



MP 55E User Manual

M-451

Vertical Positioning Stages

Release 1.1.0



***Product Description
and
Operating Notes***

This document is valid for the products:

- M-451.1DG** Vertical MicroPositioning Stage, 12.5 mm, DC Motor/Gearhead
M-451.1PD Vertical MicroPositioning Stage, 12.5 mm, ActiveDrive™ DC Motor
M-451.12S Vertical MicroPositioning Stage, 12.5 mm, Stepper Motor

***Release:* 1.1.0**
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Table of Contents :

0	Manufacturer Declarations	3
0.1	Safety Precautions	3
0.2	Declaration of Conformity	3
1	Introduction	4
1.1	Model Survey	4
1.2	Application Examples	5
1.3	Features	5
1.3.1	Limit Switches	5
1.3.2	Position Reference Signal Sensors	5
1.3.3	PWM Amplifiers	6
2	Operating M-451 Stages	7
2.1	Operating Environment	7
2.2	Mounting	7
2.3	Move the stage	8
2.4	Maintenance	8
3	M-451 and Motor Controllers	8
4	Technical Data	10
4.1	Specifications	10
4.2	Limit and Position Reference Sensors	10
4.3	Dimensions	11
4.3.1	M-451.1DG	11
4.3.2	M-451.1PD	12
4.3.3	M-451.12S	13
4.4	Pin Assignments	14
4.4.1	M-451.1DG	14
4.4.2	M-451.1PD	14
4.4.3	M-451.12S	15

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0 Manufacturer Declarations

0.1 Safety Precautions

Read This Before Operating M-451 Linear Stages:

- If the platform is not at its reference position, mounting screws could enter the case when inserted in the four M6 mounting holes on top of the platform. This could cause damage to the stage mechanics.
- M-451 stages are powered by powerful electric motors and can accelerate to high speeds. Be aware that automatic limit switch halt may not be supported by, or activated at, the motor control electronics.
- Be aware that failure of the motor controller may drive the stage into a hard stop at high speeds.
- When the stage is first connected to the motor controller, be aware that the stage could start an undesired move.
- Never put your finger anywhere where the moving platform or any connected object could possibly trap it.

0.2 Declaration of Conformity



The manufacturer, Physik Instrumente (PI) GmbH & Co. KG, Karlsruhe, Germany, declares that the M-451 Vertical Stages comply with the ISO / IEC Guideline 22 and EN 45014 European Standards.

CE markings have been affixed to the device accordingly.

1 Introduction

The M-451 is ideal for high-precision, high-load vertical positioning tasks.

M-451 vertical stages feature a precision-machined base of high-density, stress-relieved aluminum for exceptional stability and minimum weight. Precision cross-roller-guided wedges and low-friction leadscrews provide maintenance-free positioning.

Unidirectional repeatability of 0.3 μm is ensured with high-precision rotary encoders (DC-motor versions) or 2-phase microstepping stepper motors.

All versions are equipped with high-precision, non-contact Hall-effect limit switches, and the DC-motor versions with a direction-sensing reference sensor.

1.1 Model Survey

Depending on the application, integrated drives using the following motor types are offered:

- DC motor / gearhead combination:
A 3-watt DC motor with zero-backlash gearhead and shaft-mounted 2048 counts/rev optical encoder is used. The system provides 3 nm encoder resolution and < 100 nm minimum incremental motion.
- ActiveDrive™ DC motor:
A high-efficiency PWM servo-amplifier is mounted side-by-side with the motor (see “PWM Amplifiers” for details) for maximum dynamic performance. This design eliminates power losses and PWM amplifier noise radiation. The motor is equipped with a shaft-mounted optical encoder.
- 2-phase stepper motor:
A direct-drive, microstepped, 2-phase, stepper motor (20,000 counts/rev.) is used. It provides 0.2 μm minimum incremental motion and ultra-smooth, vibration-free positioning.

Order Numbers:

M-451.1DG Vertical Positioning Stage, 12.5 mm, DC Motor/Gearhead

M-451.1PD Vertical Positioning Stage, 12.5 mm, ActiveDrive™ DC Motor

M-451.12S Vertical Positioning Stage, 12.5 mm, 2-phase Stepper Motor



Fig. 1: M-451.1PD ActiveDrive version

1.2 Application Examples

The M-451 is designed to work together with a variety of PI piezo NanoPositioning stages such as the P-500 series and P-560 MARS series (see Figure below). These piezo-driven positioning and scanning stages provide sub-nanometer resolution and accuracy and very high scanning speeds.



Fig. 2: P-562.3CD MARS XYZ Piezo NanoPositioning & Scanning system (200 μm x 200 μm x 200 μm) mounted on an M-451.1PD elevation stage.

1.3 Features

- 3 Nanometer Design Resolution*
- <100 nm Minimum Incremental Motion*
- 12.5 mm (1/2") Travel Range
- 12 kg Load Capacity
- ActiveDrive™ Motor (see "PWM Amplifiers" section for details) available
- Compatible with Leading Industrial Motion Controllers
- Non-Contact Reference and Limit Switches (see "Limit Switches" and "Position Reference Signal Sensors" sections for details)
- Mounting Platform for P-500 and MARS Piezo NanoPositioning Systems
- Self Locking

*with M-451.1DG

1.3.1 Limit Switches

M-451 stages are protected against running into a hard stop by magnetic limit sensors (Hall-effect sensors with TTL drivers) at each end of travel.

The limit sensor signals work with the controller's limit sense input lines. The TTL output signal is active-high with DC-motor versions and active-low with stepper motor versions. For sensor specifications see p. 10.

1.3.2 Position Reference Signal Sensors

The DC-motor versions are equipped with position reference sensors (Hall-effect sensors with TTL drivers) located approximately in the middle of the operating range; they can be used to reference the absolute position of the stage within 0.5 μm accuracy. 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 0.2 mm to 0.4 mm.

The reference sensor in M-451 stages provides a static signal level which depends on the platform position. If the platform is on the "positive side" the reference signal

is +5 V, while if the platform is on the "negative side", the signal level is 0 V. For sensor specifications see p. 10.

1.3.3 PWM Amplifiers

The M-451.1PD stages with the ActiveDrive™ direct DC-motor drive have the revolving leadscrew connected directly to the 30-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: M-500.PS) is provided to supply the built-in amplifiers directly. This architecture allows high torques and high velocities while loading the motor controller with control signals only. The actual power is provided by the external supply.

2 Operating M-451 Stages

2.1 Operating Environment

M-451 stages should be operated in clean environments. The aluminum case is not hermetically sealed. Make sure that metal dust and liquid spray do not enter the case.

2.2 Mounting

M-451 stages can be mounted in almost any orientation, horizontally or vertically. If you mount the stage on a vertical plane, be sure to align it so that the motor housing (see Fig. 3) sits above the platform or on its left or right side. The motor housing must never sit under the platform.

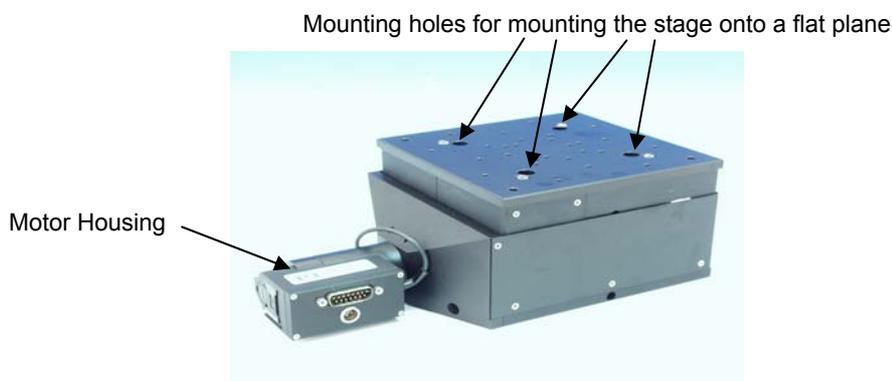


Fig. 3: Motor Housing and Mounting Holes of M-451 elevation stages.

To mount the stage onto a flat plane proceed as follows:

1. Move the stage to its reference position (approximately in the middle of the travel range):

To do this, connect the stage to a motor controller (see section 0 on p. 8; for a summary of suitable controllers see section 3.1 on p. 8) and execute the appropriate referencing commands. See the User Manual of the controller and any associated software manuals for a detailed description.

Warning

If the platform is not at its reference position, mounting screws could enter the case when inserted in the four M6 mounting holes on top of the platform. This could cause damage to the stage mechanics.

2. Insert the mounting screws¹ into the four mounting holes on top of the platform (see Fig. 3); tighten and make sure the screw heads do not interfere with stage motion.

For mounting objects onto the platform use the 27 threaded M4 holes. Note that overlength screws could cause permanent damage!

¹ from screw set # 4642 which contains six M6x16 ISO 4762 hex head cap screws, comes with the stage

2.3 Move the stage

To position an M-451 stage proceed as follows:

1. Set up the motor controller following the instructions in the controller manual. Connect a host computer to the controller for computer-controlled operation and install the host software in the host computer. This procedure is described in the controller manual or in the associated software manuals.
2. Connect the stage to the controller using the connecting cable (# C-815.38) that comes with the stage. With multi-axis controllers, be sure to note the axis designation of the connection selected.
3. M-451.1PD ActiveDrive™ (PWM) versions only: Connect the stage to the power supply (part number M-500.PS), which comes with the stage. Then connect the power supply to the local power (100-240 V / ~47-63 Hz). The power supply adjusts automatically to the supply voltage it sees.
4. Configure the controller for the connected stage using the host software. See the appropriate software manual for details.
5. Command a few test moves to make sure everything is working properly. See the appropriate software manual for details.

Note: Individual setting of motion control parameters (P-, I-, D-terms, velocity, acceleration) is required for smooth and optimized movement. Incorrect parameter setting may cause severe spindle vibration. If this occurs set the motor off and modify the parameter settings.

2.4 Maintenance

When operated in a clean environment, no maintenance is required.

3 M-451 and Motor Controllers

M-451 Vertical Translation Stages must be connected to an appropriate motor controller. PI offers DC motor and stepper motor controllers with a wide range of size and performance. In general the DC motor versions can be controlled by the C-842, C-843, C-844, C-848 and Mercury (C-860, C-862) controllers, the stepper motor drives by the C-600 and C-630 stepper-motor controllers.

Note the following restrictions:

- Stepper motor devices must all be connected to / networked with other stepper-motor devices.
- If analog DC motor devices (M-451.1DG) and PWM devices (M-451.1PD) are connected to the same C-842, C-844 or C-848 controller, a PWM converter box is required (part number C-842.AP1) for each M-451.1DG.

PWM devices and DC-motor devices (M-451.1DG) can be mixed on C-843 controllers.



Fig. 4 DC-motor controllers: C-848 and C-880 benchtop/rackmount (background, top to bottom), C-843 PCI bus and C-842 ISA bus cards and Mercury controllers, alone and networked (foreground, left to right)



Fig. 5 Stepper motor controllers: 3-axis Apollo (foreground), and 4-axis C-600 (background)—both internetworkable

Controller Summary

Drive type	DC Motor					Stepper Motor	
	C-880	C-848	C-843	C-842	Mercury	C-600	C-630
Axes per controller	up to 19*	2 or 4	2 or 4	2 or 4	1	4	3
Host PC interface	RS-232, RS-422 or IEEE (GPIB)	RS-232, RS-422 or IEEE (GPIB)	Internal (PCI bus)	Internal (ISA bus)	RS-232 bus or daisy chain	RS-232, daisy chain	RS-232, daisy chain
Multiple controllers on same host PC	yes, separate ports*	yes, separate ports	yes, separate slots	yes, separate slots	yes, same port	yes, same port	yes, same port

*Custom configurations possible with networked controllers controlling hundreds of axes.

Operation of the controller is described in the associated controller User Manual.

4 Technical Data

4.1 Specifications

Models	M-451.1PD	M-451.1DG	M-451.12S	Units	Notes
Travel range	12.5	12.5	12.5	mm	
Design resolution	0.042	0.0028	0.0084	μm	A3
Min. incremental motion	0.2	0.1	0.2	μm	A4
Unidirectional repeatability	0.3	0.3	0.3	μm	
Backlash	1	1	1	μm	
Max. velocity	3	0.5	0.8	mm/s	
Max. normal load	12	12	12	kg	B1
Encoder resolution	4000	2000	-	counts/rev.	
Motor Resolution***	-	-	20000	steps/rev.	
Leadscrew pitch	0.5	0.5	0.5	mm/rev.	
Gear ratio	-	29.6:1	-		
Wedge ratio	3:1	3:1	3:1		
Nominal motor power	30*	3	_*	W	
Motor voltage range	0 to ±24	0 to ±12	24**	V	
Body material	Al	Al	Al		
Recommended controller	C-843, C-848, C-862, C-842, C-844	C-843, C-848, C-862, C-842, C-844	C-630, C-600		

Notes

* ActiveDrive™ (integrated PWM servo-amplifier), 24 V power supply included (# M-500.PS)

**2-phase stepper, 24 V chopper voltage, max. 0.8 A / phase, 20,000 microsteps with C-600, C-630 controllers

A3 *Design Resolution*: Theoretical minimum movement that can be made, based on characteristics of mechanical drive components selected.

A4 *Minimum incremental motion*: The minimum motion that can be repeatably executed for a given input, sometimes called the “practical” or “operational” resolution

B1 *Max. Normal Load*: Centered, vertical load on horizontal stage

4.2 Limit and Position Reference Sensors

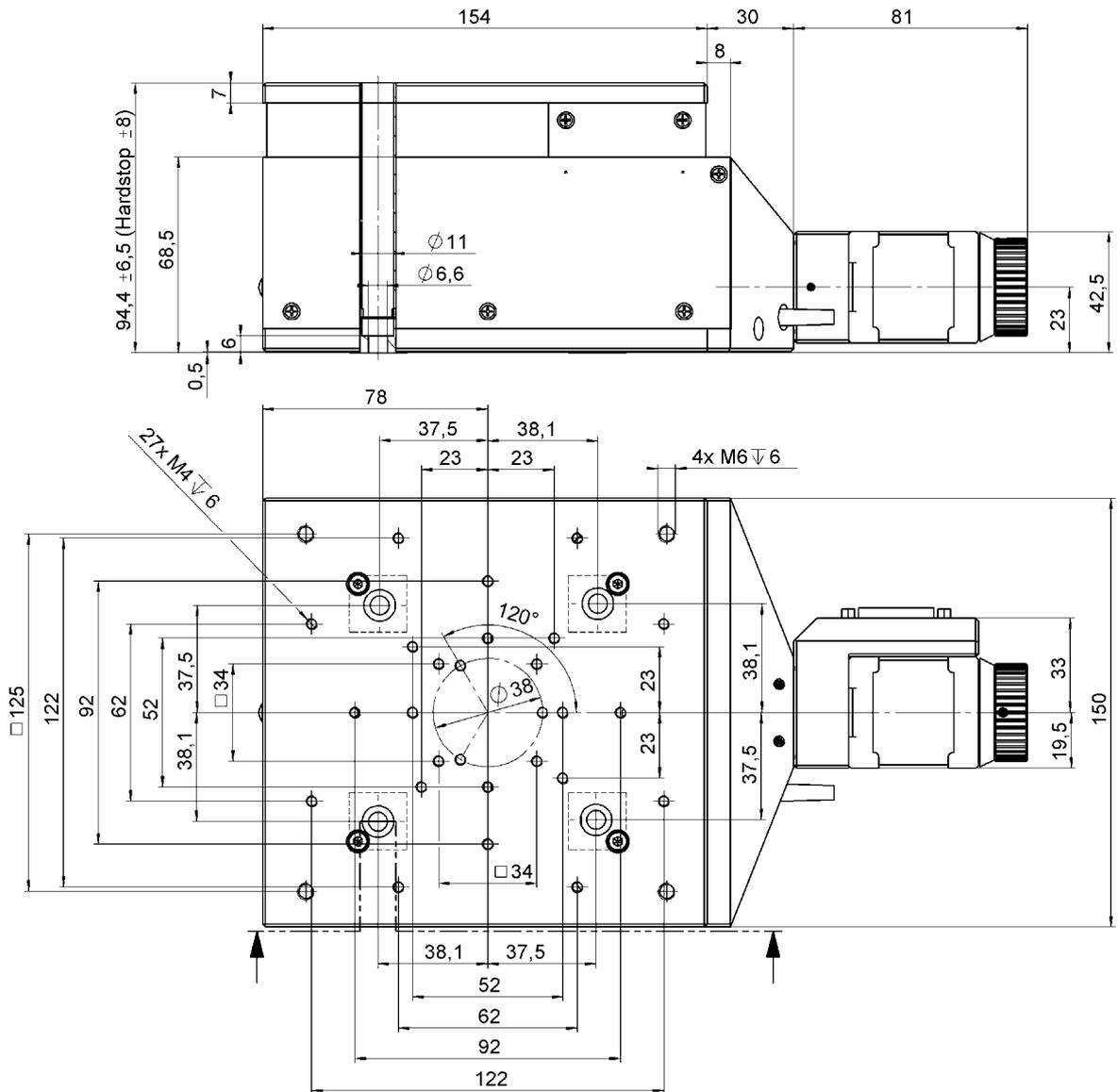
All sensors used are magnetic field triggered (Hall-effect sensors), usable with bipolar or CMOS circuitry.

Power supply: +5V / GND, supplied by the motor controller through the motor connector

Voltage output: TTL level (0 V or +5 V)

Limit Switch Logic: with DC-motor versions active-high (normal motor operation: low, overtravel condition: high)
with stepper motor version active-low (normal motor operation: high, overtravel condition: low)

4.3.3 M-451.12S



4.4 Pin Assignments

4.4.1 M-451.1DG

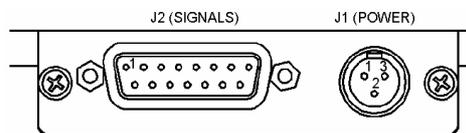
M-451.1DG stages are equipped with a sub-D15(m) socket for connecting the motor controller.

Connector type: Dsub15(m)

Pin #	Function
1	internal use
2	Motor (-) input
3	Motor (+) input
4	internal use
5	internal use
6	internal use
7	+5 V input
8	Limit Switch (negative side)
9	Limit Switch (positive side)
10	Reference signal output
11	GND (Limit Switch and Logic)
12	Encoder A (A(+)) when using RS-422-type transmission)
13	A(-) when using RS-422-type transmission
14	Encoder B (B(+)) when using RS-422-type transmission)
15	B(-) when using RS-422-type transmission

4.4.2 M-451.1PD

M-451.1PD stages are equipped with a sub-D15(m) socket for connecting the motor controller and one 3-pin, round connector for the power supply.



Connector J1 (Power Supply)

Type: 3-pin, round socket

Reference No:

Switchcraft Tini Q-G

PIN	Signal
1	GND
2	Voltage input
3	n.c.

Connector J2 (Signals, Controller connection)

Type: sub-D15 (m) connector

Reference No.: AMP #9-215594-1

Pin	Signal
1	Control input for optional motor brake (TTL)
2	n.c.
3	n.c.
4	GND (power)
5	PWM signal in: MAGN
6	PWM signal in: SIGN
7	+5 V input
8	NLIMIT (Limit signal of negative side)
9	PLIMIT (Limit signal of positive side)
10	REFS (reference signal)
11	GND (Limit)
12	Encoder out: A(+)
13	Encoder out: A(-)
14	Encoder out: B(+)
15	Encoder out: B(-)

4.4.3 M-451.12S

M-451.12S stages are equipped with a sub-D 15(m) socket for connecting the motor controller.

Connector type: sub-D 15(m)

Pin #	Function
1	phase 1a
9	phase 1b
2	phase 2a
10	phase 2b
3	n.c.
11	n.c.
4	n.c.
12	n.c.
5	n.c.
13	n.c.
6	input: + 5 V supply from controller
14	output: Limit signal positive
7	GND
15	n.c.
8	output: Limit signal negative

