MECADEMIC

INDUSTRIAL ROBOTICS

MC-UM-MVK01

Revision number: 11.1.43

Mecademic Robotics

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Contents

User Manual for the MVK01 Vacuum and I/O Module

For firmware version: 11.1

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Original instructions

About this manual

This user manual describes how to install Mecademic's MVK01 vacuum and I/O module underneath Mecademic's MCS500-R1 SCARA industrial robot arm and how to use it. You must read this manual thoroughly before installing or operating the MVK01.

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	Addition of further specifications.
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 MVK01 is a vacuum and I/O module developed by Mecademic, specifically for the MCS500-R1 SCARA robot arm. The module essentially consists of a configurable vacuum ejector with a pressure sensor and circuitry for eight digital inputs and 8 digital outputs. The MVK01 also comes with four cable connectors.

Note

Familiarity with the MCS500 robot and its user manual is required prior to installing and using the MVK01 vacuum and I/O module.

Warning

This vacuum and I/O module could function only when properly installed underneath the base of the MCS500 robot. Improper installation could damage the robot and the module itself. This module should therefore be used only by technical personnel who are familiar with the MCS500.

Inside the box

The module, shown in Figure 1, is delivered assembled with two metric push-in pneumatic fittings and a pneumatic muffler. In addition, the MVK01 comes with the following items in separate plastic bags:

- an alternative connector for the IN port, for 1/4-in (OD) tubing;
- 4 push-in cable connectors for the 8 inputs and 8 outputs (Figure 2).

Figure 1: MVK01 vacuum and I/O module (R2), as delivered

Figure 2: Push-in cable connector for the digital I/Os (Phoenix Contact, P/N 1778861)

Note

The MVK01 shown in the photos and diagrams of this manual is the latest version, R2. This revision features an improved design and a slightly updated appearance, but there are no changes to its installation, usage, or technical specifications.

Technical specifications

Table 1 lists the main technical specifications for the MVK01 vacuum and I/O module.

Table 1: Technical specifications for the MPK01 module

Characteristics	Value
Compressed air connector	port IN
Control valve state	Normally closed
Operating input pressure	2 bar to 8 bar
Optimal input pressure	7 bar
Vacuum connector	port VAC
Maximum vacuum	−75 kPa
Pressure sensor accuracy	±1.5 kPa
Suction rate (max.)	37.5 l/min
Air consumption suction	23.5 l/min
Maximum for inputs	24 V (DC), 10 mA
Minimum for inputs	3.3 V (DC), 1.1 mA
Maximum for outputs	24 V (DC), 250 mA
Ports	Three M5 threaded orifices, of which port IN comes with preinstalled push-in pneumatic fitting for 6-mm OD tubes, port VAC comes with preinstalled push-in pneumatic fitting for 4-mm OD tubes, and port EXH comes with a preinstalled pneumatic muffler.
Mechanical adjustments	Screw for adjusting the force of the air purging (marked ADJ)
Housing	Black anodized aluminum alloy
Total weight	572 g
Sound level free	72 dB (A)
Sound level suction	62 dB (A)
Operating temperature	5°C to 45°C
Operating humidity	[10%, 80%] (non-condensing)

Figure 3 presents the generated vacuum at different input pressures.

Note

To prevent the module from malfunctioning, please ensure that compressed air is supplied within the specified limits, as detailed in Table 1.

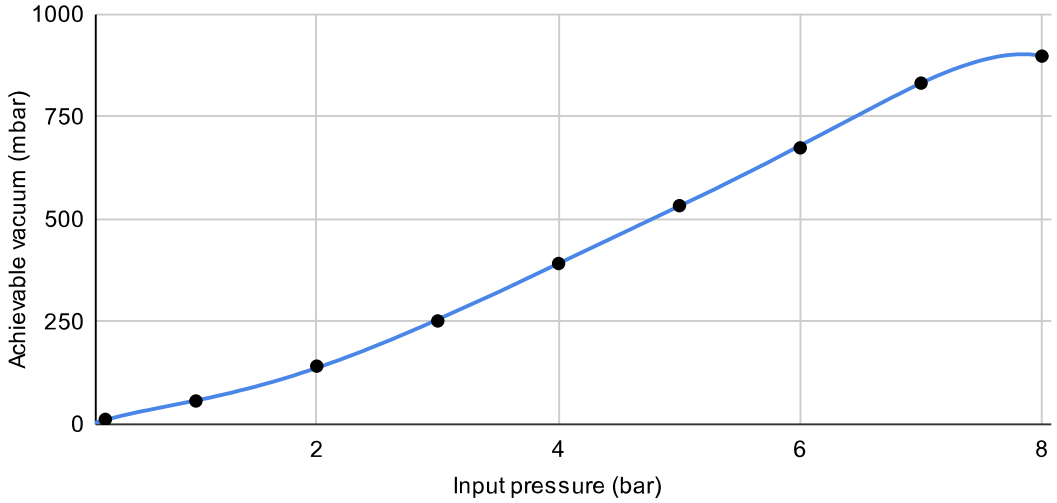


Figure 3: Achievable vacuum at various input pressures

Figure 4 presents the evacuation time at different vacuum levels.

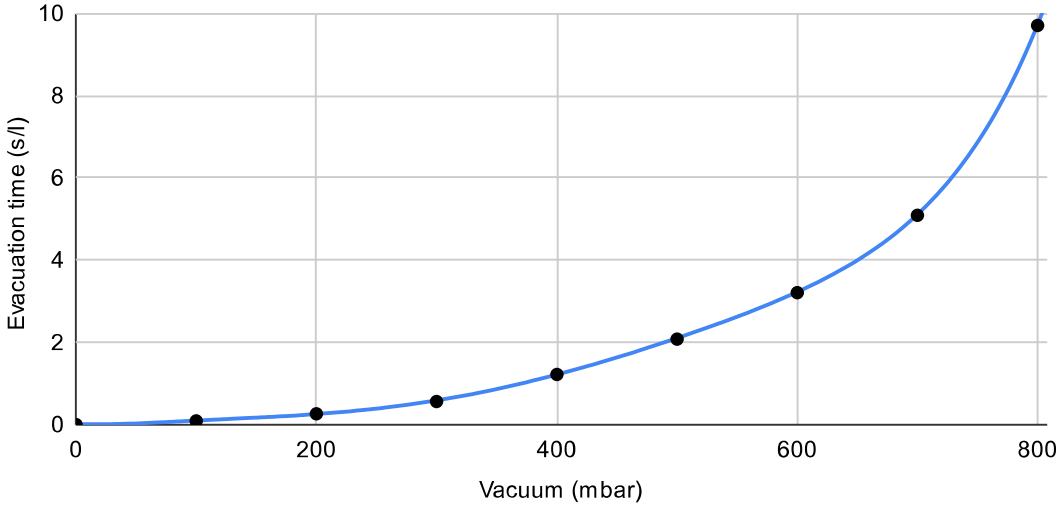


Figure 4: Evacuation time at various vacuum levels

Figure 5 shows the principal dimensions of the module.

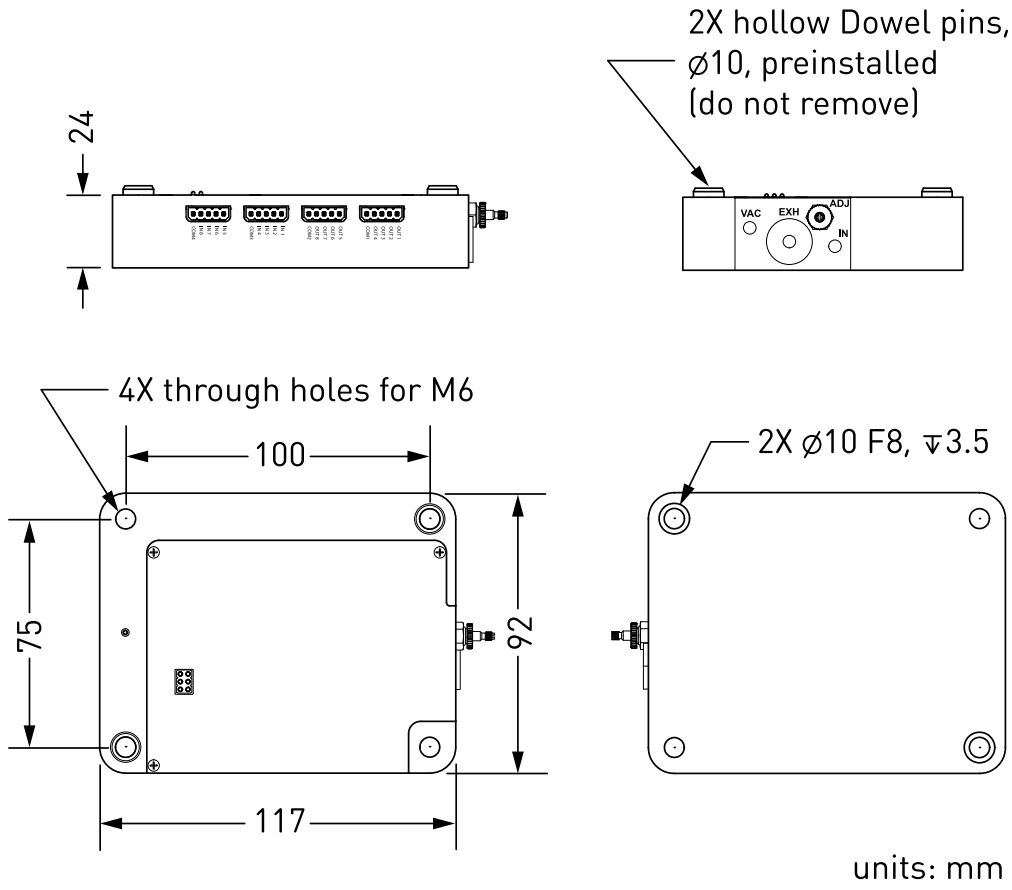


Figure 5: MVK01 module dimensions

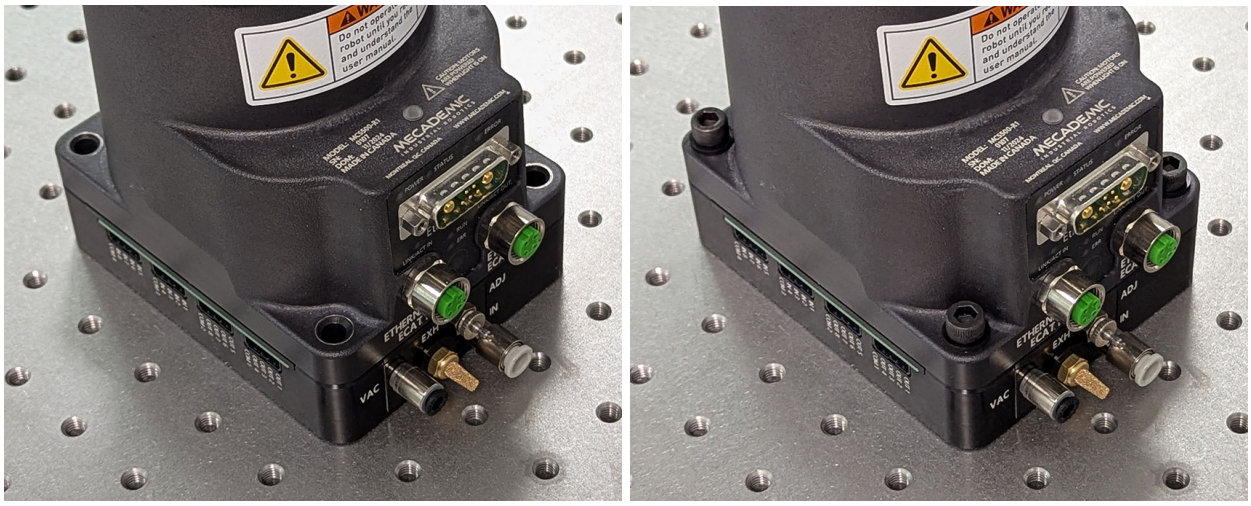
Note

You can download the CAD file of the MVK01 pneumatic module from here.

Installing the module

The MVK01 module is designed for only one type of installation, underneath the base of the MCS500 R1, as shown in Figure 6.

> **Warning**
>
> Make sure the MCS500 robot is powered off and the connectors on top of the MVK01 and on the bottom of the robot's base are unobstructed, before installing the MVK01 module.



(a) (b)

Figure 6: Installing the MVK01 module underneath the base of the MCS500 R1

The electric connection between the MCS500 robot and the MVK01 module is made through the seven spring-loaded connectors on top of the MVK01. Make sure there's nothing that obstructs that connection, before installing the MVK01 module. Then make sure the MCS500 robot is switched off and the arm fully folded and follow these steps:

1. Align the two diagonally opposed centering sleeves (hollow Dowel pins) with the corresponding locating holes at the bottom of the robot base, and then gently slide down the MCS500 until there is no gap between the top of the MVK01 module and the bottom of the robot's base (Figure 6a).
2. Carefully align the new assembly with the four M6 threaded holes for mounting the MCS500 and attach the assembly with four M6 screws of length 45 mm or more (Figure 6b). Tighten the screws with a torque of 8 Nm.

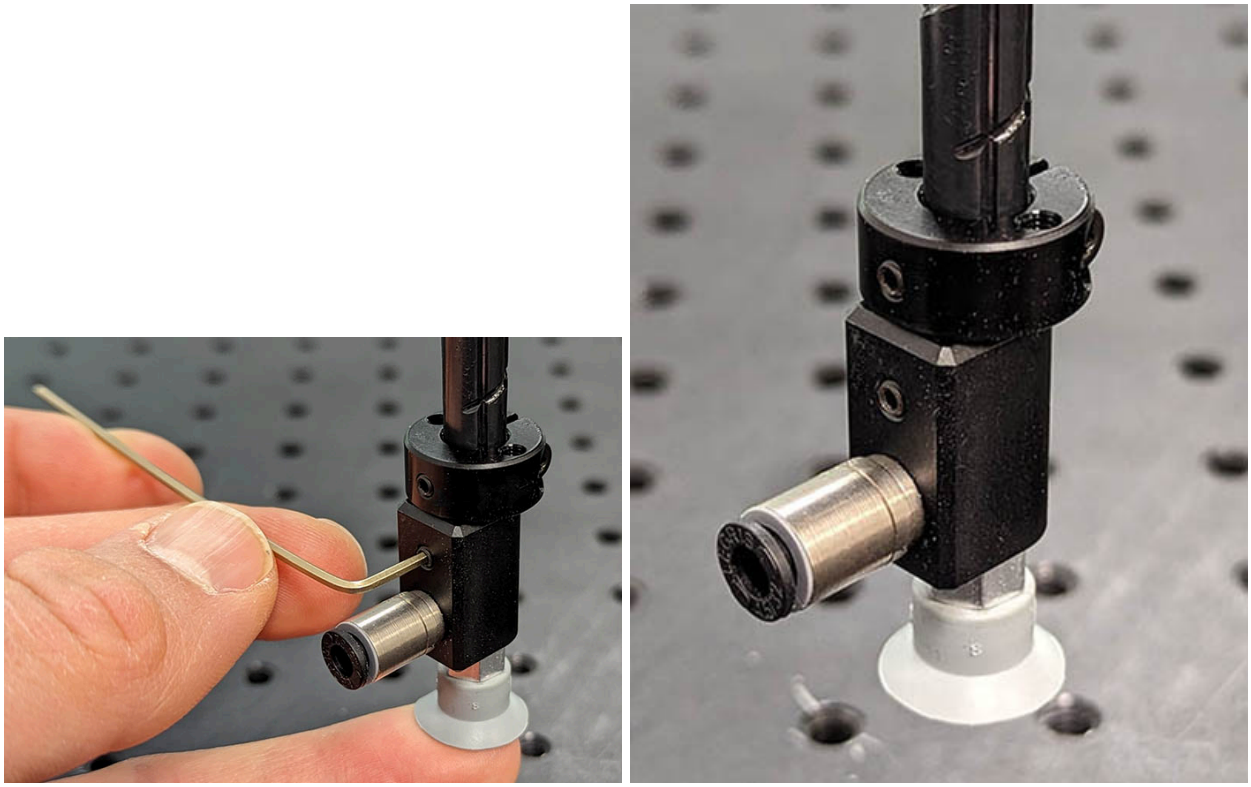
Warning

Until the base of the MCS500 is fixed with at least two M6 screws, keep the arm fully folded and always hold the robot with one hand to prevent the robot from tipping over.

Note that the MVK01 is precision machined and you can use locating pins to constrain the module, and therefore the complete robot-module assembly, in the same way as you would constrain the base of the MCS500. You can use 2+1 locating pins touching two adjacent sides of the module, as we do in our MUAP02 adaptor plate (which you can use for the module too).

Next, if you choose to use our optional suction cup holder, install it on the bottom extremity of the robot's spline shaft or on the top extremity, depending on your application, by following these steps:

1. Unscrew (if necessary) the set screw in the adaptor with a 1.5-mm Allen key so that the screw is not protruding into the 8-mm hole.
2. Slide the suction cup holder's 8-mm hole onto the extremity of the robot's spline shaft until it makes contact with the black retaining ring on the spline shaft.
3. Reorient the adaptor while pushing it against the retaining ring, until the set screw on top of the push-in connector aligns with the set screw of the retaining ring. It is extremely important to make sure that the set screw on the suction cup holder is perpendicular to the Weldon flat surface, or else you will damage the spline shaft of the robot in step 4.
4. Screw in the set screw of the suction cup holder and tightened it using a torque of 1.5 Nm (Figure 7a).
5. Screw the desired suction cup into the M5 threaded hole of the suction cup holder (this step can be done in advance, Figure 7b).



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

Figure 7: Installing the optional suction cup holder (MCS500-TA01)

Warning

Do not remove the retaining rings from the spline shaft, as doing so will cause irreversible damage to the ball-screw spline assembly.

Figure 8 shows the main dimensions of the optional suction cup holder. You can also download the CAD file of the holder from here.

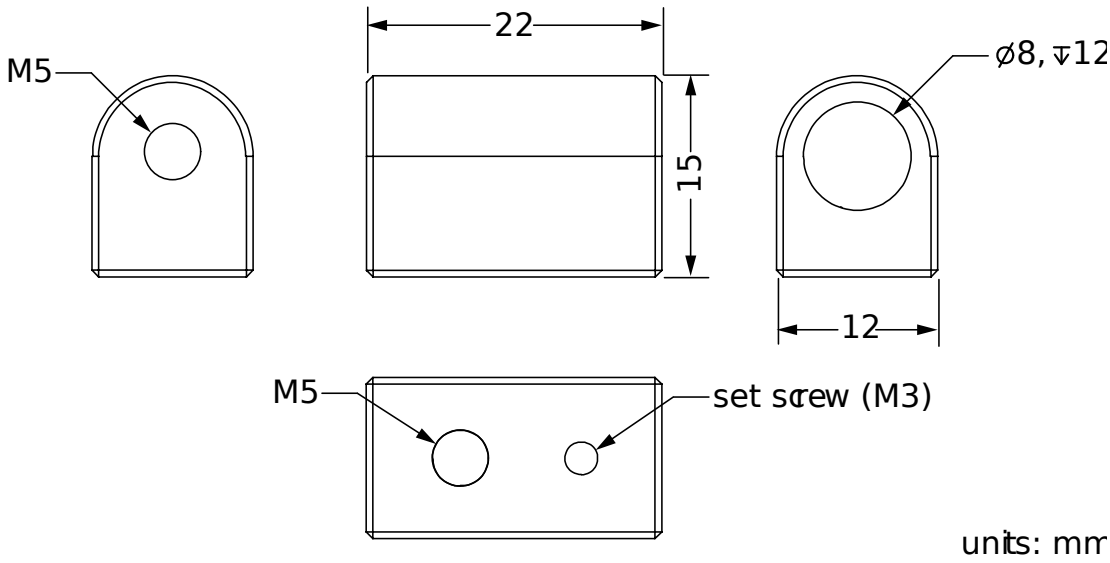


Figure 8: Main dimensions of the optional suction cup holder

Finally, insert 6-mm (OD) pneumatic tubing providing the compressed air (7 bar) into the push-in connector of the IN port on the MVK01 module. Then, cut the proper length of pneumatic tubing with 4-mm outer diameter and connect one end to the VAC port on the MVK01 module and the other to the push-in connector of the suction cup holder. Attach the tubing with a tie wrap to the rigid cable conduit of the SCARA robot as shown in Figure 9. Make sure the tubing is sufficiently long for the active joint ranges of the robot, specified by the command SetJointLimits.

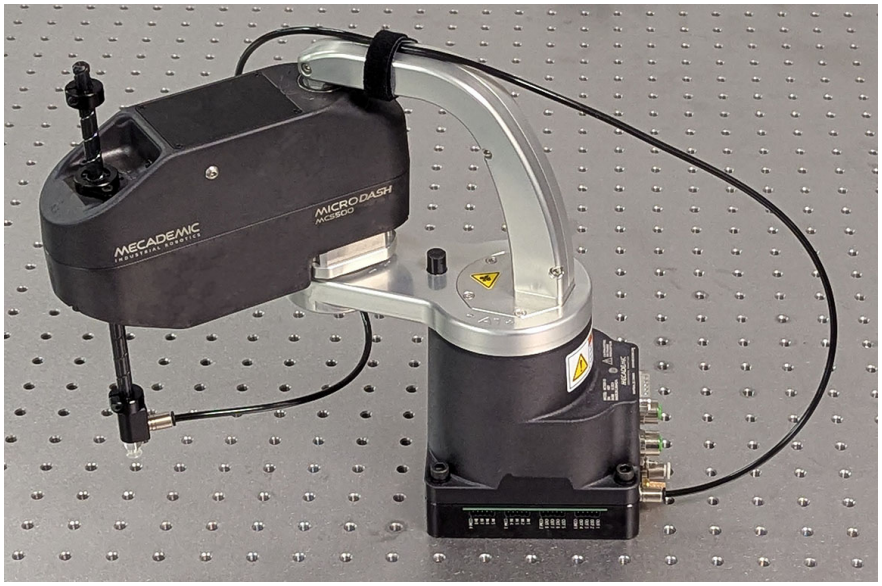


Figure 9: Complete installation of the MVK01 and the optional cup holder

Cabling the inputs and outputs

As already specified, the MVK01 provides 8 digital inputs and 8 digital outputs. Each group is divided into two sets, with its independent common terminal (Figure 10). By default, all inputs and outputs are normally open. Also, each group of four inputs or four outputs has its own common (i.e., OUT 1–4 share COM1, OUT 5–8 share COM2, IN 1–4 share COM3, and IN 5–8 share COM4).

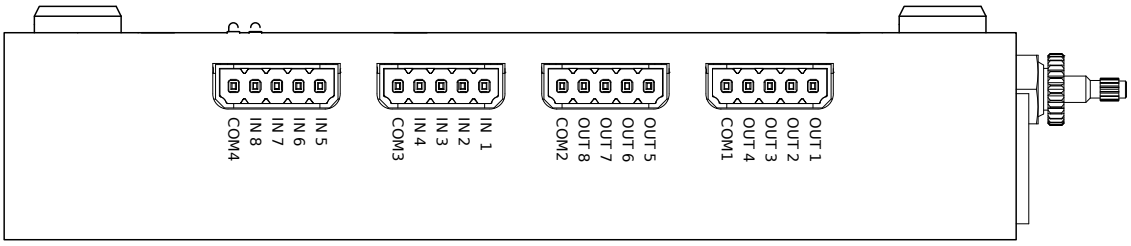


Figure 10: The four connectors on the MVK01 for the 8 digital inputs and 8 digital outputs

Warning

Each group of four inputs or outputs has its own independent common terminal.

You must use the four push-in cable connectors provided (Figure 2) to wire your inputs and outputs. Refer to the specifications of these connectors for details: Phoenix Contact, P/N 1778861.

Figure 11 and Figure 12 show the electric diagrams that you must follow to connect devices to the inputs and outputs of the MVK01.

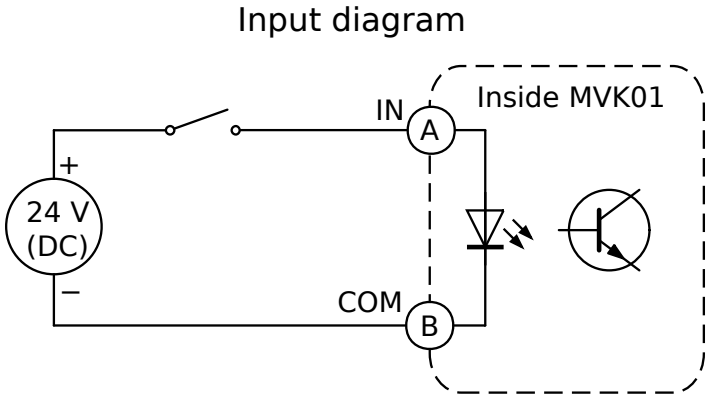


Figure 11: Electric diagrams for connecting devices at the inputs

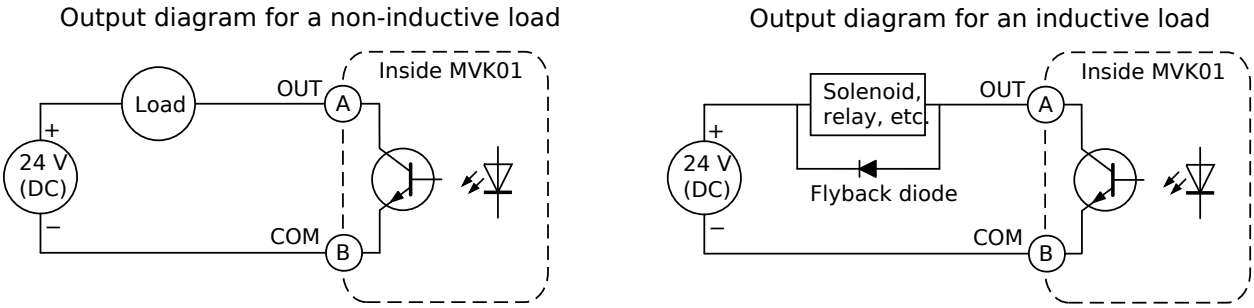


Figure 12: Electric diagrams for connecting non-inductive and inductive loads at the outputs

Warning

Inductive loads such as relays and solenoids must include a flyback (freewheel) diode in the circuit as depicted in Figure 12 (right). Otherwise, the MVK01 will be damaged permanently by the high voltage spike at the release of the inductive load..

Operating the module

The MVK01 vacuum and I/O module is controlled in the same way as the MCS500. For example, you can control the vacuum using the commands VacuumGrip/VacuumRelease and configure it using the commands SetVacuumThreshold, SetVacuumPurgeDuration. You can also set the outputs using the command SetOutputState and read the inputs using the command GetRtIoStatus. For a complete description of these and other commands, refer to the Mecademic robot's programming manual.

Adjusting the purging force

The MVK01 is equipped with a purging function for quickly ejecting a part. During purging, the negative pressure at the suction cup is essentially quickly transformed into positive pressure. The duration of the air purge is set with the command SetVacuumPurgeDuration. You can also control the force of the purging (i.e., the purge air flow) using the rotating knob marked ADJ, next to the three ports on the MVK01 module. When the knob is completely screwed in, the force of purging is smallest. The more you unscrew the knob, the larger the purging force. You will need a flat 0.4 mm screwdriver for this operation.

Firmware update

The MVK01 module will be automatically updated to the same version as the MCS500 robot, either during the update of the robot (if the module is present) or during the first boot of the robot with the MVK01 installed.

Integration into the MecaPortal

The MecaPortal web interface automatically recognizes the MVK01 module and displays a CAD model of it underneath the MCS500, as well as a widget specific to the module (Figure 13). In the widget, you can control the eight digital outputs, see the status of the eight digital inputs, control the suction action, and see the pressure in the vacuum chamber.

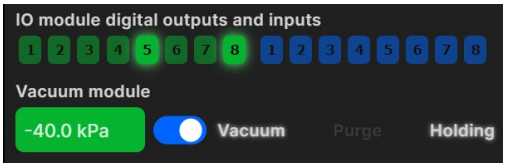


Figure 13: Widget that appears in the MecaPortal jogging panel when the MVK01 is detected

Safety

The MVK01 vacuum and I/O module is designed with safety in mind. However, additional tools connected to the VAC port may lead to risks of injuries. Make sure that all connections are properly made and that you respect the technical specifications of the MVK01 module. Regularly make sure that the suction cup holder is solidly attached to the spline shaft.

Resets of the state of the MVK01

If an activated robot with an MVK01 module becomes deactivated, the MVK01 retains its state (i.e., if it was generating vacuum, it will continue to do so, and all outputs will remain the same).

However, if an E-Stop or a P-Stop 1 is activated or in the case of various other events that cut power to the robot motors (e.g., changing the operating mode), the vacuum generation is ceased but the state of all eight outputs remains unchanged. You can also continue to read the inputs.

Danger

When power to the robot motors is removed (e.g., during an E-Stop), the vacuum generation is ceased. Therefore, if the robot's suction cup is holding a part, the part will fall.

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.