



MECADEMIC

USER MANUAL
Original instructions



MECA500 (R3)

ROBOT FIRMWARE: 7.0.6

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1 Introduction

There are two manuals that come with the Meca500 (R3): this one and the [programming manual](#). This manual will guide you through the steps required for setting up your Meca500 and for using it in a safe manner. You must read this user manual thoroughly before even unpacking your first Meca500.

The Meca500 is a six-axis industrial robot arm that is relatively easy to use, robust and lightweight. The robot is, however, a precision device with rapidly moving parts. This robot should therefore be used only by technical personnel who have read and understood every part of this user manual, in order to avoid damages to the robot, its end-effector, the workpiece and adjacent equipment, and, most importantly, in order to avoid injuries.

2 Warning messages, notes and emphases

Particular attention must be paid to the warning messages in this manual. There are only two types of warning messages, as shown below:

**WARNING:**

This presents instructions that must be followed in order to prevent injuries and possibly damage to your robot cell (robot arm, power supply, end-effector, workpiece and/or adjacent equipment).

**CAUTION:**

This presents instructions that must be followed in order to prevent damage to your robot cell (robot arm, power supply, end-effector, workpiece and/or adjacent equipment).

In addition, important notes and definitions are formatted as follows:

**NOTICE:**

This highlights important suggestions or definitions, the purpose of which is to improve the understanding of this manual and of how the robot works.

Finally, occasionally, small portions of the text in this manual that are particularly important are underlined (as already done in the previous section).

3 What's inside the box

Your shipping box contains a Meca500 robot arm (Fig. 1a), a 24 V DC intelligent power supply with an integrated safety module (Fig. 1b) and a D-SUB 15-position dongle (Fig. 1c), a 2-meter M12 D-Code to RJ45 Ethernet cable (Fig. 1d), and a 2-meter M12 Circular male to M12 Circular female DC power cable (Fig. 1e).

Your box may also contain the MEGP 25 electric gripper and accessories. Remove all items carefully and do not discard your shipping box. If your order contained a gripper, do not open its package immediately. You must read the MEGP 25 user manual prior to installing the gripper.

Note, that you must provide your own AC power cord, with three-prong IEC C13 connector on one end, and your own country's power plug on the other. You must also provide M6 screws of proper length for fixing the robot's base and the power supply.

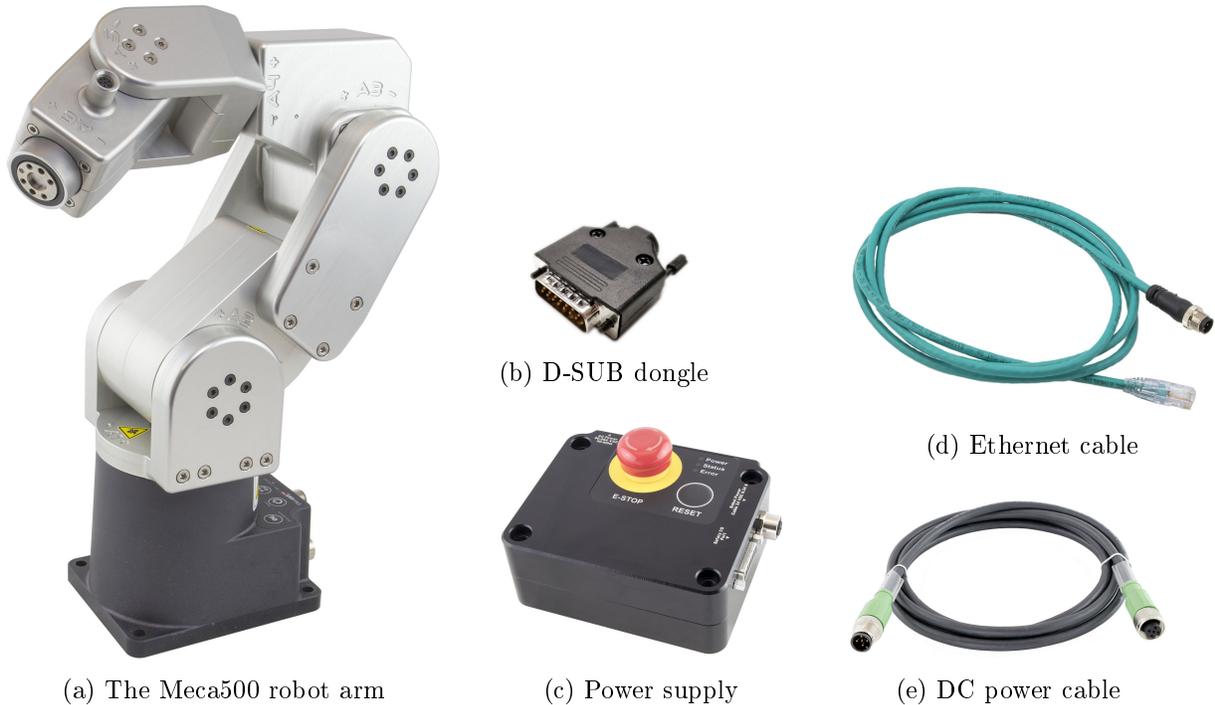


Figure 1: The main contents of your shipping box (optional items not shown)

**CAUTION:**

- Handle the robot with care.
- The Meca500 is equipped with brakes on the first three joints (the ones close to the base). When the robot is not activated, these brakes are automatically applied. Do not force the brakes of the robot, unless there is an emergency!
- Inspect the robot and the power supply for damages. If you think either of them is damaged, do not use them and contact us immediately.
- Do not modify or disassemble the robot arm or the power supply.
- Do not use or store the Meca500 in a humid environment.
- Do not operate the Meca500 at temperatures below +5°C or above +45°C.
- Do not use any other power supply but the one provided.
- Do not replace the Ethernet and DC power cables provided with longer ones, without contacting us first.

4 Safety

The Meca500 weighs less than 5 kg. It can, however, move fast and may cause injuries, especially when certain end-effectors are attached to its flange (e.g., a sharp tool or a laser). The robot also has pinch regions where two adjacent links of the robot can squeeze a finger (Fig. 2).

It is imperative that you follow the guidelines of ISO 12100:2010 and ISO 10218-2:2011 and conduct a risk assessment of your complete robot cell, including the Meca500, its end-effector and all adjacent equipment.



WARNING:

- When the Meca500 is activated, stand away from it, wear safety goggles and be attentive and alert.
- If deemed necessary, place the robot in a safety enclosure.
- In case of an emergency, press immediately the E-STOP button located on the power supply.



Figure 2: When the Meca500 is activated, keep away from the zones labeled with the pinch-point warning sign, to avoid injuries

4.1 Power supply and stopping functions

To power your Meca500 robot arm, you can only use the intelligent power supply provided by Mecademic. If you use one of our older power supplies or your own 24 V DC source, the robot would not function. Our new power supply has an integrated safety module, including a button for emergency stop (Stop Category 1), a reset button, status LEDs, and a D-SUB 15-position interface for connecting an external emergency stop (Stop Category 1), a Stop Category 1 protective stop, and a Stop Category 2 protective stop. The emergency stops and the Stop Category 1 protective stop are designed as PL=d with Safety Category 3.

To start using your robot immediately, connect the dongle provided to the D-SUB 15-position interface. This would deactivate the additional protective stops and emergency stop. Read section 9.2 if you want to remove the dongle and install such additional stops. Furthermore, to connect the power supply to the robot, you must use the DC power cable provided and never modify it.



CAUTION:

Never install an emergency stop or any kind of on/off switch on the DC side of the power supply.

When disconnecting the AC power, either by using the on/off switch on the power supply or by unplugging the AC cord, the brakes on joints 1, 2 and 3 will be immediately applied and the joints will be immobilized instantly. Therefore, to avoid premature use of the brakes, do not disconnect the AC power when the robot is moving.

When disconnecting the AC power or activating the emergency stop or the external Stop Category 1 protective and emergency stops, the wrist joints of the robot become free. This minimizes the risks of pinning and pinching from the wrist and the end-effector. However, beware that the end-effector might slowly move downwards under the effects of gravity. Depending on the type of end-effector used, this residual motion might lead to an injury.

By definition, the Stop Category 2 protective stop does not cut power to the robot, so after the robot stops all motors are active and maintain the position of all joints. The brakes are not applied and there is no residual motion due to gravity.

4.2 Disabling the brakes of the robot

In case of a collision, you can disable the brakes of joints 1, 2 and 3. This can only be done if the robot is powered AND not activated. How to activate and deactivate the robot is explained later in this manual, but for now, it suffices to say that the robot is deactivated

after pressing the E-STOP button. Thus, in case of a collision—though ideally prior to that—you must press the E-STOP button.

Then, to release the brakes of joints 1, 2 and 3, press one of the two 0G buttons on the base of the robot continuously while holding the robot with your other hand. After 3 seconds, you will hear the deactivation of the brakes. Continue holding the 0G button pressed and move the robot as far as possible from obstacles. Finally, release the 0G button, and move away from the robot. Note that there is a pair of commands to disable and re-enable the brakes. These are described in the [programming manual](#).

**WARNING:**

In case of an emergency, it is relatively easy to force the robot brakes and move the robot's joint manually. However, forcing the brakes too often will damage the robot.

4.3 Functioning of the brakes

It is extremely important to remember that the robot has brakes only on joints 1, 2 and 3. Therefore, when the robot is deactivated or powered off, the robot's end-effector will slowly go down under the effects of gravity.

In addition, it is important to remember that the brakes used on joints 1, 2 and 3 are emergency brakes, not locking brakes. Therefore, if you leave the robot in a configuration where the robot's forearm is nearly horizontal, the robot will eventually fall down under the effects of gravity (e.g., after several hours), especially if you have the maximum payload. Therefore, always deactivate the robot when the forearm is as vertical as possible (i.e., try to minimize the static torques on joints 1, 2 and 3).

5 Technical specifications

Table 1 lists the main technical specifications of the Meca500 robot arm. Note that the maximum tool-center point (TCP) linear velocity is software limited to 500 mm/s when the robot moves in Cartesian mode, regardless of the definition of the TCP with respect to the robot's flange. However, if the robot is fully stretched and all joints move at maximum speed, in joint mode, the linear velocity of the TCP can surpass 2,000 mm/s.



WARNING:

Note that in some special configurations, the robot's end-effector can move at 2,000 m/s or even faster. You must consider this fact in your risk assessment.

Table 1: Technical specifications for the Meca500

Position repeatability	0.005 mm
Rated payload	0.5 kg
Max. payload	1.0 kg (under special conditions)
Weight of robot arm	4.5 kg
Range for joint 1	$[-175^\circ, 175^\circ]$
Range for joint 2	$[-70^\circ, 90^\circ]$
Range for joint 3	$[-135^\circ, 70^\circ]$
Range for joint 4	$[-170^\circ, 170^\circ]$
Range for joint 5	$[-115^\circ, 115^\circ]$
Range for joint 6	$[-36,000^\circ, 36,000^\circ]$
Max. speed for joint 1	150°/s
Max. speed for joint 2	150°/s
Max. speed for joint 3	180°/s
Max. speed for joint 4	300°/s
Max. speed for joint 5	300°/s
Max. speed for joint 6	500°/s
Max. TCP linear velocity in joint mode	more than 2,000 mm/s
Max. TCP linear velocity in Cartesian mode	500 mm/s
Max. power consumption	200 W
Input voltage	24 VDC
Operating ambient temperature range	$[5^\circ\text{C}, 45^\circ\text{C}]$
Operating ambient relative humidity range	$[10\%, 80\%]$ (non-condensing)
IP rating	IP 40

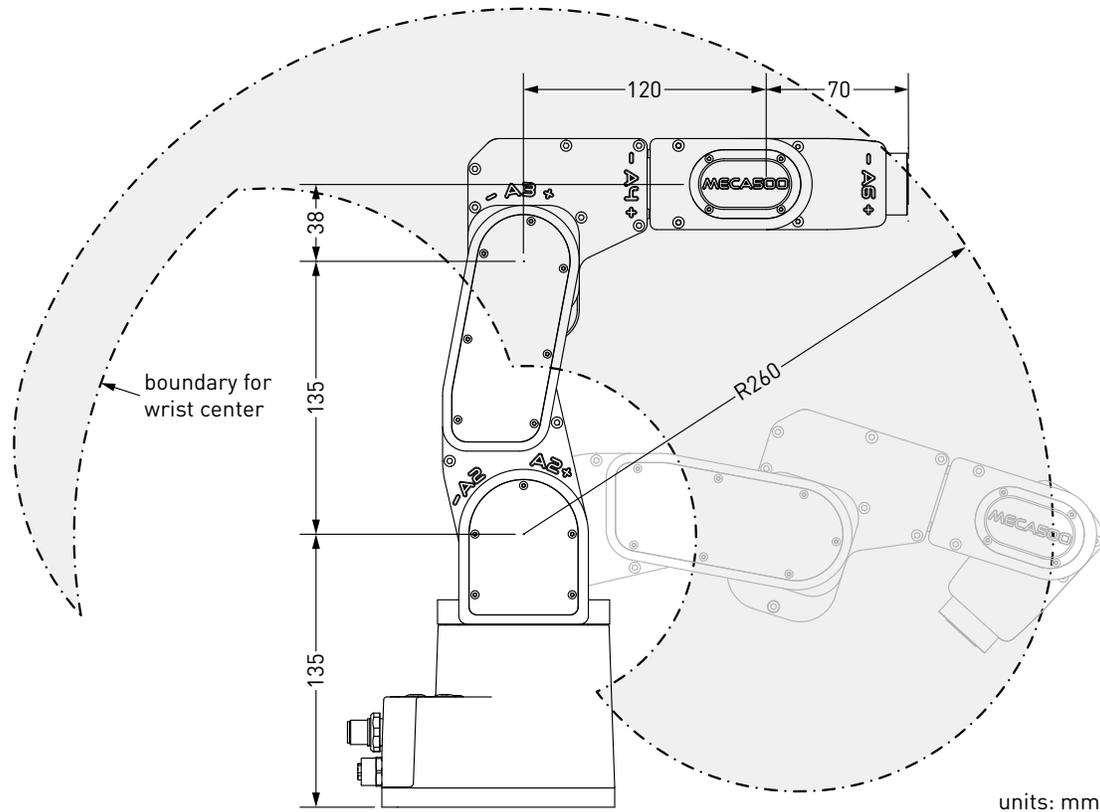


Figure 3: The dimensions of the Meca500

Figure 3 shows the main dimensions of the Meca500. Note that all joints are at zero degrees in the configuration drawn in black line. Also note that the gray zone is the area attainable by the center of the robot's wrist (the intersection point of the last three axes), for a fixed angle of joint 1. This area, or even the volume obtained by sweeping this area about the axis of joint 1 is NOT the workspace of the robot. The workspace of the robot is a six-dimensional entity depending on the definition of your tool reference frame. The workspace is the set of attainable poses (positions and orientations) of the tool reference frame with respect to the robot's base. Even for a specific choice of a tool reference frame, it is impossible to represent this six-dimensional workspace (read this [tutorial](#) of ours).

If you need the CAD files of the Meca500 (in STEP format), please contact us directly. Alternatively, you can use one of several robot simulation and offline programming software packages that include a model of our Meca500, including Visual Components and RoboDK.

Finally, as already mentioned, the power supply provided 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 264 V at frequency between 50 Hz to 60 Hz.

6 Installing the Meca500

You are surely eager to start using your Meca500. It is, however, imperative that you fix solidly the base of your robot arm before activating the robot.

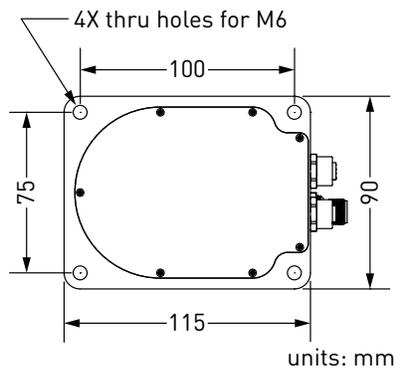


WARNING:

Fix securely the robot's base via the mounting holes (Fig. 4a) with four M6 screws, on any flat surface of a rigid, stationary and steady body.

Note that the robot will automatically detect the angle between the axis of joint 1 and the gravity vector. Also, note that you can mount the robot's base on a mobile body (e.g., on the carriage of a linear guide), but only if you do not intend to move the robot's joints, while the robot's base is moving with respect to the ground.

Next, you must solidly attach the power supply using four M6 screws (Fig. 5), at a location sufficiently close to the robot's base to allow connection with the 2-meter DC cable provided. However, unless you are using an external emergency stop wired via the D-SUB



(a) Dimensions



(b) Connectors



(c) Connectors properly attached

Figure 4: The base of the Meca500

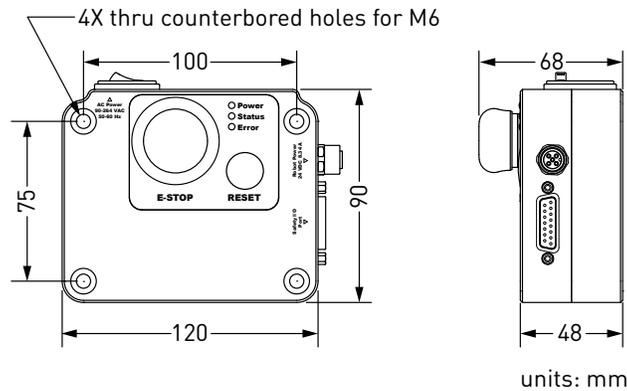


Figure 5: Dimensions of the power supply

connector, you must fix the power supply at a location that makes the integrated E-STOP button readily accessible by an operator and outside the working range of the robot.

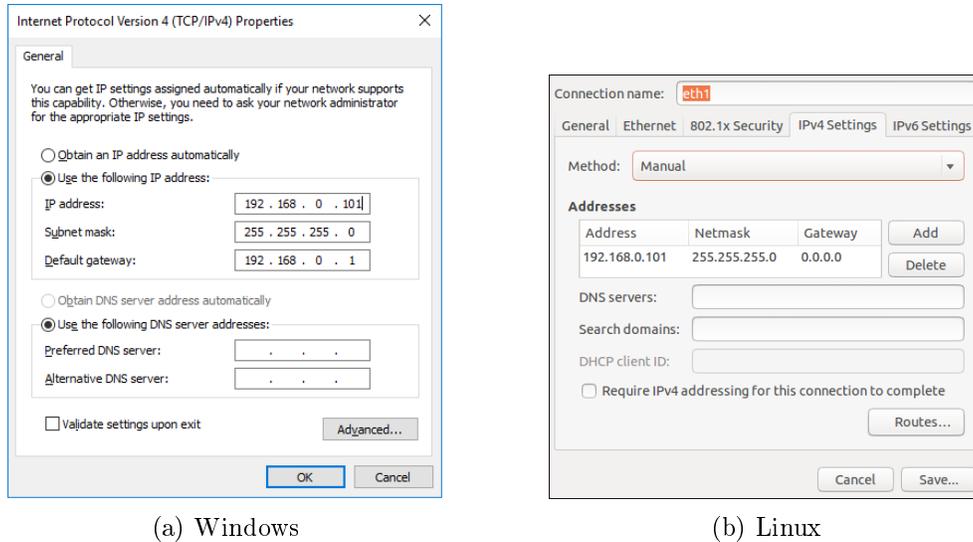
The following steps must then be executed before you can start using your Meca500:

1. 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 (Fig. 4b-c). The two Ethernet ports on the robot's base act as a bridge, so you can daisy-chain several Meca500 robots, or connect an Ethernet I/O module on the ETHERNET2 port.
2. Use the DC power cable provided to connect the unpowered power supply to the robot's DC power connector (Fig. 4b-c). Make sure the connectors are completely screwed on both sides, or else you may damage the robot controller. Then, connect the power supply to your country-specific AC power cord (not provided by us). Only then, can you connect the AC power cord to an AC outlet, and, if not already done, switch the power supply on using its on/off button.



CAUTION:

- Do not use any other power supply but the one provided, or else the warranty will be voided and the CE certification no longer valid.
- Always connect the DC power cable before connecting the power supply to an AC outlet.
- Always disconnect the power supply from the AC outlet (or switch it off) before disconnecting the DC power cable.
- Avoid un-plugging the DC power supply too often and always make sure both connectors are completely screwed.



(a) Windows

(b) Linux

Figure 6: Two examples of how to configure the IP address of your computer

4. The green LED on the power supply (next to “Power”) will be illuminate. Now, you must provide power to the robot by pressing the RESET button on the power supply.
5. You will hear a clicking sound coming from the power supply, and the robot’s LEDs will start flashing for a few seconds while the robot’s controller is booting. Once the controller ready, the red LED on the robot’s base will start flashing intermittently.
6. Depending on which of the two Ethernet ports was used in step 1, the Link/Act IN (for ETHERNET1) or Link/Act OUT (for ETHERNET2) green LED should be illuminated. If it is not, detach the Ethernet cable and repeat step 1.
7. Configure your computer with a static IP address. The way to do this differs from one operating system to another. Figure 6 shows how to do this in Windows and in Linux.
8. Open a web browser, the latest version of either Google Chrome or Firefox only, and type Meca500’s default IP address **192.168.0.100** in the address bar.
9. Meca500’s web interface should load instantaneously. If it doesn’t, repeat the previous step with a different browser.

It is also possible to change the robot’s network configuration. This option is available through the robot’s web interface, which will be described in detail in Section 8. Here is the procedure for doing so:

1. Click on the *Options* dropdown menu and then on *Settings* (Fig. 7).
2. Depending on your configuration, choose “DHCP” to automatically receive an address from your router or “Static” 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 *Save* button (Fig. 8).

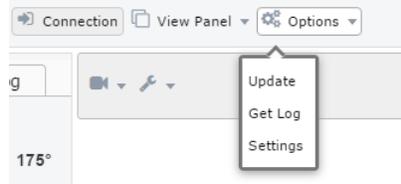
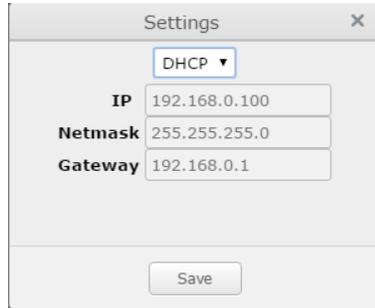


Figure 7: Options dropdown menu



(a) DHCP



(b) Static

Figure 8: Two ways to change the robot's network configuration

7 Installing an end-effector

The Meca500 comes with a proprietary tool I/O (input/output) port located at the robot extremity (Fig. 9a). However, this tool port is reserved uniquely for our electric gripper MEGP 25. We do not share the pinout of this port or its custom-made communication protocol. To install our gripper, refer to its user manual.

If you want to use any other end-effector with the Meca500, you will need to control it independently from the Meca500. You can attach the cabling of your end-effector along the robot arm using adhesive-backed tie mounts. Finally, you must fix the end-effector to the robot's flange (Fig. 9b) using four M3 screws and, optionally, one $\varnothing 3$ locating pin, all of properly selected length. The following rules should be respected:



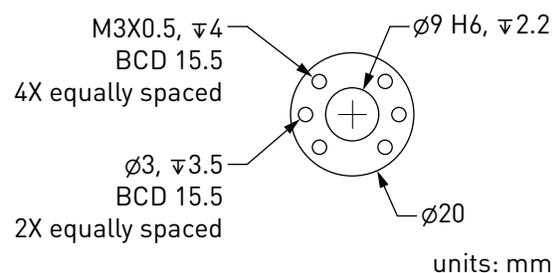
WARNING:

- Keep the robot un-powered while installing/removing a tool to its flange.
- Do not overpass the robot payload (0.5 kg).
- Securely fasten the tool to the robot flange.

Note that since joint 6 is multi-turn, there is no way of knowing the angle of joint 6 (even approximately), unless the robot is activated and homed. Therefore, prior to mounting an end-effector, it is important that you activate and home your robot, rotate joint 6 to its zero position, and finally unpower the robot. However, if the screw on the flange of the robot is not as in Fig. 9b when $\theta_6 = 0^\circ$, then you need to follow the procedure described in the subsection Homing of the [programming manual](#).



(a) Closeup



(b) Dimensions

Figure 9: The mechanical interface (flange) of the Meca500. The flange is the $\varnothing 20$ disk, inside the black isolation ring, and is the only one to rotate when joint 6 rotates.

**CAUTION:**

- Make sure that joint 6 is approximately at 0° before attaching an end-effector.
- Do not over-tighten the M3 screws.
- Attach the tool cabling in such a manner that it obstructs as little as possible the motions of the robot.
- Unless you plug the connector of our own gripper, keep the cover (screw cap, not shown in Fig. 9a) of the tool I/O port in place at all times.

8 Operating the robot

8.1 The web interface

Meca500's web interface is more or less the equivalent of the teach pendant's interface of a traditional industrial robot. The interface is essentially an HTML 5 web page with JavaScript and WebGL code, the CAD models of the robot links, and potentially the end-effector and the environment (in binary STL format). All of these files reside in the robot's controller, so you do not need to install anything on your computer.

The interface basically translates your mouse clicks and keyboard entries into proprietary commands that are sent to the robot's controller. These are the same commands described in the [programming manual](#) that you will eventually start sending from your own application, written in C++, Java, Python or any other modern programming language. In addition, the web interface displays the feedback messages received from the robot and, generally, the virtual model of the actual robot.

The web interface is intended mainly for testing and writing simple programs. You must create your own software application or program if you intend to use the robot for complex tasks, such as interacting with inputs and outputs (in which case you also need a third-party I/O module).

8.1.1 Overview

Figure 10 shows the main elements of the web interface. These are:

1. The main menu
2. The programming panel
3. The robot log panel
4. The quick command panel
5. The real-time jogging panel
6. The real-time pose of the robot end-effector and joint positions
7. The 3D view of the robot, which moves in real-time

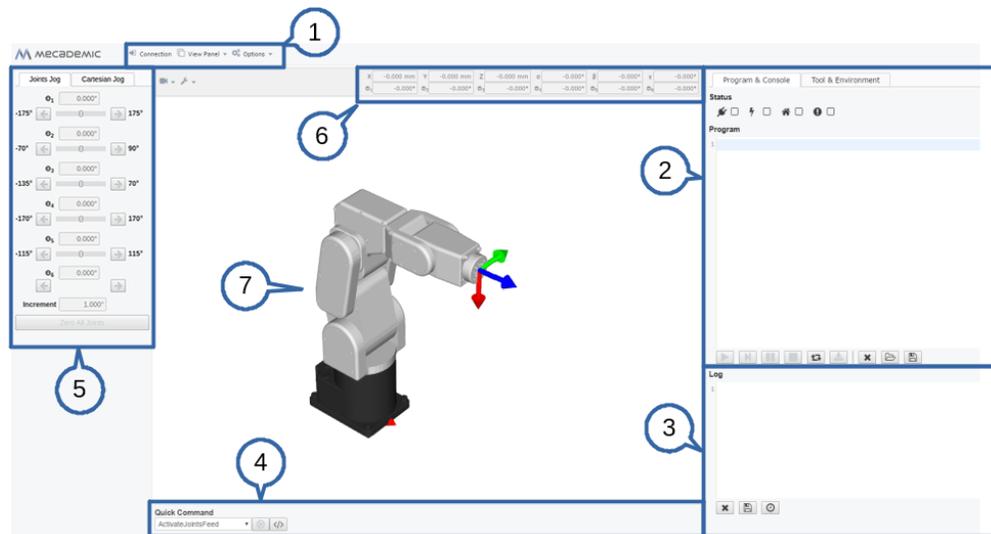


Figure 10: Overview of Meca500’s web interface

8.1.2 Connection and disconnection

Once the web interface is loaded, the first step is to connect it to the robot. So far, you have only established an HTTP connection with the robot, but not activated the socket messaging which is the only communication channel for controlling the robot via the web interface. You can connect to the robot by either selecting the  checkbox in the programming panel, or by selecting the Connection menu item in the main menu.

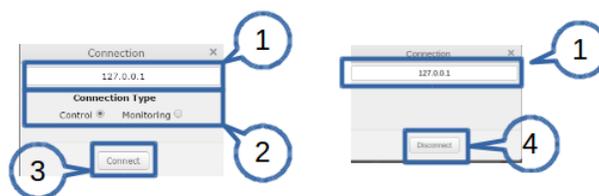


Figure 11: Connect/disconnect windows

The windows displayed in each of these two cases are shown in Fig. 11. The elements of these windows are:

1. IP address of the robot, which is automatically set
2. Connection type, which is either *Control* for sending commands to the robot or *Monitoring* for getting a real-time view of the robot’s motion
3. Connection button
4. Disconnect button

For now, leave the Control radio button in the Connect window selected. The Monitoring option can be used to see in real-time the motion of the robot when another client (other than the web interface, e.g., Matlab running on the same PC) is controlling the actual robot.

8.1.3 The programming panel

The programming panel is used mainly for writing and executing very simple programs, i.e., for testing. These programs are sequences of the proprietary commands described in the [programming manual](#). The robot's command interface does not support conditionals, loops, or other flow control statements. The robot only accepts request commands (to get information from the robot) and motion commands (to tell the robot to perform an action). The panel also supports comments in C/C++ style (e.g., `//` and `/* */`).

For complex tasks, you must write a program outside the web interface (e.g., in your preferred integrated development environment) that parses the robot's feedback, controls the robot, and handles all flow control logic. For this, you can use any language that supports communication over TCP/IP (e.g., C/C++, C#, Python, Java or even Structured Text, in the case of a PLC).

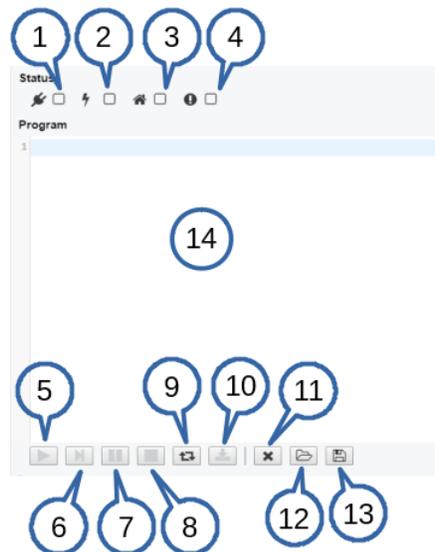


Figure 12: The programming panel

Figure 12 shows the programming panel. The different elements of this panel are enumerated below:

1. Connection/disconnection checkbox, 
2. Activation/deactivation checkbox, 

3. Homing checkbox, 
4. Error status and error reset checkbox, 
5. Send and execute program button, 
6. Send the line command where the cursor is, and move it to the next line, 
7. Hold motion (pauses and keeps the current program; motion is restarted with the  button), 
8. Clear motion (delete all commands and stops the motion), 
9. Loop the program, 
10. Save the program in the robot for offline execution (Section 8.5), 
11. Delete all entries in the program text field, 
12. Open an existing program, 
13. Save the contents of the program text field to a file, 
14. Programming text field

Now, after having connected the web interface to the robot's controller, you need to activate the robot. This can be done by selecting the  checkbox, in the programming panel. Next, you need to home the robot to get a high-accuracy measure of all joint angles.

During homing, all joints rotate slightly. First, all joints rotate simultaneously in one direction. Specifically, each of joints 1, 2 and 3 rotates 3.6° , joints 4 and 5 each rotates 7.2° , and joint 6 rotate 12° . Then, all joints rotate back to their initial positions. The whole back and forth motion, i.e., the homing, lasts approximately 4 seconds.

**CAUTION:**

Before homing the robot, make sure that there is no risk for mechanical interference.

Homing the robot can be done by selecting the  checkbox in the programming panel.

8.1.4 The log panel

The log panel (Fig. 13) displays all the messages that are sent by the robot. The elements of this panel are self explanatory:

1. Clear the log, 
2. Save the log, 
3. Display timestamp for each message, 
4. Log field

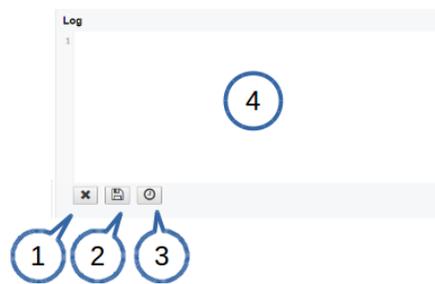


Figure 13: Robot log panel

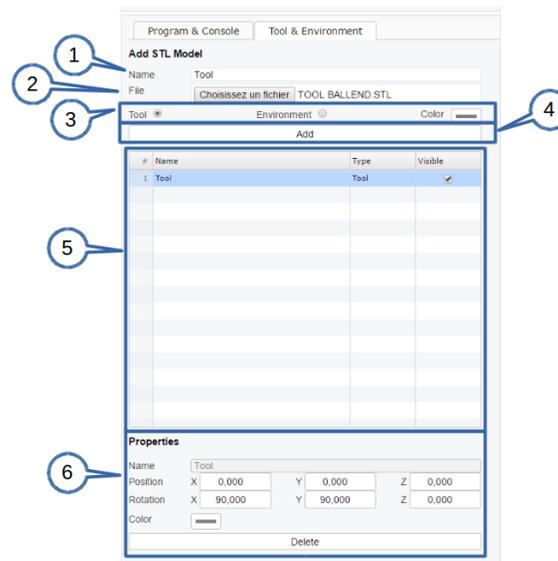


Figure 14: CAD models import panel

8.1.5 The CAD models import panel

One particularly innovative and original functionality of the robot's web interface is the possibility to upload CAD models for the robot's tool (end-effector) and static environment. These models should be in binary STL format. Currently, they serve only for visualization purposes, but in the very near future, they will be used for avoiding mechanical interferences in real time.

Figure 14 shows the CAD models import panel. The different elements of this panel are enumerated below:

1. Name of the model that will be imported.
2. This is where you open the dialog to choose a binary STL file.
3. This is where you select which type of model you are importing. If it is a tool it will be imported fixed with respect to the robot flange. Otherwise, it will be imported fixed with respect to the robot base.

4. This is where you activate the model in the 3D view.
5. The list of imported models.
6. Model properties. This is where you can position your model with respect to the robot *flange reference frame (FRF)*, in the case of a tool, or with respect to the *base reference frame (BRF)*, in the case of environment.

8.2 Power-up procedure

If you have read Sections 6 and 8.1 carefully and followed the steps, your robot is already powered up and ready to move. Nevertheless, here is a quick summary of the steps that you need to follow in order to power up your robot, as described before, as well as alternative methods. In what follows, we assume that the robot has been already installed as described in Section 6.

8.2.1 Powering the robot

- Turn the power supply on.
- Make sure that the E-STOP button on the power supply is released (by twisting it counterclockwise) and press the RESET button, next to it.
- Wait a couple of seconds.

8.2.2 Connecting to the robot

- Connect to the robot's web interface.
- Click the  checkbox in the programming panel **OR** select *Main menu* → *Connection*.
- Select the Control option and click *Connect*.
- As soon as the robot is connected, you will get the following welcome message in the log panel: [3000][Connected to Meca500 x_x_x.x.x], where the x's are numbers.

8.2.3 Activating the robot

- Select the  checkbox, in the programming panel **OR** type in the programming text field `ActivateRobot` and click the  button.

You will hear a distinctive clicking sound.

8.2.4 Homing the robot

- Select the  checkbox in the programming panel or erase `ActivateRobot`, type `Home` and click the  button in the programming panel.

**CAUTION:**

The robot will move slightly during homing. Before homing it, make sure that there is no risk for mechanical interference.

8.3 Moving the robot

A six-axis robot arm is a highly complex system and no matter how intelligent and intuitive its programming interface is, the robot will have plenty of limitations. These limitations are not always obvious even to robotics experts. For example, in any six-axis robot arm, there are often paths that the robot cannot follow, even though they seem to be inside the robot's workspace. Never forget that the workspace of a general six-axis robot is a very intricate six-dimensional entity, not just a sphere.

**NOTICE:**

If you know nothing about orientation representations and robot singularities, we strongly advise you to read some introductory notes on robotics and our interactive tutorial on [Euler angles](#).

After homing, click on the “Zero All Joints” button in the Joints Jog tab on the left. The robot will move all of its joints to their 0° positions. In this robot position (shown in Fig. 10), the robot is in a so-called *wrist singularity* and you will not be able to move it in Cartesian mode (e.g., by jogging). The simplest way to exit this singularity is to jog joint 5, but here is another, more interesting way. Move the robot's end-effector to the pose $x = 250 \text{ mm}$, $y = 0 \text{ mm}$, $z = 150 \text{ mm}$, $\alpha = 0^\circ$, $\beta = 90^\circ$, $\gamma = 0^\circ$.

**NOTICE:**

The Cartesian coordinates displayed above the robot in the web interface are those of the *Tool Reference Frame (TRF)*, fixed to the end-effector, with respect to the *World Reference Frame (WRF)*, fixed to the base of the robot. Both frames are displayed in the web interface. By default, the TRF is located at the flange 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)*.

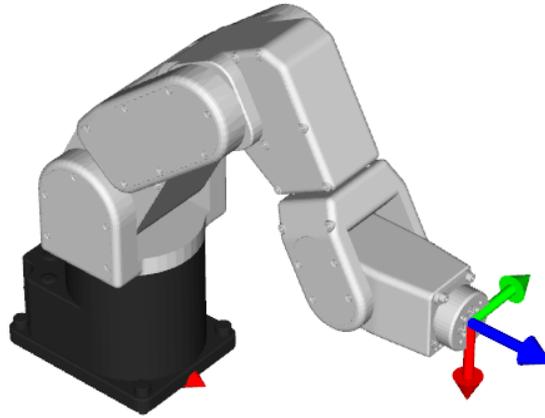


Figure 15: Robot position when its TRF is at $x = 250 \text{ mm}$, $y = 0 \text{ mm}$, $z = 150 \text{ mm}$, $\alpha = 0^\circ$, $\beta = 90^\circ$, $\gamma = 0^\circ$ with respect to its WRF

**NOTICE:**

We use Euler angles (α, β, γ) to define the orientation of a second reference frame with respect to a first one. More specifically, if we consider both frames initially coincident, we rotate the second frame about its x axis at α degrees, then about its y axis at β degrees, and finally about its z axis at γ degrees.

You can move the robot to the new end-effector pose following these steps:

- Clear the programming text field and type `MovePose(250,0,150,0,90,0)`. Send it with the ► button.

OR

- In the Quick Command panel, select MovePose, fill in the arguments with the values 250, 0, 150, 0, 90, and 0, and click on Ⓞ.

Figure 15 shows the resulting robot position.

You can now jog the robot in both joint and Cartesian mode. Note that when a joint reaches its limit (or is very close to a limit), the robot stops and a message is displayed in the log. Furthermore, if you jog the robot in Cartesian mode, you can also run into singularities and no longer be able to jog in certain directions. An error message will appear in the log to inform you about this. To get away, switch to joint jog mode, and slightly rotate joints 3 and/or 5.

**NOTICE:**

Note that in Cartesian jog, when reorienting the end-effector using the Rx, Ry and Rz arrow buttons, you do not modify independently each Euler angle, but rather rotate the TRF about axes passing through its origin (the TCP) and coincident with its x , y or z axes, if the TRF option is chosen, or parallel to the x , y or z axes of the WRF, if the WRF option is chosen.

8.4 Power-off procedure

8.4.1 Zeroing the robot (optional)

It might be a good idea to always bring the robot to its zero position, before turning it off. This can be done in two ways:

- send a MoveJoints command with all arguments equal to 0
- OR
- click on the “Zero All Joints” button in the Joints Jog panel.

8.4.2 Deactivating the robot

To deactivate the robot

- uncheck the ⚡ checkbox
- OR
- send the DeactivateRobot command via the program text area or via the Quick Command menu,

**CAUTION:**

Recall that there are no brakes on joints 4, 5 and 6. As soon as you deactivate the robot, the end-effector will slowly tilt down under the effects of gravity.

**NOTICE:**

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

8.4.3 Disconnecting the robot

To disconnect the robot

- uncheck the ⚡ checkbox

OR

- select Connection in the main menu and click Disconnect.



WARNING:

If you disconnect the robot before deactivating it, the robot will continue to move (if it was moving), even if you close the web interface.

8.4.4 Removing power

Finally, unplug the power supply from the AC outlet or switch it off.



CAUTION:

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

8.5 Offline mode

You can store an offline program in the robot's hard drive and execute it without an external computer. This program is kept, even after power off, until replaced by another one. Note, however, that if you type in directly the command *StartSaving(n)* instead of using the web interface, you can save up to 500 program. Using the procedure listed below will save only program 1 ($n = 1$).

8.5.1 Saving the program via the web client interface

- To save a program, the robot must be deactivated, i.e., the ⚡ icon must be unchecked.
- Write the program in the Program Editor panel.
- To run the program on infinite loop, insert the command `SetOfflineProgramLoop(1)`. (The checkbox has no effect on the execution of the offline program.)
- Click on the ⏴ icon.

8.5.2 Running the offline program

To execute the offline program 1, make sure there is no user connected to the robot and press the Start/Pause button on the robot base. The Start/Pause LED will flash rapidly for three seconds, after which the robot will start executing the program.



Figure 16: Robot's control panel



WARNING:

Immediately after pressing the Start/Pause button on the robot's base, move away your hand and stay outside the robot's reach.

8.6 Robot control panel

The set of buttons and LEDs on the robot's base is called the robot's control panel (Fig. 16). The meanings of the LEDs and the functionalities of the buttons will be summarized below.

8.6.1 LEDs

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

Power LED

The Power LED is red and indicates the activation state of the robot:

- the LED will flash slowly when the robot is deactivated;
- the LED will flash fast when the robot is being activated;
- the LED will be lit continuously when the robot is activated.

Home LED

The Home LED is yellow and indicates the homing state of the robot:

- the LED will be off when the robot is not homed;
- the LED will flash slowly when the robot is being homed;
- the LED will be lit continuously when the robot is homed.

Start/Pause LED

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

- the LED will flash fast when the Start/Pause button was pressed and the program saved in the robot is about to start;
- the LED will be off when the robot is not moving;
- the LED will be lit continuously when the robot is moving.

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

Used only when the robot is controlled via EtherCAT (see the [programming manual](#)).

Finally, when the robot is in error mode, the Power, Home and Start/Pause LEDs flash fast simultaneously. Also, if you press the Power button continuously, which provokes a factory reset of the robot, the Power, Home and Play LEDs, will each flash three times.

8.6.2 Buttons

The buttons on the control panel are active only when no user is connected to the robot. In what follows, you must refer to the detailed descriptions of the commands associated with each button.



WARNING:

When pressing the buttons on the robot's control panel, keep your fingers away from the pinch points of the robot, and move away from the robot as soon as a button is released.

Power button

The Power button acts as the `ActivateRobot` and `DeactivateRobot` commands:

- when the robot is deactivated, pressing Power will send the `ActivateRobot` command;
- when the robot is activated, pressing Power will send the `DeactivateRobot` command;
- when the robot is in error mode, pressing and holding Power for five seconds will send the `DeactivateRobot` command.

Pressing and holding Power during power-up will reset the robot network configuration.

Home button

The Home button acts as the `Home` and `ResetError` commands:

- when the robot is deactivated, pressing Home has no effect;
- when the robot is activated, pressing Home sends the Home command;
- when the robot is homed, pressing Home has no effect;
- when the robot is in error mode, pressing and holding Home for five seconds will send the `ResetError` command.

Start/Pause button

The Start/Pause button on the robot control panel acts as the `StartProgram`, `PauseMotion`, `ResumeMotion`, and `ClearMotion` commands:

- when the robot is activated, homed and not executing a program, pressing Start/ Pause will send the `StartProgram(1)` command three seconds after being pressed;
- when the robot is activated and homed, pressing Start/Pause will send the `ClearMotion` command, whether the robot is moving or not;
- when the robot is activated, homed and moving, pressing Start/Pause will send the `PauseMotion` command;
- when the robot is activated, homed and stopped (by the `PauseMotion` command), pressing Start/Pause will send the `ResumeMotion` command.

0G button

Pressing and holding the 0G button for three seconds, once the robot is deactivated, will release the brakes. While keeping 0G pressed with one hand, you can manually move the robot with your other hand. The brakes will reengage as soon as the 0G button is released.



CAUTION:

Once the robot is deactivated, hold the robot with one hand, before pressing the 0G button. Otherwise, the robot may fall down under the effect of gravity.

9 Operating the intelligent power supply

Mecademic's intelligent power supply is shown in Fig. 17. As already explained, release all emergency stops and the external Stop Category 2 protective stop, and then press the RESET button to provide power to the robot. Once the robot is activated and homed, pressing the E-STOP button at any time instantly sends a signal to the robot to rapidly decelerate and come to a complete stop. The power supply 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 power supply completely cuts power to the robot. Without power, the robot's brakes are instantly applied to joints 1, 2 and 3.

To restart the robot, you must release the emergency stops or the external Category 2 protective stop, and then press the RESET button. Next, you need to connect to the robot via Ethernet TCP/IP or EtherCAT, activate the robot, and finally home it. Of course, you will also need to manage the stream of commands being sent to the robot. For example, if a PLC sends commands to the robot, while the robot is powered off, the program that runs on your PLC will need to be able to detect and manage this situation, in one way or another. To do so, you can get a signal from the intelligent power supply that power to the robot has been cut by connecting your PLC to the D-SUB connected, as will be explained in the following pages.



Figure 17: The intelligent power supply

9.1 LEDs

The power supply is equipped with three LEDs. As long as the power supply is switched on (using the on/off button shown in Fig. 17b) and connected to an AC source that supplies voltage between 90 V and 264 V at frequency between 50 Hz to 60 Hz, the green LED next to “Power” stays illuminated. Supplying AC voltage outside this range may damage the power supply.

Once the power supply switched on, the yellow “Status” LED indicates the status of the power supply. If the yellow LED is off, you need to press the RESET button, which sends power to the robot. If the proper Meca500 is correctly connected to the power supply, the yellow LED will turn on and stay lit.

If, in any situation, the yellow LED blinks regularly, this means that an emergency stop (either the one on the power supply or the external one) or the external Stop Category 2 protective stop is activated. You need to release the emergency stop or remove the cause for the Stop Category 2 protective stop and then press the RESET button.

If the yellow LED illuminates in sets of two flashes, this means that the integrated or external RESET button has been pressed too long. Make sure they are not pressed and then press any of them, in a quick fashion.

Finally, the red “Error” LED indicates if there is a problem with the power supply or with some of the connections to the D-SUB interface. If the red LED flashes (0.1 s on, 0.9 s off), either there is no robot connected to the power supply or the robot connected is an old version that is not supported by this power supply. If the red LED illuminates in sets of two quick flashes, the robot has detected a problem and sent a request to the power supply to be shut down. If this happens, contact us. If the red LED blinks in regular intervals (0.5 s on, 0.5 s off), this means that there is either a problem in your external emergency stop or Stop Category 1 connections or in our power supply. If you don’t see any problem in your connections, contact us. Finally, if the red LED is constantly lit, there is a problem with the power supply. Switch off the power supply and contact us.

Table 2 summarizes the different states of the three LEDs as well as their meanings.

9.2 External connections

If you do not need to connect an external E-Stop, an external reset, or protective stops or be able to know whether the robot is powered, you need to plug the D-SUB 15-position dangle in the power supply. Otherwise, even if you only need to connect a single external E-Stop, you need to properly wire the rest of the connections in the D-SUB connector.

LED	Name	LED state	Explanation
Green	Power	Off	The power supply is turned on
		On	The power supply is turned off
Yellow	Status	Off	Robot is not powered. Press RESET.
		Blinking	Robot is not powered and a Stop Category 1 stop is pressed or the dongle is not plugged in. Remove the stop, make sure the dongle is plugged in, and press RESET.
		Two flashes	Robot is not powered because a RESET button has been pressed for too long. Press RESET again.
		On	Robot is powered.
Red	Error	Off	There is no error.
		Flashes	No proper robot connected.
		Two flashes	Robot has detected a problem and requested that power be shut down. Contact Mecademic.
		Blinking	Problem with Stop Category 1 stops detected. Check external stop connections and contact Mecademic if no solution found.

Table 2: The various states of the LEDs on the power supply

Figure 18 shows the pinout of the D-SUB 15-position connector on the power supply and gives a generic example for all connections. As already mentioned, you can connect:

- one external Stop Category 1 emergency stop (connections E-Stop – A1, E-Stop – B1, E-Stop – A2, E-Stop – B2);
- one Stop Category 1 protective stop (connections P-Stop 1 – A1, P-Stop 1 – K1, P-Stop 1 – A2, P-Stop 1 – K2);
- one reset button (connections Reset – A, Reset – K);
- one power status indicator (connections Power Status – A, Power Status – B);
- one Stop Category 2 protective stop (connections P-Stop 2 – A, P-Stop 2 – B).

Note that the external circuits shown in Fig. 18 are only suggestions. You may, for example, connect several external E-Stops in series, or instead of sending a signal to a PLC when the power to the robot is cut, you may connect a LED between the resistor and the Power Status – A line. Figure 19 shows several other examples. Specifically, Fig. 19a shows how to control the Stop Category 1 protective stop from a PLC by supplying a 24 V DC signal. Figure 19b shows how to reset the power supply from a PLC. Figure 19c shows that you can supply a 12 mA continuous forward current to pins 4 and 5 if you do not want to use the Stop Category 1 protective stop. Lastly, Fig. 19d shows that you need to short-circuit pins 1 and 9, and pins 2 and 10, if you do not intend to use an external E-Stop.

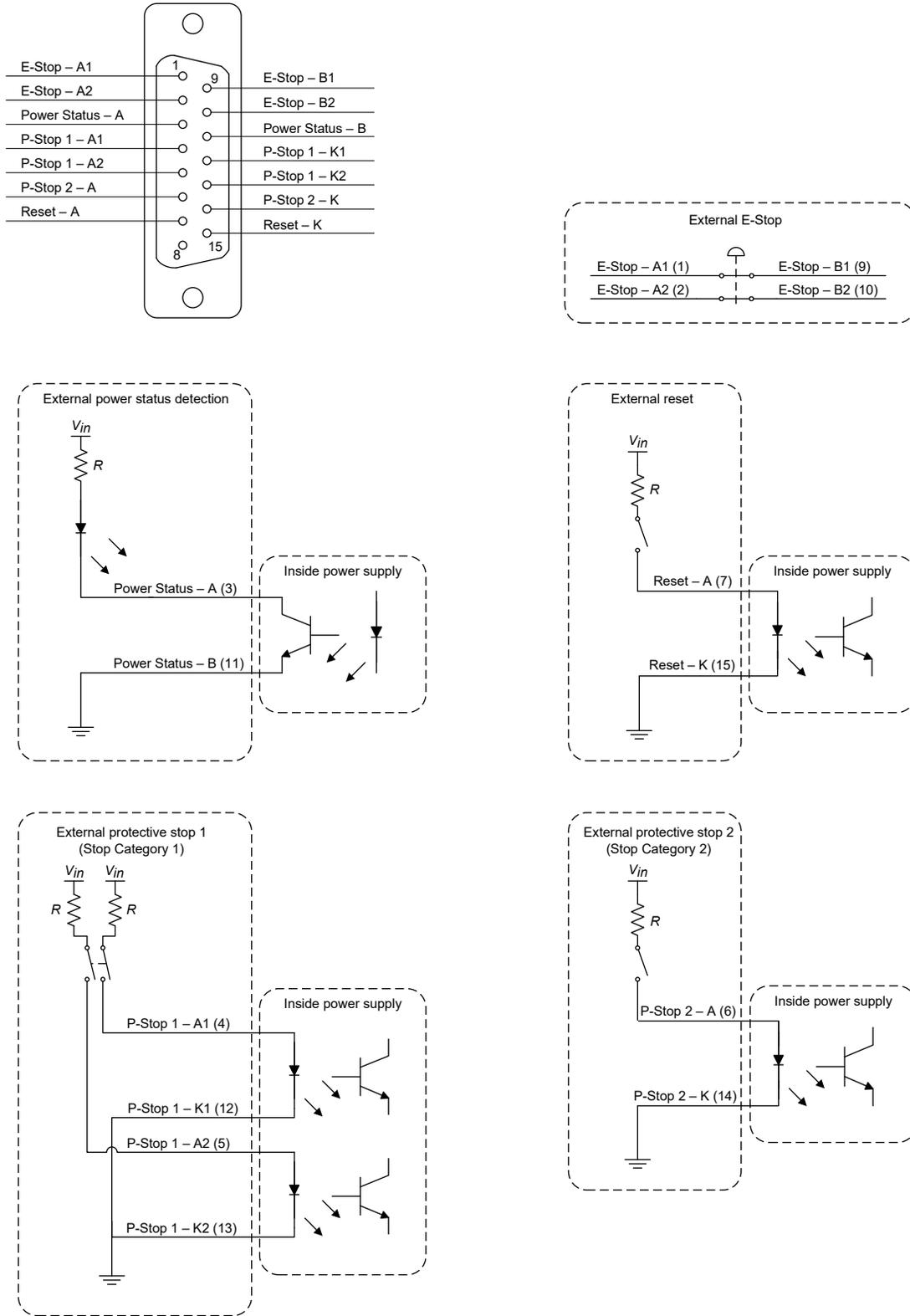


Figure 18: Electric diagram of suggested generic connections to the D-SUB connector

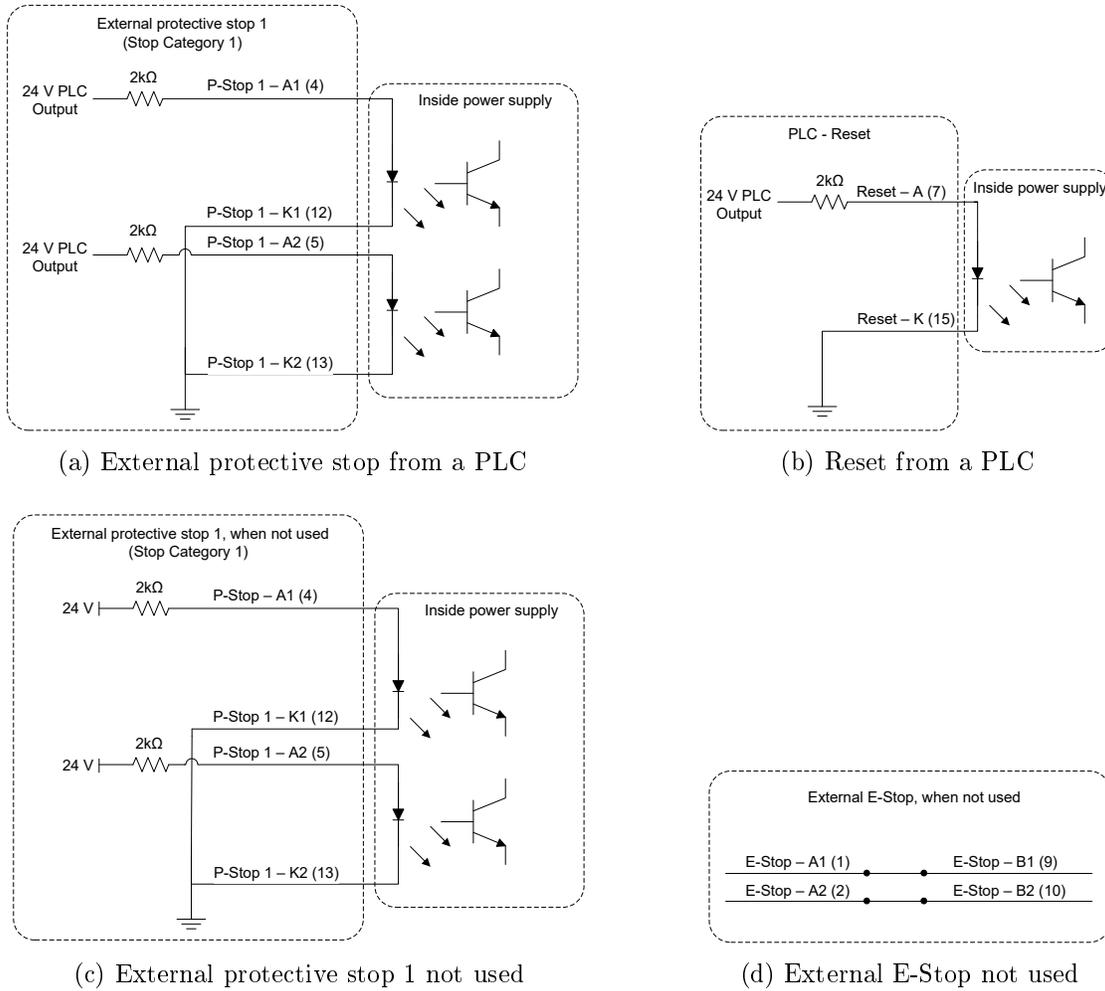


Figure 19: Additional examples of connections to D-SUB connector

Finally, in designing your external connection circuits, you must respect the specifications of the optocouplers used in our power supply. The following restrictions must be respected:

- The input voltage (V_{in} , Fig. 18) must be between 5 V DC and 48 V DC.
- The continuous forward current, I_f , must not exceed 20 mA. Thus the resistance of the resistor that must be added before each anode (pins 4-7) is calculated as $R = V_{in}/I_f$.
- The reverse voltage must not exceed 5 V DC. Thus, be extremely careful with the polarity of the input voltage supplied.



CAUTION:

Respect the above restrictions very closely or you will almost certainly damage the power supply of the robot. If you have any doubt, contact our technical support team by email, at support@mecademic.com.

10 Examples

10.1 Draw a square

Here is an example of a very simple program. Note again that there should be no empty lines in your program, nor empty spaces before or after a command (e.g., no indentation).

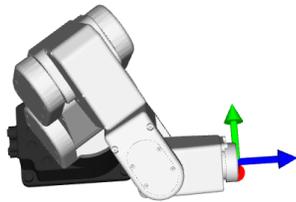
Listing 1: Square path with the MoveLin command

```

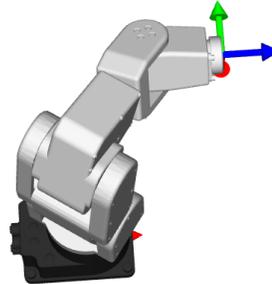
ActivateRobot
Home
MovePose(140, -100, 250, 0, 90, 0)
MoveLin(140, -100, 250, 0, 90, 0)
MoveLin(140, 100, 250, 0, 90, 0)
MoveLin(270, 100, 250, 0, 90, 0)
MoveLin(270, -100, 250, 0, 90, 0)
MoveJoints(0, 0, 0, 0, 0, 0)

```

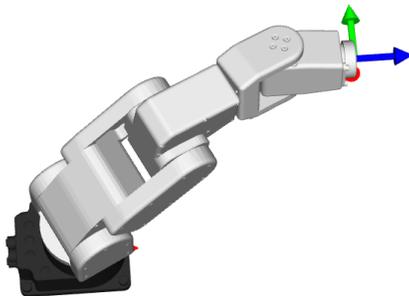
Figure 20 shows the result of each of the four MoveLin commands.



(a) MoveLin(140, -100, 250, 0, 90, 0)



(b) MoveLin(140, 100, 250, 0, 90, 0)



(c) MoveLin(270, 100, 250, 0, 90, 0)



(d) MoveLin(270, -100, 250, 0, 90, 0)

Figure 20: The four separate robot positions that define the motion sequence

11 Troubleshooting

No lights are on upon power up

- Make sure all connectors are properly attached.
- Make sure the AC outlet works (the green light on the power supply should be on).

No connection to the robot's web interface

- Make sure the EtherCAT mode has not been enabled. To switch the robot back to Ethernet TCP/IP mode, the simplest way is to do a factory reset. This can be done by unplugging the power supply from the AC side, and then replugging it while holding the Power button on the robot's base for about ten seconds.
- Make sure the Ethernet cable is properly connected. The green Ethernet light should pulse like on an RJ-45 connector. If the green LED is not illuminated, detach and reconnect the Ethernet cable.
- Make sure the router/switch works by checking the lights of the connexion 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 through your router's web interface.

Robot fails to boot

- Disconnect the power supply from the AC outlet and wait for the green light of the power supply to turn off. Then reconnect the power supply and boot the robot.

Robot's IP address forgotten

- You can do a factory reset of the robot's Ethernet configuration using the following sequence:
 1. Unplug the power supply from the AC outlet.
 2. Press the Power button on the robot's base continuously and replug the power supply from the AC outlet.
 3. Hold the Power button pressed for about ten seconds until the Power, Home and Play LEDs, each flash three times.

**CAUTION:**

Never disassemble the robot. The robot requires no maintenance, and if you think it is damaged, stop using it immediately and contact us.

**NOTICE:**

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

Whenever you contact our support team, please provide the serial number of your robot and the sequence of numbers displayed after “Meca500” in the welcome message that appears in the log panel upon connection with the robot: [3000][Connected to Meca500 x_x_x.x.x].

12 Storing the robot in its shipping box

To put the Meca500 back into the foam insert of its original shipping box, send the command `MoveJoints(0,-60,60,0,0,0)`. Recall that you must never force the brakes on joints 1, 2 and 3, unless there is an emergency.

13 EC Declaration of Incorporation (original)

According to the European Commission's Machinery Directive 2006/42/EC, Annex II, Section 1B

The manufacturer Mecademic
1300 Saint-Patrick St
Montreal, QC H3K 1A4
Canada

hereby declares that the product described below

Product designation: Extra-small six-axis industrial robot Meca500
Type: Meca500-R3

meets the applicable basic safety requirements of the Machinery Directive 2006/42/EC. This partly completed machinery may not be put into operation until conformity of the machine into which it will be incorporated is declared in conformity with the provisions of the Machinery Directive 2006/42/EC, and with the regulations transposing it into national law. Compliance with all essential requirements of Directive 2006/42/EC relies on the specific robot installation and the final risk assessment.

The manufacturer agrees to forward on demand the relevant technical documentation, compiled according to Directive 2006/42/EC, Annex VII, Part B, to state authorities.

Additionally the manufacturer declares the product in conformity with the following directives, according to which the product is CE marked:

- 2014/30/EU — Electromagnetic Compatibility Directive (EMC)
- 2011/65/EU — Restriction of the use of certain hazardous substances (RoHS)

Person responsible for the documentation: Dr. Ilian Bonev.

Montreal, QC, Canada
February 6, 2018



Ilian Bonev, Eng., Ph.D.
Scientific Advisor



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