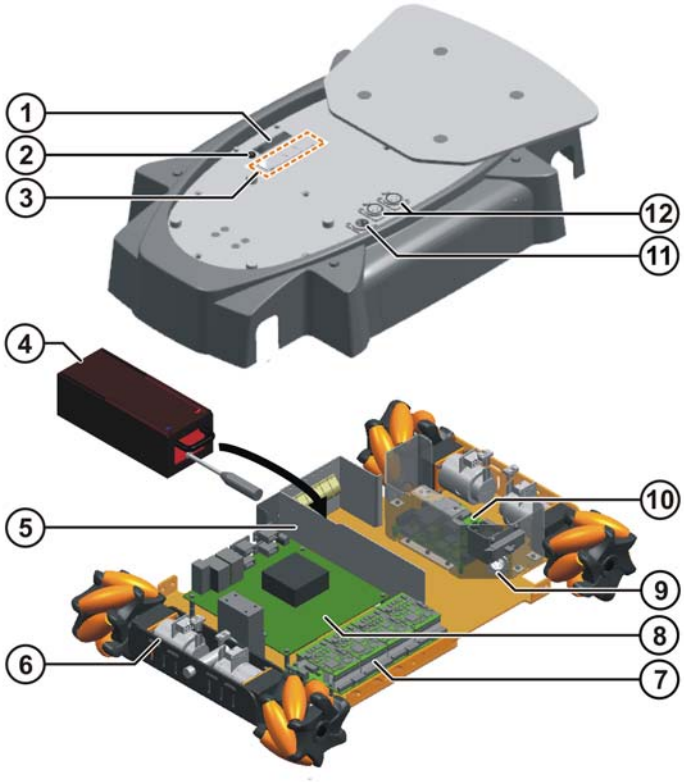


Fig. 3-5: youBot platform, electrical system

1 Multifunction display
2 ON/OFF button
3 Interfaces
4 Battery
5 Battery housing with lock
6 Drive motor (4x)
7 Drive electronics (master board with 4 drive controllers)
8 PC
9 Battery connection (2 x 12 V)
10 Power board
11 24 V input
12 24 V output (2x)

The platform has the following electrical assemblies:

- Multifunction display:
  - Voltage of power supply unit and/or battery charge
  - Status indicators (>>> 3.1.2.1 "ON/OFF function of the youBot platform" Page 14)
- ON/OFF button (>>> 3.1.2.1 "ON/OFF function of the youBot platform" Page 14):

  1 Power supply indicator (here: power supply unit)
  2 Battery charge indicator (only during battery operation)
  3 “PC on/off” status indicator (here: off)
  4 “Motor on/off” status indicator (here: on)

  If the button is then pressed and held down, the individual modes “PC on” - “Motor on” - “Switch off” are scrolled through repeatedly. If the button is

released while a mode is shown in the display, the status will then switch to this mode (e.g. “PC on”).

- Interfaces:
  - 1x Ethernet: LAN port PC
  - 2x EtherCAT: PC/arms
  - 2x USB: PC
- Battery
- Battery housing with lock
- Drive motor (4x)
- Drive electronics (master board with 4 drive controllers)
- PC

  The PC has 2 GB RAM and 32 GB solid state drive (SSD).

Further information is contained in the Advantech user manual AIMB-212D-S6A1E.

- Battery connection (2x 12 V) with the following functions:
  - Charging the battery
  - Voltage supply to platform and arm(s) via battery
- Power board (voltage supply to platform and arm(s), charging circuit for battery)
- Input 24 V (platform operation/battery charging)
- 2x output 24 V (power supply to arms)

3.1.2.1 ON/OFF function of the youBot platform

Description

If the youBot platform is battery-operated, the ON/OFF button must be pressed once in order to activate the multifunction display and to switch to the “System standby” mode. The controller automatically switches to this mode when connected to the external power supply unit.

If the button is pressed again, the type of supply voltage (1 x 24V or 2 x 12V), the battery charge (if installed) and the “on/off” status of the PC and motor (large/small rectangular symbols) are shown in the status display in the “Start-up” mode.

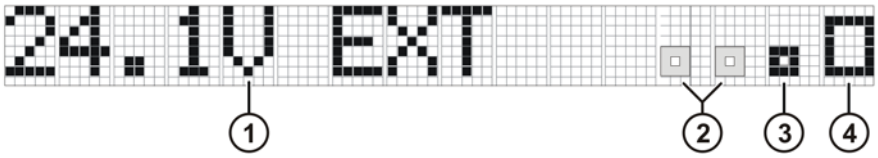


Fig. 3-6: Multifunction display with status indicator

1 Power supply indicator (here: power supply unit)
2 Battery charge indicator (only during battery operation)
3 “PC on/off” status indicator (here: off)
4 “Motor on/off” status indicator (here: on)

If the button is then pressed and held down, the individual modes “PC on” - “Motor on” - “Switch off” are scrolled through repeatedly. If the button is released while a mode is shown in the display, the status will then switch to this mode (e.g. “PC on”).

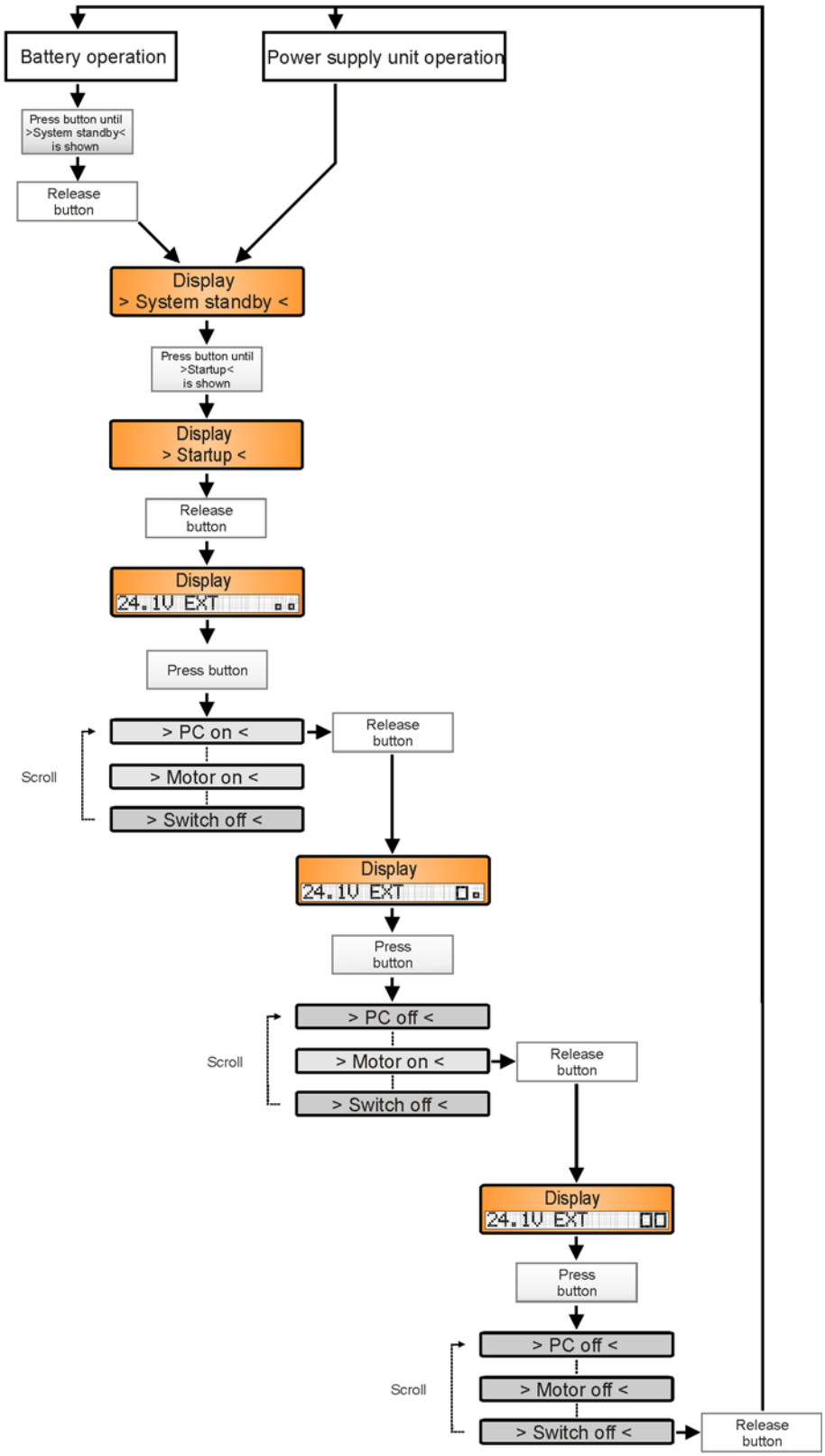


Fig. 3-7: ON/OFF button function

3.1.3 Description of the youBot gripper module (optional)

Overview

The gripper module is optionally mounted on the flange of the arm. The 2 jaws of the gripper module are each driven by a spindle motor and can be moved individually (max. 10 mm per jaw). Each jaw can be mounted separately in 3 different positions. At the narrowest jaw setting, the gripper module has a trav-

el of 0 mm to 20 mm; with the widest jaw setting, the travel can be extended to 50 mm to 70 mm.

The gripper module has a self-locking function, i.e. in the event of a power failure, the gripper continues to grip the workpiece it is holding.

Fig. 3-8: Gripper module jaw positions (example)

Item	Description
1	Travel 0 mm ... 20 mm
2	Travel 25 mm ... 45 mm
3	Travel 50 mm ... 70 mm

3.1.4 Steering concept

The platform can be moved in any direction and positioned with great precision. The direction of travel can be defined, for example, on the basis of the angles of a circle, as follows:

- 0º corresponds to the direction of travel “forwards”
- 90º corresponds to the direction of travel “right” (direct, without motion round curves)
- 180º corresponds to the direction of travel “backwards”

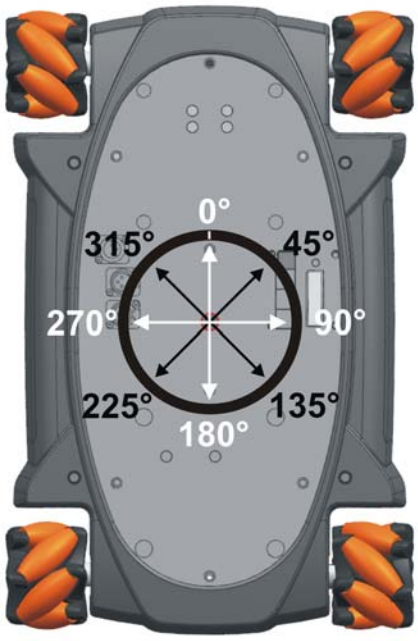
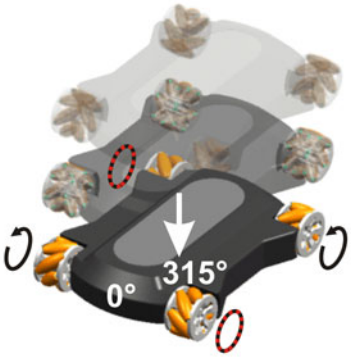
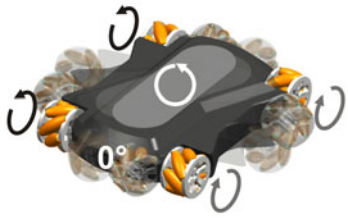


Fig. 3-9: Definition of direction of motion (example)

Direction of rotation of omniWheel/ direction of travel

The following table contains examples of the relationship between direction of travel and direction of rotation of the wheels.

Direction of motion	Direction of rotation of omniWheel
Moving straight ahead 	All omniWheels move at the same speed and in the same direction.
Moving sideways 	Each omniWheel moves in the opposite direction to the one next to it. All omniWheels move at the same speed.
Moving diagonally 	Each pair of omniWheels across a diagonal moves in the same direction and at the same speed. The diagonally opposite pair of omniWheels remains stationary.

Direction of motion	Direction of rotation of omniWheel
Rotation about the central axis  	The omniWheels on one side rotate in the opposite direction to the omniWheels on the other side. All omniWheels turn at the same speed.
Moving round curves When moving round curves, 2 motions are superimposed, e.g. straight-ahead and rotation about the central axis.	The omniWheels on one side rotate in the same direction and at the same speed. The omniWheels on the other side also rotate in this same direction, but at a faster or slower speed (the greater the difference in speed, the tighter the curve).

3.2 youBot systems

Description The components arm and platform can be operated as a group (system). Systems are available with either one or two arms.

System	Description
1-arm system	(>>> 3.2.1 "Description of 1-arm system" Page 18)
2-arm system	(>>> 3.2.2 "Description of 2-arm system" Page 19)

3.2.1 Description of 1-arm system

Overview The 1-arm system consists of the following components:

- Arm
- Platform
- Loading area (optional)

Arm and platform are connected to one another by means of a fastening kit, an Ethernet cable and a power supply cable.

Fig. 3-10: youBot 1-arm system

1	Arm	3	Platform
2	Loading area (optional)		

3.2.2 Description of 2-arm system

Overview

The 2-arm system consists of the following components:

- Arm (2x)
- Platform

Arms and platform are connected to one another by means of 2 fastening kits, 2 Ethernet cables and 2 power supply cables.

Fig. 3-11: 2-arm system

1	Arm	2	Platform

4 Technical data

4.1 Technical data, youBot system

Basic data

Protection rating of the youBot system	IP 10

Ambient temperature

Ambient temperature during operation	+5 °C to +35 °C (278 K to 308 K) Derating: 5% of the ambient temperature per 1000 m altitude
Ambient temperature during storage/transportation	-40 … +60 °C (233 … 333 K)
Altitude	max. 1000 m
Ambient conditions	Protect the electrical and mechanical systems of the components against humidity; only operate in dry environments.

The technical data for the individual components are found in the following sections:

- youBot arm
  (>>> 4.2 "Technical data, youBot arm" Page 21)
- youBot platform
  (>>> 4.3 "Technical data, youBot platform" Page 23)
- youBot gripper module (optional)
  (>>> 4.4 "Technical data, youBot gripper module (optional)" Page 24)
- youBot battery
  (>>> 4.5 "Technical data, youBot battery" Page 25)
- youBot power supply unit
  (>>> 4.6 "Technical data, youBot power supply unit" Page 25)

4.2 Technical data, youBot arm

Basic data

Number of axes	5
Protection rating of the arm	IP 20
Material	Die-cast magnesium
Height	655 mm
Weight	5.690 kg (without gripper)
Payload	0.5 kg
Data transmission	EtherCAT
Power consumption	240 W (24 V/10 A) in battery mode (with youBot platform)

Axis data

Axis	Axis range	Max. speed
1	± 168°	90 °/s
2	+ 89°/-64°	90 °/s
3	+145°/-150°	90 °/s
4	± 102°	90 °/s
5	± 166°	90 °/s

NOTICE The axis ranges are defined by mechanical end stops. The axes may slowly be moved manually against these stops in preparation for calibration or transportation. The user of the youBot arm must ensure that these stops are not hit at excessive speed.

NOTICE Due to the open source character of the product, the speed of motion of the axes cannot be limited by the manufacturer. It is entirely possible for higher speeds to be reached which, under certain circumstances, could result in destruction of the motor and gear unit. The maximum speeds and the maximum working ranges of the axes must not be exceeded.

The direction of motion and the arrangement of the individual axes may be noted from the diagram (>>> Fig. 4-1).

Fig. 4-1: Direction of rotation of the axes (home position)

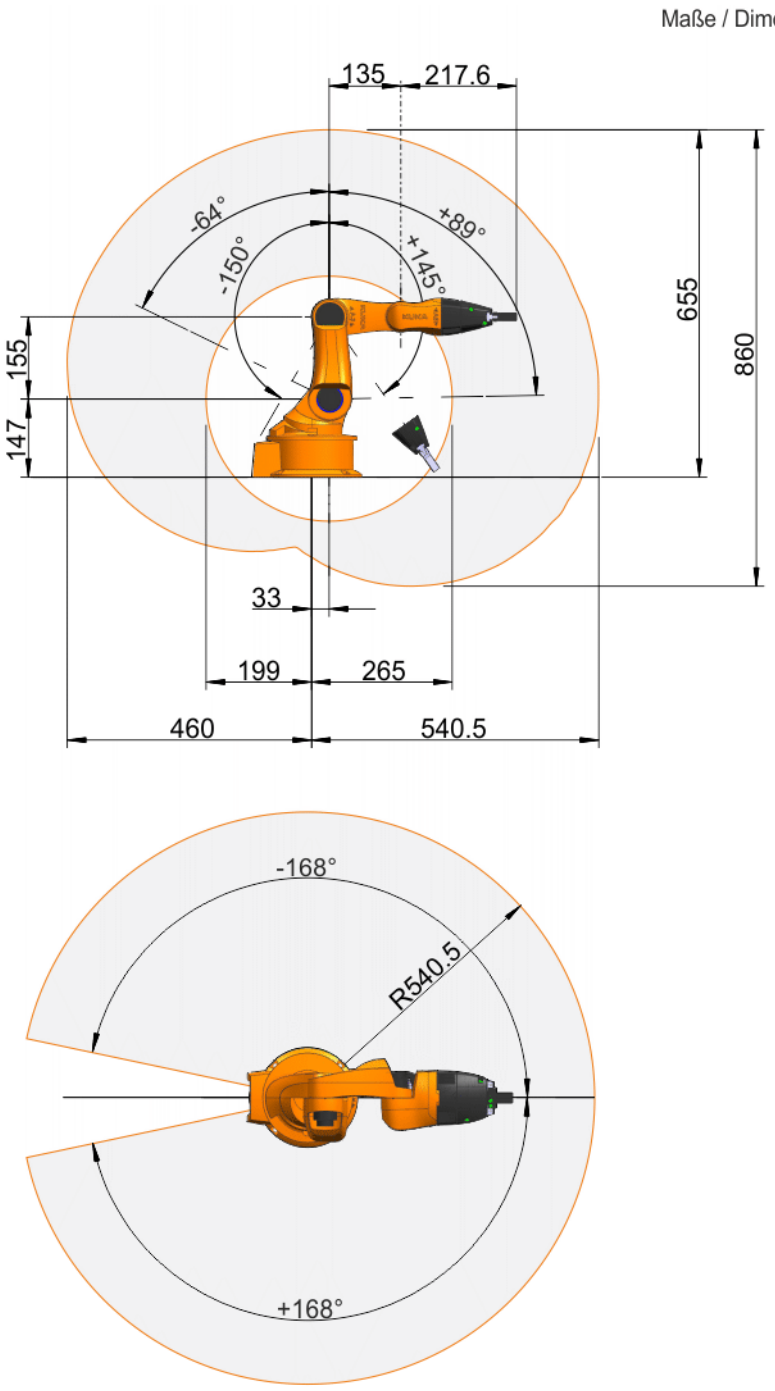


Fig. 4-2: Axis ranges

4.3 Technical data, youBot platform

Basic data

Protection rating of platform	IP 10
Material	Steel
Length	580 mm
Width	376 mm
Height	140 mm
Wheel diameter	100 mm
Ground clearance	30 mm

Weight	20 kg (without battery)
Payload	20 kg
Data transmission	EtherCAT
youBot PC (12 V/5 A)	Mini ITX board Intel Atom dual core 2 GB RAM 32 GB solid state drive (SSD) Ethernet, USB, COM

Dimensions

The following figure (>>> Fig. 4-3) shows the dimensions of the youBot platform.

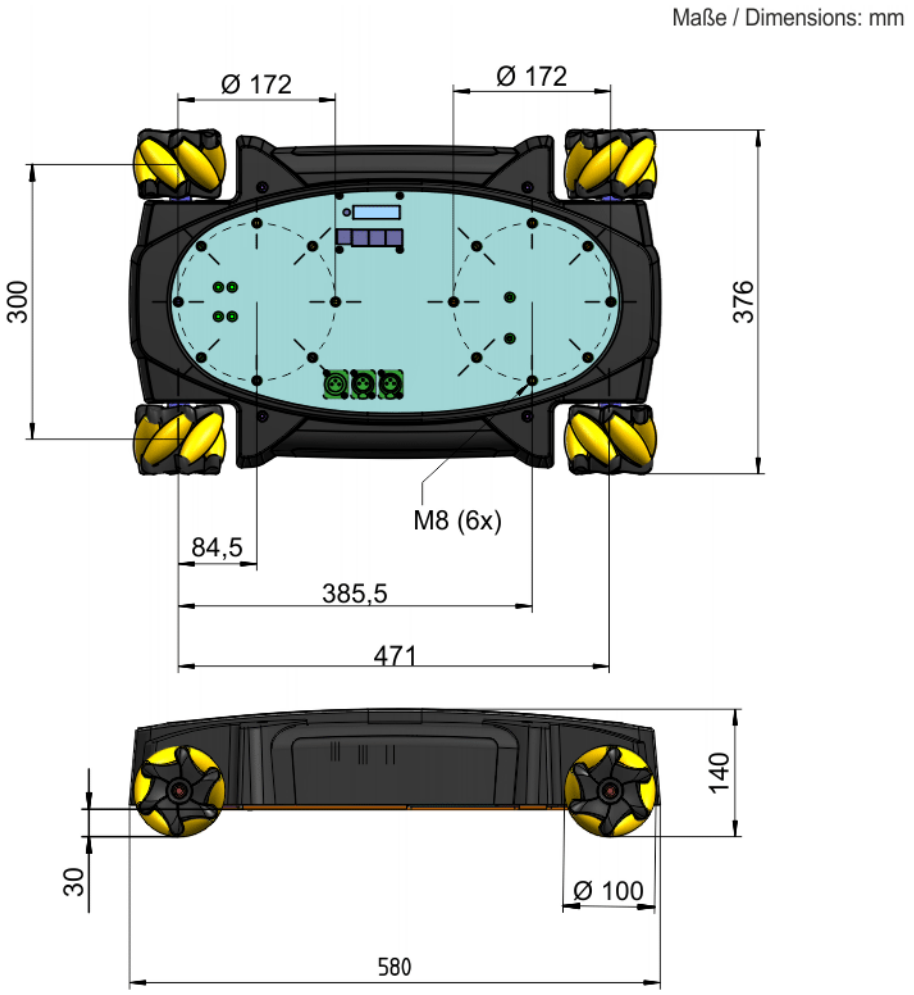


Fig. 4-3: youBot platform, dimensions

4.4 Technical data, youBot gripper module (optional)

Basic data

Design	2 jaws
Weight	0.245 kg
Travel	20 mm
Maximum opening	70 mm
Max. load	0.5 kg

4.5 Technical data, youBot battery

Basic data

Type	Lead-acid battery
Voltage	24 V (2 x 12 V)
Charging current	1.66 A
Capacitance	5.4 Ah
Weight	4 kg

4.6 Technical data, youBot power supply unit

Basic data

Input voltage	100 - 240 V
Output voltage	24 V/DC
Max. output power	200 W

4.7 Plates and labels

The following plates and labels are attached to the youBot platform and youBot arm. They must not be removed or rendered illegible. Illegible plates and labels must be replaced.

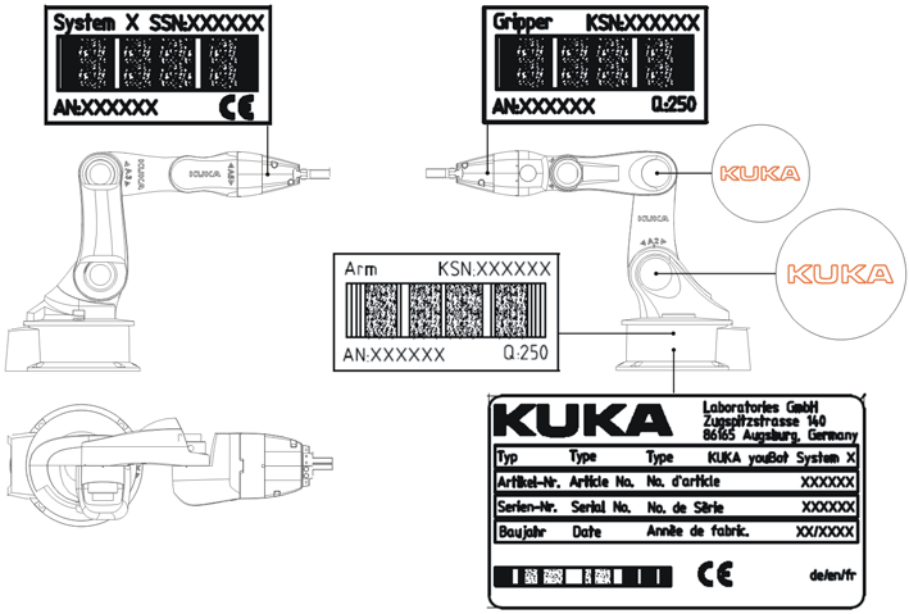


Fig. 4-4: youBot arm/gripper identification plate

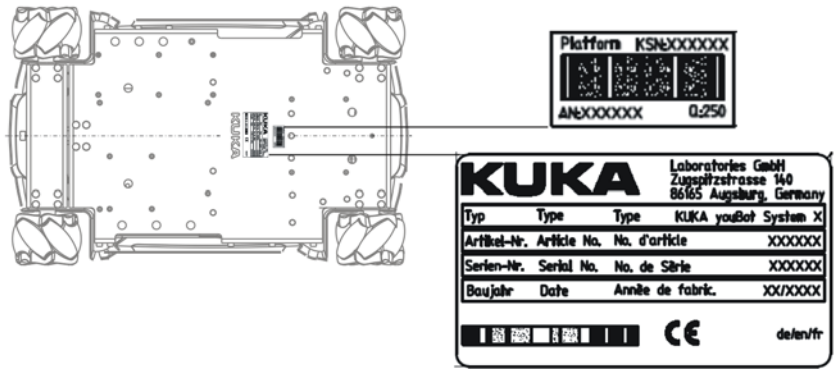


Fig. 4-5: youBot platform identification plates

5 Safety

5.1 General safety instructions

The general safety instructions apply to all youBot components and systems. Special safety instructions for the components youBot arm and youBot platform or the youBot system are specified separately in the documentation.

If a machine as defined by the EC Machinery Directive is developed on the basis of the modular youBot system, the corresponding standards and the essential health and safety requirements for the design and construction of machinery must be met.

The user/system integrator must perform a risk assessment in accordance with the EC Machinery Directive and implement the measures defined in the risk assessment.

- The youBot system and individual components must only be used in perfect technical condition.

⚠ CAUTION Risk of personal injury and damage to property: No modifications may be made to the mechanical, electrical and electronic systems by the user, system integrator or operator.

- The user/system integrator must observe the legal requirements of the EMC Directive for all components.

This is a Class A device. This device may cause radio interference in residential areas.

- No sharp, pointy or other hazardous objects may be mounted on the youBot components.
- In accordance with the applicable occupational health and safety regulations, the user/system integrator must ensure that the relevant safety measures (personal protective equipment, observation of the ESHRs and safety requirements) are taken in order to protect operators.
- The user/system integrator must also instruct the operator in accordance with all other risk assessments that have been made. An additional risk assessment for occupational health and safety must be carried out and implemented for start-up, maintenance and servicing personnel.
- The user/system integrator must ensure that all persons are outside the hazard area during operation of the youBot system or components thereof.

⚠ CAUTION Risk of collision! The individual youBot components and the youBot system have no collision protection. The user user/system integrator must ensure that the axes of the youBot arm do not hit the mechanical end stops.

⚠ CAUTION Risk of collision! The drive axes of the individual youBot components and the youBot system have no mechanical brakes. Even in the event of an EMERGENCY STOP, the drive axes remain energized (under position control). Overloading of a drive (during an EMERGENCY STOP or during operation) can result in the drive being de-energized (PWM = 0) to prevent thermal destruction of the drive. The motions of the youBot arm in such a case cannot be predicted exactly.

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⚠ CAUTION Risk of personal injury and damage to property: When programming the software, the parameters of components (e.g. axis end stops, axis speeds) and workspaces must be observed.

⚠ CAUTION Risk of personal injury and damage to property: Following modifications to the firmware parameters, the user/system integrator must carry out a function test, e.g. EMERGENCY STOP, max. speed, collision prevention with axis end stops, etc.

- EMERGENCY OFF design: User/system integrator must comply with the specifications of the EC Machinery Directive and international laws.
- The youBot system and the youBot components may only be operated in the specified ambient conditions, and not outdoors.
- youBot components must be de-energized before work is carried out on them. They are de-energized by disconnecting the youBot power supply unit and the youBot battery.
- Electrical and electronic components must not be touched.

5.1.1 Safety instructions, youBot arm

The following safety instructions apply to the youBot arm, irrespective of whether this is being operated as a stationary installation or on a youBot platform.

- The youBot arm must be fastened to a suitable surface so that the youBot arm cannot topple over or slide.
- The user/system integrator must specify the hazard area/workspace of the youBot arm and ensure that there are no persons and/or body parts in this area while the youBot arm is moving.
- The user/system integrator must inform the operator of the risk of injury from motion of the axes (e.g. risk of crushing); wear a hair net and closely fitting clothing.

NOTICE During initialization, ensure that the axes are free to move in the initialization direction and are not blocked. Further information about the initialization direction is contained in the Trinamic operating and programming instructions ETHERCAT™ MANUAL for axis controller TMCM-KR-1632/TMCM-1610-KR.

5.1.2 Safety instructions, KUKA youBot platform

The following safety instructions apply to the youBot platform, irrespective of whether the youBot platform is being operated separately or as a system (combination with youBot arm(s)):

- The user/system integrator must carry out a risk assessment for the selected velocity and load. The following must be taken into consideration for the load: transport safeguard with regard to changes of direction, acceleration and deceleration.

  Hazardous loads and loads exceeding the maximum load are not permissible.
- Do not operate the youBot platform on sloping surfaces (loss of motion control). The youBot platform may only be operated on horizontal, dry and lint-free surfaces.
- Risk of the youBot platform falling if operated on a table or similar raised surface; install correspondingly fixed safeguards or barriers. Safeguards

and barriers must be at least the same height as the wheels of the youBot platform.

- The required degree of protection of the youBot platform is only achieved with the cover mounted.
- The user/system integrator must inform the operator of the risk of injury from rotation of the wheels (e.g. risk of cutting, risk of tangling of hair or clothing); wear a hair net, sturdy, closed footwear and closely fitting clothing.

5.1.3 Safety instructions, KUKA youBot system

The following safety instructions apply to the youBot system:

- Risk of the youBot system falling if operated on a table or raised surface; install correspondingly fixed safeguards or barriers. Safeguards and barriers must be at least the same height as the wheels of the youBot platform.

⚠ CAUTION Risk of personal injury and damage to property: If the youBot system is operated on a table or raised surface, the user/system integrator must install corresponding safety equipment.

⚠ CAUTION Risk of personal injury and damage to property: The maximum permissible payload of the youBot arm is only valid for motion of the arm alone, without additional movements of the youBot platform. The forces on a payload resulting from a combined motion of the youBot arm and the youBot platform must be taken into consideration. Set down objects on the support area and secure them before commencing motion or retract the youBot arm with the load held in the gripper.

6 Transportation

6.1 Transportation

⚠ CAUTION Risk of injury (crushing/cuts) to hands and fingers during transportation of the youBot platform and youBot arm. The youBot arm has no holding brakes and, if de-energized, can be moved freely (against the resistance of the motor and gear unit of the corresponding axis). The youBot arm must be firmly secured for transportation.

With packaging

To reduce the risk of injury, only use the original transport packaging or the youBot transport case (optional).

In order to avoid invalidating the warranty, only use the original transport packaging (e.g. to allow the wheels of the youBot platform to stand freely and the chassis to absorb impacts) or comparably safe packaging (e.g. youBot transport case).

NOTICE The omniWheels and the axes may be damaged by vibrations/impacts during transportation. During transportation, the youBot platform may only bear a load on the steel chassis.

Fig. 6-1: Transport position of the youBot arm with packaging

Without packaging

Transportation of youBot components over short distances (e.g. from the floor to a table) is carried out without packaging; the following safety measures must therefore be taken:

- Only grip the youBot platform by the lower steel chassis at the front and back or by the firmly installed loading area (plastic cover may break during carrying).

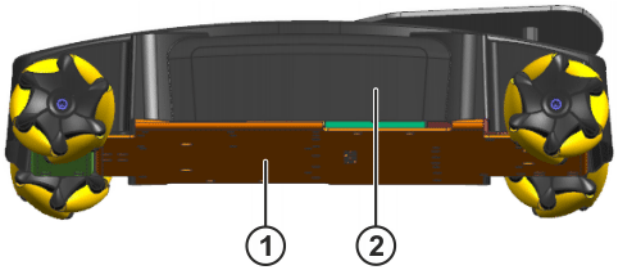

Fig. 6-2: Transporting the youBot platform

1 Steel chassis 2 Cover

- Move youBot arm to the transport position (home position), grip the base frame at both ends and carry in a vertical position. This prevents hands from being crushed, for example.

Fig. 6-3: Transport position of the youBot arm without packaging

7 Start-up and recommissioning

7.1 KUKA youBot arm start-up

Precondition

- youBot arm, youBot connection kit, youBot power supply unit and youBot platform (optional) are present.

7.1.1 Installing the KUKA youBot arm on a mounting surface

Description

Before start-up, the youBot arm is installed on a mounting surface that can withstand the forces and torques generated during operation.

Precondition

- youBot is in the home position.

Procedure

1. Mark the holes on the mounting surface, taking the minimum clearances (robot workspace) into consideration (>>> Fig. 7-1).
2. Drill and deburr holes (4 x Ø 8.4 mm).
3. Clean the mounting surface.
4. Place the youBot arm vertically onto the mounting surface.
5. Fasten the base frame with 4 M8x16 A2K Allen screws and corresponding nuts and lock washers.

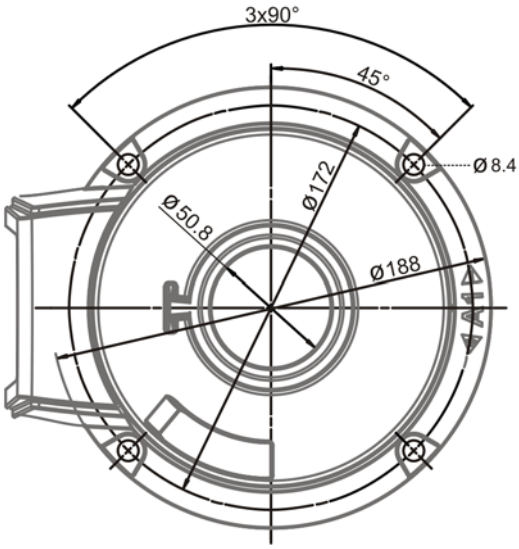

Fig. 7-1: youBot arm: hole dimensions

7.1.1.1 Connecting the KUKA youBot arm (mounting surface)

Precondition

- youBot arm is installed on a mounting surface.

> **WARNING** Electric shock hazard: do not touch electrical and electronic components!

Procedure

1. Connect the EtherCAT interfaces of the youBot arm and the PC with the EtherCAT cable (>>> Fig. 7-6).
2. Connect the youBot power supply unit to the youBot arm (>>> Fig. 7-2).
3. Check the position of all cables; cables must not be subjected to mechanical strain or located in the workspace of the youBot arm.

> If cables are located in the workspace of the youBot arm, the cables must be protected against damage in accordance with the risk assessment.

Connections

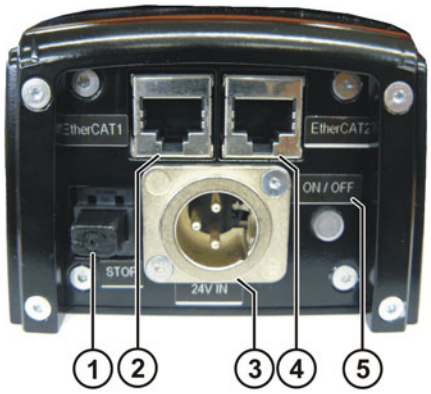

Fig. 7-2: KUKA youBot arm connections, ON/OFF LED button

1 RJ11 socket with EMERGENCY STOP jumper plug (pre-assembled)
2 EtherCAT IN
3 24 V input (power supply)
4 EtherCAT OUT
5 Power ON/OFF LED button:
   - ON LED button:
     - Red – axis controller without power
     - Green – axis controller with power
   - OFF LED button: No power supply

7.1.2 Installing the KUKA youBot arm on the youBot platform

Description

Before start-up, the youBot arm is installed on the youBot platform. There are 2 hole circles marked on the upper side of the youBot platform, indicating the 2 available installation positions. The youBot arm is positioned with the plug-in connections facing the center of the youBot platform.

⚠ WARNING Hazardous voltage: youBot components may only be installed in the de-energized state. Do not touch electrical and electronic components!

Procedure

1. Determine the installation position and alignment of the youBot arm.
2. Fasten youBot arm with 4 M8x16 screws and lock washers.

7.1.2.1 Connecting the KUKA youBot arm (youBot platform)

Precondition

- youBot arm is installed on the youBot platform.

⚠ WARNING Electric shock hazard: do not touch electrical and electronic components!

Procedure

1. Connect the EtherCAT interfaces of the youBot platform and the youBot arm with the EtherCAT cable (>>> Fig. 7-2), (>>> Fig. 7-6).
2. Connect 24 V output (youBot platform) and 24 V input (youBot arm) with power cable.

The power cable connectors can be adjusted. This means that the cable routing can be adapted to the specific installation.

Fig. 7-3: Example of power cable routing

7.1.3 Installing the KUKA youBot gripper module (optional)

Precondition

- The youBot arm is installed on the platform or mounting surface and de-energized.

Procedure

1. Rotate flange by about 90°.
2. Plug in connecting cable from wrist to gripper at the gripper; route the cable in such a way that it is not pinched when installing the gripper and can follow the rotations of the gripper in both directions as far as the stop.
3. Position the gripper module at the front of the flange and fasten it from the rear of the flange with 4 M4x30-8.8 A2K Allen screws.
4. Rotate the wrist back to its starting position.

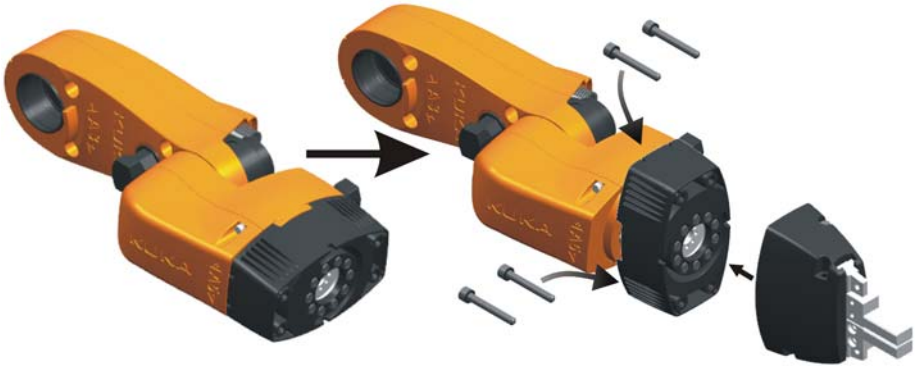

Fig. 7-4: youBot flange: 90° rotation

The gripper module is removed by reversing the above sequence.

7.1.4 EMERGENCY STOP function of the KUKA youBot arm

Description

An EMERGENCY STOP can be triggered via the RJ11 socket by means of a circuit (>>> Fig. 7-2).

The controllers monitor the EtherCAT communication during operation. If pin 2 of the RJ11 connector is set to High, the EtherCAT communication is interrupted, triggering the EMERGENCY STOP. Each controller detects the interruption of the communication and attempts to stop the assigned motor by means of position control (see Trinamic ETHERCAT™ MANUAL operating and programming instructions).

⚠ CAUTION The parameters of the controller cascade determine the method by which the controllers stop the motors by means of position control (see Trinamic ETHERCAT™ MANUAL operating and programming instructions). If these parameters differ from the factory settings, the user/system integrator/operator must ensure that the parameters are set in such a way that the stop is carried out as quickly as possible.

7.1.5 EMERGENCY OFF function of the KUKA youBot arm

Description

The youBot arm has no connection or circuit that can trigger the EMERGENCY OFF function. If the youBot arm is supplied with power by a youBot platform, the motors of the youBot arm are de-energized by an EMERGENCY OFF of the youBot platform. If this occurs while the youBot arm is not in a rest position supported by the end stops, the youBot arm will sag.

The youBot arm must be re-initialized and calibrated before it is put back into operation (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41).

7.2 KUKA youBot platform start-up

Precondition

- youBot battery and youBot power supply unit are present.

Description

The youBot platform has a maximum combined weight of 44 kg including the permissible load of 20 kg. The youBot platform is operated with an exchangeable youBot battery or the youBot power supply unit. Only batteries and power supply units approved by KUKA for the youBot platform may be used.

The battery and power management is protected on the input side by a 10 A Polyfuse.

⚠ WARNING Electric shock hazard: do not touch electrical and electronic components!

⚠ WARNING The youBot platform must be operated on surfaces that can withstand this weight and the forces and torques resulting from the motion.

Procedure, battery operation

1. Push side cover of battery upwards.
2. Insert youBot battery into battery holder and lock holder.
3. Connect battery cable to battery connection on power board.
4. Push side cover of battery downwards.

The youBot battery is removed by reversing the installation procedure.

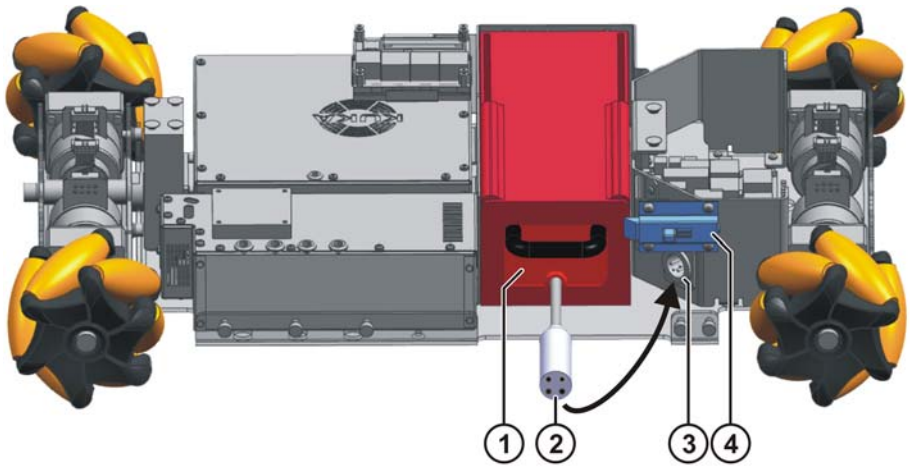

Fig. 7-5: youBot battery connection

1 youBot battery
2 Battery connector
3 Battery connection on power board
4 Battery holder locking mechanism

NOTICE Damage to the power cable: If the youBot battery is charged while installed, the youBot platform must not be moved.

Procedure, power unit operation

1. Connect the power cable of the youBot power supply unit to the 24 V input of the youBot platform.
2. Connect the power supply unit to the mains power supply.
3. Switch on the youBot platform using the On/Off button .

NOTICE Damage to the power cable: The youBot platform must not be moved while it is being operated with the youBot power supply unit.

youBot platform inputs/outputs

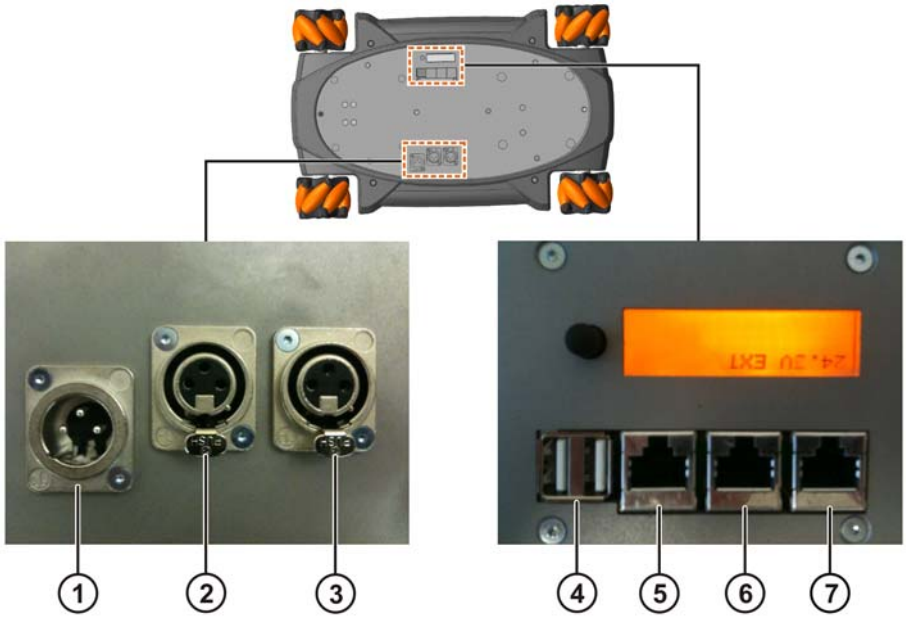

Fig. 7-6: Inputs/outputs on youBot platform

1 24 V input (power supply to youBot platform, youBot battery charging)
2 24 V output (power supply to youBot arm)
3 24 V output (power supply to youBot arm)
4 2 x USB
5 EtherCAT (youBot arm interface)
6 EtherCAT (youBot arm interface)
7 Ethernet (PC interface)

7.2.1 Charging the KUKA youBot battery

Description

The youBot battery (>>> 4.3 "Technical data, youBot platform" Page 23) has a Neutrik NC4FXX connector with the following pin assignment:

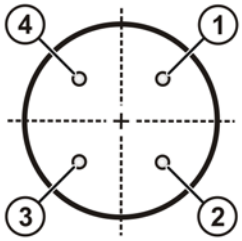

Fig. 7-7: Pin assignment of battery connector

1 Pin K1 - battery 1 (+)
2 Pin K2 - battery 1 (-)
3 Pin K3 - battery 2 (-)
4 Pin K4 - battery 2 (+)

Further information is contained in the data sheets of the battery and the power unit.

The power board of the youBot platform has a charging controller for gentle charging of the two batteries, that takes different charges of the batteries into consideration. The youBot battery is charged via the battery connection on the power board (>>> Fig. 7-5).

Procedure

1. Push side cover of battery upwards.
2. Insert youBot battery into battery holder and lock holder.
3. Connect battery cable to battery connection on power board.
4. Push side cover of battery downwards.
5. Connect the power cable of the youBot power supply unit to the 24 V input of the youBot platform (>>> Fig. 7-6).

NOTICE Damage to the power cable: The youBot platform must not be moved during the charging operation.

7.2.2 Installing the KUKA youBot loading area (optional)

Description

An optional loading area can be installed on the youBot platform. There are 2 hole circles marked on the upper side of the youBot platform, indicating the available installation positions. Each installation position has tapped holes for installing the loading area using studs.

⚠ WARNING Hazardous voltage: youBot components may only be installed in the de-energized state. Do not touch electrical and electronic components!

Procedure

1. Determine the installation position for the loading area.
2. Screw the 4 AM 825/Z7 hexagonal spacer pins into the corresponding tapped holes.
3. Fasten the loading area onto the studs with 4 M8x16 countersunk Allen screws.

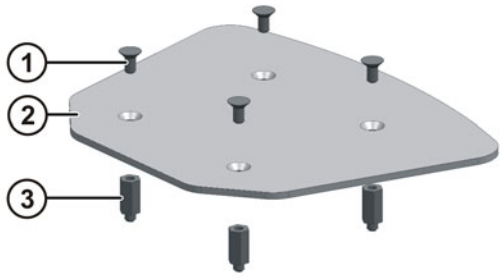

Fig. 7-8: Installing the youBot platform loading area

1 Countersunk screw M8x16 (4x)
2 Loading area
3 Spacer pin AM 825/Z7 (4x)

7.2.3 EMERGENCY STOP function of the KUKA youBot platform

Description

In order to be able to perform an EMERGENCY STOP, the jumper on the basic board must be removed and a circuit connected to the **Soft_Stop** connector.

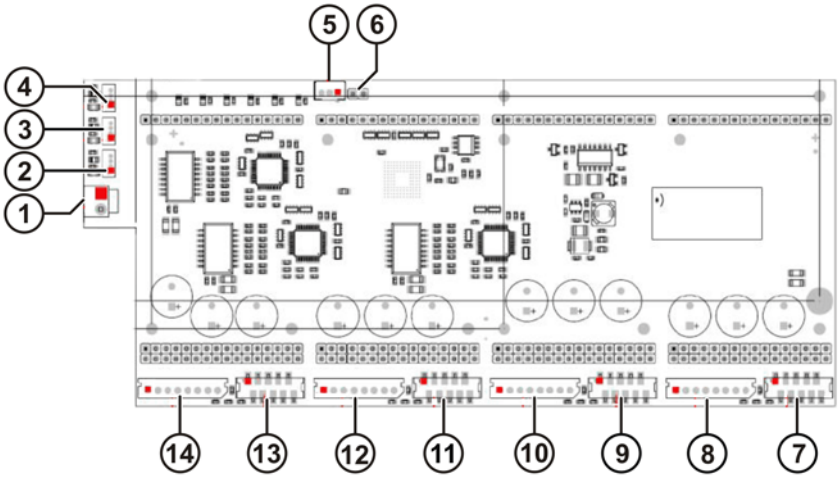

Fig. 7-9: Basic board

1 Power LED
2 EtherCAT 1
3 EtherCAT 2
4 EtherCAT 3

5 SOFT_STOP connector:
   - Pin 1: GND
   - Pin 2: SOFT_STOP; internal R 1k pull-up
   - Pin 3: VDD +24 V
6 EMERGENCY STOP jumper
7 Encoder, motor 4
8 Motor 4
9 Encoder, motor 3
10 Motor 3
11 Encoder, motor 2
12 Motor 2
13 Encoder, motor 1
14 Motor 1

The controllers monitor the EtherCAT communication during operation. If pin 2 of the SOFT_STOP connector is set to High by a circuit, the EtherCAT communication is interrupted, triggering the EMERGENCY STOP. Each controller detects the interruption of the communication and attempts to stop the assigned motor by means of position control (see Trinamic ETHERCAT™ MANUAL operating and programming instructions).

⚠ CAUTION The parameters of the controller cascade determine the method by which the controllers stop the motors by means of position control (see Trinamic ETHERCAT™ MANUAL operating and programming instructions). If these parameters differ from the factory settings, the user/system integrator/operator must ensure that the parameters are set in such a way that the stop is carried out as quickly as possible.

7.2.4 EMERGENCY OFF function of the KUKA youBot platform

Description

In the event of an EMERGENCY OFF, the 24 V voltage outputs of the power boards are disconnected from the power supply. The motors of the youBot platform and any connected devices (e.g. youBot arm) are de-energized.

⚠ CAUTION The drive wheels of the youBot platform and the joints of the youBot arm have no brakes. If the EMERGENCY OFF is carried out during a motion of the system, the subsequent motions cannot be predicted exactly. The youBot platform coasts.
If a youBot arm is supplied with power by a youBot platform, the motors of the youBot arm are de-energized by an EMERGENCY OFF of the youBot platform. If this occurs while the youBot arm is not in a rest position supported by the end stops, the youBot arm will sag.

i The youBot platform and any connected devices (e.g. youBot arm) must be re-initialized and calibrated before being put back into operation (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41).

8 Operation

8.1 KUKA youBot firmware and software

Description

The axis controllers of the youBot arm and youBot platform, as well as the required firmware, have been developed by Trinamic. Further information is contained in the following manufacturer documentation:

- Operating and programming instructions: Trinamic ETHERCAT™ MANUAL for axis controller TMCM-1632 (youBot platform) and TMCM-KR-841/TMCM-1610-KR (youBot arm)
- Operating and programming instructions: Trinamic FIRMWARE MANUAL for gripper controller TMCM-KR-842

The software for controlling the drive controllers via EtherCAT is not included in the scope of supply. The software is created in the context of research projects and/or can be obtained from publicly accessible Internet sites (e.g. www.kuka-youBot.com or www.kuka-labs-forum.com).

The user/system integrator is responsible for ensuring that the firmware and software are used in accordance with the EC Machinery Directive and the risk assessment.

8.2 Initializing and calibrating the KUKA youBot arm/platform (reference position)

Description

- **Initialization**

  Once switched on, the motors of the youBot arm and youBot platform must first be initialized. Further information can be found in the operating and programming instructions: Trinamic ETHERCAT™ MANUAL for axis controller TMCM-1632 (youBot platform) and TMCM-KR-841/TMCM-1610-KR (youBot arm).
- **Calibration**

  The axes of the youBot arm have incremental encoders which can only calculate the distance traveled after being switched on and not their absolute position. For this reason, calibration must be carried out after every switching-on operation. In order to ensure identical behavior between two switching-on operations, it is advisable to calculate the values of the incremental encoders relative to a reference position of the youBot arm. Further information can be found in the operating and programming instructions: Trinamic ETHERCAT™ MANUAL for axis controller TMCM-1632 (youBot platform) and TMCM-KR-841/TMCM-1610-KR (youBot arm).

The mechanical axis end stops, which are also used as the transport position, serve as suitable reference points on the youBot arm (>>> Fig. 8-1). The youBot platform has no mechanically defined reference points.

To prevent damage to motors and gear units of the youBot arm, the axes may only be moved to the reference position manually, with the youBot arm switched off and the axis motors de-energized. It is not permissible to move to this reference position using the drives, as it is not possible to avoid an overshoot and the drives may be damaged on hitting the mechanical end stops.

If a collision occurs while a program is being executed, the axis motors may still be energized. In order to prevent (further) damage, it is advisable to switch off the youBot arm, set the reference position manually and repeat initialization of the drives and calibration (determination of the position of the incremental encoders at the reference position).

⚠ WARNING In order to prevent damage once switched on, the youBot arm may only be controlled by a program for which the reference position of the axes is valid. An invalid reference position of the axes can lead to collisions, e.g. with the axis end stops.
This is considered misuse and leads to loss of guarantee and liability entitlements.

The firmware of each controller detects overcurrent situations, e.g. caused by collisions, and permanently saves these data in the axis controllers. These values can be read by the manufacturer.

Reference position

Selection of the mechanical end stops as the reference position simplifies calibration, as this position is easily reproducible.

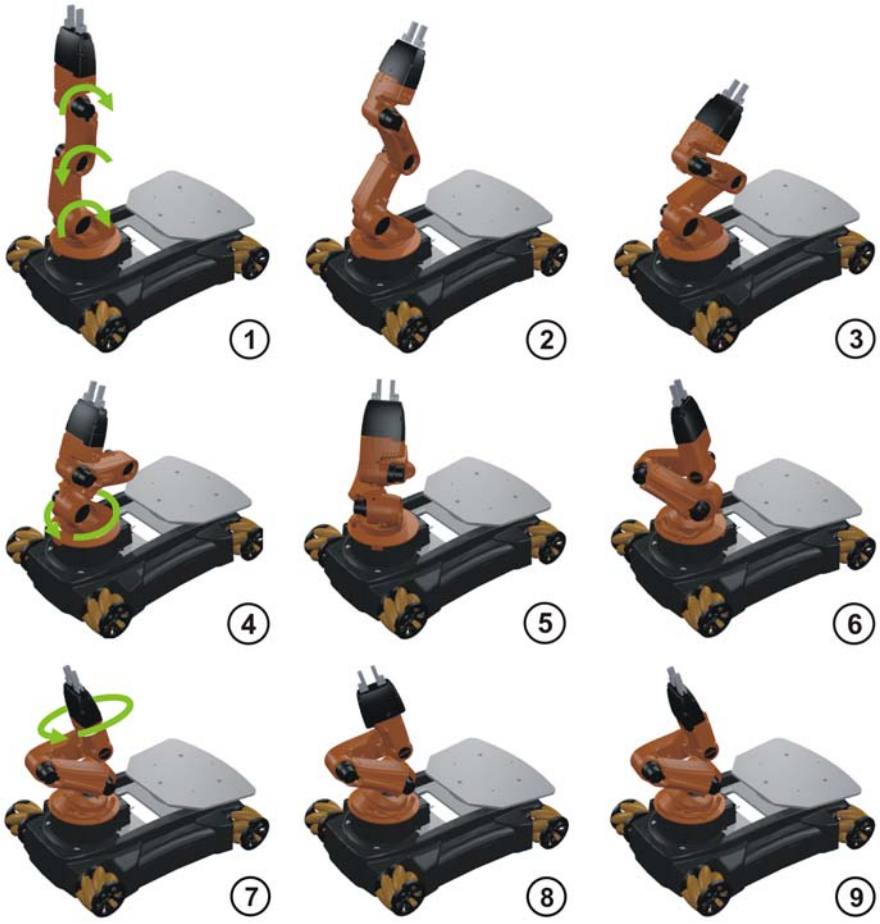

Fig. 8-1: youBot arm calibration (example)

Item	Description
1 ... 3	From the starting position (example), slowly rotate axes 2 ... 4 in the directions indicated as far as the end stops.
4 ... 6	Slowly rotate axis 1 in the direction indicated as far as the end stop.
7 ... 9	Slowly rotate axis 5 (flange with gripper module) in the direction indicated as far as the end stop.

8.3 Operating the KUKA youBot arm

Precondition

- The youBot arm is fastened to a youBot platform or suitable installation surface and connected to the power supply.

Procedure

1. Move the youBot arm to the reference position while it is switched off.
   (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41)
2. Switch on the youBot arm.
3. Initialize the motors of the youBot arm and calibrate the drives.
   (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41)
4. Create control software and test it in operation with slow motions.

⚠ CAUTION Uncontrolled motions of the youBot arm: The youBot arm has no holding brakes; in the event of an EMERGENCY OFF, the motors are de-energized and the axes move freely (only against the resistance of the motor and gear unit of the corresponding axis).

8.4 Operating the KUKA youBot platform

Precondition

- Horizontal, sturdy, dry and lint-free surface.

Procedure

1. Switch on the youBot platform.
   (>>> Fig. 3-7)
2. Initialize and calibrate the motors of the youBot platform.
   (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41)
3. Create control software and test it in operation with slow motions.

⚠ CAUTION Uncontrolled motions of the youBot platform: The youBot platform has no mechanical brakes; in the event of an EMERGENCY OFF, the motors are de-energized and the wheels move freely (only against the resistance of the motor and gear unit).

8.5 Operating the KUKA youBot 1-arm system

Precondition

- The floor surface must be horizontal, solid, dry and non-linting.
- youBot arm is installed on the youBot platform and electrically connected.

Procedure

1. Move the de-energized youBot arm to the reference position.
   (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41).
2. Switch on the youBot platform and youBot arm; the youBot arm is supplied with power by the youBot platform.
   (>>> Fig. 3-7)
3. Initialize and calibrate the motors of the youBot arm and youBot platform.
   (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41).
4. Create control software and test it in operation with slow motions.

8.6 Operating the KUKA youBot 2-arm system

Precondition

- Horizontal, sturdy, dry and lint-free surface.
- 2 youBot arms are installed on the youBot platform and connected.

Procedure

1. Move the de-energized youBot arms to the reference position.
   (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41)

2. Switch on the youBot platform and youBot arms; the youBot arms are supplied with power by the youBot platform.
   (>>> Fig. 3-7)
3. Initialize and calibrate the motors of the youBot arms and youBot platform.
   (>>> 8.2 "Initializing and calibrating the KUKA youBot arm/platform (reference position)" Page 41)
4. Create control software and test it in operation with slow motions.

9 Maintenance

9.1 Maintaining the KUKA youBot components/system

Description

If used correctly, the youBot system is maintenance-free. The following checks must be carried out daily during operation:

- Visual inspection of the youBot power supply unit and cabling/connectors/sockets in order to detect insulation faults in good time.
- Visual inspection of youBot components for cracks and ruptures (risk of accident).
- Check fastening elements.
- Check EMERGENCY STOP and EMERGENCY OFF functions.

Loss of guarantee and liability entitlements: Repairs may only be carried out by KUKA Roboter GmbH.

In the event of fouling of the youBot system, including tools and omniWheels, clean with damp, lint-free cloths; use solvent-free cleaning agent.

WARNING Hazardous voltage: Maintenance and cleaning of the youBot components/system may only be carried out in the de-energized state. Do not touch electrical and electronic components!

WARNING Hazardous voltage: Do not touch defective electrical components, e.g. youBot power supply unit, cables, connectors!

CAUTION Risk of injury: Do not place hands, feet or head near moving youBot components.

Storage

NOTICE 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.

Charging the youBot battery

(>>> 7.2.1 "Charging the KUKA youBot battery" Page 38)

10 Decommissioning, storage and disposal

10.1 Disposal

As the end user, the customer is legally required to return depleted batteries. Used batteries can be returned to the vendor or brought to the designated collection points (e.g. in communal refuse collection facilities or commercial centers) free of charge. The batteries can also be sent to the vendor by post.
The following symbols can be found on the batteries:

- Crossed-out garbage can: battery must not be disposed of with ordinary household refuse.

- Pb: battery contains more than 0.004 lead by weight.
- Cd: battery contains more than 0.002 cadmium by weight.
- Hg: battery contains more than 0.0005 mercury by weight.

When the youBot components reach the end of their useful life, they can be dismantled and the materials can be disposed of by type, or they can be returned for expert disposal by KUKA Roboter GmbH:

KUKA Roboter GmbH

Zugspitzstrasse 140

D-86165 Augsburg

Germany

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

Material, designation	Subassembly, component	Note
Cast magnesium	Rotating column, arm, link arm, wrist, base frame	
Cast aluminum	Wheel rims	
Plastic	Panels, covers	
Steel	Gear units, screws and washers	
	Motors	Dispose of motors without dismantling them.
PUR	Cable sheaths	
Copper	Cables, wires	
PU	Hoses	

11 Appendix

11.1 Product list and spare parts list

The following tables contain the material numbers for ordering systems and spare parts:

Spare part	Material number
System packaging with case for youBot arm (transport case for arm)	00-244-926
System packaging for youBot platform (transport case for platform)	00-244-927
Bracket for arm (sensor mounting on arm)	00-244-506
Bracket for platform (sensor mounting on platform)	00-244-526
youBot mains adapter (power supply unit)	00-199-684
Connecting cable for non-heating appliances, 2 m, bk (power supply cable)	00-199-683
Battery pack 2x 12 V-umm	00-194-678
youBot loading area assembly (loading area) Consisting of: ■ 1 loading area ■ 4 threaded pins ■ 4 connecting screws	00-196-557
Connection kit, arm–platform (connection kit 1) Consisting of: ■ 1 power cable for connecting the youBot arm to the youBot platform (connecting cable W24.1) ■ 1 EtherCAT cable (connecting cable W25) ■ 4 connecting screws and 4 lock washers for fastening the youBot arm	00-198-932
Connection kit 2, arm–platform (connection kit 2) Consisting of: ■ 1 power cable for connecting the youBot arm to the youBot platform (connecting cable W24.2) ■ 1 EtherCAT cable (connecting cable W26) ■ 4 connecting screws and 4 lock washers for fastening the youBot arm	00-209-558
Two-finger parallel gripper + 2 fingers (gripper module)	00-196-433

12 Service

12.1 Requesting support

Germany

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Index