

MP47E User Manual

M-060 Series Rotation Stages

Release: 1.4.1 Date: 2012-09-18



This document describes the following product(s):

- M-060.M0, M-060.PD, M-060.DG, M-060.2S
Rotation Stages, dia. 60 mm
- M-061.M0, M-061.PD, M-061.DG, M-061.2S
Rotation Stages, dia. 100 mm
- M-062.M0, M-062.PD, M-062.DG, M-062.2S
Rotation Stages, dia. 120 mm

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First printing 2012-09-18
Document Number MP47E, Release 1.4.1
M-060_User_MP47E141doc

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change without notice. Any change will be reflected in future printings.

About this Document

Users of this Manual

This manual is designed to help the reader to install and operate the M-060 Series 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-060 Series Rotation Stages as well as the software and hardware installation procedures which are required to put the associated motion system into operation.

This document is available as PDF file on the PI website (www.pi.ws), or write to 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.



DANGER

Indicates the presence of high voltage (> 50 V). 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-060 Series Rotation Stages, are described in their own manuals. All documents are available as PDF files on the PI website (www.pi.ws), or write to info@pi.ws.

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1 Introduction

1.1 M-060 Series Features

The M-060 to M-062 family of rotary stages all feature high-precision, preloaded worm gear drives that allow unlimited rotation in either direction. In addition, all motorized versions have a non-contact Hall effect reference switch and are available with optional limit switch outputs (with some limitation on travel range, if used). The models differ in turntable size and drive type. The ActiveDrive and DC motor/gearhead versions are equipped with optical encoders whereas the stepper-motor and manual versions are designed to operate in open-loop.

The ActiveDrive versions feature a direct-coupled motor/encoder with a high-efficiency PWM (pulse-width modulation) servo-amplifier mounted side-by-side with the motor. This design provides the highest performance in dynamic applications.

The DC motor/gearhead versions are equipped with shaft-mounted encoders. The gear ratio of 29.6 to 1 provides higher resolution than the direct drive motors.

The stepper motor versions use direct-drive, microstepped 2-phase stepper motors.

Manual versions are driven with a thumbwheel through a worm-gear drive with the same gear ratio as used in the motorized versions.

1.2 Safety Precautions



CAUTION

Torque Limit

Be careful not to exceed the platform's maximum torque specifications of 4, 6 or 8 newton-meter (3.0, 4.5, 6.0 foot-pounds) for the M-060, M-061 and M-062 respectively. Special attention is necessary when tightening or loosening the attachment screws. Permanent damage to the device will otherwise result.

NOTE

Location of Position Reference Sensor

The position reference sensor is mounted on the adjustable scale ring on the outer edge of the turntable, which is graduated in 2-degree increments. Adjusting the scale ring therefore affects referencing the absolute position of the stage.

1.3 Model Survey

The available models are listed in the following table:

Platform diam. Drive	60 mm	100mm	120 mm
Manual ¹	M-060.M0	M-061.M0	M-062.M0
ActiveDrive DC motor ² (PWM)	M-060.PD	M-061.PD	M-062.PD
DC motor/gearhead ²	M-060.DG	M-061.DG	M-062.DG
Stepper motor ¹	M-060.2S	M-061.2S	M-062.2S
Special order options: Limit switches			

¹ open-loop

² closed-loop

2 Quick Start

2.1 Mounting Guidelines



WARNING

Torque Limit

Be careful not to exceed the platform's maximum torque specifications of 4, 6 or 8 newton-meter (3.0, 4.5, 6.0 foot-pounds) for the M-060, M-061 and M-062 respectively. Special attention is necessary when tightening or loosening the attachment screws. Permanent damage to the device will otherwise result.

For mounting the stage on a flat plane or another stage use the three metric screws (M-060 screw size M4x12; M-061 and M-062 screw size M4x16) which are delivered with the stage.

Several adapter plates and mounting brackets are available for mounting M-060 series stages on other PI stages in the horizontal or vertical plane. See the PI catalog at www.pi.ws for more information, or contact your PI sales engineer.

2.2 Operating Motorized Versions

Rotation stages of the M-060 series can be connected to the same multi-axis controllers as other PI micropositioning stages, with the following restrictions:

- Stepper motor devices must all be connected to / networked with other stepper-motor devices
- If PWM and DC motor devices are connected to the same C-842 2- or 4-axis controller card or to the same C-844 or C-848 controller, a PWM converter box is required (part number C-842.AP1) for each analog (DC) device.
- PWM and DC-motor devices can be mixed on C-843 controllers.

Operating a motorized stage proceed as follows:

- 1 Set up the controller following the instructions in the controller manual. If you are going to connect a host computer to the controller for computer-controlled operation, install the host software in the host computer. This procedure is also be described in the controller manual or manuals.
- 2 Connect the rotary stage to the controller using the connecting cable (part number C-815.38), which comes with the stage. With multi-axis controllers, be sure to note the axis designation of the connection selected.
- 3 M-06x.PD ActiveDrive (PWM) versions only: Connect the stage to the power supply (part number M-500.PS), which comes with the stage.
- 4 Command a few test moves to make sure everything is working properly. If your controller comes with a graphic-user-interface software, use it for such testing.

NOTE

The controller's designation of positive and negative directionality may depend on mathematical conventions, software/firmware parameters (scale-factor sign), gearbox handedness, and may be different from that inferable from the scale printed on the stage's turntable.

With stepper motor versions (M-06x.2S), the rotation direction is as follows (contrary to that of the DC motor driven versions):

- Commanded positive motion values effect clockwise rotation of the platform.
- Commanded negative motion values effect counter-clockwise rotation of the platform.

3 Operational Considerations

3.1 Recommended Motor Controllers

M-06x.PD and .DG stages can be used with C-843 and C-863 controllers (details starting on p. 8), the M-06x.S2 with the C-663 stepper-motor controller.

3.2 PWM Amplifiers

The M-06x.PD stages with the ActiveDrive direct DC-motor drive have the revolving platform connected directly to the 17-watt DC motor by a flexible coupling. For maximum dynamic performance, the DC servo-motors are driven by high-efficiency PWM power amplifiers integrated into the stages. An external line-power power supply (order number: C-663.PS, with K050B0002 adaptor) is provided to supply the built-in amplifiers directly. This architecture allows high torque and high velocities while loading the motor controller with control signals only. The actual power is provided by the external supply.

The PWM stages can be driven from a controller in PWM mode.

3.3 Limit Switches

M-06x stages are optionally available with two magnetic limit sensors (Hall-effect sensors with TTL drivers). On stepper-motor versions, limit switch outputs are active low, on other versions active high. The distance between the limit switches must be specified with the order and must be between 0° and 268°; implementation is to $\pm 2^\circ$.

3.4 Position Reference Signal Sensors

The position reference sensor³ can be used to reference the absolute position of the stage with an accuracy of 20 μrad for the M-060 and 10 μrad for the M-061/M-062. Always approach the reference sensor from the same side to reach the same position. The difference in the reference points when approached from the positive side and from the negative side is about 7.5 to 15 mrad with the M-060 and 4 to 8 mrad with the M-061/M-062.

³ If the stage is equipped with optional limit switches, the position reference sensor is located approximately 90° clockwise from the positive limit switch.

NOTE

Location of Position Reference Sensor

The position reference sensor is mounted on the adjustable scale ring on the outer edge of the turntable, which is graduated in 2-degree-increments. Adjusting the scale ring therefore affects referencing the absolute position of the stage.

The reference sensor provides a static signal level which depends on the platform position. If the platform position is less than 180° clockwise from zero, the reference signal is +5 V, while if the platform is less than 180° counter-clockwise from zero, the signal level is 0 V.

4 DC-Motor Controller Setup

Individual setting of motion control parameters is required for smooth and optimized movement of the DC-motor versions. Incorrect parameter settings may cause severe vibration. If this occurs, set the motor off and modify the parameter settings.

The recommended parameter settings (see the tables below) are to regard as starting points for further optimization. See the controller's user manuals for more details.

4.1 C-843, C-863 and C-880 Motor Controllers

Using C-843 Controllers, C-863 Mercury Controllers or C-880 Controllers with					
Stage	M-060.DG	M-060.PD	M-061.PD	M-061.DG	M-062.PD
p-term	800	350	380	260	450
i-term	300	450	150	130	280
d-term	450	500	350	280	500

The C-843 is an add-on card which is installed in a PCI slot of a PC; 2-axis and 4-axis versions are available, and multiple cards can be installed in the same PC.

The C-863 Mercury is a single-axis controller. In addition to the analog motor voltage output, the C-863 always has the PWM mode enabled without any extra command.

The C-880 controller is recommended only if you have a system for complex multi-axis positioning and automation tasks.

NOTE

Discontinued Controllers

C-862 Mercury controllers and C-848 controllers are no longer sold by PI. If you have formerly purchased a C-862 or C-848, however, the values in the table above also apply.

4.2 C-842 Motor Controllers (discontinued)

NOTE

Availability of C-842

This controller type is no longer sold by PI. If you have formerly purchased a C-842, however, the following description applies.

The C-842 is an add-on card which is installed in an ISA slot of a PC; 2-axis and 4-axis versions are available, and multiple cards can be installed in the same PC. DLL, COM Server and LabView software interfaces are provided, as well a graphical user interface *WinMove*, in versions for Windows9x and NT.

WinMove allows configuration of the M-06x stages by a configuration file and automatically handles amplifier mode setting as a function of the stage model number selected.

The amplifier mode can also be set by command: PWM mode is enabled by the "SOP" command while analog mode is enabled by the "SOH" command. Use PWM mode with the ActiveDrive stages (.PD models). All axes connected to a given card must be in the same mode. Mixing PWM and non-PWM stages on the same card is possible using a PWM converter box (order number C-842.AP1) with analog stages while the card is in PWM mode.

Using C-843 Controllers, C-863 Mercury Controllers or C-880 Controllers with					
Stage	M-060.DG	M-060.PD	M-061.PD	M-061.DG	M-062.PD
p-term	510	510	360	360	450
i-term	500	500	450	450	280
d-term	400	400	400	400	500
Velocity	16 °/s	90 °/s	90 °/s	9 °/s	90 °/s
Acceleration	70 °/s ²	300 °/s ²	300 °/s ²	70 °/s ²	200 °/s ²
Notes	Gear Ratio 29.6:1				

4.3 C-844 Motor Controllers (discontinued)

The C-844 is a benchtop/rackmount unit.

NOTE

Availability of C-844

This controller type is no longer sold by PI. If you have formerly purchased a C-844, however, the following description applies.

DCMove is the standard C-844 operating program. This program uses a configuration file to define the motion control parameters. First use the parameter menu to set these values.

Use PWM mode with the M-06x.PD models. PWM mode is enabled by the OUPP:SIGN PWM command, while analog mode is enabled by the OUPP:SIGN DAC command. All axes connected to a given C-844 must be in the same mode. Mixing PWM and non-PWM stages on the same controller is possible using a PWM converter box (order number C-842.AP1) with analog stages while the card is in PWM mode.

Using C-844 Motor Controllers with					
Stage	M-060.DG	M-060.PD	M-061.PD	M-061.DG	M-062.PD
p-term	510	510	360	360	450
i-term	500	500	450	450	280
d-term	400	400	400	400	500
Velocity	16 °/s	90 °/s	90 °/s	9 °/s	90 °/s
Acceleration	70 °/s ²	300 °/s ²	300 °/s ²	70 °/s ²	200 °/s ²
Notes	Gear Ratio 29.6:1				

5 Stepper Motor Controller Setup

Controller setup (and multi-axis networking) for the stepper motor versions is fully described in the controller documentation.

NOTE

Rotation direction for stepper motor versions (M06x.2S) is as follows (contrary to the DC motor driven versions):

- Commanded positive motion values effect clockwise rotation of the platform.
- Commanded negative motion values effect counter-clockwise rotation of the platform.

6 Technical Data



	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
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 (5,5x10-5)	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
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	—	
Motor resolution	—	—	—	6,400*	steps/rev.
Max. axial force θ _x , / θ _y , / θ _z	±500 / ±550 / ±650	±500 / ±550 / ±650	±500 / ±550 / ±650	±500 / ±550 / ±650	N
Max. 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
Drive properties					
Motor type	—	ActiveDrive DC motor	DC motor, gearhead	2-phase stepper motor**	



	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
Operating voltage	—	24 (PWM)	12 differential	24	V
Electrical power	—	30	3	n/a	VA
Reference switch	—	Hall-effect	Hall-effect	Hall-effect	
Miscellaneous					
Operating temperature range	-20 to +65	-20 to +65	-20 to +65	-20 to +65	°C
Material	Aluminum	Aluminum	Aluminum	Aluminum	
Ground	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)	

* with C-663 stepper motor controller
 **Max. 0.85 A/phase; 400 full steps/rev.
 Specifications for vacuum versions can differ.

7 Dimensions

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

7.1.1 M-06x.M0

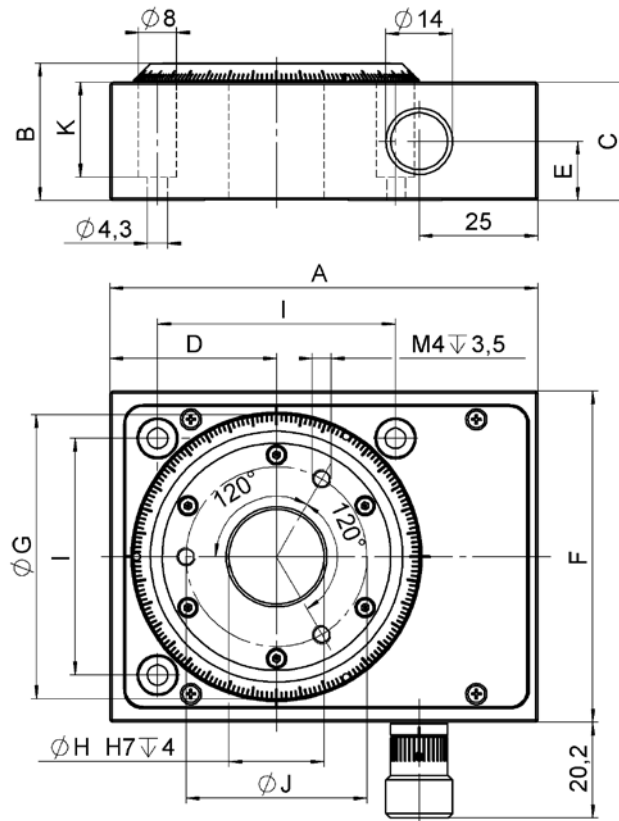


Fig. 1: M-06x.M0

Dimensions	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

7.1.2 M-06x.PD

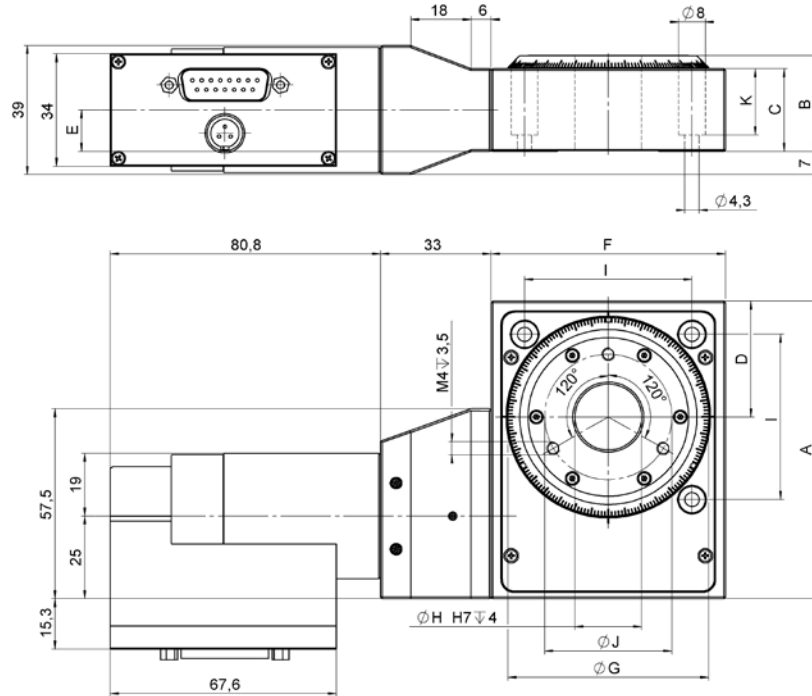


Fig. 2: M-06x.PD

Dimensions	M-060.PD	M-061.PD	M-062.PD
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

7.1.3 M-06x.DG

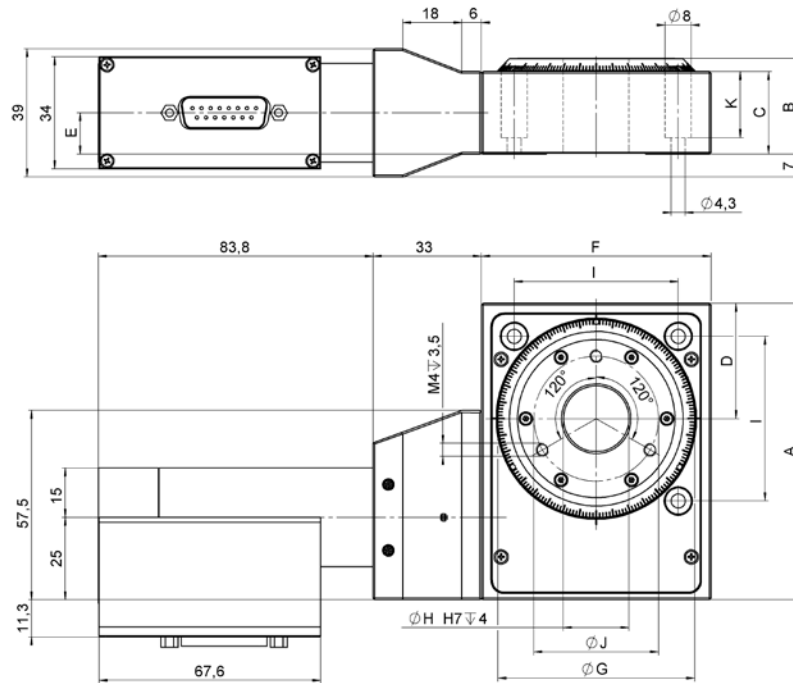


Fig. 3: M-06x.DG

Dimensions	M-060.DG	M-061.DG	M-062.DG
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

7.1.4 M-06x.2S

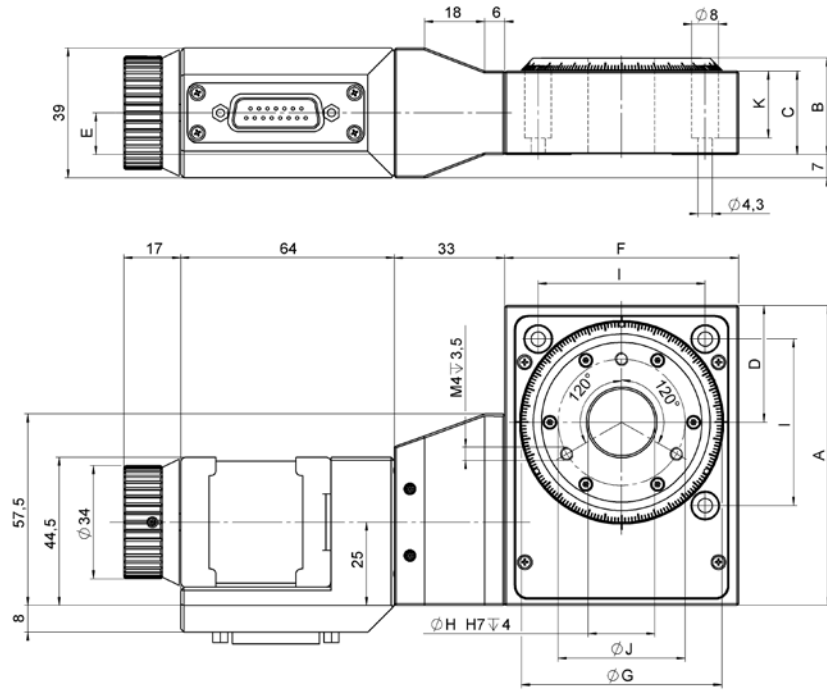


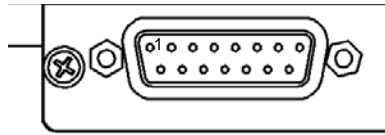
Fig. 4: M-06x.2S

Dimensions	M-060.2S	M-061.2S	M-062.2S
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

7.2 Connectors and Pin Assignments

Motor-driven M-06x series stages are equipped with sub-D15(m) sockets for connecting the motor controller. The PD versions have a separate motor power connector.

7.2.1 M-06x.DG



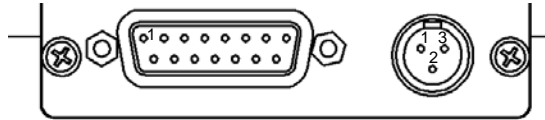
Connector (from controller)

Type: 15-pin sub-D(m)
Reference No.: AMP #9-215594-1

Pin	Signal
1	n.c.
2	Input: Motor(+)
3	Internal use
4	Input: +5V (Encoder and logic supply)
5	Output: Limit switch positive ⁴
6	GND
7	Output: Encoder A (inverted)
8	Output: Encoder B (inverted)
9	Input: Motor (-)
10	GND (power)
11	Internal use
12	Output: Limit switch negative ⁴
13	Output: Reference signal
14	Output: Encoder A (standard)
15	Output: Encoder B (standard)

⁴ Limit switches are optional, models without limit switches output a TTL “low” on these lines.

7.2.2 M-06x.PD (ActiveDrive, PWM)



Connector (motor power)

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

PIN	Function
1	GND
2	Power input
3	n.c.

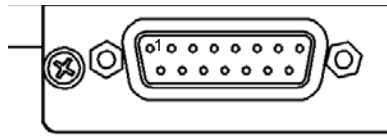
Connector (from controller)

Type: 15-pin Sub_D
Reference No.: AMP #9-215594-1

Pin	Signal
1	Input +5 to +12 V, enable PWM amplifier
2	Input: Motor(+)
3	Input: PWM magnitude
4	Input: +5 V (Encoder and logic supply)
5	Output: Limit signal positive ⁵
6	GND
7	Output: Encoder A (inverted)
8	Output: Encoder B (inverted)
9	Input: Motor (-)
10	GND (Power)
11	Input: PWM sign
12	Output: Limit signal negative ⁵
13	Output: Position reference signal
14	Output: Encoder A (standard)
15	Output: Encoder B (standard)

⁵ Limit switches are optional, models without limit switches output a TTL “low” on these lines.

7.2.3 M-06x.2S (Stepper Motor)



Connector (from controller)

Type: 15-pin sub-D(m)
Reference No.: AMP #9-215594-1

Pin	Function
1	Phase 1a (brown)
9	Phase 1b (orange)
2	Phase 2b (yellow)
10	Phase 2a (red)
3	n.c.
11	n.c.
4	n.c.
12	n.c.
5	n.c.
13	n.c.
6	+ 5 V supply from controller
14	Positive limit signal ⁶
7	GND
15	Reference Signal
8	Negative limit signal ⁶

⁶ Limit switches are optional, models without limit switches output a TTL “high” on these lines.

8 Old Equipment Disposal

Since 13 August 2005, in accordance with the EU directive 2002/96/EC (WEEE), electrical and electronic equipment can no longer be disposed of in the member states of the EU with other wastes.

When disposing of your old equipment, observe the international, national and local rules and regulations.

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

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

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



9 EU Declaration of Conformity



Declaration of Conformity

according to DIN EN ISO/IEC 17050-1:2005

Manufacturer: Physik Instrumente (PI)
GmbH & Co. KG
**Manufacturer's
Address:** Auf der Roemerstrasse 1
D-76228 Karlsruhe,
Germany



The manufacturer hereby declares that the product

Product Name: Precision Rotation Stages
Model Numbers: M-060, M-061, M-062
Product Options: all

complies with all relevant provisions of the **Machinery Directive (2006/42/EC)**.
Furthermore, it complies with all provisions of the **EMC Directive (2004/108/EC)** as well as the
RoHS Directive (2011/65/EC).

The applied standards certifying the conformity are listed below.

Safety of Machinery: EN 12100:2010
Electrical Safety: EN 61010-1:2010
Electromagnetic Emission: EN 61000-6-3:2007, EN 55011:2009
Electromagnetic Immunity: EN 61000-6-1:2007

The person authorized to compile the technical file is: Wolfgang Schobel
Address: see manufacturer's address

August 17, 2012
Karlsruhe, Germany



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