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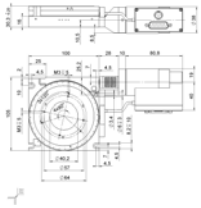
MP 34E User Manual

M-037/M-038 Worm-Gear Rotation Stages

Release: 3.7.1 Date: 2007-08-24

This document describes the following product(s):

- M-037.00
  60 mm, manual drive
- M-037.DG
  60 mm, DC motor gearhead
- M-037.PD
  60 mm, PWM DC motor direct drive
- M-037.2S
  60 mm, 2-phase stepper motor drive, open-loop
- M-038.001
  100 mm, manual drive
- M-038.DG1, M-038.VG1
  100 mm, DC motor gearhead
- M-038.VG1, M-038.VP1
  100 mm, 10^{-6} hPa vacuum versions
- M-038.PD1, M-038.VP1
  100 mm, PWM DC motor direct drive
- M-038.2S1
  100 mm, 2-phase stepper motor drive, open-loop



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Declaration of Conformity

according to ISO / IEC Guide 22 and EN 45014

Manufacturer: **Physik Instrumente (PI) GmbH & Co. KG**

Manufacturer´s Address: Auf der Römerstrasse 1
D-76228 Karlsruhe,
Germany

CE

The manufacturer hereby declares that the products

Product Name: **Worm-Gear Rotation Stages**
Model Numbers: **M-037/M-038**
Product Options: **all**

complies with the following European directives:

73/23/EEC, Low voltage directive
89/336/EEC, EMC-Directive
98/37/EC, Machinery Directive

The applied standards certifying the conformity are listed below.

Electromagnetic Emission:	EN 61000-6-3, EN 55011
Electromagnetic Immunity:	EN 61000-6-1
Safety (Low Voltage Directive):	EN 61010-1
Safety of Machinery:	EN 12100

July 09, 2007
Karlsruhe, Germany

Dr. Karl Spanner
President

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About This Document

Users of This Manual

This manual is designed to help the reader install and operate the M-037/M-038 Worm-Gear Rotation Stages. It assumes that the reader has a fundamental understanding of basic servo systems, as well as motion control concepts and applicable safety procedures.
The manual describes the physical specifications and dimensions of the M-037/M-038 Worm-Gear Rotation Stages as well as the installation procedures which are required to put the associated motion system into operation.
This document is available as PDF file. Updated releases are available for download from www.pi.ws, or by email: contact your Physik Instrumente Sales Engineer or write info@pi.ws

Conventions

The notes and symbols used in this manual have the following meanings:

WARNING

Calls attention to a procedure, practice or condition which, if not correctly performed or adhered to, could result in injury or death.

CAUTION

!

Calls attention to a procedure, practice, or condition which, if not correctly performed or adhered to, could result in damage to equipment.

NOTE

Provides additional information or application hints.

Related Documents

The motion controller and the software tools which might be delivered with M-037/M-038 Worm-Gear Rotation Stages are described in their own manuals. Updated releases are available for download from www.pi.ws or email: contact your Physik Instrumente Sales Engineer or write info@pi.ws.

Contents

1 Introduction

1.1 Description

- Ultra-High Resolution
- Compact Design
- Unlimited Rotation Range
- Preloaded Worm Drive for Zero Backlash
- ActiveDrive™ DC Motor, Stepper Motor and Manual Versions
- Compatible with National Instruments Motion Controllers
- Clear Aperture of 20 mm or 40.2 mm Ø
- Limit and Reference (Origin) Switches

Worm Gear Drive

All M-037 and M-038 rotation stages are equipped with worm-gear drives allowing unlimited rotation in either direction. An integrated spring pre-load eliminates backlash. The worm gear ratios are 180:1 (M-037s) and 176:1 (M-038s), corresponding to turntable rotations of 2.000° and 2.045°, respectively, per revolution of the drive shaft.

Three Motor-Drive Options

The M-037.DG and M-038.DG1 models are equipped with a DC motor and shaft-mounted encoder, and have a min. incremental motion of 3.5 µrad

The M-037.2S and M-038.2S1 models feature a direct-drive, 2-phase stepper motor, providing very smooth operation and a resolution of 5.5 µrad per step.

The M-037.PD and M-038.PD1 models feature the high-performance 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

Limit and Reference Switches

For the protection of your equipment non-contact Hall-effect limit and reference (origin) switches are integrated in the motorized versions. The direction-sensing reference switch supports advanced, high-precision automation applications.

1.2 Safety Precautions

The following safety precautions should be observed when operating M-03x series rotation stages:

WARNING

The stages are motorized by powerful electric motors and can accelerate to high speeds and can generate high forces. If handled improperly, the stages may cause injuries.

CAUTION

When the stage is connected to the motor controller (and/or amplifier) be aware that the stage could start an undesired move for reasons that may not be immediately apparent.

Be aware that failure of the motor controller may drive the stage into a hard stop at high speed.

CAUTION

Connecting a DC motor to a stepper motor controller or vice versa may cause damage to the motor.

1.3 Prescribed Use

M-037 and M-038 stages must not be used for applications not in conformance with this manual. Observe all safety precautions given in this User Manual.

Standard M-037 and M-038 stages are designed to operate under normal ambient conditions at least as listed here. More stringent conditions given in the Technical Data table (p. 11) are, of course, also met.

- Indoor use
- Altitude up to 2000 m
- Temperature range 5°C to 40°C
- Max. relative humidity 80% for temperatures up to 31°C, decreasing linearly to 50% relative humidity at 40°C
- Degree of pollution: 2

2 Model Survey

M-037 and M-038 stages differ in platform and aperture diameter (and related specifications, such as weight) and the slightly different worm-gear ratio. The table below summarizes the models available:

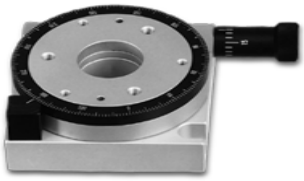
Model Number		Drive Type
60 mm Platform w. 20 mm Aperture	100 mm Platform w. 40.2 mm Aperture	
M-037.00	M-038.001*	Manual thumbscrew
M-037.DG	M-038.DG1*	Closed-loop DC motor / gearhead
	M-038.VG1	M-038.DG1 vacuum-compatible to 10^{-6} hPa
	M-038.VP1	M-038.PD1 vacuum-compatible to 10^{-6} hPa
M-037.PD	M-038.PID1	Closed-loop DC motor direct drive with integrated PWM amplifier (ActiveDrive™ DC motor)
M-037.2S	M-038.2S1*	2-phase stepper motor (open-loop)

The DC motor/gearhead versions feature 3-watt DC motors with 29.6:1 backlash-free gearheads and 2000 counts/revolution encoders mounted on the motor shaft.

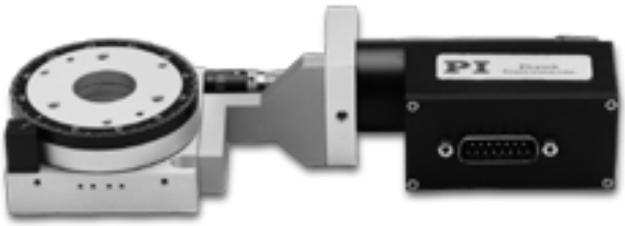
The stepper motor versions are equipped with 2-phase stepper motors providing 20 000 micro-steps / revolution.

Coarse position can be read from an adjustable scale ring on the outer edge of the turntable, graduated in 2° increments or, on the M-037 and all manual models, from a drive-shaft-mounted indicator with 0.1 degree graduations.

* The older M-038.00, M-038.DG and M-038.2S are no longer available



M-037.00



M-037.DG

M-038.PD1

Fig. 1: Sampling of M-037 and M-038 stages

3 Operation

Manual versions are operated by turning the thumbscrew. Each full turn corresponds to 2° (2.045° for M-038.001) of platform motion. The motor-driven versions require a compatible motor controller.

CAUTION

Connecting a DC motor to a stepper motor controller or vice versa may cause damage to the motor.

3.1 DC Motor Versions

The DC motor versions come in analog and PWM models. The PWM versions (M-037.PD, M-038.PD1) feature much higher power. The motor direction is determined by a TTL logic signal on the PWM-sign line, the speed by a PWM-coded TTL-level signal on the PWM-magnitude line. Only low currents flow in these lines because the motor power is drawn from a separate, 24 VDC supply.

In the DC-motor versions, the motor speed is determined by the voltage (max. 12 V differential) on the motor power lines and the direction by the polarity. If the "Motor +" line is more positive than the "Motor -" line, then the motor moves in the positive direction. The motor power thus comes from the controller.

PI offers DC motor controllers with a wide range of size and performance. In general the DC motor versions can be controlled by the C-843, C-848, C-880 and C-862 Mercury™ controllers illustrated below.

Fig. 2: DC-motor controllers: C-848 and C-880 benchtop/ rackmount (background, top to bottom), C-843 PCI bus cards and Mercury controllers, alone and networked (foreground)

DC Motor Controllers:	C-880	C-848	C-843 PCI Card	C-862 Mercury™
Axes per controller*	up to 18**	2 or 4	2 or 4	1
Host PC interface	RS-232, RS-422 or IEEE (GPIB)	RS-232, RS-422 or IEEE (GPIB)	Internal (PCI bus)	RS-232 daisy chain bus
Multiple controllers on same PC	yes, separate ports	yes, separate ports	yes, separate slots	yes, same port; also with C-663

Current models of all of PI's DC motor controllers can handle both PWM and analog motors in any combination.

The C-862 Mercury™ is internetworkable with other Mercury™ controllers, including the C-663 Mercury™ Step.

* Multi-axis controllers can drive a mix of PWM and analog motors
** Custom configurations with networked controllers operating off a single host PC port (RS-422, RS-422, GPIB, IEEE 488, USB, TCP/IP) and controlling hundreds of axes are possible.

3.2 Stepper Motor Versions

CAUTION

Commanding a velocity above the maximum possible for the stage will cause the motor to stall. Because stepper motors do not have position encoders, the position counter will continue to increment. The controller's motor position may not correspond with the actual motor position and this might endanger your application.

The maximum velocity depends on various influences like operating voltage, phase current setting and mechanical load. Datasheet values are for orientation only and may not work in all applications.

M-037.2S and M-038.2S1 stages are equipped with 2-phase stepper motors. In conjunction with the C-663 stepper motor controller, high-resolution microstepping achieves an angular resolution of 1.1 arc seconds. Note that stepper-motor versions do not have encoders and are designed for open-loop operation. See the controller User Manual for details on operating and networking stepper motor axes.

Fig. 3: Mercury™ Step stepper motor controller

Stepper Motor Controller:	C-663 Mercury™ Step
Axes per controller	1
Host PC interface	USB and/or RS-232 daisy chain bus
Multiple controllers on same PC	yes, same port, also with C-862

Internetworking of C-663 Mercury™ Step stepper motor controllers with each other and with C-862 Mercury™ DC motor controllers is supported, for control of up to 16 axes off a single RS-232* or USB port.

* The RS-232 output stages of some PCs may not be capable of driving more than 6 units; if this is a problem use USB to interface the first C-663 with the PC.

3.3 Motion Control Parameters

3.3.1 DC Motor Versions

The following tables give recommended starting values for the servo-control parameters for M-037 and M-038 stages and the different PI DC motor controllers. See the controller User Manual for details.

Using C-843, C-848 and C-880 Motor Controllers[1] with:				
Stage	M-037.DG/M-038.DG1 with Gear Drives		M-037.PD/M-038.PD1 with PWM amplifier	
Parameter	Recommended Value	Operating Range	Recom-mended Value	Operating Range
p –term (DP)	DP250	DP50 – DP300	DP200	DP150 – DP250
i –term (DI)	DI40	DI0 – DI50	DI10	DI0 – DI50
d –term (DD)	DD800	DD0 – DD1200	DD300	DD0 – DD500
L – limit (DL)	DL2000	DL0 – DL2000	DL2000	DL0 – DL2000
Velocity (SV)	SV120000	SV1 – SV190000	SV120000	SV1 – SV240000
Acceleration (SA)	SA800	SA20 – SA1200	SA450	SA10 – SA600

Using C-862 Mercury Controllers with				
Stage	M-037.DG/M-038.DG1 with Gear Drives		M-037.PD/M-038.PD1 with PWM amplifier	
Parameter	Recommended Value	Operating Range	Recom-mended Value	Operating Range
p –term (DP)	DP250	50 – DP300	DP250	50 – DP250
i –term (DI)	DI40	0 – 50	DI40	0 – 50
d –term (DD)	DD800	0 – 1200	DD800	0 – 1200
L – limit (DL)	DL2000	0 – 2000	DL2000	0 – 2000
Velocity (SV)	SV120000	1 – 190000	SV120000	1 – 220000
Acceleration (SA)	SA800000	1000 – 2200000	SA1500000	1000 – 3000000

For the stepper motor versions, the maximum velocity is the most important operating parameter.

depends on various influences like operating voltage, phase current setting and mechanical load. Datasheet values are for orientation only and may not work in all applications.

3.3.2 Stepper Motor Versions

The most important operating parameter for the stepper motor versions is the maximum velocity. Exceeding it will cause stalling, and the position counter will be incorrect. Determine the maximum velocity empirically for your individual application and make sure that it is not exceeded in normal operation. Use the datasheet value of 10°/s as a starting point.

[1] see User Manual of respective controller for detailed command survey

4 Technical Data

	M-037.00	M-037.DG	M-037.PD	M-037.2S*	M-038.001	M-038.DG1	M-038.PD1	M-038.2S1*	Units	Tolerance
Motion and positioning										
Rotation range	>360	>360	>360	>360	>360	>360	>360	>360	°	
Integrated encoder		Rotary encoder	Rotary encoder			Rotary encoder	Rotary encoder			
Encoder resolution		2000	4000			2000	4000		cts./rev.	
Design resolution*		0.59 (34 x 10^{-6})	8.75 (0.0005)	5.45 (0.00031)		0.60 (35 x 10^{-6})	8.95 (0.0005)	5.58 (0.00032)	µrad (deg)	typ.
Minimum incremental motion*		3.5	27	21		3.5	27	21	µrad	typ.
Backlash		200	200	200		200	200	200	µrad	typ.
Unidirectional repeatability*		30	30	30		20	20	20	µrad	typ.
Wobble	<150	<150	<150	<150	<75	<75	<75	<75	µrad	typ.
Velocity		6	45	10		6	90	10	deg./s	
Mechanical properties										
Worm gear ratio	180:1	180:1	180:1	180:1	176:1	176:1	176:1	176:1		
Gear ratio		$(28/12)^4$:1 ≈ 29.6:1				$(28/12)^4$ ≈ 29.6:1				
Motor resolution*				6400				6400	steps/rev.	
Axial force	±300	±300	±300	±300	±400	±400	±400	±400	N	Max.

* see TNotes to Table, p 13

	M-037.00	M-037.DG	M-037.PD	M-037.2S*	M-038.001	M-038.DG1	M-038.PD1	M-038.2S1*	Units	Tolerance
Max. torque (θ_X, θ_Y)	±3	±3	±3	±3	±6	±6	±6	±6	Nm	
Torque cw	1	1	1	1	2	2	2	2	Nm	Max.
Torque ccw	0.5	0.5	0.5	0.5	0.8	0.8	0.8	0.8	Nm	Max.
Drive properties										
Motor type			DC Motor ActiveDrive™	2-phase stepper motor			DC Motor ActiveDrive™	2-phase stepper motor		
Operating voltage		0 to ±12	24	24		0 to ±12	24	24	V	
Electrical power		3	30			3	30		W	nominal
Current				0.8				0.8	A / phase	
Origin switch		Hall-effect	Hall-effect	Hall-effect		Hall-effect	Hall-effect	Hall-effect		
Miscellaneous										
Operating temperature range									°C	
Material	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Aluminium		
Mass	0.3	0.65	0.62	0.64	0.9	1.25	1.35	1.25	kg	±5%
Cable length		3	3	3		3	3	3	m	±10 mm
Connector		Sub-D15	Sub-D15	Sub-D15		Sub-D15	Sub-D15	Sub-D15		
Recommended controller/driver		C-862 (single-axis) C-843 PCI card (1 to 4 axes)	C-862 (single-axis) C-843 PCI card (1 to 4 axes)	C-663 (single-axis)		C-862 (single-axis) C-843 PCI card (1 to 4 axes)	C-862 (single-axis) C-843 PCI card (1 to 4 axes)	C-663 (single-axis)		

* see Notes to Table, next page

Notes to Table

M-038.VG1 and M-038.VP1 10^{-6} hPa vacuum versions:
see M-038.DG1 and M-038.PD1 respectively
Two-phase stepper motors: 24 V chopper voltage, max. 0.8 A / phase, 400 full steps per revolution; resolution given is that with C-663 controller
CW: clockwise; CCW: counter-clockwise;
ActiveDrive™ (integrated PWM servo amplifier, external 24 V power supply included)
Design Resolution
The theoretical minimum movement that can be made based on the selection of the mechanical drive components (drive screw pitch, gear ratio, angular motor resolution etc.). Design resolution is usually higher than the practical position resolution (minimum incremental motion).
Minimum Incremental Motion
The minimum motion that can be repeatedly executed for a given input, which is sometimes referred to as practical or operational resolution. Design resolution and practical resolution have to be distinguished. Design resolutions of 1 nm or better can be achieved with many motor, gearbox and leadscrew combinations. In practical applications, however, stiction/friction, windup, and elastic deformation limit resolution to fractions of a micron.

4.1 Cable Connectors and Pin Assignments

Sub-D 15-pin connector (m)

Pin	M-037.DG, M-038.DG1 (gearhead)
1	n.c.
2	input: Motor(+)
3	internal use
4	input: +5 V (Encoder and logic supply)
5	output: positive-travel limit switch (TTL active high)
6	GND
7	output: Encoder A (inverted)
8	output: Encoder B (inverted)
9	input: Motor (-)
10	GND (power)
11	internal use
12	output: negative-travel limit switch (TTL active high)
13	output: Reference signal
14	output: Encoder A (standard)
15	output: Encoder B (standard)

Pin	M-037.PD, M-038.PD1 (PWM)
1	input, +5 to +12 V, enable PWM amplifier
2	
3	input: PWM magnitude
4	input: +5 V (Encoder and logic supply)
5	output: positive-travel limit switch (TTL active high)
6	GND
7	output: Encoder A (inverted)
8	output: Encoder B (inverted)
9	
10	GND (power)
11	input: PWM sign
12	output: negative-travel limit switch (TTL active high)
13	output: position reference signal
14	output: Encoder A (standard)
15	output: Encoder B (standard)

Pin	M-037.2S, M-038.2S (stepper)
1	Phase 1A (brown)
2	Phase 2A (red)
3	n.c.
4	n.c.
5	n.c.
6	input +5 V
7	GND
8	output: negative-travel limit switch (TTL active low)
9	Phase 1B (orange)
10	Phase 2B (yellow)
11	n.c.
12	n.c.
13	n.c.
14	output: positive-travel limit switch (TTL active low)
15	out: reference signal

Motor Power Connector (M-037.PD & M-038.PD1 only)

Fig. 4: Motor power socket

Type: 3-pin, round socket
Reference No: Switchcraft Tini Q-G

PIN	Function
1	Power GND
2	Power input, 24 V DC
3	n.c.

4.2 Dimensions

4.2.1 M-037 Models

NOTE

Use only the three M4 threaded holes for mounting your application. Other holes on platform are for PI use only.

Dimensions in mm, decimal places separated by commas in drawings.

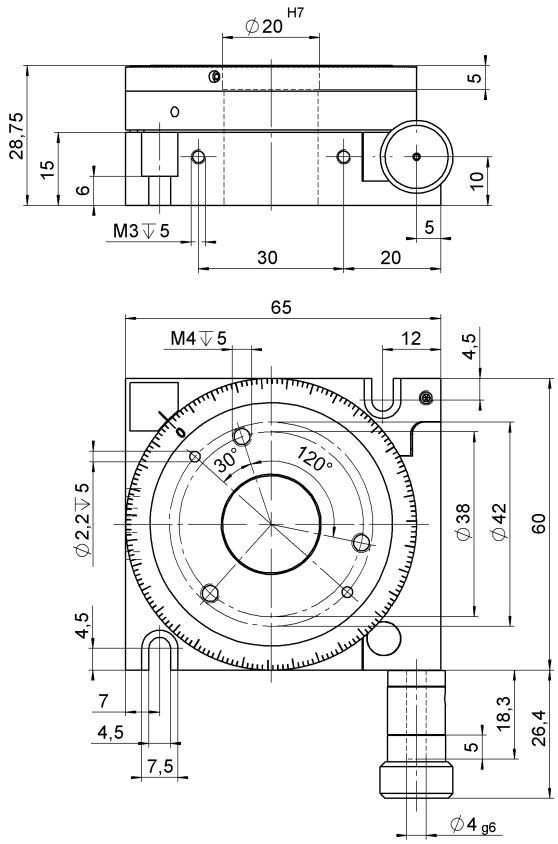


Fig. 5: M-037.00

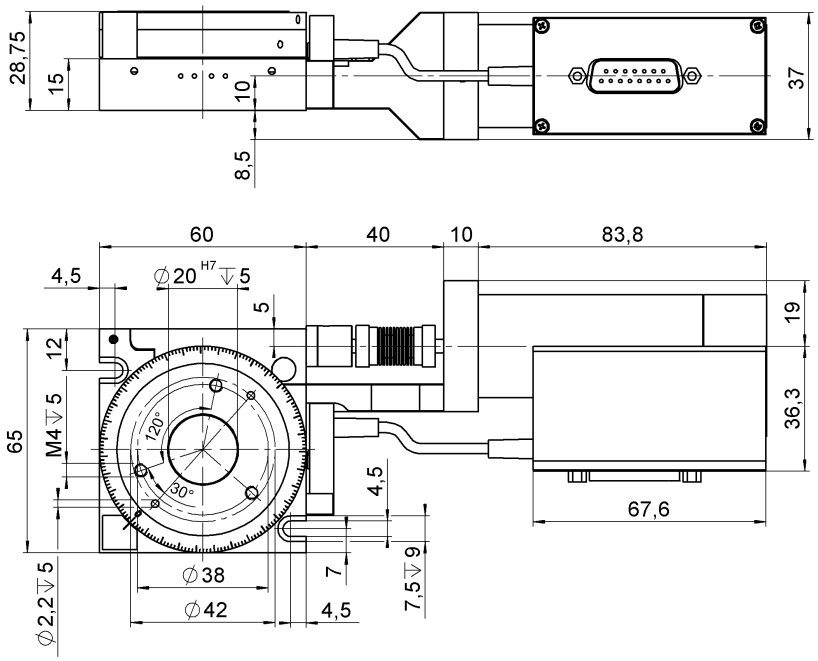


Fig. 6: M-037.DG

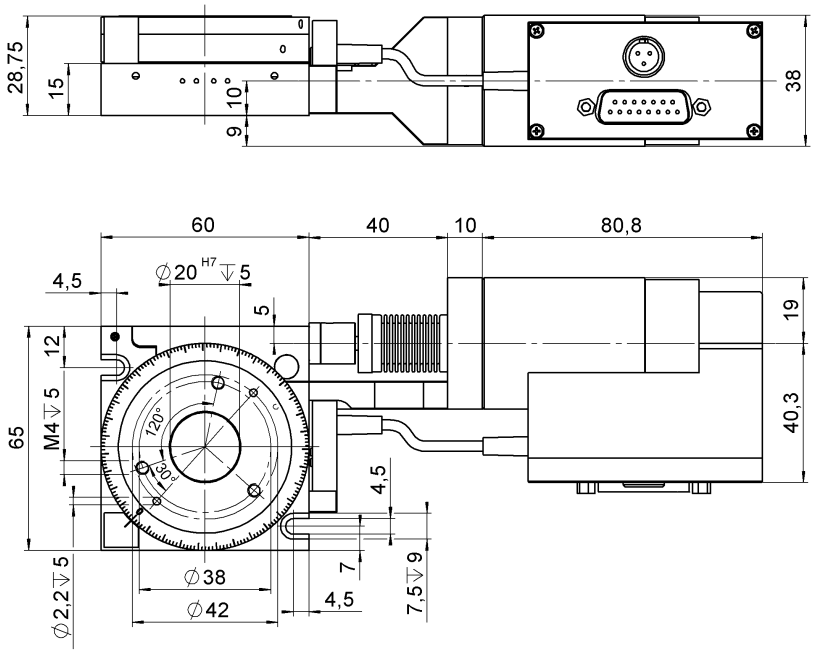


Fig: 7 M-037.PD

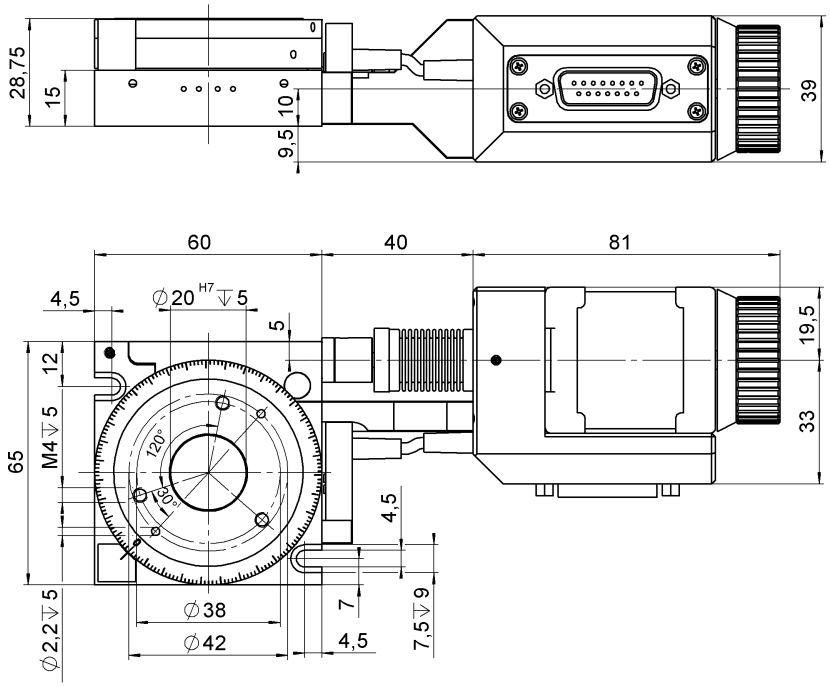

28,75
15
10
9,5
39
60
40
81
4,5
∅20 H7 ↧5
5
19,5
12
M4↧5
65
120°
30°
33
4,5
∅38
∅42
7
4,5
∅2,2↧5
7,5↧9

Fig. 8: M-037.2S

4.2.2 M-038 Models

NOTE

Use only the three M4 threaded holes for mounting your application. Other holes on platform are for PI use only.

Dimensions in mm, decimal places separated by commas in drawings.

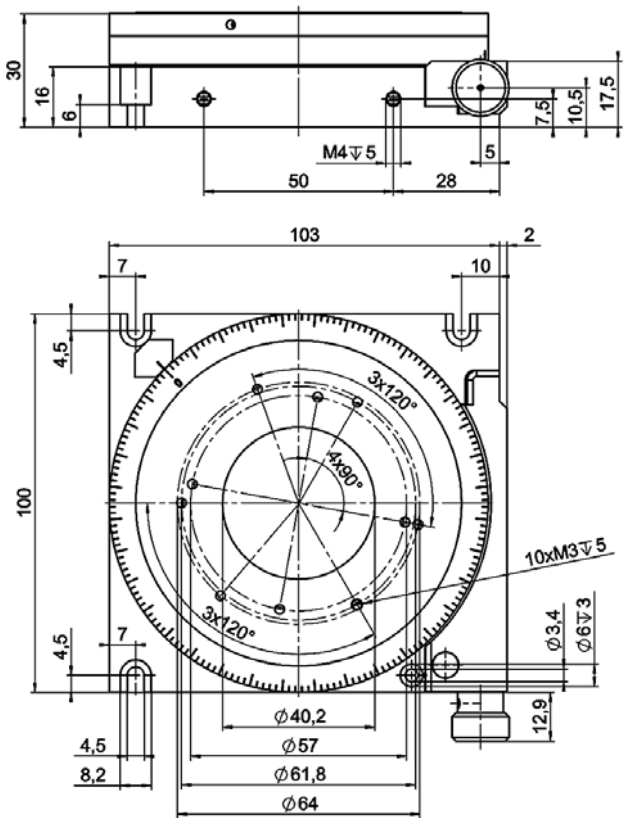


Fig. 9: M-038.001

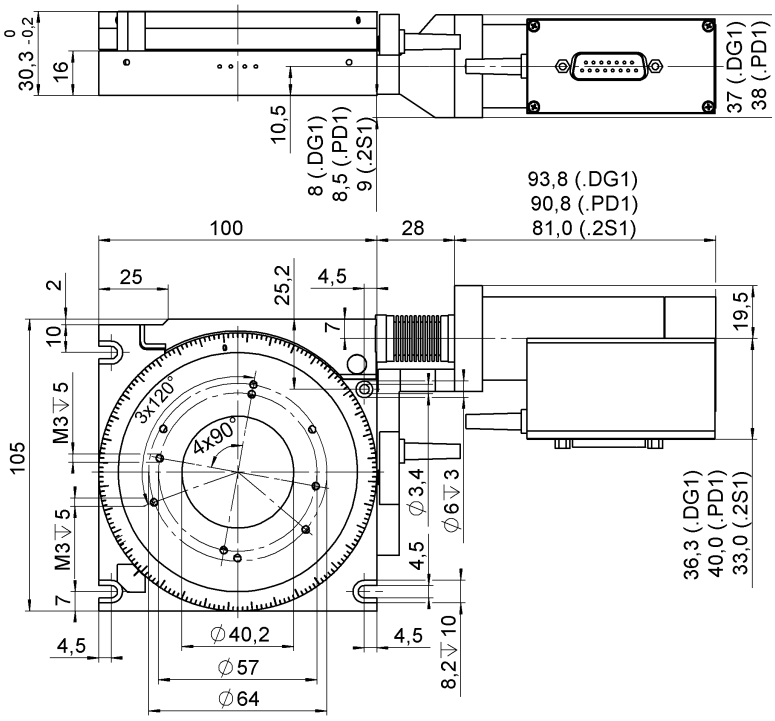
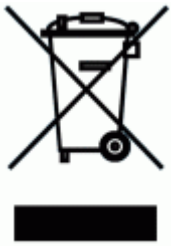


Fig. 10: M-038 motorized models

5 Old Equipment Disposal

In accordance with EU directive 2002 / 96 / EC (WEEE), as of 13 August 2005, electrical and electronic equipment may not be disposed of in the member states of the EU mixed with other wastes.

To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG will ensure environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.



If you have such old equipment from PI, you can send it to the following address postage-free:

Physik Instrumente (PI) GmbH & Co. KG
Auf der Römerstr. 1
76228 Karlsruhe, Germany