M-041 – M-044 Tip/Tilt Stage
Replaced by WT-100
Piezo Drive Option for Nanometer Precision

Ordering Information

M-041.00
Small Tilt Stage, Manual Micrometer Drive

M-041.D01
Small Tilt Stage, DC-Motor Drive

M-042.00
Small Tip/Tilt Stage, Manual Micrometer Drive

M-042.D01
Small Tip/Tilt Stage, DC-Motor Drive

M-043.00
Tilt Stage, Manual Micrometer Drive

M-043.D01
Tilt Stage, DC-Motor Drive

M-044.00
Tip/Tilt Stage, Manual Micrometer Drive

M-044.D01
Tip/Tilt Stage, DC-Motor Drive

M-041.U0
Open-Loop Piezo Drive Upgrade Kit for M-041 Tilt Stages

M-041.US
Closed-Loop Piezo Drive Upgrade Kit for M-041 Tilt Stages

M-042.U0
Open-Loop Piezo Drive Upgrade Kit for M-042 Tip/Tilt Stages

M-042.US
Closed-Loop Piezo Drive Upgrade Kit for M-042 Tip/Tilt Stages

M-043.U0
Open-Loop Piezo Drive Upgrade Kit for M-043 Tilt Stages

M-043.US
Closed-Loop Piezo Drive Upgrade Kit for M-043 Tilt Stages

M-044.U0
Open-Loop Piezo Drive Upgrade Kit for M-044 Tip/Tilt Stages

M-044.US
Closed-Loop Piezo Drive Upgrade Kit for M-044 Tip/Tilt Stages

Ask about custom designs!

M-044.D01 tip/tilt stage

M-041 through M-044 are one- and two-axis ($\theta_X$, $\theta_Y$) tip/tilt stages for small loads. They are spring preloaded for elimination of backlash and feature resolution and repeatability superior to that of goniometric cradles. Versions with piezo translators allow ultra-high-resolution dynamic scanning and tracking. See the “Fast Steering Mirrors / Active Optics” section for fast, ultra-high-resolution, tip/tilt platforms (p. 2-79 ff).

The two basic versions (with part number extension .00) are equipped with manual micrometer drives providing 65 and 80 μrad minimum incremental motion, respectively. The versions with extension .D01 are equipped with closed-loop, DC-servo-motor drives (model M-227.10 (see p. 1-42) for further details and recommended motor controllers) providing 15 and 12 μrad minimum incremental motion, respectively. Sets of limit switches eliminate the possibility of overtravel.

High-Resolution Piezo Option

For sub-μrad resolution and dynamic tracking or scanning, optional open-loop/closed-loop piezo drive upgrade kits are available. See the P-840 and P-841 (see p. 1-74) in the “Piezo Actuators & Components” section for further details and recommended controllers. The piezo drives can also be ordered subsequently to upgrade manual or motorized systems.

Notes

See “Accessories”, page 4-90 ff. for adapters, brackets, etc.
Piezo Nano Positioning

M-041.00
dimensions (in mm), see p. 4-91 for PI Standard Hole Pattern

M-041.D01
dimensions (in mm), see p. 4-91 for PI Standard Hole Pattern

M-042.00
dimensions (in mm), see p. 4-91 for PI Standard Hole Pattern

M-042.D01 with optional PZT drives
(dimensions in mm), see p. 4-91 for PI Standard Hole Pattern

Load and torque definition of M-041, M-042, M-043 and M-044 tip/tilt stages
## Technical Data

<table>
<thead>
<tr>
<th>Model</th>
<th>M-041.00</th>
<th>M-042.00</th>
<th>M-043.00</th>
<th>M-044.00</th>
<th>M-041.D01</th>
<th>M-042.D01</th>
<th>M-043.D01</th>
<th>M-044.D01</th>
<th>Units</th>
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<tbody>
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<td>±9</td>
<td>±7</td>
<td>±7</td>
<td>±9</td>
<td>±9</td>
<td>±7</td>
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<td>µrad</td>
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<tr>
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<td>5</td>
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<td>µrad</td>
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<td>200</td>
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<td>µrad</td>
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<td>Max. velocity (motor)</td>
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<td>–</td>
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<td>°/s</td>
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<td>Max. load (A)</td>
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<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>kg</td>
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<tr>
<td>Max torque (B, C)</td>
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<td>450, 150</td>
<td>750, 250</td>
<td>750, 250</td>
<td>450, 150</td>
<td>450, 150</td>
<td>750, 250</td>
<td>750, 250</td>
<td>mNm</td>
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<td>M-622 Micrometer</td>
<td>M-622 Micrometer</td>
<td>M-624 Micrometer</td>
<td>M-624 Micrometer</td>
<td>M-227.10 DC-Mike</td>
<td>M-227.10 DC-Mike</td>
<td>M-227.10 DC-Mike</td>
<td>M-227.10 DC-Mike</td>
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<td>Piezo drive (optional)</td>
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<td>P-840.20 / P-840.10 / P-840.30 / P-840.30</td>
<td>P-840.20 / P-840.10 / P-840.30 / P-840.30</td>
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<td>Mass</td>
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<td>0.8</td>
<td>1.2</td>
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<td>kg</td>
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<td>Al</td>
<td>Al</td>
<td>Al</td>
<td>Al</td>
<td>Al</td>
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</table>

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**M-043.00 dimensions (in mm)**

**M-043.D01 dimensions (in mm)**

**M-044.00 dimensions (in mm)**

**M-044.D01 with optional piezo drive (dimensions in mm)**
Parallel Kinematic Tripod / Goniometer

Precision Positioning in X, Z, \( \theta_Y \)

- Goniometer Z Stage with Freely Selectable Pivot Point
- Travel Ranges \( \pm 25 \text{ mm} / \pm 25 \text{ mm} / \pm 30^\circ \)
- Load Capacity to 4 kg
- Min. Incremental Motion to 0.1 \( \mu \text{m} \)
- ActiveDrive Servo Motors
- Compact Design with Parallel Kinematics

The parallel-kinematics tripod is designed for precision positioning, offering elevation, translation and tilt motion around the (horizontal) y-axis, with a user-defined pivot point.

M-880 3-Axis Planar Precision Positioning System

XY-Rot-Z Parallel Kinematics System with Very High Holding Force

- Travel Ranges 20 x 20 mm / 8°
- Static Load Capacity to 150 kg
- ActiveDrive Servo Motors
- Low Profile through Parallel Kinematics
- Min. Incremental Motion to 0.75 \( \mu \text{m} \)
- Large Clear Aperture
- Sophisticated Controller Included

N-510 High-Force NEXLINE® Z/Tip/Tilt Platform

Nanometer Precision for Semiconductor Industry, Wafer Alignment

- Self Locking at Rest, No Heat Generation
- Vacuum Compatible and Non-Magnetic Designs Feasible
- Parallel Kinematics for Enhanced Dynamics and Better Multi-Axis Accuracy
- NEXLINE® Piezo Walking Drive Free from Wear and Tear
- Load Capacity 200 N
- High Precision with Integrated 5 nm Incremental Sensors + Picometer Resolution Dithering Mode

The newest release for data sheets is available for download at www.pi.ws.
P-518, P-528, P-558 Piezo Z/Tip/Tilt Stage

High-Dynamics with Large Clear Aperture

They are free of friction and hysteresis, a fact which, in combination with the positioning resolution of well under 1 nm, makes it possible to achieve very high levels of linearity. A further advantage of direct metrology with capacitive sensors is the high phase fidelity and the high bandwidth of up to 10 kHz.

Excellent Guiding Accuracy
Flexures optimized with Finite Element Analysis (FEA) are used to guide the stage. FEA techniques are used to give the design the highest possible stiffness in, and perpendicular to, the direction of motion, and to minimize linear and angular runout. Flexures allow extremely high-precision motion, no matter how minute, as they are completely free of play and friction.

Flatness and Straightness is further enhanced by active trajectory control: Multi-axis nanopositioning systems equipped with both parallel kinematics and parallel direct metrology are able to measure platform position in all degrees of freedom against one common fixed reference. In such systems, undesirable motion from one actuator in the direction of another (cross-talk) is detected immediately and actively compensated by the servo-loops. This Active Trajectory Control Concept can keep deviation from a trajectory to under a few nanometers, even in dynamic operation.

Higher Precision in Periodic Motion
The highest dynamic accuracy in scanning applications is...
made possible by the DDL algorithm, which is available in PI’s modern digital controllers. DDL eliminates tracking errors, improving dynamic linearity and usable bandwidth by up to three orders of magnitude!

**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.

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### Technical Data

<table>
<thead>
<tr>
<th>Model</th>
<th>P-558.ZCD/ P-558.ZCL</th>
<th>P-558.TCD</th>
<th>P-518.ZCD/ P-518.ZCL</th>
<th>P-518.TCD</th>
<th>P-528.ZCD/ P-528.ZCL</th>
<th>P-528.TCD</th>
<th>Units</th>
<th>Tolerance</th>
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<tbody>
<tr>
<td>Motion and positioning</td>
<td>Integrated sensor</td>
<td>Capacitive</td>
<td>Capacitive</td>
<td>Capacitive</td>
<td>Capacitive</td>
<td>Capacitive</td>
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<tr>
<td>Open-loop travel, -20 to +120 V</td>
<td>60</td>
<td>60</td>
<td>140</td>
<td>140</td>
<td>240</td>
<td>240</td>
<td>µm</td>
<td>min.</td>
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<td>Open-loop tip/tilt angle, -20 to +120 V</td>
<td>±0.3 mrad</td>
<td>±0.7 mrad</td>
<td>±1.2 mrad</td>
<td>mrad</td>
<td>mrad</td>
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<td>50</td>
<td>100</td>
<td>100</td>
<td>200</td>
<td>200</td>
<td>µm</td>
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<td>Closed-loop tip/tilt angle</td>
<td>±0.25 Mrad</td>
<td>±0.5 Mrad</td>
<td>±1 Mrad</td>
<td>mrad</td>
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<td>0.8</td>
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<td>1</td>
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<td>nm typ.</td>
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<td>Linearity θx, θy</td>
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<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>% typ.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeatability θx, θy</td>
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<td>±5</td>
<td>±5</td>
<td>±10</td>
<td>±10</td>
<td>nm typ.</td>
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<tr>
<td>Repeatability θx, θy</td>
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<td>±0.06</td>
<td>±0.1</td>
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<td>Runout θy (Z motion)</td>
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<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>µrad typ.</td>
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</tr>
<tr>
<td>Runout θx, θy (Z motion)</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;100</td>
<td>&lt;100</td>
<td>&lt;100</td>
<td>µrad typ.</td>
<td></td>
</tr>
</tbody>
</table>

### Mechanical properties

- **Stiffness**: 4 to 6 N/μm ±20%
- **Unloaded resonant frequency (Z)**: 570 Hz ±20%
- **Resonant frequency @ 30 g in Z**: 410 Hz ±20%
- **Resonant frequency @ 500 g in X, Y**: 430 Hz ±20%
- **Resonant frequency @ 2500 g in Z**: 240 Hz ±20%
- **Push/pull force capacity**: 100 / 50 N Max.

### Drive properties

- **Ceramic type**: PICMA®
- **Electrical capacitance**: 6.8 µF ±20%
- **Dynamic operating current coefficient**: 15 µA/(Hz·µm) ±20%

### Miscellaneous

- **Operating temperature range**: -20 to 80 °C
- **Material**: Aluminum
- **Dimensions**: 150 x 150 x 30 mm
- **Mass**: 1380 g ±5%
- **Cable length**: 1.5 m ±10 mm

Resolution of PI Piezo Nanopositioners is not limited by friction or stiction. Value given is noise equivalent motion with E-503 (p. 2-146) or E-710 controller (p. 2-128)

Recommended controller

**CD-Version:**
- Single-channel (1 per axis): E-610 servo controller / amplifier (p. 2-110), E-625 servo controller, bench-top (p. 2-114)
- Single-channel digital controller: E-753 (bench-top) (p. 2-108)

**CL-Version:**
- Single-channel: E-500 modular piezo controller system (p. 2-142) with E-505 high-power amplifier module and E-609 servo-controller (p. 2-152)
- Multi-channel versions:
  - Multi-channel digital controllers: E-710 bench-top (p. 2-128), E-712 modular (p. 2-140), E-725 high-power (p. 2-126), E-761 PCI board (p. 2-130)

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