MP45E

M-605 High-Precision Linear Stage

User Manual

Version: 1.2.0 Date: 2019-07-02

This document describes the following products:

- M-605.1DD:
  Compact precision linear stage, 25 mm travel range, 0.1 µm linear encoder, ActiveDrive DC motor
- M-605.2DD:
  Compact precision linear stage, 50 mm travel range, 0.1 µm linear encoder, ActiveDrive DC motor

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Original instructions
First printing: 02.07.2019
Document number: MP45E, ASt, Version 1.2.0

Subject to change. This manual is superseded by any new release. The latest release is available for download from our website (p. **Fehler! Textmarke nicht definiert.**).

Contents

1 About this Document

1.1 Objective and Target Group of this User Manual

This manual is designed to help the reader to install and operate the M-605 Linear Positioning Stages. It assumes that the reader has a fundamental understanding of basic servo systems, as well as motion control concepts and applicable safety procedures.

1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

CAUTION

Dangerous situation

If not avoided, the dangerous situation will result in minor injury.

➢ Actions to take to avoid the situation.

NOTICE

Dangerous situation

If not avoided, the dangerous situation will result in damage to the equipment.

➢ Actions to take to avoid the situation.

INFORMATION

Additional information that can affect your application.

Symbol / Label	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➢	Action consisting of one or several steps whose sequential order is irrelevant
24 V DC	Labeling of an operating element on the product
	Warning sign affixed to the product that refers to detailed information in this manual.

1.3 Downloading Manuals

The devices and software tools from PI that are mentioned in this documentation are described in separate manuals. The manuals are available for download on our website.

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 19).

INFORMATION

For products that are supplied with software (data storage device in the scope of delivery), access to the manuals is protected by a password. Protected content is only displayed on the website after entering the access data. You need the data storage device for the product to get the access data.

Downloading manuals

1. Open the website **www.pi.ws**.
2. If the product was shipped with a data storage device: Log into the website:
   a) Click ***Login***.
   b) Enter the login data.
   The login data is in the ***[...]_Releasenews_[...].pdf*** in the ***Manuals*** directory on the data storage device.
   If necessary: Follow the link and register yourself to get the login data
   c) Click ***Login*** or press the Enter key.
3. Search for the product:
   a) Click ***Search***.
   b) Enter the product number up to the period (e.g., M-605) into the search field.
   c) Click ***Start search*** or press the Enter key.
   d) If necessary: Click ***Load more results*** at the bottom of the list.
4. Click the corresponding product in the list of search results.
5. Click the ***Downloads*** tab.
   The manuals are shown under ***Documentation***.
6. Click the desired manual and save it.

2 Safety

2.1 Intended Use

The M-605 is a laboratory device as defined by DIN EN 61010. It is intended for indoor use and use in an environment which is free of dirt, oil, and lubricants.

In accordance with its design, the M-605 is intended for single-axis positioning, adjusting and shifting of loads at different velocities. The M-605 is **not** intended for applications in areas, in which a failure would represent severe risks to human beings or the environment.

The intended use of the M-605 is only possible when completely mounted and connected. The M-605 must be operated with a suitable controller (p. 21). The controller is not in the scope of delivery of the M-605.

2.2 General Safety Instructions

The M-605 is built according to state-of-the-art technology and recognized safety standards. Improper use of the M-605 may result in personal injury and/or damage to the M-605.

- Only use the M-605 for its intended purpose, and only if it is in perfect condition.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for correct installation and operation of the M-605.

2.3 Organizational Measures

User manual

- Always keep this user manual available when using the M-605.
  The latest versions of the user manuals are available on our website (p. 2) for download.
- Add all information from the manufacturer such as supplements or technical notes to the user manual.
- If you give the M-605 to other users, also include this user manual as well as all other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in damage to equipment.
- Only install and operate the M-605 after you have read and understood this user manual.

Personnel qualification

The M-605 may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

3.1 Model Overview

Product number	Description
M-605.1DD	Compact precision linear stage, 25 mm travel range, 0.1 µm linear encoder, ActiveDrive DC motor
M-605.2DD	Compact precision linear stage, 50 mm travel range, 0.1 µm linear encoder, ActiveDrive DC motor

3.2 Scope of Delivery

Product number	Description
M-605.1DD or M-605.2DD	High precision linear stage, 25 mm travel range or High precision linear stage, 50 mm travel range
4295	Mounting kit, consisting of 4 metric screws M4x35 and a hex wrench
C-815.38	Motor cable D-Sub 15, 3 m
C-501.24050H	Wide-range-input power supply 24 V DC / 50 W
3763	Power cord
K050B0002	Adapter for the power supply connection; barrel connector to Switchcraft 3-pin connector (f)
MP119EK	Short instructions for positioners with electric motors

3.3 Accessories

Accessories must be ordered separately.

Product number	Description
M-605.AV1	Vertical mounting bracket for M-605 to M-605
M-110.01	Adapter plate for mounting M-110 - M-112, F-130, F-131 and M-605 stages onto honeycomb stages (metric and inches)

3.4 Technical Features

3.4.1 Linear Scale Position Encoder

M-605 stages use linear scale position encoders with 0.1 µm resolution for position detection. Maximum velocities of 50 mm/s can be achieved.

The linear encoder is mounted in the center of the stage, close to the ballscrew drive to prevent possible cosine error. The linear encoder measures the actual position of the moving carriage directly, thus eliminating drivetrain errors such as non-linearity, backlash or elastic deformations.

The encoder is based on an optical grating and a non-contacting read head with integrated signal conditioner and interpolator.

3.4.2 PWM Amplifiers

For maximum dynamic performance, the DC servo-motors are driven by high-efficiency PWM power amplifiers integrated into the stages. An external line-power power supply (order number: M-500.PS) is provided to supply the built-in amplifiers directly. This architecture allows high torque and high velocities while loading the motor controller with control signals only. The actual power is provided by the external supply.

3.4.3 Travel Limit Sensors

M-605 stages are protected against running into the hard stop by double-level magnetic limit sensors (Hall-effect sensors with TTL drivers) at each end of travel.

The **inner limit sensors** (N1 at the negative-travel end and P1 at the positive-travel end) work with the controller's limit sense input lines. The TTL output signal is active high.

The **outer limit sensors** (N2 at the negative and P2 at the positive end) work locally, opening a relay that cuts the motor current. The second-level limit switches provide for fail-safe operation in case the controller fails to stop the motor when the inner limit sensor is reached.

If the outer limit switch is reached, the stage can not be operated by the controller until the platform is moved manually. Disconnect the motor cable or set the motor into MOTOR OFF state before moving the platform back into the current-allowed area via the rotary knob.

3.4.4 Position Reference Signal Sensors

Position Reference Sensors are located approximately in the middle of the operating range and can be used to reference the absolute position of the stage. Always approach the reference sensor from the same side to reach the same position.

The reference sensor in M-605 stages provides a static signal level which depends on the platform position. If the platform is on the “positive side” the reference signal is +5 V, while if the platform is on the “negative side,” the signal level is 0 V. Most PI motor controllers and Windows libraries offer the option of starting a search run for the reference point using the current reference sensor signal to determine the appropriate direction.

The "AutoFindReference" function allows for starting a search run for the reference signal. Independent at which side relative to the reference position the stage is located, this function always starts the stage towards the reference position.

4 Unpacking

1. Unpack the M-605 with care.
2. Compare the contents with the items listed in the contract and the packing list.
3. Inspect the contents for signs of damage. If there is any sign of damage or missing parts, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

5.1 General Notes on Installation

CAUTION

Risk of crushing by moving parts!

Risk of minor injuries from crushing between the moving parts of the M-605 or the load and a fixed part or obstacle.

- ➢ Use safeguards to protect limbs in areas where they could be caught by moving parts.
- ➢ Maintain the safety distances according to DIN EN ISO 13857 when installing protective structures.

CAUTION

Risk of injury or damage if anything is put on the bellows!

Putting anything on the bellows can cause injury or damage.

- ➢ Do not put anything on the blellows.

5.2 Mounting the M-605

M-605 stages can be mounted in any orientation, horizontally or vertically. To achieve the specified guiding accuracy, the stages must be mounted on an even surface to avoid torsion of the base.

Requirements

- ✓ You have read and understood the general notes on installation (p.9).
- ✓ The place of installation is in a clean environment.

  Although provided with a flexible bellows to protect against dust and liquids, the unit is not hermetically sealed. Make sure that metal dust and liquid spray do not enter the case.
- ✓ You have provided a suitable surface with a flatness of ≤ 50 µm.

  For the required position and depth of the holes for accommodating the screws and locating pins, see "Dimensions" (p. 24).

Tools and accessories

- Mounting kit; in the scope of delivery (p. 5)
  - 4 metric screws M4x35

– Hex wrench

Mounting the positioner onto a surface

1. Place the positioner on the surface so that the corresponding mounting holes in the positioner and the surface are in line.
2. Tighten all screws in the mounting holes selected.
3. Check that the positioner is affixed firmly to the surface.

5.3 Affixing the Load to the M-605

Requirements

- ✓ You have read and understood the general notes on installation (p. 9).
- ✓ You have mounted the stage onto a surface properly (p. 9).
- ✓ The stage is not connected to the controller.
- ✓ You have prepared the load so that it can be affixed to the mounting holes on the upper platform (p. 24).

Tools and accessories

- At least 2 metric screws M4x35
- Hex wrench; in the scope of delivery (p. 5)

Affixing the load

1. Align the load so that the selected mounting holes in the platform can be used to affix it.
2. Use the screws to affix the load on the selected mounting holes in the platform.
3. Check that the load is affixed firmly to the platform of the positioner.

5.4 Connecting the M-605 to a Controller

Requirements

- ✓ You have read and understood the general notes on installation (p. 9).
- ✓ You have installed the controller.
- ✓ You have read and understood the user manual for the controller.
- ✓ The controller is switched off.

Tools and accessories

- Motor cable; in the scope of delivery (p. 5)

- Suitable tool for tightening the screws of the connector

Connecting the M-605 to a controller

1. If necessary: Remove the protective caps from all connections of the M-605.
2. Connect the M-605 and the controller to each other by means of the motor cable.
3. Use the integrated screws to secure the connections against accidental disconnection.

5.5 Connecting the Power Supply to the M-605

Requirements

✓ The power cord is **not** connected to the power socket.

Tools and accessories

- Supplied components; in the scope of delivery (p. 5):
  - Wide-range-input power supply
  - Adapter for the power supply connection; barrel connector to Switchcraft 3-pin connector (f)
  - Power cord
- If one of the components supplied for connecting to the power supply has to be replaced: Use a sufficiently rated and certified replacement component.

Connecting the power supply to the M-605

1. Connect the adapter's Switchcraft connector (f) to the M-605's ***24 V DC*** panel plug.
2. Connect the adapter's barrel connector to the power supply's barrel connector socket.
3. Connect the power cord to the power supply.

6 Startup

6.1 General Notes on Startup

CAUTION

Risk of crushing by moving parts!

Risk of minor injuries from crushing between the moving parts of the M-605 or the load and a fixed part or obstacle.

- Never put your finger anywhere where the moving platform or any connected object could possibly trap it.

NOTICE

Damage due to collisions!

Collisions can damage the positioner, the load to be moved, and the surroundings.

- Make sure that no collisions are possible between the positioner, the load to be moved, and the surroundings in the motion range of the positioner.
- Do not place any objects in areas where they can be caught by moving parts.
- Stop the motion immediately if a controller malfunction occurs.
- If possible, adapt the travel range limits of your mechanical system in the software you use for commanding the motion.

NOTICE

Unintentional motion!

M-605 stages are powered by powerful electric motors and can accelerate to high speeds. Be aware that automatic limit switch halt may not be supported by, or activated at, the motor control electronics. Be aware that failure of the motor controller may drive the stage into a hard stop at high speeds.

Unintentional motion of the M-605 is possible when it is connected to the controller.

- Do not place any objects in areas where they can be caught by moving parts.
- Before connecting the M-605, check whether a macro is defined as the startup macro in the controller, and cancel the selection of the startup macro if necessary.

6.2 Starting and Operating the M-605

Requirements

- ✓ You have read and understood the general notes on startup (p. 13).
- ✓ You have installed the stage properly (p. 9).
- ✓ You have read and understood the user manual for the controller used.
- ✓ You have read and understood the manual for the PC software used.
- ✓ The controller and the required PC software have been installed.

Starting and Operating the M-605

1. Start the controller (see user manual for the controller).
2. Configure the controller for the M-605 during startup:
   - If you are using a digital controller from PI: In the PC software, select the entry in the positioner database that matches the used M-605 model exactly.
   - If you are using a controller from another manufacturer: Configure the controller according to the parameters of the M-605 model used.
3. Start a few motion cycles for testing purposes (see user manual for the controller).

7 Maintenance

When operated in a clean environment, no maintenance is required.

If the stages are operated in extremely dusty environments, we recommend cleaning and greasing the ballscrew and linear bearings from time to time. The time interval depends on the degree of contamination and can vary from 100 to 800 operating hours.

Recommended lubricant for ballscrews:

KLÜBER Staburags Type NBU 8EP or Beacom 325

8 Troubleshooting

Fault: The positioner does not move, no operating noise can be heard	
Possible causes	**Remedial measures**
There is a motion error.	➢ Reset the motion error (see user manual of the controller).
Controller not connected correctly	➢ Check the connecting cable (p. 10).
Defective controller	➢ Check the controller.
Stage not connected correctly to the power supply	➢ Check the power supply, the adapter for the power supply, and the power cord (p. 11).

Fault: Reduced positioning accuracy	
Possible causes	**Remedial measures**
Warped base body	➢ Mount the M-605 onto an even surface (p. 9).

Fault: Uncontrolled oscillation	
Possible causes	**Remedial measures**
Large changes to the load or the alignment of the M-605	➢ Switch off the servo control system or the controller immediately. ➢ Check whether the servo control parameter settings correspond to the selected closed-loop control mode (see user manual for the controller). ➢ If necessary, correct the settings of the servo control parameters.

If the problem that occurred with your system is not in the list above or cannot be solved as described, contact our customer service department (p. 19).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an email (service@pi.de).

If you have any questions concerning your system, provide the following information:

- Product and serial numbers of all products in the system
- Firmware version of the controller (if applicable)
- Version of the driver or the software (if applicable)
- Operating system on the PC (if applicable)

If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

Customer service address:

Physik Instrumente (PI) GmbH & Co. KG
Auf der Roemerstrasse 1
76228 Karlsruhe
Germany

service@pi.de
www.pi.de

10 Technical Data

10.1 Specifications

10.1.1 Data Table

	M-605.1DD	M-605.2DD	Unit
Active axes	X	X	

Motion and positioning	M-605.1DD	M-605.2DD	Unit
Travel range	25	50	mm
Integrated sensor	Linear encoder	Linear encoder	
Sensor resolution	0.1	0.1	µm
Design resolution	0.1	0.1	µm
Minimum incremental motion	0.3	0.3	µm
Unidirectional repeatability	0.1	0.1	µm
Bidirectional repeatability	0.2	0.2	µm
Accuracy	1	1	µm
Pitch	±30	±30	µrad
Yaw	±30	±30	µrad
Velocity (max.)	30	30	mm/s
Reference switch repeatability	0.5	0.5	µm

Mechanical properties	M-605.1DD	M-605.2DD	Unit
Drive screw	Ball screw	Ball screw	
Drive screw pitch	1	1	mm
Load capacity (max.)	300	300	N
Push/pull force (max.)	20 / 20	20 / 20	N
Lateral force (max.)	100	100	N

Drive properties	M-605.1DD	M-605.2DD	Unit
Motor type	DC motor, ActiveDrive	DC motor, ActiveDrive	
Operating voltage	24 (PWM)	24 (PWM)	V
Motor power	6	6	W
Reference and limit switches	Hall effect	Hall effect	

Miscellaneous	M-605.1DD	M-605.2DD	Unit
Operating temperature range	-20 to 65	-20 to 65	°C
Material	Anodized aluminum	Anodized aluminum	
Mass	1.5	1.8	kg
Recommended controllers	C-863 (1 axis), C-884 (4/6 axes)	C-863 (1 axis), C-884 (4/6 axes)	

10.1.2 Maximum Ratings

The M-605 positioners are designed for the following operating data:

Maximum operating voltage	Maximum operating frequency	Maximum power consumption
24 V	-	6 W

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the M-605:

Area of application	For indoor use only
Maximum altitude	2000 m
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Storage temperature	0 °C to 80 °C
Transport temperature	0 °C to 80 °C
Supply fluctuations	Not more than ±10 % of the nominal voltage
Degree of pollution	2
Degree of protection according to IEC 60529	IP40

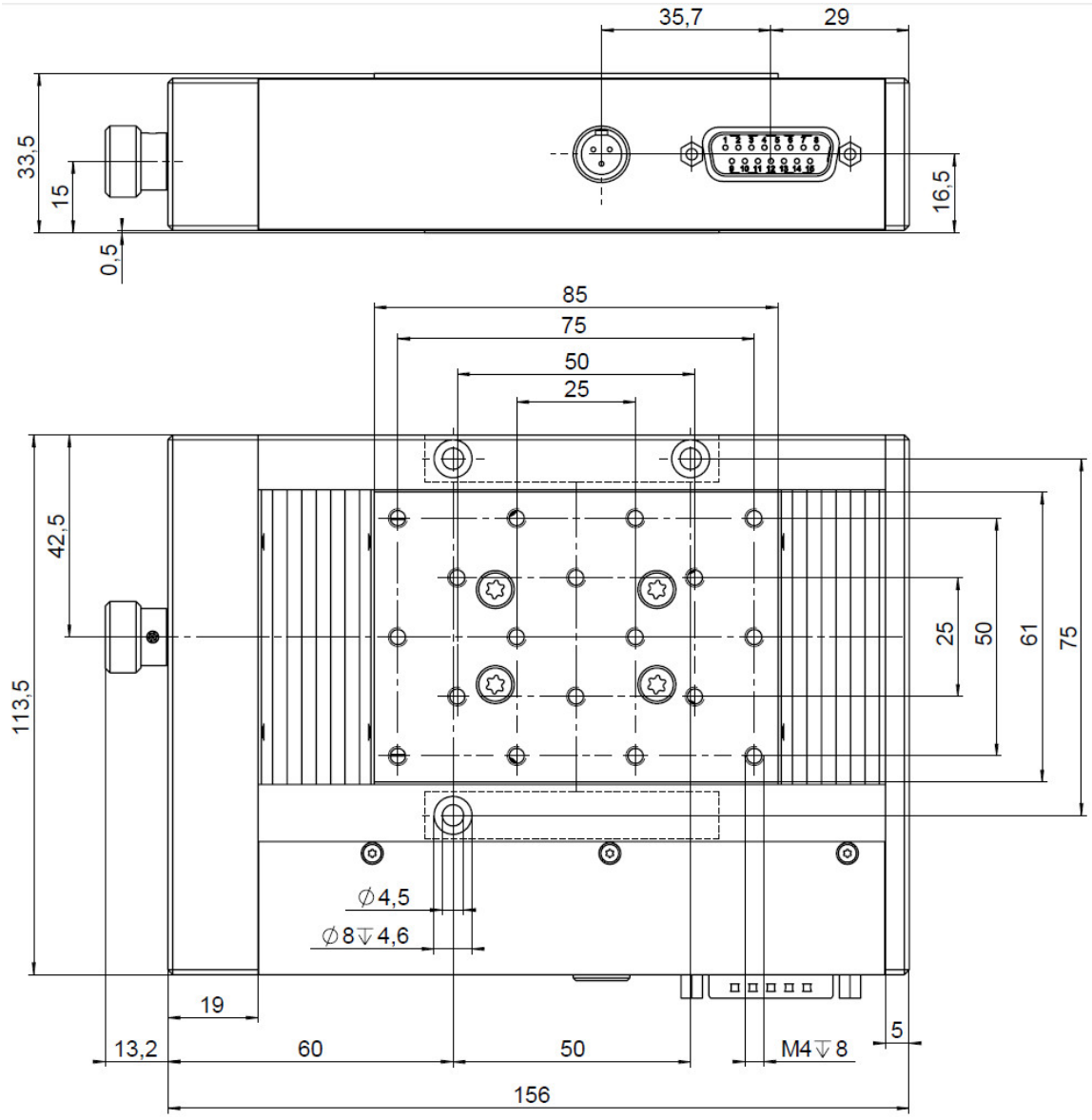
10.1.4 Limit Switch Specifications

Type	Magnetic (Hall-effect) sensors, can be used with bipolar CMOS circuits
Supply voltage	+5...+24 V / GND, supplied by the motor controller through the motor connector
Signal output	TTL level
Sink / source current	± 48 mA
Signal logic	Normal motor operation: low Limit switch reached: high

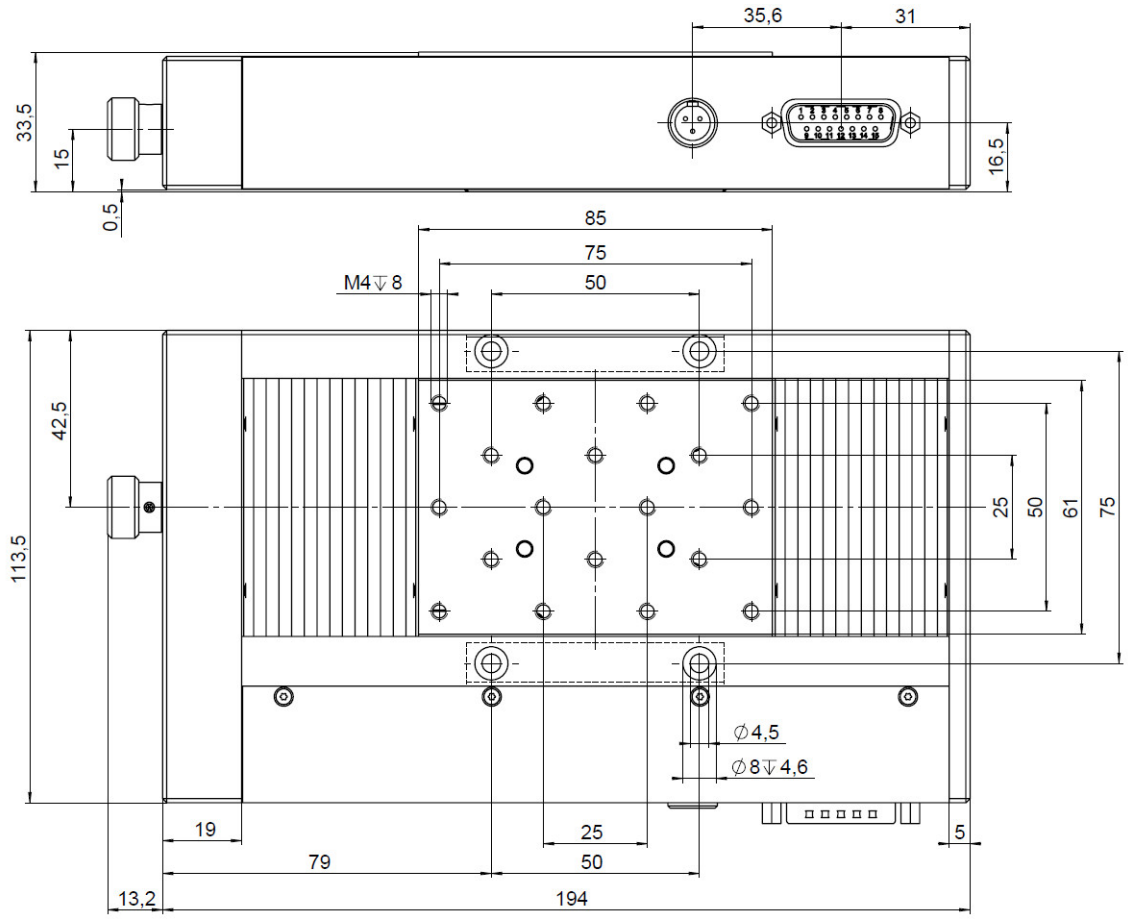
10.2 Dimensions

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

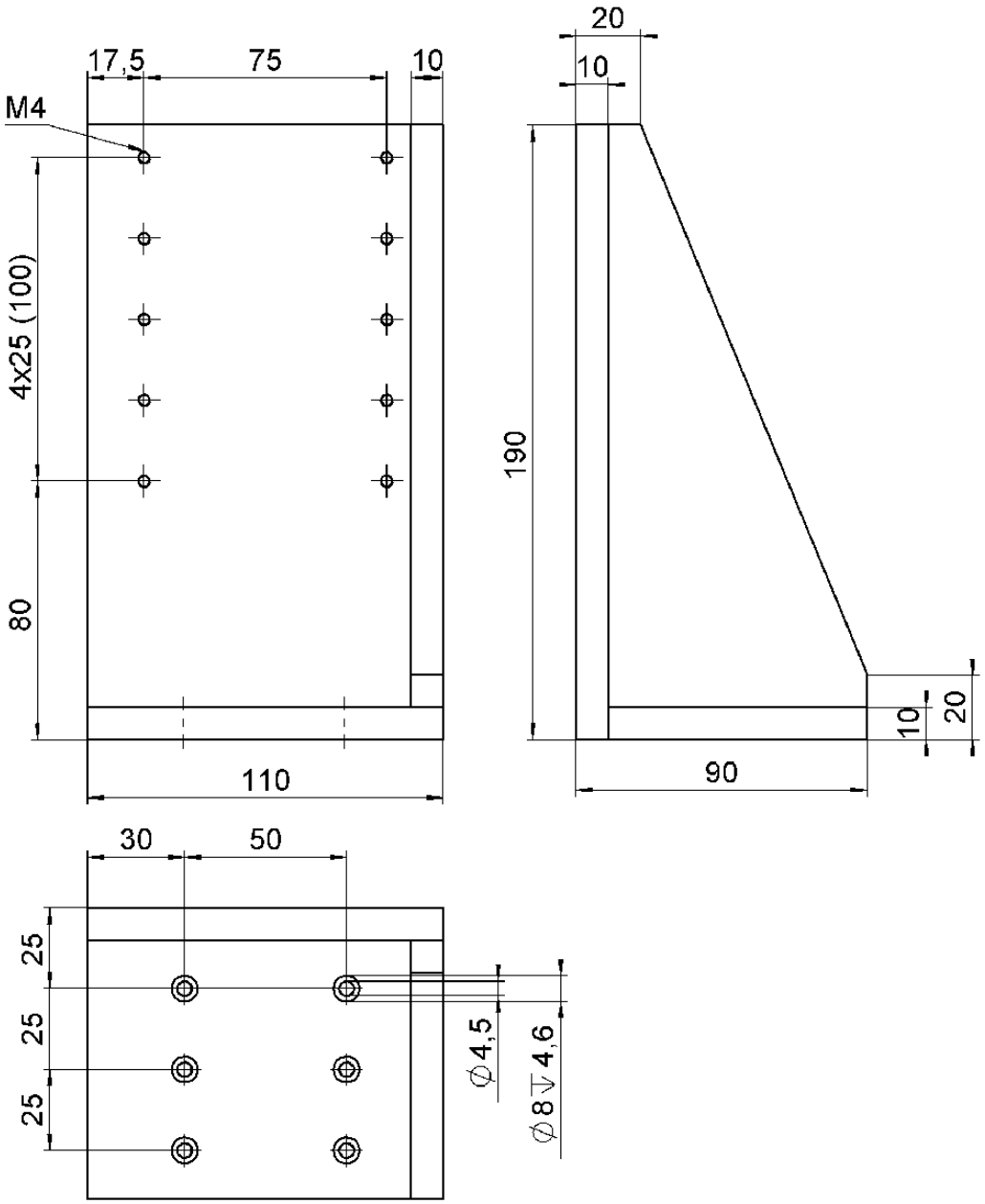
10.2.1 M-605.1DD



10.2.2 M-605.2DD

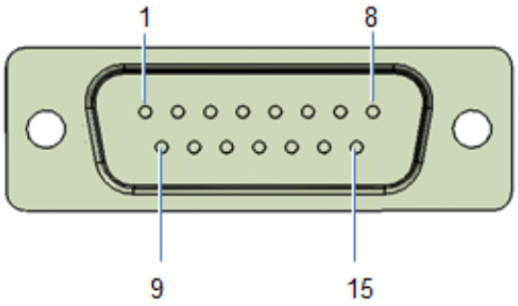


10.2.3 M-605.AV1



10.3 Pin Assignment

10.3.1 Controller Connector



D-Sub 15 (m) connector

Pin	Signal	Direction
1	Control for optional motor brake (0 to 24 V)	Input
2	Not connected	
3	PWM MAGN	Input
4	+5 V	Input
5	PLIMIT (positive limit switch)	Output
6	GND (Limit)	
7	Encoder A(-)	Output
8	Encoder B(-)	Output
9	Not connected	
10	PGND	
11	PWM SIGN	Input
12	NLIMIT (negative limit switch)	Output
13	Reference sensor	Output
14	Encoder A(+)	Output
15	Encoder B(+)	Output

11 Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

In order to fulfil the responsibility as the product manufacturer, PI miCos GmbH undertakes environmentally correct disposal of all old PI miCos equipment made available on the market after 13 August, 2005 without charge.

Any old PI equipment can be sent free of charge to the following address:

Physik Instrumente (PI) GmbH & Co. KG
Auf der Roemerstrasse 1
76228 Karlsruhe
Germany

12 EU Declaration of Conformity

An EU Declaration of Conformity has been issued for the M-605 in accordance with the following European directives:

- EMC Directive
- Low Voltage Directive
- Safety of Machinery

The standards applied for certifying the conformity are listed below.

- EMC: EN 61326-1 (formerly: EN 61000-6-3, EN 55011; EN 61000-6-1)
- Safety (Low Voltage Directive): EN 61010-1
- Safety of Machinery: EN 12100