

MP47E M-06x Rotation Stage User Manual

Version: 2.0.0

Date: 29.05.2015



This document describes the following precision rotation stages (>360°):

- M-06x.DG:
with closed-loop DC gear motor
- M-06x.PD:
with DC motor and PWM control
- M-06x.2S:
with 2-phase stepper motor
- M-06x.M0:
with manual drive

x stands for the platform diameter:

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



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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) on our website.



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1 About this Document

In this Chapter

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1.1 Objective and Target Audience of this User Manual

This user manual contains the information needed for the intended use of the M-06x. The stages of the M-060, M-061 and M-062 series are summarized under the designation M-06x in this manual. (x stands for the platform diameter here. Details can be found in the model overview (p. 7)).

Basic knowledge of servo systems, motion control concepts and applicable safety measures is assumed.

The latest versions of the user manuals are available for download (p. 3) on our website.

1.2 Symbols and Typographic Conventions

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

NOTICE



Dangerous situation

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

- Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/Label	Meaning
1.	Action consisting of several steps whose sequential order must be observed
2.	
➤	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)
	Warning sign on the product which refers to detailed information in this manual.

1.3 Definition

Term	Explanation
Load capacity	Maximum load capacity in the vertical direction when the rotation stage is mounted horizontally. The contact point of the load is in the center of the platform.
Incremental position sensor	Sensor (encoder) for capturing changes of position or changes of angle. Signals from the incremental position sensor are used for axis position feedback. After switching on the controller a reference point definition must be performed before absolute target positions can be commanded and reached.

1.4 Figures

For better understandability, the colors, proportions and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

1.5 Other Applicable Documents

The devices and software tools which are mentioned in this documentation are described in their own manuals.

Product	Document
C-863.11 DC Motor Controller	MS205E User Manual
C-663.11 Stepper Motor Controller	MS208E User Manual
C-843 DC Motor Controller PCI Board	MS77E User Manual
C-884 DC Motor Controller	MS213E User Manual
Stages with electric motors	MP119EK Short Instructions

1.6 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 37).

INFORMATION

For some products (e.g. Hexapod systems and electronics that are delivered with a CD), access to the manuals is password-protected. The password is stored on the CD. Availability of the manuals:

- Password-protected manuals: FTP download directory
- Freely available manuals: PI website
- Follow the corresponding instructions for downloading.

Downloading freely accessible manuals

1. Open the website <http://www.pi-portal.ws>.
2. Click **Downloads**.
3. Click the corresponding product category.
4. Go to the corresponding product code.

The available manuals are displayed.

5. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

Downloading password-protected manuals

1. Insert the product CD in the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including ***releasenews*** in the file name).
4. Find the user name and the password in the section "User login for software download" in the Release News.
5. Open the FTP download directory (ftp://pi-ftp.ws).
 - Windows operating systems: Open the FTP download directory in Windows Explorer.
6. Log in with the user name and the password from the Release News.
7. In the directory of the corresponding product, go to the Manuals sub-directory.
8. Copy the desired manual to the hard disk of your PC or to a data storage medium.

2 Safety

In this Chapter

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2.1 Intended Use

The M-06x is a laboratory device as defined by DIN EN 61010. It is intended for indoor use and use in an environment that is free of dirt, oil and lubricants.

In accordance with its design and realization, the M-06x is intended for single-axis positioning, adjusting and shifting of loads at different velocities. The M-06x is **not** intended for applications in areas in which a failure would present severe risks to human beings or the environment.

The M-06x is intended for horizontal or vertical mounting. For the load limits with vertical mounting, see "General Notes on Installation" (p. 17).

The intended use of the M-06x is only possible when completely mounted and connected.

The M-06x must be operated with a suitable controller (p. 13). The controller is not included in the scope of delivery of the M-06x.

2.2 General Safety Instructions

The M-06x is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the M-06x.

- Only use the M-06x for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the M-06x.

2.3 Organizational Measures

User manual

- Always keep this user manual available with the M-06x.
The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or technical notes.
- If you give the M-06x to other users, also include this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in damage to equipment.
- Only install and operate the M-06x after you have read and understood this user manual.

Personnel Qualification

The M-06x may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.

3 Product Description

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3.1 Model Overview

Classification of the stages

The stages of the M-060, M-061 and M-062 series are summarized in this manual under the designation M-06x.

All models are precision rotation stages with backlash-compensated worm drives and a continuous travel range in both directions of rotation. They differ with respect to:

- Platform diameter
- Drive type

Model	Platform diameter [mm]		
	60	100	120
M-060.xx	+		
M-061.xx		+	
M-062.xx			+

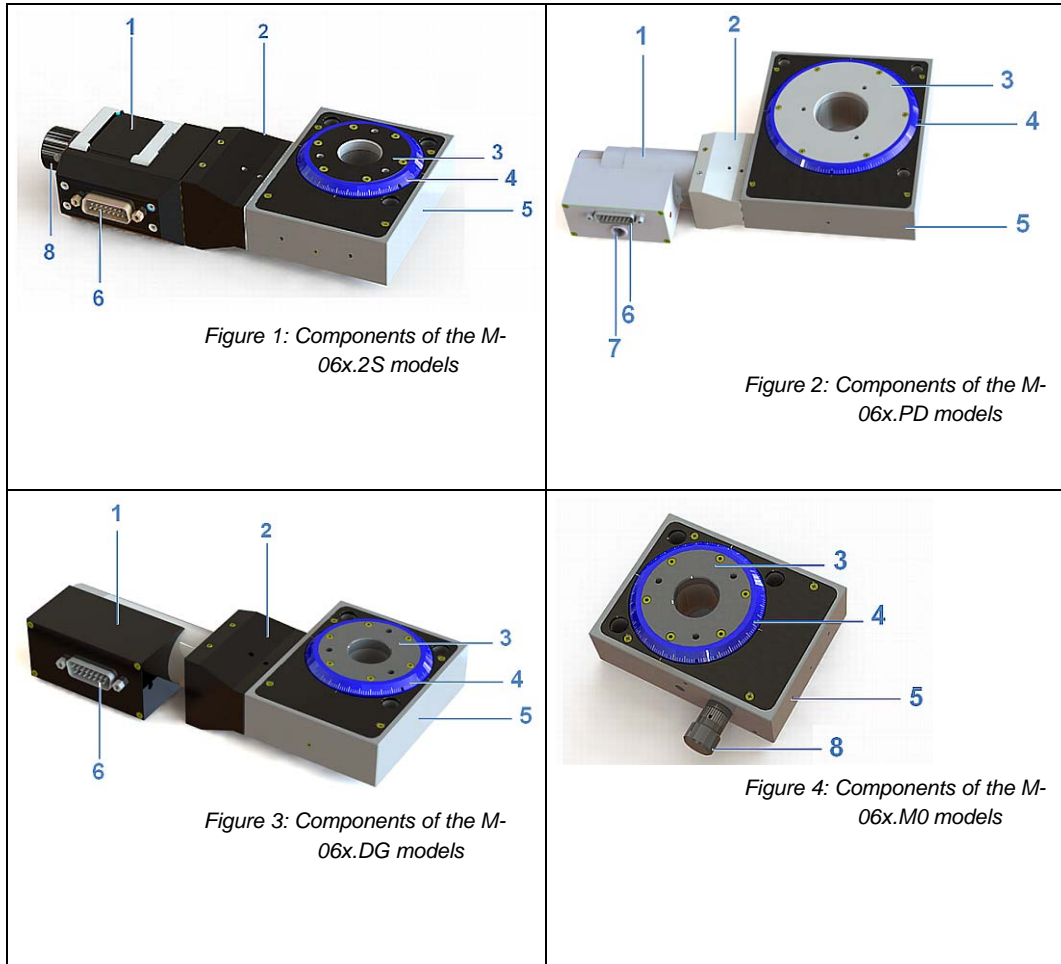
Model	Drive type			
	DC motor		Stepper motor	Manual
	Direct drive, PWM	Gearhead, analog		
M-06x.PD	+			
M-06x.DG		+		
M-06x.2S			+	
M-06x.M0				+

Detailed model overview

Order number	Product name
M-060.2S	Precision Rotation Stage, Ø 60 mm, 360°, 2-Phase Stepper Motor
M-060.DG	Precision Rotation Stage, Ø 60 mm, 360°, closed-loop DC Gear Motor
M-060.M0	Precision Rotation Stage, Ø 60 mm, 360°, Manual Drive
M-060.PD	Precision Rotation Stage, Ø 60 mm, 360°, ActiveDrive DC Motor
M-061.2S	Precision Rotation Stage, Ø 100 mm, 360°, 2-Phase Stepper Motor
M-061.DG	Precision Rotation Stage, Ø 100 mm, 360°, closed-loop DC Gear Motor
M-061.M0	Precision Rotation Stage, Ø 100 mm, 360°, Manual Drive
M-061.PD	Precision Rotation Stage, Ø 100 mm, 360°, ActiveDrive DC Motor
M-062.2S	Precision Rotation Stage, Ø 120 mm, 360°, 2-Phase Stepper Motor
M-062.DG	Precision Rotation Stage, Ø 120 mm, 360°, closed-loop DC Gear Motor
M-062.M0	Precision Rotation Stage, Ø 120 mm, 360°, Manual Drive
M-062.PD	Precision Rotation Stage, Ø 120 mm, 360°, ActiveDrive DC Motor

➤ For further technical data, see the specifications (p. 39).

3.2 Product View



- 1 Motor
- 2 Motor flange
- 3 Platform
- 4 Scale ring
- 5 Base body
- 6 Controller connection (Sub-D 15 panel plug)
- 7 Power supply connection (Mini XLR3 panel plug)
- 8 Handwheel

3.3 Product Labeling

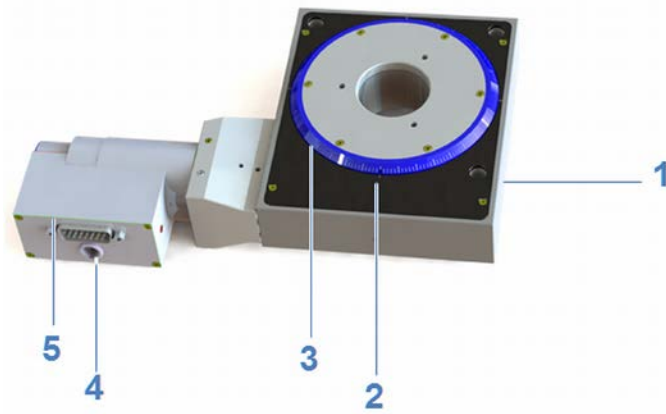




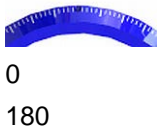


Figure 5: Position of the product labeling

Position	Labeling	Description
1		Manufacturer's logo
1		CE conformity mark
1		Warning sign "Observe manual!"
1	M-060.PD	Product name (example), the places after the point refer to the model
1	113050975	Serial number (example), individual for each M-06x Meaning of the places (counting from left): 1 = internal information, 2 and 3 = manufacturing year, 4 to 9 = consecutive numbers
1	WWW.PI.WS	Manufacturer's address (website)
1		Old equipment disposal (p. 49)
1	Country of origin: Germany	Country of origin
2	0	0° mark in the base body

Position	Labeling	Description
3	 <p>0 180</p>	Graduation on the scale ring of the moving platform (detail) <ul style="list-style-type: none"> ▪ Short line: 2° ▪ Medium line: 10° ▪ Long line: 90° and 270° ▪ Numbers: 0° and 180°
4	24 VDC	Power supply connection (only for M-06x.PD models)
5	Controller	Controller connection (only for M-06x.DG, M-06x.PD and M-06x.2S models)

3.4 Direction of Motion

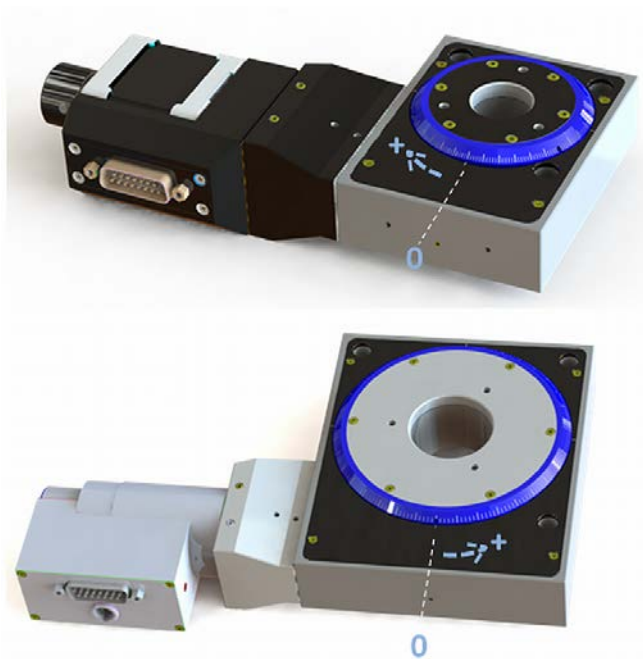


Figure 6: Direction of motion of the M-06x.2S (top) and M-06x.PD / M-06x.DG (bottom) models

- + Direction of motion on positive command
- 0 0° mark in the base body: After a reference move, the 0° mark on the scale ring of the moving platform is above the 0° mark in the base body.

3.5 Scope of Delivery

Item number	Component
M-06x.xx	Rotation stage according to the order (p. 7)
MP119EK	Short instructions for stages with electric motors
Only M-060.xx models:	
2493	Screw set for mounting the rotation stage: <ul style="list-style-type: none"> ▪ 6 M4x12 socket head cap screws ISO 4762 ▪ Allen wrench AF 3 DIN 911
Only M-061.xx / M-062.xx models:	
2498	Screw set for mounting the rotation stage: <ul style="list-style-type: none"> ▪ 6 M4x16 socket head cap screws ISO 4762 ▪ Allen wrench AF 3 DIN 911
Only M-06x.DG / M-06x.PD / M-06x.2S models:	
C-815.38	Motor cable, 3 m, Sub-D 15 (m/f)
Only M-06x.PD models:	
C-663.PS	Wide-range-input power supply 24 V / 42 W
3763	Power cord
K050B0002	Adapter from 5.5 mm x 2.1 mm barrel connector to Mini XLR3 (f) for the power supply connection

3.6 Accessories

Order number	Description
C-815.83	Motor cable, 10 m, Sub-D 15 (m/f)

To order, contact our customer service department (p. 37).

3.7 Suitable Controllers

For the M-06x.DG, M-06x.PD and M-06x.2S models, the following applies:

The M-06x must be connected to a suitable controller. The following controllers from PI are suitable for the operation of the M-06x:

Drive type	Controller	Axes per controller	PC interface	Multiple controllers on the same PC
DC motor	C-843	2 or 4	Internal (PCI bus)	Yes, separate boards
	C-863	1	USB, RS-232, daisy chain	Yes, same interface
	C-884	1 to 4	USB, RS-232, TCP/IP	Yes
Stepper motor	C-663	1	USB, RS-232, daisy chain	Yes, same interface

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

3.8 Technical Features

3.8.1 Encoder

The M-06x.DG and M-06x.PD models are equipped with an incremental rotary encoder. For the encoder resolution, refer to the table in the "Specifications" section (p. 39).

A rotary encoder is implemented at a rotating point in the drivetrain, e.g. the motor shaft.

3.8.2 Reference Point Switch

The M-06x.DG, M-06x.PD and M-06x.2S models are equipped with a direction-sensing reference point switch (see "Reference Point Switch Specifications" (p. 41)).

The commands that use the reference signal are described in the user manual of the controller and/or in the corresponding software manuals.

After a reference move of the M-06x, the 0° mark on the scale ring of the moving platform is above the 0° mark in the base body.

3.8.3 Integrated PWM Amplifier

The M-06x.PD models with direct drive are equipped with a PWM amplifier ("ActiveDrive concept"). The PWM amplifier only receives the control signals from the controller, whereas the supply voltage is provided via an external power supply. The ActiveDrive concept allows high motor power and dynamics at low power loss.

4 Unpacking

1. Unpack the M-06x with care.
2. Compare the contents against the items covered by the contract and against the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

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5.1 General Notes on Installation

5.1.1 Notes on all Models

NOTICE



Unintentional changes in position with vertical mounting!

If the load exceeds the self-locking of the drive when the stage is mounted vertically, unintentional changes in the position of the moving platform occur. Unwanted changes in the position of the moving platform can damage the drive, the load or the environment.

- When the stage is mounted vertically, make sure that the installed load is lower than the self-locking of the drive.

INFORMATION

For optimum repeatability, all components must be firmly affixed to each other.

- If possible, simulate the rotation stage motions with a mounted load or make suitable calculations to detect collisions or unfavorable center of gravity constellations.
- If necessary, take suitable constructive measures to avoid collisions and instability in the overall system.

- Avoid or mark danger zones that result from the installation of the rotation stage and the application, in accordance with the legal regulations.

5.1.2 Notes on Models with a Motor

NOTICE



Cable break!

A cable break leads to a failure of the rotation stage.

- Install the rotation stage so that the cable is not bent or crushed too strongly during operation.
- M-06x.DG and M-06x.PD models: If you change the connection orientation of the rotation stage (p. 18), avoid overstretching the cable between the motor flange and the motor case.

NOTICE



Heating up of the M-06x during operation!

The heat produced during operation of the M-06x can affect your application.

- Install the M-06x so that your application is not affected by the dissipating heat.

5.2 Optional: Modifying the Connection Orientation on the M-06x

INFORMATION

Motor and connections of the M-06x.DG and M-06x.PD models can be rotated around the axis of the motor and fixed at any position.

- Check whether the connections of the rotation stage are at a position that is suitable for your installation situation.

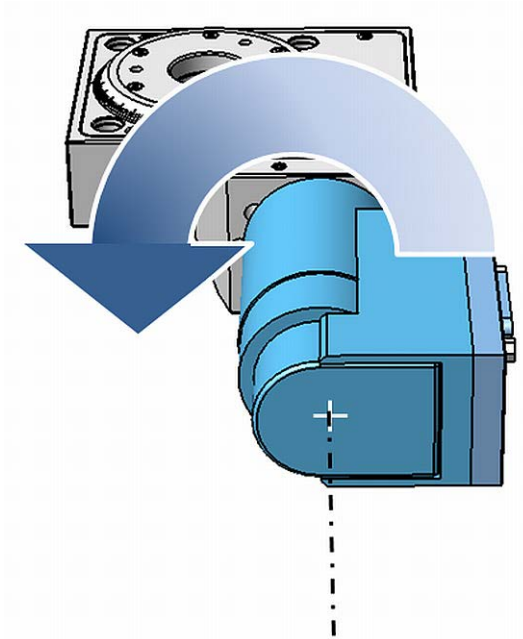


Figure 7: Optional: Continuous rotation of the motor around its axis

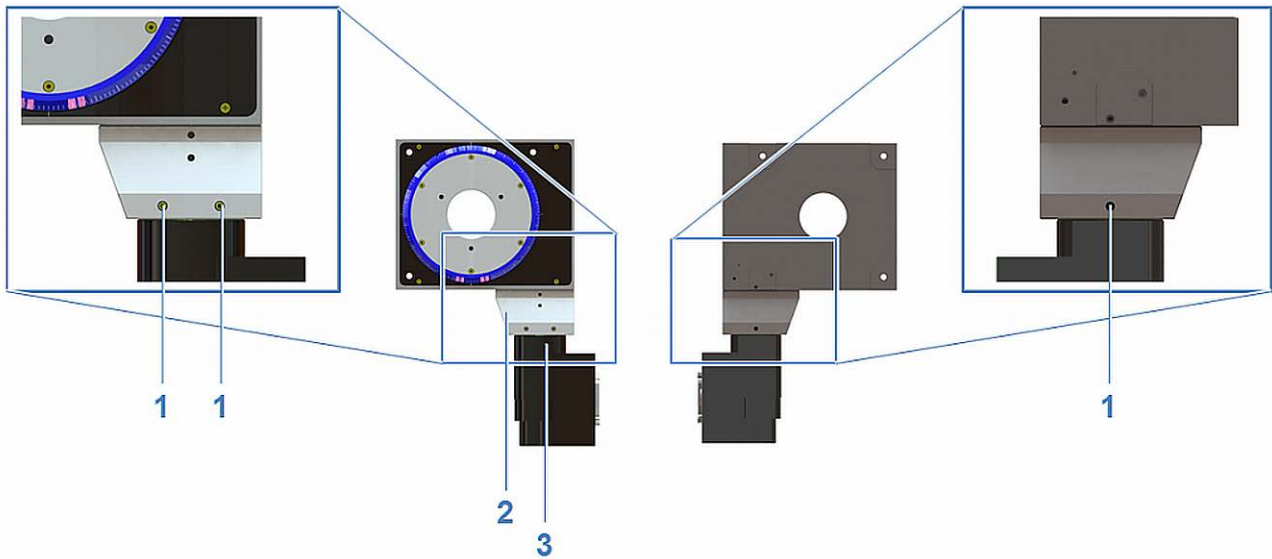


Figure 8: Position of the grub screws on the motor flange (left: top side, right: bottom side)

- 1 Grub screw
- 2 Motor flange
- 3 Motor case

Prerequisites

- ✓ The rotation stage is **not** mounted on a surface.
- ✓ The rotation stage is **not** connected to the controller and the power supply.

Tools and accessories

- Allen wrench AF 2

Changing the orientation for connection

1. Turn out the grub screws on the motor flange of the rotation stage (see figure) by a few rotations.
2. Rotate the motor case with the connections to the desired orientation:
 - Avoid overstretching the cable between the motor flange and the motor case.
 - Make sure that **no** cables are crushed or bent at the desired orientation.
3. Tighten the grub screws on the motor flange.
4. Check that the motor case is affixed firmly to the motor flange.

5.3 Optional: Aligning the Hole Pattern of the Platform

INFORMATION

If necessary, you can change the orientation of the 0° mark to the hole pattern for mounting a load. The change is made by rotating the scale ring on the moving platform.

- Note the following: Irrespective of how the scale ring is oriented on the moving platform, the 0° mark on the scale ring is always above the 0° mark in the base body of the M-06x after a reference move.

The scale ring is fixed on the moving platform of the M-06x with three grub screws.

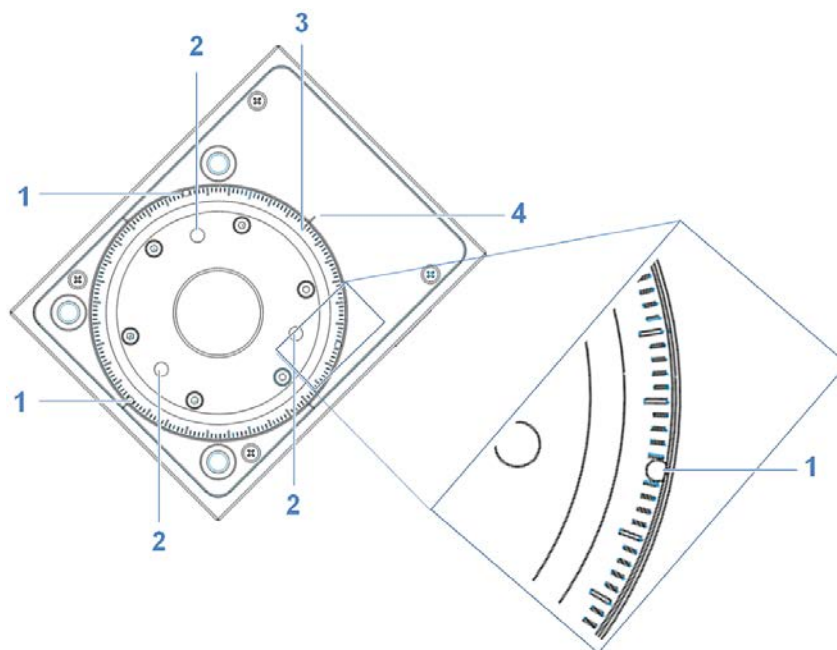


Figure 9: Position of the grub screws on the scale ring

- 1 Access to the grub screw
- 2 Mounting hole for load
- 3 Scale ring
- 4 0° mark in the base body

Prerequisites

- ✓ M-06x.DG / M-06x.PD / M-06x.2S models: The rotation stage is **not** connected to the controller and the power supply.

Tools and accessories

- Allen wrench AF 0.9

Aligning the hole pattern of the platform

1. Turn out the three grub screws on the scale ring (see figure) by a few rotations.
2. Rotate the scale ring until it has reached the desired orientation to the hole pattern of the platform.
3. Tighten the grub screws on the scale ring.
4. Check that the scale ring is affixed firmly.

5.4 Mounting the M-06x on a Surface

NOTICE



Warping of the M-06x due to mounting on uneven surfaces!

Mounting the M-06x on an uneven surface can warp the M-06x. Warping reduces the accuracy.

- Mount the M-06x on an even surface. The recommended evenness of the surface is $\leq 10 \mu\text{m}$.
- For applications with large temperature changes:
Only mount the M-06x on surfaces that have the same or similar thermal expansion properties as the M-06x.

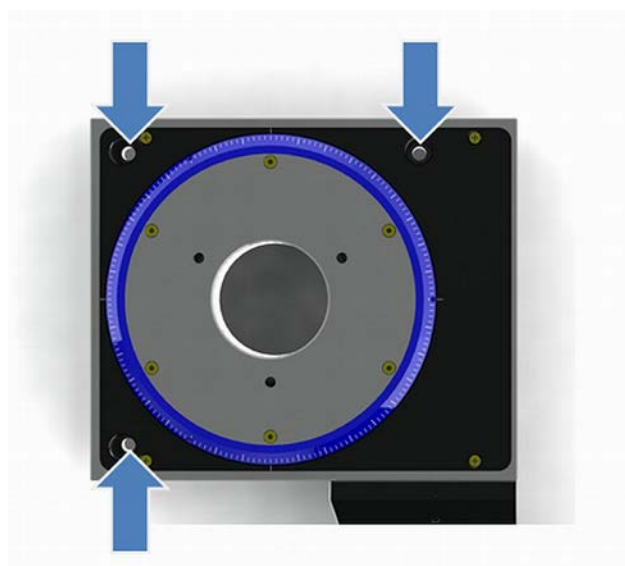


Figure 10: Position of the holes for mounting the rotation stage on a surface

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ You have provided a suitable surface (for the required position and depth of the holes for accommodating the screws, see "Dimensions" (p. 42)):
 - There are three M4 threaded holes.
 - The evenness of the surface is $\leq 10 \mu\text{m}$.

- For applications with large temperature changes: The surface should have the same thermal expansion properties as the M-06x (e.g. surface made of aluminum).
- ✓ You have accounted for the space required to route cables without bending and according to regulations.
- ✓ M-06x.DG / M-06x.PD / M-06x.2S: The rotation stage is **not** connected to the controller and the power supply.

Tools and accessories

- Mounting accessories, in the scope of delivery (p. 12):
 - M-060.xx: 3 M4x12 screws
 - M-061.xx / M-062.xx: 3 M4x16 screws
 - Allen wrench AF 3

Mounting the rotation stage on a surface

1. Align the rotation stage on the surface so that the corresponding mounting holes in the rotation stage and the surface overlap.
2. Completely screw in the screws into all mounting holes.
3. Check that the rotation stage is affixed firmly to the surface.

5.5 Affixing the Load to the M-06x

NOTICE



Impermissibly high load on the rotation stage!

An impermissibly high load interferes with the motion of the moving platform and can damage the rotation stage.

- In respect to the mass and mounting type of the load, observe the maximum permissible forces that are allowed to act on the moving platform according to the specification (p. 39).

NOTICE



Screws that are too long!

Screws that are inserted too deeply can damage the M-06x.

- Observe the depth of the mounting holes in the moving platform (p. 42).
- Only use screws of the correct length for the respective mounting holes.

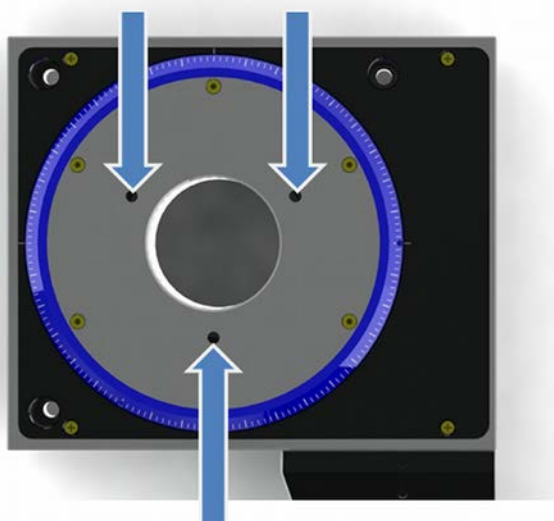


Figure 11: Position of the mounting holes for affixing the load

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ You have properly attached the rotation stage to a surface (p. 22).
- ✓ M-06x.DG / M-06x.PD / M-06x.2S: The rotation stage is **not** connected to the controller and the power supply.
- ✓ You have prepared the load so that it can be affixed to the mounting holes on the moving platform:
 - The distance between the center of gravity of the load and the center of the platform is as small as possible in all directions.
 - At least two points are provided for mounting the load on the platform (ideally: three attachment points).

Tools and accessories

- At least 2 M4 screws of suitable length
- Suitable tools for fastening the screws

Affixing the Load

1. Align the load so that the selected mounting holes in the platform can be used to affix it.
2. Use the screws to affix the load on the selected mounting holes in the platform.
3. Check that the load is affixed firmly to the platform of the rotation stage.

5.6 Connecting the Motor Cable to the M-06x

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ The motor cable is **not** connected to the controller.

Tools and accessories

- Suitable motor cable from PI, e.g.:
 - C-815.38 motor cable, 3 m, Sub-D, 15-pin (m/f), in the scope of delivery (p. 12).
 - C-815.83 motor cable, 10 m, Sub-D, 15-pin (m/f), available as optional accessory (p. 12).

Connecting the motor cable to the M-06x

1. Connect the connector (f) of the motor cable to the Sub-D 15-pin panel plug (m) of the rotation stage.
2. Secure the connector (f) with the two integrated screws against being unintentionally pulled out of the rotation stage.

5.7 Connecting the Power Supply to the M-06x

Connecting a power supply is only necessary for the M-06x.PD models.

Prerequisites

- ✓ The power cord is **not** connected to the power socket.

Tools and accessories

- Supplied components:
 - 24 V wide-range-input power supply
 - Adapter for the power supply connection; barrel connector 5.5 mm x 2.1 mm to Mini XLR3 (f)
 - Power cord
- If one of the components supplied for connection to the power source has to be replaced: Use a sufficiently measured and certified replacement component. Details:
 - Power supply: Output 24 V DC, maximum output current 2 A
 - Power cord: Three wires, cable cross section at least 3 x 0.75 mm² (3 x AWG18), maximum length 2 m

Connecting the power supply to the M-06x

- Connect the Mini XLR3 connector (f) of the adapter to the Mini XLR3 panel plug of the M-06x.
- Connect the barrel connector of the adapter to the barrel connector socket of the power supply.
- Connect the power cord to the power supply.

6 Start-Up

In this Chapter

General Notes on Start-Up	27
Starting Up the rotation stage	29

The instructions and descriptions in this chapter apply to models with a motor (M-06x.DG, M-06x.PD, M-06x.2S).

6.1 General Notes on Start-Up

NOTICE



Damage from collisions!

Collisions can damage the rotation stage, the load to be moved and the environment.

- Make sure that no collisions are possible between the rotation stage, the load to be moved and the environment in the motion range of the rotation stage.
- Do not place any objects in areas where they can get caught by moving parts.
- Stop the motion immediately if a controller malfunction occurs.
- If possible, adapt the travel range limits of your mechanical system in the software that you use for commanding the motion.

NOTICE



Damage if an incorrect controller is connected!

Connecting a rotation stage to an unsuitable controller can cause damage to the rotation stage or controller.

- Connect a rotation stage with DC motor to a DC motor controller only.
- Connect a rotation stage with stepper motor to a stepper motor controller only.
- If you use controllers and software from other manufacturers, check their technical data to make sure that they are suitable before starting up the stage!

NOTICE**Operating voltage too high or incorrectly connected!**

Operating voltages that are too high or incorrectly connected can cause damage to the M-06x.

- Do **not** exceed the operating voltage range (p. 41) for which the M-06x is specified.
- Only operate the M-06x when the operating voltage is properly connected; see "Pin Assignment" (p. 46).

NOTICE**Damage or considerable wear due to high accelerations!**

High accelerations can cause damage to or considerable wear on the mechanical system.

- Stop the motion immediately if a controller malfunction occurs.
- Determine the maximum velocity for your application.

NOTICE**Unintentional motions!**

When the M-06x is being connected to the controller, it can carry out unintentional motions. Defective software or wrong operation of the software can also result in unintentional motions.

- Do not place any objects in areas where they can get caught by moving parts.
- Before connecting the M-06x, check whether a macro is defined as the start-up macro in the controller, and cancel the selection of the start-up macro if necessary.

INFORMATION

The maximum velocity for a rotation stage with a stepper motor should be determined in the application. If the commanded velocity is too high, the stepper motor might stop without the controller detecting this condition.

INFORMATION

The repeatability of the positioning is only ensured when the reference point switch is always approached from the same side. Controllers from PI fulfill this requirement due to the automatic direction sensing for reference moves to the reference point switch.

INFORMATION

For models with DC motors:

Unsuitable settings made to the servo-control parameters can impair the performance of the M-06x. The consequences of this can be expressed as follows:

- Oscillations
- Imprecise approach of the position
- Settling time is too long
- If the performance of the M-06x is not satisfactory, check the settings for the servo-control parameters of your controller.

6.2 Starting Up the Rotation Stage

Prerequisites

- ✓ You have read and understood the General Notes on Start-Up (p. 27).
- ✓ You have properly installed the stage (p. 17).
- ✓ You have read and understood the user manual of the controller used.
- ✓ You have read and understood the manual of the PC software used.
- ✓ The controller and the required PC software have been installed. All connections on the controller have been set up (see user manual of the controller; the stage is connected via the motor cable).

Starting up the rotation stage

1. Only M-06x.PD models: Connect the power cord of the power supply to the power socket.
2. Start up the controller (see user manual of the controller).

Configure the controller during start-up using the PC software for the stage used (see user manual of the controller and of the PC software):

- If you use a controller from PI: Select the entry in the stage database that exactly fits the stage model used (p. 30).

- If you use a controller from another manufacturer: Enter the parameters into the corresponding PC software that exactly fit the stage model used; see the overview of the operating parameters for DC motor controllers (p. 30) or stepper motor controllers (p. 31).
- 3. Start a few motion cycles for testing purposes (see user manual of the controller).

6.2.1 M-06x Entries in the Stage Database of PI

For controllers from PI, you can select the connected rotation stage from a stage database in the corresponding PC software. The appropriate operating parameters are thus loaded to the controller. You can find a detailed description in the user manual for the controller or in the manual for the PC software used.

INFORMATION

For models with an analog DC gear motor, the stage database contains entries with the name affix "-PWM". When these entries are used, the controller outputs PWM signals for operating the stage. The PWM signals must be converted into the analog signal for the stage by external electronics (PWM/analog converter and separate amplifier).

- Only select an entry containing "-PWM" after you have consulted our customer service department (p. 37) and provided suitable external electronics in your application.

6.2.2 Operating Parameters of the Models with DC Motor

If you use a DC motor controller from a third-party supplier, it may be necessary to enter operating parameters for adaptation to the rotation stage used.

Parameter	M-060 model		M-061 model		M-062 model		Unit
	.DG	.PD	.DG	.PD	.DG	.PD	
P term	800	350	260	380	260	450	-
I term	300	450	130	150	130	280	-
D term	450	500	280	350	280	500	-
I limit	2000	2000	2000	2000	2000	2000	-
Maximum acceleration	100	1000	100	1000	100	1000	%/s ²

Parameter	M-060 model		M-061 model		M-062 model		Unit
	.DG	.PD	.DG	.PD	.DG	.PD	
Maximum velocity*	16	90	9	90	7.5	90	°/s
Maximum velocity*	131742	50000	133388	90000	135859	110000	counts/s
Motor gear ratio	29.6:1		29.6:1		29.6:1		-
Worm gear ratio	50:1	50:1	90:1	90:1	110:1	110:1	
Encoder resolution	8233	556	14820	1000	18115	1222	counts/°

* **Not** recommended for continuous operation

6.2.3 Operating Parameters of the Models with Stepper Motor

If you use a stepper motor controller from a third-party supplier, it may be necessary to enter operating parameters for adaptation to the rotation stage used.

Parameter	M-060.2S	M-061.2S	M-062.2S	Unit
Recommended start values:				
Holding current	200			mA
Operating current	600			mA
Holding current delay	500			ms
Max. motor current	850			mA
Max. acceleration	100			°/s ²
Max. velocity	36	20	16	°/s
Max. velocity*	18	10	8	°/s
Hardware properties:				
Full steps	400			steps/motor revolution
Phase resistance	6.6			ohm
Max. phase current, bipolar	850			mA

* Recommended for continuous operation

7 Maintenance

In this Chapter

General Notes on Maintenance.....	33
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Cleaning the M-06x	34

7.1 General Notes on Maintenance

NOTICE



Damage due to improper maintenance!

Improper maintenance can lead to misalignment and failure of the M-06x.

- Only loosen screws according to the instructions in this manual.

7.2 Performing a Maintenance Run

Depending on the operating conditions and the period of use of the M-06x, the following maintenance measures are required:

Maintenance run

The maintenance run serves to distribute the existing lubricant.

- To evenly distribute the existing lubricant, perform a maintenance run over at least 360° after 500 hours of operation or after 1 year at the latest.
- If you operate the M-06x continuously over a small working range (<20°), perform a maintenance run over at least 360° every 5000 motion cycles.

Lubrication

Under laboratory conditions, the rotation stage only needs extra lubrication in exceptional cases. For continuous industrial use, the lubrication intervals must be defined individually.

- Do **not** lubricate the M-06x without consulting our customer service department (p. 37).
- To lubricate, follow the instructions in the maintenance manual which you can obtain from our customer service department.

7.3 Cleaning the M-06x

Prerequisites

- ✓ You have disconnected the rotation stage from the controller and the power supply.

Cleaning the rotation stage

- If necessary, clean the surfaces of the rotation stage with a cloth that is lightly dampened with a mild cleanser or disinfectant.

8 Troubleshooting

Problem	Possible causes	Solution
Reduced positioning accuracy	Warped base body	➤ Mount the M-06x on an even surface. The recommended evenness of the surface is 10 µm.
	Increased wear due to small motions over a long period of time	➤ Perform a maintenance run over at least one rotation of the platform.
Only M-06x.DG, M-06x.PD and M-06x.2S models: Impairment of the function after system modification	<ul style="list-style-type: none"> ▪ Controller has been replaced. ▪ M-06x has been replaced with another model. 	<p>Controller from PI:</p> <ul style="list-style-type: none"> ➤ Load the parameters from the stage database that correspond to the combination of controller and M-06x model. <p>Controller from a third-party supplier:</p> <ul style="list-style-type: none"> ➤ Check the operating parameters.
Only M-06x.DG, M-06x.PD and M-06x.2S models: Mechanical system does not move; no operating noise can be heard.	Controller and/or power supply are incorrectly connected or defective.	<ul style="list-style-type: none"> ➤ Check all connecting cables. ➤ Check the controller. ➤ If present: Check the power supply of the stage.

Problem	Possible causes	Solution
	When a controller from PI is used: There is a motion error of the axis.	<p>Motion error = The difference between the current position and the commanded position exceeds the specified maximum value in closed-loop operation. For example, motion errors can be caused by malfunctions of the drive or the position sensor of the stage.</p> <ol style="list-style-type: none"> 1. Read out the error code of the controller in the PC software. If there is a motion error, error code -1024 is output. 2. Check your system and make sure that all axes can be moved safely. 3. Switch on the servo mode in the PC software for the affected axis. <p>For details, see the user manual of the controller.</p>
Only M-06x.2S models: The mechanical system no longer moves but generates operating noise.	The motor is overloaded by an external load torque or the mass to be driven in the case of strong acceleration or deceleration.	<p>The motor skips steps. The information on the current position is lost without the controller recognizing this state.</p> <ul style="list-style-type: none"> ➤ Determine the maximum acceleration and velocity in the application for the rotation stage.

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 37).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (<mailto:info@pi.ws>).

- If you have questions concerning your system, have the following information ready:
 - Product codes and serial numbers of all products in the system
 - Firmware version of the controller (if present)
 - Version of the driver or the software (if present)
 - Operating system on the PC (if present)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

The latest versions of the user manuals are available for download (p. 3) on our website.

10 Technical Data

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10.1 Specifications

10.1.1 Data Table

	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	Unit	Tolerance
Active axes	Rotation	Rotation	Rotation	Rotation		
Motion and positioning						
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 x 10 ⁻⁵) / 0.96 (5.5 x 10 ⁻⁵)	19.7 (0.0011) / 10.9 (0.00063) / 8.9 (0.00051)*	μrad (°)	
Incremental motion	–	32 / 17.5 / 15	6.3 / 6 / 5	40 / 20 / 18*	μrad	min.
Backlash	–	200 / 200 / 240	200 / 200 / 240	200 / 200 / 240	μrad	
Unidirectional repeatability	–	50 / 50 / 60	50 / 50 / 60	50 / 50 / 60	μrad	
Velocity	–	90	16 / 9 / 7.5	36 / 20 / 16	°/s	max.
Mechanical properties						
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) 4:1 29.6:1	–		

	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	Unit	Tolerance
Motor resolution	–	–	–	6400*	steps/rev.	
Load capacity / axial force	±500 / ±550 / ±650	±500 / ±550 / ±650	±500 / ±550 / ±650	±500 / ±550 / ±650	N	
Torque θ_x , θ_y	±6 / ±6 / ±7	±6 / ±6 / ±7	±6 / ±6 / ±7	±6 / ±6 / ±7	Nm	max.
Torque θ_z	±4 / ±6 / ±8	±4 / ±6 / ±8	±4 / ±6 / ±8	±4 / ±6 / ±8	Nm	max.
Drive properties						
Motor type	–	DC motor, ActiveDrive	DC gear motor	2-phase stepper motor**		
Operating voltage	–	24 (PWM)	12 differential	24	V	
Motor power	–	30	3	4.8	W	
Reference point switch	–	Hall effect	Hall effect	Hall effect		
Miscellaneous						
Operating temperature range	-10 to 40	-10 to 40	-10 to 40	-10 to 40	°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) C-843 PCI board, for up to 4 axes	C-663 (single-axis)		




Specifications for vacuum versions can differ.

* With C-663 stepper motor controller.

** Max. 0.85 A/phase; 400 full steps/rev..

10.1.2 Maximum Ratings

The M-06x rotation stages are designed for the following operating data:

Device	Maximum operating voltage 	Operating frequency 	Maximum power consumption 
M-06x.DG	12 V	0 Hz	3 W
M-06x.PD	24 V	0 Hz	30 W
M-06x.2S	24 V	0 Hz	4.8 W

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the M-06x:

Area of application	For indoor use only
Maximum altitude	2000 m
Relative humidity	Max. 80 % for temperatures up to 31 °C Linearly decreasing to 50 % at 40 °C
Storage temperature	-10 °C to 40 °C
Transport temperature	-10 °C to 40 °C
Supply fluctuations	Max. ± 10 % of the nominal voltage
Degree of pollution	2
Degree of protection according to IEC 60529	IP40

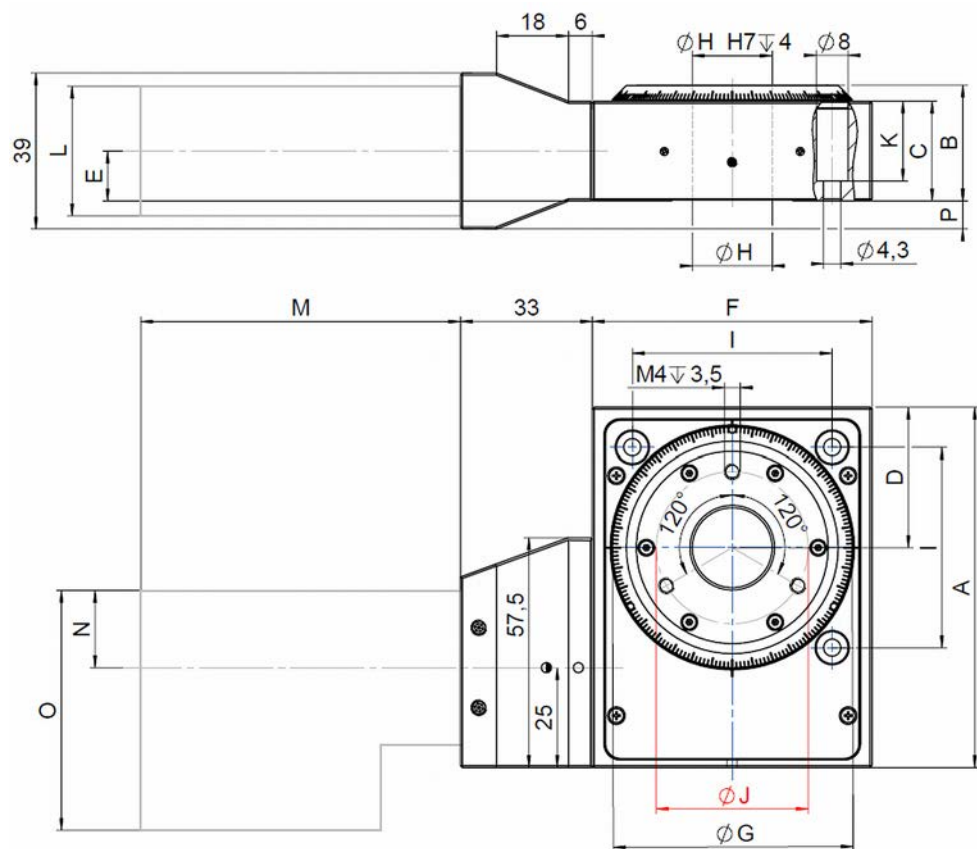
10.1.4 Reference Point Switch Specifications

Type	Magnetic (Hall effect) sensor
Supply voltage	+5 V/GND, supplied via the motor connector
Signal output	TTL level

10.2 Dimensions

10.2.1 M-06x.DG / M-06x.PD / M-06x.2S Models

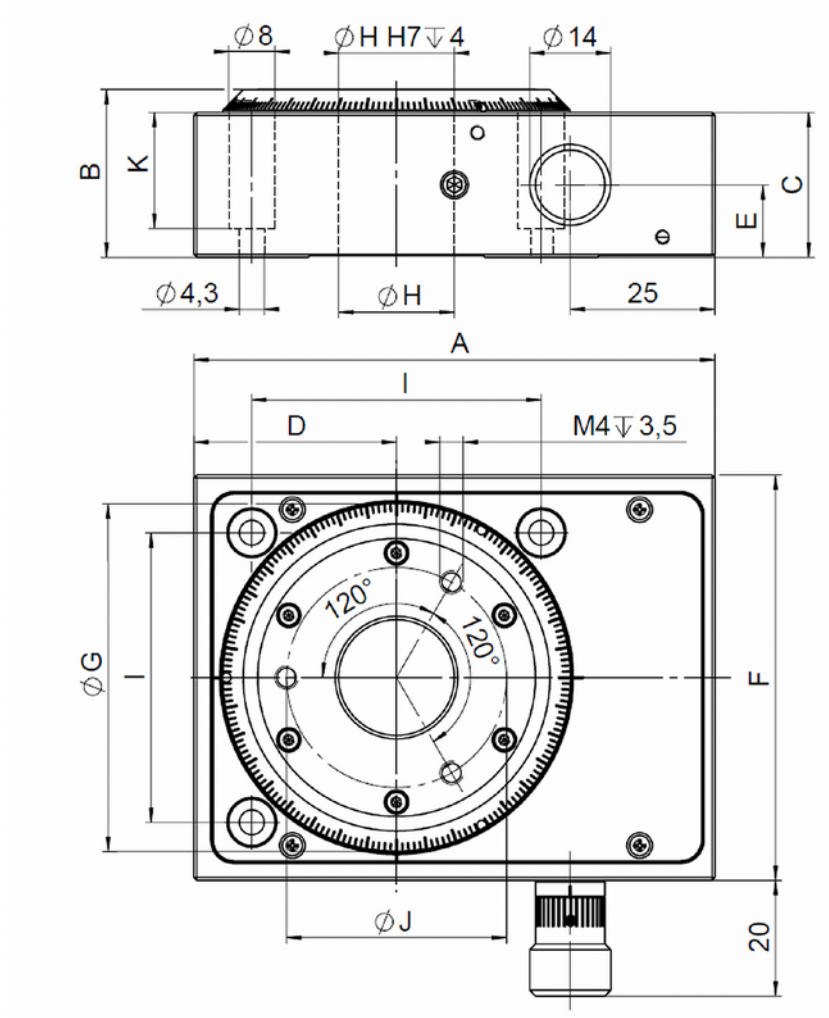
Dimensions in mm. Note that the decimal places are separated by a comma in the drawings



Series	M-060			M-061			M-062		
Model	PD	DG	2S	PD	DG	2S	PD	DG	2S
A	90	90	90	130	130	130	150	150	150
B	29	29	29	34	34	34	42	42	42
C	25	25	25	30	30	30	38	38	38
D	35	35	35	55	55	55	65	65	65
E	12.5	12.5	12.5	15	15	15	21.5	21.5	21.5
F	70	70	70	110	110	110	130	130	130
G	60	60	60	100	100	100	120	120	120
H	20	20	20	35	35	35	45	45	45
I	50	50	50	90	90	90	110	110	110
J	38	38	38	50	50	50	60	60	60
K	20	20	20	20	20	20	28	28	28
L	39	34	39	39	34	39	39	34	39
M	80.8	83.8	86.5	80.8	83.8	86.5	80.8	83.8	86.5
N	19	15	19.5	19	15	19.5	19	15	19.5
O	59.3	51.3	52.5	59.3	51.3	52.5	59.3	51.3	52.5
P	7	7	7	4.5	4.5	4.5	-	-	-

10.2.2 M-06x.M0 Models

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings



Model	M-060.M0	M-061.M0	M-062.M0
A	90	130	150
B	29	34	42
C	25	30	38
D	35	55	65
E	12.5	15	21.5
F	70	110	130
G	60	100	120
H	20	35	45
I	50	90	110
J	38	50	60
K	20	20	28

10.3 Pin Assignment

10.3.1 Sub-D 15 (m) Controller Connection

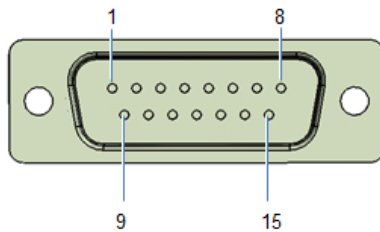


Figure 12: Sub-D 15 (m) controller connection, front view

M-06x.DG models

Pin	Signal	Direction
1	Not connected	-
9	Motor (-)	Input
2	Motor (+)	Input
10	GND	GND
3	Not connected	-
11	Not connected	-
4	+ 5 V (encoder)	Input
12	Not connected	-
5	Not connected	-
13	Reference	Output
6	GND	GND
14	Encoder A (+)	Output
7	Encoder A (-)	Output
15	Encoder B (+)	Output
8	Encoder B (-)	Output

M-06x.PD models

Pin	Signal	Direction
1	Not connected	-
9	Not connected	-
2	Not connected	-
10	GND	GND
3	MAGN (PWM magnitude)	Input
11	SIGN (PWM sign)	Input
4	+ 5 V	Input
12	Not connected	-
5	Not connected	-
13	Reference	Output
6	GND	GND
14	Encoder A (+)	Output
7	Encoder A (-)	Output
15	Encoder B (+)	Output
8	Encoder B (-)	Output

M-06x.2S models

Pin	Signal	Direction
1	Motor phase 1A	Input
9	Motor phase 1B	Input
2	Motor phase 2A	Input
10	Motor phase 2B	Input
3	Not connected	-
11	Not connected	-
4	Not connected	-
12	Not connected	-
5	Not connected	-
13	Not connected	-
6	+5 V	Input
14	Not connected	-
7	GND	GND
15	Reference	Output
8	Not connected	-

10.3.2 Mini XLR3 (m) Power Supply Connection

Connecting a power supply is only necessary with the M-06x.PD models.



Figure 13: Mini XLR 3 (m) power supply connection, front view

Pin	Signal	Direction
1	GND	GND
2	24 V DC supply voltage	Input
3	Not connected	-

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 fulfil its responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

Any old PI equipment can be sent free of charge to the following address:

Physik Instrumente (PI) GmbH & Co. KG

Auf der Roemerstr. 1

D-76228 Karlsruhe, Germany



12 EC Declaration of Conformity

For the M-06x, an EC Declaration of Conformity has been issued in accordance with the following European directives:

2004/108/EC, EMC Directive

2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

EMC: EN 61326-1:2013

Safety: EN 61010-1:2010

RoHS: EN 50581:2012

