# P-603 PiezoMove Linear Actuator

## Low-cost and with Large Travel Ranges


P-603 linear actuators with 500 and 100 µm travel range (from left to right). CD for size comparison

- **Frictionless, High-Precision Flexure Guiding System**
- **Travel Ranges to 500 µm**
- **Cost-Effective Design**
- **Outstanding Lifetime Due to PICMA® Piezo Actuators**
- **Available with Integrated Position Sensor**
- **Ideal OEM Actuators for Precision Motion Control in Optics, Medical, Biotech and Microfluidics Applications**
- **Custom Designs with Larger Travel or Faster Response and Non-Magnetic Versions Feasible**

P-603 PiezoMove flexure-guided piezo actuators integrate a frictionless high-efficiency motion amplifier to combine large travel ranges up to 500 µm with high stiffness and very fast response. The flexure guides reduce tip at the drive head to a minimum saving the cost for additional guiding systems when integrating these actuators in micro-dispensing devices, pumps or servo valves. The overall precision of 10s of nanometers also makes these devices ideal for nanomanipulation applications.

### Application Example

- Nanopositioning
- CCD / CMOS camera technology / Micro scanning
- Cell manipulation, biohandling
- Medical technology
- Micropumps
- Micro-dispensing
- Slit width adjustment
- Cavity Tuning
- Beam stabilization
- Photonics / integrated optics
- Switches

### Options and Custom Versions

For OEM applications, PiezoMove actuators can be modified in various ways to suit the customer's requirements. The stiffness and force generation can be influenced via the lever design and the dimensions of the piezo ceramics used in the actuator. If only a small force and low guiding accuracy are required, large strokes of several 100 µm and high frequencies can be achieved with small actuators, e.g. for micropump drives. For high-accuracy applications, an integrated position feedback sensor is available. The actuators were designed to allow for considerable cost savings in large production runs.

### OEM Control Electronics

PI also supplies a variety of controllers to match the actuators. These range from simple amplifier modules (see p. 2-164) and analog closed-loop OEM controllers (see p. 2-110) to high-performance digital controllers (see p. 2-100*ff*). The great choice of actuators and controllers allows customers to select the optimum combination of performance and cost for their application.

### Increased Lifetime Through Humidity Resistance

The monolithic ceramic-encapsulated design provides better humidity protection than polymer-film insulation. Diffusion of water molecules into the insulation layer is greatly reduced by the use of cofired, outer ceramic encapsulation. Due to their high resonant frequency the actuators are suitable for highly dynamic applications with small loads; depending on the load an external preload for dynamic applications is recommended. The high Curie temperature of 320° gives PICMA® actuators a usable temperature range extending up to 150 °C, far beyond 80°C as is common for conventional multilayer actuators. With conventional multilayer actuators, heat generation – which is proportional to operating frequency – either limits the operating frequency or duty cycle in dynamic operation, or makes ungainly cooling provisions necessary. At the low end, operation down to a few Kelvin is possible (with reduced travel range).

### Ordering Information

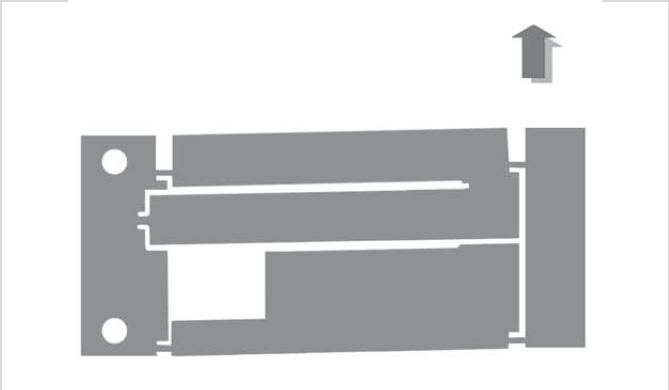
**PiezoMove® OEM Linear Actuator with High Stiffness**

**P-603.** □ □

- **1** Travel Range 100 µm
- **3** Travel Range 300 µm
- **5** Travel Range 500 µm

- **00** Open loop
- **S0** SGS Sensor
- **SL** SGS Sensor, LEMO Connector

**Ask about custom designs!**

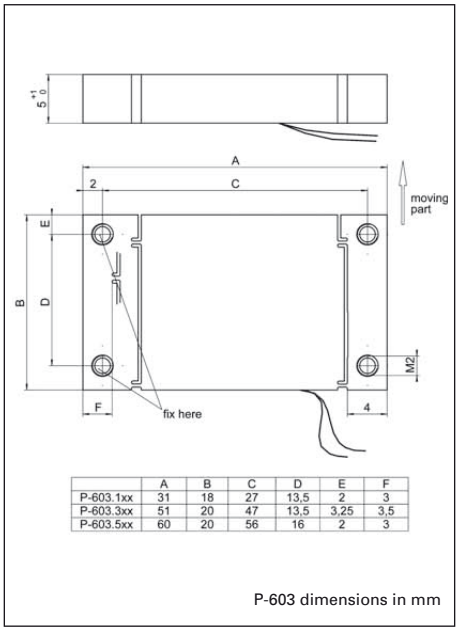


The flexure guiding system prevents tip and tilt at the drive head!

**Levels of Integration: From Stack Actuator to 6-Axis Stage**

| | Stack actuators | Lever-amplified actuators | Positioning systems |
|---|---|---|---|
| Travel ranges | up to approx. 150 µm | up to 1 mm | up to 2 mm |
| Axes moved | one | one | up to three linear axes and three tip/ tilt axes |
| Sensors | SGS optional | SGS optional | SGS or direct measuring capacitive sensors |
| Linearity | up to 99.8 % | up to 99.8 % | over 99.9 % |
| Guidance | none | flexures for rotations <10" | flexures for rotations <2" |
| Space required | low | low | depends on features |
| Price | low | low | depends on features |
| Integration effort | high | low | low |

Flexure guided, lever-amplified actuators form a reasonably priced and easily integrated class of products between conventional piezo stack actuators and the complex piezo nanopositioning systems




| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| P-603.1xx | 31 | 18 | 27 | 13,5 | 2 | 3 |
| P-603.3xx | 51 | 20 | 47 | 13,5 | 3,25 | 3,5 |
| P-603.5xx | 60 | 20 | 56 | 16 | 2 | 3 |

P-603 dimensions in mm



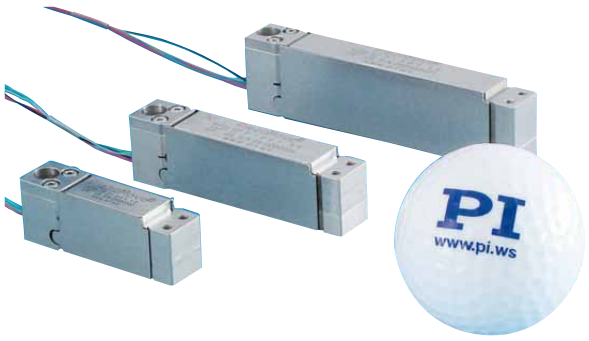
## Technical Data (preliminary)

| Model | P-603.1S0<br>P-603.1SL | P-603.3S0<br>P-603.3SL | P-603.5S0<br>P-603.5SL | P-603.x00<br>open-loop<br>versions | Units | Tolerance |
|---|---|---|---|---|---|---|
| Active axes | X | X | X | X | | |
| **Motion and positioning** | | | | | | |
| Integrated sensor | SGS | SGS | SGS | – | | |
| Open-loop travel, -20 to +120 V | 100 | 300 | 550 | as P-603.xS0 | µm | min. (+20%/-0) |
| Closed-loop travel | 100 | 300 | 500 | – | µm | calibrated |
| Open-loop resolution | 0.2 | 0.3 | 0.4 | as P-603.xS0 | nm | typ. |
| Closed-loop resolution | 2 | 4 | 7.5 | – | nm | typ. |
| Linearity, closed-loop | 0.3 | 0.3 | 0.3 | – | % | typ. |
| Repeatability | 8 | 10 | 30 | – | nm | typ. |
| **Mechanical properties** | | | | | | |
| Stiffness in motion direction | 0.25 | 0.14 | 0.06 | as P-603.xS0 | N/µm | ±20% |
| Unloaded resonant frequency | 900 | 450 | 300 | as P-603.xS0 | Hz | ±20% |
| Push/pull force capacity in motion direction | 20 / 2.5 | 15 / 2 | 10 / 1.5 | as P-603.xS0 | N | max. |
| Blocking force | 20 | 35 | 25 | as P-603.xS0 | N | max. |
| **Drive properties** | | | | | | |
| Ceramic type | PICMA® P-885 | PICMA® P-885 | PICMA® P-885 | PICMA® P-885 | | |
| Electrical Capacitance | 1.5 | 3.1 | 3.7 | as P-603.xS0 | µF | ±20% |
| Dynamic operating current coefficient | 1.9 | 1.3 | 1.6 | as P-603.xS0 | µA/(Hz•µm) | ±20% |
| **Miscellaneous** | | | | | | |
| Operating temperature range | -20 to 80 | -20 to 80 | -20 to 80 | -20 to 80 | °C | |
| Material | Stainless steel | Stainless steel | Stainless steel | Stainless steel | | |
| Mass | 0.02 / 0.031 | 0.032 / 0.043 | 0.038 / 0.049 | as P-603.xS0 | kg | ±5% |
| Cable length | 0.5 | 0.5 | 0.5 | 0.5 | m | ±10 mm |
| Sensor / voltage connection | S-version:<br>open leads<br>SL-version:<br>LEMO connector<br>(SGS Sensor) | S-version:<br>open leads<br>SL-version:<br>LEMO connector<br>(SGS Sensor) | S-version:<br>open leads<br>SL-version:<br>LEMO connector<br>(SGS Sensor) | Open leads | | |

Recommended controller / amplifier
E-610 controller / amplifier see p. 2-110, E-625 bench-top controller see p. 2-114

# P-601 PiezoMove™ Z-Actuator

## Flexure-Guided OEM Piezo Actuator with Long Stroke to 400 µm




PiezoMove™ Lever-amplified piezo actuators of the P-601 series

- **Flexure Guidance for Frictionless, Ultra-Straight Motion**
- **Travel Ranges to 400 µm**
- **Resolution to 0.2 nm**
- **High Dynamics and Stiffness**
- **Custom Designs with Longer Travel or Faster Response and Non-Magnetic Versions Feasible**
- **Outstanding Lifetime Due to PICMA® Piezo Actuators**
- **Choice of Closed-Loop and Open-Loop Models**
- **Ideal OEM Actuator for Precision Motion Control in Optics, Medical, Biotech and Microfluidics Applications**

The flexure-guided, lever-amplified PiezoMove™ P-601 actuators provide large vertical travel ranges up to 400 µm, fast response and high positioning accuracy in a very small package. With settling times of only a few milliseconds and a resolution in the sub-nanometer range they are well suited for both static and dynamic applications.

P-601 PiezoMove™ lever-amplified actuators cover the range between direct-driven preloaded piezo translators, such as the P-840 series (see p. 1-74) and single-axis nanopositioning stages, like the P-611 series (see p. 2-20). Compared to direct-driven piezo translators, lever-amplified actuators offer larger travel ranges and much higher lateral stiffness and guiding precision. Compared to single-axis nanopositioning stages, they offer significantly smaller sizes. PiezoMove™ lever-amplified actuators feature a resolution to 0.2 nm and a repeatability to 8 nm.

### Application Example

- Nanopositioning
- Imaging
- High-speed switching
- Patch clamp
- Micro-dispensing
- Semiconductor testing
- Adaptronics / Automation
- Photonics / integrated optics
- Biotechnology

### OEM Actuator with Integrated Guidance

With their highly precise, frictionless flexure guidance, a very high stiffness and excellent straightness of motion are achieved. Together with their small dimensions and the cost-effective design, the P-601 lever amplified actuators are especially suited for OEM applications. Versions with strain-gauge sensors (SGS) are equipped with a full bridge circuit that is insensitive to thermal drift. Versions without sensors are also available for open-loop applications such as in high-speed switches and pumps. In addition to the standard steel models, special invar and non-magnetic versions are available on request.

### Ceramic Insulated Piezo Actuators Provide Long Lifetime

Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators. PICMA® actuators are the only actuators on the market with ceramic-only insulation, which makes them resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.

### Ordering Information

**P-601.1S**
PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 100 µm, SGS-Sensor

**P-601.3S**
PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 250 µm, SGS-Sensor

**P-601.4S**
PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 400 µm, SGS-Sensor

**P-601.1SL**
PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 100 µm, SGS-Sensor, LEMO Connector

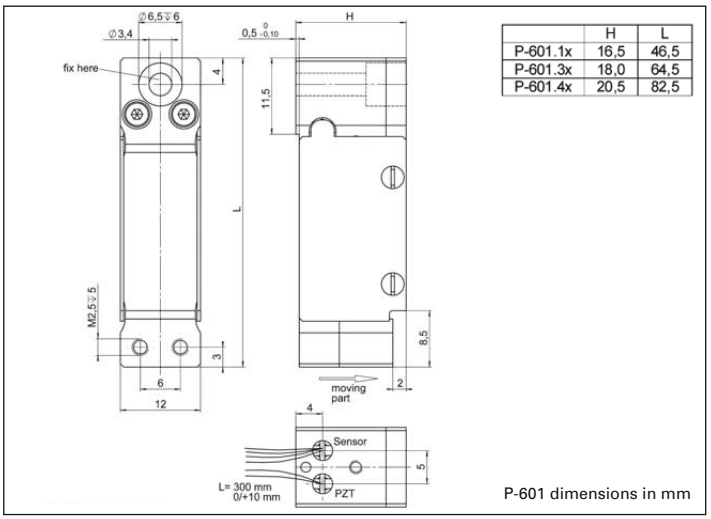
**P-601.3SL**
PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 250 µm, SGS-Sensor, LEMO Connector

**P-601.4SL**
PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 400 µm, SGS-Sensor, LEMO Connector

**P-601.10**
PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 100 µm, Open-Loop

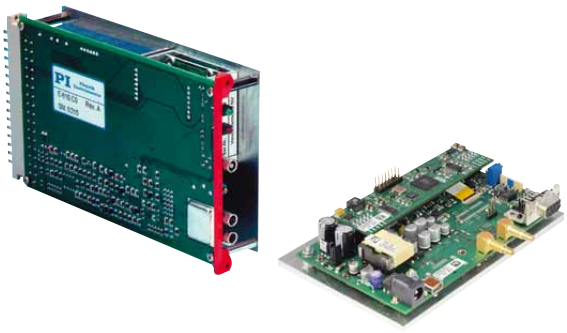
**P-601.30**
PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 250 µm, Open-Loop

**P-601.40**
PiezoMove™ OEM Flexure-Guided, Lever-Amplified Actuator, 400 µm, Open-Loop

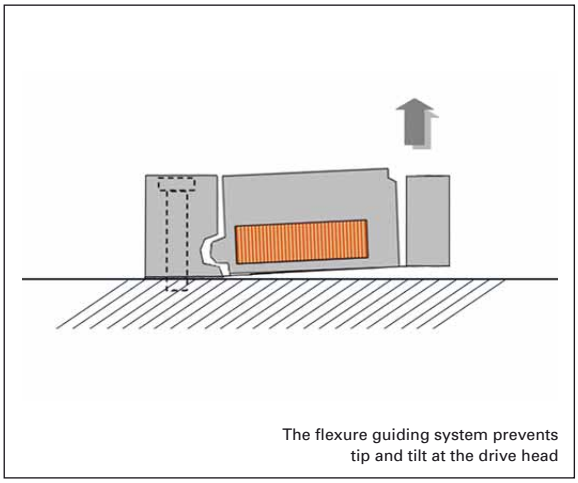



| | H | L |
|---|---|---|
| P-601.1x | 16,5 | 46,5 |
| P-601.3x | 18,0 | 64,5 |
| P-601.4x | 20,5 | 82,5 |

P-601 dimensions in mm



The E-610 analog controller OEM module left or the E-609 digital OEM controller are available for closed-loop versions with position sensor



The flexure guiding system prevents tip and tilt at the drive head



## Technical Data

| Model | P-601.1S<br>P-601.1SL | P-601.3S<br>P-601.3SL | P-601.4S<br>P-601.4SL | P-601.x0<br>Open-loop versions | Units | Tolerance |
|---|---|---|---|---|---|---|
| Active axes | Z | Z | Z | Z | | |
| **Motion and positioning** | | | | | | |
| Integrated sensor | SGS | SGS | SGS | – | | |
| Open-loop travel, -20 to +120 V | 100 | 250 | 400 | as P-601.xS | µm | min. (+20 %/-0 %) |
| Closed-loop travel | 100 | 250 | 400 | – | µm | calibrated |
| Open-loop resolution | 0.2 | 0.3 | 0.4 | as P-601.xS | nm | typ. |
| Closed-loop resolution | 2 | 6 | 12 | – | nm | typ. |
| Linearity, closed-loop | 0.1 | 0.3 | 0.3 | – | % | typ. |
| Repeatability | 8 | 10 | 30 | – | nm | typ. |
| Runout $\theta_X$, $\theta_Y$ | 20 / 10 | 20 / 10 | 20 / 10 | as P-601.xS | µrad | typ. |
| **Mechanical properties** | | | | | | |
| Stiffness in motion direction | 0.8 | 0.38 | 0.28 | as P-601.xS | N/µm | ±20 % |
| Unloaded resonant frequency | 750 | 440 | 350 | as P-601.xS | Hz | ±20 % |
| Resonant frequency @ 30 g | 620 | 350 | 290 | as P-601.xS | Hz | ±20 % |
| Push/pull force capacity in motion direction | 30/10 | 20/10 | 15/10 | as P-601.xS | N | Max. |
| Lateral force | 30 | 30 | 30 | as P-601.xS | N | Max. |
| **Drive properties** | | | | | | |
| Ceramic type | PICMA® P-885 | PICMA® P-885 | PICMA® P-885 | as P-601.xS | | |
| Electrical capacitance | 1.5 | 3.1 | 4.6 | as P-601.xS | µF | ±20 % |
| Dynamic operating current coefficient | 1.9 | 1.6 | 1.4 | as P-601.xS | µA/(Hz•µm) | ±20 % |
| **Miscellaneous** | | | | | | |
| Operating temperature range | -20 to 80 | -20 to 80 | -20 to 80 | -20 to 80 | °C | |
| Material | Stainless steel | Stainless steel | Stainless steel | Stainless steel | | |
| Mass without cables | 0.05 | 0.08 | 0.11 | as P-601.xS | kg | ±5 % |
| Cable length | S-version: 0.3<br>SL-version: 1.5 | S-version: 0.3<br>SL-version: 1.5 | S-version: 0.3<br>SL-version: 1.5 | 0.3 | m | ±10 mm |
| Sensor / voltage connection | S-version:<br>open leads<br>SL-version:<br>LEMO | S-version:<br>open leads<br>SL-version:<br>LEMO | S-version:<br>open leads<br>SL-version:<br>LEMO | Open leads<br>(no sensor) | | |

Recommended controller / amplifier
E-610 controller / amplifier (p. 2-110), E-625 bench-top controller (p. 2-114)