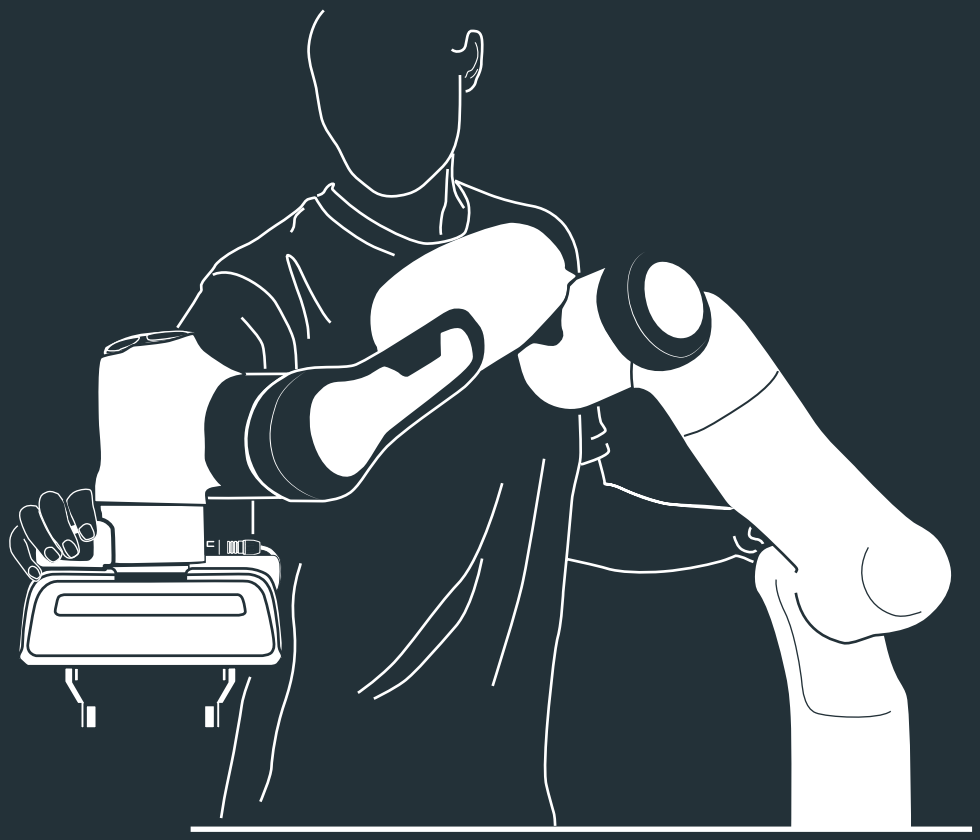
# USER MANUAL

## PANDA RESEARCH



FRANKA
EMIKA

TRANSLATED USER MANUAL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The content of this document has been carefully checked against compliance with the hardware and software described. However, discrepancies cannot entirely be ruled out, which is why we assume no liability for complete compliance.

In the interest of our customers, we reserve the right to undertake improvements and corrections to hardware, software and documentation at any point in time without notice.

We are always grateful for your suggestions and criticism at documentation@franka.de

The German documentation is the ORIGINAL DOCUMENTATION. Other languages are translations of the original document.

**RELEASE VERSION**: October 6th 2017

# CONTENTS

# LEGAL FRAMEWORK

## About this manual

### Safety

Before installation, start-up and operation of the device carefully read this manual and any additional documentation related to it. In particular, take note of the safety instructions and general indications, which are marked as follows:

**DANGER**

DANGER that nonobservance of instructions or measures will lead to death or severe injury.

**WARNING**

WARNING indicates that nonobservance of instructions or measures may lead to death or severe injury.

**CAUTION**

CAUTION indicates that nonobservance of instructions or measures may lead to minor injury.

Warnings marked with a yellow exclamation mark indicate general safety-related information.

**SAFETY - INSTRUCTION**

SAFETY INSTRUCTION indicates processes that need to be strictly observed.

### Indications

***NOTE***

A text section marked with NOTE indicates that nonobservance of instructions or measures may result in material damage.

Indicates where further information can be obtained.

## Notice of liability

**The present Panda research system is intended for exclusive use as a research device.**

Panda research has been developed according to the quality standards of ISO 9001. The production of our devices is carried out in a production company certified according to ISO 9001. A risk assessment according to ISO 12100 has been carried out through the course of development and is the basis for Panda research and this user manual. Misuse can, nevertheless, cause danger to life and limb and impairments and damages to the research robot and other material assets.

Therefore:

Panda research may only be used in perfect technical condition, for its intended purpose and within the technical specifications and operating conditions,
with awareness of safety and possible dangers
Use must comply with the instructions of this user manual
Malfunctions that may impair safety need to be rectified immediately
Modifications of Panda research are not permissible

The producer is not liable for damages caused by misuse as exemplified above.

## Staff

**WARNING**

Insufficiently qualified staff may cause severe damage to persons or material damage to machinery and equipment!

Therefore:

- All persons that may enter the operating area of the Arm need to have read and understood this documentation, in particular the chapter on safety. They need to be able to use their knowledge and experience to understand any risks the robot system may present and be adequately prudent in their behavior.
- The operator has to inform these persons explicitly about the limitations and restrictions of Panda research.

## Operator

The operator of Panda research can be e.g. the entrepreneur, director of the institute, the employer or a delegate responsible for the use of Panda research. The operator is responsible for compliance with regulations of occupational health and the operational safety ordinance.
These include the following things:

- The operator must fulfill his monitoring obligations.
- The operator must ensure that all staff members working with Panda research are suitably qualified to do so and have been informed about the possible dangers Panda research may present.
- The operator must provide training and instructions in given intervals in order to create and consolidate risk awareness.

In this regard, we refer to the Franka Academy, where appropriate training courses on the handling of Panda research are offered.

Also take note of further product documentation on the use of the Franka Control Interface (hereinafter also referred to as FCI)

# Intended purpose of Panda research

The producer is not liable for damages caused by misuse. All the risk is borne by the operator alone.

If applicable, already existing, internal operating policies of the operator, such as trainings, safety instructions, operating policies and, possibly, country-specific restrictions are to be taken into account and respected.

## Intended purpose

The Arm and its control system (hereinafter: Control) with mounted gripper (hereinafter: Hand) are intended exclusively for use in research.

Intended purpose includes:

- researching and testing path planning algorithms
- researching and testing control algorithms
- researching and testing gripping strategies
- researching and testing interaction scenarios
- researching and testing machine learning algorithms

Panda research has not been released for commercial use.

## Misuse

Any application different to the intended purpose is considered to be misuse and is not permitted. This includes:

- transporting humans and animals
- use outside of the specified operating limits
- use as climbing assistance or leaning against the robotic arm
- use in potentially explosive areas
- use below ground
- handling of radioactive objects
- use outdoors
- use as a medical product
- use as service robotic arm, e.g. for nursing care
- use in the vicinity of children

***NOTE***

Modifications of Panda research (e.g. attaching objects, drilling holes) cause damages to the system. This is considered misuse and will lead to the loss of warranty and liability claims.



# EG Declaration of Conformity

The operator is responsible for operating Panda research and its possible integration into a bigger research construct. The operator is furthermore solely responsible for carrying out a risk assessment based on the contents of the user manual and implementing and ensuring appropriate or necessary measures (e.g. constructional or organizational measures) resulting from it.

## Panda research

The Arm, Control with the Franka Control Interface (FCI) and the Hand make up Panda research. According to the intended purpose Panda research is a research object and therefore exempt from the Machinery Directive (2006/42/EG).
For further information see also the excerpt from the Machinery Directive 2006/42/EG, article 1, scope paragraph (2):
“Excluded from the scope of this directive are [...] g) machinery, specially designed and constructed for research purposes and intended for temporary use in laboratories”

## EMC Directive
## Low-Voltage Directive

The Control in connection with the Arm is CE-certified according to:

- the EMC Directive(2014/30/EC)
- and the Low-Voltage Directive (2014/35/EC)

The Hand in connection with the Arm and the Control is CE-certified according to:

- the EMC Directive(2014/30/EC)

For the declarations of conformity see /Product Conformity/Declarations of Conformity/

## EU Machinery Directive

As described above, Panda research is exempt from the EU Machinery Directive 2006/42/EG and therefore does not comply with all of its requirements. Therefore, the operator is prohibited from using or marketing Panda research or parts of it in terms of the Machinery Directive.

## RoHS, REACH, WEEE

Control, Arm, Hand and accessory parts are exempt from regulations according to RoHs, REACH and WEE directives. Nevertheless, our products comply with the requirements according RoHS.
For the corresponding confirmation, see /Product Conformity/Further Information/.

# General safety measures

In addition to the “general safety measures” described here, this documentation includes information on safety during installation, start-up, operation, maintenance, reparation and disposal, which must also be noted.

WARNING

Panda research is exempt from the Machinery Directive 2006/42/EG and therefore does not comply for a provision according to the EU machine directive 2006/42/EG, or the corresponding C-normative for industrial robots ISO 10218 or the TS 15066 for collaborative robots, respectively (see also /Legal Framework/).

For the commercial version of Panda research, safety-rated functionalities for increasing user safety will be provided. The functionalities for user safety presented for the version Panda research cannot be used as “safety-rated functionalities for the safeguarding of persons” (according to Performance Level d and category 3 of EN ISO 13849-1:2008).
Even though the user is offered several functionalities for increasing user safety (internal activation button, external activation device, monitored stop, protection from self-collision, monitoring of joint angles, speed monitoring, force/torque monitoring and collision detection), the user CANNOT rely on these functionalities! Dangerous and uncontrolled movements of the robotic arm need to be expected at all times! Such a malfunctioning is to be regarded as extremely rare and will only occur under highly unfavorable conditions. Therefore, maintaining attention focused and alert for any malfunctioning presents a challenge. The listed movements can lead to risks of crushing, shearing, impact, puncture or penetration and may cause severe injury.

Therefore:

- The operator is solely responsible for conducting a risk assessment based on the above-mentioned and the following contents and subsequently implementing appropriate measures (constructional or organizational measures), thereby ensuring that the user is aware of the absence of certain functionalities.
- The user must maintain the greatest possible distance to the Arm at all times to be able to avoid collision. In particular:
  - The Arm may never be operated while embracing it
  - The head or other body parts may never be brought between Arm segments or the Arm and stationary objects
  - The hands may never be brought between Arm/end effector and stationary objects
- The Arm may never be operated in confined spaces without possibility of retracting.

Please also note the information provided under “Practical Information on how to place and use Panda research” under /Safety concept/.

## Collaboration functionalities not safely applicable

## Perfect condition

**WARNING**

Panda research may only be used in perfect condition, according to its intended purpose and with possible dangers and risks in mind. Misuse can cause personal and material damage. The manufacturer is not liable for damages caused by misuse.

## Modifications

**WARNING**

The Arm is equipped with an ISO end effector flange. Basically, different end effectors can be mounted on it. In our risk assessment, we have only considered our own gripper (Hand). Should other end effectors be mounted, the operator is responsible for carrying out the appropriate risk assessment and implement the corresponding measures. We are not liable for damages caused by mounted equipment.

Apart from mounting end effectors, modifications to Panda research are not allowed. Such modifications may include:

- drilling holes, screw threads in the casing structures (modification of the load carrying capacity of the casing, pollution or damage to internal parts caused by chippings, etc.)
- varnishing (modification of drain-off capacity, contamination of the fail-safe safety locking systems caused by entering of varnish, heating, etc.)
- enwrapping the robotic structure (prevention of adequate convection, etc.)
- opening the devices (if devices are opened by the customer we will assume that a modification has been carried out by the customer)
- etc.

## Malfunction

**WARNING**

If Panda research indicates possible malfunctions or the user notices malfunctions, these need to be rectified before continuing operation. Until malfunctions have been rectified the system must be shut down.



## Dead weight

**WARNING**

The Arm weights approx. 18kg, the Control approx. 7kg, the Hand approx. 1kg. Due to the dead weight and partly geometric design (e.g. mounting flanges), lifting and handling the device can lead to back injury, and, should it fall, to serious injury to fingers, hands, toes and feet.

Therefore:

- always wear personal protective equipment (e.g. safety shoes), when transporting mounting or demounting these devices
- the devices must be placed such as to prevent tilting or sliding
- when lifting or handling the devices, pay attention to lift correctly (lift with your legs, not your back)

***NOTE***

The Arm contains sensitive mechanical and mechatronic components. These can be decalibrated or damaged due to wrong handling or misuse!

Therefore:

- The Arm may only be handled, lifted and transported at the points indicated in this manual in order to avoid overstressing the joints of the Arm
- The Arm is to be handled gently even when set-up and switched on or off. If, for example, the arm is moved by force when in stopped and locked state, an internal safety system is triggered and will cause a momentary slipping of internal parts. This slipping causes decalibration and damage to the Arm

***NOTE***

The Arm and Control contain sensitive electromechanical components. These can be decalibrated or damaged by shock!

Therefore:

- Avoid shocks or setting the device down roughly.
- Always store and transport devices in their original packing, even during transport inside buildings

# INTRODUCTION

- Terminology
- About us - Franka Emika
- This is Panda research
    - The powerful tool for research
    - Some features
    - Device overview
    - Scope of delivery and additionally required equipment

# INTRODUCTION

## Terms

| GERMAN | ENGLISH | Description |
|---|---|---|
| Franka Emika GmbH | Franka Emika GmbH | Franka Emika GmbH (abbreviated FE) is the company name. We produce Panda research. |
| Panda research | Panda research | The overall robotic system consisting of Arm, control with Franka Control Interface (FCI), Hand and Pilot form the Panda research system, hereinafter simply referred to as Panda |
| Arm | Arm | The Arm is our sensitive robotic arm with 7 axes and is part of Panda research. Hereinafter referred to as Arm or robotic arm. |
| Controller | Control | The Control is the main control computer and part of Panda research. |
| Hand | Hand | The Hand is our electrical two-finger parallel gripper and part of Panda research. |
| Franka Control Interface bzw. FCI | Franka Control Interface (FCI) | The Franka Control Interface is the software interface for controlling Panda research. Hereinafter also referred to as FCI. |
| Pilot | Pilot | The Pilot is the user interface on the Arm for guiding and operating Desk and Hand and is part of Panda research. |
| Desk | Desk | Desk is our web-based, intuitive and graphical programming and user interface. |
| Endeffektor | end effector | The Arm has a standardized mounting flange for mounting different grippers. The Hand, for example, is such an end effector. |
| Manipulator | manipulator | The manipulator consists of the Arm and the attached end effector (in this manual the Hand is the equivalent of the end effector). |
| Bediengerät | interface device | The interface device (a commercially available PC, tablet or notebook with web browser) is connected to the base of the Arm via Ethernet cable. The interface device Desk can be opened in a web browser. |
| Workstation PC | workstation PC | A PC workstation can optionally be connected to the Control via Ethernet. A workstation is required for using the real-time interface FCI of Panda research. |
| Web-Browser | web browser | A web browser (Chrome, Chromium, Firefox) on the interface device serves as connection to Desk, and thereby to the intuitive, graphical user and programming interface. |
| Franka Academy | Franka Academy | Franka Academy (abbreviated FE Academy) is our training center |
| Franka World | Franka World | Franka World is our online platform, which provides access to all our products and services. |
| Franka Store | Franka Store | Via the Franka Store, you can online purchase Apps and hardware by Franka Emika. Under www.franka.de/store |
| App | App | Apps are modular robot programs, each representing a partial step of a robot task. They can be purchased from the Franka Store and can be parametrized in Desk to form entire automation Tasks. |
| Research App | Research App | Research Apps are Apps designed for Panda research |
| Task | Task | A Task in Desk represents an entire automation routine. A Task consists of one or several Apps |

| | | |
|---|---|---|
| Betreiber | operator | The operator of Panda research can be for example the entrepreneur, director of the institute, the employer or a delegate responsible for using Panda research. For further information, see also /Legal Framework/. |
| Anwender | user | The user can use Panda research within the limits defined by the operator and the admin. See also /Safety Concept/Staff/. |
| Admin | admin | The admin has the authorization to edit IT and safety settings for Panda research. |
| Griff | grip | The grip is part of the Pilot and is used for manual guidig. |
| Bedienfeld | disc | The disc is part of the Pilot and is used for interacting with the Arm and/or desk. |
| Aktivierungstaster | activation button | The activation button is part of the grip and thus also part of the Arm. It is used to activate the hand-guiding of the Arm. |
| externer Aktivierungsschalter | external activation device | The external activation device is plugged into the female connector X3 of the Arm. Once the activation button is in the position ‘clear’, i.e. activated, movements can be carried out with the Arm. |
| Verbindungskabel | connection cable | The connection cable connects the arm with the Control. |
| Fail-Safe Sicherheitsblockiersystem, bzw. Sicherheitsblockiersystem | fail-safe safety locking system | The fail-safe safety locking system locks all 7 axes of the Arm, as soon as the Arm is no longer powered. This way, the Arm stays in position even when turned off. Hereinafter also referred to as safety locking system. |
| Entriegelungswerkzeug | unlocking tool | The unlocking tool provided can be used for manually unlocking the safety locking system in case of emergency to move the Arm. |



| | | |
|---|---|---|
| Notentriegelung | emergency unlocking | Emergency unlocking is the process of using the unlocking tool to unlock the safety locking system in order to manually move the Arm. |
| emergency unlock | emergency unlock | The “emergency unlock” labels on the Arm indicate the three positions on the Arm, where an emergency unlock can be carried out. |
| Achsen/ Gelenke | axis/ joints | The robotic arm consists of 7 consecutive joints or axes. The movement is created in these joints. |
| Handführen/ Guiding | guiding | Guiding describes the procedure of taking the Arm by the Hand and moving it manually, for example to teach a new pose. |
| Geste | guesture | A gesture is a movement of the arm similar to a human gesture (e.g. nodding to confirm a procedure). |
| Guiding Modus | guiding mode | Guiding modes facilitate guiding by locking or unlocking different directions or rotations in space. For example, the Arm can be moved in three directions in space. You can switch between guiding modes either using the guiding button on the grip or directly from Desk. |
| Guiding Taster | guiding button | The guiding button is located on the grip of the Pilot. Using this button, you can select guiding modes. |
| Teaching | teaching | The process of teaching uses guiding in order to move the Arm into a certain pose and then learn and memorize this pose, for example. |
| Tracking Fehler | tracking error | The actual motion of the Arm follows the target motion with a small deviation, a so-called tracking error. |
| Pose | pose | A pose is the position of the Arm including its positioning and orientation in space. |

| | | |
|---|---|---|
| Arbeitsbereich | operating area | The area, in which the Arm performs its Task is called operating area. For further information, see also the description under /Safety Concept/Hazardous and safe areas/. |
| Anhaltebereich | stopping area | The operating area of the Arm including its stopping distance. If the Arm is stopped within its operating area, it will stop its movement at the latest within the stopping area. See also the description under /Safety Concept/Hazardous and safe areas/. |
| Gefährdungsbreich | hazard-area | An area in which humans may be harmed. See also the description under /Safety Concept/ Hazardous and safe areas/. |
| Sicherheitsbereich | safety area | An area in which humans are separated from a hazardous area by protective measures (here e.g. safety fence). See also the description under /Safety Concept/Hazardous and safe areas/. |
| Schutzeinrichtungen | protective measures | Protective measures are supplementary, often structural or technical measures such as safety fences, laser scanners etc., which serve to safely separate humans from a hazardous area. |
| Anhalteweg | stopping distance | The stopping distance is the distance the Arm will cover after activation of the emergency off until it comes to a full stop. |
| Anhaltezeit | stopping time | The stopping time is the time that passes after the emergency off has been activated until the arm comes to a full stop. |
| Kartesisch | Cartesian | The Cartesian space is the three-dimensional space. |



| | | |
|---|---|---|
| Kollaboration | collaboration | Collaboration exists, when a person works directly together with a robot within a determined operating area. See also the description under / Safety Concept/Hazardous and safe Areas/. |
| Koexistenz | co-existence | While collaboration is understood as the entire or the greater part of the operating area being occupied by human and robotic arm at the same time, the more frequent case is co-existence. This means that only a small part of the operating area is shared. In addition, this common operating area is usually rarely used by human and robotic arm at the same time. In this case danger presented by the Arm is also limited and therefore easier to take into account. See also the description under /Safety Concept/Hazardous and safe areas/. |
| Massenangriffspunkt | center of mass | The center of mass is the center of gravity of an object. At this point, gravitational force comes into effect. |
| Maschinenrichtlinie 2006/42/EG | Machinery Directive 2006/42/EG | The Machinery Directive (2006/42/EG), hereinafter referred to as Machinery Directive or MD, regulates a standardized level of protection for the prevention of accidents for machinery and partly completed machinery within the European Economic Area, Switzerland and Turkey. |
| Niederspannungsrichtline 2014/35/EC | Low Voltage Directive 2014/35/EC | The Low Voltage Directive (2014/35/EC), hereinafter referred to as Low Voltage Directive, regulates the safety of electronically operated devices within the European Economic Area, Switzerland and Turkey. |
| EMV Richtlinie 2014/30/EU | EMI Directive 2014/30/EU | The EMV Directive (2014/30/EU), hereinafter referred to as EMV Directive, regulates the electromagnetic compatibility of devices within the European Economic Area, Switzerland and Turkey |

| | | |
|---|---|---|
| RoHs Richtlinie 2011/65/EU | RoHs Directive 2011/65/EU | The RoHs Directive (2011/65/EU), hereinafter referred to as RoHs Directive, restricts the use of certain dangerous substances in electrical and electronic equipment within the European Economic Area, Switzerland and Turkey. |
| REACH Verordnung (EG) Nr. 1907/2006 | REACH 1907/2006 | The REACH regulation (EG) No 1907/2006, hereinafter referred to as REACH, is a chemicals regulation. |
| libfranka | libfranka | libfranka is our C++ program library, which can be accessed at https://www.github.com/frankaemika/ – libfranka is part of the Franka Control Interface (FCI) for researchers |
| franka_ros | franka_ros | franka_ros is our ROS interface with ROS control and MoveIt integration, which can be accessed at https://w ww.github.com/frankaemika/ – franka_ros is part of the Franka Control Interface (FCI) for researchers |

## Presenting Franka Emika

FRANKA
EMIKA

**The vision of a robot for everyone – sensitive, interconnected and adaptive**

Even today, robotics remains a technology accessible only to few. The reasons for this are the high costs, difficult programming and the separation of humans and robots by safety fences. So how can this complex technology be made accessible to the general population?

We at Franka Emika GmbH, the high-tech start-up company from Munich, want to solve this problem.

To us, the ideal robot of the future is a tool which can be used by anybody and which supports humans in carrying out unpleasant or even dangerous tasks. Panda is the first system of an entirely new generation of tools, which are developed with the following main objectives: first as a research robot, then as a colleague in a factory and finally as an assistant in daily life for elderly or sick people.

We presented the Panda “power tool” at the Hannover trade fair 2017. The system can be operated via Apps like a smartphone and be taught new Tasks within a few minutes, without requiring any programming skills. At the same time the system is sensitive to such an extent, that it can take over assembling, testing or inspecting tasks next to a human colleague without the need for a safety fence. The online platform Franka World represents the center of this ecosystem, in which the community can interact, developers and clients can be assigned and new solutions and applications are provided.

The system was developed based on the globally leading German robot technology, and is now produced in series in Allgäu, Bavaria. Panda research has been ready for use for the research community since August 2017; later in 2017 it will also be ready for use in industry, and this is only the beginning of a new generation of universal tools.

*Panda – designed, developed and made in Germany.*

# THIS IS PANDA RESEARCH

## The powerful tool for research

### Panda research

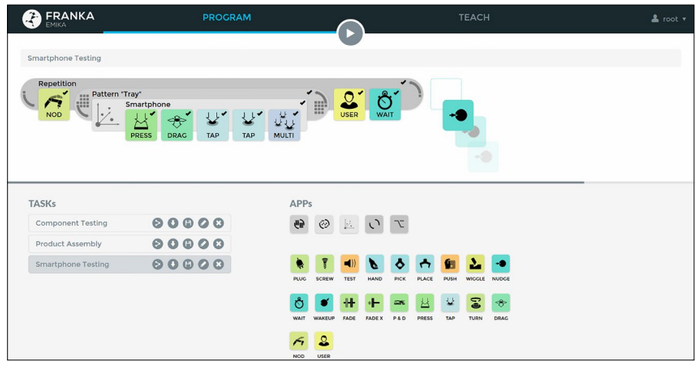
Panda research is our sensitive and extraordinarily versatile power tool for research.The torque sensors in all seven axes enable Panda research to skillfully and delicately manipulate objects. It also enables the user to directly and intuitively interact with the Arm. Using the specially developed programming paradigm, the lightweight robotic system is easy to set up and use, despite its numerous and highly complex capabilities. Combined with Research Apps, Panda research can be deployed within a few minutes. In addition, we provide researchers with our FCI (Franka Control Interface). The FCI offers a direct command interface, which facilitates extensive access to the underlying technology, so that individual controllers and path planning algorithms can be implemented.

### An app for everything

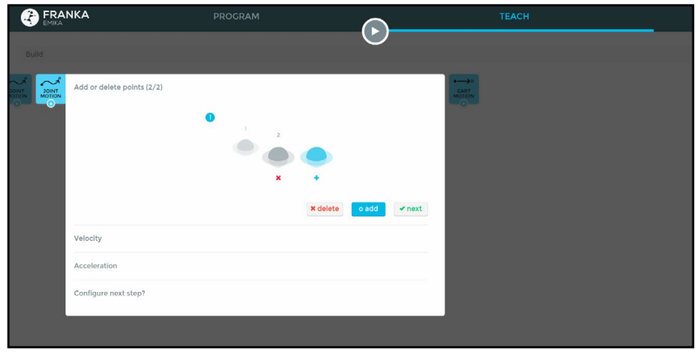
Apps are modular robot programs that each represent a partial step of a robot task and can be purchased from the Franka Store. These Apps can vary in size from highly complex to very simple Apps. When selected in Desk, each App opens a context menu in which the user is interactively lead through the process parameters.



### Programming with one swipe




A Task can be composed in Desk by arranging Apps, which are then parametrized directly at the robot in the operating area.




Pilot is the interface integrated in the Arm, which allows for smooth interaction between Arm and Desk.

### Teaching by demonstration

### The FCI package – the bonus for researchers

Panda research allows for real-time, bidirectional connection between a workstation PC and the Arm. Also commanding the Hand is possible. This interface (FCI) enables the user to implement specially created controllers and applications with the robot. The package consists of libfranka, a C++ program library, and franka_ros, an ROS interface with ROS Control and MoveIt integration, which can be accessed at https://www.github.com/frankaemika/. Detailed information can be found in the corresponding API descriptions and quick start guides.

## Some Features

### Joint space

A joint space is the description of a robot pose using the rotation angles of the robot's individual joints. In contrast to most industrial robots, which have 6 joints, our Arm has 7. This allows for an extremely high flexibility. A certain pose can be uniquely identified with 7 values in units of degrees. Movements in the joint space move all joints simultaneously from the current position to a defined target joint pose. Here it is important that the movement of the end effector results from the rotation of the joints and does not follow a specific path (e.g. a line).

### Cartesian space

The Cartesian space allows an alternative description of the robot pose. Here, the position and orientation of the end effector are the main focus. The representation of Cartesian poses in three-dimensional space usually consists of three values (in meters) for determining the position and three values (in degrees) for orientating the end effector. For a robot with 7 joints this representation is not complete for defining a certain robot pose. For more information, see the section "Redundancy".
Movements in Cartesian space allow the exact tracking of predefined paths in space, such as straight lines. The changing of position is called translation, while the changing of orientation is called rotation. The Cartesian movement of a robot always depends on the reference coordinate system, which can be configured for Panda via the configuration of the end effector in the admin section of Desk.

### Redundancy

The Arm can reach a certain Cartesian pose with various joint configurations. This capability is called redundancy. At Panda research this additional motion capability is often called elbow, because it matches the motion capability of the elbow in a human arm. The redundancy of the Arm allows for a greater flexibility when teaching or executing Tasks. For example, it can be used to circumnavigate an obstacle in order to grip an object located behind it. The behavior of the elbow can be changed and adapted to each situation. It can be set to freely movable or immovable.



### Sensitivity

The arm has real torque sensors in all 7 joints. These enable it, among other things, to recognize and react to even the smallest forces acting on the Arm. This sensitivity facilitates numerous functionalities and capabilities, which are not possible with conventional industrial robots, such as impedance, guiding of the robot or collision detection. It should be noted that for achieving maximum sensitivity it is absolutely necessary to best possibly compensate additional forces acting on the robot (e.g. a mounted end effector). This is why the end effector to be used should be configured as precisely as possible in the admin section of Desk.

### Impedance

Impedance is a behavior of the robot, which imitates the ability of a mechanical spring. This behavior can be used to interact gently with the environment, for example as not to damage fragile objects. The ability of changing impedance can be seen as similar to that of a human arm. It tenses the muscles in order to change rigidity and can adapt depending on the situation, in order to increase robustness when executing a Task.

### Collision detection and reaction

We have incorporated torque sensors in all seven axes. These provide information on the currently applied torques per axis at any given time. In combination with our model-based control, deviation between the expected torque and the actual torque can be identified and the Arm can respond to it. For example, if a user reaches into the motion path of the robotic arm when it is moving, this will be recognized in real-time by one or several torque sensors. Such a torque magnification is classified as a collision and can for example stop the robot's movement.

### Virtual walls

Our Panda research arm has numerous position sensors in order to identify the actual positon of the Arm in space. In control, virtual walls can be set either on the level of individual joints or for the Cartesian space. While for individual joints the boundary works as a limit to the possible angles of the axes, in the Cartesian space it represents a box or wall, that cannot be penetrated by any part of the Arm. In this way, the operating space of the Arm can be restricted.

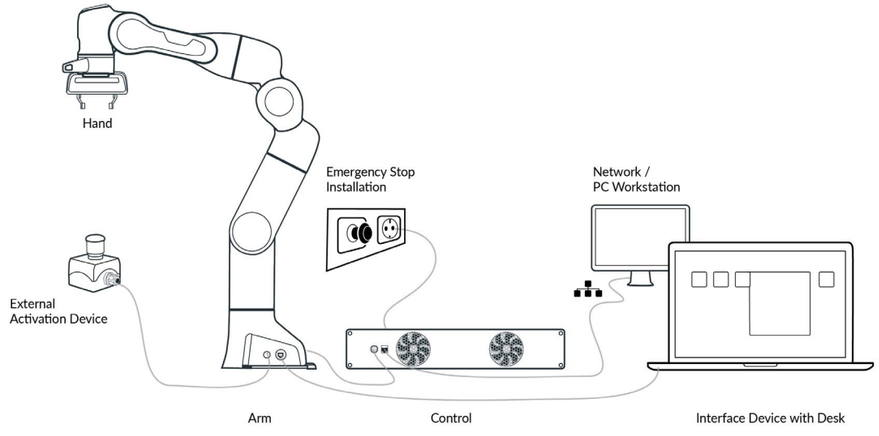
### Generating forces

If the Arm is in intended contact with its surroundings, sensor signals of the seven torque sensors can be used to generate a defined force on the point of contact.

# Device Overview

## Basic set-up

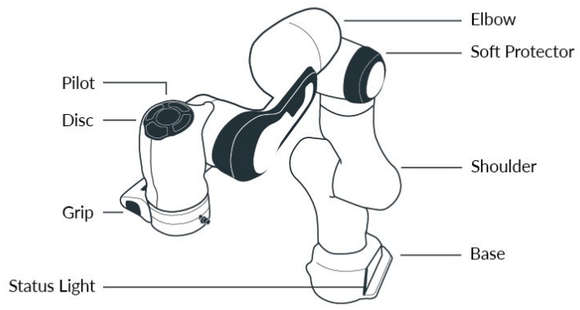
The basic set-up of Panda research looks like this:




- The Arm is connected to the Control via a connection cable.
- Between the Control and the power supply there is an emergency off installation that will cut the power to Panda research in case of emergency.
- At the base of the Arm an external activation device is connected, in order to deliberately activate movements of the Arm.
- There is also the interface device with web browser in order to program using Desk.
- A network Ethernet interface can be used at the front of the Control to program Panda research via FCI.

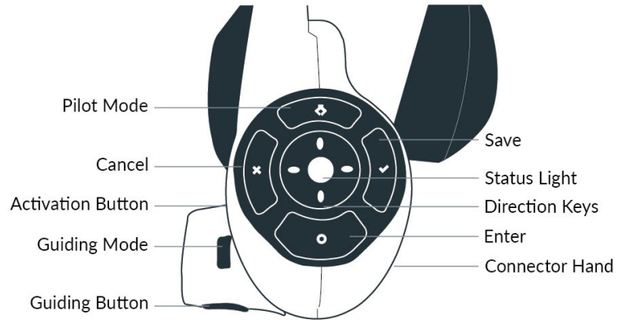
## The arm

The Arm has the following components:





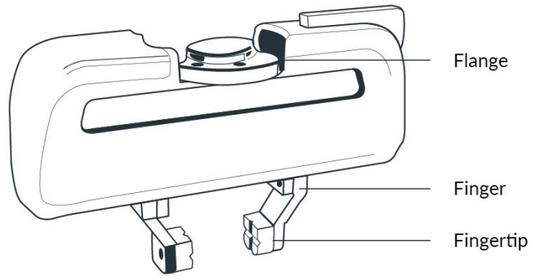

## View from above




Via the Pilot the user interface Desk and the Hand can be operated directly from the robotic arm.

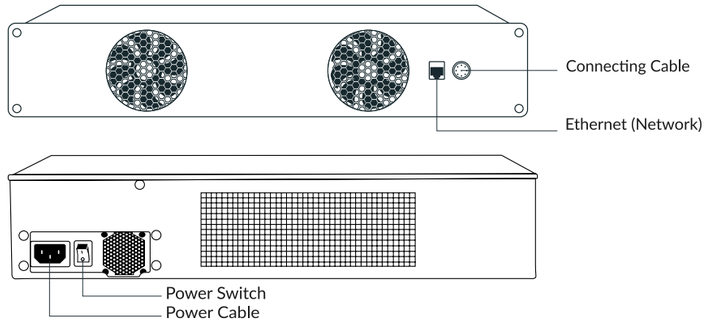
## The Hand

The Hand communicates directly via the connection in the Arm and is also supplied with power from the Arm. No cumbersome external wiring and integration is necessary!



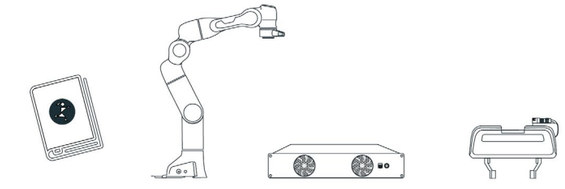

- The fingertips can easily be changed and adapted to the objects to be gripped (e.g. using 3D-printed fingertips).
- The fingers can also be simply mounted differently in order to increase the span length of the gripper.
- The plug is simply plugged into the connector port on the grip of the Arm.

## The Control




# Scope of delivery and additionally required equipment

## In the box





- Main components
  - Arm
  - Control
  - Hand + 1 set of finger tips
- Accessories
  - Connection cable 2.5m (for connecting Arm and Control))
  - Cold device cable
  - External activation device
  - 2x unlocking tool
  - Mounting accessories Hand:
    - 2 x DIN7984 M6X12 ST 8.8 screw
    - 1 x ISO2338B 6X10 h8 A2 cylindrical pin
- Documentation
  - User manual
  - Drilling template for mounting the Arm
  - Quick installation guides



## Additionally required

Not included, but required:

Interface device

- Tablet/ Notebook/ PC
  - with web browser (Chrome, Chromium, Firefox)
  - with Ethernet port
  - ideally with touch functionality

Material

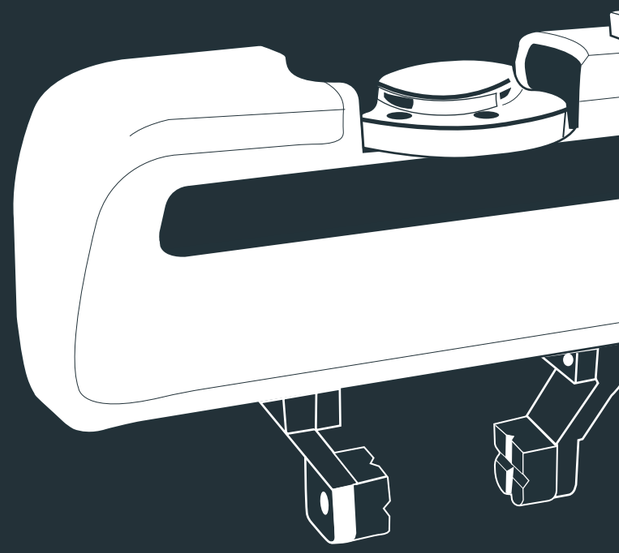
- Emergency off installation with emergency off switch
- Ethernet cable with RJ 45 connector for connecting the interface device to the Arm
- Ethernet cable with RJ 45 connector for optional connection of Control to the company network or PC workstation
- Mounting accessories for mounting the Arm on the stand, e.g. according to our suggestion:
  - 4x cylinder head screw with hexagon socket M8x25mm – strength class 8.8
  - 4x washers M8
  - 2x 6mm h8 pins for precise mounting, if applicable
- Functional earth cable with eye
- For attaching functional earth: screw M5x8 incl. lock washer

Tools

- Screw driver for mounting the Arm on the base
- Screw driver for connecting the functional earth
- Hex key size 4 for attaching the Hand to the end effector flange of the Arm
- Level for ensuring the horizontal installation of the Arm

# TECHNICAL DATA

- Technical specifications



# TECHNICAL DATA

## Technical specifications

**Panda research**
TECHNICAL DATA [1, 2]

| **Arm** | |
|---|---|
| degrees of freedom | 7 DOF |
| payload | 3 kg |
| sensitivity | joint torque sensors in all 7 axes |
| maximum reach | 855 mm |
| joint position limits [°] | A1: -170/170, A2: -105/105, A3: -170/170, A4: -180/5, A5: -170/170, A6: -5/219, A7: -170/170 |
| joint velocity limits [°/s] | A1: 150, A2: 150, A3: 150, A4: 150, A5: 180, A6: 180, A7: 180 |
| Cartesian velocity limits | up to 2 m/s end effector speed |
| repeatability | +/- 0.1 mm (ISO 9283) |
| interfaces | ▪ Ethernet (TCP/IP) for visual intuitive programming with Desk<br>▪ 1x input for external activation device<br>▪ Control connector<br>▪ Hand connector |
| interaction | buttons for: guiding, selection of guiding mode |
| mounting flange | DIN ISO 9409-1-A50 |
| installation position | upright |
| weight | ~ 18 kg |
| protection rating | IP30 |
| ambient temperature | +15°C to 25°C (typical)<br>+5°C to + 45°C (extended) [3] |
| air humidity | 20% to 80% non-condensing |
| **Control** | |
| interfaces | ▪ Ethernet (TCP/IP) for Internet /network connection<br>▪ power connector IEC 60320-C14 (V-Lock)<br>▪ Arm connector |
| controller size (19”) | 355 x 483 x 89 mm (D x W x H) |
| supply voltage | 100 $V_{AC}$ - 240 $V_{AC}$ |
| mains frequency | 47- 63 Hz |
| power consumption | ▪ max. 600 W<br>▪ average ~ 300 W |
| active power factor correction (PFC) | yes |
| weight | ~ 7 kg |
| protection rating | IP20 |
| ambient temperature and air humidity | see Arm |
| **Pilot** | |
| interaction and remote control | navigation pad and buttons for: Hand/Desk control mode, OK, SAVE, CANCEL |

| **Hand** | |
|---|---|
| parallel gripper | with exchangeable fingers |
| grasping force | force up to 70 N |
| travel (travel speed) | 80 mm (30 mm/s) |
| **Desk** [4] | |
| platform | via browser on regular devices |
| architecture | distributed, service-oriented |
| programming | visual & intuitive, dialog-based |
| Apps | can be composed into complex workflows to create Tasks and Solutions |
| **Panda research** [5] | |
| Franka Control Interface (FCI) | General information<br>▪ Ethernet based communication up to 1 kHz [6]<br>▪ provided as C++ library<br><br>Control modes<br>▪ gravity & friction compensated joint level torque command<br>▪ desired joint position or velocity command<br>▪ desired Cartesian position or velocity command<br>▪ Hand control<br><br>Feedback data<br>▪ measured joint data<br>▪ low-level desired joint goals<br>▪ estimation of externally applied torques and wrenches<br>▪ various collision and contact information |
| Robot Model Library | ▪ forward kinematics<br>▪ Jacobian matrix<br>▪ inertia, Coriolis and gravity terms |
| ROS support | ▪ access to Franka Control Interface (FCI) from ROS<br>▪ URDF model of Panda research |
| license | non-commercial use only |

[1] **technical data is subject to change**
[2] the user is responsible for the performance of a risk analysis and safe operation of the robot in accordance to its intended use and applicable standards and laws
[3] performance can be reduced when operating outside the typical temperature range
[4] Desk is deactivated when using the Franka Control Interface (FCI)
[5] view ANNEX for further information
[6] depending on computing equipment and network setup

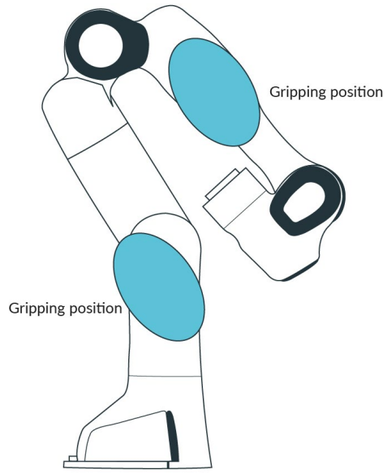


### Additional technical operating conditions

Respect torque limits for each joint at all times:

- Axes 1 & 2: allowed, repeatable peak torque <= 87 Nm
- Axes 3 & 4: allowed, repeatable peak torque <= 87 Nm
- Axes 5, 6, 7: allowed, repeatable peak torque <= 12 Nm

### Transport position of Arm and indication of handling positions



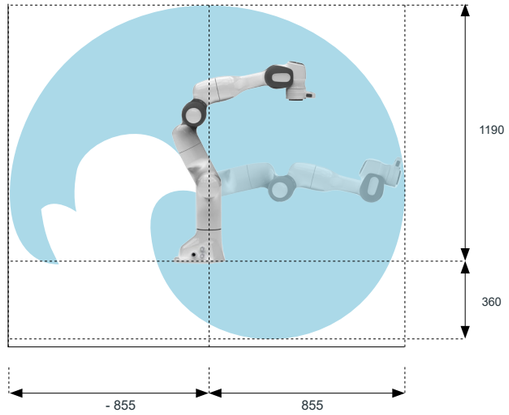

- According to the joint angles of axis 1 to 7: [0°, -32.08°, 0°, -170.17°, 0°, 0°, 45°]
- The Arm may only be handled in the positions indicated here

### Zero position

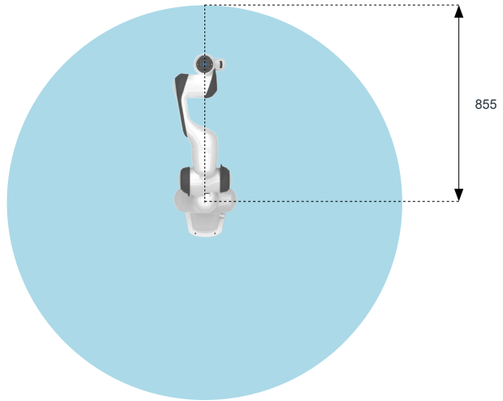
The mechanical zero position of the joints is reached when the two triangles on each side of the gap between the Arm segments align.

## Operating space

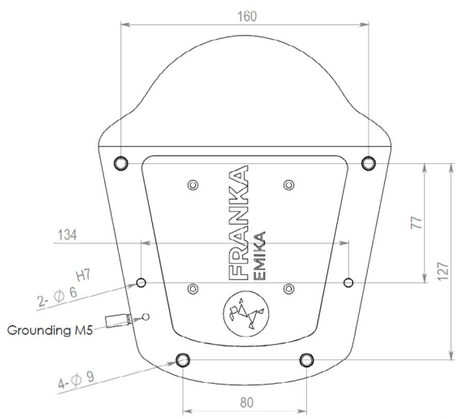
Side view of motion range:




View from above:

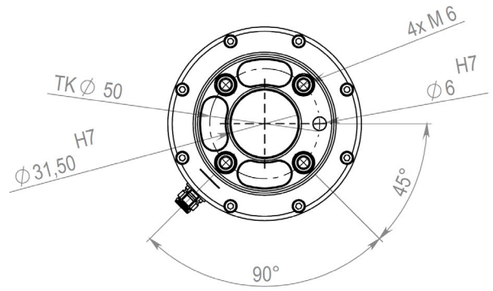



## View from below

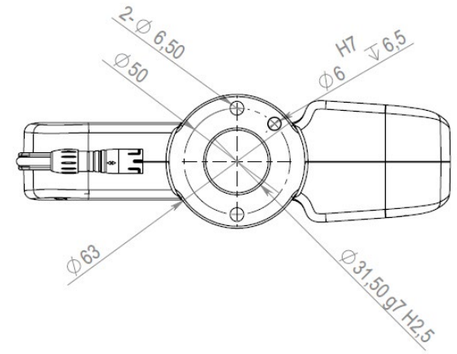





## End effector flange



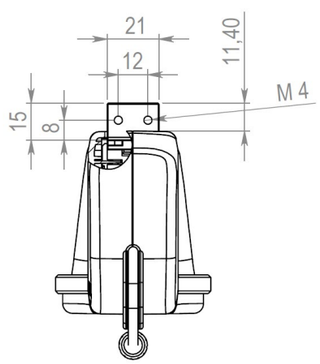

## Flange pattern of Hand



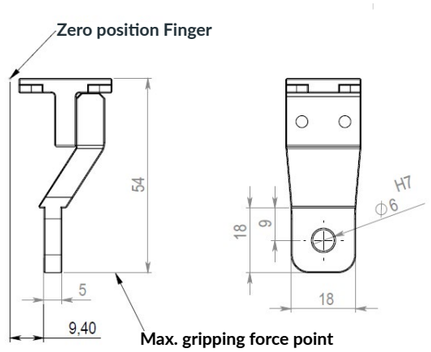

For mounting the Hand to the end effector flange the following tools are required:

- Assembly material (included in scope of delivery of the Hand)
  - 2 x DIN7984 M6X12 ST 8.8 screw
  - 1 x ISO2338B 6X10 H8 A2 cylindrical pin
- Tools (not included in scope of delivery of the Hand):
  - Hex key, size M4

## Interface Hand to fingers



## Interface finger to finger tips




- These fingers are included in the scope of delivery of the Hand and are suitable for being mounted to the Hand
- Should you design and mount other fingers to the Hand, the following needs to be noted:
  - Carry out a risk assessment and implement the measures resulting from it
  - Gripping of an object at a distance of the finger to the Hand will lead to tilting loads. The Hand is designed and tested for a finger length of 54mm.

## Mechanical data of Hand

Select Hand in the drop-down.

e.g. at initial operation of the arm: see chapter Start-up

mass of Hand [kg]

| |
|---|
| 0.73 |

center of mass of Hand to end effector flange [m]

| | | |
|---|---|---|
| -0.01 | 0 | 0.03 |

inertia sensor [kg x m2]

| | | |
|---|---|---|
| 0.001 | 0 | 0 |
| 0 | 0.0025 | 0 |
| 0 | 0 | 0.0017 |

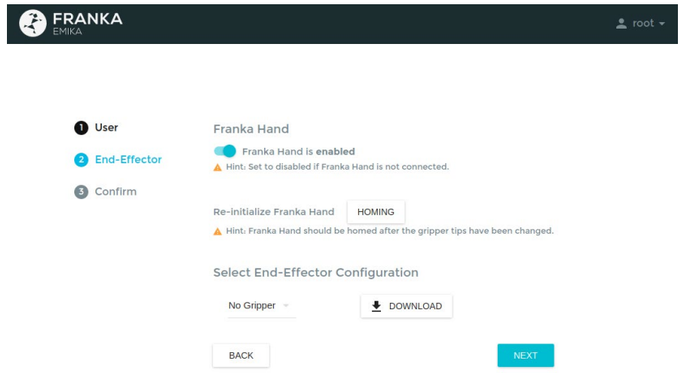
Transformation matrix of end effector flange to Hand (center point of finger tips when closed)

| | | | |
|---|---|---|---|
| 0.707 | 0.707 | 0 | 0 |
| -0.707 | 0.707 | 0 | 0 |
| 0 | 0 | 1 | 0.1034 |
| 0 | 0 | 0 | 1 |



If no end effector is used, select “No Gripper” in the drop-down.

## System settings without use of end effector




## Ambient conditions

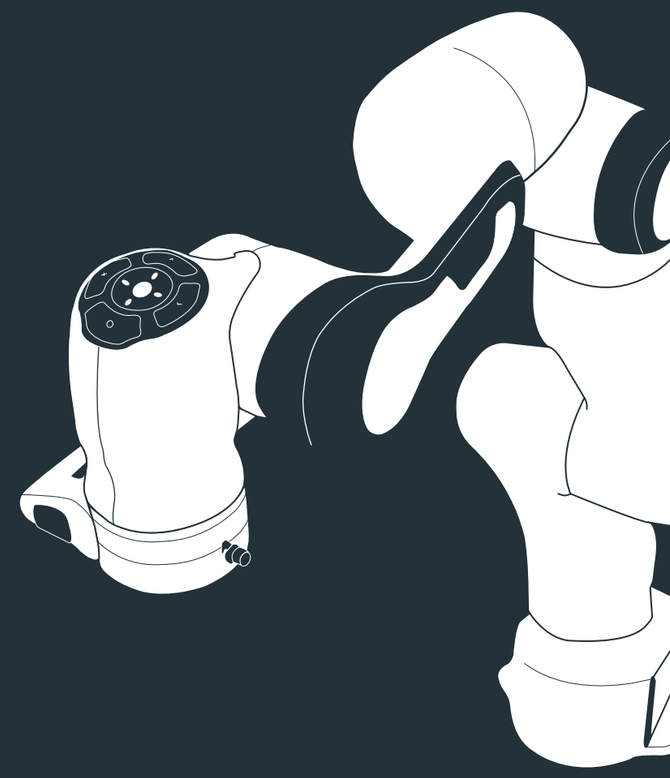
see /Correct Site of Installation/Ambient Conditions/

## Production standard

Arm, Control and Hand are manufactured in a production company certified according to ISO 9001

# CONFORMITIES

- Declaration of conformity
  - Control with Arm
  - Hand
- Further information



# CONFORMITIES

## Declaration of conformity

Control with Arm

### Declaration of Conformity

CE

We declare that the products listed below are in conformity with the provisions of the following Directives:
EC Directives 2014/30/EC relating to electromagnetic compatibility (EMC)
EC Directives 2014/35/EC relating to electrical equipment (LVD)

**Product identification**
*Control* (#75196354) in combination with *Arm* (#73687214) – in *Panda research* version

**Applied harmonized standards**
**Electrical safety**

| Standard | Name |
|---|---|
| EN 60204-1:2006<br>IEC 60204-1:2005 (Modified)<br>EN 60204-1:2006/AC:2010<br>EN 60204-1:2006/A1:2009<br>IEC 60204-1:2005/A1:2008 | Safety of machinery - Electrical equipment of machines - Part 1: General requirements |
| EN ISO 12100:2010<br>ISO 12100:2010 | Safety of machinery - General principles for design - Risk assessment and risk reduction |
| EN 61800-5-1:2007<br>IEC 61800-5-1:2007 | Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy |

**EMC**

| **Standard** | **Name** |
|---|---|
| EN 61000-6-2:2005<br>EN 61000-6-2:2005/AC:2005<br>IEC 61000-6-2:2005 | Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments |
| EN 61000-6-4:2007<br>IEC 61000-6-4:2006<br>EN 61000-6-4:2007/A1:2011<br>IEC 61000-6-4:2006/A1:2010 | Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments |
| DIN EN 61000-4-2:2009<br>IEC 61000-4-2:2008 | Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test |

**Manufacturer:**
Franka Emika GmbH
Infanteriestr. 19
80797 München
Deutschland

**Date**
30.08.2017

**Philipp Zimmermann, CEO**



Hand

### Declaration of Conformity

CE

We declare that the products listed below are in conformity with the provisions of the following Directives:
EC Directives 2014/30/EC relating to electromagnetic compatibility (EMC)

**Product identification**
*Hand* (#71913548) – in *Panda research* version

**Applied harmonized standards**
**Machinery**

| Standard | **Name** |
|---|---|
| EN ISO 12100:2010<br>ISO 12100:2010 | Safety of machinery - General principles for design - Risk assessment and risk reduction |

**EMC**

| **Standard** | **Name** |
|---|---|
| EN 61000-6-2:2005<br>EN 61000-6-2:2005/AC:2005<br>IEC 61000-6-2:2005 | Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments |
| EN 61000-6-4:2007<br>IEC 61000-6-4:2006<br>EN 61000-6-4:2007/A1:2011<br>IEC 61000-6-4:2006/A1:2010 | Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments |
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**Manufacturer:**
Franka Emika GmbH
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80797 München
Deutschland

**Date**
30.08.2017

**Philipp Zimmermann, CEO**

# Further Information

**status: 30.08.2017 Panda research**

**Restriction of Hazardous Substances (RoHS):**

The products *Control*, *Arm* and *Hand* do not fall within the scope of EU RoHS Directive 2011/65/EU, but still meet the requirements of the restricted substances and maximum concentration values that are allowed in homogenous materials:

- Lead (0.1%)
- Mercury (0.1%)
- Cadmium (0.01%)
- Hexavalent chromium (0.1%)
- Polybrominated biphenyls (PBB) (0.1%)
- Polybrominated diphenyl ethers (PBDE) (0.1%)

The following exceptions are also applied:
6a: Lead as an alloying element in steel for machining purposes and in galvanized steel containing up to 0,35 % lead by weight
6b: Lead as an alloying element in aluminum containing up to 0,4 % lead by weight
6c: Copper alloy containing up to 4 % lead by weight

**REACH:**

*FRANKA EMIKA GmbH* is a "downstream user" as defined in REACH. Our products are exclusively non-chemical products (manufactured items). In addition, under normal conditions of use and the conditions which can reasonably be predicted, no substances are released (Article 7, REACH).
We confirm that our products do not contain more than 0.1 percent by mass of any of the listed substances on the published ECHA candidate list (SVHC). Extensions published by the ECHA candidate list are matched with our products and if it is known that one of these newly added substances contained in our products, we will inform you immediately.
This confirmation was created based on currently available information of our suppliers.

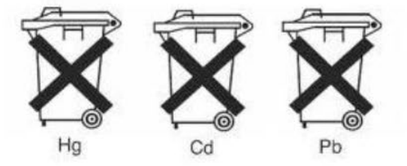
**WEEE Directive:**

The products *Control*, *Arm* and *Hand* are not subject to the WEEE Directive 2002/96/EC for collection, recycling and recovery for electrical goods.

**Battery Directive:**

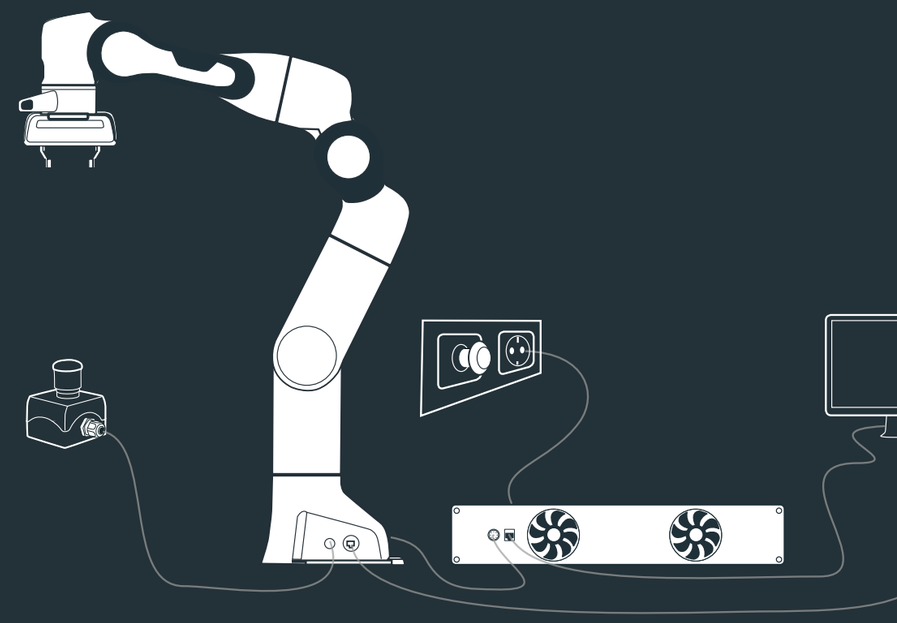
The product *Control* contains a BIOS battery.

Disposal of batteries:
There is an obligation to return rechargeable and non-rechargeable batteries by Battery Directive 2006/66/EC; do not dispose them with consumer waste. Dispose them according to statutory orders and lead them to a recycler. Batteries will be recycled.
The signs below the crossed out trashcan indicate the substances lead (Pb), cadmium (Cd), or mercury (Hg).



# CORRECT SITE OF INSTALLATION

- Ambient conditions
  - Arm and Hand
  - Control



# CORRECT SITE OF INSTALLATION

## Ambient conditions Arm and Hand

### Permissible conditions at site of installation

Site of installation

- indoors, in enclosed buildings
- not exposed to direct sunlight
- no vibrations
- no magnetic fields

Type of installation

- device may only be installed vertically (base horizontal to the earth's surface)

Protection class

- Arm: IP 30 (according to EN 60529:1991)
  - IP 3x: protected against ingress of solid bodies with a diameter >= 2.5mm
  - IP x0: no protection against water
- Hand: IP 20 (according to EN 60529:1991)
  - IP 2x: protected against ingress of solid bodies with a dimeter >=12.5mm
  - IP x0: no protection against water

Ambient medium

- air
  - free from flammable substances (dust, gas, liquid)
  - free from aggressive media
  - free from corrosive substances
  - free from "flying parts"
  - free from spraying liquids

Pollution degree

- degree 2 (according to IEC 60664)
  - "only dry, non-conductive pollution occurs; occasionally temporary conductibility caused by condensation may occur"

Ambient temperature

- +15°C to 25°C (typical)
- +5°C to + 45°C (extended)
- -10°C to + 60°C (transport)
- +5°C to + 25°C (storage)

Relative air humidity

- 20 % - 80 %, non-condensing

Set-up altitude

- <= 2000 m above sea level



### Stable platform

The Arm is equipped with highly sensitive sensor technology and fine-tuned control algorithms. The Control algorithm requires installation on a stable, non-moving and non-vibrating platform.

In particular, the following maximum forces must be supported during static and dynamic operation:

- vertical force: 410 N
- horizontally force: 300 N
- tilting torque: 280 Nm
- torque around axis 1: 90  Nm

### Screw connection to baseplate

The Arm has to be connected to the baseplate with 4 screws sized accordingly. For this purpose, 4 drill holes with a diameter of 9mm are provided in the base flange of the Arm. The screw connection must be suitable for withstanding the static and dynamic forces generated.

Example for possible screw connection:

- thickness of baseplate: 20mm
- 4x cylindrical head screw with hexagon socket M8x25mm – strength class 8.8
- 4x washer M8
- tightening torque for screws 23 Nm
- Note that after 100 hours of operation the screws need to be tightened again with the tightening torque indicated!

**WARNING**

If the Arm is installed on moving, instable ground, this may cause malfunctions and unforeseeable movements of the robotic arm or cause it to fall. This may lead to severe injuries.

Therefore:

- always install the Arm so that its base is horizontal to the earth's surface
- the Arm may not be installed hanging
- the platform of the Arm must be stable
- the platform may not move, vibrations are not permissible
- When used in earthquake-prone areas this needs to be considered during the risk assessment.
- the screw connection must be laid out correctly and must hold tight
- after 100 hours of operation the screws need to be tightened again with the tightening torque indicated!

### Adequate ventilation

*NOTE*

The Arm contains power electronic components and modules (electric drives, CPUs, etc.) which heat up depending on the stress the device is subject to. The Arm does not contain active cooling systems, meaning that the produced heat is given off via the Arm's surface.

Therefore:

- make sure that the Arm is adequately ventilated
- make sure the Arm is not exposed to direct sunlight
- make sure that the Arm is not painted, pasted up with something or enwrapped

### Derating

When operating within the "extended temperature range", the possibilities for application of the Arm may be limited (e.g. the speed or acceleration may need to be reduced), in order not to overheat the system.

## Ambient conditions Control

### Permissible conditions at site of installation

Site of installation

- indoors, in enclosed buildings
- not exposed to direct sunlight
- no vibrations
- no magnetic fields

Type of installation

- device can be installed vertically and horizontally to the earth's surface
- mounting in angle brackets e.g. under tables
- mounting in control cabinets (2U, 4HP)

Protection class

- IP 20 (according to EN 60529:1991)
  - IP 2x: protected against ingress of solid bodies with a dimeter >=12.5mm
  - IP x0: no protection against water

Ambient medium

- air
  - free from flammable substances (dust, gas, liquid)
  - free from aggressive media
  - free from corrosive substances
  - free from "flying parts"
  - free from spraying liquids

Pollution degree

- degree 2 (according to IEC 60664)
  - " only dry, non-conductive pollution occurs; occasionally temporary conductibility caused by condensation may occur"

Ambient temperature

- +15°C to 25°C (typical)
- +5°C to + 45°C (extended)
- -10°C to + 60°C (transport)
- +5°C to + 25°C (storage)

Relative air humidity

- 20 % - 80 %, non-condensing

Set-up altitude:

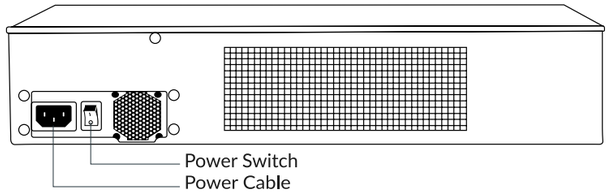
- <= 2000 m above sea level

### Connection to power-supply

The Control is equipped with a wide-range input for mains supply voltages from 100 $V_{AC}$ to 240 $V_{AC}$ and mains frequencies from 47 to 63 Hz.

### Switch for disconnecting from the power supply

The power switch for disconnecting Panda research from the mains supply is located at the back of the Control next to the connector port for a cold device cable.




### Energy consumption

Panda research requires on average < 300 W for standard operation. Temporarily, electrical power of up to 600 W can be drawn from the mains.

If too many consumers are connected to a power outlet this can lead to an overload of the electrical installation and may result in smoldering fires.

Therefore:

- make sure that the connection of Panda research will not lead to an overload of the electrical installation
- make sure that overload protection devices are installed accordingly

*NOTE*

If a fuse in the upstream power supply of the Control blows, Panda research is disconnected from the power supply. The Arm reacts with braking as much as possible before the fail-safe locking bolts catch in the 7 axes. If the residual energy is not sufficient to bring the Arm to a full stop, the locking bolts may damage the Arm.

Therefore:

- the mains fuse is to be selected accordingly

## Adequate ventilation

*NOTE*

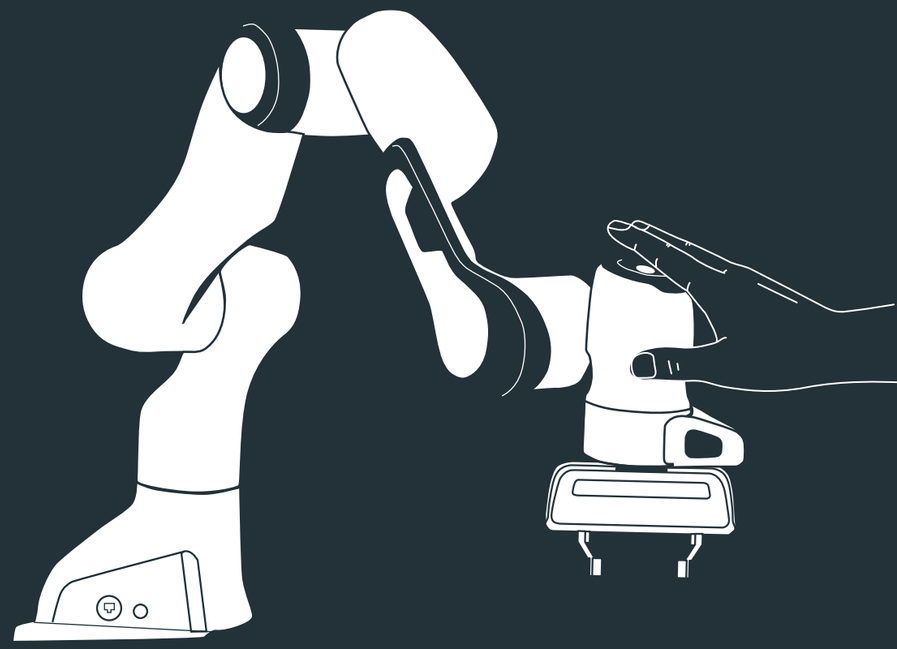
The Control contains power electronic components and modules (electric drives, CPUs, etc.) which heat up depending on the stress the device is subject to. An internal, active ventilation system sucks in air from the environment and channels it through the casing of the Control.

Therefore:

- make sure that the Control is adequately ventilated
- make sure there is enough distance between the front ventilators and covering components
- make sure there is enough distance between the back ventilators and covering components
- make sure that the ventilators are not blocked by pollution
- make sure the control is not exposed to direct sunlight

# SAFETY CONCEPT

- Staff
- Dangers that Panda research may present
- Hazardous and safe areas
- Emergency off system
- Fail-safe safety locking system
  - Manually moving the Arm in case of emergency
- General safety instructions
- Operating modes of Panda research
  - Teach your Task
  - Step back and watch - Check if the Task is being executed correctly
  - Let Panda work
    - Let Panda work - Automatically
    - Let Panda work - Collaboratively
- Risk assessment
- Practical information on how to use and place Panda research
- Name plates and warnings



# SAFETY CONCEPT

## Staff

All persons working with Panda research have to have read and understood the documentation, in particular the chapters on safety. Users need to be able to comprehend any risks the robotic system may present and be prudent in their behavior. Furthermore, it is to be ensured that users always pay attention and are aware of potential dangers.

**WARNING**

Persons using Panda research in any form must be in full possession of their physical and mental powers at all times. Failing this, serious injuries may occur. Therefore:

- Never operate Panda research under the influence of drugs, alcohol or medication impacting your reactions.

## Operator

see: /Legal Framework/

## Determining the users and their authorizations

In Desk, there are two predefined roles: The user and the admin. The admin has more authorizations than the user.

## Admin

The admin has the authorization to edit the following settings in Panda research:

- Network configuration (see /Start-up/)
- Setting up and adapting the safety settings (see /Start-up/)

The admin needs to have:

- Basic IT knowledge
- Expert knowledge of occupational safety and safety engineering

## User

The user can operate the system within the limits defined by the operator and the admin.

Users may be:

- Persons installing Panda research
- Persons using Panda research
- Persons cleaning Panda research

The user needs to have:

- Basic knowledge of mechanical engineering and automation
- Basic knowledge of robot operation



## Transport and logistics

Persons handling Panda research or parts of it need to have received:

- Training for handling sensitive devices

## Installation

The person installing Panda research needs to have:

- advanced knowledge of electrical installation and safety engineering (in particular for the installation of the emergency off and the mains fuse)
- training for handling and installation according to this user manual

## Cleaning staff

Cleaning may only be carried out by trained users. For information on the correct cleaning, see /Maintenance, Service & Support/

In this regard, we refer to the Franka Academy, where appropriate training courses on the handling of Panda research are offered.

# Dangers that Panda research may present

## Abstract of possible dangers

**WARNING**

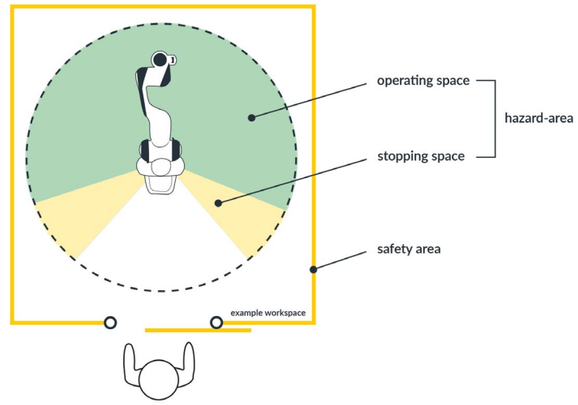
An extensive but not definitive list of dangers that generally may be presented by a robot system can be found under ISO 10218-1:2011 ANNEX A. Special attention will be drawn here to the following dangers that Panda research may possibly present:

- Mechanical dangers
  - Crushing
    - by falling or tilting over of the robotic arm in particular or the control during transport and incorrect mounting
    - between robot/end effector and robot/end effector
    - between robot/end effector and environment (operating area, objects in the operating area)
    - by objects falling out of the gripper
    - during manual unlocking of the fail-safe safety locking system
- Shearing
  - between robot/end effector and object in the end effector and environment (operating area, objects in the operating area)
  - during manual unlocking of the fail-safe safety locking system
- Impact, puncture, penetration
  - between end effector/object in the end effector and humans
- Electrical hazards
  - electric shock when touching live part
    - when wiring the emergency off installation in particular
    - when operating Panda research with damaged supply cables or incorrect electrical installation
- Environmental hazards
  - Crushing, shearing, impact, puncture, penetration
    - by falling caused by an earthquake
    - by unexpected movements of the robot caused by an earthquake combined dangers
- Combined hazards
  - Crushing, shearing, impact, puncture, penetration
    - by unexpected movements of the robot caused by incomplete functionalities (such as monitored stop)



# Hazardous and safe areas

## Classification of areas



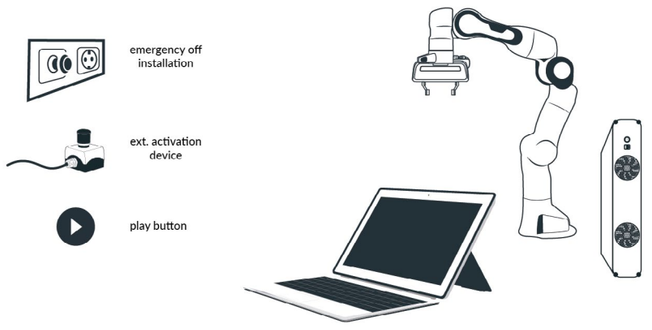

Distinction of the different areas:

- Operating area: The area, in which the Arm executes its Task
- Stopping area: The operating area of the Arm including its stopping distance. If the Arm is stopped within its operating area, it will stop its movement at the latest within the stopping area.
- Hazardous area: An area in which humans may be harmed.
- Safety area: An area in which humans are separated from a hazardous area by protective measures (here by a security fence).

# Emergency off system

## Emergency off system

An emergency off system is to be installed according to generally valid and accepted engineering standards (e.g. European standards EN 60204, EN 418, and related standards)
The emergency off system needs to safely disconnect the control from the power supply. As a result of the safe disconnection from the power supply, the locking bolts of the fail-safe safety locking system will catch in all 7 axes and thereby prevent any further movement of the Arm.



### Protective measures

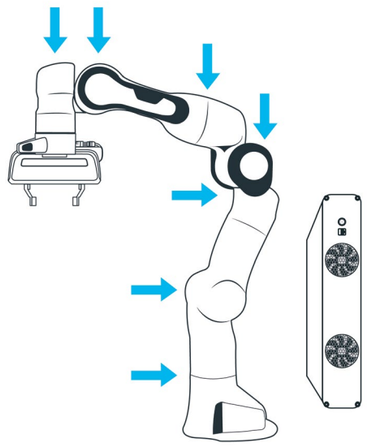
Protectivemeasures which safely prevent access to the Arm (safety fences with access monitoring, safe laser scanners, etc.) can be integrated. These must be installed such as to safely disconnect the Control from the power supply, as soon as a person enters the hazardous area.

The emergency off system must be activated and tested for functional capability at start-up and at least once every 12 months. To avoid damaging Panda research, the emergency off should always be tested at standstill. It should be noted, that when disconnecting from the power supply the safety bolts will catch in all 7 joints and the robot will sink a little due to gravitational force.

## Fail-safe safety locking system

### Safety locking system

When the Arm is disconnected from the power supply locking bolts automatically catch in all 7 axes of the Arm. They mechanically lock any movement of the joints so that the Arm stays in position even when not supplied with power.
Due to the technology of these locking bolts, the position of the Arm cannot be held perfectly when the power is switched off. The locking bolts catch with an audible click and let the Arm sink, in particular at those joints on which gravitational force comes into effect. This should be taken into consideration.





## Manual moving of the Arm in case of emergency

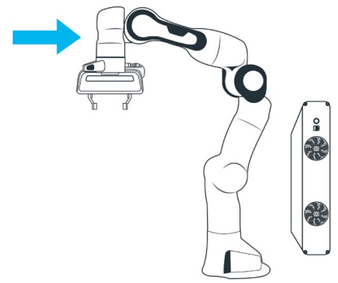
There are several possibilities to move the Arm even without a power supply in case of emergency. They are listed below in order of criticality of the hazardous situation:

- In case of acute mortal danger (e.g. person is severely crushed or can no longer breathe)
  - action: immediately push the Arm away manually
- In case of non-acute mortal danger and jamming of the Arm itself
  - action: unlock safety locking system with the use of the unlocking key
  - action: loosen the screws attaching the Arm to the base

### Moving the Arm without electrical power

SAFETY - INSTRUCTION

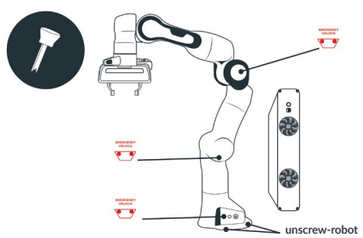
In case of acute mortal danger, the Arm needs to be immediately pushed or pulled out of the dangerous position manually.



### Action: pushing away manually

SAFETY - INSTRUCTION

When the Arm is to be moved in a non-powered condition, (e.g. when it is jammed between surrounding objects), the emergency unlocking system is to be used. For this purpose, trapezoidal openings are available at three joints of the Arm. These are marked with the label emergency unlock. By gently inserting the unlocking tool, the joint is unlocked and the Arm segments below it can be moved manually.



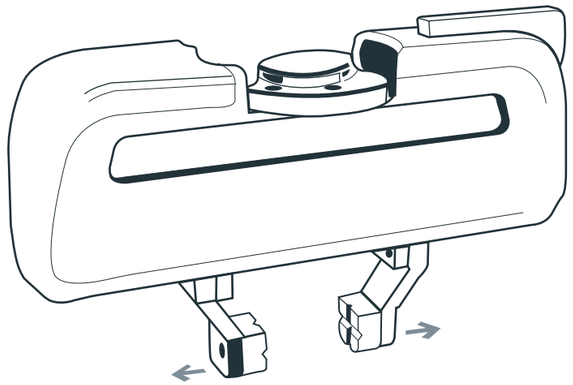

### Action: emergency unlock

### Action: unscrewing of the manipulator from the baseplate

Jamming of the Arm can also be remediated by loosening the screws attaching the Arm to the baseplate.

### Moving of fingers without electrical power

When the device is turned off, the Hand is not supplied with power either. A jamming between the fingers of the Hand can be loosened by simply pulling the finger open.





## General safety instructions

**WARNING**

Panda research is a research object and therefore does not need to be compliant with all requirements for a provision according to the EU Machinery Directive 2006/42/EG, or the corresponding C-norm for industrial robots ISO 10218 or the TS 15066 for collaborative robots, respectively (see also /Legal Framework/).

For the commercial version of Panda research, safety-rated functionalities for increasing user safety will be provided. The functionalities for user safety presented for the version Panda research cannot be used as “safety-oriented functionalities for the safeguarding of persons” (according to Performance Level d and category 3 of EN ISO 13849-1:2008).

Even though the user is offered several functionalities for increasing user safety (internal activation button, external activation device, monitored stop, protection from self-collision, monitoring of joint angles, speed monitoring, force/torque monitoring and collision detection), the user CAN NOT rely on these functionalities! Dangerous and uncontrolled movements of the robotic arm need to be expected at all times! Such a malfunctioning is to be regarded as extremely rare and will only occur under highly unfavorable conditions. Therefore, maintaining attention focused and alert for any malfunctioning presents a challenge. The listed movements can lead to risks of crushing, shearing, impact, puncture or penetration and may cause severe injury.

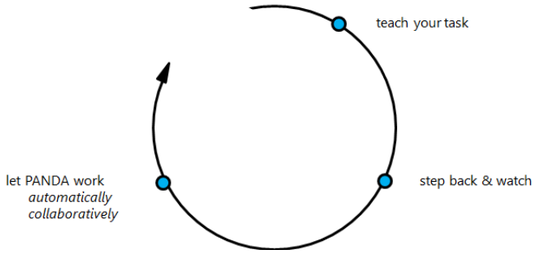
Therefore:

- The operator is solely responsible for conducting a risk assessment based on the above-mentioned and the following contents and subsequently implementing appropriate measures (constructional or organizational measures), thereby ensuring that the user is aware of the absence of certain functionalities.
- The user must maintain the greatest possible distance to the Arm at all times to be able to avoid collision. In particular:
  - The Arm may never be operated while embracing it
  - The head or other body parts may never be brought be between Arm segments or the Arm and stationary objects
  - The hands may never be brought between Arm/end effector and stationary objects
- The Arm may never be operated in confined spaces without the possibility to avoid collisions.

Please also refer to “Practical information on How to place and use Panda research” under /Safety Concept/

# Operating modes of Panda research

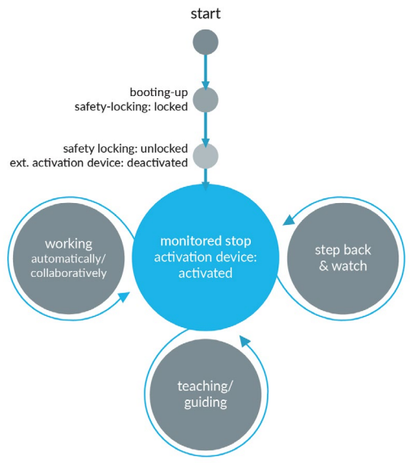
## Our operating philosophy




Our operating philosophy consists of three basic steps you can repeat any number of times:

- teach your Task: teach Panda research a Task by taking the Arm by the hand
- step back and watch: then step out of the Arm's operating area and check, if the demonstrated Task is executed correctly
- let Panda work: Once Panda research has learned the Task, it can execute it autonomously

## Operating states




- Panda research boots up as soon as the Control has been turned on or is supplied with power. At this point the safety locking system is still active, movements are thus mechanically locked. The signal lights on the base and the Pilot flash yellow.
- Before the safety locking system can be deactivated, the system must check if the external activation device works. For this purpose, please activate and deactivate the external activation device once.
- Now the safety locking system can be opened in the footer of Desk with the button ("Open brakes"). The signal lights now glow continuously yellow. In the footer of Desk, it is indicated that the bolts are unlocked.

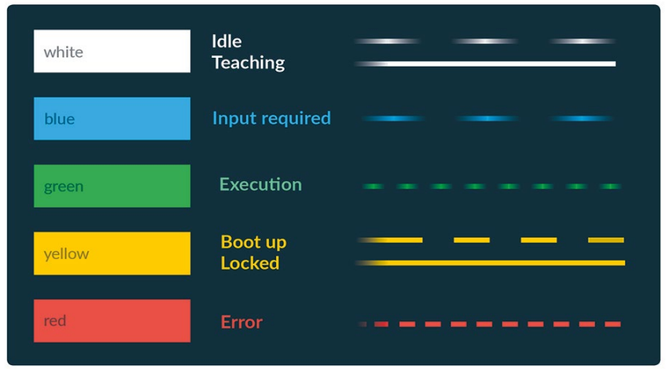


- By activating the external activation device, Panda will go into "monitored stop" and flash white. In the footer of Desk, it is indicated that the activation button is active.
- By simultaneously pressing the activation button and the guiding button on the grip of the Arm, the Arm can be guided manually, e.g. for saving positions (teaching). During teaching mode, Panda continuously glows white.
- Once the buttons are released, Panda returns to the "monitored stop" condition and flashes white.
- From this mode, you can also turn to the "step back & watch" mode by taking the external activation device and, if applicable also the emergency off switch, leaving the hazardous area and pressing the play key in Desk. Now Panda should flash green. When Panda is waiting for input it flashes blue.
- You can also enter "working" mode to let Panda execute a task autonomously
- In case an error is detected, Panda flashes red.

## Overview of status indicators

On the Pilot, there is a circular status light in the center of the disc. Depending on the state of the system, the color and the blinking pattern changes. This is supported by the two status lights on both sides of the base, which has the respective signalcolor, similar to a traffic light. However, there is no blinking pattern here.

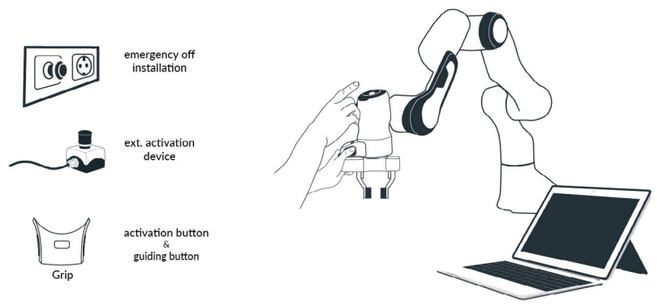
Note: Only when the system is booting up, the status lights of the base flash along with the status light at the Pilot as long as the system is booting up and all status lights are solid yellow.



# teach Panda your Task

## Short description

Keep both buttons on the grip of the Arm pressed (activation & guiding buttons) and the Arm can be moved freely (but limited according to the corresponding guiding mode) by guiding it. This mode is used for teaching new poses or for manually moving the Arm to another pose.




## Preconditions

Safety conditions:

- Emergency off must be installed within easy reach

Preconditions for operation:

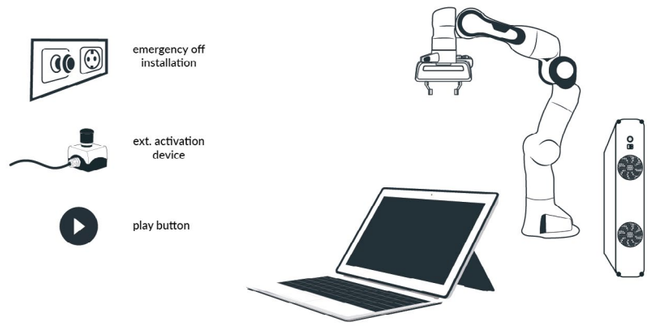
- The control is switched on and booted-up
- The emergency off is in open position
- The external activation device must be connected and activated
- The activation button on the grip is being pressed halfway down. The activation button has three states:
  - Not pressed: Arm is deactivated
  - Pressed halfway: Arm is activated
  - Pressed: Arm is deactivated
- In addition, the guiding button must be pressed continuously
  --> Only now can the Arm be moved manually and freely in guiding mode



# step back and watch - check if the Task is being executed correctly

## Short description

After teaching a robot movement you usually want to check the learned movement. To do so, leave the operating area of the Arm (step back). You can activate the robot for movements using the external activation device. Activate only when you are ready to pay full attention to the robot movement. If you detect an incorrect movement, use the external activation device to stop the robot. In case of unsafe movements always use the emergency off to safely deactivate Panda research.




## Preconditions

Safety condition:

- Emergency off must be within easy reach
- The user has left the operating area of the Arm /hazardous area (step back)
- The user pays full attention to the upcoming robot movement

Preconditions for operation:

- The Control is switched on and booted-up
- The emergency off is in open position
- The external activation device is connected and active. Ideally, a multi-stage activation button is to be used, which needs to be continuously half pressed during “step back & watch”, in order to ensure that full attention is being payed to the robot movement.

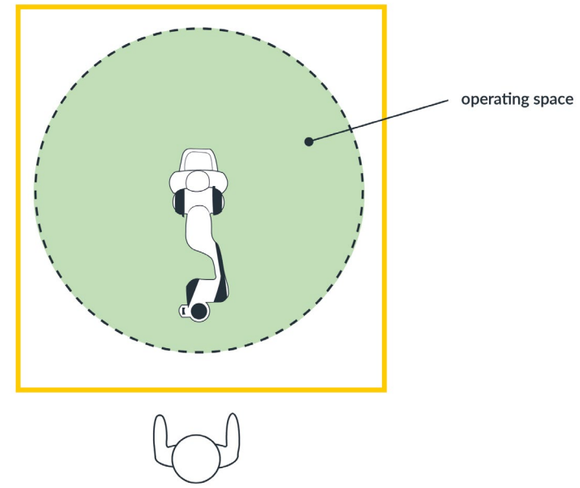
--> Only now can a movement of the Arm be executed, e.g. using the play button in Desk.

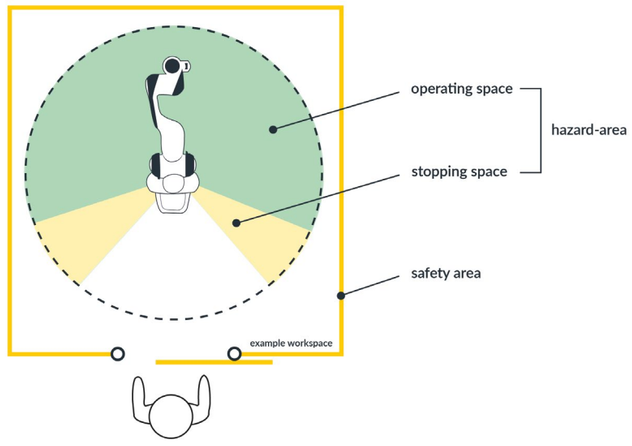
# Let Panda execute a task autonomously

## Short description

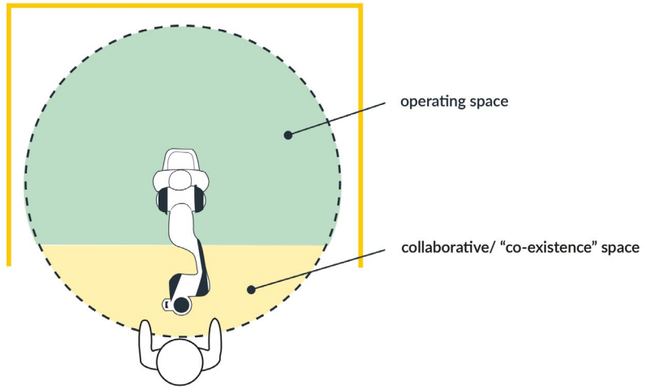
After Panda has learned and mastered its Tasks, they shall be executed autonomously. This can be done in two ways:

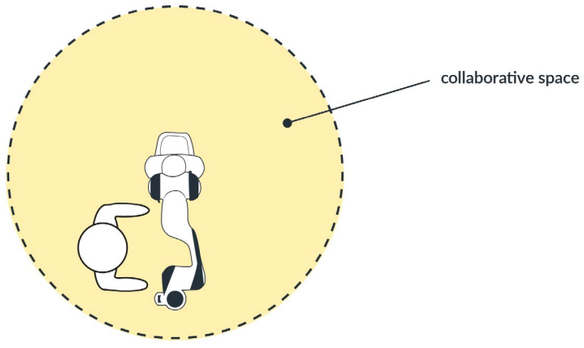
- automatically:
  The person is safely separated from dangers presented by the Arm (in ISO 10218 this is referred to as “automatic mode”):




- collaboratively:
  The risk assessment has shown that the Task can safely be executed collaboratively. Collaboratively means that there is a shared operating area, which both the Arm and a person can enter. We differentiate between collaboration and co-existence. While collaboration is understood as the entire or the greater part of the operating area being occupied by human and robotic arm at the same time, the more frequent case is co-existence. This means that only a small part of the operating area is shared. In addition, this common operating area is usually rarely used by human and robotic arm at the same time. In this case any danger presented by the Arm is limited and therefore easier to take into account.

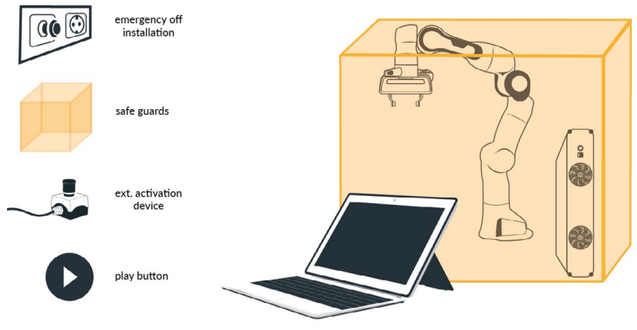


# let Panda work - automatically

## Short description

As soon as the system performs a Task repeatedly (e.g. machine learning tasks) it needs to be ensured that no persons accidentally enter the operating area of the robot arm and are harmed as a result. Safeguards can be installed around Panda research to prevent access to the hazardous area (e.g. a safety fence with access monitoring, safe laser scanners or similar safeguards). This operating mode corresponds to “automatic mode” as described in EN ISO 10218-1:2012.




## Preconditions

Safety conditions:

- The operator is responsible for preventing persons from entering the hazardous area of the robotic arm
- The safeguards installed must safely cut the power supply to the control once a person enters the safe area.
- The size of the safe area must be such that the maximum stopping time and the maximum stopping area are taken into account.
- The emergency off must be installed within reach

Operating conditions:

- The Control is switched on and booted-up
- The emergency off is in open position
- The external activation device is connected and active.

--> Only now can a movement of the Arm be executed, e.g. using the play button in Desk.



# let Panda work - collaboratively

## Short description

Panda research offers numerous functionalities to increase user safety (e.g. virtual walls, soft end stops, torque monitoring, etc.). However, the user CAN NOT under any circumstances rely on these functionalities! They serve for evaluation purposes only. Interaction with the Arm may include for example: Stopping the robot movement by reaching into the movement, Starting a robot movement with a gesture such as tapping or similar. Before Panda research can be operated collaboratively, a risk assessment must have been carried out, the result of which must allow for collaborative operation under consideration of the limitations.

## Preconditions

Safety conditions:

- emergency off must always be installed within reach
- a risk assessment must have been carried out – the result must allow for collaborative operation
- the user must pay full attention to the upcoming robot movement

Operating conditions:

- The Control is switched on and booted-up
- The emergency off is in open position
- The external activation device is connected and active

--> Only now may the robotic arm be operated collaboratively.

## Additional functionalities for increasing user safety

The following functionalities can be used to increase user safety. However, they have NOT been tested to comply with PLd CAT 3. The functionalities include:

- **Monitored stop** (ATTENTION: no safety-rated stop according to EN ISO10218-1:2012, resp. ISO TS 15066:2016!)
- **Protection from self-collision** (ATTENTION: no safety-rated software for limiting axes and space according to EN ISO 10218-1:2012, resp. ISO TS 15066:2016!)
- **Joint angle monitoring** (ATTENTION: no safety-rated software for limiting axes and space according to EN ISO 10218-1:2012, resp. ISO TS 15066:2016!)
- Speed monitoring (ATTENTION: no safety-rated speed monitoring according to EN ISO 10218-1:2012, resp. ISO TS 15066:2016!)
- **Force/torque monitoring** (ATTENTION: no safety-rated monitoring of forces and torques according to EN ISO 10218-1:2012, resp. ISO TS 15066:2016!)
- **Collision detection** (ATTENTION: no safety-rated force and torque monitoring according to ISO TS 15066:2016!)

## Performing a risk assessment

Panda research is a research object and therefore does not need to be compliant with all requirements for a provision according to the EU Machinery Directive 2006/42/EG, or the corresponding C-norm for industrial robots ISO 10218 or the TS 15066 for collaborative robots, respectively (see also /Legal Framework/).

The operator is solely responsible for conducting a risk assessment based on the above-mentioned and the following contents according to existing standards. Franka Emika recommends performing a risk assessment according to the Machinery Directive, taking into account the list of hazards from ISO 10218-1:2011 ANNEX A (the C standard for robots) and the limitations in the ISO 10218-2:2011.

Appropriate measures (constructional or organizational measures) for safeguarding are to be implemented.

## Practical information on how to use and place Panda research

The following information on how to use and place the Arm are practical tips and may not be exhaustive when it comes to concrete application. They do not replace a risk assessment but may suggest layout options.



### Space for retracting

Humans instinctively retract from unexpected movements. This is why the area in which the user stands should allow for sufficient space to retract or recoil. Furthermore, it is to be made sure that this space is free of obstacles (e.g. cables, objects) to prevent persons from tripping over these obstacles and harming themselves.

### Greatest possible distance to the Arm

The Arm should be kept at the greatest possible distance at any given time to allow the user to react and recoil.

RIGHT WRONG

DO NOT operate the robotic arm while embracing it.

RIGHT WRONG

DO NOT place your head or other body parts between or underneath segments of the robotic arm!

RIGHT WRONG

NEVER place body parts (especially hands, fingers) between the robotic arm or its end effector and stationary objects.

## Workspace design

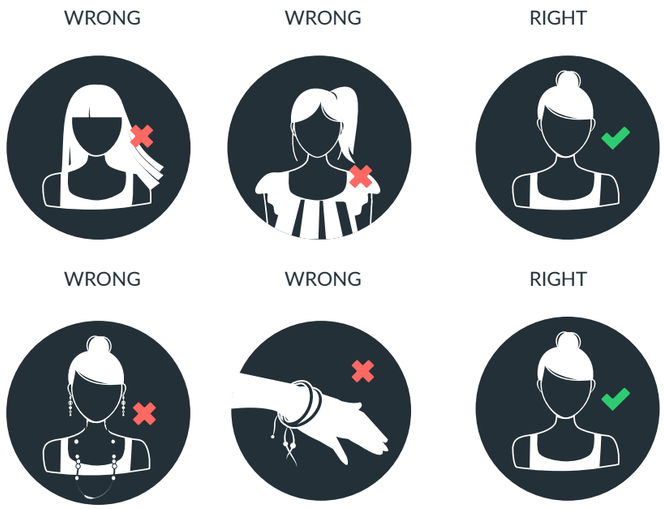

NO sharp edges in the operating area and NO pointed objects!

NO unnecessary objects in the operating area

Ergonomic position for teaching:

- Robotic arm is within easy reach
- The Arm is installed at an ergonomic height

## Clothes, hair & jewellery




DO NOT wear long hair loose, tie it up!

DO NOT wear loose clothing or clothing with ribbons!

NO loose jewelry such as necklaces or bracelets!



## Labeling on the devices

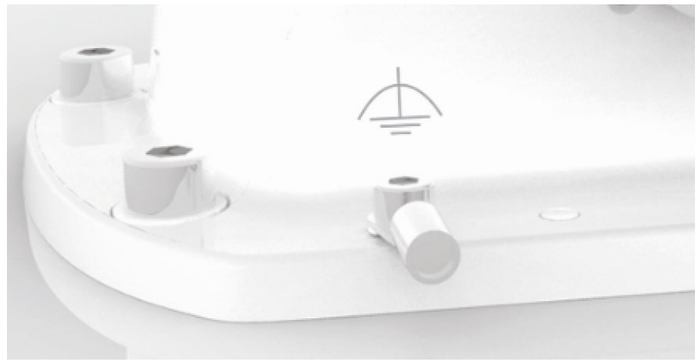
### Name plate: Arm


### Emergency unlock label on Arm

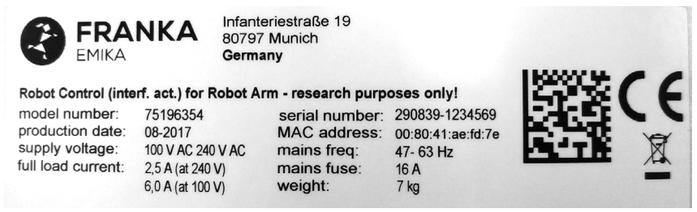
There are 3 labels for the EMERGENCY UNLOCK on the Arm. They indicate the places in which the unlocking tool can be inserted in order to manually unlock the fail-safe safety locking manually in case of emergency.


### Functional earth label on Arm

Indicates where a functional earth can be connected on the base of the Arm.

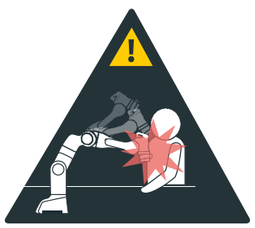


### Name plate: Control



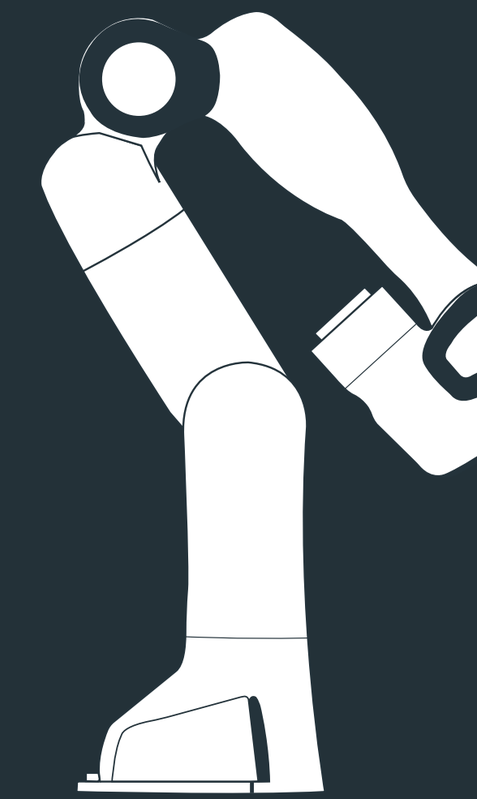

### Name plate: Hand


### Safety label: Arm



# DELIVERY & TRANSPORT

- Delivery & transport
- Handling & lifting



# DELIVERY AND TRANSPORT

**WARNING**

The Arm weighs approx. 18kg, the Control approx. 7kg, the Hand approx. 1kg. Due to the dead weight and partly geometric design (e.g. mounting flanges), lifting and handling the device can lead to back injury, and, if it falls down, to serious injury to fingers, hands, toes and feet.

Therefore:

- Always wear personal protective equipment (e.g. safety shoes), when transporting, mounting or demounting these devices
- The devices must be placed such as to prevent tilting or sliding
- If applicable, existing company regulations regarding e.g. the lifting of loads and personal protective equipment are to be observed

The Arm and Control contain sensitive electromechanical components. These can be decalibrated or damaged by shock. Cables need to be in perfect condition. Damaged components can, for example, cause electrical risks and may lead to severe injury.

Therefore:

- Check if the packaging is in perfect condition and fulfils its protective function
- Cables or plugs must be free of damages
- If damages are found, the devices are to be taken out of operation (e.g. 'disabled' label). In cases of doubt, contact the manufacturer.

## Delivery

Panda research is delivered in original packaging. The scope of delivery is described under /Introduction/This is Panda research.

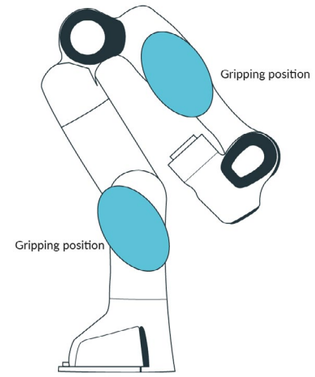
## Transport pose

Since both the Arm and Control contain sensitive electromechanical components, we recommend storing and transporting them in their original packaging at all times. The transport position is described under /Technical Data/Technical Specifications/.

- Furthermore, we offer an App for bringing the Arm in transport position with one click.
- Before the App can be used, the end effector must be removed
- It is to be ensured that the robot can move freely to adopt the transport position and is not encumbered by obstacles.

## Handling & lifting

Always lift the Arm in the positions intended for lifting, as not to overstress the joints of the Arm during handling and lifting. In particular, the Arm may never be carried in extended position with one person holding each end of the Arm!




***NOTE***

The Arm contains sensitive mechanical and mechatronic components. These can be decalibrated or damaged due to wrong handling or misuse!

Therefore:

- The Arm may only be handled, lifted and transported at the points indicated in this manual in order to avoid overstressing the joints of the Arm
- The Arm is to be handled gently even when mounted and switched on or off. If, for example, the Arm is moved by force when in stopped and locked state, an internal safety system is triggered and will cause a momentary slipping of internal components. This slipping causes decalibration and damage to the Arm.

***NOTE***

The Arm and Control contain sensitive electromechanical components. These can be decalibrated or damaged by shock.

Therefore:

- Avoid shocks or setting the device down roughly
- Always store and transport devices in their original packing, even during transport inside buildings

*NOTE*

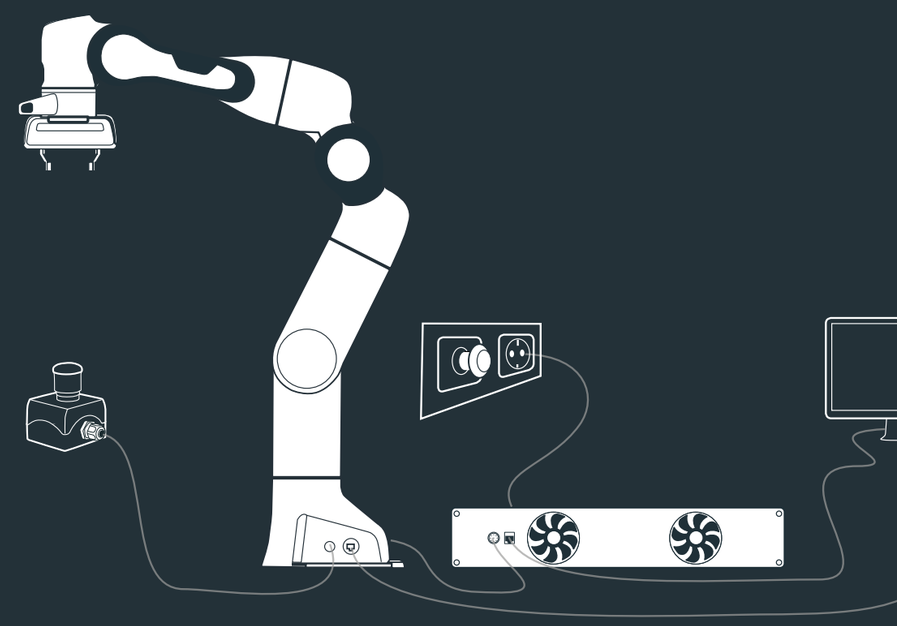
The Arm and Hand contain sensitive electromechanical components. These can be damaged if the Arm is moved to adopt the transport position while the end effector is still attached! Furthermore, when moving into transport position, objects in the operating area of the Arm may be damaged.

Therefore:

- Make sure that the end effector has been dismounted before adopting the transport position
- Make sure that the operating area allows for safe movement to adopt the transport position

# MOUNTING & INSTALLATION

- Preparing the site of installation
- Unpacking Panda research
- Mounting the Arm
- Mounting the Hand
- Unpacking and mounting the Control
- Wiring & electrical installation



# MOUNTING & INSTALLATION

## Preparing the site of installation

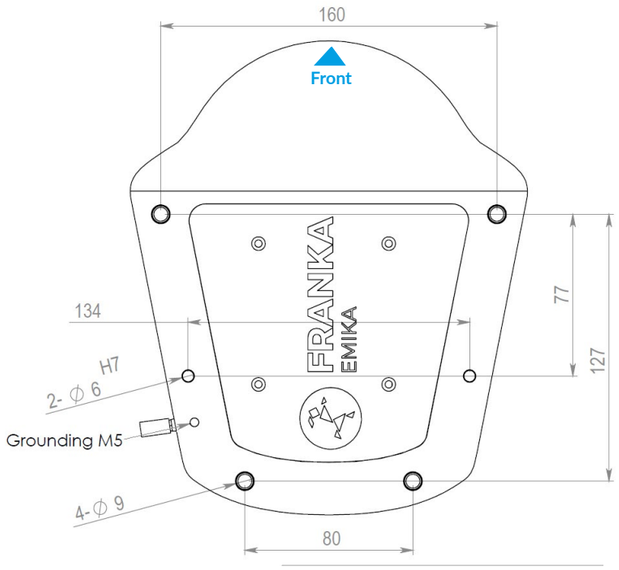
### Correct site of installation

Under/Correct Site of Installation/ the most important requirements for the location are summarized.

### Preparing the baseplate

Prepare positions for screws in baseplate:

- The Arm has 4 drill holes with a diameter of 9mm in its mounting flange
- For fixing the corresponding screws, threaded holes need to be made in the baseplate, or the corresponding lock nuts need to be used
- Use the drilling template provided to position the holes
- Also note the indication for the front of the Arm
- The hole spacing is designed to be compatible with flexible assembly parts by ITEM
- Two holes for dowel pins (diameter 6mm H7) in the mounting flange allow for accurate repeatable assembly of the Arm using 2 x 6mm H8 pins
- A detailed mounting layout for the baseplate is described under /Correct Site of Installation/




## Unpacking Panda research

WARNING

### Dead weight

The Arm weighs approx. 18kg, the Control approx. 7kg, the Hand approx. 1kg. Due to the dead weight and partly geometric design (e.g. mounting flanges), lifting and handling the device can lead to back injury, and, should it fall down, to serious injury to fingers, hands, toes and feet.

Therefore:

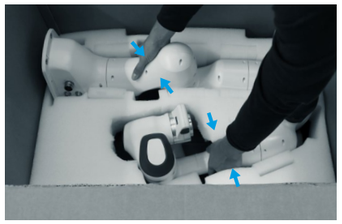
- Always wear personal protective equipment (e.g. safety shoes), when transporting mounting or demounting these devices
- The devices must be placed such as to prevent tilting or sliding
- When lifting and handling the equipment, always ensure correct lifting (from the knees and not from the back)

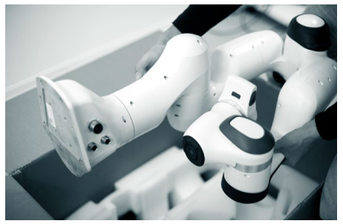
### Unpacking

- Carefully open the box by removing the sealing adhesive strips on top of the cardboard box.
- Open the foil coating.
- Take out the user manual and read it carefully.
- First take out the accessories and cables and set them aside.
- Then take out the Control by grasping it with one hand on each side of the casing and set it aside as well.



- Now grasp the Arm at the indicated gripping position and carefully lift it out of the box. We recommend doing this together with another person to help you, because the Arm weighs approx. 18kg.





*NOTE*

The Arm contains sensitive mechanical and mechatronic components. These can be decalibrated or damaged due to wrong handling or misuse!

Therefore:

- The Arm may only be handled, lifted and transported at the points indicated in this manual in order to avoid overstressing the joints of the Arm
- The Arm is to be handled gently even when mounted and switched on or off. If, for example, the Arm is moved by force when in stopped and locked state, an internal safety system is triggered and will cause a momentary slipping of internal components.
  This slipping causes decalibration and damage to the Arm.

*NOTE*

The Arm and Control contain sensitive electromechanical components. These can be decalibrated or damaged by shock!

Therefore:

- Avoid shocks or setting the device down roughly
- Always store and transport devices in their original packing, even during transport inside buildings



## Mounting the Arm

WARNING

The Arm weighs approx. 18kg, the Control approx. 7kg, the Hand approx. 1kg. Due to the dead weight and partly geometric design (e.g. mounting flanges), lifting and handling the device can lead to back injury, and, should it fall down, to serious injury to fingers, hands, toes and feet.

Therefore:

- Make sure the Arm is stable and placed such as to prevent it from tilting
- The Arm is to be let go only after all four fixing screws are securely fastened to mount the base flange to the baseplate.

### Mounting


- Work in twos to place the Arm in its target position
- Make sure that the front of the Arm points in the right direction
- One person holds the Arm in position on the points indicated, while the other mounts it to the baseplate, e.g. using 4 previously prepared screws
- An example with screws and tightening torque is given under /Correct Site of Installation/
- After 100 hours of operation the screws are to be tightened again with the nominal torque!

*NOTE*

The Arm contains power electronic components and modules (electric drives, CPUs, etc.) which heat up depending on the load the device is subject to. The arm does not contain active cooling systems, meaning that the produced heat is given off via the Arm's surface.
Therefore:

- Make sure that the Arm is adequately ventilated
- Make sure the Arm is not exposed to direct sunlight
- Make sure that the Arm is not painted, pasted up with something or enwrapped

### Adequate ventilation

# Mounting the Hand

## Mounting the gripper

The following materials are included in the scope of delivery of the Hand:

- 2 x DIN7984 M6X12 ST 8.8 screw
- 1 x ISO2338B 6X10 H8 A2 cylindrical pin

Have an Allen wrench size 4 ready for use.

Mounting:

- If desired, insert the cylindrical pin in the H7 fit of the flange of the Hand.
- Position the Hand with its flange on the end effector flange on the Arm. Should you not use the cylindrical pin, make sure that the side of the Hand with the cable is also attached on the side of the grip where the connector port is located.
- Attach the Hand with 2 x M6x12 screws (do not use other types of screws!)
- with the above noted screws the screw depth is 8mm. This must not be exceeded!

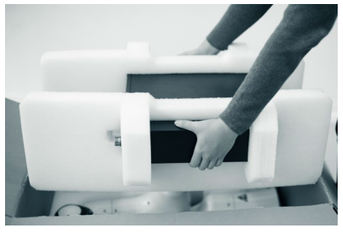
*NOTE*

Only use the screw types listed above. Do not use screws of lengths other than those indicated. The Arm may be damaged by screws that are too long, for example.
Therefore:

- Only use the screw types listed in this manual
- The screwing depth must not exceed 8mm

# Unpacking and mounting the Control

## Unwrapping



- Work in twos to remove the foam packaging of the Control, one person holding the Control and the other removing the foam packaging.

## Positioning

- Place the Control in its designated position or attach it in a rack designed for 19 inch units (the control has two height units)
- Note that the standard length of the connection cable is 2.5m!



*NOTE*

The Control contains power electronic components and modules (electric drives, CPUs, etc.) which heat up depending on the load the device is subject to. An internal active ventilation system sucks in air from the environment and channels it through the casing of the Control.
Therefore:

- Make sure that the Control is adequately ventilated
- Make sure there is enough distance between the front ventilators and covering components
- Make sure there is enough distance between the back ventilators and covering components
- Make sure that the ventilators are not blocked by pollution
- Make sure the Control is not exposed to direct sunlight

**Adequate ventilation**

# Wiring & electrical installation

WARNING

Damaged or inadequate wires and electrical installations can cause serious personal injury by electric shock, as well as material damage

Therefore:

- Only use Panda research when in perfect technical condition
- The installation of the emergency off system may only be carried out by qualified personnel.
- Live cables and electrical installations need to be in sound condition.

**Perfect condition**

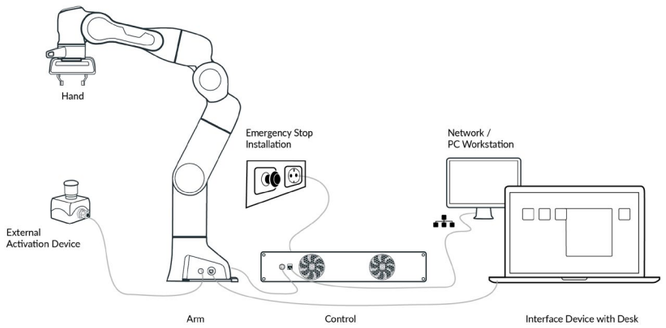
WARNING

Badly laid wires and cables can present obstacles in the operating area and cause a user to trip and fall.
Therefore:

- Always lay cables safely

**Risk of falling**

## Wiring diagram



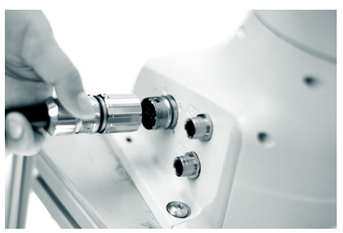

## Connecting the functional earth

- Connect the earth as functional earth to the base of the Arm at the indicated position (bottom left corner of the image).
- For this purpose, an M5 screw thread is available – the corresponding grounding cable with end sleeve and an M5x8 screw with lock washer are to be provided.

## Connecting the Hand to the power supply

- Insert the connector port of the Hand into the designated connector on the grip of the Arm. The connector port is simply inserted along the axis and not screwed!

## Connecting Arm and Control



- Carefully place the connector port onto the connector X1 the triangular marking pointing upward.
- By turning the movable front part of the connector port, it is pulled into the connector. Turn hand-tight.
- Apply the same principle to connect the other end of the connection cable with the connector on the front of the Control.



## External activation device

- Connect the external activation device with the connector X4 on the base of the Arm.
  - Make sure that the guide pins are pointing in the right direction.
  - By turning the movable front part of the connector port, it is pulled into the connector. Turn hand-tight.
- Place the external activation device within easy reach of the user.
- Make sure that the external activation device is closed.

## Connecting the interface device (for operation via Desk)

To operate Panda research via the intuitive programming interface Desk and using Apps:

- Connect your interface device (tablet, notebook, PC, etc.) with a network cable (RJ45) to the connector X5 on the base of the Arm

## Connecting to a network – optional (e.g. for use of the FCI)

To connect the Control to the network or directly to a PC workstation for using the FCI programming interface:

- Connect the Control to the network (optional) via an RJ 45 Ethernet cable (not included)
- or connect the Control directly with a PC workstation, in order to access Panda research via the FCI programming interface

## Emergency off system

- Install an emergency off system according to regulations of state-of-the-art technology (e.g. European Standards EN 60204, EN 418 and related standards)
- The emergency off system must safely cut the power supply to the Control
  - e.g. by interposing a safety relay

## Protective devices

- Protective devices which safely prevent access to the Arm (safety fences with access monitoring, safe laser scanners, etc.) can be integrated
- These must be installed such as to safely cut the power supply to the control, as soon as person enters the safe area.

## Connection to the power supply

- Make sure that the power switch on the Control is switched off (position 0)
- First connect the electric cable with the rubber connector and then connect the Control to the electric circuit secured by the emergency off system (100-240 V / 47-63Hz frequency).



***NOTE***

Live electric cables or connectors may never be connected or disconnected during operation (in particular rubber connectors, connection cable, connection cable to hand, etc.)  This can damage the Arm or Hand.

Therefore:

- Never connect or disconnect cables before safely disconnecting Panda research from the power supply.
- Never connect or disconnect the Hand before safely disconnecting Panda research from the power supply.

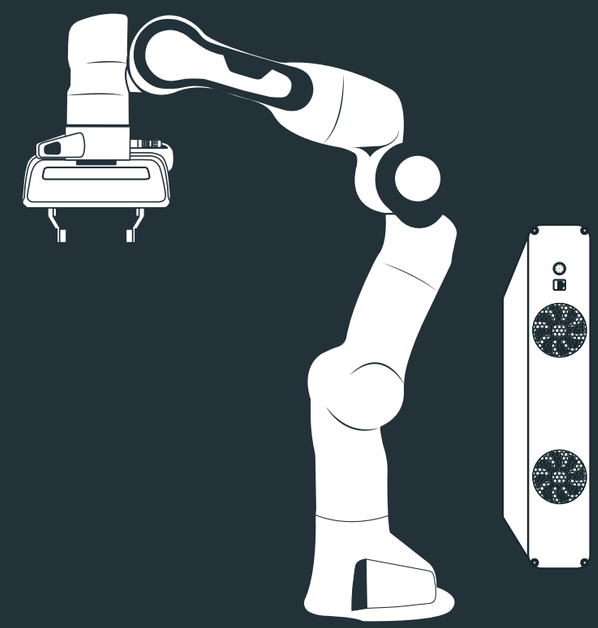
***NOTE***

The connection cable does not support being folded, rolled over or stepped on. Therefore:

- Lay the connection cable in such a way, that it will not be overstressed (no bending, rolling over it).

# START-UP

- Switching on
- Connecting a user interface device
- Software-setup
- Guiding
- Testing the emergency off system
- Switching off



# START-UP

## Switching on

**WARNING**

Devices can be very cold after transport and may develop condensation when being placed in warmer surroundings with higher humidity. Wet devices can lead to a short circuit and may present the risk of electric shock.
Therefore:

- Leave devices to acclimatize after transport
- Do not switch on wet devices

**WARNING**

The system may only be used in perfect technical condition and as intended, in a safety-conscious manner and aware of any dangers, while observing the instructions in the present documentation. Malfunctions compromising safety must be eliminated immediately.

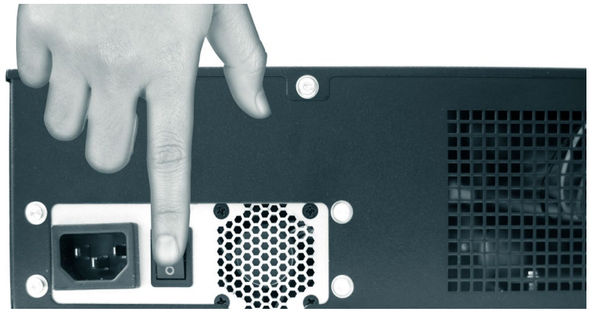
***NOTE***

Switching on wet devices can not only lead to life-threatening injuries, but can also cause material damage.
Therefore:

- Leave devices to acclimatize after transport
- Do not switch on wet devices

### Switching on

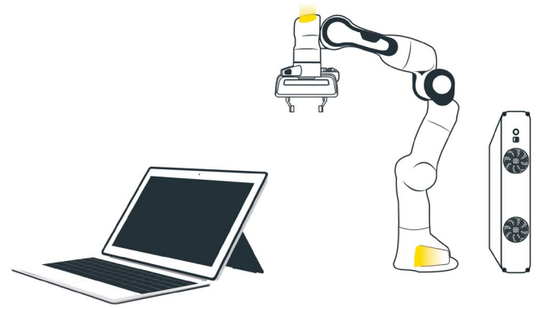
Now you may switch on Panda research for the first time:



- make sure that the external power supply is provided (emergency stop installation)
- Now switch on the Control. The power switch is located on the back of the Control.



The following behavior is to be expected:

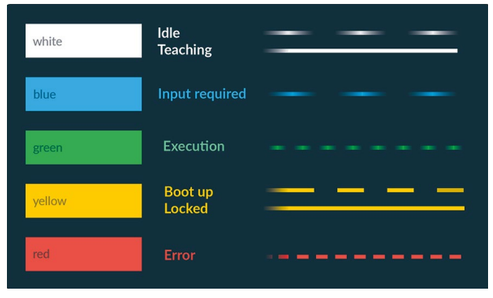


- The Control will boot up and the cooling system is activated, so that you will hear and see the ventilation working.
- The status lights on the Pilot and on both sides of the base will start to flash yellow.
- Should you notice any malfunction, see /Maintenance, Service & Support/ Troubleshooting.
- Booting up may take a short while (approx. 1 minute).
- Booting up is completed once the status light glows continuously yellow.
- The safety locking system is still active, meaning that the axes are still mechanically locked in this condition (how to unlock the safety locking system is described in the sections to follow).

### Color coding

On the Pilot, there is a circular status light in the center of the disc. Depending on the state of the system, the color and the blinking pattern changes. This is supported by the two status lights on both sides of the base, which has the respective signalcolor, similar to a traffic light. However, there is no blinking pattern here.

Note: Only when the system is booting up, the status lights of the base flash along with the status light at the Pilot as long as the system is driven up and all status lights are solid yellow.



## Connecting a user interface device

The configuration and programming environment of Panda research runs on all modern browsers. However, we recommend using Chrome, Chromium or Firefox. No further software is necessary:

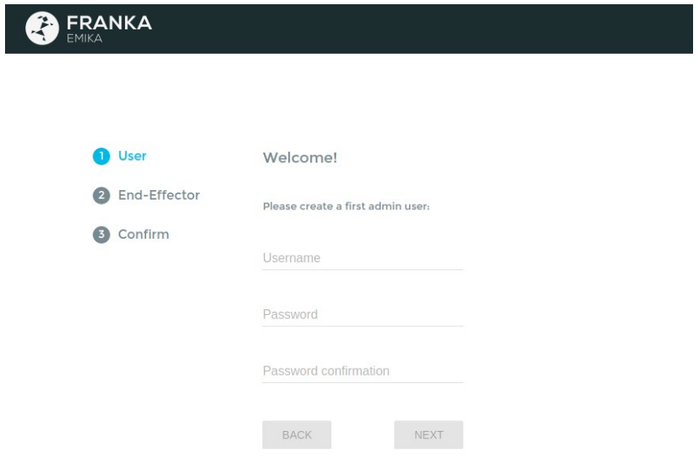
- To open the initial configuration interface, an interface device must be connected via Ethernet cable to the X5 connector on the base of the arm (see also /Mounting & Installation/).
- The interface device must obtain the IP address automatically via DHCP.
- Once Panda research has been switched on, the interface device will automatically be assigned an IP address.
- Then the URL "robot.franka.de" can be entered and opened in a web browser.

## Software set-up

All persons working with Panda research must have read and understood the documentation (in particular the chapters on safety), be able to comprehend any risks the robotic system may avoid risks and act with adequate care. In contrast to a regular user, the admin has extensive rights to edit IT and safety settings of Panda research! Please refer to /Safety Concept/Staff/.

### Configuring Panda research

When first starting Panda research or after resetting the Control to default settings, the initial configuration is shown in the web browser when you enter the URL "robot.franka.de":




### Creating an admin

**Procedure:**

- Initially, an admin user must be created
- This step is mandatory
- To create an admin, enter the user name and password and confirm the password. Always use secure passwords to prevent unauthorized persons from accessing the system!

NOTE: You can also complete this step at a later point in time by carrying out the following steps:

- To create an admin: In Desk, click on the user name on the right-hand side of the header in order to open the administrator's interface.
- Then click "admin". In the submenu "users", new users can be added or existing ones edited.
- There must always be one admin defined, this means that the last admin cannot be deleted. Every user must be assigned a role, several users can have the same role. The Panda research version only exists the following role:
  - **Admin:** no restrictions to authorizations. The admin can edit all parameters and create new Tasks.

**WARNING**

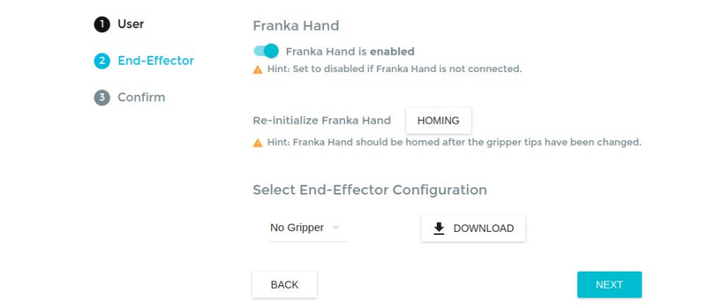
If the end effector is configured incorrectly, Panda research will operate based on the wrong masses and mass inertia ratios of the end effector. This means that Panda research will regulate to the wrong parameters and gravitational forces will not be entirely compensated. This can lead to unexpected movements during guiding, which may subsequently lead to injuries caused by the movement itself or by the user flinching.

Therefore:

- Always check the configuration of the end effector
- When copying an already parametrized app or task to another Panda research system, also make sure that the end effector configuration still is identical to the original one

## End effector configuration

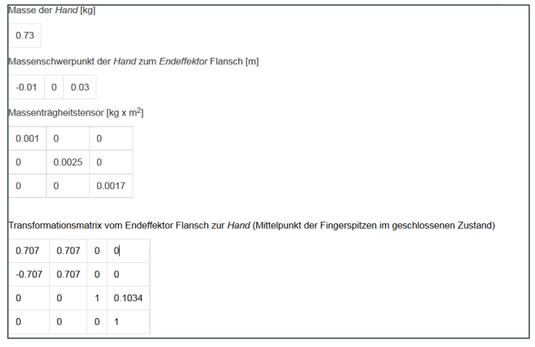
If you do not have a gripper, select „No Gripper“ from the drop-down. Keep the following DEFAULT setting:




When you have mounted the Hand, select „Hand“ from the drop-down.



If you want to use another gripper or adjust the configuration of the Franka Hand, select “User Defined” from the dropdown and enter the corresponding values into the text fields. The appropriate values are usually found in your gripper’s manual.
The default settings of the Hand are as follows:




NOTE: You can edit the end effector settings at a later point in time.
To edit the end effector settings:

- In Desk, click on the user name on the right-hand side of the header in order to open the administrator’s interface.
- Then click “admin” and select the submenu “end effector”.
- The input mask opens and technical data such as mass, mass inertia matrix etc. can be entered.

A correct configuration is essential for operating Panda research. When configured incorrectly, gravitational forces are not entirely compensated and the Arm regulates to the wrong target values.

When configured incorrectly:

- The Arm may pull towards certain directions in guiding mode
- The regulation in operating mode may be affected so that the expected sensitivity of the Arm for collision detection is reduced
- The tracking behavior may be affected

## Completing configuration set-up

Once initial configuration has been completed and confirmed, Panda research will restart and is then ready for operation. After successful restart the programming interface Desk is displayed in the web browser and the Arm glows continuously yellow.

# Guiding

Please read the chapters /Safety Concept/ and /Interaction/Programming/ before using guiding mode for the first time. Not using it correctly may cause serious injury and/or material damage!

## Unlocking the safety locking system

Before Panda research can be moved you need to unlock the safety locking system:

- Make sure, that the external activation device is closed and within reach.
- Make sure, that the emergency off is within reach.
- Before opening the safety locking system, the functioning of the external activation device needs to be tested. To test the external activation device:
  - Open the external activation device.
  - Close it again. The system must recognize both states.
- On the programming interface of Desk, click “open brakes”.

The following behavior is to be expected:

- Each axis will perform a small movement to open the safety bolts.
- You will hear 7 clicking sounds.
- The Arm is kept in position by the Control and is now in the status “monitored stop”.
- Panda now flashes white.

**WARNING**

Sharp-edged or pointed objects near the end effector or in the operating area can lead to injuries during guiding.

Therefore:

- Avoid sharp-edged or pointed objects whenever possible
- Please also read the chapter /Practical information on how to use and place Panda research/ under /Satety concept/.

**CAUTION**

Before entering guiding mode, check that the correct mass and center of gravity are set for the end effector, respectively the correct masses are set for other objects. If Panda research operates assuming a lower mass, the Arm will sink when the guiding button is pushed, if the mass is higher than expected, it will rise. This can lead to an unexpected movement which makes the user flinch and may lead to injury such as crushing.

Therefore:

- always set the correct mass for the end effector and/or mass on the end effector before guiding.





Now the Arm can be guided. To guide the Arm:

- Half press the activation button on the grip and simultaneously press the guiding button. Panda will glow continuously white.
- As soon as you release one of the buttons, the Arm stops
- When you press the activation button too far down, the Arm will stop moving. (panic function of the activation button).
- Go ahead and try it!

## Switching between guiding modes

For initial boot-up, the guiding mode “translation” is selected. This means that the Arm can only be moved in the three directions (X, Y, Z) of the Cartesian space and rotational movements are locked. The guiding mode button is located on the top of the grip. With this button, or directly in Desk, different guiding modes can be selected. Which mode is currently selected is indicated in the footer of Desk. A guiding mode limits certain movements of the Arm to facilitate easy operation.

***NOTE***

Panda research allows you to switch guiding modes. They are used for limiting predefined movements during guiding. A guiding mode can for example only allow the Cartesian directions X, Y and Z, while rotations around these axes are locked. If the locked directions and rotations are overstressed by the user by force, this can damage Panda research.

Therefore:

- If you feel that a direction or rotation is locked during guiding, check if you are in the correct guiding mode. Avoid overstressing the locked directions.

## Testing the emergency off system

The emergency off system must be activated and tested for functional capability at start-up and at least once every 12 months. Please refer to /Safety concept/Emergency off system.

**WARNING**

The emergency off also cuts off power supply to the Hand. This means that objects can fall out of the gripper and cause injuries, in particular to hands or fingers on a table or to the toes.
Therefore:

- Make sure that objects falling out of the gripper cannot cause any injuries (e.g. by safety shoes)

### Testing emergency off

**SAFETY - INSTRUCTION**

Please carry out the following SAFETY INSTRUCTIONS exactly as described below:

- Panda research must be in the state of “monitored stop”. The locking bolts of the safety locking system need to be open and the arm may not move.
- Activate the emergency off
- By activating it, the Arm will slightly sink. Make sure that there is enough space for the Arm to sink to avoid causing damages. Bring the Arm into a position that is free from obstacles, e.g. 200mm above stationary objects. Use guiding to do so.
- If the emergency off is installed as to additionally switch off other devices apart from Panda, this needs to be taken into account during testing.

**NOTE**

Due to the technology of locking bolts, the position of the Arm cannot be held perfectly when the power is switched off. This means that Arm segments will sink, in particular at those joints on which gravitational force comes into effect. Due to this sinking, workpieces or sensitive objects in the proximity of the device can be damaged.

Therefore:

- Take the sinking movement of the axes into account when switching off Panda research. Place the Arm in a free position (e.g. 200mm above stationary objects) before switching it off.



**NOTE**

As soon as the control is no longer supplied with power, Panda research is safely stopped and mechanically locked by the fail-safe safety locking system. The emergency off is designed for stopping the Arm as quickly as possible in case of emergency. This can damage the Arm or, when stopping at an unfavorable point in the process, also the hand, work pieces or the surroundings.

Therefore:

- The emergency off system should only be used in safety-critical situations.
- If possible, use the external activation device before activating the emergency off. This will stop the robot movements more gently than the emergency off system and will not activate the safety locking system.

## Switching Off

### Shutting down

Via the option “shut-down” in the footer of Desk the safety locking system is activated and Panda research will be shut down.

### Switching off

Disconnect Panda research from the mains after shutting down the system (e.g. using the power switch on the back of the control). Once the front ventilators stand still, Panda research has been shut down and can be switched off. Otherwise the ventilators on the back will remain active.

**NOTE**

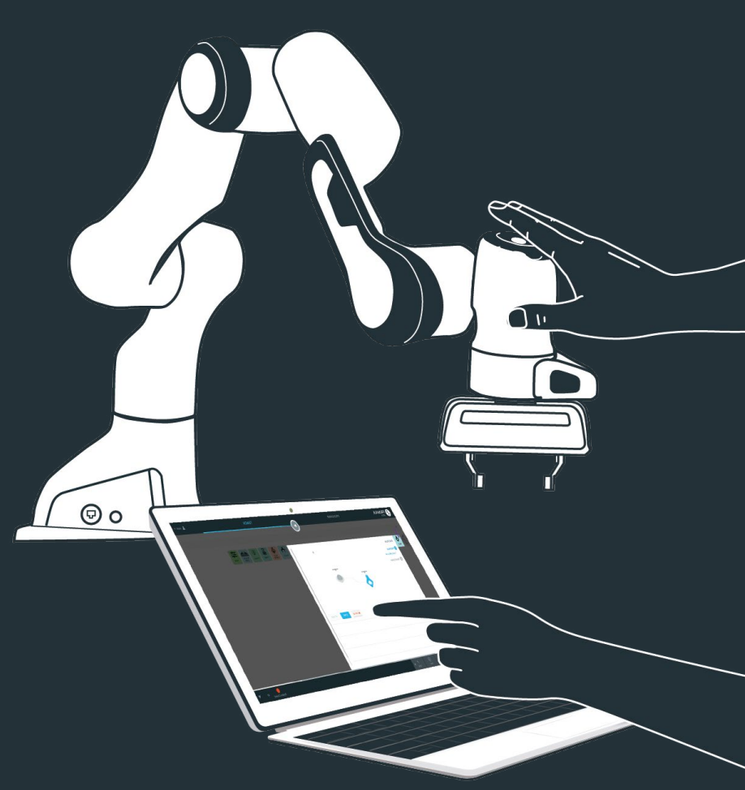
Due to the technology of locking bolts, the position of the Arm cannot be held perfectly when the power is switched off. The locking bolts catch with an audible click and let the Arm sink, in particular at those joints on which gravitational force comes into effect. This can cause to damages to work pieces in the proximity.

Therefore:

- Take the sinking movement of the axes into account when switching off Panda research. Place the Arm in a free position (e.g. 200mm above stationary objects) before switching it off.

# INTERACTION & PROGRAMMING

- Direct human-robot interaction
- Creating Tasks in Desk
  - Desk overview
  - An App for everything
  - Configuring Apps
    - Parametrizing
- Executing a Task
  - Manual unlocking of Arm and Hand in case of emergency
- Available Research Apps



# INTERACTION AND PROGRAMMING

## Direct human-robot interaction

### Interaction concept

We provide several software and hardware components that interact smoothly with each other to offer you intuitive and effective usability for Panda research. You can purchase robot apps in the Franka Store and arrange them in Desk to form Tasks. These Tasks can then be saved and archived. You can operate Desk directly on the computer or from the Pilot disc on the Arm.

### Pilot

The Pilot is the user interface integrated directly into the Arm for smooth interaction with Panda research and Desk.


1. On the grip of the Pilot there are two grey buttons, one on each side. By pressing them, the guiding mode is activated. Once the buttons are released the Arm can no longer be moved.

Note: The left button is a three-stage activation button and needs to be half-pressed for guiding. When pressed all the way Panda will stop the guiding mode and make the Arm immovable.

2. Using the disc on top of the Pilot, different entries for programming can be made. Disc can be used to navigate in Desk (3), select individual Apps and parametrize, e.g. by adjusting the slider or activating/deactivating certain functionalities. In addition, robot poses can be entered by manually guiding the Arm using the set button.

Note: You can also operate Desk directly via the touchscreen or using your mouse/keboard.

3. Desk is the software used for progamming and operating Panda.

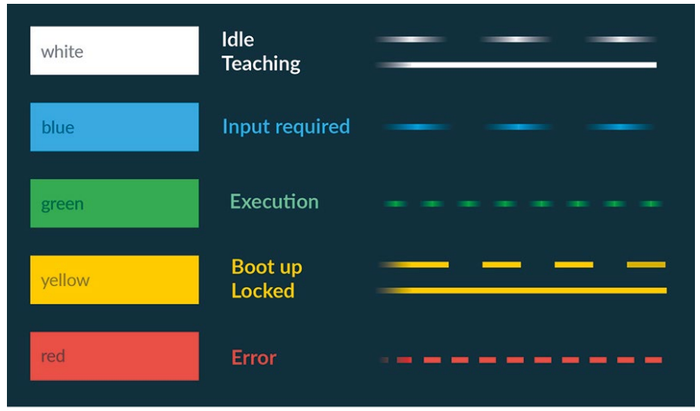
### Guiding (1)

When the guiding button and the activation button are pressed on the grip, Panda research is in guiding mode and can be moved manually. Once the buttons are released, guiding mode is deactivated and Panda can no longer be moved.

### Color code

On the Pilot, there is a circular status light in the center of the disc. Depending on the state of the system, the color and the blinking pattern changes. This is supported by the two status lights on both sides of the base, which has the respective signalcolor, similar to a traffic light. However, there is no blinking pattern here.

Note: Only when the system is booting up, the status lights of the base flash along with the status light at the Pilot as long as the system is driven up and all status lights are solid yellow.

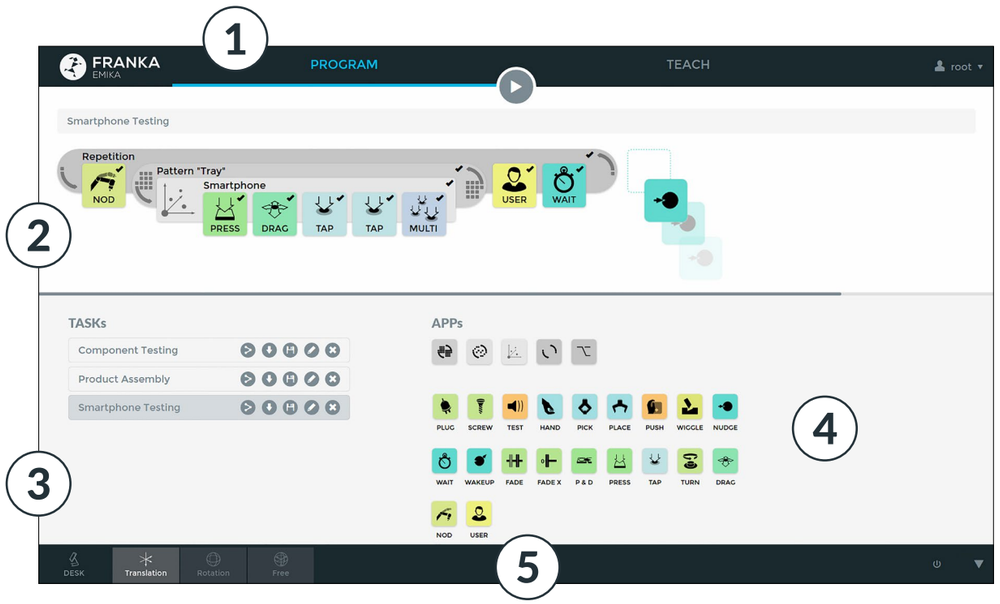


# Creating Tasks in Desk

## Desk overview

Panda is programmed using the web application Desk, which can be opened by entering the URL https://robot.franka.de/in your browser. From the admin interface Desk can be opened via the corresponding link in the navigation bar.

Desk allows you to create Tasks. Tasks are program sequences and consist of a chronological sequence of Apps. Apps are the building blocks of a Task and describe the basic capabilities of Panda, such as “grip”, “put down”, “push button”, etc. The Apps within a Task need to be parametrized, meaning that parameters such as poses, orientations, speeds etc. need to be set. This process is called “teaching”. The parameters can also be set directly on Panda via disc. Controlling the Hand or navigating within a context menu (i.e. the teaching dialogs in the apps) is also possible using the Pilot.






Desk is divided into 3 main areas:

- The timeline showing the Task currently selected (top) and the Apps added (2)
- The list of Tasks currently available on Panda (3)
- The list of available Apps: Apps are building blocks used for creating Tasks (4)

## List of existing Research Apps

A list and short description of the existing Research Apps is given under /Interaction and Programming/Available Research Apps/
Below you find a non-extensive list of Research Apps:

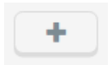
- Repeat
- Set Cartesian Compliance
- Set Joint Compliance
- Set Collision Thresholds
- Cartesian Motion
- Joint Motion
- Relative Motion
- Move Contact
- Apply Force
- Line
- Lissajous Figures
- Spiral
- User Interaction
- Wait
- Change Gripper Width
- Grasp
- Transport Motion
- Modbus Wait
- Modbus Out
- Modbus Pulse

## First steps

1. In the header, you can see if you are in programming mode, where you can create a Task for Panda, or in teaching mode, where you can parametrize Apps or teaching positions. The play button for executing a Task on Panda is also located in the header, as is the user menu.
2. The timeline is the area in which you can string Apps together in order to program Tasks.
3. In the Task area, you can save and manage your programmed tasks or click on already programmed Tasks to activate them.
4. The App area shows all installed Apps that are available for programming. You can simply use drag & drop to move them to the timeline and parametrize them in the next step.
5. On the left-hand side of the footer you can see which teaching mode is currently active. It shows you, for example, if translational or rotational movements are unlocked for guiding Panda. On the right-hand side important information on Panda’s state is given, for example if the external activation device is open or closed or if an error has occurred.

## Creating a task (2)

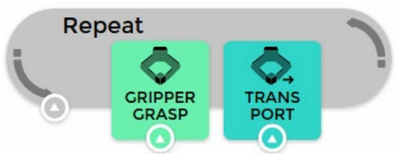
Click on the “+“-icon in the Task area to create and select a new Task. The new Task is created with an empty timeline.



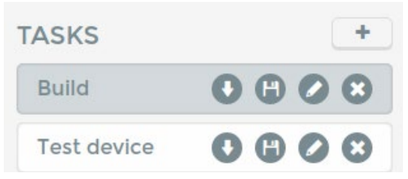
You can now use drag & drop to move Apps from the App area (4) to the Task area (2) and create a sequence of Apps. They will be executed in order from left to right.

Apps can be removed from the timeline by dragging them from the Task area and dropping them in the App area. You can also change the sequence of Tasks and reorder them using drag & drop.

**Groups**
Groups are a special variation of Apps, e.g. Pattern, Repeat or Relative. In contrast to normal Apps, which implement certain functionalities, Groups modify the execution and teaching behavior of the Apps they comprise.
First, drag & drop a Group to the Task area. Then move Apps to this Group. The Group “Repeat” for example will repeat all Apps included in it according to the Group settings. Groups such as “Pattern” or “Points” allow the same App to be executed repeteadly at different points in time.




## Managing tasks




Rename the Task.

Copy the Task and save it under a new name.

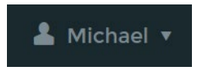
Download the Task file and save it locally. The Task can later be moved to the Task area again using drag & drop.

Delete the Task.



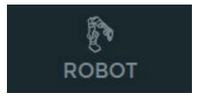
## Header (1)

Click on the arrow in the top right corner of the header to open the user menu in a drop-down next to the user name. Here you can switch to the admin section, log out or shut down the system. The Arm and Control need to be shut down before the system can be turned off.




## Footer (5)

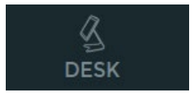
Click on the small arrow at bottom right corner of the screen to open the footer to display further information or open and close the brakes.




## Pilot mode (5, far left)

Robot mode: in this mode, the Hand can be controlled using the direction buttons in the Pilot disc:

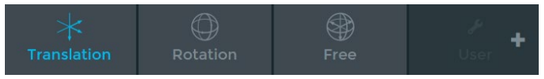
- keep the “left” button pressed to slowly open the Hand
- keep the “right” button pressed to slowly close the Hand
- press the “down” button once to open the Hand to full width
- press the “up” button once to make the Hand grasp something, meaning that it closes around a grasped object and holds it with its holding force.



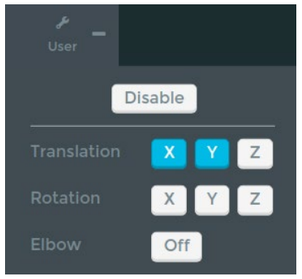

Desk mode: using the direction buttons on the disc of the Pilot you can navigate in Desk and the context menus of Apps in the timeline.

## Guiding mode (5)

In guiding mode, movements of the Arm follow the corresponding guiding configuration, which is displayed in the footer. The guiding configuration can be changed by pressing the guiding mode button on top of the grip. You can also select the desired configuration from the footer.



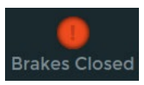

- Translation: in guiding mode, the Arm can only be moved to change the Cartesian position of the end effector; its orientation remains as it was before entering the guiding mode
- Rotation: in guidig mode, the Arm can only be moved to change the Cartesian orientation of the end effector; its position remains as it was before entering guiding mode. The reference coordinate system for this rotation is the predefined coordinate system of the end effector
- Free: the Arm can be moved completely freely, all 7 joints can be moved freely
- User: the user can freely define the guiding behavior in this mode, meaning that it is possible to define for each Cartesian translation and rotation axis if it is movable or immovable




## Error status (5)

A green light means that Panda is ready for use.


A red light means that an error has occurred or the safety locking system or the external activation device are still closed.






## An App for everything

Apps are modular robot programs, each representing a partial step of a robot task. They can be purchased in the Franka Store and can be parametrized in Desk to form entire automation tasks. These Apps can vary in size from highly complex to very simple Apps. When selected in Desk, each App opens a context menu in which the user is interactively lead through the process parameters.

## Configuring Apps

After creating a Task in Desk, all Apps need to be taught, this means that all necessary parameters of the Apps need to be configured so that Panda knows how to execute the App.
To activate teaching mode, click on the tab “Teach” in the header or press the “Play” button, if not all Apps of a Task have not yet been fully parametrized.


In addition, an App can also be selected directly in order to parametrize it. Clicking on an App will open the corresponding context menu.

## Teaching

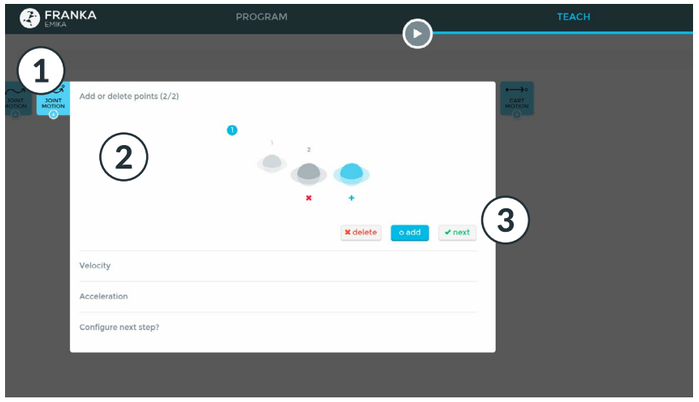
## App dialog

You can set the parameters for individual Apps in the context menu. The context menu of an App comprises one or several steps. Each step can be divided into sub-steps. For example, for many Apps where a pose is needed, usually two poses are taught. The actual pose for carrying out an activity and a transitional pose, which is used for assuring movement in the operating area without risk of collision.

You can switch between and within steps by pressing the arrow keys on your key-board or using the direction buttons on the Pilot disc when Desk navigation mode is activated (see footer).

In general, parameter values in the context menu are entered either by pressing the blue “Set” button or the corresponding (blue) button on the Pilot. Pressing the green “Save” button with the tick mark completes the current step and will jump to the next or next unconfigured step.

## Configuration – first steps




1. When selecting an App and clicking to confirm, the rest of the timeline moves to the background and the context menu of the selected App opens.
2. In a dialog window the system asks the user to enter the parameters required for App configuration step by step. This can be a request to teach one or several poses or to enter parameters such as speed and duration of execution.
3. In the active window the step to be edited is always highlighted in light blue and the preview of the following steps is grayed out. Once an entry has been made and confirmed, it is displayed in black and the next step to be entered is highlighted in light blue.

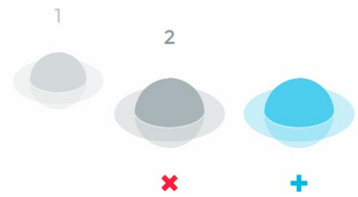


# Parametrizing

So that Panda knows how to execute Apps, these need to be parametrized. For this purpose, context menus offer you different interactive elements, which differ in terms of visualization and type of interaction. An overview of interaction with these widgets is given below.

## Widgets

## Poses




This widget allows you to define several positions within an App.

**Left/right:** modify the focus between the positions

**V:** save value and focus on the next step to be configured

**X:** delete the position marked by a ‘-‘

**O:** add a position at the point marked by a‘+’

## Slider

This widget allows you to set a vallue within a defined range of values.


**Right**: : increase value

**Left**: decrease value

**V:** save value and go to next step to be configured

**X:** if the value has been changed, use X to reset to the previous value

**Click on the number:** opens a textbox to edit the value

- To confirm the value, press <Enter> on your keyboard or click in a free area on the screen.
- Press <Escape> to cancel. The value will then be reset to the previous value.

**Touch/mouse interaction:**

- Change the value by:
  - directly clicking on the line
  - sliding the marker

**Click on the number:** opens a textbox to edit the value

- To confirm the value, press <Enter> on your keyboard or click in a free area on the screen.
- Press <Escape> to cancel. The value will then be reset to the previous value.

## Group of sliders


This widget enables you to set several variables using the slider. The buttons on the side are used for changing the focus/precision of the variables. The precision defines which variable the slider shall modify.

**Up/down:** modify previous/next variable

**Right/Left:** modify the value oft he currently selected variable

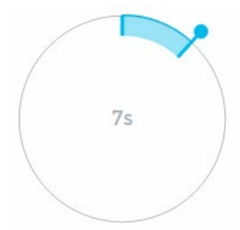
**V:** save value and go to next variable to be configured

**X:** if the value has been changed, use X to reset to the previous value

**Touch/mouse interaction**:

- Modify value: see /Slider/
- Modify focused variable: click the corresponding button

## Circular slider




This widget enables you to set a value within a limited or unlimited range of values.

**Rright/Left:** modify value

**V:** save value and go to next variable to be configured

**X:** if the value has been changed, use X to reset to the previous value

**Touch/mouse interaction**:
Change the value by

- direct click on the line
- sliding the marker

- **Click on the number:** opens a textbox to edit the value
  - To confirm the value, press <Enter> on your keyboard or click in a free area on the screen.
  - Press <Escape> to cancel. The value will then be reset to the previous value.



## Switch button


This widget allows you to select one of two values.

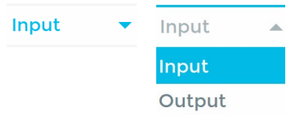
**Rright/Left:** modify value

**V:** save value and go to next variable to be configured

**X:** if the value has been changed, use X to reset to the previous value

**Touch/mouse interaction**: modify the value by clicking the button

## Drop-down




This widget allows you to select one of several values.
**V**: open and close the drop-down menu
**Up/Down**: when the drop-down is opened, use the arrows to navigate through the options
**X**: if the value has been changed, use X to reset to the previous value
**Touch/mouse interaction:**

- Click drop-down: open/close drop-down menu
- Click drop-down entry: select this entry

## Haptic gestures

This widget allows you to define directions of movements, from which user interaction is to be accepted. Accepted directions are represented by a full circle, not accepted directions by an empty circle.

**Rright/Left: :** focus on next / previous

**V:** save value and go to next variable to be configured

**X:** if the value has been changed, use X to reset to the previous value

**Touch/mouse interaction**: activate/deactivate a direction by clicking the circle

## Selector


This widget enables you to select from several options.

**Left/ Rright: :** modify selection

**V:** save value and go to next variable to be configured

**X:** if the value has been changed, use X to reset to the previous value

# Executing a Task

- Before letting Panda execute a task by way of trial, take note of the safety instructions under /Safety concept/ (in particular: /Step Back and Watch/).
- In addition, the unlocking tool must be within immediate reach of the Arm. By no means may it stay inserted into the emergency unlock openings of the Arm!

**WARNING**

The technology of step back and watch ensures the safety of the user during automatic execution of robot movements. It is based on the principle that humans are safely separated from possibly dangerous movements.

Therefore:

- The user has to leave the hazardous area during the execution of a robot movement.
- The robot movement is to be triggered only when paying full attention to the movement.

## Testing the settings (step back and watch)

Once you have completely taught a Task, you can execute it by clicking the “Play” button in Desk. The App currently being executed will be displayed with a green frame and Panda will start flashing green.

## Speed

Change the speed for the Task execution by clicking on the Task name in the timeline.

## Activating / deactivating Apps

Right-clicking on one or several Apps opens a select menu, from wich you can activate, deactivate or delete individual Apps. Only activated Apps are executed and need to have been taught.

## Optimization and troubleshooting

If an error occurs, such as a collision, program execution is stopped. The failed App is bordered in red and an error description is displayed. In this mode, the Arm can be moved using guiding and any causes of error can be eliminated. If an error stops program execution, further information on the error and how to eliminate it is displayed in the robot “traffic light” in the status bar. Click the “Play” symbol in the error window or use a haptic gesture on the Arm (pushing down from above) to continue Task execution. Click the stop button to end the Task. Alternatively, you can restart the entire group or the current sequence.



# Manual unlocking of Arm and Hand in case of emergency

**WARNING**

The Arm weighs approx. 18kg. With mounted end effector and objects in the end effector, the total weight can amount to 21kg. If unscrewed, the manipulator may tilt or fall, causing severe injury by crushing or cutting, in particular of hands, fingers and toes.

Therefore:

- Make sure that the Arm is held in place and cannot tilt or fall while unscrewing the Arm

**CAUTION**

When unlocking the safety locking system, the dead weight of the Arm segment below the lock will lead to movement (especially sinking and dropping of the Arm). This movement may cause injuries by crushing or penetrating body parts.
Therefore:

- Arm segments below locks are to be supported manually before carrying out the emergency unlock.
- Never carry out an emergency unlock when the Arm is switched on – Panda research must always be safely disconnected from the power supply before an emergency unlock

## Manually moving the Arm in case of emergency

There are several possibilities to move the Arm even without a power supply in case of emergency. They are listed below in order of criticality of the hazardous situation:

- In case of acute mortal danger (e.g. person is severely crushed or can no longer breathe)
  - --> Action: immediately remove Arm manually
- In case of non-acute mortal danger and jamming of the Arm itself
  - --> Action: unlock safety locking system with the use of the unlocking key
  - --> Action: loosen the screws attaching the Arm to its base

See also /Safety concept/Manually moving the Arm in case of emergency/

***NOTE***

The Arm is equipped with an integrated safety mechanism, which allows it to be moved manually in emergency situations (by pushing away etc.) If this safety mechansim has been activated, the system is to be shut down afterwards and replaced.

*NOTE*

The emergency unlock may only be used in exceptional circumstances. The unlocking tool included in the delivery is designed such as not to damage the mechatronics inside of the Arm. Inappropriate handling may damage the Arm.

Therefore:

- Only use the unlocking tool provided for an emergency unlock. The unlocking tool is to be inserted gently into the opening as not to damage the mechatronicals.
- The safety locking system should unlock upon slight moderate pressure.

⚠ CAUTION

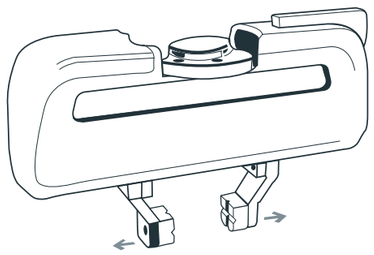
When unlocking the safety locking system, the dead weight of the Arm segment below the lock will lead to movement (especially sinking and dropping of the Arm). This movement may cause injuries by crushing or penetrating body parts.

Therefore:

- Arm segments below locks are to be supported manually before carrying out the emergency unlock.
- Never carry out an emergency unlock when the Arm is switched on – Panda research must always be safely disconnected from the power supply before an emergency unlock.

## Moving the fingers without a power supply

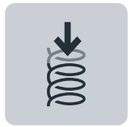
When the device is turned off, the Hand is not supplied with power either. A jamming between the fingers of the Hand can be loosened by simply pulling the fingers open.



## Available Research Apps

### Repeat

'Repeat' allows you to repeatedly execute a sequence of Apps. Select the number of repetitions and the action to be carried out at the end of each cycle. You can choose from three actions: Wait: the system pauses for the set amount of time between each iteration. User: the system waits for the user to confirm with a haptic gesture from above before continuing Repeat: simply starts again from the beginning



### Set Cartesian Compliance

'Set Cartesian Compliance' allows you to set the impedance of the Arm in all Cartesian axes. The axes to be set are defined by the settings in the transformation matrix of the flange to the end effector because impedance is defined in the coordinate system for the end effector. The lower a value for an axis, the higher the impedance of the arm in this axis. The values set here are maintained for all subsequent Apps.

### Set Joint Compliance

'Set Joint Compliance' allows you to set the impedance of the Arm on joint level. The stiffness for each joint can be defined here. The lower the value, the softer and more compliant the Arm is in the corresponding axis. The values set here are maintained for subsequent Apps and can negatively influence the behavior of Panda when following paths. They can, hower, also be used to implement guiding of the Arm within the environment.

### Set Collision Thresholds

'Set Collision Thresholds' allows you to define collision thresholds. Because Panda is equipped with an external force and torque estimation based on internal sensors, the Arm can stop its current activity when exceeding a ceratin force or torque limit. The limits should always be chosen with regard to the Task to be carried out. The values set are valid for all subsequent Apps. In a first step the App allows you to set the force limits. For each Cartesian direction, an individual limit can be defined. This facilitates exact adaption of the limits to the specific Task. In the next step the torque limits for each joint can be set. If a defined torque or force limit is exceeded, the current action is interrupted and can be continued with after rectifying the error.

## Cartesian Motion

‘Cartesian Motion’ lets the Arm move in the Cartesian space within the points taught by the user. The Arm moves on a straight line between two points, the actual points are only striked and do not need to be reached. For execution of this App, the impedance values set under a ‘Joint Compliance’ App are used.
The first step of the configuration is teaching the points between which the Arm should move. Then the speed and acceleration for the movement are defined and set in percent of the maximum speed and acceleration. The maximum values can vary depending on the configuration, the weight of the end effector and the defined maximum speed.

## Joint Motion

‘Joint Motion’ allows the Arm to move in the joint space between the points taught by the user. Panda moves all joints synchronized to reach the next point. For execution of this App, the impedance values set in a ‘Joint Compliance’ app are used.
The first step of the configuration is to teach the desired points. Then the speed and acceleration for the movement are defined and set in percent of the maximum speed and acceleration. The maximum values can vary depending on the configuration, the weight of the end effector and the defined maximum speed.

## Relative Motion

The App “Relative Motion” moves the Arm relative to its current position along a configured vector. The motion is in Cartesian space similar to the App “Cartesian Motion”. The motion can be configured to be executed in  the end-effector frame or in the coordinate system of the base.



## Move Contact

‘Move Contact’ allows the tracing of a taught sequence of points within the Cartesian space. The difference to ‘Cartesian Motion’ is the different reaction to collision within a strictly defined area. The app offers the additional possibility of recognizing a contact within a strictly defined area as having reached the target position. This can be used for implementing stacking for example. For execution of this App, the impedance values set in a ‘Joint Compliance’ App are used.
The first step of the configuration is to teach the trajectory and configure the speed and acceleration. The maximum values can vary depending on the configuration, the weight of the end effector and the defined maximum speed. In addition, the radius around the last point can be defined, in which contact will be considered as a successful end to the movement.

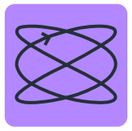
## Apply Force

‘Apply Force’ enables Panda to apply a defined force within a time frame set by the user. The force is applied in the current position of the Arm. Nonconfigured end effectors or other weights impeding the external force estimation of the Arm will also negatively influence the precision of the applied force.
For execution of this App, the impedance values set in a ‘Set Cartesian Compliance’ App are used.
The first step of the configuration is setting the desired time frame in which the force shall be applied. Then the desired forces are set for the different direction in the coordinate system of the end effector. Setting the force to 0 means that no force is applied. In addition, the maximum distance that the Arm may cover during execution of the App needs to be entered. For this purpose, different limits are defined for deviation in X, Y and Z, and an additional limit for the permissible change of orientation.

## Line

‘Line’ lets the Arm move with a defined speed along a line. The App also allows the application of force during a movement.
For executing this App, the impedance values set in a ‘Set Joint Compliance’ app are used. Should the option ‘Apply Force’ have been selected, the values from the ‘Set Cartesian Compliance’ App are used.
Parametrization of the App is done as follows:
At first, two points are taught to define the direction the Arm shall follow. Then the time duration is set, for which Panda shall follow the line, and the speed with which it shall trace the line. In addition, the maximum distance for all Cartesian directions needs to be defined, for which the Arm is allowed to distance itself from the starting point. If the Arm is to apply force in addition to the movement, the force needs to be defined. This is done as described for the ‘Apply Force’ App.

## Lissajous Figures



‘Lissajous Figures’ allows Panda to trace different Lissajous figures. In addition, force can be applied during the movement. For executing this App, the impedance values set in a ‘Set Joint Compliance’ App are used. Should the option ‘Apply Force’ have been selected, the values from the ‘Set Cartesian Compliance’ App are used.
For parametrization, first the duration of the movement needs to be defined. Then the movement can be configured more precisely. For this purpose, the number of movements in both directions and the amplitude of them ovement in both directions is configured. Finally, the level on which the movement is to be executed is defined. If the Arm is to apply force in addition to the movement, the force needs to be defined. This is done as described for the ‘Apply Force’ App.

## Spiral

‘Spiral’ is used for executing a spiral mvement with the Arm. In addition, force can be applied uring the movement. For executing this App, the impedance values set in a ‘Set Joint Compliance’ App. Should the option ‘Apply Force’ have been selected, the values from the ‘Set Cartesian Compliance’ App are used.
For parametrization, first the duration of the movement needs to be set. In the following steps the spiral is defined more precisely by setting the ascent, width and direction of rotation of the spiral. Then the level on which the movement is to be carried out can be selected. Should the option ‘Apply Force’ have been selected, the values from the ‘Apply Force’ App are used.



## User Interaction

‘User Interaction’ enables Panda to wait for a haptic confirmation by the user. After successfully triggering a haptic gesture in one of the configured directions, the App is closed and the following App will be executed.
At first, the force limit, which needs to be exceeded for triggering the gesture, needs to be defined. In the next step all directions from which contact is to be recognized need to be defined.

## Wait

‘Wait’ provides the option to pause execution for a certain time period. The desired waiting period can be configured in seconds.

## Change Gripper Width

Change Gripper Width’ allows the user to change the gripper width during the execution of a Task, for example to open the Hand before gripping an object.
The desired gripper width and the speed with which the gripper shall move can be set on the Arm or using the slider.

## Grasp

‘Grasp’ allows Panda to grasp objects.
The configuration is done similarily to the configuration in the ‘Change Gripper Widht’ App. The grasping force and the mass of the object to be grasped can be configured additionally.
This should be done very precisely in order to avoid negative effects on the performance of force application or subsequent movements.

## Transport Motion

‘Transport Motion’ allows the tracing of a taught sequence of points in the Cartesian space. In contrast to the ‘Cartesian Motion’ App, here the system checks whether a gripped object is lost during the movement, which terminate the movement.
For executing this App, the impedance values set in a ‘Set Joint Compliance App.
The configuration is done similarily to the ‘Cartesian Motion’ App, by teaching a trajectory and configuring speed and acceleration. The maximum values can vary depending on the configuration, the weight of the end effector and the defined maximum speed.

## Modbus Wait

‘Modbus Wait’ will wait for the configured Modbus inout to accept the expected value. Once this has happened, the App is closed and the subsequent App is executed.
For configuring this App, the corresponding Modbus input needs to be selected, meaning that the module, the card and the input of the value to be expected need to be configured.

## Modbus Out

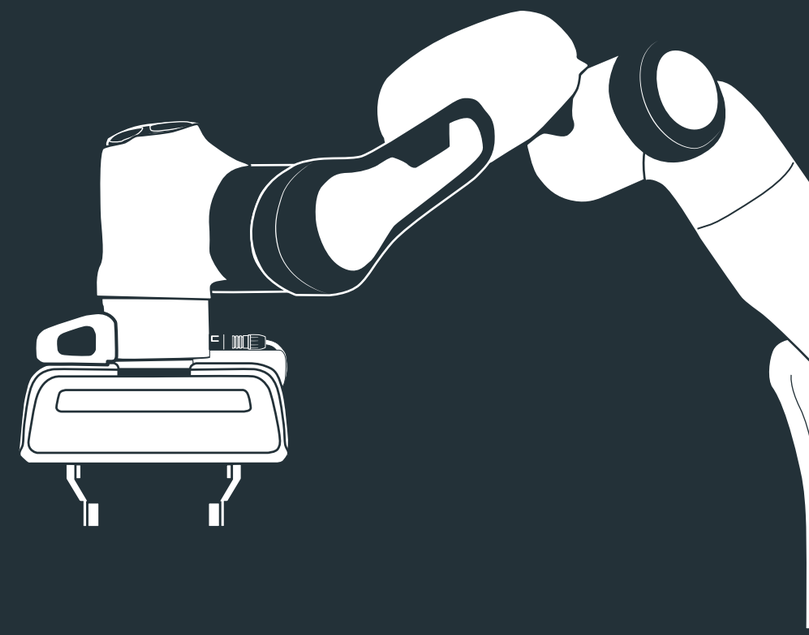
‘Modbus Out’ sets the configured Modbus output to the confgured value.
For configuring this App, the corresponding Modbus output needs to be selected, meaning that the module, the card and the input of the value to be expected need to be configured.

## Modbus Pulse

‘Modbus Pulse’ sets the configured modbus output tot he configured value. After the defined waiting period has passed, the output is reset again.
For configuring this App, the corresponding Modbus output needs to be selected, meaning that the module, the card and the input of the value to be expected need to be configured. In the next step, the waiting period can be defined.

# MAINTENANCE, SERVICE & SUPPORT

- Cleaning
- Backup
- Updates
- Service & support
  - Troubleshooting
- Shut-down, storage and disposal



# MAINTENANCE, SERVICE & SUPPORT

## Cleaning

**WARNING**

Improper use of liquid cleaning agents and devices that are not correctly disconnected from the mains supply before cleaning can cause fatal accidents by electric shock.
Therefore:

- never clean devices that have not been safely disconnected from the mains supply
- never use liquid cleaning agents for cleaning the devices
- do not switch on devices that have not fully dried

The following things need to be kept in mind while cleaning:

- Cleaning may only be carried out by qualified users.
- Arm, Control and Hand
  - Cleaning of components is only permissible when Panda is safely disconnected from the power supply (control disconnected from the mains)
  - Switching off and unplugging the device is to be carried out by qualified users
  - Do not spray any liquids directly onto the device
  - Do not use any cleaning chemicals
  - The components may only be cleaned using a damp, entirely wrung out cloth or using a dry cloth. Make sure that no moisture enters the devices.
  - Do not apply great force to the Arm. The parts to be cleaned are to be supported manually, as not to overload and possibly damage the Arm.
  - Restarting is only permitted when all surfaces have dried completely.

*NOTE*

Improper cleaning may cause material damage to the devices.

## Backup

### Backup of Tasks

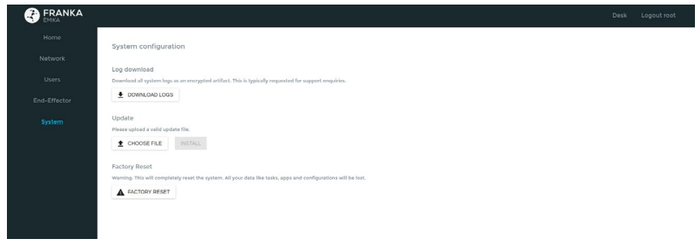
Tasks can be saved locally on a hard drive by downloading them. They can be imported to the Task list again any time using drag & drop.



## Updates

### System updates

System updates are imported via the admin interface under ‘System’. Click on the ‘Upload’ button to select an update file. After the file has been successfully uploaded, the update can be installed by clicking the ‘Install’ button. For this purpose, the system will reboot.




## Service & support

For any requests regarding service & support please contact us at support@franka.de A ticket for your request will be issued in our service & support center and our experts will respond as soon as possible.

## Toubleshooting

### The safety locking system cannot be opened via Desk

Panda glows yellow. Switch the external activation device on and off (the system needs to have recognized both states before the locks can be unlocked). In addition, the external activation device needs to be open before the locks can be opened via Desk. Check to see if the display in the footer of Desk changes – the status of the safety locking system and the external activation device are visually represented by traffic lights.

### Guiding / teaching does not work

Panda flashes white: Probably one of the two buttons on the grip has not been pressed correctly. Release both buttons and press them again. Make sure that the activation button is not pressed down completely because this will stop the movement!
Panda glows or flashes yellow: either the safety locking system is still active, or the external activation device has not been activated.

### Creaking noise in certain poses

Certain loads may cause structural components to creak. This does not affect functionality in any way.

### Arm pulls strongly towards a certain direction during teaching

Immediately check the end effector settings. Has the correct end effector been selected and parametrized? See also /Start-up/Software Set-up/

### Loud clicking when switching off

The clicking sound comes from the activation of the safety locking system and is absolutely normal. The locking bolts catch in the joints in order to mechanically lock them.

**Desk continuously displays “Shutting down the system”**

You have probably shut down the system. As soon as the front ventilators of the Control stop turning, it can be switched off using the switch on the back of the Control. Then the browser window for Desk can be closed as well.

## Shut-down, storage and disposal

**Disposal**

Shut-down, storage and disposal of Panda research may only take place according to the relevant country-specific laws, standards and regulations.

**Battery**

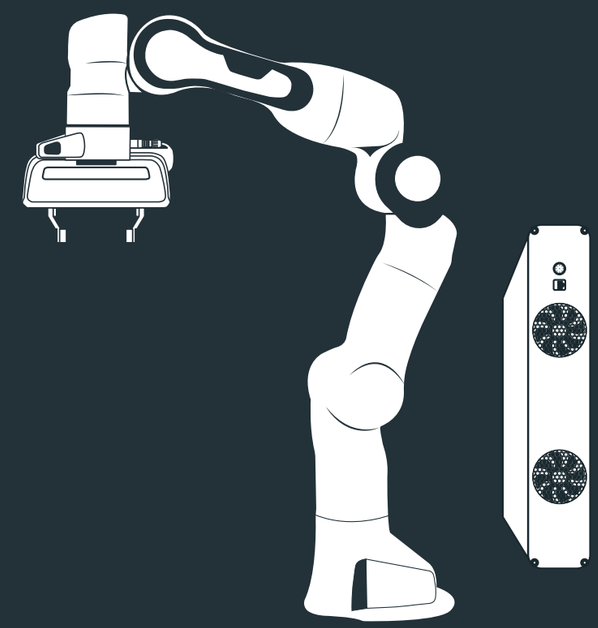
The Control contains a coin cell battery. This battery is to be disposed of separately according to the relevant country-specific laws, standards and regulations.

**Return of waste**

Please contact us to process any returns of waste.

# RIGHTS OF USE AND PROPERTY RIGHTS

- Identification
- Rights of use and property rights



# RIGHTS OF USE AND PROPERTY RIGHTS

## Identification

### Removal of identification

Copyright notices, serial numbers and any other kind of labelling serving to identify the product or operating software may not be removed or modified.

## Rights of use and property rights

### Granting of rights of use

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### Use of open source codes

A complete list of all open source licenses used by Panda research can be accessed via Desk.

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