MECADEMIC

INDUSTRIAL ROBOTICS

MC-UM-MCS500

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Contents

User Manual for the MCS500 Industrial Robot

For firmware version: 11.1

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Original instructions

About this manual

This manual describes how to use MCS500 industrial robot system (revision R1). It will guide you through the steps required for setting up your MCS500 and for using it in a safe manner. You must read this user manual thoroughly during the unpacking and first use of your MCS500.

Symbol definitions

The following table lists the symbols that may be used in Mecademic documents to denote certain conditions. Particular attention must be paid to the warning and danger messages in this manual.

Note

Identifies information that requires special consideration.

Warning

Provides indications that must be respected in order to avoid equipment or work (data) on the system being damaged or lost.

Danger

Provides indications that must be respected in order to avoid a potentially hazardous situation, which could result in injury.

Revision history

The firmware that is installed on Mecademic products has the following numbering convention:

{major}.{minor}.{patch}.{build}

Each Mecademic manual is written for a specific {major}.{minor}.{*}.{*} firmware version. On a regular basis, we revise each manual, adding further information and improving certain explanations. We only provide the latest revision for each {major}.{minor}.{*}.{*} firmware version. Below is a summary of the changes made in each revision.

Revision	Date	Comments
B	July 14, 2025	Revision of Sections 2 and 5. Replaced references to “Power supply” with “MSIPS module”.
A	March 17, 2025	Original version

The document ID for each Mecademic manual in a particular language is the same, regardless of the firmware version and the revision number.

Introduction

The MCS500 is a four-axis industrial robot arm of type SCARA that is easy to use, robust, and lightweight. However, the robot is a precision device with rapidly moving parts and should therefore be used only by *trained technical personnel* who have read and understood this user manual, to avoid damages to the robot, its end-effector, the workpiece and adjacent equipment, and, most importantly, to avoid injuries.

> **Warning**
>
> DO NOT remove the contents of the box until you read Section 4.

Inside the box

The following table lists the items that come with a standard shipment of an MCS500 robot system.

Table 1: Standard parts lists

Qty	SKU	Description	Photo
1	9101-002 OR 9101-003	MCS500-R1, SCARA robot arm OR MCS500-R1-HS, SCARA robot arm with hollow spline shaft	
1	9200-002	MSIPS-R1 module	
1	9403-003	Dual D-Sub DB15 dongle	
1	2003-005	2-meter, M12 D-Code to RJ45, Ethernet cable	
1	2003-008	2-meter *proprietary* communications and DC power cable for MCS500	

Note

You are responsible for supplying the following components:

- An AC power cord with a three-prong IEC C13 connector on one end and a country-specific power plug on the other, along with a surge protector.
- M6 screws of appropriate length for securing the robot's base and MSIPS module.
- Two cables with DB15 connectors.

- A three-position enabling device.
- Properly wired safety I/O connections.

Note

Do not discard your shipping box and packing foam.

Overall description

The MCS500 is a four-axis SCARA robot consisting of four actuated joints, numbered as shown in the figure below. Joint 1 is between the base and the *proximal link* (page 71) and joint 2 is between the proximal link and the *distal link* (page 70). Finally, two motors work in tandem to control the translational and rotational movements of the *spline shaft* (page 72) with respect to the distal link. The translational motion is referred to as joint 3, while the rotational motion as joint 4. The axes of joints 1, 2, and 4 are parallel to the direction of joint 3.

A *retaining ring* (page 71) is mounted on both sides of the spline shaft. The two retaining rings are used for mounting tools but also for retaining the spline shaft. Never remove these rings or else you will permanently damage the spline shaft assembly.

In Figure 1, all joints are at their zero position. The figure also shows the positive directions of rotation or translation.

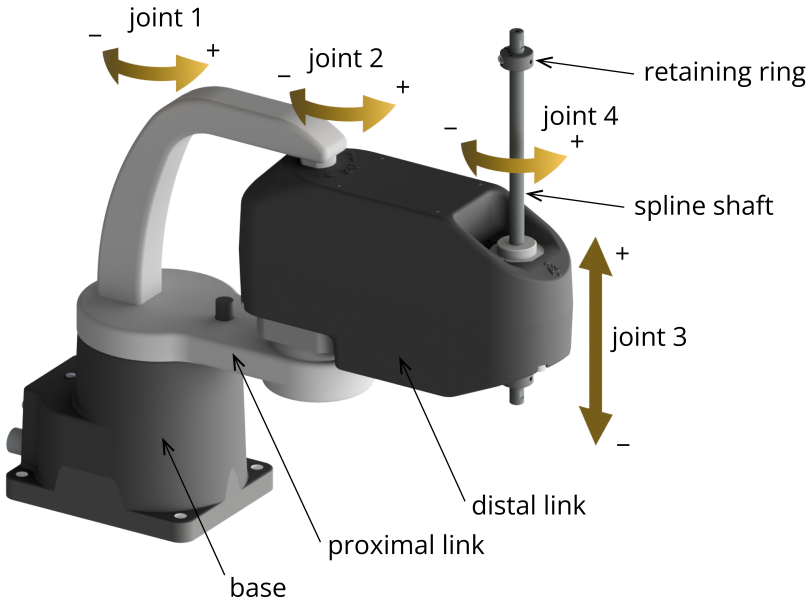


Figure 1: Joint numbering and nomenclature of the MCS500 SCARA robot

The figure below shows a schematic of the complete MCS500 robot system in a typical installation. The dual DB15 dongle provided is not shown as it must be used only during setup and testing.

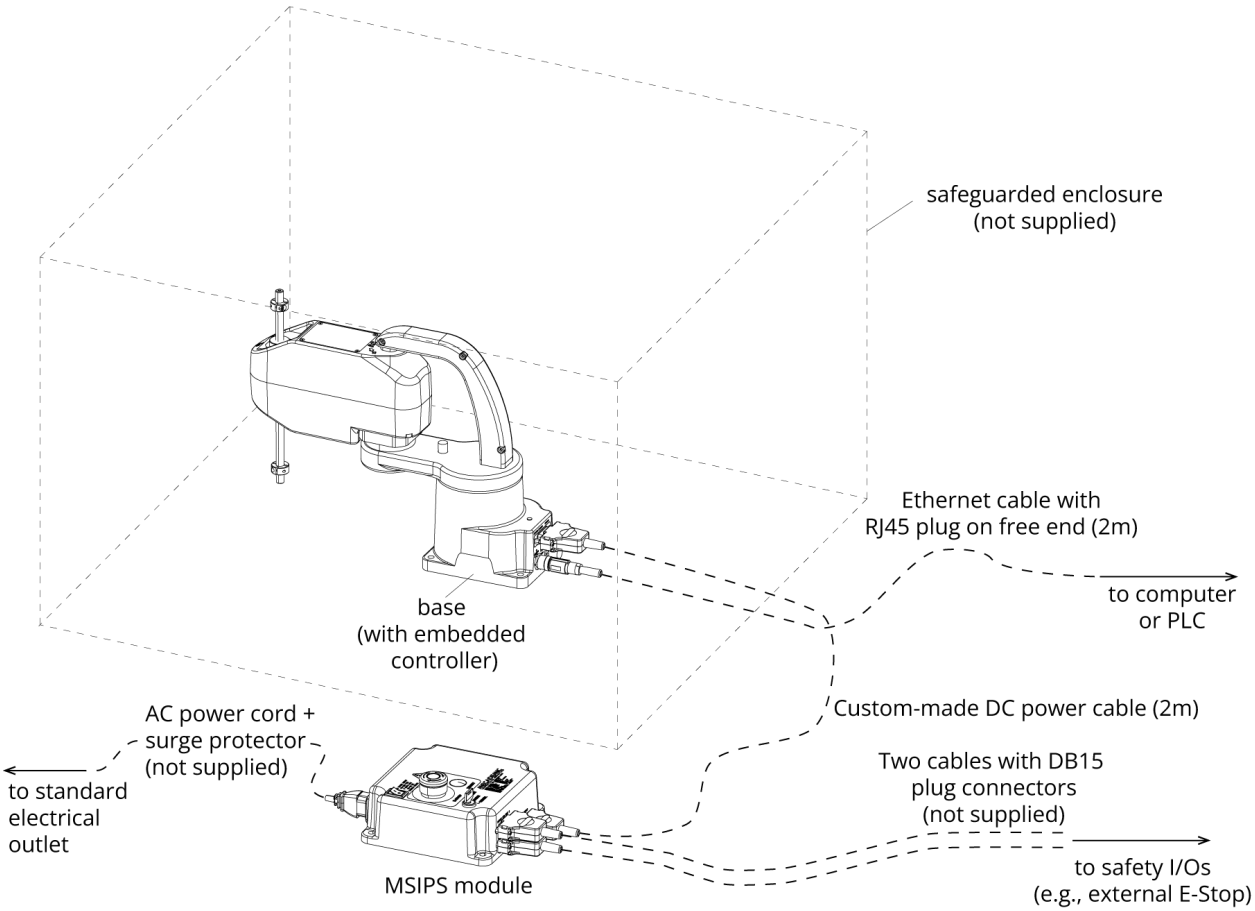


Figure 2: Schematic of the MCS500 robot system installed

Description of the MSIPS module

The MSIPS module, which includes the AC-DC power adapter, must be connected to an AC source supplying 90–250 V at 50–60 Hz, via a surge protector. *Applying AC voltage outside this range may damage the MSIPS module*.

Referring to the figure below, the main features of the MSIPS module are:

- A: system on/off switch (“I” stands for ON, “O” stands for OFF);
- B: emergency stop button (Stop Category 1), designed as PL=d with a Category 3 safety architecture, MUST BE PROPERLY WIRED IN ORDER TO FUNCTION;
- C: indicator LEDs;
- D: reset button;
- E: operating mode key switch;
- F, G: D-Sub DB15 interface for connecting safety I/Os to the robot;
- H: connector for robot communications and DC power cable.

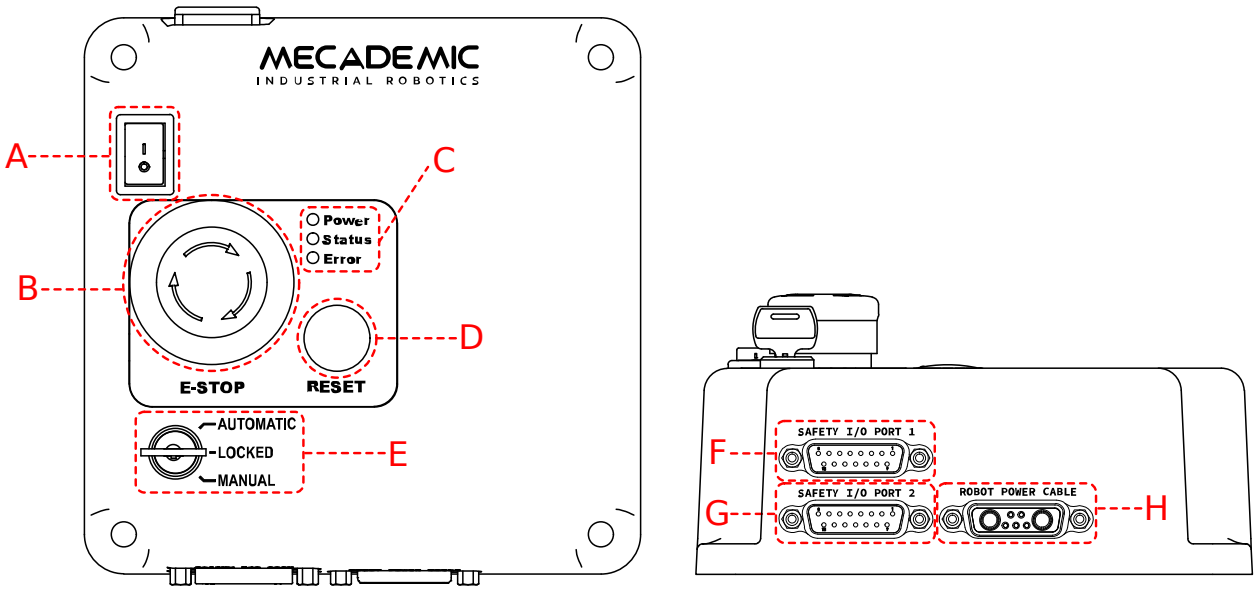


Figure 3: Description of the MSIPS module

The following illustration shows the AC power connector, of type IEC C14, and indicates the Neutral (N), Protective Earth (PE) and Live (L) pins.

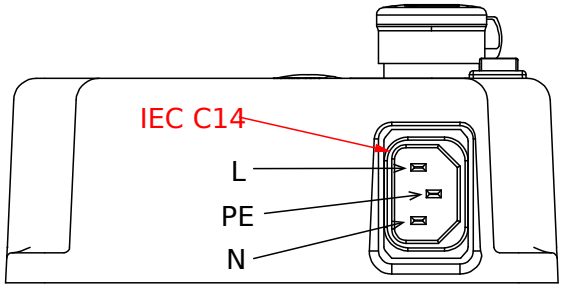


Figure 4: IEC C14 power entry receptacle on MSIPS module

Use only the supplied, custom-made, communications and DC power cable to connect the robot to the MSIPS module and never modify this cable. Once the robot is connected to the MSIPS module and the module is plugged into a suitable AC source, you may switch on the MSIPS module.

When disconnecting the AC power, either by using the on/off switch on the MSIPS module or by unplugging the AC cord, the brakes on the last two motors will engage immediately, immobilizing the spline shaft. Therefore, to avoid premature wear of the brakes, *NEVER disconnect the AC power when the robot is moving*.

When disconnecting the AC power, activating the E-Stop function or activating the protective stop 1, joints 1 and 2 of the robot become free. This minimizes the risks of pinning and pinching from the robot.

The MSIPS module is equipped with

- one E-Stop Button, *which must be properly wired in order to function*,
- one Reset button,
- one input connection for an external Reset,

safety (redundant) input connections for

- one E-Stop function (Stop Category 1),
- one external protective stop (Stop Category 1) that will be referred to as P-Stop 1,
- one external protective stop (Stop Category 2) that will be referred to as P-Stop 2,
- one external three-position enabling device,

and output connections for

- one safety (redundant) Power Status signal,
- one Reset Ready signal.

In order to be able to use the MCS500, you must properly connect your safety inputs on the D-Sub 15-position interface, as described in Section 4 or temporarily connect the dual DB15 dongle.

Safety

The MCS500 weighs less than 5 kg, but it can move very fast and cause injuries, especially when certain end-effectors are attached to its flange (e.g., a sharp tool).

Fundamental safety information

Safety symbols and signal words

The following are the three types of safety indicators used in this manual. Each is visually distinguished by a specific color, an icon, and a signal word to convey certain information.

Note

Identifies information that requires special consideration.

Warning

Provides indications that must be respected in order to avoid equipment or work (data) on the system being damaged or lost.

Danger

Provides indications that must be respected in order to avoid a potentially hazardous situation, which could result in injury.

The following table lists the safety labels and engravings on the robot arm and MSIPS module, respectively.

Table 2: Safety labels and engravings

Symbol	Description
	Read the user manual carefully before operating the robot system.
	Pinch point hazard — Keep hands and fingers away.
	Crush hazard — Stay clear of reciprocating spline shaft and robot's distal link.
	Electric shock hazard — Do not disassemble.
	Hot surface — Do not touch for extended periods.
	Sensitive material beneath — Do apply pressure on plate.
	Electrostatic sensitive device — Do not touch connectors.

Required personnel qualifications

Only trained and qualified personnel who have read and understood this manual are permitted to install, operate, maintain, or decommission the MCS500 robot system. Personnel must be familiar with applicable safety standards and should have received appropriate training in industrial robot safety procedures.

Intended use

Use the MCS500 robot system only in industrial settings for handling an end-effector. For the required operating conditions, see the remainder of this user manual.

Risk assessment

Conduct a risk assessment to satisfy legal obligations. Because the MCS500 is partly completed machinery, its safe operation depends on how it is integrated into the overall system. A qualified third-party integrator or the user acting as integrator must evaluate the hazards of the entire robot cell, including the MCS500, its end effector, and all adjacent equipment. We recommend following the guidelines of ISO 12100:2010 and ISO 10218-2:2025 when conducting and documenting this assessment.

Limitation of liability

Mecademic assumes no responsibility for injuries or damages resulting from improper installation, operation, maintenance, or unauthorized modification of the MCS500 robot system.

This manual provides comprehensive safety guidelines specific to the MCS500, but does not cover the design, installation, or operation of the complete robot application or peripheral equipment that may affect system safety. System integrators are responsible for ensuring that the complete robot application complies with all applicable laws, standards, and regulations in the relevant jurisdiction and for identifying and mitigating any significant hazards.

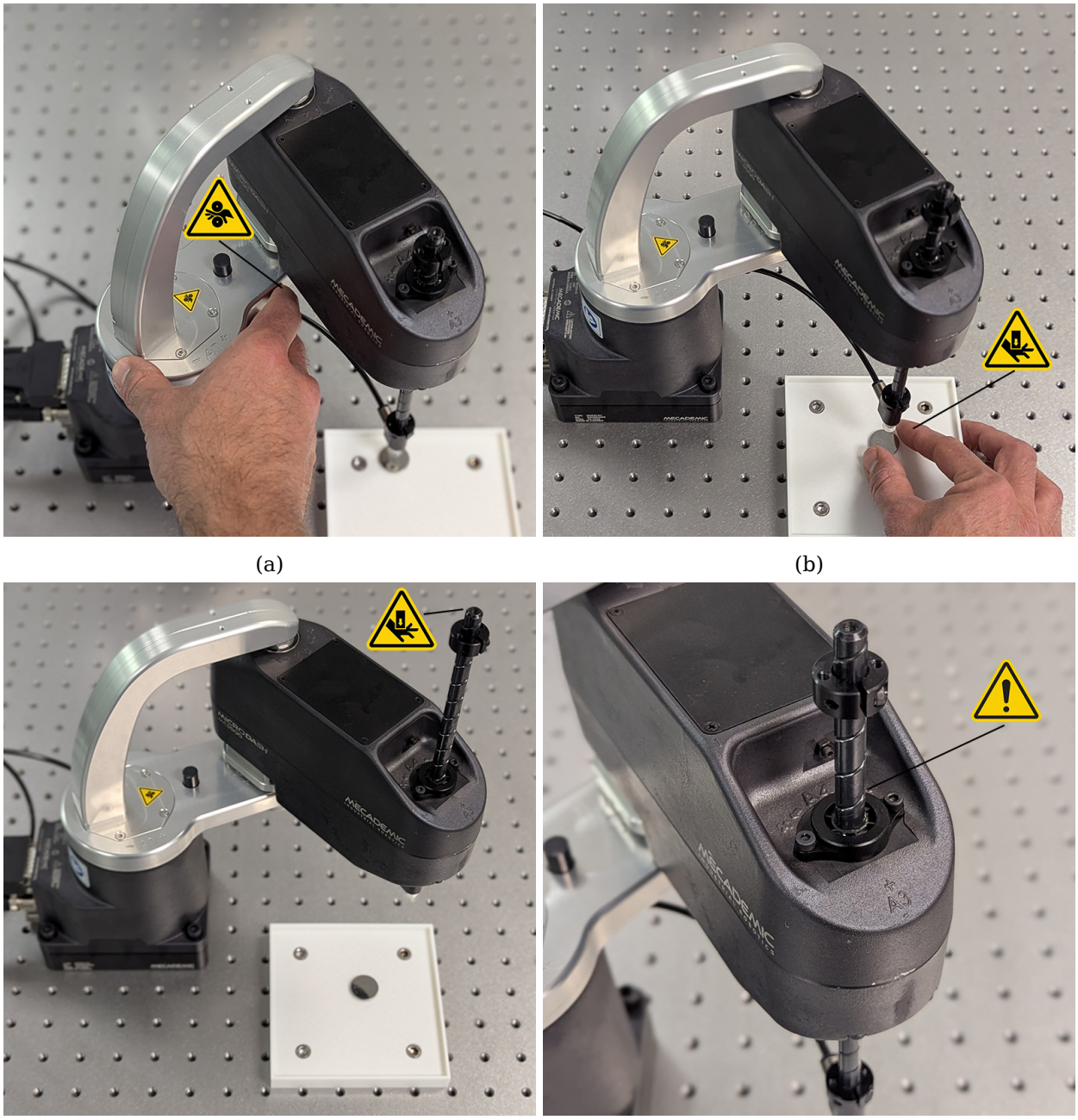
Even when all instructions in this manual are followed, residual risks may remain. Mecademic cannot be held liable for any resulting harm or property damage.

Residual risks

Despite full compliance with installation guidelines and protective measures, certain residual hazards remain — especially during manual interventions or whenever a safety system is overridden:

- *pinching* of fingers or hands (Figure 5a);
- *crushing* or *pinning* of fingers or hands (e.g., Figure 5b);
- *impact* on body parts (e.g., Figure 5c).
- *entanglement* of loose clothing or long hair in moving parts (e.g., Figure 5d);

The risk of sustained pinning or pinching is low because the robot joints are easily back-driven (overpowered), allowing an operator to push the arm away.



(a) (b)

(c) (d)

Figure 5: Examples of residual risks: (a) pinching between proximal and distal link; (b) pinning between end-effector and fixed objects; (c) impact between spline shaft tip and body part such as head of hand; (d) entanglement of long hair or loose clothing with spline shaft.

General safety guidelines

Before removing the robot from its shipping box, you must familiarize yourself with the following general safety guidelines.

Danger

When the robot arm is fully folded, it can be temporarily deposited on its base, as shown in Figure 6a. In other robot positions (e.g., Figure 6b), the robot will tip and should not be placed on its base without fixing it. If the robot tips and falls from a height, it may cause an injury, and certainly get damaged.

(a) correct

(b) NOT correct

Figure 6: You may temporarily place the MCS500 on its base, but only if the robot arm is fully folded.

Danger

- Ensure the robot arm and end of arm tooling are securely fastened.
- Do not modify or disassemble the robot arm or the MSIPS module.
- Do not touch the MSIPS module for extended periods, while in operation.
- Keep your head and hands away from the robot arm and its reciprocating spline shaft.
- Ensure all clothing fits closely and remove jewelry before operating the robot. Secure long hair away from any moving parts.
- Wear protective gloves and/or safety glasses when required for specific end-of-arm tooling and manipulated objects.

Warning

- Handle the robot with care.
- *Do not force the brakes* on the robot's spline shaft, unless there is an emergency!
- *Never unscrew the retaining rings* on the spline shaft.

- Inspect the robot and the MSIPS module for damages. If either appears damaged, do not use them and contact us immediately.
- Do not apply pressure to the cover plate on the bottom of the robot’s base.
- Do not place any labels on the bottom of the robot’s base.
- Do not touch the connectors at the bottom of the robot’s base.
- Do not use or store the MCS500 in a humid environment.
- Do not expose the robot to strong magnetic fields.
- Do not operate the MCS500 at temperatures below 5°C or above 45°C.
- Use only the MSIPS module provided with your system.
- Use only the Ethernet and DC-power cables provided. If you need a longer Ethernet cable, contact us.
- Fix solidly the base of the robot using four M6 screws, tightened at 3 Nm.

Safety-related functions and operating modes

The MSIPS module features built-in safety functions and provides safety I/O digital control signals via two ports on the MSIPS module for connection to PLCs and protective devices (Figure 7). All safety functions and I/O channels are designed in accordance with EN ISO 13849-1, using a Category 3 architecture to achieve Performance Level d (PL d).

Figure 7: The MSIPS module

Stop categories

The robot can initiate three stop categories—as defined in IEC 60204-1—depending on the circumstances, as shown in Table 3.

Table 3: Stop categories

Stop Category	Description
0	The robot stops immediately by cutting power to the motors.
1	When initiated, the robot decelerates in a controlled manner to a full stop within 150 ms. Power is removed from the motors after 380 ms regardless of system state. During deceleration, the robot may deviate from its initial path.
2	The robot decelerates to a full stop while maintaining its original path, with power remaining available to the motors.

Safety functions

The MCS500's safety functions are listed in Table 4. For each function, the table indicates the robot operating mode in which it is active and the resulting stop category.

Table 4: Safety functions

Trigger	Description	Oper. Mode	Reaction
E-Stop	Emergency Stop	Auto/Man	Stop Category 1
P-Stop 1	Protective Stop 1	Auto	Stop Category 1
P-Stop 2	Protective Stop 2	Auto	Stop Category 2
Monitored standstill	Prevents robot from moving after a Stop Category 2	Auto/Man	Stop Category 0
Start interlock	Prevents motors from getting power before required conditions are satisfied	Auto/Man	Stop Category 1
	Prevents motors from getting power	Locked	Stop Category 1
3P enabling	Prevents robot from moving if the enabling device is not activated	Manual	Stop Category 2
Reduced speed	Prevents robot from moving faster than 250 mm/s	Manual	Stop Category 1

The E-Stop function of the MCS500 meets the performance level required by ISO 10218-1:2025 (5.4.2) which is PL=d with a circuit structure of Category 3 based on ISO 13849-1:2023. As per ISO 10218-1:2025 (5.4.2), a Category 3 structure means that:

- A single fault in any subcomponent does not lead to the loss of the safety functions.
- The single fault shall be detected at or before the next demand upon the safety function.
- When the single fault occurs, the safety function is always performed and a safe state shall be maintained until the detected fault is corrected.

Safety equipment connected to the Protective Stop 1 function must meet the same requirements (PL=d and Category 3).

The E-Stop and the P-Stop 1 functions on the MCS500 are Stop Category 1, as per ISO 13850:2015 (4.1.4).

The E-Stop and the P-Stop 1 inputs are redundant with two separate channels and monitoring circuitry is used to ensure that no tampering is possible. This means the inputs must switch states in tandem within 50 ms otherwise a Stop Category 0 will occur (power is removed from the motors).

Robot operating modes

The physical key switch on the MSIPS module (Figure 7) is the only way to select the robot's operating mode. This key-operated switch has three positions: (1) automatic mode, (2) locked mode (motors off), and (3) manual mode.

Automatic mode

Automatic mode is a control state in which the robot executes programmed tasks without continuous operator intervention. In automatic mode, the robot can move at full speed, as long as all safety conditions are satisfied (i.e., the E-Stop function and the two protective stops must remain at logic high). In this mode, the three-position enabling device signal is ignored.

Locked mode

Locked mode is intended for preventing robot movements. In locked mode, power from the motors is removed and the brakes are engaged. In this mode, you can still change settings and save programs.

Manual mode

Manual mode is a control state intended for programming, testing, and fine-tuning robot motions. In manual mode, the robot can move at a limited speed as long as you keep the enabling device engaged (i.e., pressed to the midpoint position). Specifically, the linear speed of the TCP (the origin of the tool reference frame, set with the SetTRF command) is limited to 250 mm/s, and the angular speed of the TRF is limited to 500 °/s. In manual mode, as long as you keep the enabling device pressed halfway, the protective stop signals are muted (ignored).

E-Stop button and safety I/O connections

E-Stop button

The MSIPS module is equipped with one E-Stop button (Figure 7), sometimes referred to as internal E-Stop. By default, *this button is not wired*. To map it to the E-Stop function, you must either make the proper wiring connections or attach the D-Sub DB15 dongle, as described in the following two subsections.

Danger

The E-Stop button on the MIPS module must be properly wired in order to function.

Safety I/O connections

After performing a risk assessment for your installation, you must design and connect the appropriate safety circuit to the two safety I/O DB15 ports on the MSIPS module (Figure 7). *At minimum, you must supply a third-party power supply and a three-position enabling device, and you must wire both the enabling device and the internal E-Stop.* Figure 8 shows the pinout of the DB15 connectors. The following explains the different connections:

- E-Stop Button, four pins. These are the four terminals of the E-Stop button on the MSIPS module. The four pins of the E-Stop button MUST BE WIRED to the circuitry of the E-Stop Function, along with other external E-Stops (if necessary). Otherwise, the E-Stop button on the MSIPS module will not function.
- E-Stop Function, four pins. This is the input that provides the E-Stop functionality to the robot.
- Protective Stop Category 1 (P-Stop 1), four pins. This (redundant) safety input is intended for connecting optical curtains, or other presence-sensing safety devices.
- Protective Stop Category 2 (P-Stop 2), four pins. This (redundant) safety input is used to stop the robot's motion without removing power from the motors.
- Reset, two pins. This input is for wiring an external reset button that will have the same functionality as the one on the MSIPS module.
- Enabling Device, four pins. This is for connecting a three-position enabling device, necessary for operating the robot in manual mode.
- Reset Ready, two pins. This output is enabled when the motors are ready to be powered (i.e., no safety stop is active) by activating the reset function.
- Power Status, four pins. This (redundant) safety output indicates whether the robot motors are powered.

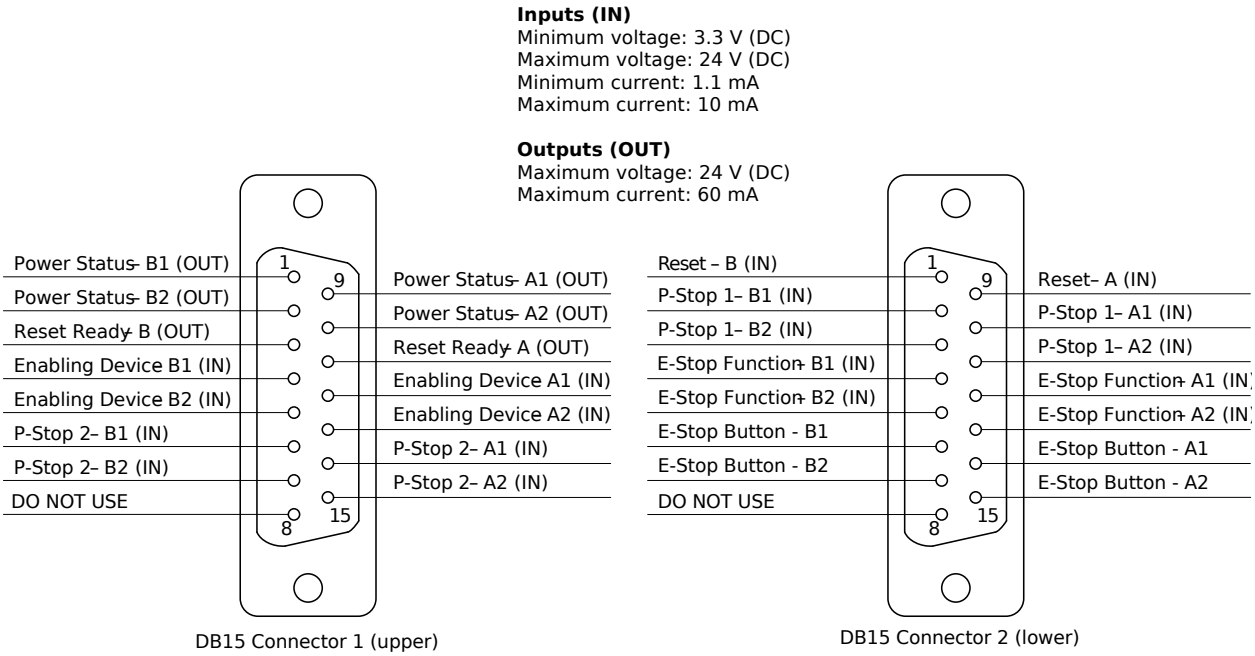


Figure 8: Pinout for the two DB15 connectors (Safety I/O ports)

Danger

- The E-Stop Function, Enabling Device, P-Stop 1 and P-Stop 2 are activated when the corresponding signal is logic low.
- The Reset is activated when its signal is logic high.
- The four pins of the E-Stop Button MUST BE WIRED to the circuitry of the E-Stop Function, along with other external E-Stops (if necessary). Otherwise, the E-Stop button will not work.

Warning

Beware that the two DB15 connectors are identical on the outside.

Warning

Do not use pins 8 from both DB15 connectors. These are for internal use only.

Note that the dimensions of the DB15 plug connectors must be at most 42 mm × 15.5 mm, as shown in Figure 9, or else they will interfere with each other or with the power cable. An example of a cable that meets all requirements is the CABLE-D-15SUB-M-OE-0,25-S from Phoenix Contact. That cable is shielded and has a DB15 plug connector on one side and single

wires that are marked and fitted with ferrules on the other side, and can be ordered with a custom length. Off-the-shelf variants of the cable (in several lengths) are also offered.

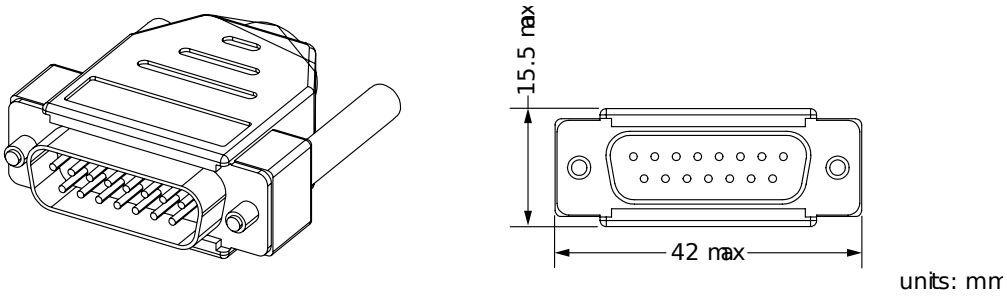


Figure 9: Maximal feasible dimensions for the DB15 plug connectors

The following two tables show further important details regarding the two connections of the two Safety I/O ports.

Warning

The safety outputs are designed to be connected to PLC inputs and not to control loads, especially inductive ones (e.g., a relay or a solenoid). There is no internal protection against the high voltage spike at the release of an inductive load.

Warning

Output signal switching device (OSSD) signals are not supported.

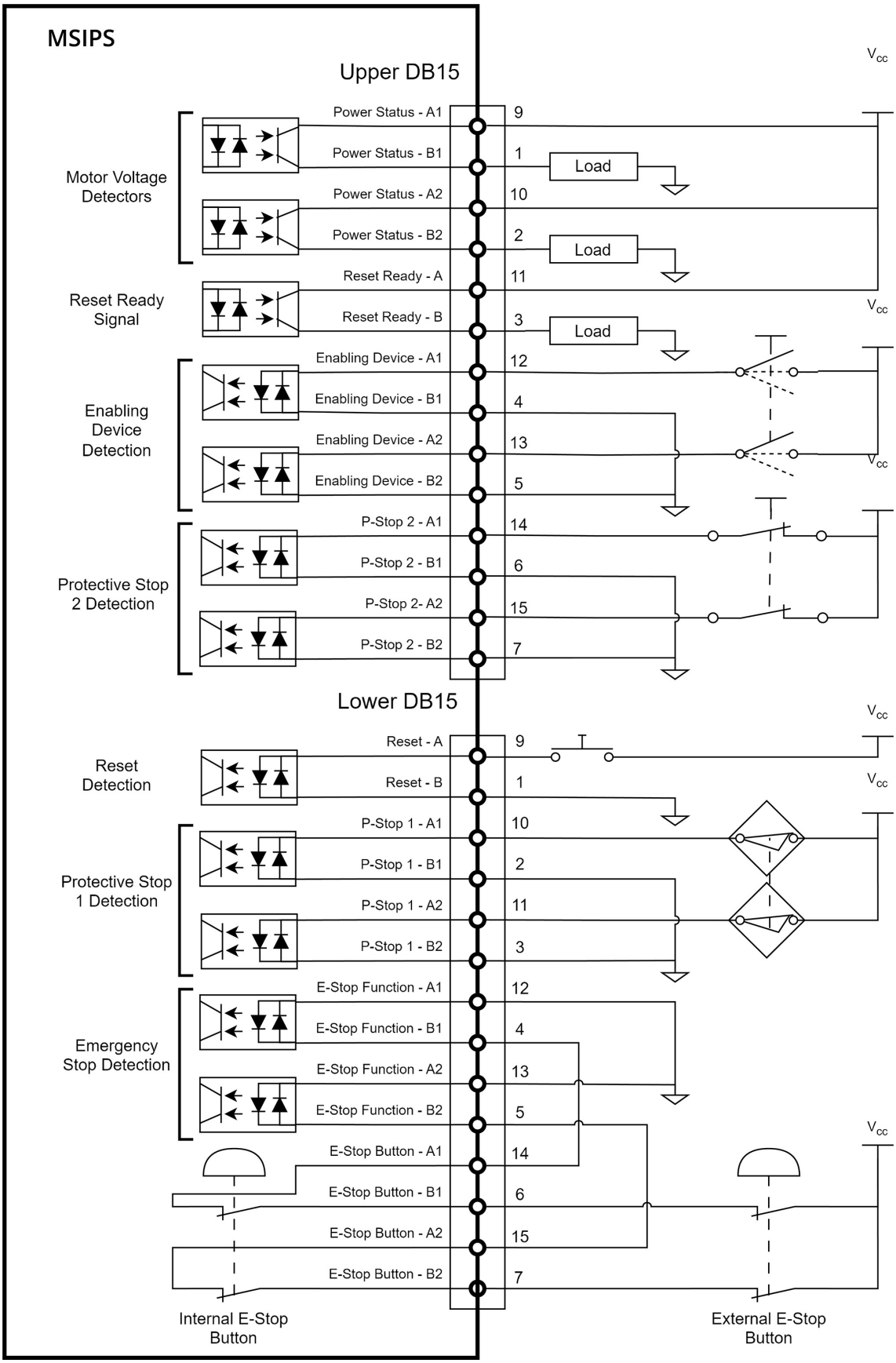
Table 5: Notes for the Safety I/O port 1 (upper)

Pin	Name	Type	Usage	Notes
3	Reset Ready – B	Output	The robot is ready for reset	• This signal is logical high when the robot is ready to reset (safety conditions E-Stop and P-Stop 1 are satisfied and therefore MSIPS Status LED is blinking).
11	Reset ready – A			
1	Power Status – B1	Output	Robot motor power status	• This signal is logical high when robot motor power is enabled. • Use this signal for zero-energy monitoring, if needed.
9	Power Status 1 – A1			
2	Power Status 1 – B2			• This is a redundant safety signal. It must be connected using two independent signals.
10	Power Status – A2			
4	Enabling Device – B1	Input	Enabling device signal for manual mode only	• This signal is logical high when the enabling device is pressed midway. • When this signal is logical high and the key is in manual mode, the robot can be powered, activated, and jogged (at < 250 mm/s) even if the P-Stop 1 (fence) is open.
12	Enabling Device – A1			
5	Enabling Device – B2			• This is a redundant safety signal. It must be connected using two independent signals.
13	Enabling Device – A2			• All faults (differences) between signals will generate a non-resettable MSIPS error.
6	P-Stop 2 – B1	Input	P-Stop 2 (hold) signal, muted in manual mode	• Robot can’t move while P-Stop 2 signal is logical low. • Robot motor power can be restored/reset while P-Stop 2 signal is logical low. • P-Stop 2 cannot be reset by reset button. P-Stop should be reset by the ResumeMotion command.
14	P-Stop 2 – A1			
7	P-Stop 2 – B2			• This is a redundant safety signal. It must be connected using two independent signals.
15	P-Stop 2 – A2			• All faults (differences) between signals will generate a non-resettable MSIPS error.
8	DO NOT USE	n/a	n/a	n/a

Table 6: Notes for the Safety I/O port 2 (lower)

Pin	Name	Type	Usage	Notes
1	Reset – B	Input	External Reset Signal	• Pulse logical high for at least 15 ms but less than 1 s to reset robot. Recommended pulse duration is between 50 ms and 500 ms. • Safety conditions E-Stop and P-Stop 1 must be satisfied (MSIPS Status LED blinking) to reset the robot.
9	Reset – A			
2	P-Stop 1 – B1	Input	P-Stop 1 signal (e.g. fence), muted in manual mode	• Robot motor power is disabled while P-Stop 1 signal is logical low. • This is a redundant safety signal. It must be connected using two independent signals. • All faults (differences) between signals will generate a non-resettable MSIPS error.
10	P-Stop 1 – A1			
3	P-Stop 1 – B2			
11	P-Stop 1 – A2			
4	E-Stop Function – B1	Input	E-Stop signal	• Robot motor power is disabled while E-Stop signal is logical low. • This is a redundant safety signal. It must be connected using two independent signals. • All faults (differences) between signals will generate a non-resettable MSIPS error.
12	E-Stop Function – A1			
5	E-Stop Function – B2			
13	E-Stop Function – A2			
6	E-Stop Button – B1	Switch	E-Stop button on MSIPS module	• The E-Stop Button pins must be connected to E-Stop Function pins. • If E-Stop Button is not connected, it will not stop the robot even if it is pressed. • Not connecting this button will cause major safety risks. • This is a redundant safety signal. It must be connected using two independent signals.
14	E-Stop Button – A1			
7	E-Stop Button – B2			
15	E-Stop Button – A2			
8	DO NOT USE	n/a	n/a	n/a

In addition, the following figure shows the electric diagrams for the safety inputs and outputs, as well as for the E-Stop button on the MSIPS module.



~~Figure 10: Electric diagram for the outputs, the inputs and the E-Stop button on the MSIPS module~~

Dual D-Sub DB15 dongle (first time use and maintenance only)

The provided dual D-Sub DB15 dongle can be used to temporary bypass safety connections as during first time use or during maintenance. Connect the dongle to the D-Sub interface of the MSIPS module (Figure 11). This not only connects the internal E-Stop button to the E-Stop safety function but also completes the necessary wiring to satisfy the P-Stop 1 and P-Stop 2 safety functions.

Figure 11: Dual D-Sub DB15 safety dongle installed

Warning

Connect the dual DB15 dongle to the D-Sub interface of the MSIPS module, while the module is still switched off. NEVER CONNECT OR UNPLUG THE DONGLE WHILE THE MODULE IS ON.

Danger

The DB15 dongle is a bypass device for setup and maintenance only. Ensure proper safety I/O connections are wired when using the robot in production mode (see Section 4).

Danger

When using the dual DB15 dongle, *you cannot use the robot in manual mode*. (This is because the enabling device signal must be removed at least once upon entering the manual mode). Therefore, you must take extra precautions and keep the robot in a safety enclosure.

Danger

Stand away from the robot when it is activated, wear safety goggles and close-fitting clothing, keep long hair securely tied back and be attentive and alert. In case of an emergency, press the E-Stop button (on the MSIPS module) immediately.

Further safety information

Recall Section 3 for a general description of the robot arm.

Brakes and limitations

As already mentioned, the MCS500 is equipped with brakes at joints 3 and 4, i.e., at the spline shaft. These brakes can be disabled mechanically by removing the screw cap near the spline shaft, using a 2.5-mm Allen key, and keeping the button inside the hole pressed, as shown in the figure below.

(a) Remove the screw cap (b) Press the recessed button

Figure 12: Releasing mechanically the brakes on the spline shaft

Danger

For safety reasons, release the brakes on joints 3 and 4 only when the robot is in locked mode or powered off.

When the brakes on the spline shaft are released, the shaft will not fall down, even if a 0.5 kg tool is attached to it. This is due to the friction in the assembly. You therefore need to apply external force to make the spline shaft move.

Warning

In case of an emergency, you can always overpower the brakes on the spline shaft.

However, *doing so frequently will damage the brakes*.

Note

Note that in the case of a collision, the robot is not deactivated and you can easily reset the motion error and jog the robot away, without entering the safety enclosure of the robot. If you are worried about damaging your equipment, it is advisable to first enter recovery mode (as described in the Programming Manual).

Joint limits

Because of the robot's compact dimensions, mechanical means to limit joint range have not been incorporated. It is possible to design a fixture that can be attached to the robot's base and that limits mechanically the range of joint 1. However, remember to not modify the robot itself (e.g., by removing screws from the robot).

The robot's joint limits can be reduced by software means using the MecaPortal or the command SetJointLimits. The new software limits remain active even after power shutdown. However, they will be reset to the default values, if a factory reset is performed on the robot. These software limits are not safety rated.

Danger

Due to the extremely compact size of the robot, there are no provisions for adjustable hardware joint limits.

Joint torque limits

Once a robot is activated and homed, you can also reduce the joint torque limits using the command SetTorqueLimits. However, the joint torque limits are reset to 100% each time the robot is reactivated. Furthermore, *these joint torque limits are not safety rated*.

Local control

The MCS500 provides no built-in means of local control. It is therefore the responsibility of the robot integrator to equip the control station with a suitable local interface, such as keyed switch or safety-gate interlock, that lets an operator enable or disable the remote connection whenever local intervention is required. The control station must be designed and installed in full compliance with all applicable local laws, regulations, and safety standards.

Loss of Ethernet connection

When using the MecaPortal web interface or any other TCP/IP client, as soon as the robot detects a loss in the connection while moving, it will stop within 0.1 s. To prevent delays due to the use of Ethernet switches, at all times (not only while the robot is moving), use the ConnectionWatchdog command (available since firmware 10.1).

Locking up the robot system

To prevent unauthorized or accidental powering of the robot, we suggest unplugging the AC cord and using a detachable IEC Plug Lockout device such as the one from Brady.

Technical specifications

The following table lists the main technical specifications of the MCS500 robot arm.

Table 7: Technical specifications for the MCS500 robot arm (R1)

Characteristics	Value
Position repeatability	0.005 mm
Rated payload	0.5 kg
Weight of robot arm	4.3 kg
Mounting orientations	tabletop or upside down
Range for joint 1	[−140°, 140°]
Range for joint 2	[−145°, 145°]
Range for joint 3	[−102 mm, 0 mm]
Range for joint 4	[−3,600°, 3,600°]
Maximum speed for joint 1	300°/s
Maximum speed for joint 2	500°/s
Maximum speed for joint 3	700 mm/s
Maximum speed for joint 4	5,000°/s
Maximum continuous torque for each joint	50% of the acceleration torque value
Input voltage	36 V (DC)
Maximum / peak input current	12 A / 16.67 A
Operating ambient temperature range	[5°, 35°]
Operating ambient relative humidity range	[10%, 80%] (non-condensing)
Airborne noise level	75dB (only when the robot is moving fast; when it is immobile, the noise is barely perceptible)
Maximum operating altitude	2000 m
Robot body material	Anodized aluminum alloy
IP rating	IP 40

The following figure shows all important dimensions of the MCS500. Recall from Section 3 that all joints are at zero in the configuration shown below.

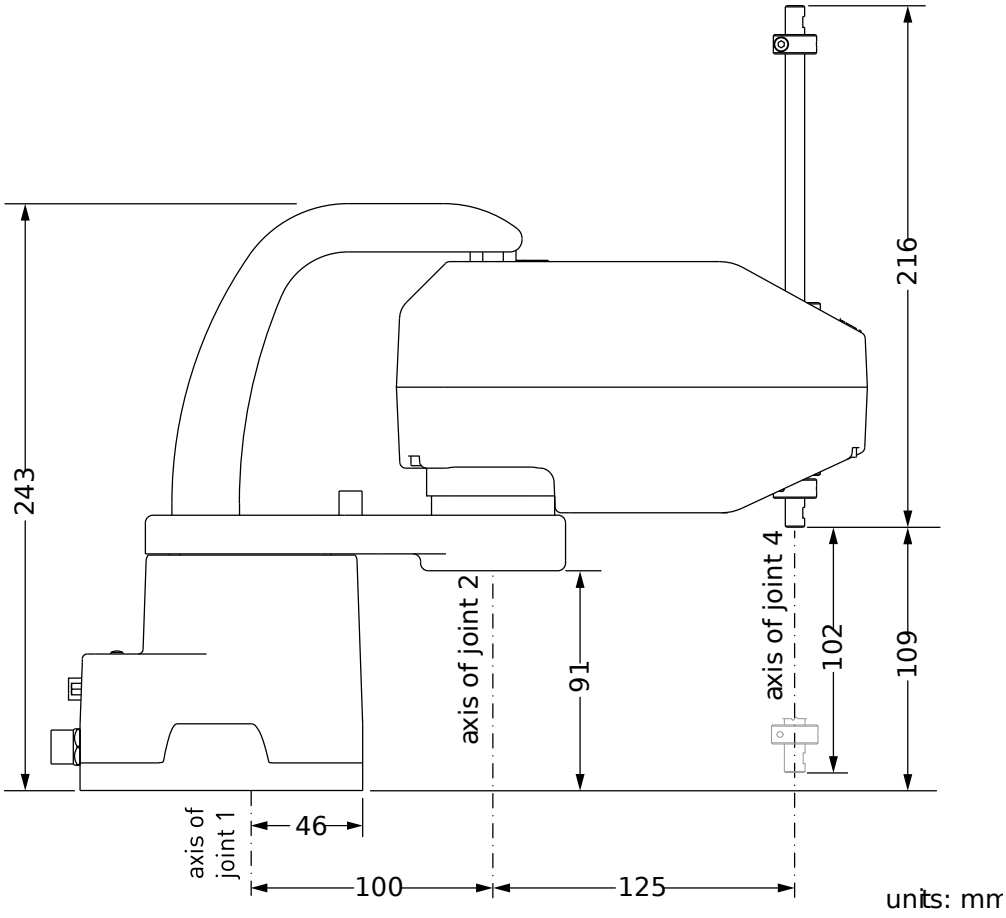


Figure 13: The principal dimensions and offsets of the MCS500 robot

Additionally, the schematic below illustrates a top view of the MCS500 workspace, specifically for an end-effector whose origin is located on the axis of the spline shaft. It is important to note that most reachable end-effector positions can be achieved with two different robot configurations: one commonly referred to as “lefty” and the other as “righty.” This topic is discussed in more detail in the Programming Manual.

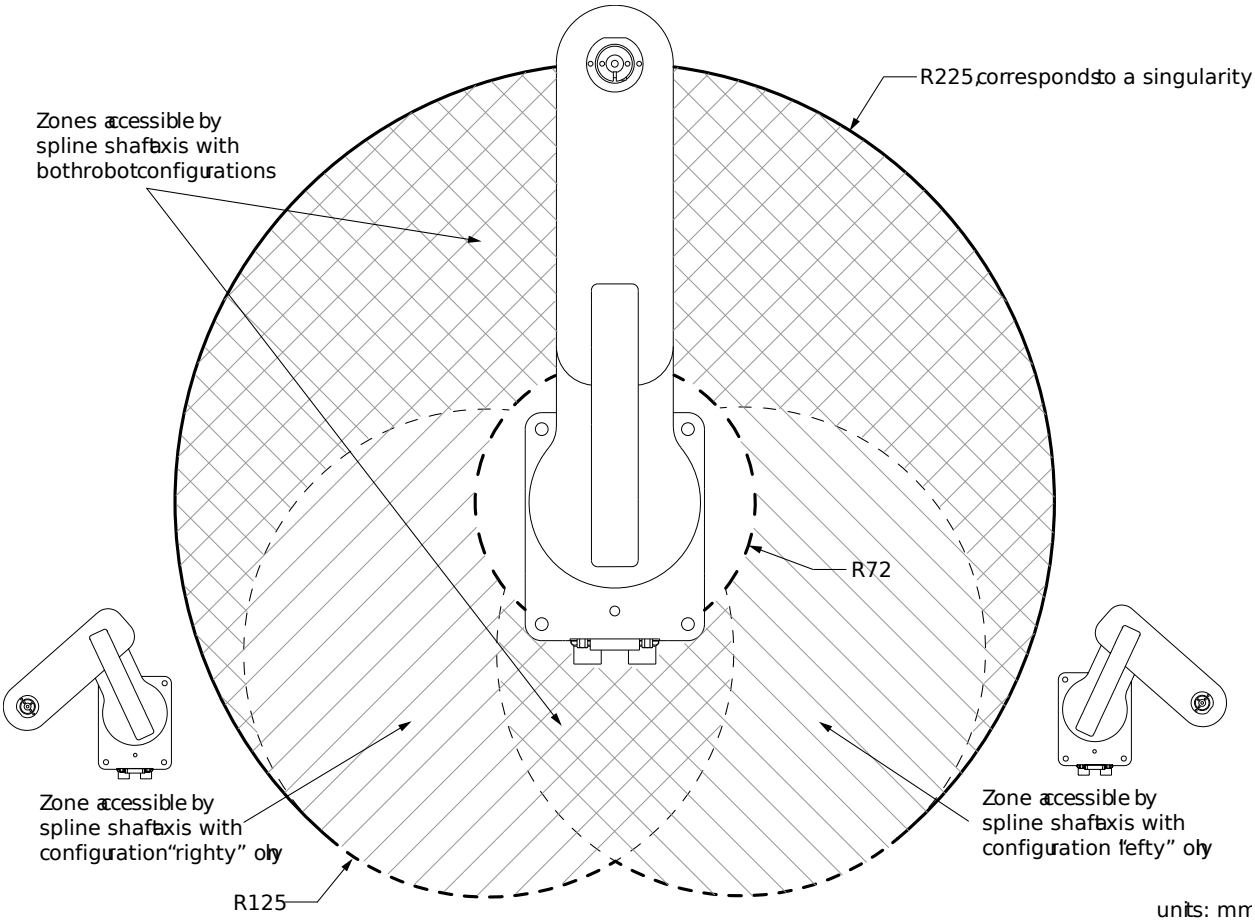


Figure 14: The working range of the MCS500 robot

The CAD files of the MCS500 robot arm and of the MSIPS module (in STEP format) can be downloaded from here. You can also use one of several robot simulation and offline programming software packages that include a model of our Meca500, including Visual Components and RoboDK. Note that we also offer a Mecademic-only version of RoboDK, for exclusive use with our robots.

The table below lists the technical specifications for the MSIPS-R1 module. As already mentioned, the MSIPS module has an IEC C14 connector that accepts an AC power cord with three-prong IEC C13 connector on one end, and your own country's power plug on the other. You can connect this power cord to any AC source that supplies voltage between 90 V and 250 V at frequency between 50 Hz and 60 Hz.

Table 8: Technical specifications for the MSIPS-R1 module

Characteristics	Value
Weight	1.3 kg
Mounting orientations	any
Input voltage range	[90 V, 250 V], AC, single phase
Input frequency range	[50 Hz, 60 Hz]
Maximum input current	8 A at 110 V
Input power connector	IEC C14
Power factor	0.99 @ 115 V (AC)
Maximum power output	432 W @ 5% (DC)
System grounding type	TN
Operating ambient relative humidity range	[10%, 80%] (non-condensing)
Maximum operating altitude	2000 m
Robot body material	Anodized aluminum alloy
IP rating	IP 40

Warning

We recommend that you use a surge protector when connecting the MSIPS module to an AC power source.

Finally, the requirements for the I/O connections on the MSIPS module are provided in the following table. Further details will be provided in Section 4.

Table 9: Technical specifications for the safety I/O interface on the MSIPS module

Parameter	Min.	Typical	Max.	Unit
Safety input voltage	3.3	–	24	V (DC)
Safety input current	1.1	–	10[2]	mA
Safety output voltage	–	–	24	V (DC)
Safety output current	–	–	60	mA

[2] Current is internally limited to 10 mA.

Installing the robot system

It is imperative that you fix solidly the base of your robot arm with four M6 screws, tightened at 3 Nm, before activating the robot. We typically use metric breadboards such as those from Thorlabs, but you can also use our adapter plate (MUAP02.zip), build your entire robot cell at Vention, or use the modular system made by Tessella Automation. We recommend that you use three *kinematic positioners* against the vertical edges of your base to constrain its position, ensuring it can be repeatedly removed and reinstalled in the same location.

The dimensions of the base are provided below, along with an example of an installation. *Note that you can also install the robot base upside-down*. The robot will automatically detect the angle between the base and the gravity vector (no need to manually specify this angle). Also, note that you can mount the robot's base on a mobile body (e.g., on the carriage of a linear guide), but care must be taken to ensure that the combined acceleration of the robot and the linear guide won't exceed the capacity of the robot in case an emergency deceleration is required.

Note

While the base of the MSC500 has the same bolt pattern as the base of the Meca500, it is slightly larger. Therefore, you cannot use our adapter plate for the Meca500 (MUAP01) unless you remove the locating pins. You should rather use our MUAP02 adapter plate, designed for the MCS500.

Warning

Ensure the mounting surface is perfectly flat, and that nothing presses on the underside cover of the robot base or contacts the exposed connectors.

Danger

Secure the robot base firmly using four M6 screws tightened to a torque of 3 Nm. Periodically inspect the screws to ensure they remain properly tightened.

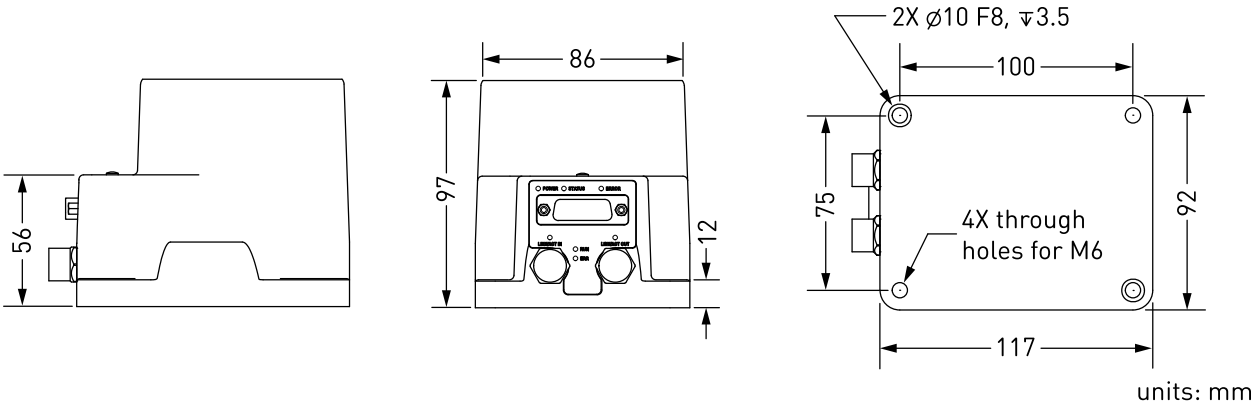


Figure 15: Dimensions of the base of the MCS500

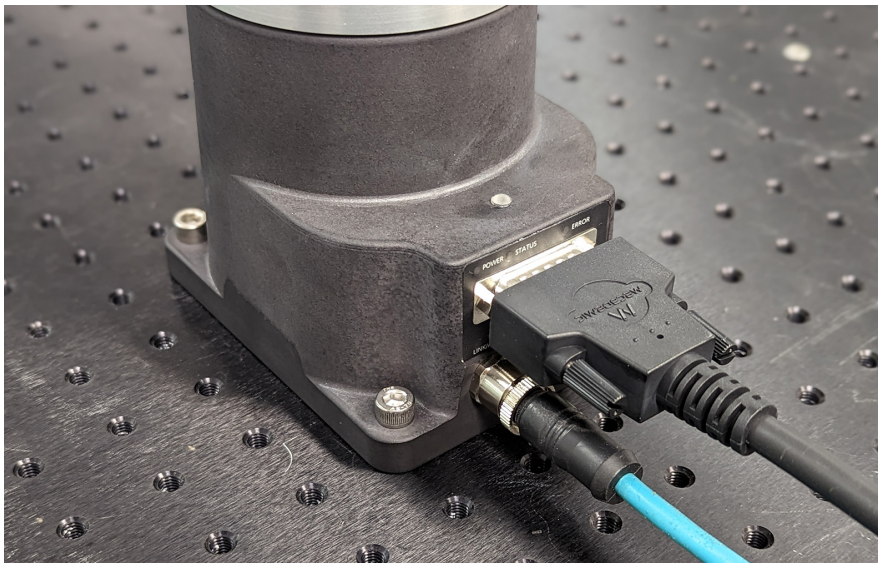


Figure 16: The robot base installed

If you are using the MVK01 Vacuum and I/O module, refer to its user manual. The MVK01 module must be installed underneath the base of the MCS500.

Do not install any end-effector yet. We will cover this topic in Section 8.

Next, *securely mount the MSIPS module* ` using four M6 screws (see figure below), positioning it close enough to the robot base to accommodate the provided 2-meter DC cable. However, unless an external emergency stop is connected via the D-Sub connector, the MSIPS module must be mounted in a location where the internal E-Stop button remains easily accessible to the operator and outside the robot's working range.

⚠ Warning

Mount the MSIPS module vertically. To improve heat dissipation, secure it to a solid metal

plate.

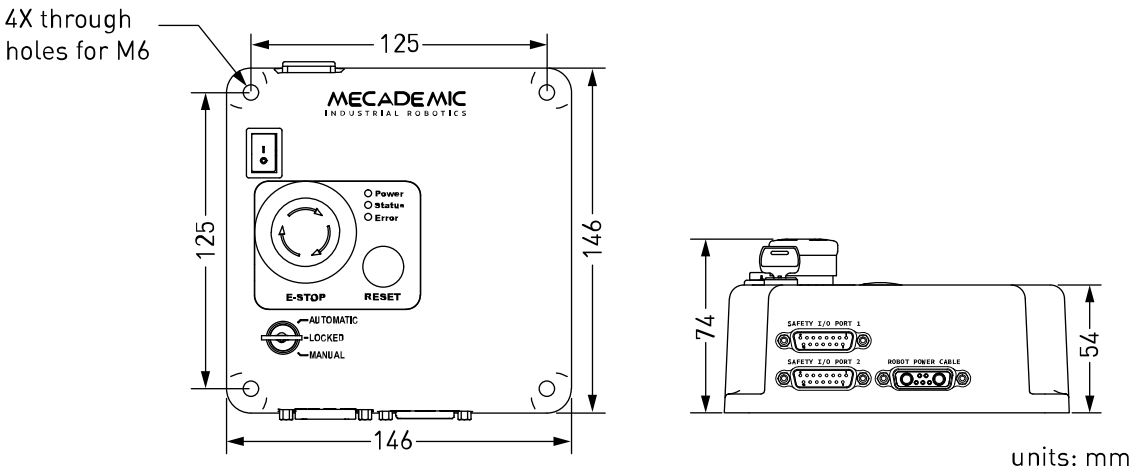


Figure 17: Dimensions of the MSIPS module

Next, attach the circular connector of the Ethernet cable to the ETHERNET1 port on the robot's base and connect the RJ-45 jack to your computer or router (see the figure Figure 16). The two Ethernet ports on the robot base act as a bridge, so you can daisy-chain several MCS500 robots, or connect an Ethernet I/O module on the ETHERNET2 port.

Finally, use the DC power cable provided to connect the *unpowered* MSIPS module to the robot's DC power connector (see the figure Figure 16). Make sure the connectors are completely screwed, or else you may damage the robot. Then, connect the MSIPS module to your country-specific AC power cord (not provided).

Warning

Always connect the DC power cable before connecting the MSIPS module to an AC outlet. Always disconnect the MSIPS module from the AC outlet before disconnecting the DC power cable.

Operating the robot system

This section presents the basic procedures for setting up and operating the MCS500 robot system. For further details, refer to the MecaPortal Operating Manual (MC-OM-MCS500), which describes the web interface of the robot, and to the Programming Manual (MC-PM-MCS500).

First-time use

Danger

For prototyping purposes, the MCS500 comes with its own dual DB15 dongle (recall Section 4). NEVER CONNECT THE DONGLE OF A MECA500 TO THE MSIPS MODULE OF THE MCS500, OR ELSE YOU WILL DAMAGE THE MCS500.

Danger

To start using the MCS500, plug the dual D-Sub dongle, while the MSIPS module is unpowered. Once you have become acquainted with the MCS500 and performed your risk assessment, remove the dongle and wire your safety I/O connections (see Section 4).

Danger

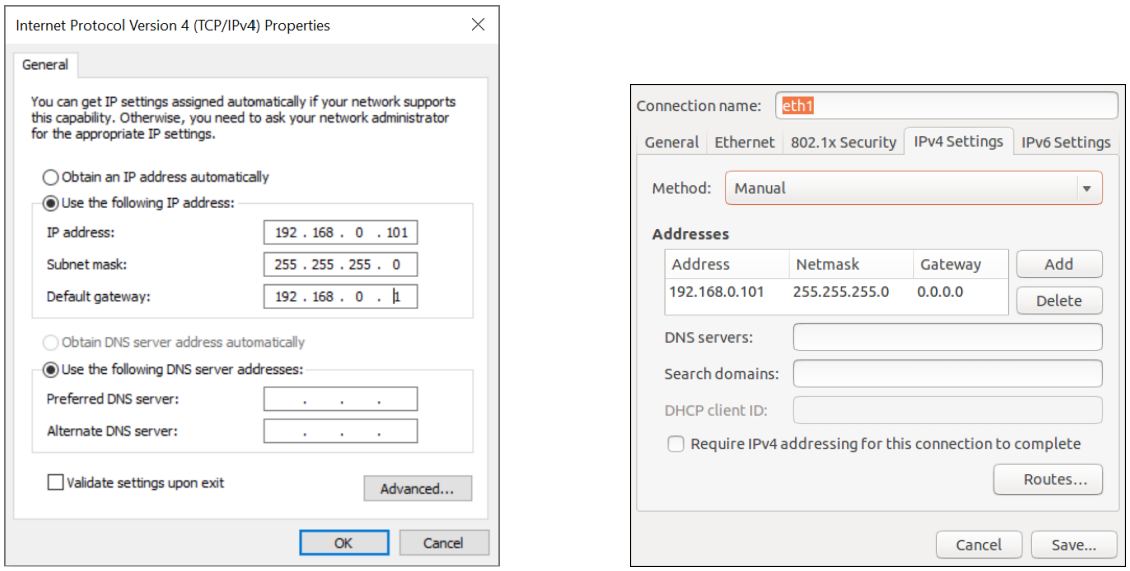
When using the dual DB15 dongle, *you cannot use the robot in manual mode*. (This is because the enabling device signal must be removed upon entering the manual mode). Therefore, you must take extra precautions and keep the robot in a safety enclosure.

Configuring your Ethernet connection (first time use)

Configure your computer Ethernet connection with a static IP address, on the same subnet as the robot's default IP address: *192.168.0.100*. The way to do this differs from one operating system to another. The figure below shows how to do this in Windows and in Linux.

Note

The default IP address of the robot is *192.168.0.100*.



(a) Windows (b) Linux

Figure 18: Two examples of how to configure the IP address of your computer

Power-up procedure

Powering the robot

1. Turn the MSIPS module on. The green LED on the module (next to “Power”) will be illuminated. The robot’s LEDs will start flashing for about twenty seconds while the robot’s controller is booting. Once the controller is ready, the three small LEDs on the robot’s base will stop flashing, unless there is a stop condition.
2. Make sure that all stop signals are removed and the three small LEDs on the robot’s base has stopped flashing (after about twenty seconds), and the Status LED on the MSIPS module is blinking.
3. Change the operating mode to manual or automatic mode with the physical switch key.
4. Now, you must provide power to the robot motors by briefly activating the Reset function (e.g., by pressing the RESET button on the MSIPS module). Before you do so, make sure the E-Stop function is deactivated and that all safety conditions are satisfied. You will hear a clicking sound and the big yellow LED on the robot’s base will light up. It will start blinking, once all safety conditions are satisfied and reset is possible.

Connecting to the robot

1. Open (preferably) the latest version of Google Chrome and type MCS500’s default IP address *192.168.0.100* in the address bar.
2. MCS500’s web interface, called MecaPortal, should load instantaneously (see figure below). The MecaPortal is described in detail in a separate manual (MC-OM-MCS500).

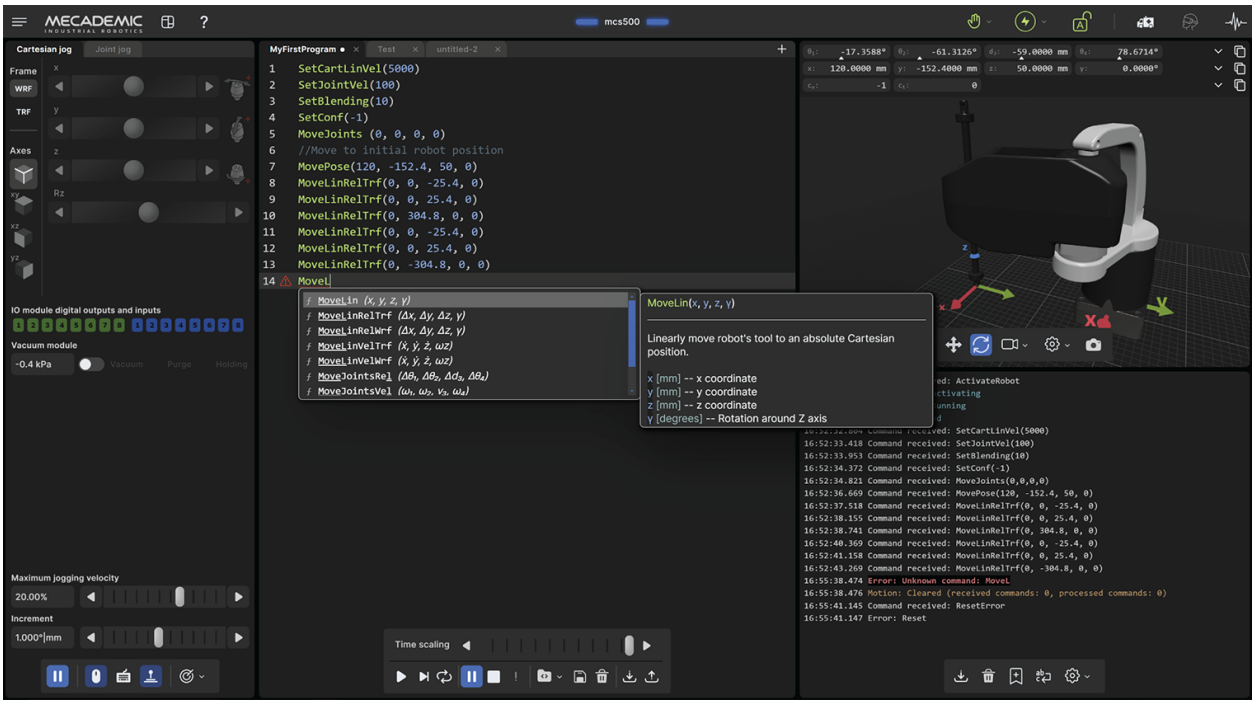


Figure 19: Overview of the MecaPortal

Changing the robot's network configuration (optional)

1. Click on the connection state button on the top right of the MecaPortal and select "Control" (see figure below).

Figure 20: Connection state button

2. Click on the configuration menu button, ☰, in the top left corner of the MecaPortal and select "Network configuration".
3. Depending on your configuration, activate the toggle DHCP to automatically receive an address from your router or leave untoggled to force a specific IP. You don't need to reboot the robot; the new configuration will be applied as soon as you click on the Apply button (see figure below).

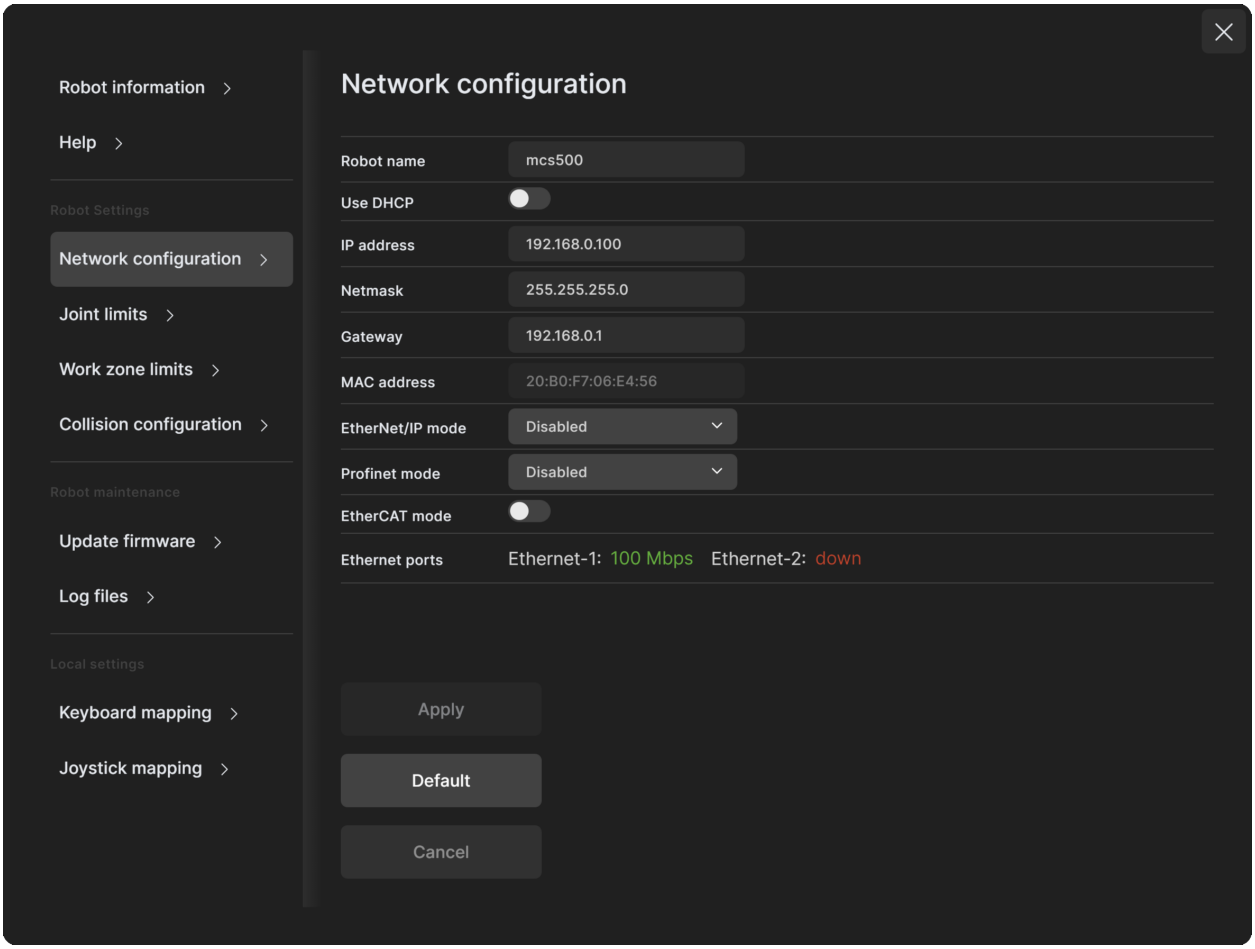


Figure 21: Changing the robot's network configuration

Resetting the operation mode

After an operation mode change, the robot immediately decelerates to a complete stop, and power is removed from the robot motors. Depending on the new operation mode, the following actions should be performed before using the robot:

- **Locked**: In locked mode, you cannot power the robot motors, but you can do everything that can be done while the robot is deactivated (e.g., use it in simulation mode, change settings, etc.).
- **Manual**: In manual mode, you need to first press your enabling device halfway, then press the Reset button, then click on ⚡ to activate the robot, which will power the motors. As soon as you release the enabling device, the robot decelerates to a complete stop. At that time, if no other safety stop signal is present (the P-Stop 1 and P-Stop 2 signals are muted only while the enabling device signal is active), the robot is simply put in pause mode. To resume using your robot, press the enabling device again, and then click on "ResumeMotion" in the red banner that will appear in the MecaPortal. If a P-Stop 1 signal was present upon releasing the enabling device, then you would need to remove the signal, press the Reset button, and then activate the robot.

- **Automatic**: In automatic mode, you only need to press the Reset button in order to power the motors.

Activating the robot

Once the motors are powered, click the button in the menu bar and select "Activate". This starts the motors control and disengages the brakes.

Moving the robot

After activating the robot, click the button in the jogging panel and select "Zero all joints". The robot will move all of its joints to their zero positions. In this robot joint set (shown in Figure 1), the robot is in a so-called singularity. Most industrial robots cannot move in Cartesian mode from such a singularity. In order to simplify the use our robots, we have implemented an algorithm that allows them robot to move through such a singularity.

Note

The Cartesian coordinates displayed above the robot in the web interface are those of the Tool Reference Frame (TRF) with respect to the World Reference Frame (WRF). Both frames are displayed in the web interface. By default, the TRF is located at the mechanical interface of the robot and the WRF at the bottom of the robot's base. The origin of the TRF is called the TCP (Tool Center Point).

Note

In the MCS500, the z-axis of all reference frames point "upwards" (relative to a table-top installation), so we use only one angle, γ (gamma), to define the orientation of one reference frame with respect to another.

Thus, for example, you can simply go to the Cartesian tab of the jogging menu, and with the TRF option selected, press the right arrow button of the x jogging bar. Alternatively, you can perform a joint motion by following these steps:

- Clear the programming text field, type MoveJoints(-45,45,-80,0), and press .

The following figure shows the resulting robot position.

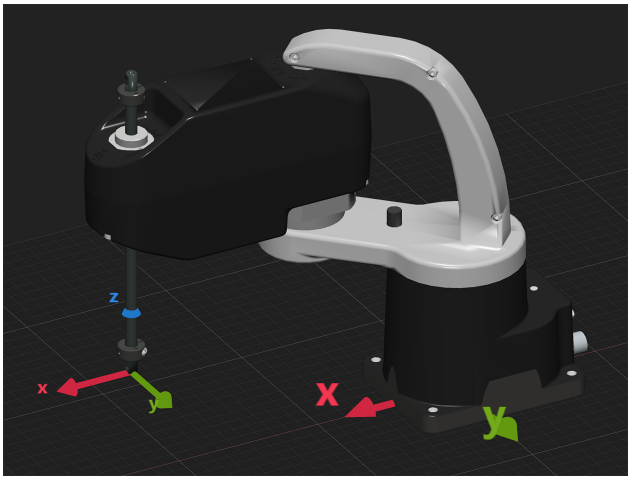


Figure 22: Robot position for MoveJoints(-45,45,-80,0)

Power-off procedure

Zeroing the robot joints (optional)

It might be a good idea to always bring the robot joints to their zero positions before turning the robot off. This can be done in two ways:

- send a MoveJoints command with all four arguments equal to 0

OR

- click the button in the jogging panel and select “Zero all joints”.

Deactivating the robot

To deactivate the robot

- click the button and then select “Deactivate”

OR

- send the DeactivateRobot command via the programming editor.

Note

If you accidentally close your web interface before deactivating the robot, the robot will stop (in case it was moving) but will remain activated.

Disconnecting the robot

To disconnect the web interface from the robot, select the option from the connection state group.

Danger

If you disconnect the web interface from the robot before deactivating the robot, the robot will stop moving.

Removing power

Finally, switch the MSIPS module off.

Warning

Never detach the DC power connector from the robot’s base, before switching the MSIPS module off or unplugging the module’s AC power cord from the AC outlet.

Robot's base

A series of LEDs are located at the rear of the robot's base (see Figure 23). The meanings of these LEDs will be summarized in what follows.

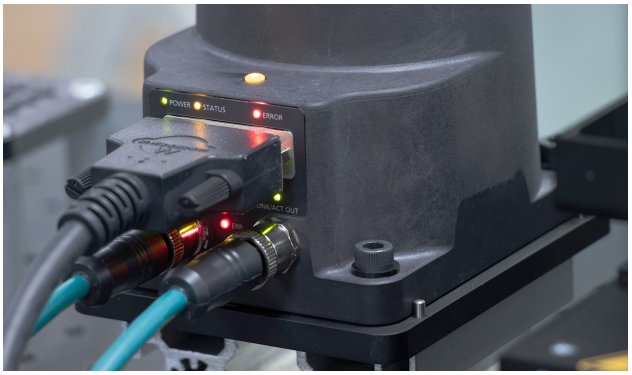


Figure 23: Robot's base

LEDs

After a power up, the Power, Status and Error LEDs will flash fast simultaneously during a couple of seconds. After that, the LEDs will be lit as described below.

Motors ON LED

The large yellow LED on the top of the robot's base is on when the motors are powered and off when power is removed from the motors (e.g., after an E-stop or when the switch key is in Locked operating mode position). Note that the light will also light up temporarily if you are moving manually the robot joints 1 or 2 (due to the induced current in the motors).

Power LED

The Power LED is green and indicates that the robot is powered:

- off, when the robot is not powered;
- on, when the robot is powered (though not necessarily its motors);
- fast blink (100 ms on,100 ms off), when the MSIPS module encounters a fatal error.

Status LED

The Start/Pause LED is yellow and indicates the state of the robot:

- off, when the robot can not be activated (e.g., safe boot);
- on, when the robot is activated;
- slow blink, when the robot can be activated.

Error LED

The Error LED is red and indicates the error state of the robot:

- off, when there is no error or a protective/emergency stop;
- on, when the robot is in error state;
- one flash (every second), when a P-Stop 2 is activated;
- two flashes (every second), when a P-Stop 1 is activated;
- three flashes (every second), when an E-Stop is activated.

Combined LED sequences

In certain special situations, all three LEDs may flash simultaneously or in sequence, as outlined in the table below. Additional sequences occur during network and factory resets, as detailed in Section 7.

Table 10: LED pattern sequences for special situations

Situation	Power (green)	Status (yellow)	Error (red)
Booting	slow blink (all three LEDs blink simultaneously once every second)		
Booting in Safe mode (occurs during firmware update)	quick blink (all three LEDs blink simultaneously once per 200 ms)		
Updating the firmware	quick traveling blink (each LED blinks quickly in sequence, once every second)		

Link/Act IN and Link/Act Out LEDs

Both LEDs are green and flash when there is network activity in the corresponding Ethernet port. The LEDs function in the same manner as on a normal Ethernet RJ-45 port.

Run LED

This green LED is used only when the robot is controlled via EtherCAT (see the Programming Manual).

ERR LED

This red LED is used only when the robot is controlled via EtherCAT (see the Programming Manual).

MSIPS module

Emergency and protective stops

Once you power up the robot, you must make sure all safety stops are disengaged. Then, pressing the RESET button (or enabling the RESET input) sends power to the robot motors.

Once the robot is activated, pressing an E-Stop at any time instantly sends a signal to the robot to rapidly decelerate and come to a complete stop. The MSIPS module then waits for a signal from the robot indicating that the robot is completely stopped, and as soon as that signal is received, but no later than in 500 ms, the MSIPS module completely cuts power to the robot motors. The robot brakes are then automatically applied to the spline shaft (i.e., to joints 3 and 4). To use the robot again, you must remove all stops signals, and press Reset, then activate the robot.

LEDs on the MSIPS module

The MSIPS module is also equipped with three LEDs. Their description is presented in Table 11.

Table 11: MSIPS module LED pattern sequences

Situation	Power (gre	Status (yel	Error (red)
MSIPS module is switched off	off	–	–
A fatal error detected (e.g., invalid voltage or safety input mismatch)	fast blink (100ms on, 100 ms off)	–	on
Reset button pressed for too long, redundant signal mismatch detected, monitored standstill not respected, voltage fluctuation detected, or internal minor software error detected	–	–	on
The MSIPS module is turned on	on	–	–
The robot motors are not powered and a RESET is not allowed	–	off	–
The robot motors are not powered but a RESET is allowed	–	slow blink (500 ms on, 500 ms off)	–
The robot motors are powered	–	on	–
There is no error or a stop signal	–	–	off
P-Stop 2 is activated	–	–	1 flash per second
P-Stop 1 is activated	–	–	2 flashes per second
E-Stop is activated	–	–	3 flashes per second
Operation mode changed or enabling device released in manual mode	–	–	slow blink
Upgrading the firmware	all LEDs flash sequentially		
Booting	all LEDs are slowly blinking simultaneously		
Shutdown	all LEDs are on for about 7 seconds		

Installing an end-effector

You can install end-of-arm tooling (EOAT) on the MCS500 and control it via the optional MVK01 I/O and vacuum module or directly from your PLC.

The MCS500 can be mounted table-top or upside-down. For that purpose, the two ends of the spline shaft are identical and symmetric. Each of these two ends is called the mechanical interface and should be used for fixing EOAT. The dimensions of the mechanical interface are shown in Figure 24.

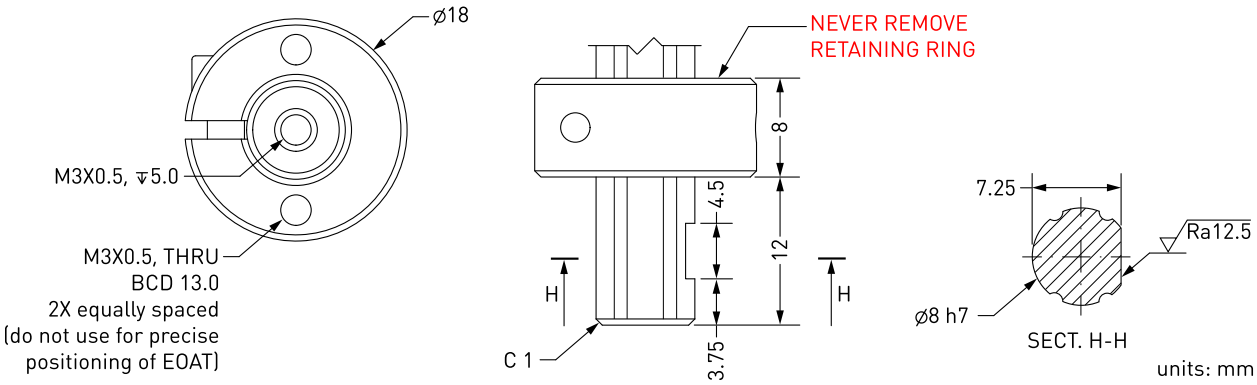


Figure 24: The mechanical interface of the MCS500

Note that we also offer a special hollow-shaft version of our MCS500. The only difference is that a Ø3 opening runs through the entire shaft and that the threaded holes at both ends are M5X0.8 instead of M3X0.5. The dimensions of the mechanical interface for the hollow-shaft version are shown in Figure 25.

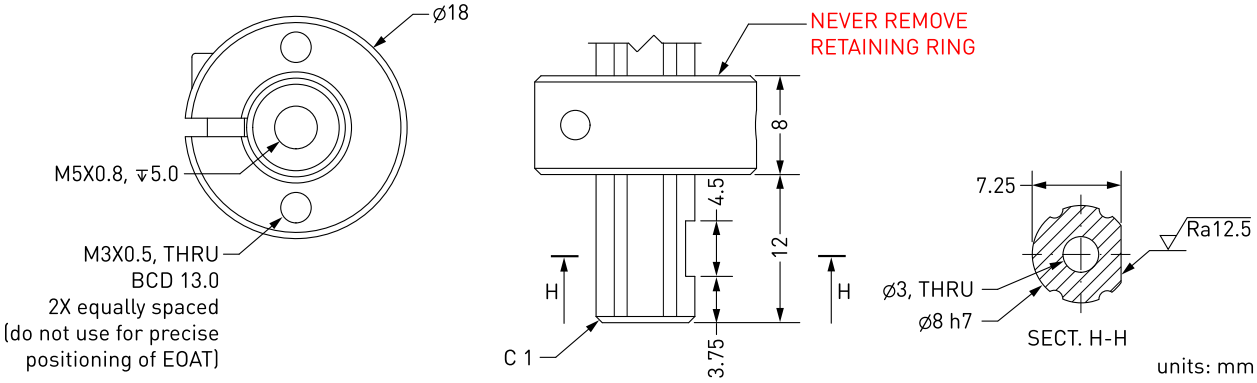


Figure 25: The mechanical interface of the MCS500-HS (hollow shaft special version)

The FRF (flange reference frame) is fixed *to the end of the spline shaft that is closer to the robot's base*, so that its z axis coincides with the axis of the spline shaft and points away from the robot's base, its origin (called the flange center point, or FCP) is at the very end of

the spline shaft, and its x axis is perpendicular to the plane of the Weldon flat, as shown in Figure 26.

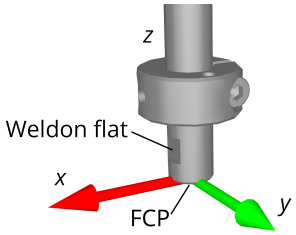


Figure 26: Placement of the FRF (always on the end closer to the robot base)

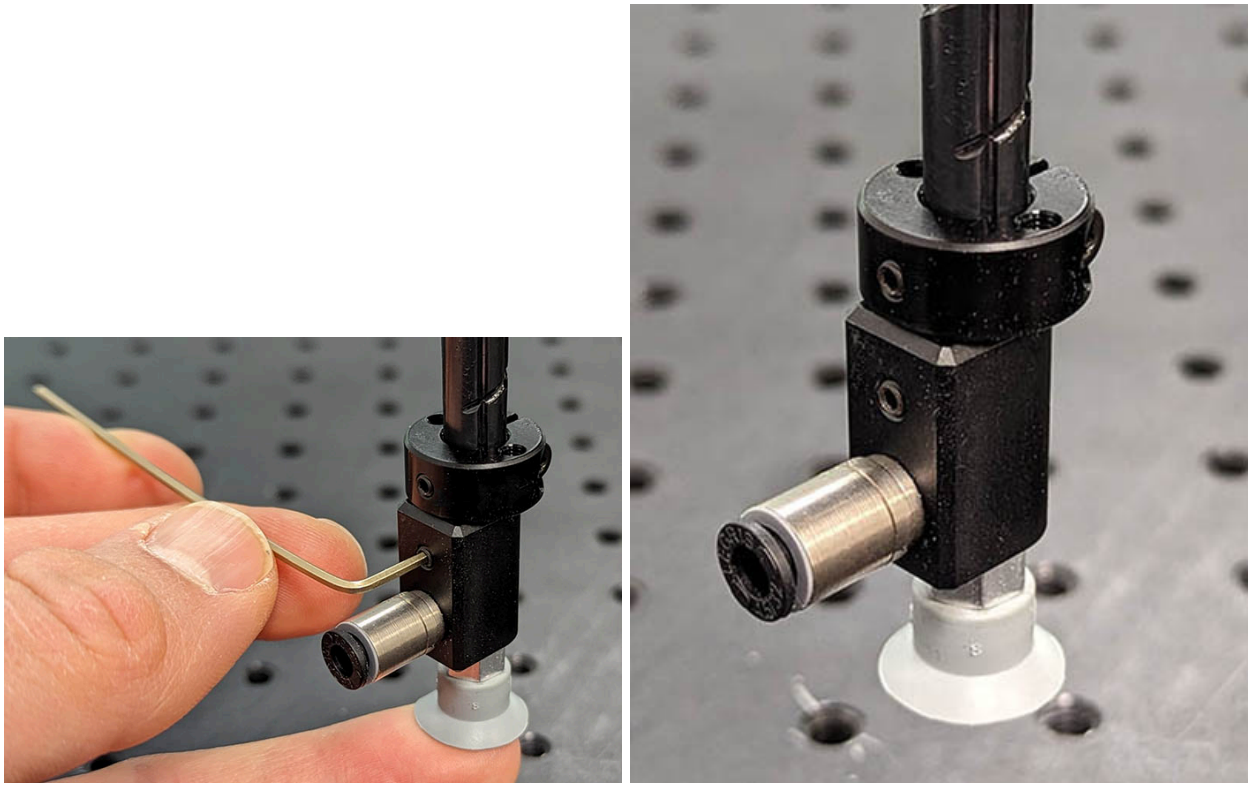
Danger

- Keep the robot unpowered while installing/removing EOAT to its mechanical interface.
- Do not exceed the robot payload.
- Securely fasten the EOAT to the mechanical interface using M3 screws and a set screw applied against the Weldon flat.

Warning

- *Never remove either of the retaining rings from the spline shaft — doing so will cause permanent damage to the ball-screw spline assembly.*
- Do not over-tighten the M3 screws. Use a torque of 1.5 Nm.
- Securely fasten the EOAT to the mechanical interface using a set screw applied against the Weldon flat. For added safety, especially with heavier payloads, use M3 screws to attach your EOAT to the retaining ring.

For the standard MCS500, we also offer an optional suction cup holder (MCS500-TA01) for light loads, which can be easily mounted using a set screw, as shown in Figure 27. (The suction cup does not come with the holder.)



(a) Installing the suction cup holder (b) Suction cup fully installed

Figure 27: Installing the optional suction cup holder (MCS500-TA01)

The dimensions of the optional suction cup holder are shown in Figure 28. You can also download the CAD file of the holder from here.

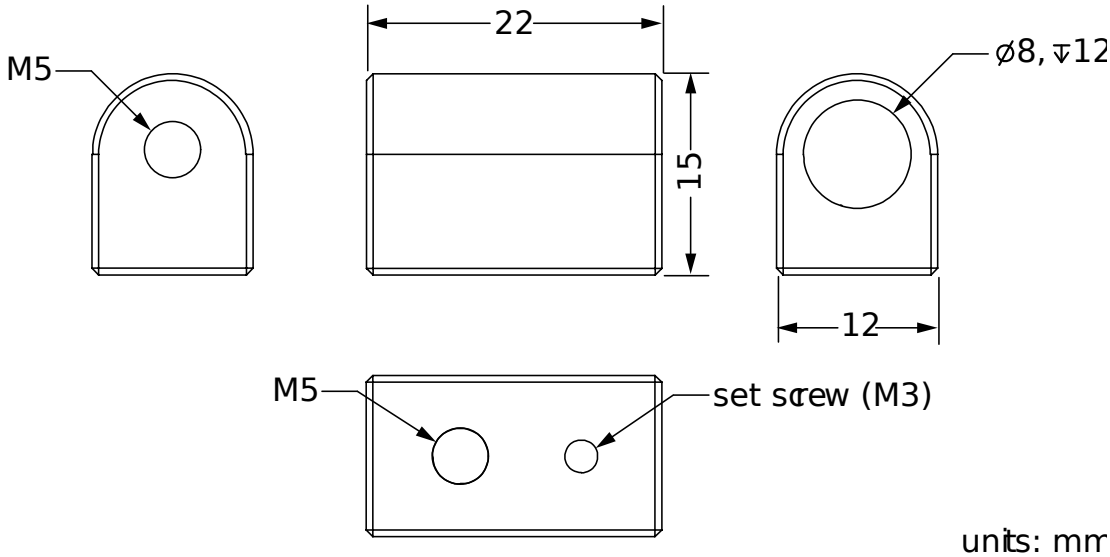


Figure 28: Main dimensions of the optional suction cup holder

Finally, cables or tubing from the end-effector can be rerouted to the base by attaching them onto the arch-shaped cable conduit of the robot, using the two M3 threaded holes shown in Figure 29.

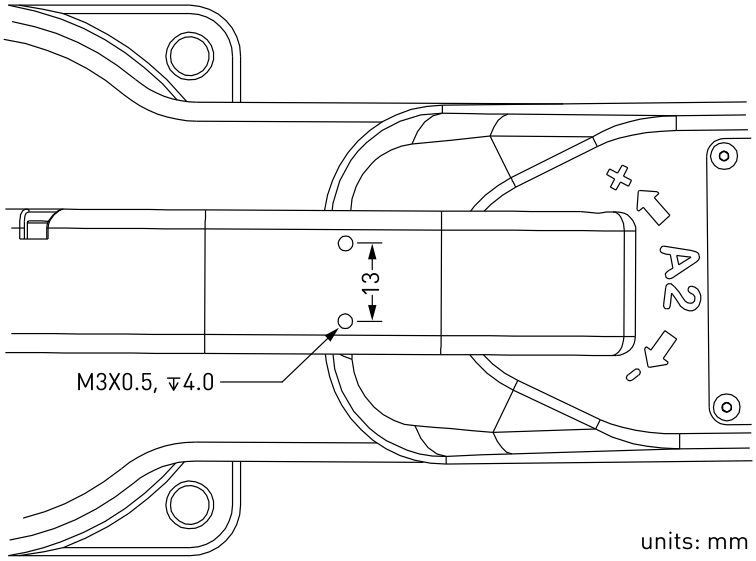


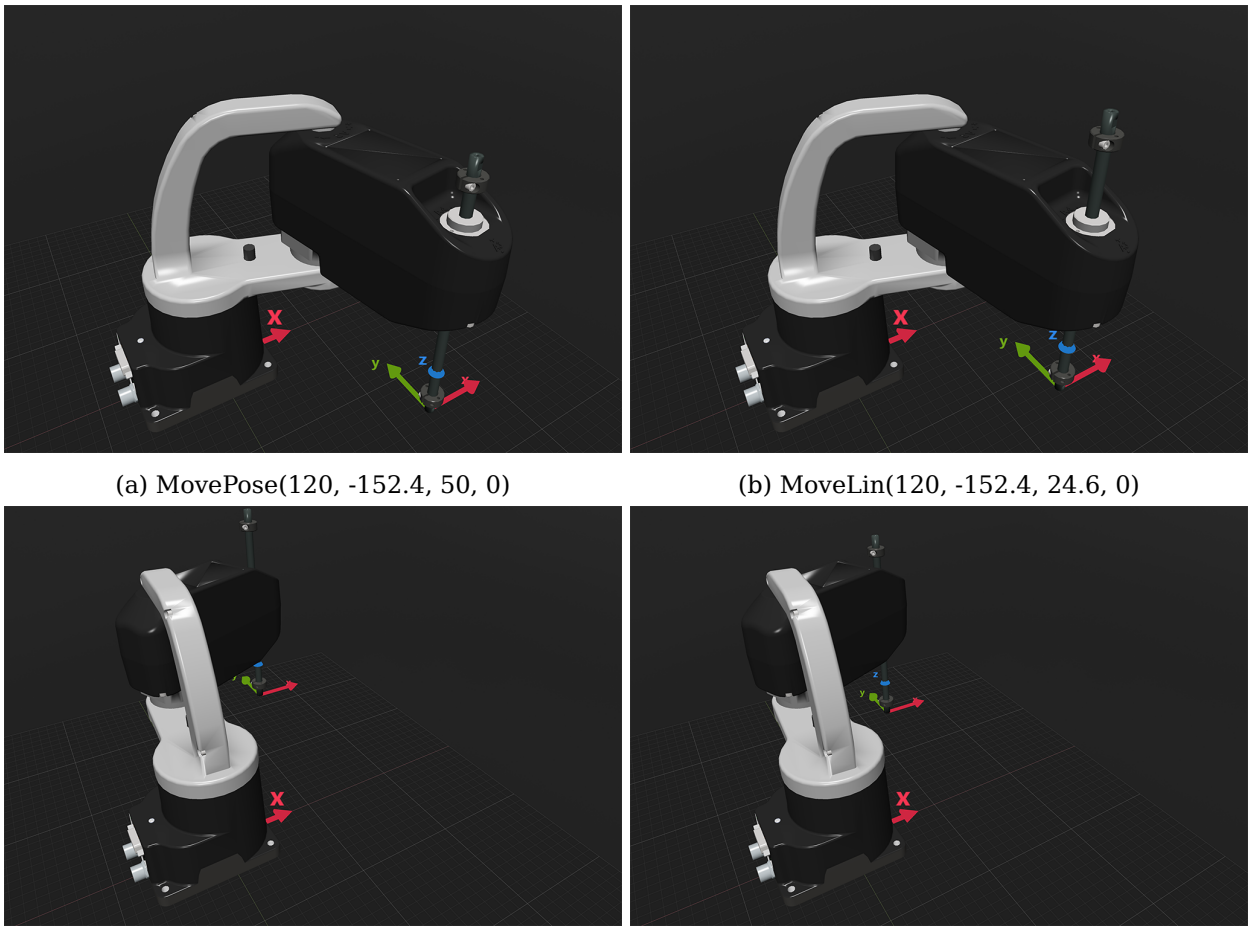
Figure 29: Placement of the threaded holes on the cable conduit of the robot

Examples

Here is an example of a very simple program that makes a pick and place motion:

```
// Set reference frames
SetTrf(0, 0, 0, 0)
SetWrf(0, 0, 0, 0)

// Set motion parameters
SetCartLinVel(5000)
SetJointVel(100)
SetBlending(10)

// Fix robot configuration
SetConf(-1)

// Move to pick position
MovePose(120, -152.4, 50, 0)
MoveLin(120, -152.4, 24.6, 0)
MoveLin(120, -152.4, 50, 0)
MoveLin(120, 152.4, 50, 0)

// Move to drop position
MoveLin(120, 152.4, 24.6, 0)
MoveLin(120, 152.4, 50, 0)
MovePose(120, -152.4, 50, 0)

// For faster cycle times, use the command MoveJump
```

Figure 30 shows the result of four of the motion commands.



(a) MovePose(120, -152.4, 50, 0)

(b) MoveLin(120, -152.4, 24.6, 0)

(c) MovePose(120, 152.4, 50, 0)

(d) MovePose(120, 152.4, 24.6, 0)

Figure 30: The four separate robot positions that define the motion sequence

Inspection and maintenance

Depending on the usage of your MCS500, the robot may require some minimum maintenance. However, it does never require disassembly. There is no battery to replace and joints 1 and 2 do not require greasing.

Locking up the MSIPS module

Follow the procedure described in Section 4.

Cleaning

Turn off the MSIPS module and wipe away any dust or dirt observed on the robot arm using a soft, lint-free cloth and Isopropyl alcohol. *Never use compressed air to clean the robot arm.*

Greasing the ball screw spline

The first application of grease on the spline shaft is needed after approximately 50,000 m of travel. Subsequent applications of grease must be made every 100,000 m of travel. Use only AFB-LF grease, from THK. AFB-LF Grease is a general-purpose grease developed with a lithium-based consistency enhancer using refined mineral oil as the base oil. It excels in extreme pressure resistance and mechanical stability.

We do not provide this grease, but it can be easily ordered from THK or various distributors.

Warning

Keep the ball screw spline assembly sufficiently greased. Operating the robot with insufficient grease will permanently damage the assembly (i.e., joints 3 and 4).

Danger

Follow the safety instructions provided by the manufacturer of the grease, THK. A summary of these instructions is given below.

- Avoid breathing mist or vapor. Work in a properly ventilated area. Contaminated work clothing must not be allowed out of the workplace. Wear protective gloves. Avoid release to the environment.
- If grease gets onto your skin, wash with plenty of water. If skin irritation or rash occurs, get medical attention. Wash contaminated clothing before reuse.
- If grease gets into your eyes, rinse immediately with water. Get medical attention if irritation develops and persists.
- If grease gets into your mouth, rinse mouth immediately. Get medical attention if symptoms occur.
- The grease is inflammable. If contents gets on fire, extinguish with foam, carbon dioxide or dry powder. Do not use water or halogenated extinguishing media.
- Store in tightly closed container. Store away from strong oxidizing agents, and from heat.

To grease the spline shaft, cover the surrounding area and the end-effector in case the grease drips and follow the steps below:

- Turn the power off.
- Move the robot (joints 1 and 2) to a position where joint 3 can achieve it full stroke.
- Move the spline shaft to its upper limit manually while pressing the brake release button (Figure 12).
- Wipe off the old grease from the upper part of the spline with a clean cloth and then

apply new grease, by directly filling the grooves on the shaft. Wipe off excess grease from the shaft.

- Move the spline shaft to its lower limit manually while pressing the brake release button.
- Repeat step 4 for the lower part of the spline.
- Move the shaft up and down several times while pressing the brake release button. Wipe off excess grease from the shaft.
- Store away grease and remove all cloths and covers.
- Power on the robot and verify the motion of joints 3 and 4.

Making large-amplitude joints movements

If you operate the revolute joints of your robot repeatedly within a small angle of 10° or less, an oil film shortage will develop locally and the bearings will get damaged. To prevent premature failure, move the joints at least 60°, ten times a day.

Similarly, if you repeatedly move joint 3 of your robot within less than 20 mm, move it at least 50 mm up and down, ten times a day.

Verifying the overall condition of the robot

Verify on a regular basis the overall condition of your robot by following these steps:

- During boot-up, and then once the robot is activated, verify the correct functioning of the LEDs on the MSIPS module (Section 7) and on the robot's base (Section 7).
- Move joints, one by one, slowly and then at maximum speed, as much as you can without risking interference and listen carefully for suspicious noise.
- Remove power from the robot and gently press up or down the spline shaft, by applying no more than the equivalent of about 1 kg of load. The spline is not supposed to move under a small load like this.
- Make sure all cables are correctly screwed in the robot's base and on the MSIPS module.
- Make sure there are no loose D-Sub connections.
- Verify that the four M6 screws on the base of the robot are sufficiently tightened. They must be tightened with a torque of 3 Nm.
- Verify that the four M3 screws attaching your tool to the flange of the robot are sufficiently tightened. They must be tightened with a torque of 1.5 Nm.

Danger

If you detect any anomalies, cease using the robot and contact our support team by creating a ticket at https://support.mecademic.com.

Troubleshooting

No LEDs are on upon power up

- Make sure all connectors are properly attached.
- Make sure the AC outlet works (the green LED on the MSIPS module should be on).

No connection to the robot's web interface

- Make sure EtherCAT mode has not been enabled. To switch the robot back to Ethernet TCP/IP mode, the simplest way is to do a network configuration reset (see below).
- Make sure the router/switch works by checking the LEDs of the connection socket.
- Make sure you are connected to the same network as the robot.
- If you are using static IP addresses, make sure that the robot's IP default address (192.168.0.100) does not conflict with any other device on the network. For example:

  Robot: IP = 192.168.0.100, netmask = 255.255.255.0, gateway = 192.168.0.1
  Computer: IP = 192.168.0.101, netmask = 255.255.255.0, gateway = 192.168.0.1

- If you are using DHCP, make sure to verify the robot's IP address via your router's web interface.
- Make sure you do not have a firewall preventing traffic on TCP ports 80, 10000, 10001, 10010, 10011, 10020, 10021. These ports are used by the MecaPortal for communicating with the robot.
- Make sure the Ethernet cable is properly connected. The green Ethernet LED should pulse like on an RJ-45 connector when there is communication between the robot and the computer. If the green LED is not illuminated, detach and reconnect the Ethernet cable.

Robot fails to boot

- Disconnect the MSIPS module from the AC outlet and wait for the green LED of the module to turn off. Then reconnect the MSIPS module and boot the robot.

Robot's IP address forgotten

- You can reset the robot's Ethernet configuration (i.e., set the robot's IP address to 192.168.0.100 and the communications mode to TCP/IP) by performing a network configuration reset.

Network configuration reset

Continuously pressing for about 10 s the button between the two Ethernet connectors on the robot's base, *once the robot is powered* resets the robot's IP address and the communication mode to Ethernet TCP/IP. When you press that button, the Power (green) LED will start blinking slowly. As soon as the network configuration reset is done (after about 10 s), the Power (green), Status (yellow) and Error (red) LEDs will start flashing quickly in a sequence (two quick flashes each) and you can release the button.

Factory reset

Continuously pressing the button on the robot's base during boot-up for about 45 s will reset all configuration parameters (including the network ones) to their defaults, as well erase all robot programs. This factory reset will not erase the robot logs and the mastering parameters, or re-install the original firmware. During the procedure, there will be different sequences of LEDs flashing and blinking:

- The first 5 s of pressing the button, the three LEDs (Power, Status and Error) will blink slowly, then they will start blinking faster for another 10 s. This is the boot-up sequence in safe mode.
- Next, it is the network configuration reset that will take place and, as explained earlier, the Power LED only will start blinking slowly for about 10 s, and then the three LEDs will start blinking in a sequence for about 5 s. Keep pressing the button on the robot base.
- Then, the Power LED only will start blinking, but faster than before (indicating that factory reset it about to be performed), for about 15 s. Finally the three LEDs will start blinking fast in a sequence. You can now release the button.

Storing the robot in its shipping box

To put the MCS500 back into the foam insert of its original shipping box, click the button in the jogging panel of the MecaPortal and select "Shipping position" or simply send the command MoveJoints(-140,145,-102,0). Recall that you must not force the brakes on the spline shaft.

Warning

Never disassemble the robot. If the robot appears damaged, stop using it immediately and contact us.

Note

If you are unable to solve your technical problem, do not hesitate to contact our technical support team by creating a ticket at support.mecademic.com.

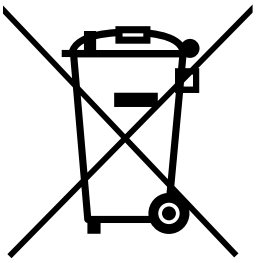
Decommissioning

Even when the MCS500 reaches the end of its product's life cycle or is deemed to be damaged beyond repair, we encourage you to contact us to verify if complete disposal can be avoided.

If you do decide to dispose of the MCS500 system (robot arm, MSIPS module and cables), you must do so in accordance with the applicable national laws, regulations and standards.

The MCS500 system is produced with restricted use of hazardous substances to protect the environment; as defined by the European RoHS directive 2011/65/EU. These substances include mercury, cadmium, lead, chromium VI, polybrominated biphenyls and polybrominated diphenyl ethers. Specialized organisms can dismantle the unit and sort out these materials. They can also remove and recycle the aluminum parts of the robot.

If the robot is not contaminated, you can also ship it back to us.



Terminology

Below is the list of terms used by us in our technical documentation.

active line: The line in the MecaPortal where the cursor is currently positioned.

BRF: Base Reference Frame.

Cartesian space: The four-dimensional space defined by the position (x, y, z) and orientation (γ) of the TRF with respect to the WRF.

control port: The TCP port 10000, over which commands to the robot and messages from the robot are sent.

data request commands: Commands used to request some data regarding the robot (e.g., GetTrf, GetBlending, GetJointVel). These commands are executed immediately and generally return values for parameters that have already been configured (sent and executed) with a Set* command (or the default values).

default value: There are different settings in the robot controller that can be configured using Set* commands (e.g., SetCartAcc). Many of these settings have default values. Every time the robot is powered up, these settings are initialized to their default values. In the case of motion commands settings, their values are also initialized to their default values every time the robot is deactivated. In contrast, some settings are persistent and their values are stored on an SD drive.

detailed event log: This file mirrors the content of the event log panel in the MecaPortal when in detailed mode. It can be downloaded from the MecaPortal (see *troubleshoot-prog* of the Programming Manual).

distal link: In the MCS500, this is the black-anodized body that holds the spline shaft.

EOAT: End-of-arm tooling.

EOB: End-of-block message, [3012][], sent by default every time the robot has stopped moving AND its motion queue is empty. You can disable this message with the command SetEob.

EOM: End-of-motion message, [3004][], sent by the robot whenever it has stopped moving for at least 1 ms, if this option is activated with SetEom.

error mode: The robot goes into error mode when it encounters an error while executing a command or a hardware problem (see *tab:error-messages*).

FCP: Flange Center Point. The origin of the FRF.

FRF: Flange Reference Frame.

instantaneous commands: These are commands that are executed immediately, as soon as received by the robot. All data request commands (Get*), all robot control commands, all work zone supervision and collision prevention commands and some optional accessories commands (*_Immediate) are instantaneous.

inverse kinematics: The problem of obtaining the robot joint sets that correspond to a desired end-effector pose. See *inverse-kinematics* of the Programming manual for more details.

joint position: The joint angle associated with a rotary joint or the position of joint 3.

joint set: The set of all joint positions.

joint space: The four-dimensional space defined by the positions of the robot joints.

monitoring port: The TCP port 10001, over which data is sent periodically from the robot.

motion commands: Commands used to construct the robot trajectory (e.g., Delay, MoveJoints, SetTRF, SetBlending). When a Mecademic robot receives a motion command, it places it in a motion queue. The command will be run once all preceding motion commands have been executed.

motion queue: The buffer where motion commands that were sent to the robot are stored and executed on a FIFO basis by the robot.

offline program: A sequence of commands saved in the internal memory of the robot. The term *offline* is often omitted and will eventually be removed altogether.

online mode programming: Programming the robot in online mode involves moving it directly to each desired robot position, typically using jogging controls.

PDO (**Process Data Object**): In EtherCAT, a Process Data Object (PDO) is a data structure used for exchanging real-time cyclic data between an EtherCAT master and its slave devices. PDOs can contain individual bits, bytes, or words.

persistent settings: Some settings in the robot controller have default values (e.g., the robot name set by the command SetRobotName), but when changed, their new values are written on an SD drive and persist even if the robot is powered off.

pose: The position and orientation of one reference frame with respect to another.

position mode: One of the two control modes, in which the robot's motion is generated by requesting a target end-effector pose or joint set (see *pos-vel-modes* of the Programming Manual).

robot posture configuration: The two-value (−1 or 1) parameter c_e that normally defines each of the two possible robot postures for a given pose of the robot's end-effector.

proximal link: This is the clear-anodized body between the base and the distal link.

queued commands: Commands that are placed in the motion queue, rather than executed immediately. All motion commands are queued commands, as well as some external-tool commands.

reach: The maximum distance between the axis of joint 1 and the axis of joint 4.

real-time data request commands: Commands used to request some real-time data regarding the current status of robot (e.g., GetRtTrf, GetRtCartPos, GetStatusRobot).

retaining ring: In the MCS500, this is each of the two circular clamps on both ends of the spline shaft.

robot control commands: Commands used to immediately control the robot, (e.g., ActivateRobot, PauseMotion, SetNetworkOptions). These commands are executed immediately, i.e., are instantaneous.

robot is ready for motion: The robot is considered *ready* to receive motion commands, i.e. when it is activated.

Note that if the robot is in error or if a safety stop condition is present, it will refuse motion commands, but it will still be considered *ready* since its motion queue remains initialized and retains the latest received settings (e.q., velocity, acceleration, blending, WRF, TRF, etc.).

robot log: This file is a more detailed version of the user log, intended primarily for our support team. It can be downloaded from the MecaPortal (see *troubleshoot-prog* of the Programming Manual).

robot position: A robot position is equivalent to either a joint set or the pose of the TRF relative to the WRF, along with the definitions of both reference frames, and the robot posture and last joint turn configuration parameters.

robot posture: The arrangement of the robot links. Equivalent to a joint set in which all joint angles are normalized, i.e. have been converted to the range $(-180°, 180°]$.

SDO (**Service Data Object**): In EtherCAT, a Service Data Object (SDO) is a data structure used for non-real-time communication between an EtherCAT master and its slave devices. SDOs are typically used to configure device parameters and access diagnostic information through the object dictionary. Unlike PDOs, SDOs exchange structured data rather than individual bits or bytes.

singularities: A robot posture where the robot's end-effector is blocked in some directions even if no joint is at a limit (see *singularities* of the Programming Manual).

spline shaft: This is the the groved reciprocating shaft.

TCP: Tool Center Point. The origin of the TRF. Not to be confused with Transmission Control Protocol.

TRF: Tool reference frame.

turn configuration parameter: Since the last joint of the robot can rotate multiple revolutions, the turn configuration parameter defines the revolution number.

user log: This file is a simplified log containing user-friendly traces of major events (e.g., robot activation, movement, E-Stop activation). It can be downloaded from the MecaPortal (see *troubleshoot-prog* of the Programming Manual).

velocity mode: One of the two control modes, in which the robot's motion is generated by requesting a target joint velocity vector or end-effector Cartesian velocity vector (see *pos-vel-modes* of the Programming Manual).

workspace: The Cartesian workspace of a robot is the set of all feasible poses of its TRF with respect to its WRF. Note that many of these poses can be attained with more than one set of

configuration parameters.

WRF: World reference frame.