INSTRUCTION MANUAL

Version: 1.5.2 EN08

Collaborative robot arm

Model: Arm KR0810 + KR1018 + KR1205 + KR1410 + KR1805

Serial No.: See Identification Plate on the robot and controller cabinet.
Generation: 1st generation

Kassow Robots ApS
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Identification

0.1 Supplier Information

Manufacturer:	**Kassow Robots ApS** Oliefabriksvej 57 2770 Kastrup
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0.2 Product Description

Description:	**Collaborative robot arm** Model: Arm 0810 / 1018 / 1205 / 1410 / 1805 Serial No.: See Identification Plate on the robot and controller cabinet. Generation: 1st generation Year: 2021

0.3 Incorporation Certificate

(See the next page)

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Declaration of incorporation

(according to the EU Machinery Directive 2006/42/EC, Annex II 1. B)

Manufacturer:
Kassow Robots ApS
Oliefabriksvej 57
DK - 2770 Kastrup
Person in the Community

authorised to compile the technical file:
Kristoffer Sminge, mechanical engineer
Kassow Robots ApS
Oliefabriksvej 57, DK - 2770 Kastrup

Description and identification of the partly completed machinery:
Type: Collaborative Robot / Industrial Robot
Function: Function is determined by the completed machine
Model: KRxxxx (KR810, KR1205, KR1410, KR1805, KR1018)
Serial no: YYMMDDARxxxx (Year/Month/DayARxxxx where xxxx is a random number) effective *23/1/2019*
Robot controller no: YYMMDDARxxxx (Year/Month/DayRCxxxx where xxxx is a random number)
Teach Pendant no: YYMMDDARxxxx (Year/Month/DayRCxxxx where xxxx is a random number)

Important note! The partly completed machinery must not be put into service until the final machinery, into which it is to be incorporated, has been declared in conformity with the provisions of below Directives, where appropriate.

It is expressly declared that the partly completed machinery fulfils all relevant provisions of the following EU Directives or Regulations:

2006/42/EC	Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery and amending Directive 95/16/EC. Published in L 157/24 of 09-06-2006. The following essential requirements have been fulfilled 1.1.2, 1.2.1, 1.2.2, 1.3.1, 1.3.4, 1.5.1, 1.5.4, 1.5.8, 1.6.3, 1.7.1.2, 1.7.3, 1.7.4. It is also declared that the relevant technical documentation has been compiled in accordance with B of Annex VII.
2014/30/EU	Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility. Published in 2014/L 96/79 of 29-03-2014
2011/65/EU	Corrigendum to Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. Published in 2012/L 209/18 of 04-08-2012
2014/35/EU	Low-Voltage Directive

Reference to the harmonised standards used, ref. Article 7 (2) of MD/LVD and Article 6 of EMC Directive:

EN 60204-1:2006/A1:2009
EN ISO 12100:2010-11
EN ISO 10218-1:2011
EN ISO 13850:2015
EN ISO 13849-1:2015
EN ISO 13857:2008
EN ISO 10218-2:2011
EN ISO 14120:2015
EN 61000-6-2:2005
EN 61000-6-4:2007 / A12011

Reference of the other technical standards and specifications used:
ISO/TS 15066:2016

The manufacturer or his authorised representative undertake to transmit, in response to a reasoned request by the national authorities, relevant information on the partly completed machinery. This transmission does not affect the intellectual property rights!

Kastrup, Denmark 01/01/2021

Kristian Kassow, Managing Director

1 General

This instruction manual must be carefully read and understood before the robot is commissioned!

This warning symbol indicates that special precautionary measures must be taken.

If the safety precautions are not observed, it may lead to hazardous conditions and result in personal injury or damage to property.

This symbol indicates that the following information is important.

1.1 Introduction

Congratulations! You've purchased one of our collaborative robot arms. This **Instruction Manual** aims to provide you with all the basic safety and maintenance information, as well as basic hardware operation instructions, to ensure that you have the optimal experience with our product.

For more detailed instructions about the operation of the Kassow Robot software, please refer to our separate **Software Manual**.

If you feel that any information is missing or you have more specific questions, please don't hesitate to contact us directly and we will be happy to address your inquiries.

This manual must be read **prior** to operating your robot.

1.2 Function Description

The industrial robot arm is a robot system used for manufacturing. It is automated, programmable and capable of moving within up to seven axes.

The robot is typically used for welding, painting, assembly, pick and place, packaging and labelling. These

actions are all carried out while ensuring high endurance, speed, and precision.

1.3 Technical Terms and Abbreviations

The technical terms and abbreviations used in this instruction manual are described below.

Word	Explanation
RC	**Robot Controller** is the main controlling unit required for each Kassow Robot manipulator.
TP	**Teach Pendant** stands for the portable programming and manual platform providing all necessary user interface and safety controls.
TPUI	Teach Pendant **User Interface** is the software user environment running on the manual platform (TP). This provides all software tools necessary for the robot programming, teaching and accessing extension modules.
Instructed Person	A person who has received the necessary training to carry out the programming of the robot in a safe and responsible way.
Operator	A person who has received the necessary training to carry out daily operation and cleaning.
Integrator	This is the person who puts together the partly completed machinery so that it functions as a whole. The integrator is also responsible for analysing the product to identify any potential health and safety risks, and providing the appropriate solutions to minimise any such risks. Hence the final application, following the integrator's analysis and implementation of any potential solutions, is safe and risk free to use. The Integrator is also responsible for the risk assessment of the product.

2 Safety

2.1 Introduction

This manual does not detail how to design and install a complete robot application, nor does it cover the specifics of any additional equipment in the designated environment that could influence safety.

As mentioned in the definitions, specific safety requirements should be handled by the **Integrator**, whose role includes but is not limited to:

- Conducting a risk assessment for the entire system and environment in which it will be operated.
- Ensuring the correct installation of the robot.
- Ensuring that all appropriate safety measures are put forth in the software.
- Making sure that procedures are in place to avoid the modification of mandatory safety measures by users.
- Specifying necessary safety procedures to user.

It is necessary when using the equipment that:

- The instructions in this manual are followed closely.
- The user always ensures that the unit is maintained as described in this manual before any operation.
- All safety precautions provided in the instruction manual are complied with.
- The unit must only be operated within the specifications indicated in this manual. In chapter 4, there are detailed specification tables for each robot.

Kassow Robots ApS cannot be held liable for inadequate use of the unit, which may cause poor performance of the unit and/or breakdowns of any type and importance. Inadequate use is defined in section 3.4: Improper Use.

2.2 Precautionary Measures

In the event that specific tasks require the use of personal protective equipment, these measures must be observed by all occupational groups.

- During cleaning and maintenance, the robot arm must be put into safe mode.
- The **Integrator** must provide a circuit breaker and a description of how to disconnect other connections, such as the air supply.

2.3 Intended Use

The KR robot arms (810/1205/1410/1805/1018) are only intended to be incorporated into, or assembled with, other machinery or other partly completed machinery or equipment to form one completed piece of machinery that complies with 2006/42/EC.

Improper use of the unit may cause injuries and damage to property and may void the warranty.

If at any point you wish to modify any element of the equipment, you should consult Kassow Robots ApS prior to doing so. However, Kassow Robots ApS will not be liable for any danger that the user might be exposed to in the case of any significant amendment.

The unit should not be used for materials other than those instructed. Please contact Kassow Robots ApS if you need the unit for something else.

2.4 Improper Use

Any use or application deviating from the proper use is deemed to be improper use.

Improper use of the unit may cause injuries and damage to property and may void the warranty.

Modification of any element of the unit is subject to prior consultation with Kassow Robots ApS, who will not be liable for any danger that may occur as a result of modifications.

Examples of improper use of the unit include, but are not limited to:

- Using the unit to process flammable materials that may cause an explosion.
- Using the unit in humid areas (relative humidity min 35%, max 85%).
- Using the unit for foodstuffs.
- Using the unit in temperatures over 45 °C or below 0 °C.
- Installing or operating the unit in explosive and/or fire danger zones.

2.5 Operating Personnel

The owner must ensure that the personnel receives training and knowledge so that they become familiar with the unit and are able to protect themselves from workplace hazards.

- Only qualified personnel must operate the equipment and only after having received precise

instructions. The unit must not be operated by nor maintained by untrained personnel.

- Only persons whose jobs require it are allowed access to the unit. Suitable safety precautions are required if personnel need to access the unit or installation.
- Always wear the proper personal protective equipment as defined in this manual or in applied data sheets.
- No loose clothing, and long hair must be put up.
- Never operate the unit if you are under the influence of alcohol and/or medication that could impair your judgement.
- Kassow Robots ApS recommends keeping the area around the unit clean at all times.
- Always use safety harnesses when working above ground level where there is no platform.
- Never work alone.
- If intervention tasks take place above floor level, the owner must establish a temporary working platform.

2.6 Transportation and Handling

The robot arm, controller, Teach Pendant, cables and documents are delivered by Kassow Robots in two boxes, which can be handled safely by one person.

- The unit must not be exposed to any damage, impacts or the like during transportation as this may impair its performance during operation.
- The unit and its components are heavy. Use proper lifting methods and wear proper protective equipment as defined in this manual. Failure to lift and support the equipment properly may result in serious physical injury and/or equipment damage. It is not recommended to handle heavy parts of the unit manually. Ergonomic risks must be considered when handling heavy unit parts manually.
- Use proper lifting methods and wear safety shoes and working gloves during rigging and de-rigging.
- Make sure that the lifting equipment is in good condition.
- It is prohibited to stand below a lifted load at any time.
- Make sure that the lifting straps are protected against sharp edges.

2.7 Safety during Commissioning and Installation

The following must be adhered to when commissioning and installing the unit:

1. On receipt of the unit, check whether it was damaged in transit, especially that gear, motor, grease nipples, guards, etc., have not been exposed to impacts or the like during transportation.
2. The unit must be placed in a way that allows for mechanical lifting.
3. The unit must not be installed and operated in explosive and/or fire danger zones.
4. The unit must not process explosive materials.
5. The unit must be installed and operated in an indoor industrial, non-dusty environment.
6. The unit must be placed in a way that enables maintenance and repair works.
7. Make sure that the space around the unit is sufficient. This facilitates ventilation, inspection, service, maintenance and cleaning.
8. It is prohibited to commission the unit without all guards in place. This also includes inlet and outlet installations preventing access to hazardous parts.
9. Unit interfaces must be connected as defined in this manual.
10. Make sure that there are no foreign objects in the unit (e.g. bolts, tools, etc.), and check that all guards are mounted and fastened.
11. The unit is designed and constructed so that vibrations and noise produced by the unit are reduced to the lowest possible level. This means that the unit must be installed as described in this manual.
12. The installer and user of the unit must ensure that it is properly aligned. Check the alignment of frame-mounted units before operation. Failure to do so can result in equipment damage or decreased performance.
13. Make sure that the power is OFF before any work on electric installations.
14. Check the supply disconnecting device and make sure that the power is always disconnected before starting any electrical work.
15. All electrical installations must be made by a qualified electrician/technician and in compliance with local regulations.
16. Make sure that there is sufficient space around the unit. This facilitates ventilation, inspection, service, maintenance, cleaning, etc.
17. The installer and user of the unit must ensure that it is properly aligned. Check the alignment of frame-mounted units before you operate the unit. Failure to do so can result in equipment damage or decreased performance.

2.8 Storage

The delivery boxes can also be used for safe storage if necessary.

No aggressive, corrosive substances (contaminated air, ozone, gases, solvents, acids, alkalis, salts, radioactivity, etc.) should be in the immediate vicinity. There should be no vibration or oscillation. Surfaces must be treated during storage if specified in this manual.

All disposal and recycling must be carried out in an environmentally acceptable manner according to local legislation and regulations.

2.9 Miscellaneous

Seismic Movement

After any severe seismic movement, which might cause material and structural damage to the machine, the damage of the machine must be estimated according to the details below:

Seismic movement of low intensity

The location where the machine is installed has not suffered great damage (for instance the building is not damaged). In this case, stop the machine and carry out a visual inspection of all its components to estimate the damage. Restart the machine after the inspection if it has been satisfactory.

Seismic movement of moderate intensity

The building and the machine have both suffered some damage; objects have fallen on the machine, structural damage, damage in peripheral equipment, etc. In this case:

- Stop the machine if it is still running (in case the electric power or any other energy source has not failed), provided this does not imply any additional danger.
- Following this, carry out a comprehensive inspection of the machine and repair the damaged elements.
- If the structure of the machine has suffered severe damage such as crushing, warping, deformation of the shell, and this is severe, the machine must be taken out of service.

Seismic movement of maximum intensity

Severe material damage has occurred, such as the collapse of the building. In this case, inspect the equipment when permitted by the physical conditions.

Lifecycle Time limits

The machine is intended for an operational life of 30,000 hours, provided that all service and maintenance has been carried out in accordance with the recommended service intervals.

2.10 Safety Check

A manual functional test is required to detect any accumulation of faults.

Such tests must be carried out within the following test intervals at least every **12 months.**

Below is a table that outlines the steps that must be taken prior to first use. Please check that you have adhered to all of the points in this table before proceeding to operate the robot.

Before the first use:
Robot must be inspected before first use.
Make sure that the robot and the robot components are intact when unpacking the robot.
The robot socket must be properly clamped to a surface suitable for the purpose.
The robot must be lifted from the bottom and can be easily handled by one person.
Check the Teach Pendant connection to RC. The Teach Pendant will automatically start after the RC is switched on, after a while it will indicate the connection in the top-left corner.

Figure 1: E-Stop button on the Robot Controller (left) and Teach Pendant (right).

Safety circuits test

Visual inspection of whether the Emergency Stop (**E-Stop**) and Protective Stop (**P-Stop**) buttons are intact.

Before starting the robot arm, press and release the **E-Stop** and **P-Stop buttons** to check that they are undamaged and work as intended.

The **E-Stop button manual functional test** is provided as following:

1. Verify that the external **E-Stop** or **P-Stop** circuit is properly connected to the RC IO section.
2. Release all safety buttons and turn the main switch on.
3. After the RC is powered up, wait until the **resume button** start **flashing blue** (~1 min).
4. Press the resume button to bring the power to the robotic arm**.**
5. After that, the resume button goes **solid blue** and RC initiates brake release sequence, which unlocks and readjusts joint positions by a small amount for each of the 7 joints.
6. If the robot initialisation fails (i.e. it doesn't end up in the **solid green** state), try to repeat the procedure. Do press/release the **E-Stop button** and use the resume button. Please contact your service provider if the brake release sequence keep failing.
7. When the robot comes online, verify the function of the **E-Stop** by pressing the **E-Stop button** which should followed by a check of lost power to the robot arm (all brakes engaged). The E-Stop message also appears on the TP.
8. Release the **E-Stop button** again and observe that the Robot returns to normal condition again and the LED or the **release button** is flashing blue.

The **P-Stop button manual functional test** is provided as following:

1. Verify the **P-Stops** one by one by creating a simple program providing a movement of the robot.
2. Start the program and press the **P-Stop button**.
3. Observe that the robot pauses the movement.
4. Release the **P-Stop button** and observe that the robot continues the movement after pressing the green resume button or continue on the Teach pendant.

Each **P-Stop** and **E-Stop** must be tested individually one by one including the external circuits connected to the Robot controller.

Repeat the functional tests after each installation or re-installation of any robotic tool.

If all tests pass successfully, then the robot is ready for operation.

If any of the safety related tests fail, the robot must not be operated and your service provider must be contacted for troubleshooting and repair.

2.11 Instructions for Safe Operation

Before opening the electrical cabinet, the operator must wait for 5 seconds to make sure that the robot is de-energized.

- Only an **Instructed person** may access the electrical cabinet. An Instructed person is a person who has been adequately informed or supervised by an electrical expert to be able to notice any risks and avoid any electricity hazards (e.g. maintenance personnel). See definitions section.
- The robot generates noise and the noise level is <70 dB(A).
- If the robot has detected any internal overload, it engages the **P-Stop** function.

2.12 Safety Functions

The safety functions of the robot are constantly checking external and internal signals from the whole system and can act immediately to halt the robot or cut the power if necessary.

Safety-related parts of control systems have been designed so that they comply with **PL-d** with structure **category 3** as described in **ISO 13849-1:2006**. Before operating the robot, the operator must seek information about the safety functions and protection equipment of the robot.

The robot may only be used and operated when all safety functions are fully available and operable!
Defective safety functions and protective equipment may lead to loss of safety and hazardous situations.

In the case of defective safety functions and protective equipment, do as follows:

1. Stop the robot immediately (press the P-Stop button followed by the program Terminate) and press the E-Stop button.
2. Make sure that the robot cannot restart by disconnecting the power sources to the robot.

In the following sections you can find detailed descriptions of safety and protective functions installed on the robot.

2.12.1 Emergency Stop

The **Emergency Stop (E-Stop)** function is a supplementary safety function, which serves to prevent a hazard from arising due to improper use of the robot. A hazard could result in personal injury, damage to the robot or ongoing work, or it may arise because another safety function is failing.

The **E-Stop buttons** are provided at both the Teach Pendant and the robot cabinet (see diagram in section 2.10). These buttons are used to engage inbuilt safety measures and halt the robot in order to prevent a potentially hazardous situation.

While emergency buttons provide immediate interaction and safety for the operator, the internal variables are also continuously monitored to avoid any internal damage to the system.

The integrity guards check the basic conditions of the system, including temperature, voltage or currents. Further safety checks keep track of sensor data consistency.

The **E-Stop** always triggers the robot to halt immediately, followed by a power cut of all vital parts of the robot.

The Emergency Stop must be tested at least every 12 months.
The emergency stop is stop category 0 in accordance with to **IEC60204-1**

The emergency function is unchanged throughout any operation modes of the robot.

Components Included in the Safety Function		
Input part	**Logical part**	**Output Part**
		
The E-Stop circuit - Teach Pendant – Robot Controller	I/O Board	Power circuits
The E-Stop is activated by pressing one of the E-Stop buttons, or by the activation of the external E-Stop circuit.	I/O Board monitoring the safety function.	Disconnects the power supply to the moving parts.
	The service life of the controller is 30,000 hours.	The maximum number of couplings per annum is assumed to be 52.
The E-Stop push buttons are placed in the following places on	The safety function, i.e. the robot, must not be used beyond 30,000	The service life of the components

the robot: • Teach pendant • Robot Controller cabinet (see Figure 1) The component is fault-free and is considered to always work when the emergency stop push-button is activated.	hours. Any use beyond 30,000 hours is conditional on the relevant components being replaced by new components of identical or improved properties.	(T10d value) is calculated based on the number of couplings. An increased number of couplings may affect the performance of the safety device.

Displays and alarms

When activating the E-Stop, the status will appear on the Teach pendant:
"External emergency stop activated"

Operating conditions

The E-Stop is unchanged throughout any operation modes of the robot.

Maintenance and test

The **E-Stop** function must be activated and tested before commissioning after each installation or reinstallation of the robot.

As a minimum, the E-Stop function must be visually checked and activated at least every 12 months.

The safety functions complies with **EN ISO 13849-1:2015**.

The following safety-oriented functions are preconfigured and can be integrated into the system via the safety interface of the robot controller:

Operator safety (= connection for the monitoring of physical safeguards)

- External Emergency stops (Electro mechanical switch)

2.12.2 Protective Stop

The **Protective Stop (P-Stop)** can be used interactively by the operator to pause and continue the running program.

Internally, the system can also trigger the **P-Stop** by applying energy guards on the system when specific conditions are met and warn the user. Depending on the type of diverging values, the program can continue its normal operation when the **P-Stop** is released.

There are 2 types of Protective stops.

P-Stop Path:

The robot arm stops as fast as possible without deviating from its trajectory. The program can be resumed by releasing the protective stop button and then pressing play on the Teach Pendant screen or the pause play buttons.

The protective stop is Stop category 2.

P-Stop Fast:

Each robot joint utilizes full stopping torque power, which stays on the robot but is limited by a safety power system. The program cannot be resumed but must be started again by pressing unlock on the Teach pendant screen and then pressing play on the Teach pendant screen or the pause play buttons.

The protective stop is Stop category 2.

The P-Stop must be tested at least every 12 months.

The P-Stop is stop category 2 in accordance with **IEC60204-1**

Displays and alarms
When activating a P-Stop, the status will appear on the Teach pendant: ***"External protective stop activated"***

Maintenance and test
The safety functions comply with **EN ISO 13849-1:2015**.
The following safety-oriented functions are preconfigured and can be integrated into the system via the

safety interface of the robot controller:

Operator safety (= connection for the monitoring of physical safeguards)

- External Protective stops (Electro mechanical switch)

3 Product Description

3.1 Robot Arm Construction

The robot consists of the robot arm, a controller cabinet, a Teach pendant and the connection cables.

Figure 2: Functional parts of the KR collaborative robot

1. The robot arm consists of 7 geared servo motors connected mechanically by machined extrusions and castings and connected electrically by a 48V power supply bus and a serial communication bus.

2. The controller cabinet houses various power supplies:

- The computer, which coordinates the movements of the 7 geared servo motors.
- The I/O board, which has a range of safety related functions and allows various electrical connections.
- The relays on the robot arm power supply bus.
- Connectors for connecting to a wall socket, robot arm and Teach pendant.
- An Emergency stop button.
- A Protective stop button.
- A play/pause/resume toggle button.

3. The Teach pendant / HMI allows the user to program the robot system and houses two buttons. When pushed, this allows the user to manually manipulate the robot arm. There is also an Emergency stop button, a Protective stop button and a play/pause/resume toggle button.
4. The cables connecting the system components are:
    - Two cables with a connector on both ends between the robot arm and the controller cabinet.
    - One cable is fixed to the Teach pendant and with a connector in the other end to connect the Teach pendant to the controller cabinet.
    - One cable has a 3P CEE female connector on one end and a male connector on the other end to connect the wall socket with the controller cabinet.

3.2 Using the Robot

Operating Modes

The robot can be operated manually and automatically. It is automated, programmable and capable of moving in up to 7 axes. The robot is typically used for welding, painting, assembly, pick and place, packaging and labelling. These are all carried out while ensuring high endurance, speed, and precision.

Only the use of appropriate and standardized tools is considered. The robot is intended for use in an indoor industrial environment.

The robot is intended for a professional use only and to be used by persons with a proper knowledge and experience with collaborative robots.

This documentation is aimed at **Instructed persons** with the following knowledge and skills:

- Knowledge of mechanical engineering

- Knowledge of electrical and electronic systems
- Knowledge of the robot controller system

The robot:

- May only be used under the operating conditions foreseen in this Instruction manual.
- Is intended to be programmed and maintained by a skilled/qualified user following the instructions given in the operating Instruction manual
- Is only intended as a collaborative robot. Any other use beyond such operating conditions is deemed not to conform with the Instruction manual, and the manufacturer cannot accept any liability whatsoever for subsequent loss or damage.

3.3 Use Limits

The integrator must define use limits according to the specific task where the robot arm is to be used. Special attention must be shown according to EN ISO 12100 pk. 5.3.2

3.4 Space Limits

The robot must be placed on a solid surface that can withstand up to minimum **1000 Nm**. The robot must not be used in a wet environment.

4 Robot Arm Specifications

The following section outlines the specifications for each robot.

4.1 Robot Model KR810

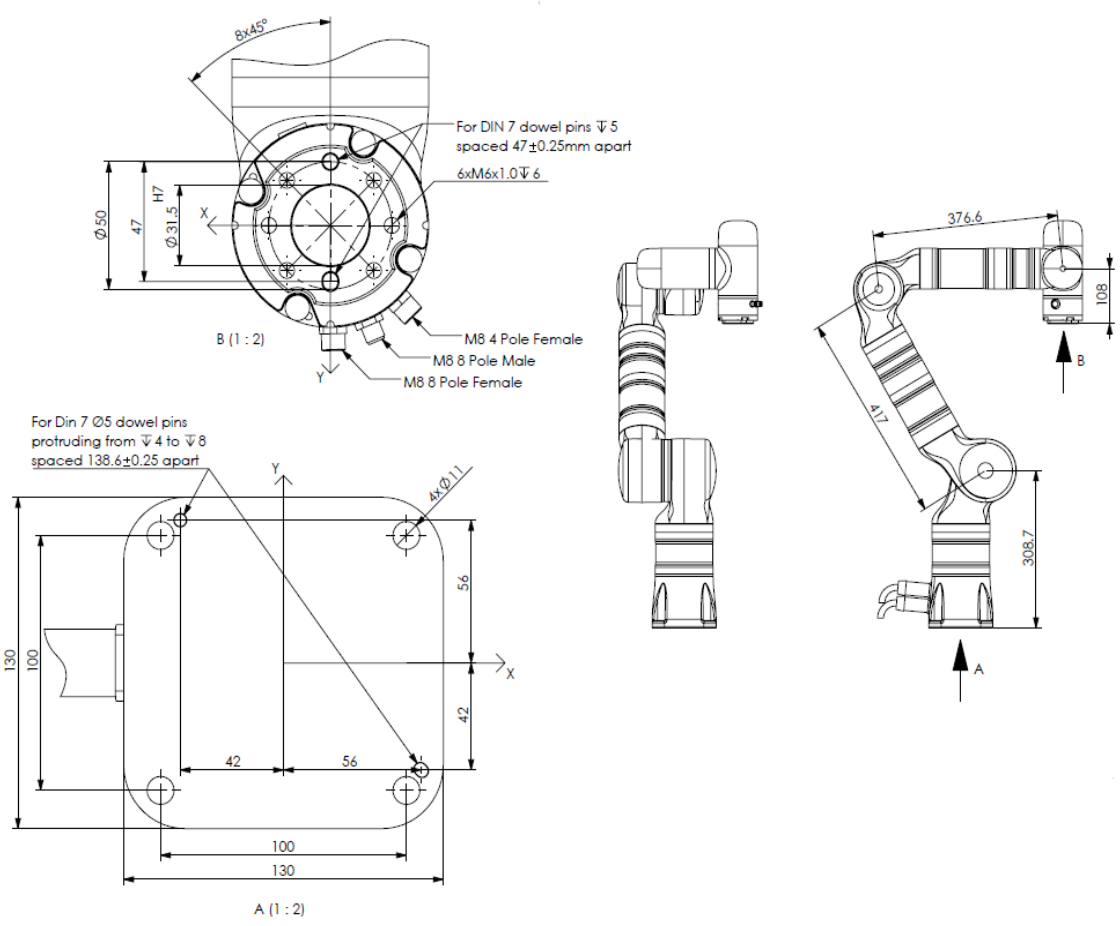

Figure 3: Diagram of Robot Model KR810

Description	Value
Reach [mm]	850
Operating temperature range [°C]	0-45
Operating humidity [%RH]	30-85 non condensing
Operating Altitude [m]	3000
Weight [kg]	24
AC Power connector	1 Phase CEE
Typical Power consumption (with max load) [W]	400-600W
Supply voltage [VAC]	100-120 and 200-240 (50/60hz)
Supply current (Pre-fuse requirement) [A]	16
IO power supply [VDC]	24
Digital input max voltage limits [VDC]	Max 30V
Max. joint speed [°/s]	225
Max. static force on tool flange centre (payload) [kg]	10
Max. static torque on tool flange centre [Nm]	25
Required bed plate flatness [mm/m]	0.5
Sound level [dB]	Below 70dB (A)
Ingress protection	IP54
Joint ranges [°]	Joint 1,3,5,6,7 +/- 360 Joint 2,4 -70/+180
Cable lengths [m]	5m Controller to robot arm 4.5m Controller to Teach Pendant
Footprint [mm]	130 x 130

4.2 Robot Model KR1018

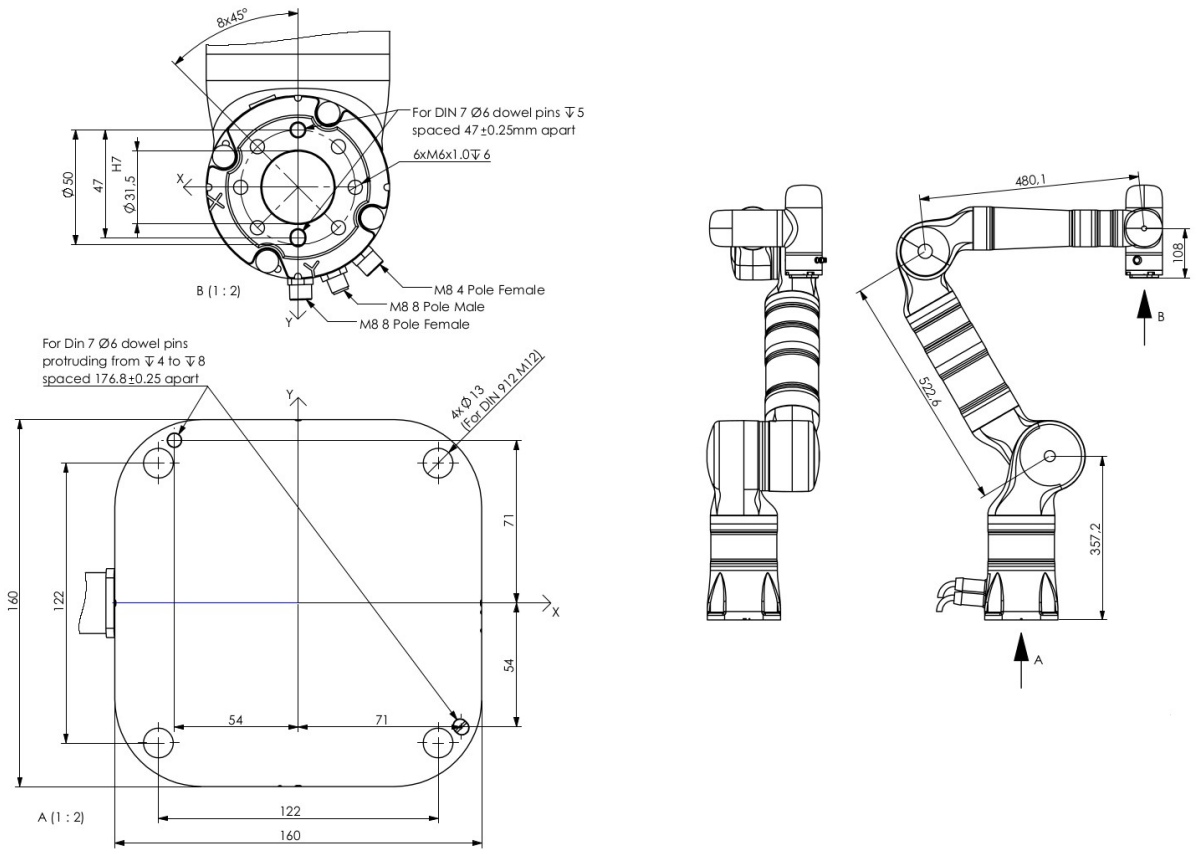

Figure 7: Diagram of Robot Model KR1018

Description	Value
Reach [mm]	1000
Operating temperature range [°C]	0-45
Operating humidity [%RH]	30-85 non condensing
Operating Altitude [m]	3000
Weight [kg]	34
AC Power connector	1 Phase CEE
Typical Power consumption (with max load) [W]	400-1200W
Supply voltage [VAC]	100-120 and 200-240 (50/60hz)
Supply current (Pre-fuse requirement) [A]	16
IO power supply [VDC]	24
Digital input max voltage limits [VDC]	Max 30V
Max. joint speed [°/s]	163/225
Max. static force on tool flange centre (payload) [kg]	18
Max. static torque on tool flange centre [Nm]	25
Required bed plate flatness [mm/m]	0.5
Sound level [dB]	Below 70dB (A)
Ingress protection	IP54
Joint ranges [°]	Joint 1,3,5,6,7 +/- 360 Joint 2,4 -70/+180
Cable lengths [m]	5m Controller to robot arm 4.5m Controller to Teach Pendant
Footprint [mm]	160 x 160

4.3 Robot Model KR1205

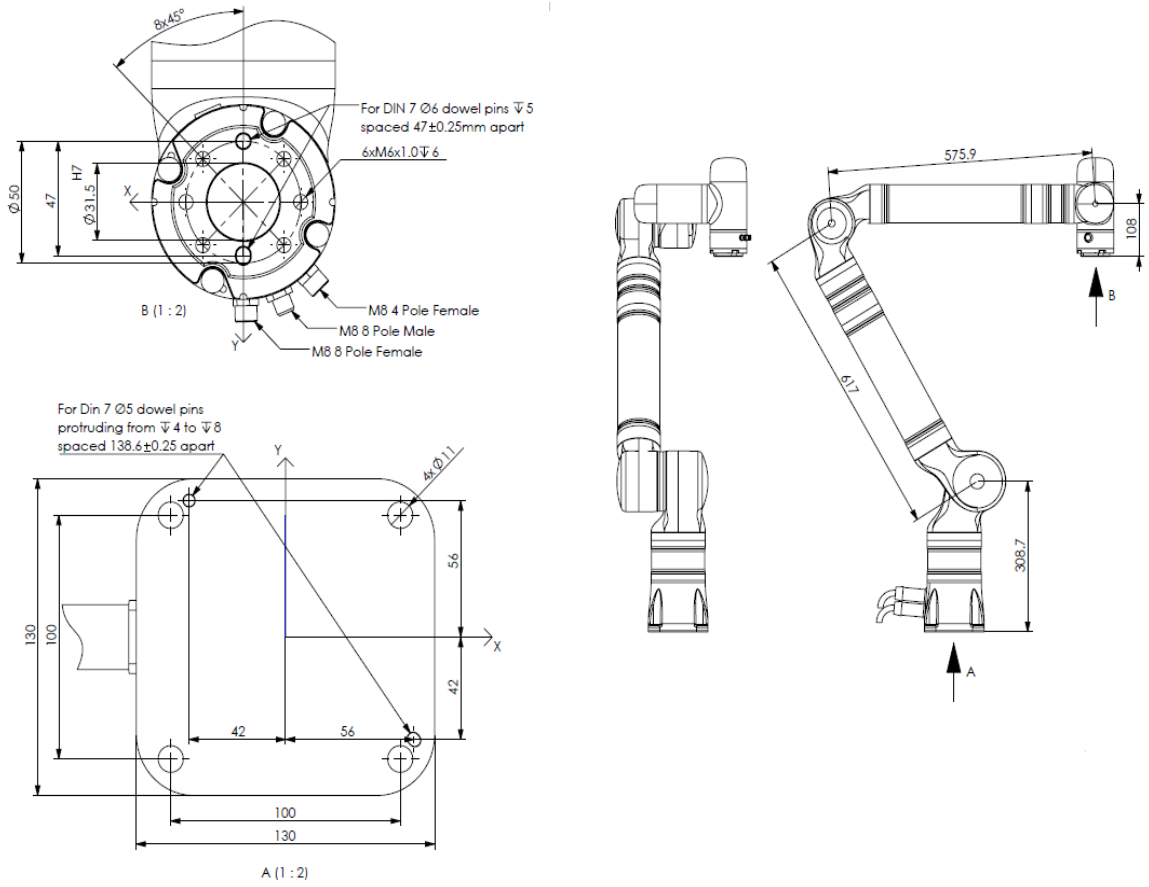

Figure 4: Diagram of Robot Model KR1205

Description	Value
Reach [mm]	1200
Operating temperature range [°C]	0-45
Operating humidity [%RH]	30-85 non condensing
Operating Altitude [m]	3000
Weight [kg]	25
AC Power connector	1 Phase CEE
Typical Power consumption (with max load) [W]	400-600W
Supply voltage [VAC]	100-120 and 200-240 (50/60hz)
Supply current (Pre-fuse requirement) [A]	16
IO power supply [VDC]	24
Digital input max voltage limits [VDC]	Max 30V
Max. joint speed [°/s]	225
Max. static force on tool flange centre (payload) [kg]	5
Max. static torque on tool flange centre [Nm]	25
Required bed plate flatness [mm/m]	0.5
Sound level [dB]	Below 70dB (A)
Ingress protection	IP54
Joint ranges [°]	Joint 1,3,5,6,7 +/- 360 Joint 2,4 -70/+180
Cable lengths [m]	5m Controller to robot arm 4.5m Controller to Teach Pendant
Footprint [mm]	130 x 130

4.4 Robot Model KR 1410

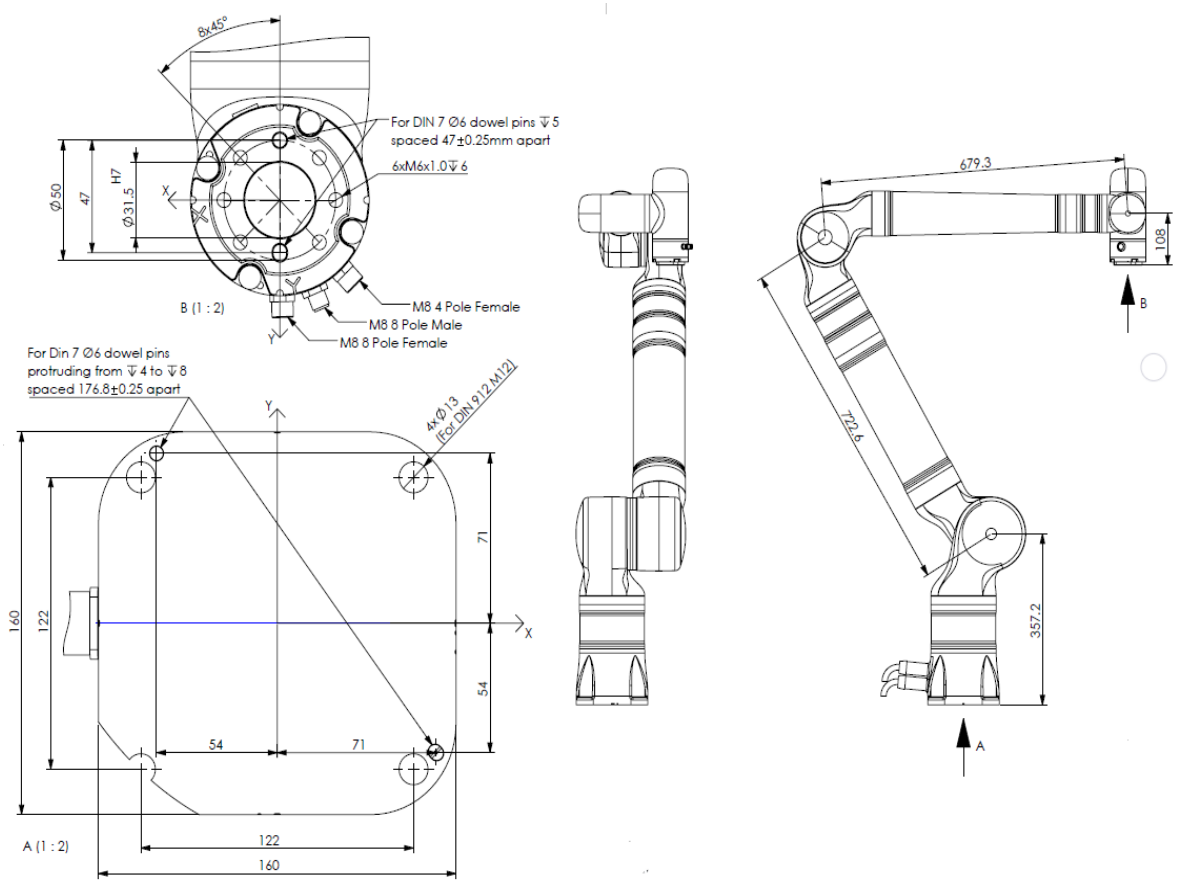

Figure 5: Diagram of Robot Model KR1410

Description	Value
Reach [mm]	1400
Operating temperature range [°C]	0-45
Operating humidity [%RH]	30-85 non condensing
Operating Altitude [m]	3000
Weight [kg]	35
AC Power connector	1 Phase CEE
Typical Power consumption (with max load) [W]	400-1200W
Supply voltage [VAC]	100-120 and 200-240 (50/60hz)
Supply current (Pre-fuse requirement) [A]	16
IO power supply [VDC]	24
Digital input max voltage limits [VDC]	Max 30V
Max. joint speed [°/s]	163/225
Max. static force on tool flange centre (payload) [kg]	10
Max. static torque on tool flange centre [Nm]	25
Required bed plate flatness [mm/m]	0.5
Sound level [dB]	Below 70dB (A)
Ingress protection	IP54
Joint ranges [°]	Joint 1,3,5,6,7 +/- 360 Joint 2,4 -70/+180
Cable lengths [m]	5m Controller to robot arm 4.5m Controller to Teach Pendant
Footprint [mm]	160 x 160

4.5 Robot Model KR1805

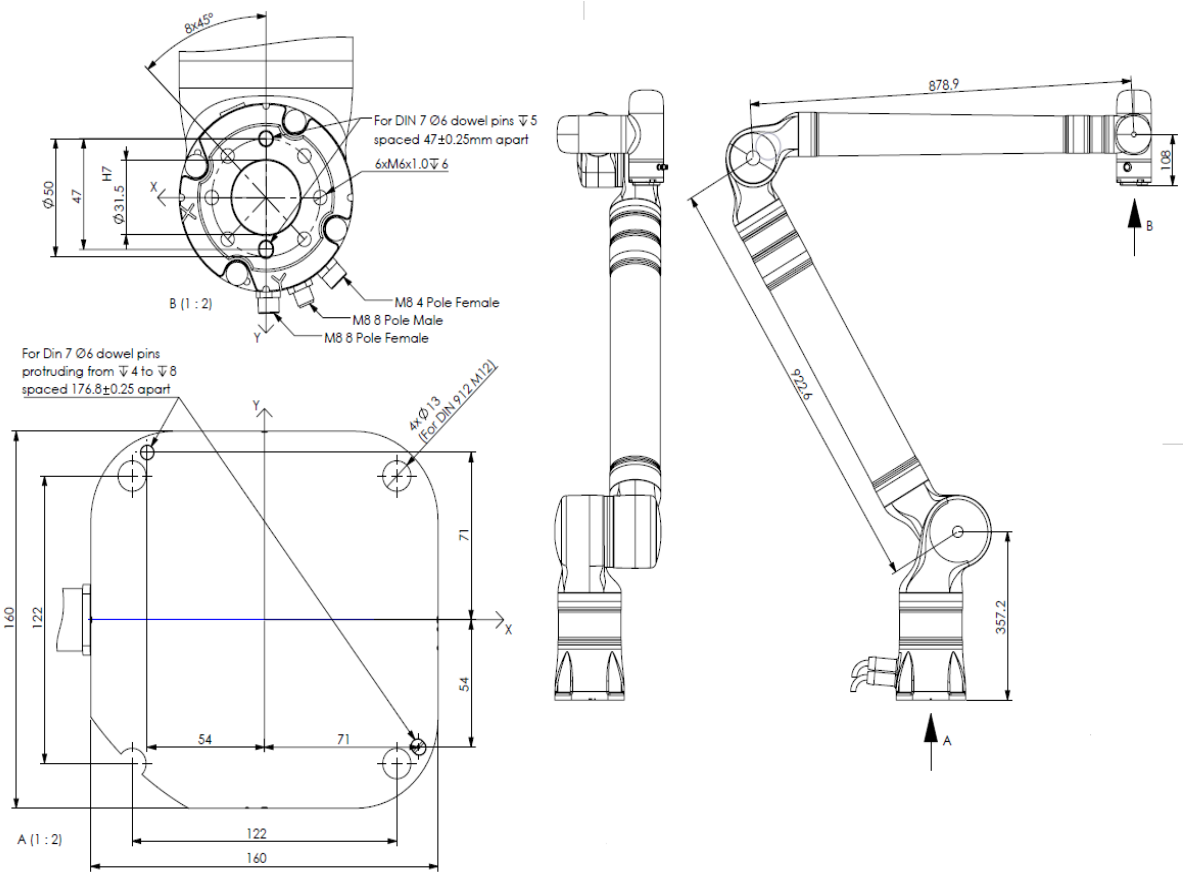

Figure 6: Diagram of Robot Model KR1805

Description	Value
Reach [mm]	1800
Operating temperature range [°C]	0-45
Operating humidity [%RH]	30-85 non condensing
Operating Altitude [m]	3000
Weight [kg]	38
AC Power connector	1 Phase CEE
Typical Power consumption (with max load) [W]	400-1200W
Supply voltage [VAC]	100-120 and 200-240 (50/60hz)
Supply current (Pre-fuse requirement) [A]	16
IO power supply [VDC]	24
Digital input max voltage limits [VDC]	Max 30V
Max. joint speed [°/s]	163/225
Max. static force on tool flange centre (payload) [kg]	5
Max. static torque on tool flange centre [Nm]	25
Required bed plate flatness [mm/m]	0.5
Sound level [dB]	Below 70dB (A)
Ingress protection	IP54
Joint ranges [°]	Joint 1,3,5,6,7 +/- 360 Joint 2,4 -70/+180
Cable lengths [m]	5m Controller to robot arm 4.5m Controller to Teach Pendant
Footprint [mm]	160 x 160

4.6 Payload Diagram

Due to the static torque limit of the wrist joints, the allowed payload is reduced if the distance between the payload centre of gravity and the tool flange centre is over 150 mm. The payload diagram shows the allowed payload as a function of this distance.

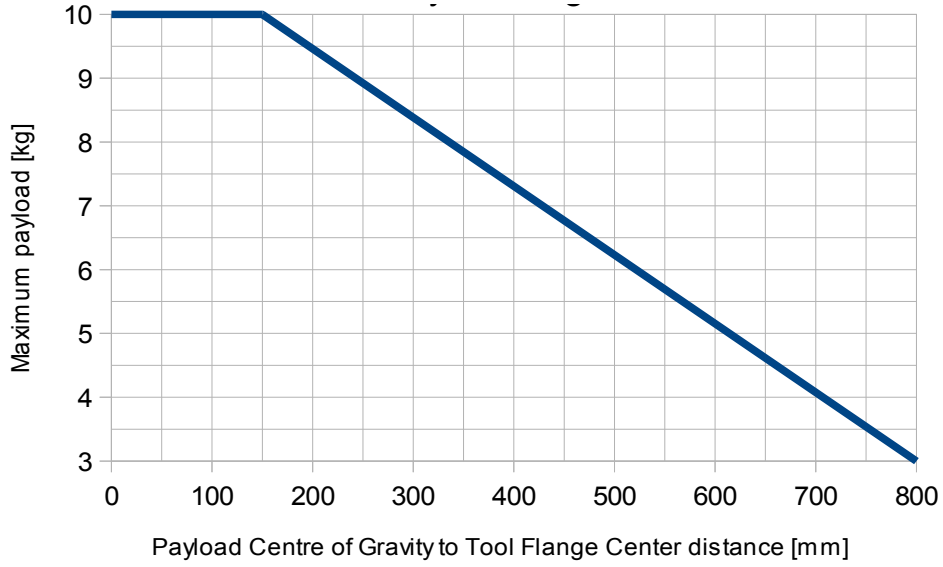

Figure 8: Payload diagram

4.7 Stopping Distance

The time and distance it takes to stop the robot, for instance with an emergency stop or protective stop, depends on the load, speed and configuration of the robot.

Conservative estimations of the stopping time and distance are made by firstly identifying how fast the slowest joints can decelerate. This depends on the payload, the direction in which the payload is heading relative to gravity, and the distance between the load or *TFC* and joint axis 1 or 2, depending on whatever distance is the longest.

The values can be seen the table below.

Load [kg]	Direction [deg]	Distance from Joint axis 1 or 2 to Load centre of gravity or Tool Flange Center, whichever is larger						
		800-950	700-800	600-700	500-600	400-500	300-400	0-300
7-10	0-40	292	416	610	883	1274	1833	2606
	40-80	427	563	768	1052	1453	2017	2783
	80-120	767	934	1168	1481	1907	2483	3232
	120-160	1155	1356	1623	1969	2423	3013	3742
	160-180	1408	1631	1920	2287	2760	3359	4074
4-7	0-40	478	611	839	1151	1580	2165	2928
	40-80	612	754	992	1313	1748	2334	3087
	80-120	950	1117	1380	1723	2175	2762	3487
	120-160	1335	1531	1821	2190	2661	3250	3943
	160-180	1587	1800	2109	2494	2977	3568	4240
0-4	0-40	763	887	1158	1511	1976	2573	3300
	40-80	895	1026	1304	1663	2131	2724	3437
	80-120	1230	1378	1674	2049	2522	3106	3782
	120-160	1612	1779	2096	2487	2968	3541	4175
	160-180	1861	2040	2371	2773	3259	3824	4432

Table: Braking accelerations

The table states braking accelerations a_{brake} at different robot configurations and loads *[deg/s²]*. The "Direction" is defined as an angle *[deg]* between the direction of the load and gravity.

The stopping time can now be conservatively estimated based on the knowledge of the set speed in the robot program. If the set speed is a joint speed, this value is used directly. If the set speed is a linear *TCP* speed or a general workspace speed limitation v_{max} *[mm/s²].T his value is converted into joint speed* ω, again using the distance between shoulder joints and either load or tool flange centre r *[mm].*

$$\omega = 180\frac{v_{max}}{r\pi} \qquad [deg\ s^{-1}]$$

The braking time t_{brake} *[seconds],* and braking distance s_{brake} *[mm],* is now calculated as:

$$t_{brake} = \frac{\omega}{a_{brake}} + 0.020 \qquad [s]$$

$$s_{brake} = \frac{(t_{brake} + 0.02)\ \pi r w}{360} \qquad [mm]$$

Example:

The robot is running in reduced speed mode (*"rabbit"),* corresponding to a maximum frame speed of 1000 *mm/s*.

In the portion of the program where the robot moves fast, the load is 5 kg, and the load is moved roughly in the horizontal plane around 750 mm from the Joint 1 axis, when this distance peaks. A horizontal plane movement corresponds to an angle between gravity and load direction of 90 degrees.

From the table above, it can be seen that the robot is capable of decelerating at 1117 *deg/s*^{2}. Angular speed, stopping time and stopping distance are:

$$\omega = 180\frac{v_{max}}{r\pi} = 180\frac{1000}{750\ \pi} \approx 76.4 \qquad [deg\ s^{-1}]$$

$$t_{brake} = \frac{\omega}{a_{brake}} + 0.020 = \frac{76}{1117} + 0.020 \approx 0.088 \qquad [s]$$

$$s_{brake} = \frac{(t_{brake} + 0.02)\ \pi r w}{360} = \frac{(0.088 + 0.02)\ \pi \times 750 \times 76}{360} \approx 54 \qquad [mm]$$

5 Handling

This section describes how the robot should be operated in various situations. Where specific personal qualifications are required, they will be described.

Installation and dismounting of the robot must be carried out by qualified and trained personnel. All safety instructions must be observed in order to prevent accidents.

As mentioned earlier in the manual, the robot arm, controller, Teach Pendant, cables and documents are delivered by Kassow Robots in two suitable boxes which can be handled safely by one person.

The delivery boxes can also be used for safe storage, if necessary.

5.1 Unpacking and General Handling of the Robot Arm

When unpacking the robot, it must be checked if the robot has been damaged during transport. Any damage affecting the functionality or safety of the robot must be repaired before the robot is put into operation.

Unpacking the robot arm:

- The robot arm can be taken directly from the box to the mounting platform by two persons, one holding the robot arm while the other mounts the robot base with four screws.
- If the robot arm needs to be stored temporally after being removed from the box, it should be stored on a soft surface.
- The robot controller can be placed directly on the floor or mounted on the wall using the wall mounting brackets.
- The Teach pendant can be placed in the Teach pendant bracket in front of the controller or on a wall.
- Cables are connected once the controller and robot arm have been mounted correctly.

5.2 Safe Disposal of Packing Material and Robot Arm

Packing materials, robot arm, control cabinet and Pendant must be disposed of according to local legislation.

5.3 Installation and Assembly of the Robot Arm

5.3.1 Electrical Installation

The robot must only be connected by an authorized electrician. Installation is subject to national legislation.

For proper connection and information of voltage and power consumption, see the Specification tables in chapter 4.

The robot is supplied with power via the single-phase CEE connector on the front. The pre-fuse requirement is 16A for 230V installations and 32A for 110V installations.

Ensure the input power to the controller is protected with a Residual Current Device (RCD).

The controller must be properly grounded through the ground connection in the power cable. Always ensure that electrical installation is made in a star configuration when the robot is installed alongside other equipment where large current transients are present such as electric motors, solenoids, welding equipment etc.

The circuit breaker of the robot is placed on the left side of the controller cabinet.

5.3.2 Installing the Robot

The following are instructions to install the robot:

1. First of all, a sturdy mount for the robot must be constructed (see chapter 4 for layout of base).

2. 4 pcs of M10 DIN 912 (grade 10.9 or higher) bolts must be used to secure the robot to the constructed mount, either by taping M10 holes in the mount or using an M10 nut on the other side of the holes in the mount. The bolts must be torqued to minimum 70Nm (or higher if a higher grade is used).

3. The mount MUST be able to withstand 500Nm and 1000N of force in any direction. The more rigid it can be made, the better. Any deflection in the mount will be multiplied at the end of the tool affecting precision in respect to payload and speed. Generally, it should not deflect by more than 3-5 mm as a maximum under full speed and load.

4. Various tools can be mounted on the mounting flange on the robot (see diagram below).

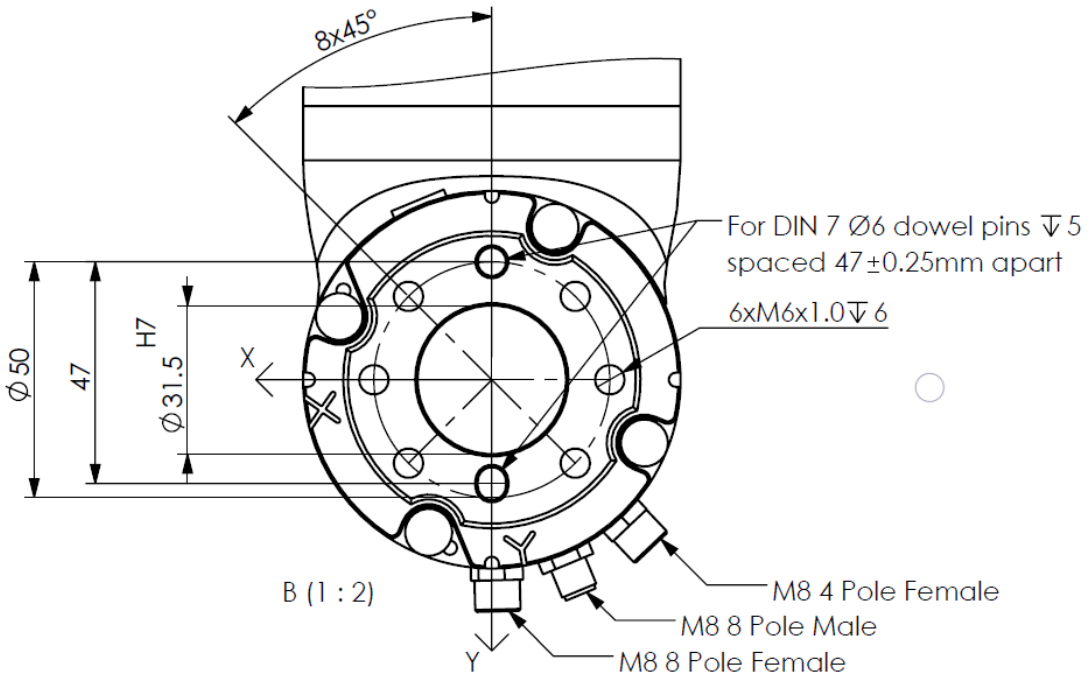

Figure 9: Robot arm tool flange

6 Operating the Robot Arm

The following describes how the robot arm is operated properly and safely. The safety instructions described in this instruction manual must be observed.

Refer to the Software Manual and Controller Cabinet Documentation for detailed descriptions.

6.1 Safe Operation

The integrator of the collaborative robot must provide an overall Declaration of Conformity (CE) regarding the work area. Special attention must be paid to the tools applied to the collaborative robot and external emergency stop and safety functions.

6.2 Error Situations

Errors are communicated on the Teach pendant. Any error description can be accessed by pushing the red triangle on the upper right side of the display, POS 8 on Figure 10. **Refer to the Software Manual for details.**

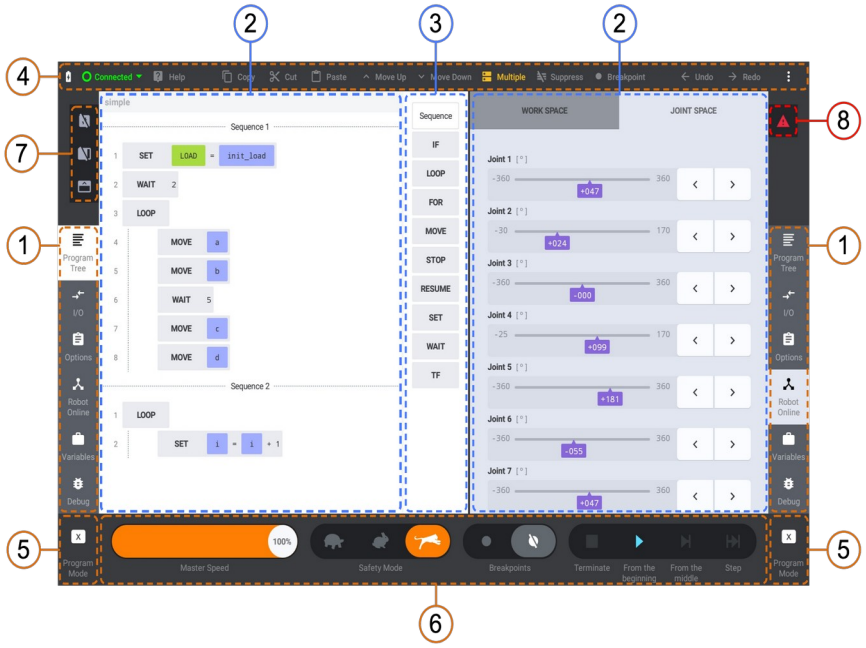

Figure 10: The main screen on the Teach Pendant

6.3 Hard Reset of Tablet

If the Teach pendant is frozen beyond recovery by the software, a hardware reset can be necessary. The procedure is simple:

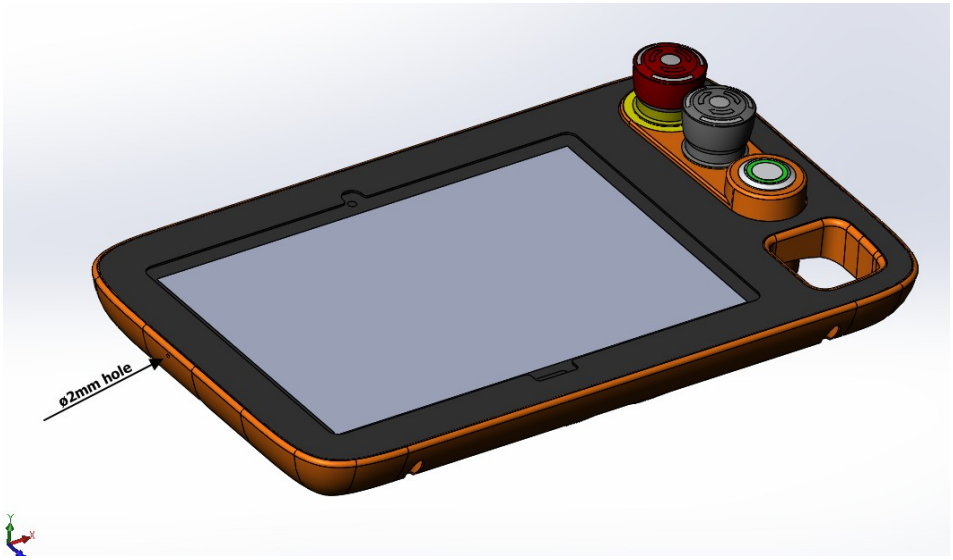

Figure 11: Diagram of location of ø2 mm hole on Teach Pendant

1. Locate the small ø2 mm hole on the left side of the Teach pendant.
2. Use the small tool delivered with the robot* and guide it into the hole.
3. Push it in until you feel that the button inside the cover is pushed.
4. Hold it until the restart option opens on the screen and select this option.
5. The Teach pendant will restart and automatically boot and open the robot controller screen.
6. You have now successfully restarted the Teach pendant.

If the restart option does not open:

1. Keep pushing (8 sec) until the Teach pendant shuts down.
2. Release the button and press again once to start the Teach pendant.
3. The Teach pendant will restart and automatically boot and open the robot controller screen.

4. You have now successfully restarted the Teach Pendant.

*If this tool is lost, you can use the shank of a 2 mm drill bit (do not use the sharp end of the drill!).

6.4 Signals to be Observed

A button on the Teach pendant shows the different states of the robot.

Green
Robot is operating normally

Flashing green
Robot is holding its position/is paused. Program can be resumed

Red
Emergency stop / Protective stop is activated

Yellow
RC detected an unusual event

Blue
Indicates that the robot is in a 'ready to initialize' phase.

Figure 12: Teach Pendant (toggle/resume button)

6.5 Accessories

If the robot arm is to be placed in extremely dusty, wet, hot or cold environments, please contact Kassow Robots for advice on additional equipment.

6.6 Service Intervals, Maintenance and Cleaning

The daily tidying-up and cleaning of the robot and its surroundings is carried out by the operator or specially trained cleaning staff. During this work, the same requirements for the use of tools and personal protective equipment apply as for the operational work.

It is recommended to clean visible and reachable surfaces which are contaminated with a moist cloth and soap.

It is recommended to perform service on the robot at least every 12 months.

6.7 List of Spare parts and Consumables

Order-able part number	Description
FRU01200227	Robot arm power and communication cable
FRU02200227	Teach pendant complete with cable
FRU03200227	Tool flange
FRU04200227	Emergency stop button for Robot controller or Teach Pendant
FRU05200227	Protective stop button for Robot controller or Teach Pendant
FRU06200227	230 V CEE mains power cable 5m
FRU07200227	Motor 80 field replaceable unit
FRU08200227	Motor 60 field replaceable unit
FRU09200227	Motor 50 field replaceable unit
FRU10200227	Rotor Encoder PCB
FRU11200227	Joint Encoder PCB
FRU13200227	Joint 60 cable harness
FRU14200227	Joint 50 cable harness
FRU15200227	Joint Controller module
FRU16200227	Male/Male communication cable
FRU17200227	Female/Female communication cable
FRU18200227	Male/Female communication cable

No changes may be made to the robot arm control cabinet. Any replacement, service and maintenance of parts must be done by Kassow Robots or by one of its service partners.

7 Controller

This section contains general information about the controller, and detailed information about the parts of the controller which the user will use directly.

The controller has the following 3 main purposes:

1. Providing power to the robot arm and controlling it
2. Providing electric interfaces to connect the robot with external devices
3. Providing Emergency stop, Protective stop and Pause/Resume buttons. These allow the simple control of the Robot program execution and exchange of information with the Teach Pendant, which allows the user to program the Robot system and see and manipulate the state of the Robot arm and the Controller.

7.1 Controller Outside

This chapter provides a quick overview of all the elements in the Controller. Some of the elements refer to other chapters in the manual. The functionality of the components on the outside of the Controller can be seen below.

Figure 13: Outside of Controller

- The Controller and any robot connected to it are turned on when the main on/off switch is turned to position “1”.
- When the switch is turned to position “0”, the robot controller will initiate a shutdown procedure, and only after the coloured light indicator ring is turned off will the cabinet no longer be powered.
- Never dismantle the Controller without unplugging the connection to the wall socket.
- The Controller is ventilated by fans placed in the cabinet base.
- The Controller should never be turned on while standing on the floor or in a dusty environment, since the dust may be sucked into the cabinet by the ventilation fans and damage the electronics inside the cabinet.
- The replaceable cable through hole plate allows the user to equip the cabinet with, for instance, a plate with a hole fitted to the cable bundle going to the controller’s electric connections in a particular robot installation.
- The Controller door can be opened by a key, which is delivered with the Controller.
-

The main power on/off switch is not considered an emergency stop.

7.2 Controller Inside and Electric Connections

This section provides an overview of the inside of the Controller. Each input/output has its own subsection with a functional description.

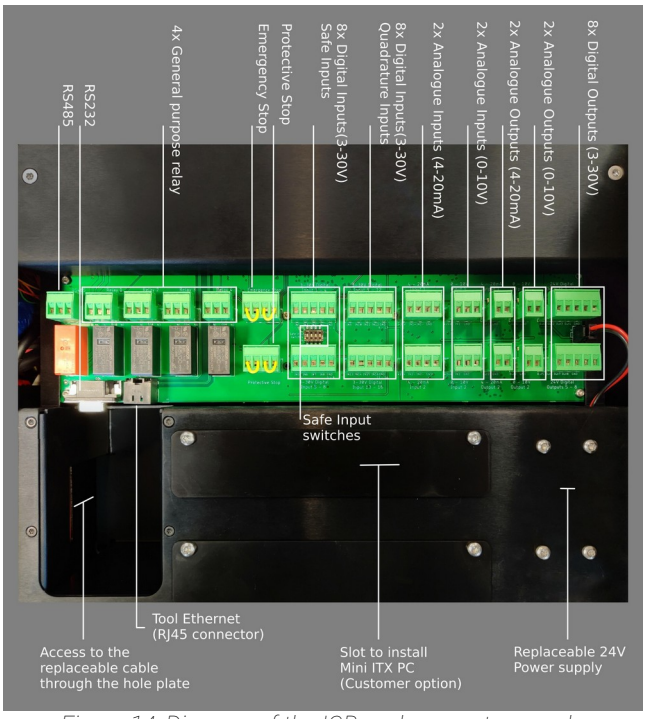

Figure 14: Diagram of the IOBoard connector panel

7.3 RS485

The controller provides the user with RS485 communication, where the controller is the master. The controller can send messages with a baud-rate of maximum 1Mbit/s.

A connection should be set up according to the following diagram:

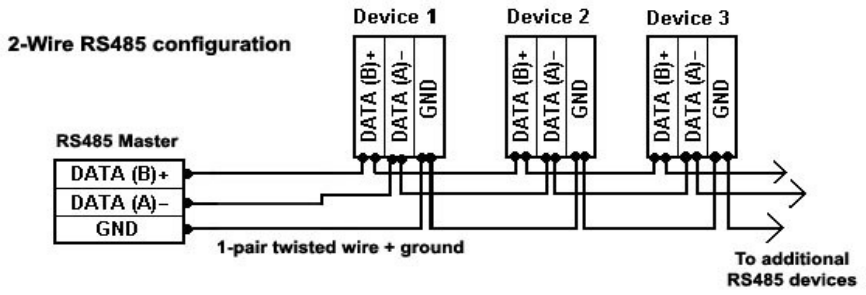

Figure 15: 2-Wire RS485 connection schema

7.4 RS232

The controller can also communicate through the RS232 connection, which has a standard D-SUB9 plug connector. The following diagram describes the pin-out:

1. Not Connected
2. TX
3. RX
4. Not Connected
5. GND
6. Connected to pin 9
7. CTS
8. RTS
9. Connected to pin 6

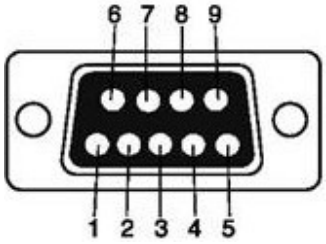

Figure 16: RS232 connector schema

7.5 Tool Ethernet

This is the Ethernet extension to the 4pole connector in the tool head. This Ethernet line can be used for auxiliary purposes (sensor, camera etc.). The Ethernet extension can, for instance, be connected in the cabinets empty Mini ITX PC slot to a customer-installed PC for vision processing or other data processing.

For further details regarding the wiring schema, please check the chapter 8.1.3 which is dedicated to ToolIO.

7.6 General Purpose Relays

There are 4 general purpose relays that can either be normally-open or normally-closed. The relays are rated at **250VAC/10A** on one single input, but rated at **20A** in total.

Relays can be controller through the TP user interface and mapped to custom variable for the programming purposes. Each relay has its own indicator diode that lights up when the relay is activated.

7.7 Emergency stop and Protective stop

The user can connect external Emergency and/or Protective stop switches. The external switch must contain two normally-closed contacts.

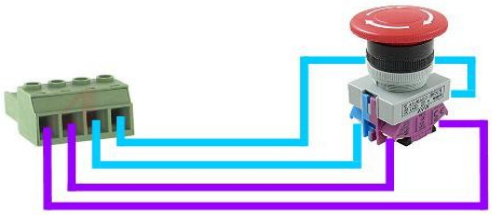

Figure 17: External E-Stop circuit wiring schema

7.8 Digital Inputs (3-24V)

There are total of 16 digital inputs available in the Kassow Robots RC, where each can properly operate up to the voltage of **24VDC** but can handle a voltage rating of 30VDC.

The 16 inputs are split into four plug connectors. Each plug has 4 inputs and 1 common ground and is galvanic isolated from the rest of the system.

Each input has an indicator diode that lights up when the input is recognized as high (**above 3V**).

Digital Input values can be directly monitored in real-time through the TPUI and mapped to custom variables for the programming purposes.

Optionally, the set **DI01-DI08** of Digital Inputs can be configured and used as 4 independent **safe inputs**. The set of **DI09-DI16** Digital Inputs provides 2x independent **quadrature interface** to connect quadrature encoders.

Figure 18: Diagram of digital inputs
(here demonstrating various high levels for each one of them)

7.9 Analogue Inputs (4-20mA)

The controller provides two **4-20mA** inputs, which support 2wire, 3wire and 4wire 4-20mA outputs.

The resolution is **12bit**. The indicator diode lights up when the input is above **4mA**.

Analogue Input values can be directly monitored in real-time through the TP UI and mapped to custom variables for programming purposes.

7.10 Analogue Inputs (0-10V)

The IOBoard user interface provides two **0-10VDC** inputs.

The resistance from the source should be **10Kohm**. The resolution is **12bit**. The indicator diode lights up when the input is above **2VDC**.

Analogue Input values can be directly monitored in real-time through the TPUI and mapped to custom variables for the programming purposes.

7.11 Analogue Outputs (4-10mA)

The controller user interface provides two **4-20mA** outputs.

The resolution is **12bit**. The indicator diode lights up when the input is above **4mA**.

Analogue Output values can be controller through the TPUI and mapped to custom variables for the programming purposes.

7.12 Analogue Outputs (0-10V)

The controller provides two **0-10VDC** outputs.

The resolution is **12bit**. An indicator diode lights up when the input is above **2VDC**.

Analogue Output values can be controller through the TPUI and mapped to custom variables for the programming purposes.

7.13 Digital Outputs (0-24V)

The controller provides eight **24VDC** outputs.

The 8 outputs can deliver up to **4A together** if the internal **24VDC** power supply provides it.

An indicator diode lights up when the output is high (24V).

Digital Output values can be controller through the TPUI and mapped to custom variables for the programming purposes.

7.14 Replaceable 24VDC Power supply

The controller comes with a **24VDC** Power supply rated to output **6.5A**. The user can replace this with a more powerful 24VDC Power supply if required.

Kassow Robots is not liable for EMC performance or any failures or malfunction that may occur if the PS is replaced.

The user or integrator must perform the necessary validation to ensure the integrity of the entire system.

7.15 Safe Inputs

The Kassow Robots RC provides Safe Inputs that allows to integrate the robotic system with peripherals and controls in applications, where redundant and highly reliable digital signal exchange is required.

Digital Inputs **DI01-DI08** can be set and configured exactly for this purpose.

The setup assumes use of two redundant complementary inputs (A and B) for a particular safe input. The **Safe Input switch** has to be set into ON position (up) to “couple” given input signals. Once the digital input pair was “coupled”, the RC will report **P-Stop** state anytime the redundant input signals do not match.

As the result it is possible to configure 8 standard digital inputs as 4 safety inputs complying with **PL-d** structure **category 3**.

Please note, the input levels and programming are identical to regular use of those described in the paragraph above (7.8).

Safe Input	IOBoard Digital Input	Description
SDI01	**DI01** **DI02**	Safe input 1 signal A Safe input 1 signal B
SDI02	**DI03** **DI04**	Safe input 2 signal A Safe input 2 signal B
SDI03	**DI05** **DI06**	Safe input 3 signal A Safe input 3 signal B
SDI04	**DI07** **DI08**	Safe input 4 signal A Safe input 4 signal B

7.16 Quadrature Inputs

Quadrature encoders are handy sensors that let you measure the speed and direction of a rotating shaft (or linear motion) and keep track of how far you have moved.

With the Kassow Robots RC Digital Inputs **DI09-DI16** can be optionally used to provide 2 independent quadrature interfaces. Specifically, inputs **DI09-DI11** for the first one and **DI13-DI15** for the second one.

The inputs shall be capable of accepting frequency rates starting from **45kHz** quadrature signal, whereby the voltage levels are the same as for normal digital inputs (0-30V).

To use the quadrature encoder with the RC, the encoder A, B and Z signals have to be connected with the chosen quadrature set of Digital Inputs.

IOBoard Digital Input	Specification
DI09	Quadrature 1 input pulse signal **A**
DI10	Quadrature 1 input pulse signal **B**
DI11	Quadrature 1 index signal **Z**
DI12	-
DI13	Quadrature 2 input pulse signal **A**
DI14	Quadrature 2 input pulse signal **B**
DI15	Quadrature 2 index signal **Z**
DI16	-

Having the quadrature encoder properly connected and powered, the user has to specify Lines per Revolution (**LPR**) setting to activate the DSP processing. Navigate to the *IO/Input/Quadratures* section using the TP UI and open the configuration dialog by a single tap on any "Q" item. Set the LPR value (given by the encoder range) and confirm by using the *Apply* button.

This will activate the DSP responsible for the quadrature encoder signal reading and processing.

Once the DSP and encoder reading was initiated, the basic quadrature variables (*IO/Output/Quadratures*) are available for the real-time inspection through the TP UI. These values can be also mapped to custom variables for the programming purposes.

Quadrature output variables	Description
QDR01	Quadrature 1 direction (+1/-1)
QDR02	Quadrature 2 direction (+1/-1)
QALC01	Quadrature 1 absolute lines count
QALC02	Quadrature 2 absolute lines count
QF01	Quadrature 1 frequency
QF02	Quadrature 2 frequency
QLCNT01	Quadrature 1 lines count (per given LPR)
QLCNT02	Quadrature 2 lines count (per given LPR)
QLPS01	Quadrature 1 lines per second
QLPS02	Quadrature 2 lines per second

8 Tool IO

Kassow Robots are equipped with an advanced Tool flange containing 3 connectors and a push button.

The Push button can be used to activate the back-drive to freely move the robot by hand to teaching positions. The 3 M8 circular connectors contain a large range of I/O and Power supply signals. Signal description and specification can be found in the tables stated below.

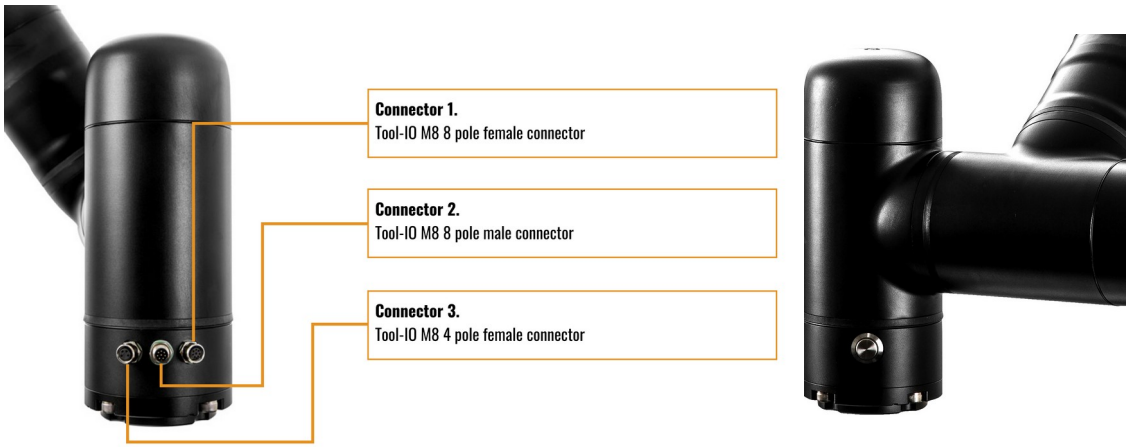

Figure 19: Connectors for ToolIO

Please refer to the SW manual and the Kassow Robots online documentation on how to program and operate the Tool IO.

Make sure when installing an end effector that it is designed/configured in such a way that total power loss will not cause the payload to fall out of the tool/gripper. Pushing the emergency stop on the robot will remove power from the entire robot including the Tool IO.

8.1 I/O connectors

Connectors 1. and 2. are used for the regular I/Os and RS485 to connect grippers or other digital peripherals. Further programming specifics and routing details can be found in the software documentation.

8.1.1 M8 8-pole female connector

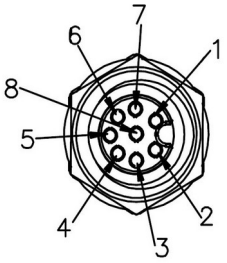

Figure 20: ToolIO M8 8-pole female connector (1)

Pin no.	M8 8-pole female connector	Specification
8	Ground	N/A
5	0V/12V/24V DC Power output 1	12V or 24V +5% / -15% .
7	Digital Output 1	12 or 24 V +5% / -15% max 100mA *
6	Digital Output 2	12 or 24 V +5% / -15% max 100mA *
4	Analogue output 1	4-20mA or 0-10V
3	Analogue output 2	4-20mA or 0-10V
1	4-20mA in +	Max 12V relative to GND
2	4-20mA in -	Max 12V relative to GND

* The total combined current that can be drawn from the Tool IO is below 800mA @24V or 1.6A @12V. Exceeding the specification may damage the electronics or cause robot to stop. The digital outputs are equivalent to PNP outputs and pin will be pulled to 12/24V when set to 1.

8.1.2 M8 8-pole male connector

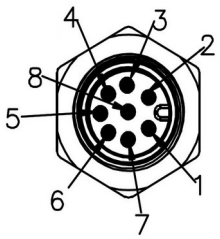

Figure 21: ToolIO M8 8-pole male connector (2)

Pin no.	M8 8-pole male	Specification
8	Ground	N/A
5	V/12V/24V DC Power output 2	12V or 24V +5% / -15% max 700mA *
7	Digital Output 3	12 or 24 V +5% / -15% max 100mA *
6	Digital Output 4	12 or 24 V +5% / -15% max 100mA *
4	Analogue Input 3	0-10V input, 30V max
3	Analogue Input 4	0-10V input, 30V max
1	RS 485 +	Baud rate programmable Up to 1Mbps
2	RS 485 -	Baud rate programmable Up to 1Mbps

* The total combined current that can be drawn from the Tool IO is below 800mA @24V or 1.6A @12V. Exceeding the specification may damage the electronics or cause the robot to stop. The digital outputs are equivalent to PNP outputs and pin will be pulled to 12/24V when set to 1.

8.1.3 M8 4-pole male connector (100BASE-TX uplink)

This 4 pole outlet connects two twisted pairs providing the 100Mbit independent uplink which is terminated inside the RC cabinet by a RJ45 connector (check the IOBoard interface overview at *Figure 13*, paragraph 7.2).

It can be used for connecting an IP camera in the tool to a PLC or PC standing next to the robot controller.

The two twisted pairs can be used for Ethernet communication or signals such as IO-link or MODBUS TCP or RTU. The wires are not shielded and run through the robot arm.

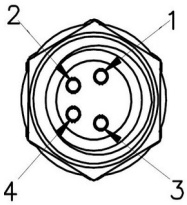

Figure 22: ToolIO M8 4-pole male connector (3)

M8 4-pole (3) pin no.	100BASE-TX specification	EIA/TIA 568B Ethernet UTP
1	TX-_D1	RJ45 pin 2 (solid orange)
2	TX+_D1	RJ45 pin 1 (white with orange stripe)
3	RX-_D2	RJ45 pin 3 (white with green stripe)
4	RX+_D2	RJ45 pin 6 (solid green)

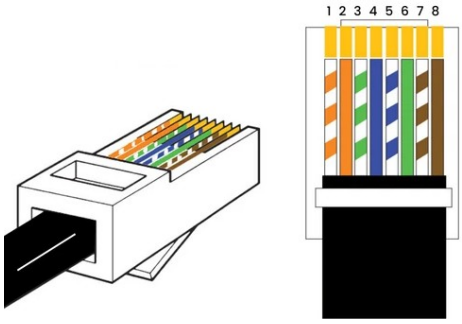

Figure 23: RJ45 Pinout T568B Ethernet UTP