

M-227

High-resolution linear actuator with DC motor
With optional piezo actuator



This document describes the following products:

- **M-227.50**
High-resolution linear actuator with DC motor, 50 mm
- **M-227.25**
High-resolution linear actuator with DC motor, 25 mm
- **M-227.10**
High-resolution linear actuator with DC motor, 10 mm

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User Manual



MP40E, version 1.3.0, valid for M-227.10, M-227.25, M-227.50

CBo, 7/27/2020

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About this Document

This user manual contains information necessary for using the M-227 as intended.

It assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

Explanation of Symbols

This section explains the symbols and markings used by PI in this document.

Typographic Conventions

Symbol	Meaning
1.	Action consisting of several steps whose sequential order must be observed
2.	
➤	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5

Symbols Used

CAUTION



Dangerous situation

Failure to comply could lead to minor injury.



➤ Precautionary measures for avoiding.

NOTICE



Dangerous situation

Failure to comply could cause damage to equipment.

➤ Precautionary measures for avoiding.

INFORMATION

Additional information that can affect your application.

Symbol / Label



Meaning

Warning sign on the product that refers to detailed information in the documentation.

Other Applicable Documents

The devices and software tools mentioned in this document are described in separate manuals.

Product	Document
M-22x / M-23x linear actuators	MP122EK short instructions
C-863	MS249 user manual
C-863.20C885	C863T0005 user manual
C-884	MS243 user manual
PIUpdateFinder	A000T0028 user manual

Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

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

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., M-227) or the product family (e.g., linear actuator).
3. Click the corresponding product to open the product detail page.
4. Click **Downloads**.
The manuals are shown under **Documentation**.
5. Click the desired manual and fill out the inquiry form.
The download link will then be sent to the email address entered.

Safety

Intended Use

The M-227 linear actuator is a laboratory device as defined by DIN EN 61010-1. It is intended for indoor use and use in an environment that is free of dirt, oil and lubricants.

According to its design, the M-227 is intended for single-axis positioning, adjusting and shifting of loads at different velocities. The M-227 is **not** intended for high duty cycles and applications in areas in which a failure would present severe risks to human beings or the environment.

It is only possible to use the M-227 as intended when completely mounted and connected and only in conjunction with suitable electronics (p. 9) that provide the required operating voltages. To ensure proper performance of the servo-control system, the electronics must also be able to read out and process the signals from the rotary encoder.

The M-227 may only be started up, operated, maintained and cleaned by authorized and qualified staff.

Safety Precautions

Mechanical Dangers

CAUTION



Risk of crushing!

Risk of minor injuries or damage to equipment from crushing between the pusher and a fixed part or obstacle.

- Use protective structures to keep limbs away from areas in which they could be seized by moving parts.
- Maintain safety distances according to DIN EN ISO 13857.
- Mount the M-227 so that the motion of the pusher is not hindered by objects in the workspace.

NOTICE



Damage due to excessive torque on the pusher!

Excessive torque on the pusher (e.g., when the tip is replaced) can damage the M-227.

- Do **not** exceed a torque of 1 Nm on the pusher.

NOTICE



Increased friction from lateral forces on the pusher!

Lateral forces acting on the pusher impair the motion of the pusher and increase wear on the drive components.

- Avoid lateral forces on the pusher of the M-227.

NOTICE



Damage from wrong clamping or clamping too tightly!

Wrong clamping or clamping too tightly can damage the M-227.

- Do **not** clamp the M-227 on the motor housing (p. 8).
- Do **not** clamp the M-227 too tightly.

NOTICE



Cable break due to excessively bent or crushed cable!

A cable break leads to failure of the M-227.

- Install the M-227 so that the cable cannot be bent too strongly or crushed during operation.

Electrical Dangers

NOTICE



Operating voltage too high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the M-227.

- Only operate the M-227 with electronics and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 20) for which the M-227 is specified.
- Operate the M-227 only when the operating voltage is properly connected; refer to "Pin Assignment" (p. 24).

Thermal Dangers

CAUTION



Risk of burning!

The M-227 can overheat in continuous operation with high load. Touching an overheated M-227 can cause slight injuries from burning. In addition, overheating can damage the M-227.

- To prevent overheating, do **not** operate the M-227 continuously with high load.
- If overheated accidentally:
Do **not** touch the M-227 until it has cooled off.

Product Description

Model Overview

The following standard versions of the M-227 are available:

Model	Description
M-227.10	High-resolution linear actuator with DC motor, 10 mm
M-227.25	High-resolution linear actuator with DC motor, 25 mm
M-227.50	High-resolution linear actuator with DC motor, 50 mm

Product View



Figure 1: Product view (example view of an M-227.50)

- 1 Flat tip (non-rotating)
- 2 Pusher
- 3 Clamping shank, \varnothing 16 mm
- 4 Micrometer scale
- 5 Micrometer housing, \varnothing 19 mm
- 6 Motor housing (with bellows coupling inside):
Do **not** use the motor housing for clamping!
- 7 Connecting cable

Directions of Motion

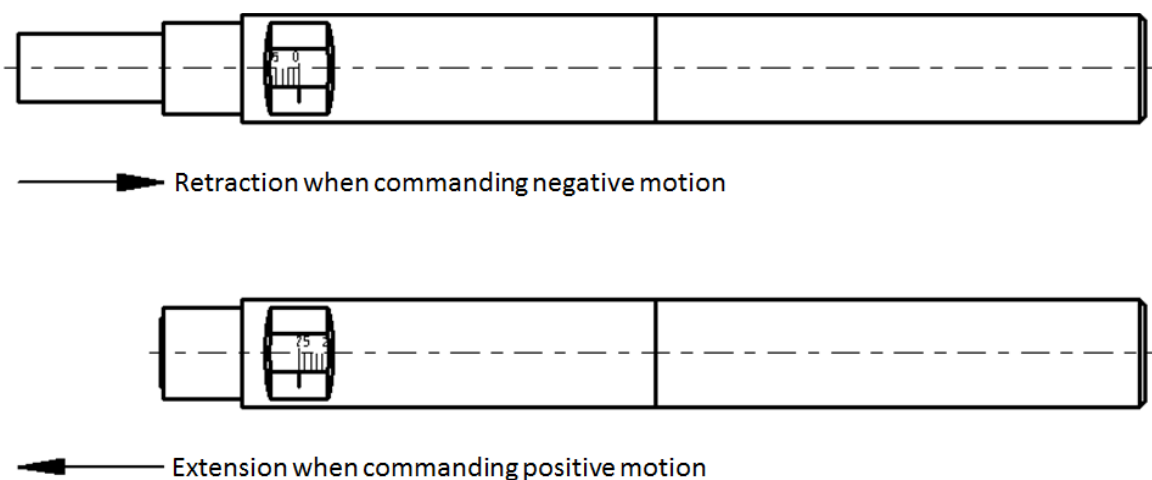






Figure 2: Directions of motion of the M-227

Product Labeling

Labeling	Description
M-227.50	Product number (example), the digits after the period refer to the model
123456789	Serial number (example), individual for each M-227 Meaning of each position (from the left): 1 = internal information 2 and 3 = year of manufacture 4 to 9 = consecutive numbers
	Warning sign "Pay attention to the manual!"
	Old equipment disposal (p. 25)
Country of origin: Germany	Country of origin
WWW.PI.WS	Manufacturer's address (website)
	CE conformity mark
	Manufacturer's logo

Scope of Delivery

Product number	Description
M-227	High-resolution linear actuator with DC motor according to order (p. 7)
MP122EK	Short instructions for M-22x / M-23x linear actuators

Suitable Electronics

Product number	Description
C-863.12	Mercury servo controller, 1 axis
C-863.20C885	Motion controller module, 2 axes, for C-885 PIMotionMaster
C-884	Motion controller, 4 or 6 axes

Note that the cables required for connecting the M-227 to the electronics must be ordered separately.

- To order, contact our customer service department (p. 19).

Accessories

Optional Piezo Actuator

Product number	Description
P-885.20	Piezo actuator for micrometer screws

- To order, contact our customer service department (p. 19).

Optional Tips

Product number	Description
M-219.00	Spherical tip, M10 × 0.5 mm
M-219.10	Ball tip, M10 × 0.5 mm
M-219.20	Tip with M5 outer thread, M10 × 0.5 mm
M-219.30	Tip made of hardened steel, M10 × 0.5 mm

- To order, contact our customer service department (p. 19).

Technical Features

Rotary Encoder

The M-227 is equipped with a rotary encoder. A rotary encoder, also called an incremental or incremental rotary encoder, is implemented at a rotating point in the drivetrain, e.g., the motor shaft. To determine the relative position, the controller counts the encoder signals, the so-called impulses.

Unpacking

1. Unpack the M-227 with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department immediately.
4. Keep all packaging materials in case the product needs to be returned.

Installation

Installing the M-227

NOTICE



Damage from wrong clamping or clamping too tightly!

Wrong clamping or clamping too tightly can damage the M-227.

- Do **not** clamp the M-227 on the motor housing (p. 8).
- Do **not** clamp the M-227 too tightly.

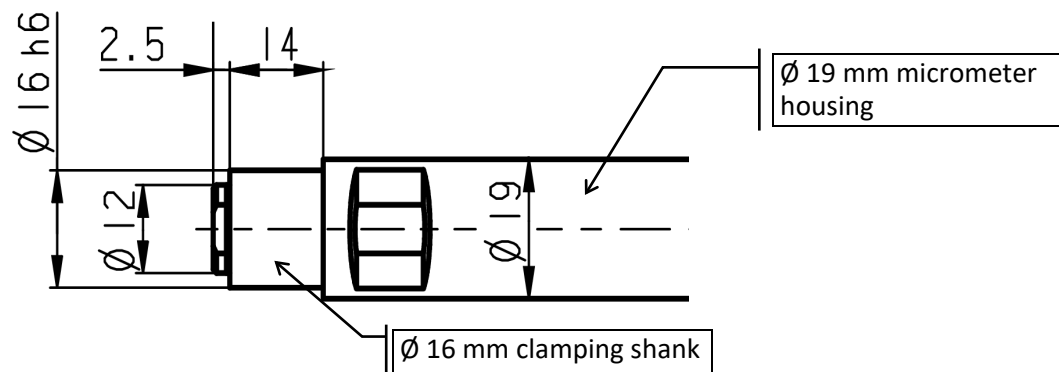


Figure 3: Clamping surfaces of the M-227

Requirements

- ✓ You have read and understood the safety precautions (p. 6).
- ✓ The M-227 is **not** connected to the electronics.
- ✓ You have accounted for the space required to route cables without bending and according to regulations.

Tools and accessories

- Suitable holder(s) for clamping the M-227

Installing the M-227

- Clamp the M-227 on the clamping surfaces intended for this purpose (refer to Figure 3 above). Ensure that the clamping is neither too tight nor too loose.

Replacing the Standard Flat Tip (Optional)

NOTICE



Damage due to excessive torque on the pusher!

Excessive torque on the pusher (e.g., when the tip is replaced) can damage the M-227.

- Do **not** exceed a torque of 1 Nm on the pusher.

Requirements

- ✓ You have read and understood the safety precautions (p. 6).
- ✓ The M-227 is **not** connected to the electronics.

Tools and accessories

- M-219 tip or P-855.20 piezo actuator (p. 10)
- AF 10 open-end wrench
- AF 13 open-end wrench (only for P-855.20)

Replacing the standard flat tip (optional)

1. Unscrew the standard flat tip from the pusher carefully using an AF 10 open-end wrench. Do **not** exceed a torque of 1 Nm when unscrewing.
2. Screw the new tip into the pusher:
 - Only with the M-219 tip:
 - a) Screw in the M-219 tip by hand.
 - b) If necessary, tighten the connection lightly using an AF 10 open-end wrench. Do **not** exceed a torque of 1 Nm when tightening.
 - Only with the P-855.20 piezo actuator:
 - a) Screw in the P-855.20 piezo actuator by hand.
 - b) If necessary, tighten the locking ring of the P-855.20 lightly using an AF 13 open-end wrench. Do **not** exceed a torque of 1 Nm when tightening.

Connecting the M-227 to the Electronics

NOTICE



Damage if the wrong electronics or motor cable is connected!

Connecting an actuator to unsuitable electronics or using an unsuitable motor cable can cause damage to the actuator or electronics.

- Only connect the actuator to suitable electronics (p. 9).
- To connect the actuator to the electronics, only use a motor cable that is suitable for the electronics. Note that the cable must be ordered separately.

Requirements

- ✓ You have read and understood the safety precautions (p. 6).
- ✓ You have read and understood the user manual for the electronics.
- ✓ The electronics are switched off, i.e., **not** connected to the power source.

Tools and accessories

- Motor cable, suitable for the electronics (p. 9)

Connecting the M-227 to the electronics

1. Plug the connector on the M-227 into the corresponding socket on the electronics. If the actuator is to be connected to the electronics using an adapter cable, use a suitable adapter cable from PI.
2. If possible, use the integrated screws to secure the connections against accidental disconnection.

Startup and Operation

General Notes on Startup and Operation

CAUTION



Risk of crushing!

Risk of minor injuries or damage to equipment from crushing between the pusher and a fixed part or obstacle.

- Use protective structures to keep limbs away from areas in which they could be seized by moving parts.
- Maintain safety distances according to DIN EN ISO 13857.
- Mount the M-227 so that the motion of the pusher is not hindered by objects in the workspace.

NOTICE



Collision with the hard stop or an obstacle!

Collision with the hard stop or an obstacle leads to damage or considerable wear on the M-227.

- Do **not** place any objects in areas where they can get caught by moving parts.
- If the pusher or the load mounted on it collides with an obstacle, switch off the motor.
- Only command target positions that are located within the travel range.
- Use external limit switches to avoid collisions.
- Stop the motion immediately if a controller malfunction occurs.
- Ensure that the M-227 does neither abruptly stop at the end of the travel range nor attempt to continue moving.
- Ensure that the end of the travel range is approached at low velocity.
- Determine the maximum velocity for your application.

NOTICE



Unintentional motion!

Unintentional motion of the M-227 is possible when connecting it to the controller.

- Before connecting the M-227, check whether a macro is defined as the startup macro in the controller and cancel the selection if necessary.

INFORMATION

Unsuitable settings made to the servo control parameters can impair the performance of the M-227. The consequences of this can be expressed as follows:

- Oscillation
- Imprecise approach of the position
- Settling time is too long
- If the performance of the M-227 is not satisfactory, check the settings for the servo control parameters of your controller.
- Use the default parameters for the first startup only.

INFORMATION

Due to its compact design, the M-227 does not have internal limit switches. Without limit switches, the M-227 must be stopped manually to avoid collision with the hard stop. Therefore, we strongly recommend using external limit switches. Note that all PI motor controllers support limit switches.

INFORMATION

If the programmed velocity is too high, accelerating and decelerating ramps will not be performed as programmed, and the physical velocity will be lower than the profile velocity. When this happens the trajectory generator may have already completed its move while the actuator is still trying to catch up.

Operating Parameters

If you use the software from the scope of delivery of the electronics (p. 9), the operating parameters can be loaded from the positioner database. The records in the positioner database are updated regularly.

- Install the PIUpdateFinder from the product CD for the electronics onto your PC and update the positioner database on your PC.

Further information can be found in the user manual for the electronics (p. 9).

Starting and Operating the M-227

Requirements

- ✓ You have read and understood the safety precautions (p. 6).
- ✓ You have read and understood the general notes on startup and operation (p. 13).
- ✓ You have read and understood the user manual for the electronics (p. 5).
- ✓ You have read and understood the user manual for the PC software.
- ✓ You have installed (p. 11) the M-227 correctly.
- ✓ The electronics and the required PC software were installed. All connections to the electronics were made (refer to the user manual for the electronics).

Starting and operating the M-227

- Follow the instructions in the user manual for the electronics (p. 9) used for startup and operation of the M-227.

Maintenance

NOTICE



Damage due to improper maintenance!

The M-227 can become misaligned as a result of improper maintenance.

- Loosen any screws only when instructed in this user manual.

INFORMATION

Frequent motion over a limited travel range can cause the lubricant to be distributed unevenly on the drive screw.

- Perform a maintenance run over the entire travel range at regular intervals (refer to the user manual for the controller). The more motion is done over a limited travel range, the shorter the time must be between the maintenance runs.

Cleaning the M-227

Requirements

- ✓ You have disconnected the M-227 from the electronics.

Cleaning the M-227

- Clean the surfaces of the M-227 with a cloth that is dampened with a mild cleanser or disinfectant (e.g., isopropyl alcohol).

Troubleshooting

General Notes on Troubleshooting

NOTICE



Damage due to mechanical overload of the bellows coupling!

The bellows coupling of the actuator is a sensitive part that can be damaged if handled improperly.

- Avoid bending forces on the bellows coupling.
- Avoid pull forces on the bellows coupling.

INFORMATION

For details on the different parts of the actuator, refer to “Product View” (p. 8).

INFORMATION

Abbreviations used in this section:

CW: clockwise

CCW: counterclockwise

Actuator Got Stuck at the Hard Stop

If the M-227 is driven into a hard stop, the spindle may get jammed so that the M-227 cannot retract any more.

Unblocking the Actuator Electrically

If the M-227 got stuck at the hard stop, you can try to unblock it by applying an external DC voltage of 15 V.

Requirements

- ✓ You have disconnected the M-227 from the electronics.
- ✓ The power supply to be used is switched off, i.e., **not** connected to the power source.

Tools and accessories

- DC power supply with a variable output voltage

Unblocking the actuator electrically

1. Connect the switched **off** power supply to the M-227. The required connections depend on the direction of motion:
 - For positive motion (p. 8):
Pin 2: +15 V
Pin 9: GND
 - For negative motion (p. 8):
Pin 2: GND
Pin 9: +15 V
2. Apply a voltage of 15 V DC to the motor of the M-227 for a short moment (less than 2 seconds).

Unblocking the Actuator by Hand

If the M-227 cannot be unblocked electrically (p. 17), you need to unblock the M-227 by hand.

Requirements

- ✓ You have disconnected the M-227 from the electronics.
- ✓ You have read and understood the “General Notes on Troubleshooting” (p. 16).

Tools and accessories

- Hex key, size 1.2 mm

Unblocking the actuator by hand

1. Remove the set screw located about in the middle of the motor housing (p. 8). This screw clamps the motor/gearhead assembly inside the housing.
2. Hold the M-227 with both hands and turn the motor housing CCW relative to the micrometer housing (p. 8) until it breaks loose.

3. Look for the small hole (\varnothing 2.5 mm) in the motor housing near the edge to the micrometer housing. This hole allows access to two set screws which clamp the bellows coupling to the spindle.
Turn the motor housing CCW until you see the first set screw through the hole and untighten it.
4. Turn the motor housing until you see the second set screw and untighten it.
5. Turn the motor housing CCW until you can pull it off the micrometer housing.
Important note: To prevent damage, avoid bending and pull forces on the bellows coupling.
6. Turn the spindle CW or CCW in order to unblock the jammed spindle.
7. Reassemble the M-227.

Coupling of the Actuator Slips

Retightening the Coupling

The metal bellows coupling is clamped by two small radial set screws to the spindle. In the rare case that the coupling slips, these two screws need to be retightened. To do this, the M-227 must be disassembled.

Requirements

- ✓ You have disconnected the M-227 from the electronics.
- ✓ You have read and understood the “General Notes on Troubleshooting” (p. 16).

Tools and accessories

- Hex key, size 1.2 mm

Retightening the coupling

1. Remove the set screw located about in the middle of the motor housing (p. 8). This screw clamps the motor/gearhead assembly inside the housing.
2. Hold the M-227 with both hands and turn the motor housing CCW relative to the micrometer housing (p. 8) until it breaks loose.
3. Look for the small hole (\varnothing 2.5 mm) in the motor housing near the edge to the micrometer housing. This hole allows access to two set screws which clamp the bellows coupling to the spindle.
Turn the motor housing CCW until you see the first set screw through the hole and untighten it.
4. Turn the motor housing until you see the second set screw and untighten it.
5. Turn the motor housing CCW until you can pull it off the micrometer housing.
Important note: To prevent damage, avoid bending and pull forces on the bellows coupling.
6. Examine the connection of the coupling bellows with the gear shaft and tighten both fixing screws.
7. Reassemble the M-227.

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.

The latest versions of the user manuals are available for download (p. 5) on our website.

Technical Data

Specifications

Motion and positioning	M-227.10 / M-227.25 / M-227.50	Unit	Tolerance
Travel range	10 / 25 / 50	mm	
Integrated sensor	Rotary encoder		
Sensor resolution	2048	Cts./rev.	
Design resolution	0.0035	μm	Typ.
Minimum incremental motion	0.05	μm	Typ.
Backlash	10	μm	Typ.
Unidirectional repeatability	±0.1	μm	Typ.
Velocity	0.75	mm/s	Max.
Mechanical properties			
Drive screw	Leadscrew		
Thread pitch	0.5	mm	
Gear ratio	69.12:1		
Push / pull force*	40	N	Max.
Permissible lateral force	0.1	N	Max.
Drive properties			
Motor type	DC gear motor		
Operating voltage	0 to ±12	V	
Motor power	1.78	W	Nominal




Miscellaneous			
Operating temperature range	-20 to 65	°C	
Material	Aluminum anodized, chrome steel		
Mass	0.16 / 0.22 / 0.26	kg	±5 %
Cable length	0.1	m	±10 mm
Connector	D-sub 15 (m)		
Recommended controllers / drivers	C-863, C-884		

* Higher forces on request

Ask about customized versions.

Maximum Ratings

The M-227 is designed for the following maximum ratings:

Maximum operating voltage 	Maximum operating frequency 	Maximum power consumption 
0 to ±12 V	---	3.8 W

Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the M-227:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Operating temperature	-20 °C to 65 °C
Storage temperature	-25 °C to 85 °C
Transport temperature	-25 °C to 85 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP30

Dimensions

Dimensions of the M-227

Dimensions in mm. Note that a comma is used in the drawings instead of a decimal point.

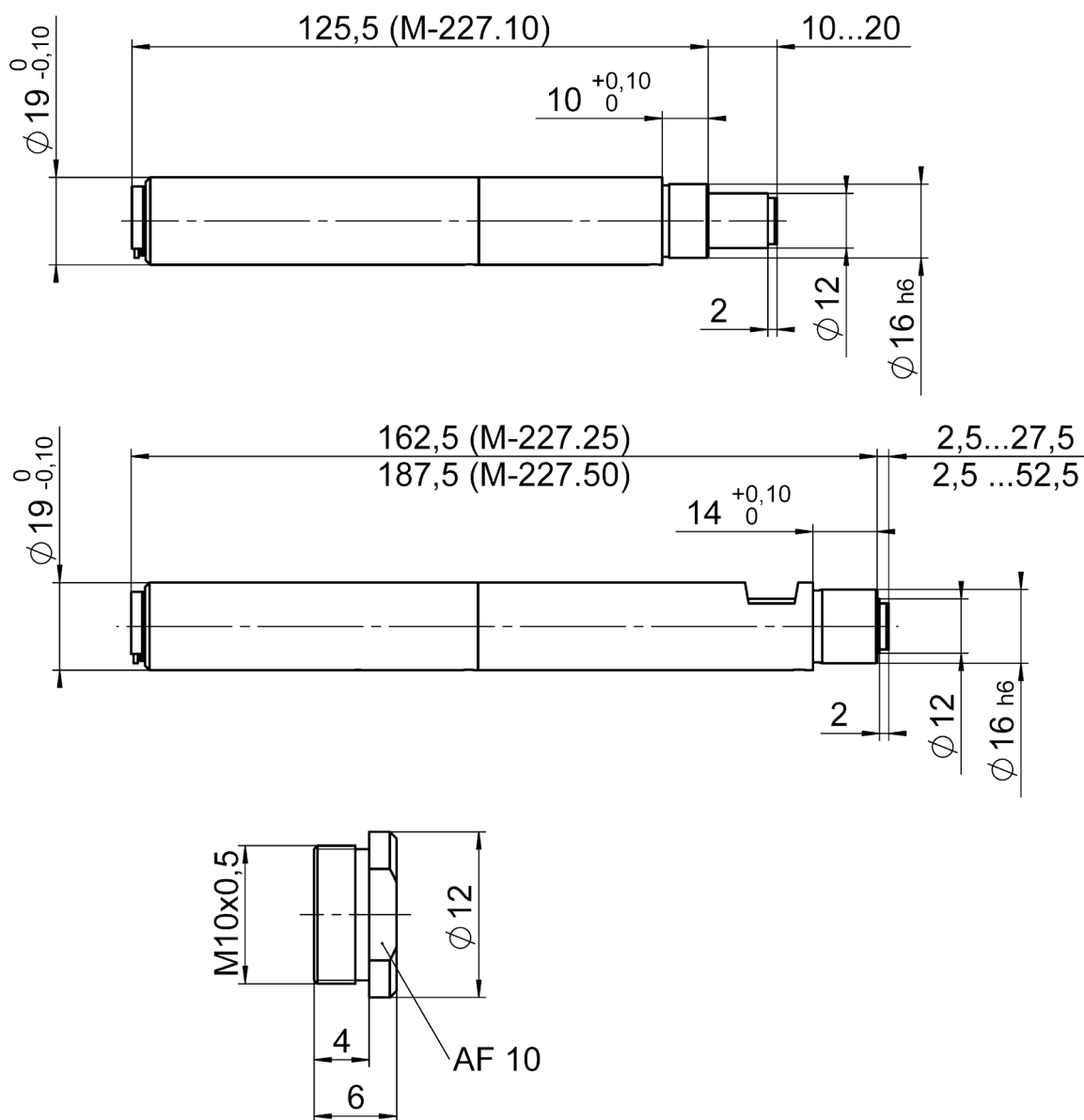


Figure 4: Dimensions of the M-227

Dimensions of the P-885.20 Piezo Actuator

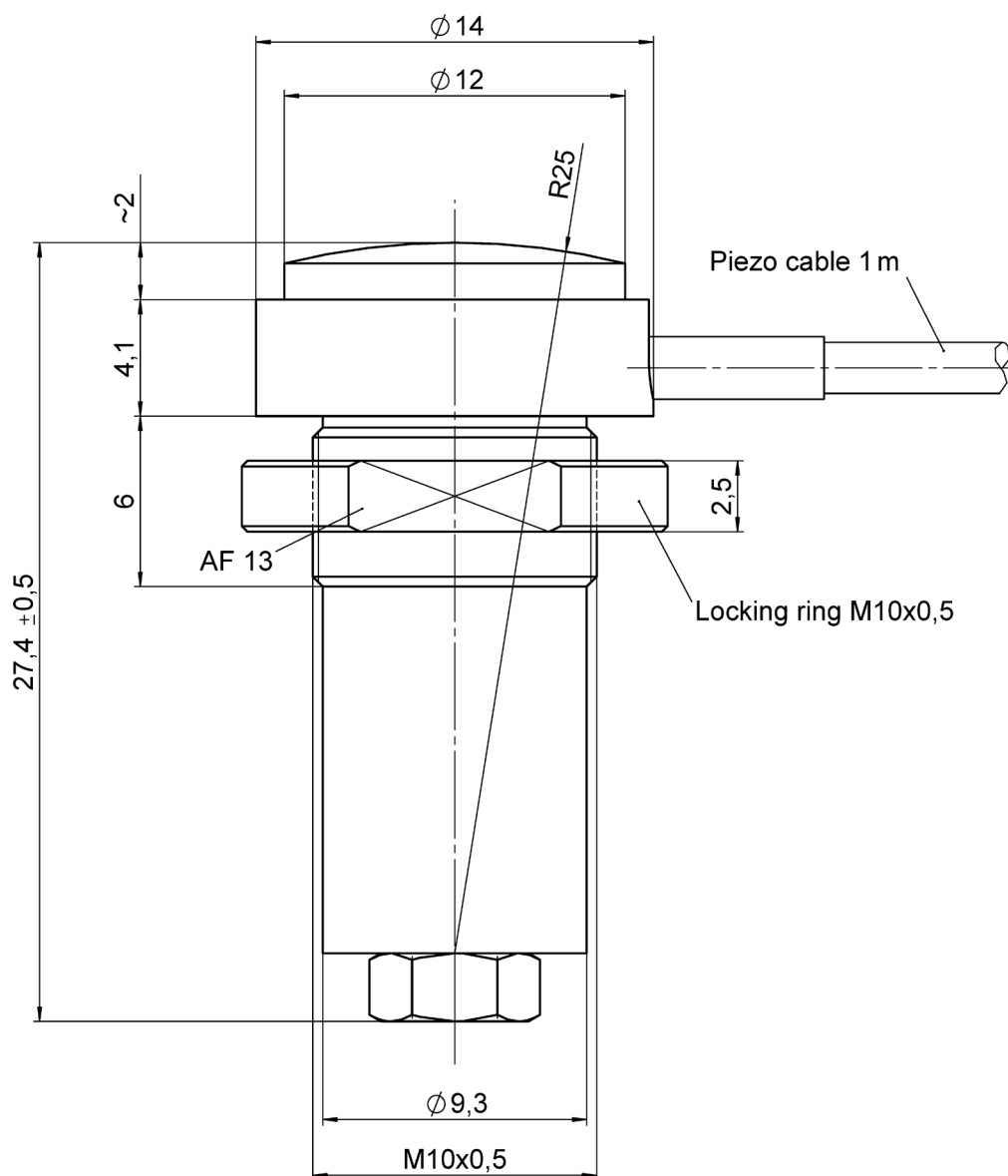


Figure 5: P-885.20 piezo actuator (optional accessory)

Dimensions of the M-219 Tips

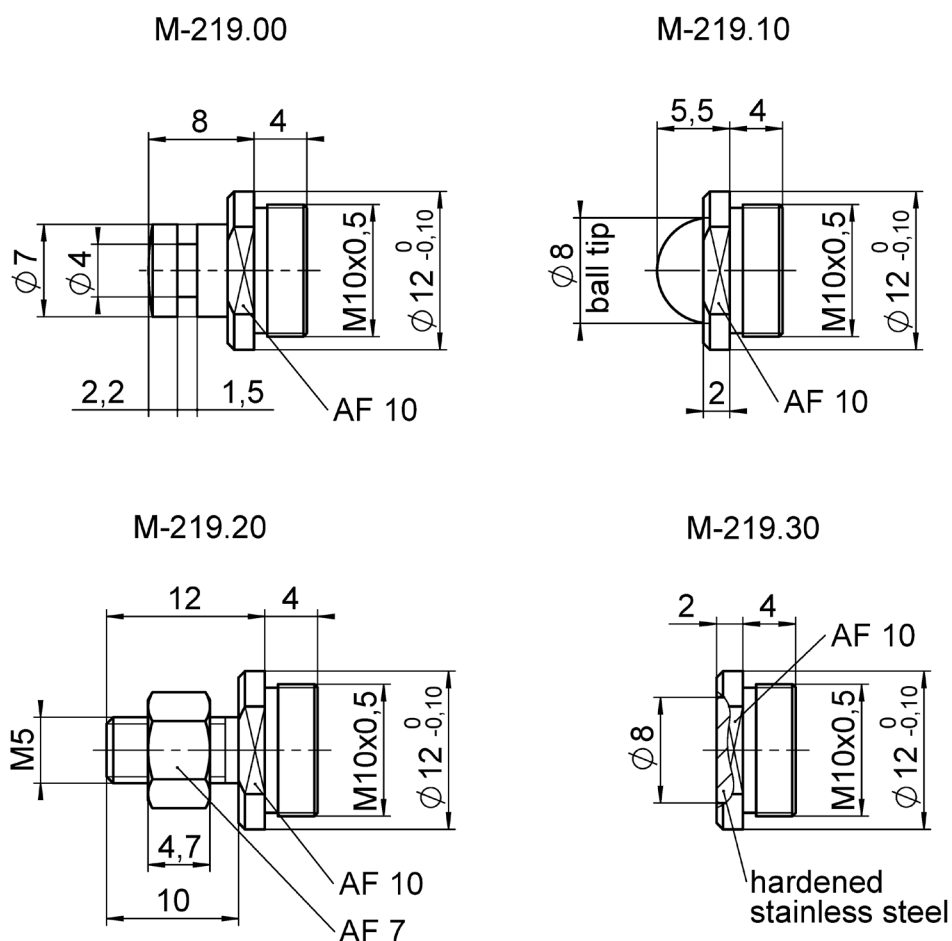


Figure 6: M-219.xx tips (optional accessories)

Pin Assignment

Connector: D-sub 15 (m)

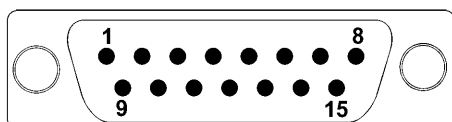


Figure 7: Front view of the D-sub 15 (m) connector (**not** the solder side)

Pin	Function
1	Internal use
2	Motor (+) input
3	Internal use
4	+5 V input
5	Not used
6	GND (logic)
7	A(-) when using RS-422 transmission
8	B(-)when using RS-422 transmission
9	Motor (-) input
10	Internal use
11	Internal use
12	Not used
13	Not used
14	Encoder A (A(+) when using RS-422 transmission)
15	Encoder B (B(+) when using RS-422 transmission)

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 its responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI 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 Roemerstr. 1
D-76228 Karlsruhe, Germany

