

MP77E M-238 High-Load Linear Actuator User Manual

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This document describes the following high-load-linear actuators with 50 mm travel range:

- **M-238.5PG**
with DC gear motor with PWM power amplifier (ActiveDrive), with rotary encoder
- **M-238.5PL**
with DC gear motor with PWM power amplifier (ActiveDrive), with linear encoder



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Original instructions

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Subject to change. This manual is superseded by any new release. The latest release is available for download from our website (p. 2).

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1 About this Document

1.1 Objective and Target Group of this User Manual

This user manual contains the information necessary for using the M-238 as intended.

Basic knowledge of closed-loop systems, motion control concepts, and applicable safety measures is assumed.

1.2 Symbols and Typographic Conventions

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

CAUTION



Dangerous situation

Failure to comply could lead to minor injury.

- Measures for avoiding the risk.

NOTICE



Dangerous situation

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

- Measures for avoiding the risk.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/ Label	Meaning
1. 2.	Action consisting of several steps with strict sequential order
➤	Action consisting of one or more steps without relevant sequential order
▪	Lists
p. 5	Cross-reference to page 5
RS-232	Label on the product indicating an operating element

1.3 Other Applicable Documents

The devices and software tools from PI mentioned in this documentation are described in separate manuals.

Document number	Document type	Product
MP122EK	Short Instructions	Linear actuators
	Manual	Manual for the electronics

1.4 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 21).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., F-238).
3. Click the corresponding product to open the product detail page.
4. Click the **Downloads** tab.
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.

2 Safety

2.1 Intended Use

The M-238 is a laboratory device as defined by DIN EN 61010-1. It is intended for indoor use and use in an environment which is free of dirt, oil, and lubricants.

According to its design, the M-238 is intended for positioning, adjusting and shifting loads in one axis at various velocities. The M-238 can be mounted horizontally or vertically.

It is only possible to use the M-238 as intended when it is installed and connected properly, and only in conjunction with a suitable controller. The controller must be able to read and process the signals from reference and limit switches, and from the incremental position sensors. The controller is not included in the scope of delivery of the M-238.

2.2 General Safety Information

The M-238 is built according to state-of-the-art technology and recognized safety standards. Improper use may result in personal injury and/or damage to the M-238.

- Use the M-238 only for its intended purpose, and only when it is in perfect technical condition.
- Read the user manual.
- Eliminate any malfunctions that may affect safety immediately.

The operator is responsible for the correct installation and operation of the M-238.

2.2.1 Organizational Measures

User manual

- Always keep this user manual together with the M-238.
If the user manual is lost or damaged, please contact our customer service (see p. 2). 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-238 to other users, include this user manual as well as all other relevant information provided by the manufacturer.
- Do the work only if the user manual is complete. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Install and operate the M-238 only after you have read and understood this user manual.

Personnel qualification

The M-238 may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

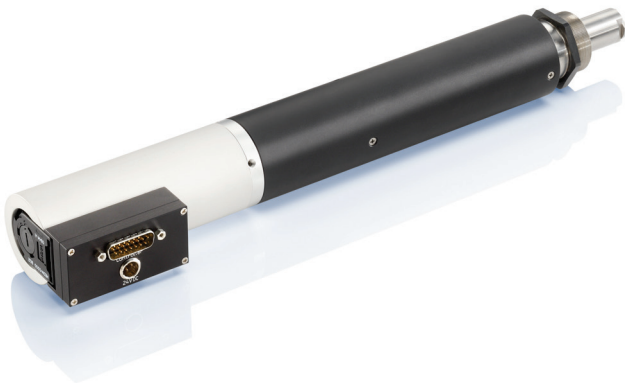
3 Product Description

3.1 Model Overview

Model	Description
M-238.5PG	High-load linear actuator, 400 N, 50 mm, DC gear motor, ActiveDrive
M-238.5PL	High-load linear actuator, 400 N, 50 mm, DC gear motor, ActiveDrive, direct position measuring

3.2 Product View

3.2.1 Elements of the M-238



Elements of the M-238

Labeling	Type	Function
Controller	D-sub 15 (m) (p. 26)	Drive connector: Connects the M-238 to the electronics
24 V DC	Mini XLR 3-pole (m) (p. 27)	Connector for the power supply

3.2.2 Type plate

Labeling	Description
	Manufacturer's logo
M-238.5PL	Product name (example); the characters after the period refer to the model
415002159	Serial number (example), individual for each M-238 Meaning of each position (from the left): 1 = internal information, 2 and 3 = year of manufacturer, 4 to 9 = consecutive numbers
	Warning sign "Pay attention to the manual!"
Country of origin: Germany	Country of origin
	CE conformity mark
WWW.PI.WS	Manufacturer's address (website)
	Old equipment disposal
M-238	Product series

3.3 Scope of Delivery

Order number	Components
000023194	24 V 120 W wide input range power supply, with barrel connector socket
3763	Power cord
K050B0002	Power adapter, barrel connector 5.5 mm x 2.1 mm to mini XLR3 (f)
MP122EK	Short instructions for linear actuators

3.4 Suitable Electronics

The M-238 must be connected to suitable electronics. The following electronics are suitable:

Product number	Description
C-863	Mercury DC motor controller
C-884	DC motor controller

The required PC software is included in the scope of delivery of the electronics from PI. The operation of the controllers is described in the corresponding user manuals.

Note that the cables required for connecting the M-238 to the electronics must be ordered separately.

To order, contact the customer service department (p. 21).

3.5 Technical Features

3.5.1 Integrated PWM amplifier

The M-238 model is equipped with a PWM amplifier ("ActiveDrive concept").

The integrated PWM amplifier for ActiveDrive DC motors only receives control signals from the control electronics, whereas the supply voltage is provided via an external power adapter. The higher motor performance allows better dynamics.

3.5.2 Encoder

The **M-238.5PG** model is equipped with a **rotary encoder**. A rotary encoder is implemented at a rotating point in the drivetrain, e.g., the motor shaft. The encoder provides a certain number of signals for each change of position. The controller counts the encoder signals, the so-called pulses, in order to determine the relative position. The M-234 must be moved to a limit or reference switch in order to measure the absolute position (referencing).

The **M-238.5PL** model is equipped with an optical **linear encoder**. Optical linear encoders measure the actual position directly and therefore eliminate drive errors such as nonlinearity, backlash or elastic deformation.

The resolution of the encoders can be found in the data table (p. 23).

3.5.3 Limit Switches

The limit switches are sensors at each end of the travel range that enable the electronics to abort motion in order to prevent the pusher from colliding with the mechanical hard stop.

The M-238 is equipped with noncontact Hall effect limit switches (p. 25).

3.5.4 Reference Switch

The reference switch is a sensor whose fixed position serves as the reference point for incremental sensor signals.

The M-238 is equipped with a magnetic (Hall effect), direction-sensing reference switch (p. 25) positioned approximately at the midpoint of the travel range. This sensor sends a TTL signal that indicates whether the positioner is on the positive or negative side of a specified point. Both the rising and falling edges of the signal can serve as reference (accuracy approx. 0.5 µm, depending on the controller). The difference between the reference points is approx. 0.2 to 0.4 mm when approached from the positive or negative direction.

The commands that use the reference signal are described in the user manual for the controller.

4 Unpacking

1. Unpack the M-238 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 Installing

5.1 General Notes on Installing

NOTICE

**Damage due to mechanical stress on the cable!**

The cable will break from excessive bending or crushing. A broken cable will lead to failure of the M-238 or damage to the actuator or the electronics.

- Install the M-238 so that the cable cannot be bent or crushed too strongly.

NOTICE

**Increased friction!**

Lateral forces acting on the pusher of the linear actuator increase the friction of the internal drive components. Increased friction impairs the motion of the pusher and increases wear on the drive components.

- Avoid lateral forces on the tip and on the pusher of the M-238.

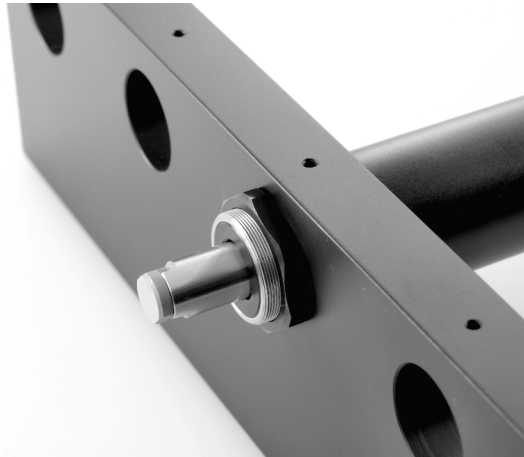
NOTICE

**M-238 heating up during operation!**

The heat produced while operating the M-238 can affect your application.

- Install the M-238 so that the application is not impaired by dissipating heat.

5.2 Providing a Suitable Mechanical Mounting and Installation Environment



Example of installing a linear actuator

A suitable mechanical mounting and installation environment are necessary for the proper use of the actuator.

- Make sure that the following conditions have been met:
 - Material and statics of the mounting are designed so that the static and dynamic forces that occur can be safely and continuously managed.
 - The dimensions of the mounting are adapted to the dimensions of the actuator (see dimensions, (p. 25).
 - The intended motion of the pusher and the load must not be inhibited by the dimensions of the installation environment.
- Take into account the following specifications as well when planning the application and installing the actuator:
 - Tip dimensions (see Dimensions (p. 25))
 - Travel range (see data table (p. 23))
 - Space requirements for bend-free and proper guiding of the connecting cable and additional motor cables
 - Length of the connecting cable and the motor cable
- If the limit switches of the actuator cannot be reached with the planned minimum and maximum displacements: Make sure that the actuator and the load **only move within the planned range**. Suitable measures:
 - Corresponding programming of the controller
 - Emergency off switch
 - Automatic shutdown systems
- In accordance with the legal regulations, avoid or label danger areas resulting from the installation of the actuator and from use (e.g., risk of crushing in the case of heavy moving loads, fast actuator motion and/or high drive torques).

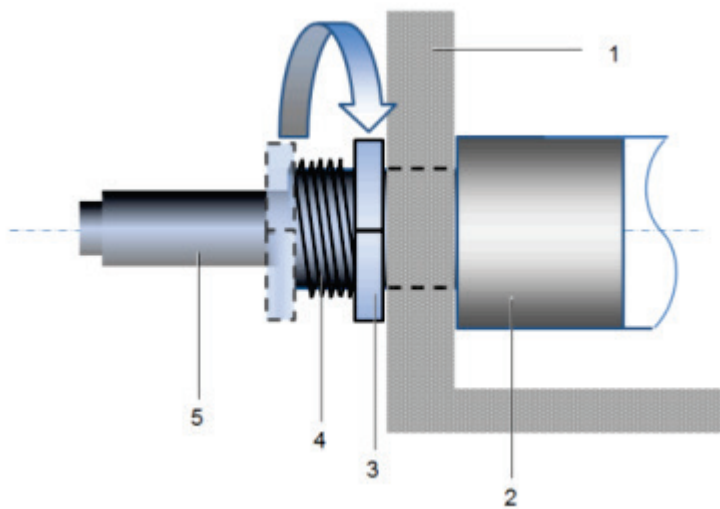
5.3 Installing the M-238 into a Mechanical Mounting

INFORMATION

To achieve an optimal repeatability, the mounting shaft must not have any backlash.

- When assembling, make sure that the actuator and the mechanical mounting have been connected perfectly.

We recommend installing the actuator into the mounting with a clamp connection. The following instructions refer to this case.



Clamp connection (schematic)

1. Mechanical mounting
2. Sleeve
3. Mounting nut
4. Mounting shaft with thread
5. Pusher with tip

Requirements

- ✓ You have read and understood the general notes on installation (p. 11).
- ✓ You have provided your application with a suitable mounting for the mounting shaft of the actuator (p. 12).

Tools and Accessories

- Open-end wrench AF 41

Installing the Actuator

1. Loosen the mounting nut on the mounting shaft of the actuator.
2. Position the actuator in the mounting of your application.

3. If necessary, put a suitable flat washer or a suitable spring washer onto the mounting shaft.
4. Turn the mounting nut a few times by hand into the thread of the mounting shaft.
5. To clamp the actuator in the mounting, tighten the mounting nut using the open-end wrench until you feel a resistance. The torque may not exceed 2 Nm!
6. Check that the actuator is fixed firmly in the mounting.

5.4 Connecting the M-238

NOTICE



Damage if the wrong controller is connected!

Connecting a linear actuator to an unsuitable controller can damage the linear actuator or controller.

- Connect the M-238 to a DC motor controller only.

Requirements

- ✓ You have read and understood the general notes on installation (p. 11).
- ✓ You have read and understood the user manual for the electronics.
- ✓ You have installed the electronics properly.
- ✓ The electronics are switched off.

Tools and Accessories

- Suitable electronics (p. 6)
- Cable set suitable for the electronics used
- Wide input range power supply with power adapter and power cord (included in the scope of delivery, p. 6)
- If necessary: Suitable screwdriver for the locking screws of the connectors

Connecting the Actuator

1. If necessary: Remove the ESD protective caps from the M-238's connectors.
2. Connect the electronics:
 - a) Connect the M-238's drive plug to the drive socket on the electronics.
 - b) Secure the connectors against unintentional removal.
3. Connect the power adapter:
 - a) Connect the power cord to the M-238's power connector with the help of the power adapter.
 - b) Connect the power cord to the power adapter.

6 Starting

6.1 General Notes on Starting

CAUTION

**Unintentional movement of the linear actuator when switching the controller on!**

Failure to comply could lead to minor injury.

- Do not place any objects in areas where they could be caught by moving parts.
- Keep a safe distance from the motion range of the linear actuator.

NOTICE

**Damage due to the pusher hitting the hard stop!**

When the limit switches are deactivated, the motion of the pusher is stopped by the hard stop and the M-238 could be damaged.

- Do **not** deactivate the limit switches in the software.
- Test the function of the limit switches at low velocities only.

NOTICE

**Damage or considerable wear due to high acceleration!**

High acceleration could cause considerable wear and damage the mechanics.

- Stop motion immediately if a controller malfunction occurs.
- Make sure that the end of the travel range is approached at low velocity.
- Set the control signal so that the moving part does not stop abruptly or try to continue motion at the end of the travel range.
- Determine the maximum velocity for your application.

6.2 Starting and Operating the M-238

Requirements

- ✓ You have read and understood the general safety instructions (p. 3).
- ✓ You have installed the M-238 properly (p. 11).
- ✓ You have read and understood the user manual for the electronics.
- ✓ If a digital controller is used: You have read and understood the manual for the PC software used.
- ✓ The electronics and if required, the PC software, have been installed (refer to the user manual for the electronics).

Starting and Operating the Actuator

1. Plug the power cord of the power adapter into the power socket.
2. Start the electronics (refer to the user manual for the electronics).
3. Configure the electronics for the M-238 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 M-238 model exactly.
 - If you are using electronics from another manufacturer: Configure the electronics according to the parameters of the M-238 (p. 23).
4. Start a few motion cycles for testing purposes (refer to the user manual for the electronics).

7 Maintenance

NOTICE

**Damage due to improper maintenance!**

The M-238 can become misaligned by incorrect maintenance.

- Loosen screws only according to the instructions in this manual or the instructions of our customer service department (p. 21).

7.1 Lubricating the M-238

Depending on the operating conditions and the period of use of the M-238, the following maintenance measures are required:

Maintenance Run

The maintenance run serves the purpose of distributing the existing lubricant.

- If the M-238 is moved continuously over a short travel range (<20 % of the entire travel range) in an industrial situation, do a run across the entire travel range approximately every 2000 motion cycles.

Relubricating

Under laboratory conditions, the positioner needs relubrication in exceptional cases only. For continuous industrial use, the lubrication intervals must be determined individually.

- If you have any questions on relubricating, contact our customer service department (p. 21).

7.2 Cleaning the M-238

Requirements

- ✓ You have disconnected the linear actuator from the controller.

Cleaning the Linear Actuator

- Do **not** use any organic solvents.
- If necessary, clean the surfaces of the linear actuator using a cloth dampened with a mild cleanser or disinfectant.

8 Troubleshooting

Problem	Possible causes	Solution
Reduced positioning accuracy	Mounting nut is fastened too tight	➤ Tighten the mounting nut with a maximum torque of 1 Nm.
Function impairment after system modification	- Controller was replaced - M-238 was replaced by another model	Controller from PI: ➤ Load the parameters from the positioner database that correspond to the combination of controller and the M-238 model. Controller from a third-party supplier: ➤ Check the operating parameters.
The mechanics do not move	The cable is not connected correctly or is defective	➤ Check the connecting cable.
	Lateral forces are acting on the pusher	Lateral forces increase the friction on the internal drive components. ➤ Avoid lateral forces on the tip and on the pusher of the M-238.
The mechanics do not move, but generate operating noise	Values for the velocity, acceleration and/or load are too high	➤ Reduce the velocity. ➤ Reduce the acceleration. ➤ Reduce the load on the mechanics.
The mechanics did not stop in time and ran into the hard stop	- Velocity is too high (see chapter Limit Switches p. 7) - Limit switch is defective - Controller ignores the limit switch signal	1. Stop the motor. 2. Command the mechanics away from the hard stop. 3. Check the settings of the controller for limit switch evaluation.

If the problem with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 21).

9 Customer Service Department

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

- If you have 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)
 - PC operating system (if applicable)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

10 Technical Data

10.1 Specifications

10.1.1 Data Table

Motion and positioning	M-238.5PG	M-238.5PL	Unit	Tolerance
Travel range	50	50	mm	
Integrated sensor	Rotary encoder	Linear encoder		
Sensor resolution	4000 cts/rev	0.1 µm		
Design resolution	0.13	0.1	µm	Typ.
Minimum incremental motion	0.5	0.3	µm	Typ.
Backlash	3	1	µm	Typ.
Unidirectional repeatability	±1	±0.3	µm	Typ.
Velocity	30	30	mm/s	Max.
Reference switch repeatability	1	1	µm	Typ.

Mechanical properties	M-238.5PG	M-238.5PL	Unit	Tolerance
Drive screw pitch	2	2	mm	
Gear ratio	3.71:1	3.71:1		
Push/pull force	400	400	N	Max.
Permissible lateral force	100	100	N	Max.

Drive properties	M-238.5PG	M-238.5PL	Unit	Tolerance
Motor type	DC motor, ActiveDrive	DC motor, ActiveDrive		
Motor voltage	24 V	24 V	V	
Motor power	80	80	W	Nominal

Miscellaneous	M-238.5PG	M-238.5PL	Unit	Tolerance
Operating temperature range	-10 to 50	-10 to 50	°C	
Material	Aluminum anodized, chrome steel	Aluminum anodized, chrome steel		
Mass	2.4	2.4	kg	±5 %
Connector	D-sub 15 (m)	D-sub 15 (m)		
Recommended controllers / drivers	C-863, C-884	C-863, C-884		

10.1.2 Maximum Ratings

The linear actuator is designed for the following operating data:

Model	Maximum operating voltage	Operating frequency	Maximum power consumption
			
M-238.5PG	24 V	DC	80 W
M-238.5PL	24 V	DC	80 W

10.1.3 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the M-238:

Area of application	For indoor use only
Maximum altitude	2000 m
Relative humidity	Max. 80 % for temperatures up to 31 °C Decreasing linearly to 50 % at 40 °C
Overvoltage category according to EN 60664-1 / VDE 0110-1	II
Supply voltage fluctuations	Max. ±10 % of the nominal voltage
Degree of pollution	2
Degree of protection according to IEC 60529	IP20

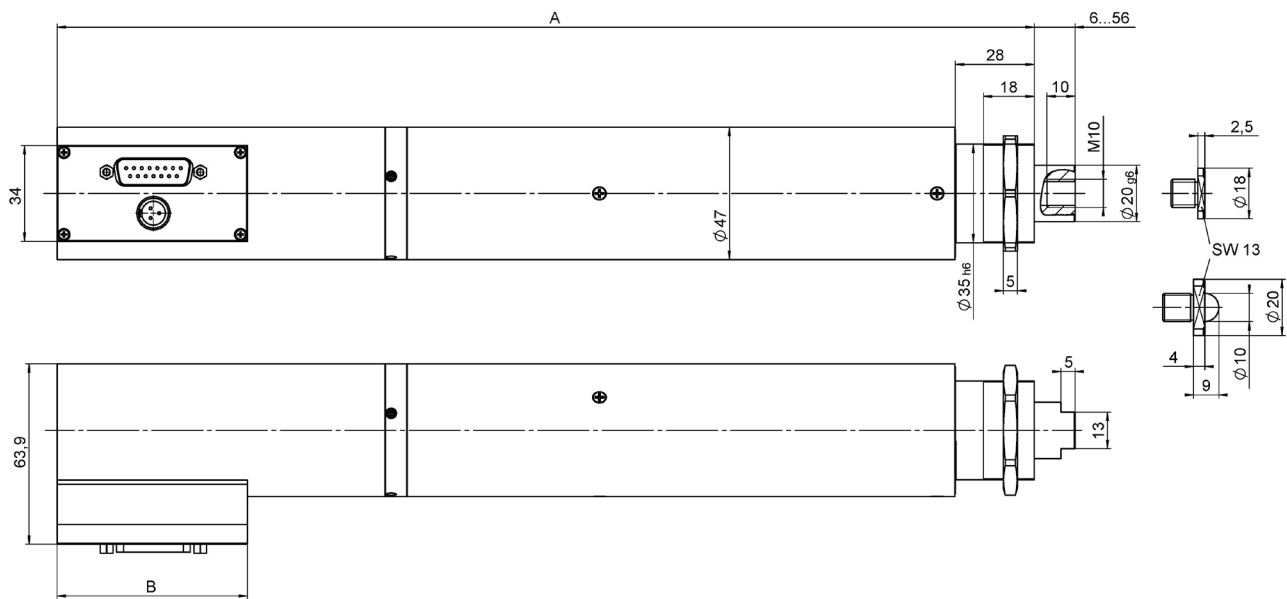
10.1.4 Limit Switch Specifications

Type	Magnetic (Hall effect) sensor
Supply voltage	+5 V / ground
Signal output	0V / +5V (TTL level)
Sink/Source capability	20 mA at 18°C
Signal logic	The signal level changes when passing the limit switch. The signal logic is active high. That means: - Normal motor operation: low - Limit switch reached: high

10.1.5 Reference Switch Specifications

Type	Magnetic (Hall effect) sensor
Supply voltage	+5 V / ground
Signal output	0V / +5V (TTL level)
Signal logic	Direction sensing via different signal levels on the left and right of the reference switch.

10.2 Dimensions

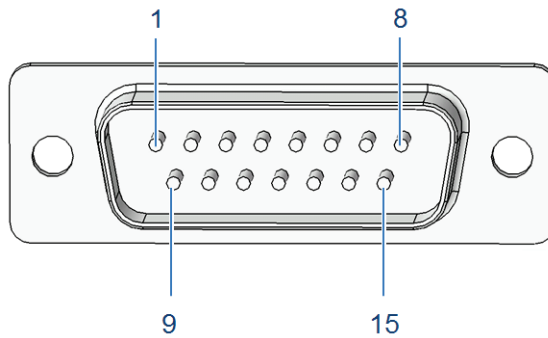


	A	B
M-238.5PL	336,2	90
M-238.5PG	347,2	67,6

Dimensions of the M-238, values in mm

10.3 Pin Assignment

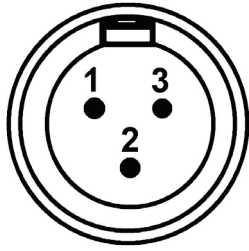
10.3.1 Drive connector



D-sub 15 (m)

Pin	Signal	Function
1	ENABLE	Input enabling signal for PWM amplifier and brake, (+5 V to +12 V)
2	n.c.	Not connected
3	MAGN	PWM signal input
4	+5 V	+5 V for encoder and digital signals
5	PLIM	Positive limit switch, TTL
6	GND	Ground (digital)
7	Encoder A-	Encoder signal A (inverted), TTL
8	Encoder B-	Encoder signal B (inverted), TTL
9	n.c.	Not connected
10	PGND	Ground
11	SIGN	PWM signal input
12	NLIM	Negative limit switch, TTL
13	REF	Reference switch, TTL
14	Encoder A+	Encoder signal A, TTL
15	Encoder B+	Encoder signal B, TTL

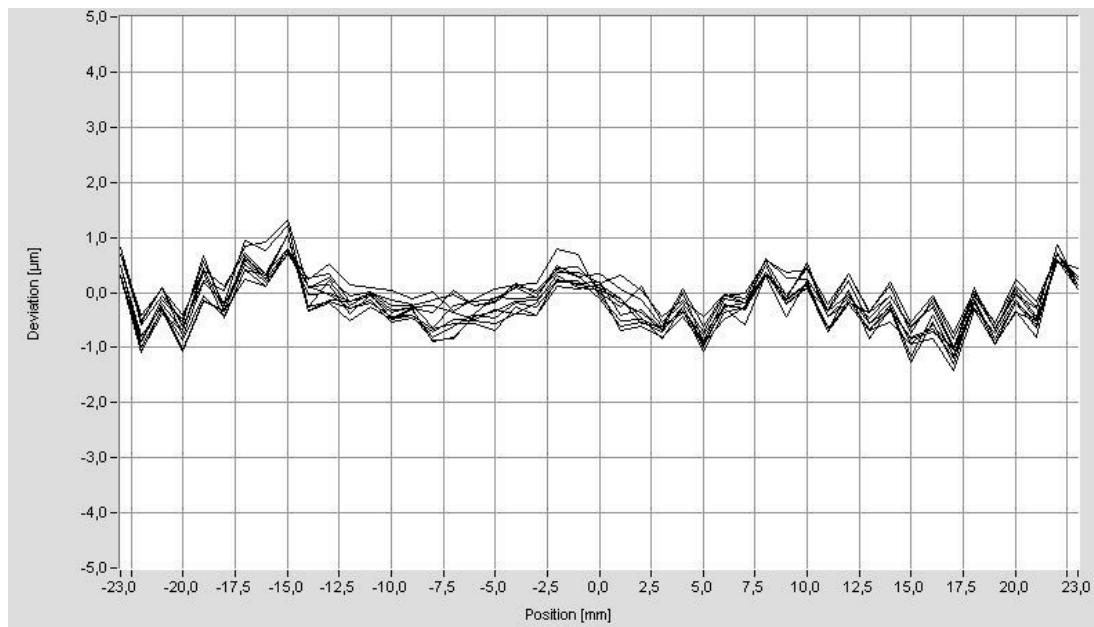
10.3.2 Voltage connector



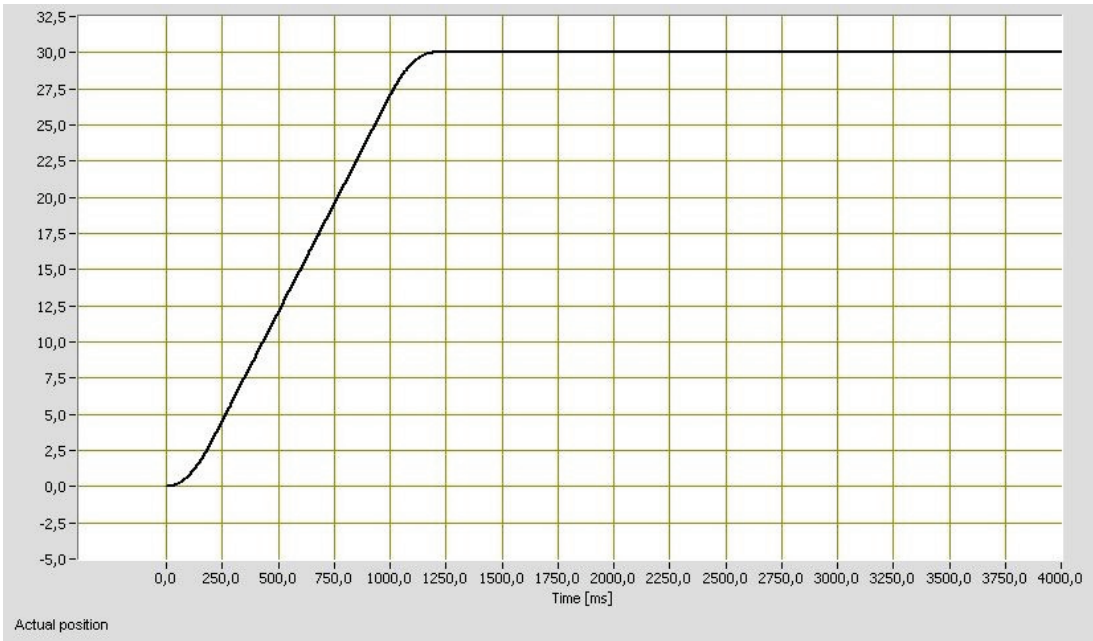
Mini XLR 3-pole (m)

Pin	Signal	Function
1	GND	Ground
2	Vcc	24 V DC supply voltage
3	n.c.	Not connected

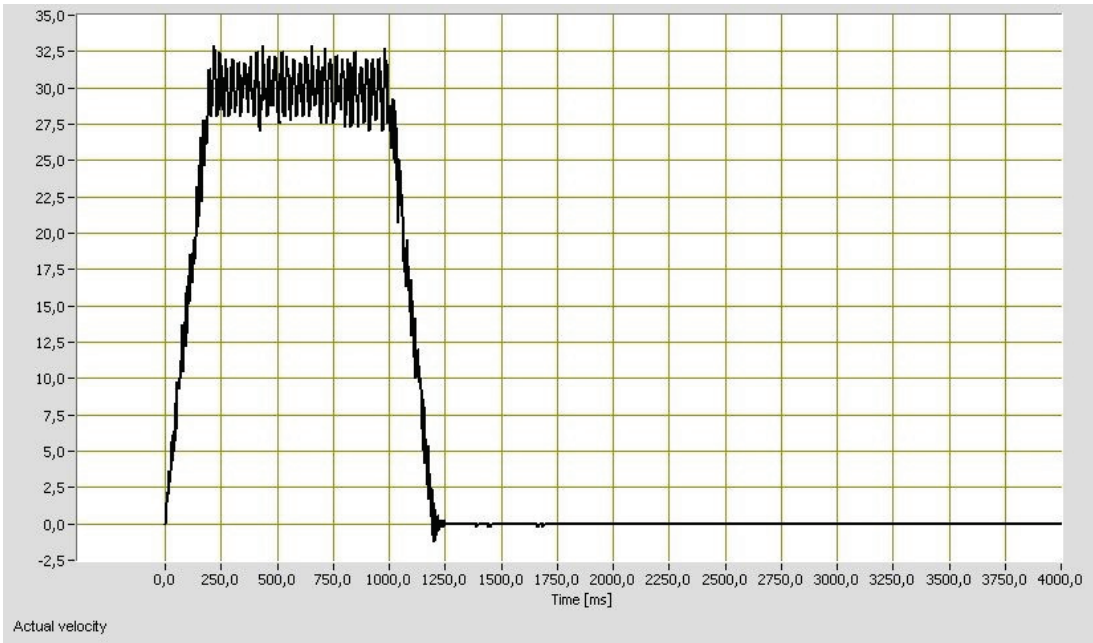
10.4 Measured Curves



The repeatability of the M-238.5PL with linear encoder is less than 0.3 µm.



The M-238 requires less than 1.5 seconds for a 30-mm step.



The velocity constancy of an M-238.5PL at 30 mm/s.

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 fulfill 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 miCos equipment can be sent free of charge to the following address:

PI miCos GmbH
Freiburger Strasse 30
79427 Eschbach, Germany



12 EU Declaration of Conformity

An EU Declaration of Conformity was issued for the M-238 in accordance with the following European directives:

Machinery Directive

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

Safety of Machinery: EN ISO 12100

Electrical Safety: EN 61010-1

EMC: EN 61326-1

RoHS: EN 50581 or EN IEC 63000