

# Micropositioning Rotation Tables

UNLIMITED TRAVEL RANGE



HIGH SPEED



COMPACT

# Rotation Stages



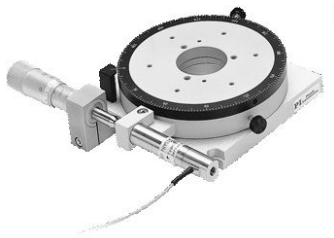
High Performance Stages w/ Worm Gear Drive



High Speed, Low-Profile Rotary Stage with Piezo Motor Direct Drive



Small, Precise Tangent Arm Rotary Stage



Precision Tangent Arm Rotation Stage



Mini Rotary Stage w/ Worm Gear Drive

# High Precision Micropositioning Rotation Table

## Unlimited Travel Range



M-060.PD, M-061.PD and M-062.PD

- Continuous Rotation Range
- Ultra-High Resolution
- Max. Velocity 90 deg/sec
- Preloaded Worm Drive for Zero Backlash
- ActiveDrive DC-Servo, Stepper-Motor and Manual Drives
- Direction-Sensing Reference Switch

M-06x series rotation stages are equipped with ultra-precise, ultra-low-friction, spring-preloaded worm gear drives allowing unlimited rotation in either direction. Models M-060 feature a 60 mm diameter turntable, models M-061, a 100 mm table and models M-062, a 120 mm table.

### DC-Motor and Stepper-Motor Drive

One manual drive and three motor drives (four with M-062 models) are available:

### Application Examples

- R&D
- Semiconductor testing
- Mass storage device testing
- Metrology
- Photonics packaging
- Quality assurance testing

### M-06x.PD with ActiveDrive

This version features a direct-coupled motor/encoder. For superior dynamic performance, we integrated our unsurpassed ActiveDrive system. The ActiveDrive design, developed by PI, features a high-efficiency PWM (pulse width modulation) servo-amplifier mounted side-by-side with the DC-Motor and offers several advantages:

- Increased efficiency, by eliminating power losses between the amplifier and motor
- Reduced cost of ownership and improved reliability, because no external driver is required
- Elimination of PWM amplifier noise radiation, by mounting the amplifier and motor together in a single, electrically shielded case

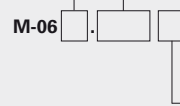
### M-06x.DG with Zero-Backlash DC-Motor/Gearhead Drive

The M-06x.DG are equipped with 3-watt DC motors

### Ordering Information

Precision Rotation Stage, 360°

- 0 = Ø 60 mm
- 1 = Ø 100 mm
- 2 = Ø 120 mm



- PD = ActiveDrive DC Motor
- DG = Closed-Loop DC Motor Gearhead
- 2S = 2-Phase Stepper Motor
- MO = Manual Drive
- V = Vacuum Compatible to 10<sup>-6</sup> hPa

Ask about custom designs!

with zero-backlash gearhead and shaft-mounted encoders (2048 counts/rev.). The gear ratio of 29.6:1, provides higher resolution than the direct drive motors.

### M-60x.2S Stepper-Motor Drive

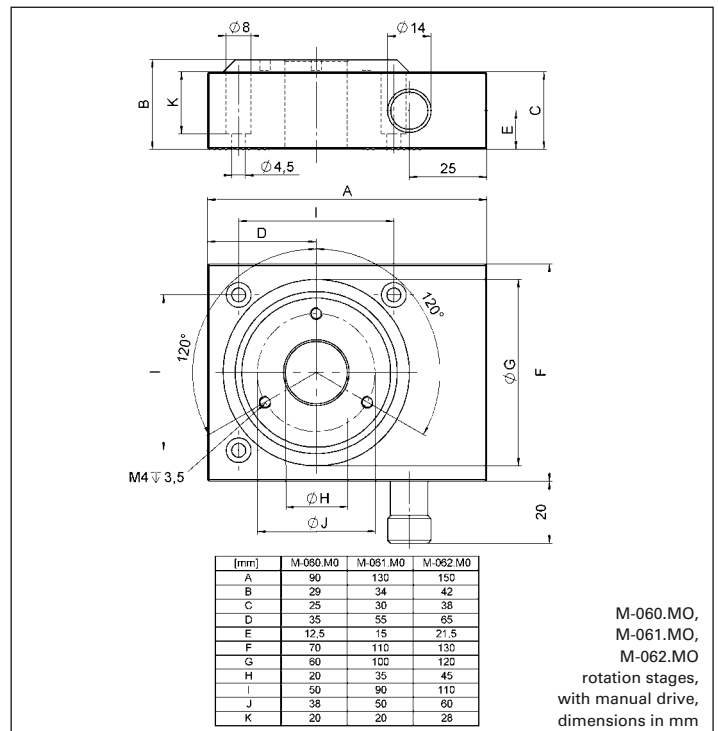
The M-060x.2S models feature a cost-effective direct-drive, 2-phase stepper-motor, providing very smooth operation and a resolution of 6400 steps/rev.

equipment and increase versatility in automation applications, the rotary stage can optionally be equipped with Hall-effect limit switches. Travel can be limited to a range between 0° and 268° ±2°.

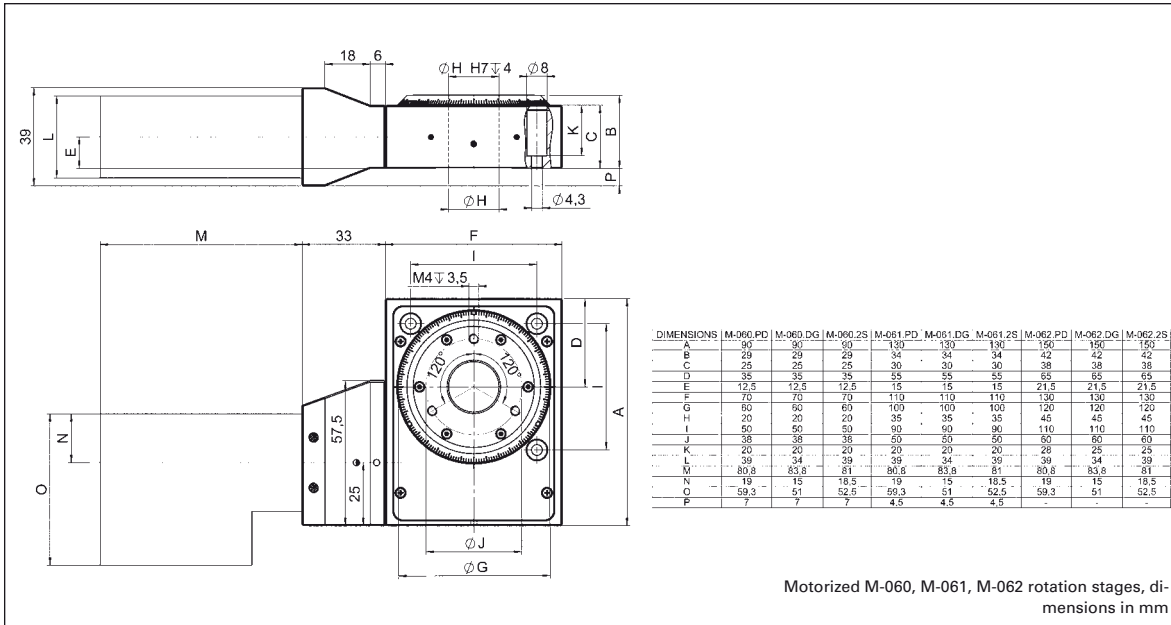
Coarse position can be read from an adjustable scale ring on the outer edge of the turntable graduated in 2 degree increments. The manual versions also feature a drive-shaft-mounted indicator with 0.1-degree graduations.

### Non-Contact Limit and Reference Switches

Motorized models are equipped with an integrated Hall-effect origin switch. To protect your



M-060.MO, M-061.MO, M-062.MO rotation stages, with manual drive, dimensions in mm



Motorized M-060, M-061, M-062 rotation stages, dimensions in mm

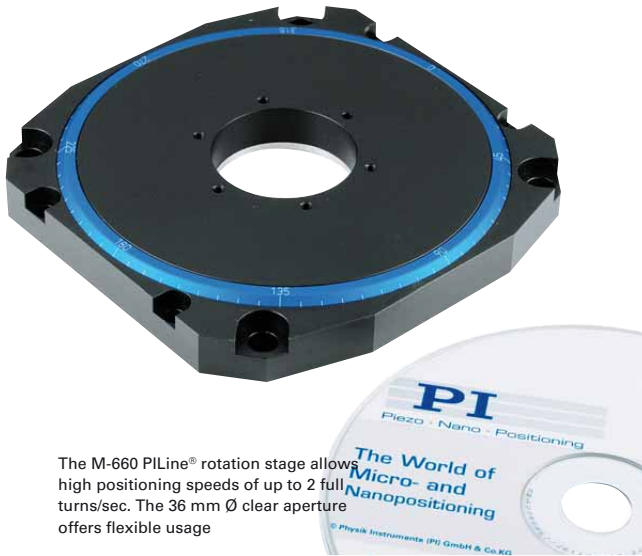
### Technical Data

Model	M-060.M0 / M-061.M0 / M-062.M0	M-060.PD / M-061.PD / M-062.PD	M-060.DG / M-061.DG / M-062.DG	M-060.2S / M-061.2S / M-062.2S	Units
Active axes	Rotation	Rotation	Rotation	Rotation	
<b>Motion and positioning</b>					
Rotation range	>360	>360	>360	>360	°
Integrated sensor	-	Rotary encoder	Rotary encoder		
Sensor resolution	-	4000	2000		Cts./rev.
Design resolution	-	32 (0.0018) / 17.5 (0.001) / 15 (0.0008)	2.1 (0.00012) / 1.2 (6.9 × 10 <sup>-5</sup> ) / 0.96 (5.5 × 10 <sup>-5</sup> )	19.7 (0.0011) / 10.9 (0.00063) / 8.9 (0.00051)*	μrad (°)
Min. incremental motion	-	32 / 17.5 / 15	6.3 / 6 / 5	40 / 20 / 18*	μrad
Backlash	-	200 / 200 / 240	200 / 200 / 240	200 / 200 / 240	μrad
Unidirectional repeatability	-	50 / 50 / 60	50 / 50 / 60	50 / 50 / 60	μrad
Max. velocity	-	90	16 / 9 / 7.3	36 / 20 / 16	°/s
<b>Mechanical properties</b>					
Worm gear ratio	50:1 / 90:1 / 110:1	50:1 / 90:1 / 110:1	50:1 / 90:1 / 110:1	50:1 / 90:1 / 110:1	
Gear ratio	-	-	(28/12) <sup>4</sup> : 1 ≈ 29.6:1	-	
Motor resolution	-	-	-	6400*	steps/rev.
Axial force	±500 / ±550 / ±650	±500 / ±550 / ±650	±500 / ±550 / ±650	±500 / ±550 / ±650	N
Max. torque $\theta_x, \theta_y$	±6 / ±6 / ±7	±6 / ±6 / ±7	±6 / ±6 / ±7	±6 / ±6 / ±7	Nm
Max. torque $\theta_z$	±4 / ±6 / ±8	±4 / ±6 / ±8	±4 / ±6 / ±8	±4 / ±6 / ±8	Nm
<b>Drive properties</b>					
Motor type	-	ActiveDrive DC-Motor	DC-Motor, gearhead	2-phase Stepper-Motor**	
Operating voltage	-	24 (PWM)	12 differential	24	V
Electrical power	-	30	3	-	
Reference switch	Hall-effect	Hall-effect	Hall-effect	Hall-effect	
<b>Miscellaneous</b>					
Operating temperature range	-20 to +65	-20 to +65	-20 to +65	-20 to +65	°C
Material	Aluminum	Aluminum	Aluminum	Aluminum	
Mass	0.42 / 1.36 / 2.24	0.94 / 1.88 / 2.76	0.94 / 1.88 / 2.76	0.96 / 1.9 / 2.78	kg
Recommended controller/driver		C-863 single-axis C-843 PCI board, for up to 4 axes	C-863 single-axis (p. 4-114) C-843 PCI board (p. 4-120), for up to 4 axes	C-663 single-axis (p. 4-112)	

\*with C-663 stepper-motor controller  
\*\*2-phase stepper-motor, 24 V chopper voltage, max. 0.8 A/phase, 400 full steps/rev  
Data for vacuum versions may differ.

# High-Speed, High Precision Micropositioning Rotation Table

## Fast Positioning, Ultra-Low Profile



The M-660 PILINE® rotation stage allows high positioning speeds of up to 2 full turns/sec. The 36 mm Ø clear aperture offers flexible usage

- **Unlimited Travel Range**
- **Max. Velocity 720 °/s**
- **Low Profile: Only 14 mm in Height**
- **Self-Locking Ceramic Direct Drive: Energy Saving & High Position Stability**
- **Direct Metrology Linear Encoder, up to 4 µrad Resolution**
- **PILINE® Direct Drive: Non-Magnetic and Vacuum-Compatible Working Principle**
- **Compact Combinations with Linear Stages**

M-660 precision rotation stages use PILINE® ultrasonic piezo

### Application Examples

- Biotechnology
- Micromanipulation
- Microscopy
- Quality assurance testing
- Metrology
- Mass storage device testing
- R&D
- Photonics packaging

motors that act on a ceramic friction ring to drive the platform. This direct drive principle allows for the compact design and low profile of the stage. An integrated incremental encoder offers precision position control with up to 4 µrad resolution. The integrated U-164 PILINE® linear motors provide a maximum torque of 0.3 Nm, independent from the direction of motion, and a maximum velocity of up to 720 °/sec. The maximum load is 2 kg.

M-660s can be built in different sizes or with other specifica-

tions, and they are available upon request as vacuum-compatible versions.

### Advantages of PILINE® Micropositioning Systems

Positioning systems equipped with ceramic ultrasonic drives of the PILINE® series provide several advantages over positioners that apply classic drive technology:

- Smaller dimensions
- Higher holding force when powered down; no holding current
- Increased acceleration of up to 5 g
- Increased velocity of up to 500 mm/s or 720 °/s, resp.
- No leadscrews, gears or other mechanical components, no wear or maintenance
- No lubricants
- Non-magnetic and vacuum-compatible operating principle

### Optimized Controller and Drive Electronics

For optimum performance, the highly specialized C-867 motion controller (s. p. 4-116) is recommended. This dedicated piezo motor controller also integrates the drive electronics which PILINE® motors require to generate the ultrasonic oscillations on the piezoceramic element.

Furthermore, the controller has a number of special characteristics to address the requirements of ultrasonic motors, such as continuous automatic drive frequency adjustment, dynamic parameter switching for optimized high-speed motion and settling behavior. The broad-band encoder input (50 MHz) supports the outstanding high accelerations and

### Ordering Information

**M-660.55**  
PILINE® Rotation Stage, Ø 108 mm, 360°, 34 µrad Resolution

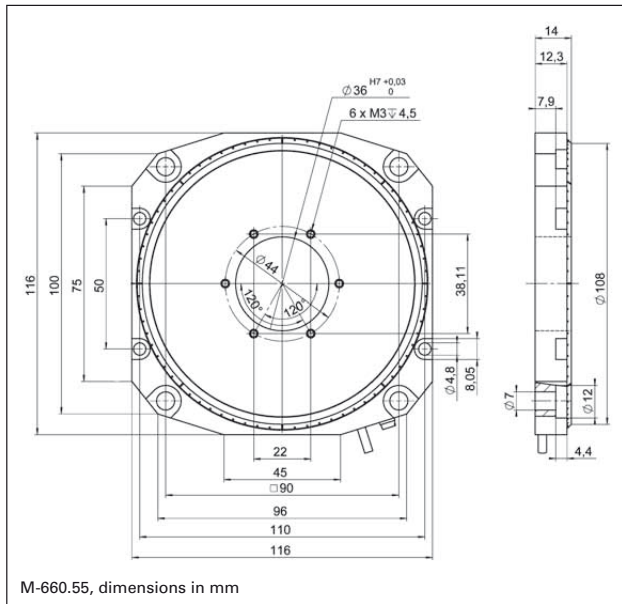
**M-660.45**  
PILINE® Precision Rotation Stage, Ø 108 mm, 360°, 4 µrad Resolution

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velocities of PILINE® drives at high resolutions.

### Patented Technology

The products described in this document are in part protected by the following patents:  
US Pat. No. 6,765,335  
German Patent No. 10154526



## Technical Data

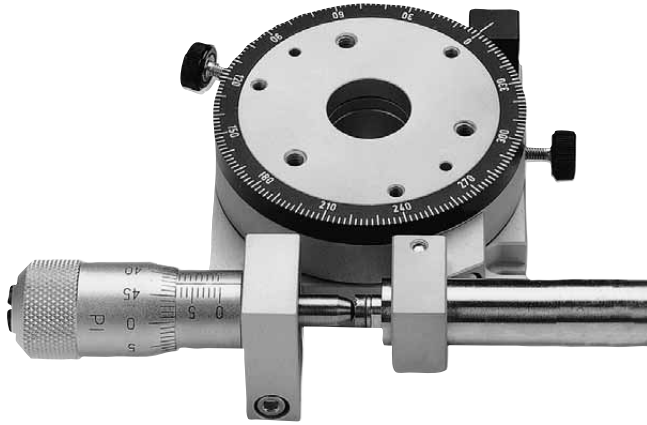
Model	M-660.55 / M-660.45	Units	Tolerance
Active axes	Theta Z		
<b>Motion and positioning</b>			
Rotation range	No limit	°	
Integrated sensor	Incremental encoder		
Design resolution	34 (0.00195) / 4 (0.00023)	μrad (°)	typ.
Min. incremental motion	34 / 12	μrad	typ.
Bidirectional repeatability	±68 / ±24	μrad	
Max. velocity	720	°/s	
<b>Mechanical properties</b>			
Load capacity / axial force	20	N	max.
Holding force	0.3	Nm	max.
Max. torque cw/ccw (θ Z)	0.3	Nm	max.
<b>Drive properties</b>			
Motor type	2 x U-164 PILine® ultrasonic piezo drive		
Operating voltage	60 (RMS)*	V	
Current consumption**	0.3 (2 max.)	A	
Reference switch	optical		
<b>Miscellaneous</b>			
Operating temperature range	-20 to +50	°C	
Material	Al (black anodized)		
Mass	470	g	±5%
Cable length	1.3	m	±10 mm
Connector	MDR, 14-pin		
Recommended controller / driver	C-867 single-axis controller / driver		

\* The operating voltage is supplied by the drive electronics

\*\* For drive electronics

# M-035 Compact Precision Micropositioning Rotation Table

## Piezo Drive Option for Nanometer Precision



M-035.P0 Rotation stage with piezo drive

- Sub-Microradian Resolution
- 360° Coarse Range, up to 19° Fine Range with Resolution <math><1 \mu\text{rad}</math>
- Precision Micrometer or DC Motor Drives
- Piezo Option for High-Resolution Scanning and Tracking
- Clear Aperture  $\varnothing 20 \text{ mm}$

M-035 series precision rotation stages with tangent-arm drive feature high resolution, excellent repeatability and minimum wobble. The stages are equipped with double-row ball bearings for zero backlash and high load capacity. Both the rotation platform and the scale ring (graduated in 2-degree increments) can be independently coarse positioned over 360° degrees and then locked with screws.

### Drive Options

A total of six different drive types are offered. They include various combinations of piezoelectric fine-positioner (closed-loop or open-loop), manual and motorized micrometer drives.

### Manual Drive

The basic version, the M-035.50, is equipped with a micrometer drive and a zero-backlash magnetic coupling. The micrometer motion, when converted into ro-

tation, provides a positioning range of 19° degrees. The resolution is approximately 23  $\mu\text{rad}$ .

### DC Motor Drive

The motorized version, the M-035.D01 features a high-resolution DC motor drive unit (M-227.10, see p. 1-42 ff) and has a range of about 12.6° with resolution of 2  $\mu\text{rad}$ . A set of limit switches on the rotation stage protects against over-travel damage.

### High-Resolution Piezo Option

For applications requiring extremely high angular resolution, models M-035.PS and M-035.P0 (with manual micrometer drive) and M-035.DS1 and M-035.DP1 (motorized) are available. They have an additional piezoelectric fine adjustment, which can also be used for dynamic operation. The piezo drive has a linear travel range of 45  $\mu\text{m}$  with sub-nanometer-resolution, which con-

verts to a rotation range of approx. 1 mrad and sub- $\mu\text{rad}$  resolution.

The piezo drives in the M-035.PS and M-035.DS1 versions is also equipped with a position sensor, making closed-loop operation possible with higher stability, reproducibility and accuracy. For more details on the piezo drives, see the "Piezo Actuators" section.

### Flexibility

M-035 stages without PZT or DC-motor drives can be upgraded at a later date.

### Notes

For adapters, bracket, etc. see p. 4-90 ff

### Ordering Information

#### M-035.50

Rotation Stage,  $\varnothing 60 \text{ mm}$ , Micrometer Drive

#### M-035.P0

Rotation Stage,  $\varnothing 60 \text{ mm}$ , Micrometer Drive + Piezo Drive

#### M-035.PS

Rotation Stage,  $\varnothing 60 \text{ mm}$ , Micrometer Drive + Closed-Loop Piezo Drive

#### M-035.D01

Rotation Stage,  $\varnothing 60 \text{ mm}$ , DC Motor Drive

#### M-035.DP1

Rotation Stage,  $\varnothing 60 \text{ mm}$ , DC Motor + Piezo Drive

#### M-035.DS1

Rotation Stage,  $\varnothing 60 \text{ mm}$ , DC Motor + Closed-Loop Piezo Drive

### Upgrade Kits

#### M-035.U0

Upgrade Kits with Open-Loop Piezo Drive

#### M-035.US

Upgrade Kits with Closed-Loop Piezo Drive

#### M-035.UD

Upgrade Kits with DC Motor Drive (Factory installed)

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### Rotation Range Conversion

M-035 and M-036 rotation stages use a tangent-arm which extends beyond the platform. The angular equivalent of the linear actuator displacement can be calculated by the following equation:

$$\alpha \approx \arctan(x/r_0)$$

where:

$x$  = displacement of linear actuator [mm]

$\alpha$  = rotation angle [°]

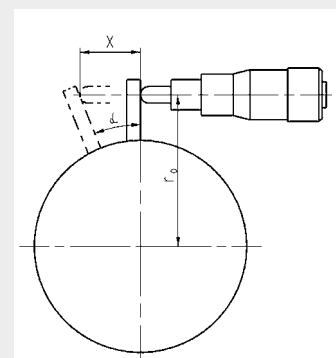
$r_0$  = distance of linear actuator contact point to center of rotation @ 0 degrees [mm]

$r_0$  is 44 mm for the M-035 rotation stages and 66 mm for the M-036 rotation stages.

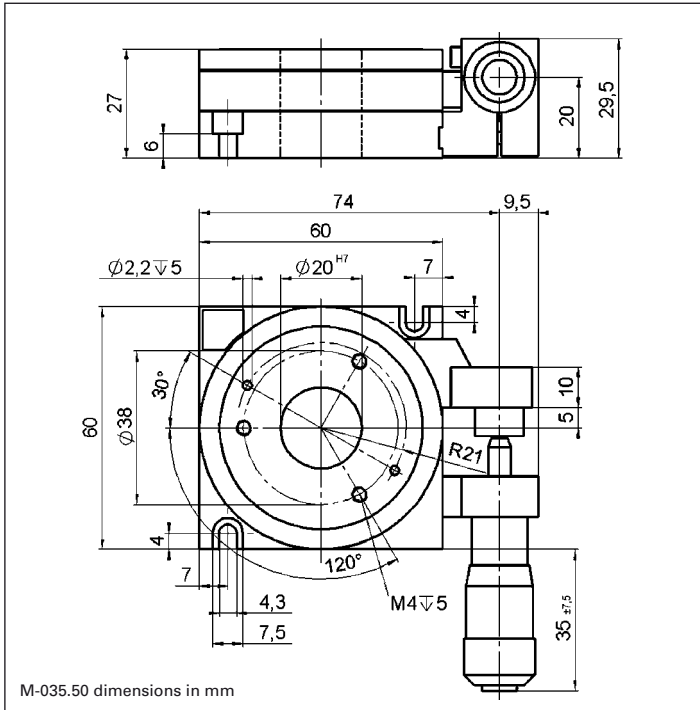
### Example:

The rotation angle of an M-035 for a linear displacement  $x = 5 \text{ mm}$ :

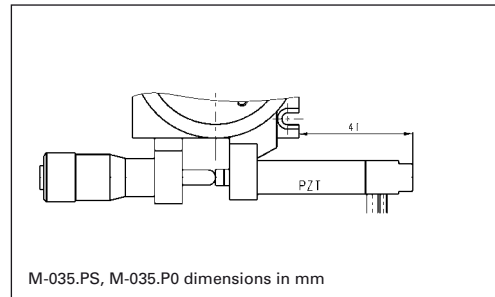
$$\alpha \approx \arctan(5/44) \approx 6.48^\circ$$



Relation between linear displacement and rotation



M-035.50 Rotation stage



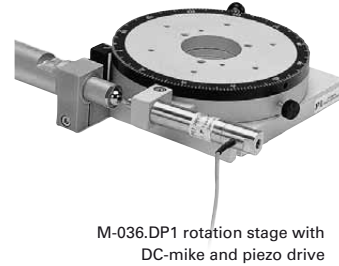
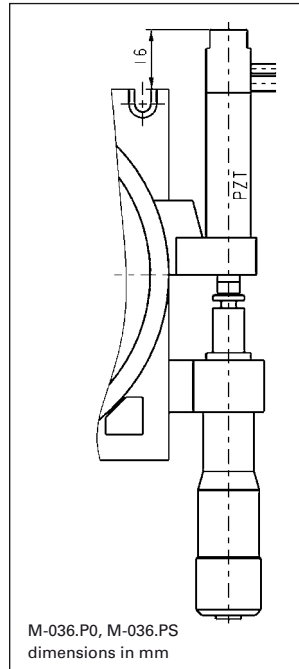
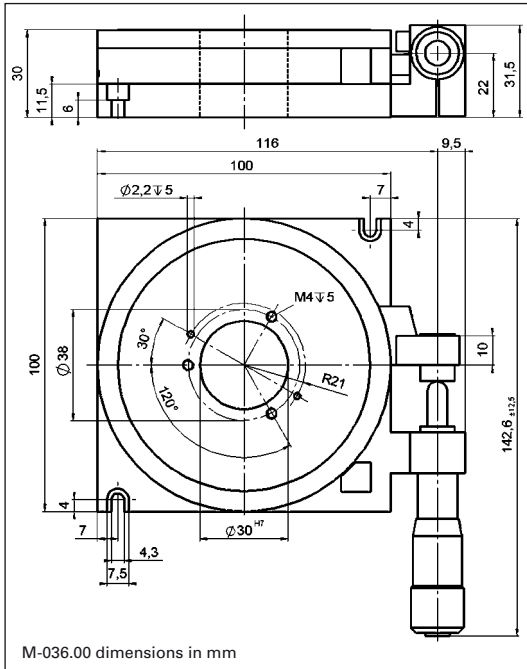
## Technical Data

Model	M-035.50	M-035.P0	M-035.PS	M-035.D01	M-035.DP1	M-035.DS1	Units
Coarse rotation range	360	360	360	360	360	360	°
Rotation range (micrometer drive)	19	19	19	11	11	11	°
Rotation range (piezo drive)	-	1,040	1,040	-	1,040	1,040	μrad
Min. incremental motion (piezo drive)	-	<1	<1	-	<1	<1	μrad
Repeatability (piezo drive)	-	-	2	-	-	2	μrad
Unidirectional repeatability (motor drive)	-	-	-	10	10	10	μrad
Backlash (motor drive)	-	-	-	50	50	50	μrad
Design resolution (motor drive)	-	-	-	0.08	0.08	0.08	μrad
Min. incremental motion (motor)	-	-	-	2	2	2	μrad
Minimum incremental motion (micrometer drive)	23	23	23	-	-	-	μrad
Rotation / linear input	22.7	22.7	22.7	22.7	22.7	22.7	μrad/μm
Tangent-arm length	44	44	44	44	44	44	mm
Wobble	<150	<150	<150	<150	<150	<150	μrad
Max. velocity	-	-	-	1.2	1.2	1.2	°/s
Max. axial force	±300	±300	±300	±300	±300	±300	N
Max. torque (θ <sub>x</sub> , θ <sub>y</sub> )	±3	±3	±3	±3	±3	±3	Nm
Max. torque CW*	1.7	1.7	1.7	1.7	1.7	1.7	Nm
Max. torque CCW*	0.05	0.05	0.05	0.05	0.05	0.05	Nm
Drive (manual or motor)	M-622	M-622	M-622	M-227.10	M-227.10	M-227.10	
Piezo drive	-	P-840.30	P-841.30	-	P-840.30	P-841.30	
Mass	0.4	0.5	0.52	0.6	0.65	0.67	kg
Body material	Al, St	Al, St	Al, St	Al, St	Al, St	Al, St	
Recommended controller	-	-	-	C-863, single axis, C-843 PCI board for up to 4 axes	C-863, single axis, C-843 PCI board for up to 4 axes	C-863, single axis, (p. 4-114) C-843 PCI board (p. 4-120) for up to 4 axes	
Recommended piezo controller	-	E-660, E-610 E-500 System	E-610 E-500 System	-	E-660, E-610 E-500 System	E-610 (p. 2-110) E-500 System (p. 2-142)	

\*CW: clockwise; CCW: counter-clockwise







## Technical Data

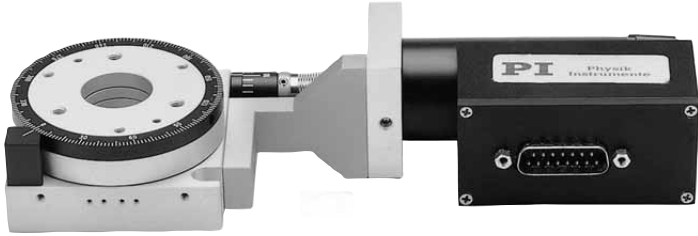
Model	M-036.00	M-036.P0	M-036.PS	M-036.D01	M-036.DP1	M-036.DS1	Units
Coarse rotation range	360	360	360	360	360	360	°
Rotation range (micrometer drive)	21	21	21	19**	19**	19**	°
Rotation range (piezo drive)	-	700	700	-	700	700	μrad
Minimum incremental motion (piezo drive)	-	<1	<1	-	<1	<1	μrad
Repeatability (piezo drive)	-	-	2	-	-	2	μrad
Unidirectional repeatability (motor drive)	-	-	-	10	10	10	μrad
Backlash (motor drive)	-	-	-	40	40	40	μrad
Design resolution (motor drive)	-	-	-	0.08	0.08	0.08	μrad
Minimum incremental motion (motor drive)	-	-	-	2	2	2	μrad
Minimum incremental motion (micrometer drive)	23	23	23	-	-	-	μrad
Rotation / linear input	15	15	15	15	15	15	μrad/μm
Tangent-arm length	66	66	66	66	66	66	mm
Wobble	<75	<75	<75	<75	<75	<75	μrad
Max. velocity	-	-	-	0.8	0.8	0.8	°/s
Max. axial force	±400	±400	±400	±400	±400	±400	N
Max. torque (θ <sub>x</sub> , θ <sub>y</sub> )	±6	±6	±6	±6	±6	±6	Nm
Max. torque CW*	2.6	2.6	2.6	2.6	2.6	2.6	Nm
Max. torque CCW*	0.075	0.075	0.075	0.075	0.075	0.075	Nm
Drive (manual or motor)	M-624	M-624	M-624	M-227.25	M-227.25	M-227.25	
Piezo drive	-	P-840.30	P-841.30	-	P-840.30	P-841.30	
Mass	0.85	0.95	0.97	1.05	1.15	1.17	kg
Body material	Al, St	Al, St	Al, St	Al, St	Al, St	Al, St	
Recommended controllers	-	-	-	C-843, C-848, C-863	C-843, C-848, C-863	C-843, C-848, C-863 (p. 4-120, p. 4-122, p. 4-114)	
Recommended piezo controllers	-	E-660, E-610 E-500 System	E-610 E-500 System	-	E-660, E-610 E-500 System	E-610 (p. 2-110) E-500 System (p. 2-142)	

\*CW: clockwise CCW: counter-clockwise

\*\*Limited by limit switch position.

# M-037 Compact Micropositioning Rotation Table

## Unlimited Travel Range, Vacuum-Compatible Versions



M-037.DG Rotation stage

- Ultra-High Resolution
- Compact Design
- Continuous Rotation Range
- Preloaded Worm Drive for Zero Backlash
- ActiveDrive™ Manual, DC-Servo and Stepper-Motor Drives
- Clear Aperture Ø 20 mm
- Vacuum-Compatible Versions Available to 10<sup>-6</sup> hPa

M-037 rotation stages are equipped with ultra-precise worm gear drives allowing unlimited rotation in either direction. An integrated spring preload eliminates backlash. Double-row ball bearings allow zero backlash, high load capacity and extremely low wobble.

The worm gear ratio is 180:1, which allows an extraordinary position resolution of the turntable.

### DC-Motor and Stepper Motor Drives

A variety of servo and stepper motors are available, besides the manual version.

Model M-037.DG is closed-loop DC motors with shaft-mounted position encoders and precision gearheads providing 3.5 µrad at a design resolution of 0.6 µrad.

Model M-037.2S models feature a cost-effective direct-drive, 2-phase stepper motor,

providing very smooth operation and a resolution of 5.45 µrad at a minimum incremental motion of 21 µm.

### ActiveDrive™

Model M-037.PD is equipped with the high efficient Active Drive™ direct drive and provides velocities up to 45%/s. The ActiveDrive™ design, developed by PI, features a high-efficiency PWM (pulse width modulation) servo-amplifier mounted side-by-side with the DC motor and offers several advantages:

- Increased efficiency, by eliminating power losses between the amplifier and motor
- Reduced cost of ownership and improved reliability, because no external driver is required
- Elimination of PWM amplifier noise radiation, by mounting the amplifier and motor together in a single, electrically shielded case

Coarse position can be read from an adjustable scale ring on the outer edge of the turntable graduated in 2 degree increments.

Each M-037 stage is individually broken in before delivery to achieve the exceptional mechanical precision.

### Notes

For adapters, bracket, etc. see page 4-90 ff.

### Ordering Information

**M-037.00**  
Rotation Stage, Ø 60 mm, 360°, Manual Drive

**M-037.DG**  
Rotation Stage, Ø 60 mm, 360°, Closed-Loop DC Motor Gearhead

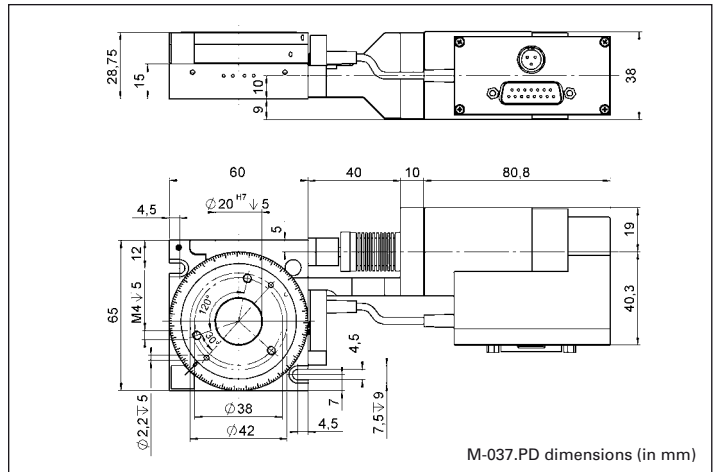
**M-037.VG**  
Vacuum Compatible to 10<sup>-6</sup> hPa of M-037.DG

**M-037.PD**  
Rotation Stage, Ø 60 mm, 360°, ActiveDrive™ DC Motor (includes 24 V power supply)

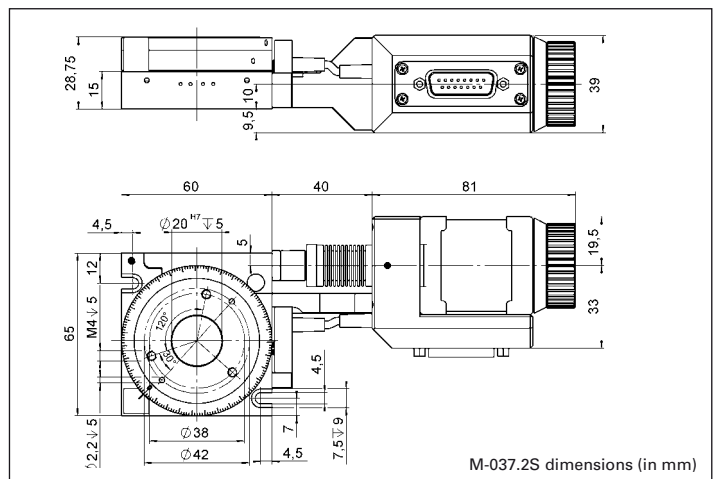
**M-037.VP**  
Vacuum Compatible to 10<sup>-6</sup> hPa of M-037.PD

**M-037.2S**  
Rotation Stage, Ø 60 mm, 360°, 2-Phase Stepper Motor

Ask about custom designs!



M-037.PD dimensions (in mm)

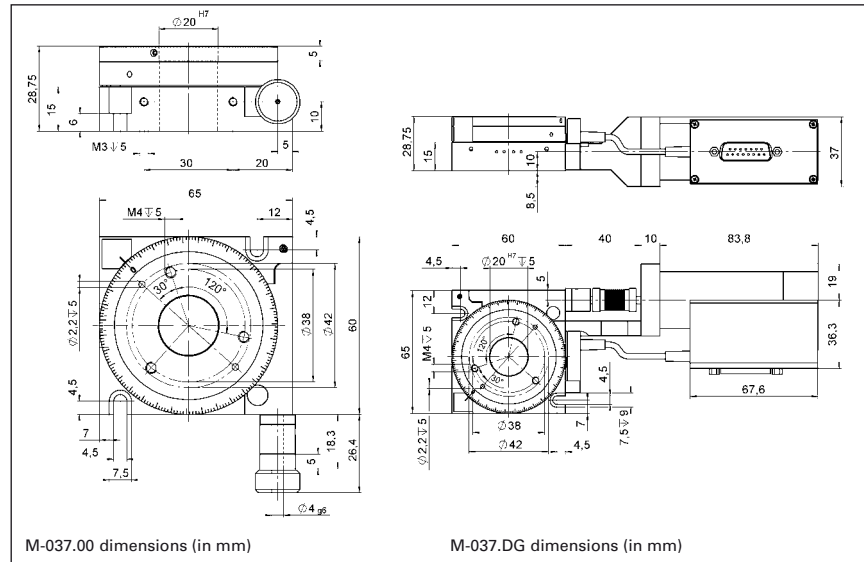


M-037.2S dimensions (in mm)

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M-037.00 Rotation stage



## Technical Data

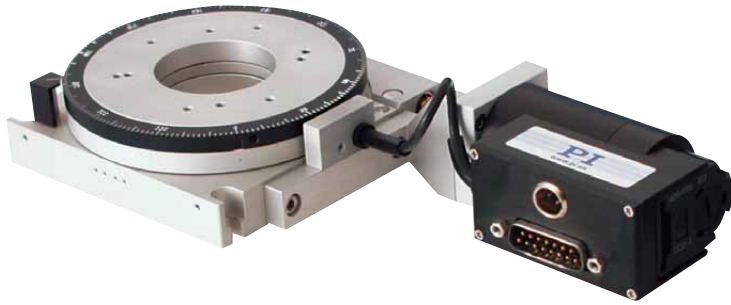
Model	M-037.00	M-037.DG	M-037.PD	M-037.2S	
Active axes	Rotation	Rotation	Rotation	Rotation	
<b>Motion and positioning</b>					
Rotation range	>360	>360	>360	>360	°
Integrated sensor	–	Rotary encoder	Rotary encoder	–	
Sensor resolution	–	2000	4000	–	cts./rev.
Design resolution	–	0.59 (34 x 10 <sup>-6</sup> )	8.75 (0.0005)	5.45* (0.00031)	μrad (°)
Min. incremental motion	–	3.5	27	21	μrad
Backlash	–	200	200	200	μrad
Unidirectional repeatability	–	30	30	30	μrad
Wobble	<150	<150	<150	<150	μrad
Max. velocity	–	6	45	10	%s
<b>Mechanical properties</b>					
Worm gear ratio	180:1	180:1	180:1	180:1	
Gear ratio	–	(28/12) <sup>4</sup> ≈ 29.6:1	–	–	
Motor resolution	–	–	–	6400*	steps/rev.
Load capacity/axial force, self-locking	±300	±300	±300	±300	N
Max. torque (θ <sub>x</sub> , θ <sub>y</sub> )	±3	±3	±3	±3	Nm
Max. torque clockwise (θ <sub>z</sub> )	1	1	1	1	Nm
Max. torque counter clockwise (θ <sub>z</sub> )	0.5	0.5	0.5	0.5	Nm
<b>Drive properties</b>					
Motor type	–	DC motor, gearhead	ActiveDrive™ DC Motor	2-phase stepper motor*	
Operating voltage	–	0 to ±12	24 (PWM)	24	V
Electrical power	–	3	30		W
Reference switch	–	Hall-effect	Hall-effect	Hall-effect	
<b>Miscellaneous</b>					
Operating temperature range	-20 to +65	-20 to +65	-20 to +65	-20 to +65	°C
Material	Aluminum	Aluminum	Aluminum	Aluminum	
Mass	0.3	0.65	0.62	0.64	kg
Recommended controller/driver	–	C-863 (single-axis) C-843 PCI-Karte (for up to 4 axes)	C-863 (single-axis, p. 4-114) C-843 PCI-Karte (p. 4-120) (for up to 4 axes)	C-663 (single-axis, p. 4-112)	

incl. motor cable, 3 m, sub-D connector 15-pin

\*2-phase stepper motor, 24 V chopper voltage, max. 0.8 A/phase, 400 full steps/rev., motor resolution with C-663 stepper motor controller

# M-038 Precision Micropositioning Rotation Table

## Unlimited Travel Range, Vacuum-Compatible Versions



M-038.PD1 Rotation Stage

- Ultra-High Resolution
- Max. Velocity 90°/s
- Continuous Rotation Range
- Preloaded Worm Drive for Zero Backlash
- ActiveDrive™ Manual, DC-Servo and Stepper-Motor Drives
- Clear Aperture Ø 40.2 mm
- Vacuum-Compatible Versions Available to 10<sup>-6</sup> hPa

M-038 rotation stages are equipped with an ultra-precise worm gear drive allowing continuous rotation in either direction. Double-row ball bearings allow high load capacity, zero backlash and extremely low wobble. The new and improved

M-038.xx1 versions now feature a larger central aperture and a higher-performance worm wheel drive.

The worm gear ratio of 176:1 allows an extraordinary high position resolution of the turntable.

### DC-Motor and Stepper Motor Drives

A variety of servo motor and stepper motors are available, besides the manual version.

Model M-038.DG1 equipped with a closed-loop DC motor with shaft-mounted position encoder and precision gearhead providing minimum incremental motion of 3.5 µrad at a design resolution of 0.6 µrad.

Model M-038.2S1 models feature a cost-effective direct-drive, 2-phase stepper motor,

providing very smooth operation and a resolution of 5.45 µrad at a minimum incremental motion of 21 µm.

### ActiveDrive™

Model M-038.PD1 is equipped with the highly efficient Active Drive™ direct drive and reaches velocities up to 90°/s. The ActiveDrive™ design, developed by PI, features a high-efficiency PWM (pulse width modulation) servo-amplifier mounted side-by-side with the DC motor and offers several advantages:

- Increased efficiency, by eliminating power losses between the amplifier and motor
- Reduced cost of ownership and improved reliability, because no external driver is required
- Elimination of PWM amplifier noise radiation, by mounting the amplifier and motor together in a single, electrically shielded case

Coarse position can be read from an adjustable scale ring on the outer edge of the turntable graduated in 2 degree incre-

### Ordering Information

- M-038.001**  
Rotation Stage, Ø 100 mm, 360°, Manual Drive
  - M-038.DG1**  
Rotation Stage, Ø 100 mm, 360°, Closed-Loop DC Motor Gearhead
  - M-038.VG1**  
Rotation Stage, Ø 100 mm, 360°, Closed-Loop DC Motor Gearhead, Vacuum Compatible to 10<sup>-6</sup> hPa
  - M-038.PD1**  
Rotation Stage, Ø 100 mm, 360°, ActiveDrive™ DC Motor (Includes 24 V Power Supply)
  - M-038.VP1**  
Rotation Stage, Ø 100 mm, 360°, ActiveDrive™ DC Motor (Includes 24 V Power Supply), Vacuum Compatible to 10<sup>-6</sup> hPa
  - M-038.2S1**  
Rotation Stage, Ø 100 mm, 360°, 2-Phase Stepper Motor
- Ask about custom designs!**

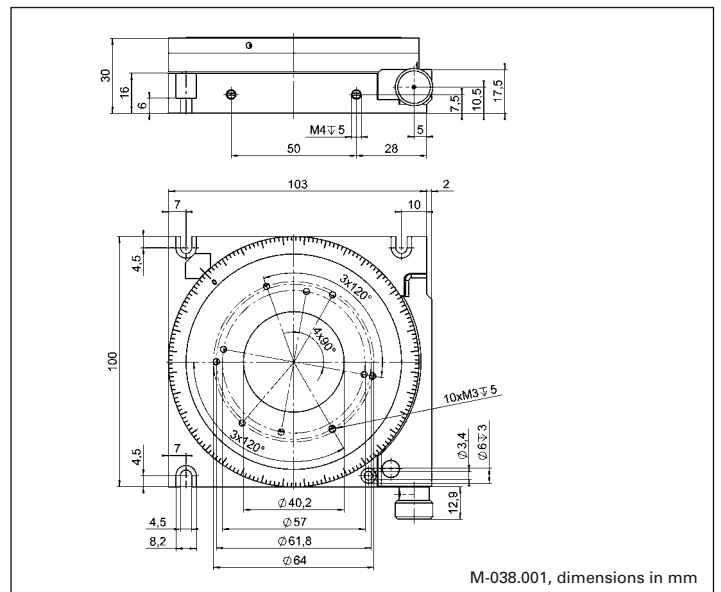
ments. Each M-038 stage is individually broken-in before delivery to achieve the exceptional mechanical precision.

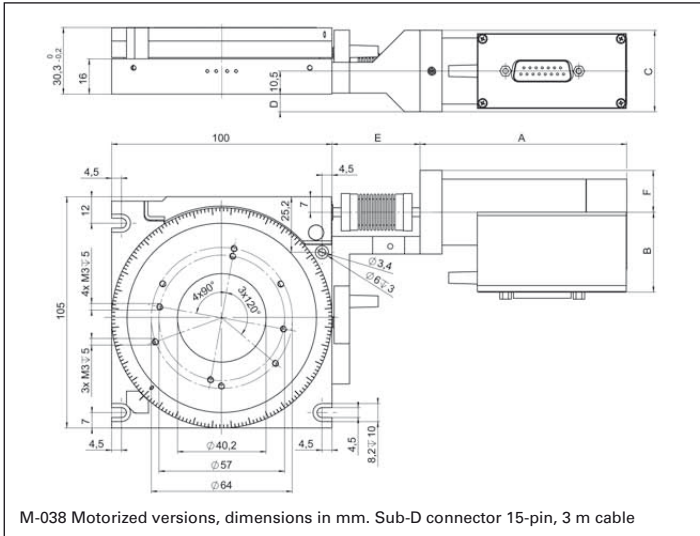
### Notes

See "Accessories" for adapters, bracket, etc. see page 4-90 ff.



Custom M-038 stages at the coordinate measuring machine





Custom M-038 with folded drive

## Technical Data

Model	M-038.001	M-038.DG1	M-038.PD1	M-038.2S1	Units
Active axes	Rotation	Rotation	Rotation	Rotation	
<b>Motion and positioning</b>					
Rotation range	>360°	>360°	>360°	>360°	
Integrated sensor	–	Rotary encoder	Rotary encoder	–	
Sensor resolution	–	2000	4000	–	steps/rev.
Design resolution	–	0.60 (35 x 10 <sup>-6</sup> )	8.95 (0.0005)	5.58* (0.00032)	µrad (°)
Min. incremental motion	–	3.5	27	21	µrad
Backlash	–	200	200	200	µrad
Unidirectional repeatability	–	20	20	20	µrad
Wobble	<75	<75	<75	<75	µrad
Max. velocity	–	6	90	10	°/s
<b>Mechanical properties</b>					
Worm gear ratio	176:1	176:1	176:1	176:1	
Gear ratio	–	2401:81 ≈ 29.6:1	–	–	
Motor resolution	–	–	–	6400*	steps/rev.
Max. load/axial force	±400	±400	±400	±400	N
Maximum torque (θ <sub>x</sub> , θ <sub>y</sub> )	±6	±6	±6	±6	
Maximum torque CW**	2	2	2	2	Nm
Maximum torque CCW**	0.8	0.8	0.8	0.8	Nm
<b>Drive properties</b>					
Motor type	–	DC Motor, gearhead	ActiveDrive™ DC Motor	2-phase stepper motor*	
Electrical power	–	3	30	–	W
Reference switch	–	Hall-effect	Hall-effect	Hall-effect	
<b>Miscellaneous</b>					
Operating voltage	–	12 V differential	24 (PWM)	24	V
Operating temperature range	-20 to +65	-20 to +65	-20 to +65	-20 to +65	°C
Material	Aluminum	Aluminum	Aluminum	Aluminum	
Mass	0.9	1.25	1.35	1.25	kg
Recommended controller/driver		C-863 (single-axis) C-843 PCI board (for up to 4 axes)	C-863 (single-axis, p. 4-114) C-843 PCI board (p. 4-120) (for up to 4 axes)	C-663 (single-axis, p. 4-112)	

\*2-phase stepper motor, 24 V chopper voltage, max. 0.8 A/phase, 400 full steps/rev., motor resolution with C-663 stepper motor controller

\*\*CW: clockwise; CCW: counter-clockwise

# M-116 Mini Precision Micropositioning Rotation Table

## Compact, Multi-Axis Combinations with M-110 Translation Stage Series



M-116.DG micro rotary stage

- Compact Design
- Continuous Rotation Range
- Encoder Resolution 2.5  $\mu$ rad
- Clear Aperture
- Max. Velocity 20 degrees/second
- Preloaded Worm Drive for Zero Backlash
- Fits Directly on M-110 Micro Translation Stages
- Non-Contact Reference Switch
- Repeatability to  $\pm 10$   $\mu$ rad

M-116 rotation stages are equipped with low-friction, spring-preloaded worm gear drives allowing unlimited rotation in either direction in an extremely compact package.

### Stepper and Servo Motors

Both drive options provide a cost-effective solution for industrial and OEM environ-

### Application Examples

- R&D
- Laser technology
- Metrology
- Adjustment of optics
- Photonics packaging
- Quality assurance testing

ments. A miniature DC or stepper motor actuates motion via a spring-preloaded worm gear drive and zero-backlash (with M-116.xxH versions) gearhead.

To meet the most critical positioning demands, the DC motor is equipped with a high-resolution encoder featuring resolution of 2048 counts per revolution. The combination of the extremely low-stiction/low-friction construction and high-resolution encoder allows for minimum incremental motion of 25  $\mu$ rad at speeds up to 20 degrees/second.

### Multi-Axis Combinations

M-116 rotary stages can be combined with the M-110, M-111 and M-112 micro linear stages without an additional

adapter plate to keep the total height at a minimum.

### Clear Aperture, Lens Adapter

The M-116 is designed with a clear aperture for extended versatility in optics applications. The M-116.AL1 lens adapter is available to accommodate 0.5" optics such as polarizers.

### Non-Contact Limit and Reference Switches

Motorized models are equipped with an integrated Hall-effect origin switch. To protect your equipment and increase versatility in automation applications, the rotary stage can optionally be equipped with Hall-effect limit switches. Travel can be limited to a range between 0° and 330°  $\pm 2^\circ$ .

For ease of operation and setup, all models come with a scale ring on the outer edge of the turntable.

### Ordering Information

**M-116.DG**  
Rotation Stage, 360°, Closed-Loop DC Motor Gearhead

**M-116.DGH**  
Rotation Stage, 360°, Closed-Loop Backlash-Free DC Motor Gearhead

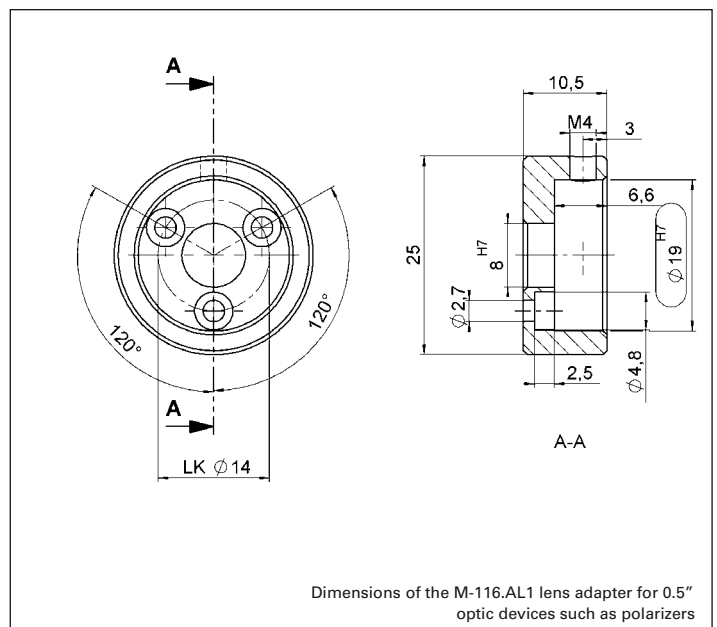
**M-116.2SH**  
Rotation Stage, 360°, 2-Phase Stepper Motor with Backlash-Free Gearhead

**M-116.AL1**  
Lens Adapter for 0.5" Optics

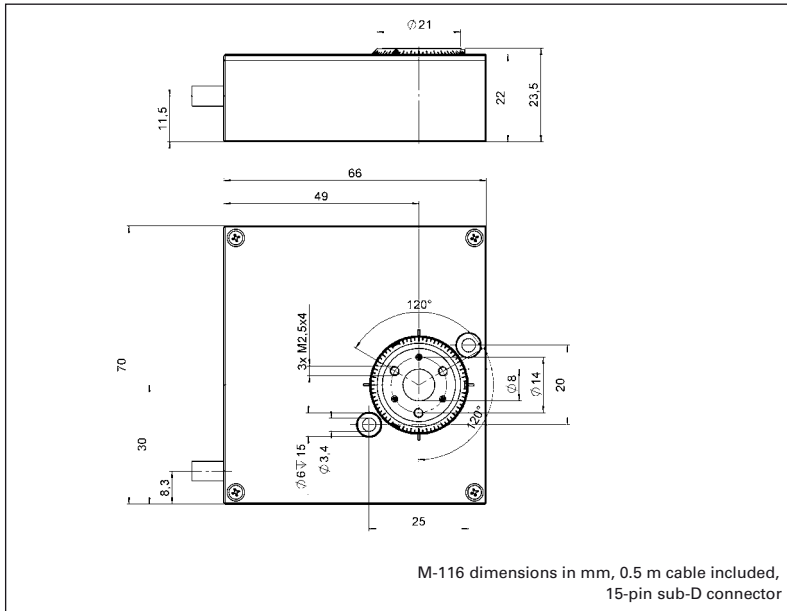
Ask about custom designs!



XY  $\theta_z$  micropositioning combination consisting of (from top to bottom) M-116 micro rotary stage and two M-111 translation stages (M-110.01 adapter for mounting the M-111 on a honeycomb breadboard with M6 on 25 mm centers)



Dimensions of the M-116.AL1 lens adapter for 0.5" optic devices such as polarizers



## Technical Data

Model	M-116.DG	M-116.DGH	M-116.2SH	Units
Active axes	Rotation	Rotation	Rotation	
<b>Motion and positioning</b>				
Rotation range	>360	>360	>360	°
Integrated sensor	Rotary encoder	Rotary encoder	–	
Sensor resolution	2048	2048	–	Cts./rev.
Design resolution	2.45 (0.00013)	3.16 (0.00018)	16.9* (0.00097)	μrad (°)
Min. incremental motion	50	25	30	μrad
Backlash	1000	500	500	μrad
Unidirectional repeatability	12	10	10	μrad
Max. velocity	20	20	20	°/s
<b>Mechanical properties</b>				
Worm gear ratio	44:1	44:1	44:1	
Gear ratio	28.444:1	22.0335:1	22.0335:1	
Motor resolution	–	–	384*	steps/rev.
Axial force	±15	±15	15	N
Max. Torque ( $\theta_x, \theta_y$ )	±1.5	±1.5	±1.5	Nm
Max. Torque clockwise ( $\theta_z$ )	0.4	0.4	0.4	Nm
Max. torque counterclockwise ( $\theta_z$ )	0.8	0.8	0.8	Nm
<b>Drive properties</b>				
Motor type	DC-motor, gearhead	DC-motor, gearhead	2-phase stepper motor*	
Operating voltage	0 to ±12	0 to ±12	24	V
Electrical power	1.75	1.75		W
Reference switch	optical	optical	optical	
<b>Miscellaneous</b>				
Operating temperature range	-20 to +65	-20 to +65	-20 to +65	°C
Material	Aluminum	Aluminum	Aluminum	
Mass	0.4	0.4	0.4	kg
Recommended controller/driver	C-863 single-axis C-843 PCI board, for up to 4 axes	C-863 single-axis (p. 4-114) C-843 PCI board (p. 4-120), for up to 4 axes	C-663 single-axis (p. 4-112)	

\*2-phase stepper motor, 24 V chopper voltage, max. 0.25 A/phase, 24 full steps/rev., motor resolution with C-663 stepper motor controller



## Program Overview

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