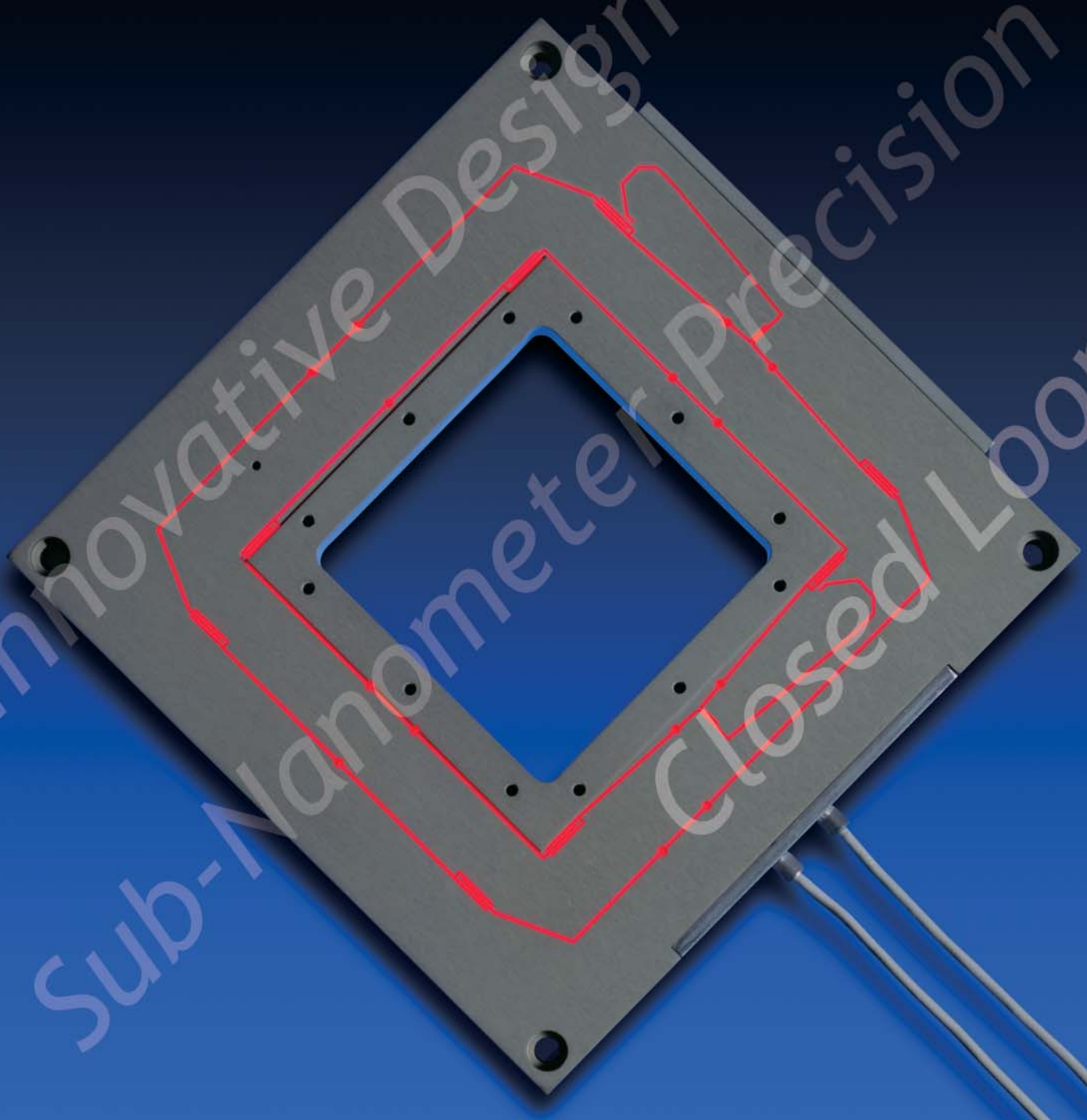


Mad City Labs, Inc.

Nanopositioning systems



Product Catalog 604

Contents

<i>About Mad City Labs, Inc.</i>	4
<i>INTEGRATED SOLUTIONS</i>	
<i>NANO-VIEW™</i>	5
<i>NANO-ALIGN</i>	7
<i>NANO-MAN5</i>	8
<i>SINGLE AXIS SYSTEMS</i>	
<i>NANO-MINI</i>	9
<i>NANO-OP SERIES</i>	10
<i>NANO-LR200</i>	11
<i>NANO-P SERIES</i>	12
<i>NANO-Z100</i>	13
<i>NANO-MZ</i>	14
<i>PIEZOACTUATORS</i>	15
<i>MULTI-AXIS SYSTEMS</i>	
<i>MICROSTAGE</i>	16
<i>NANO-H SERIES</i>	17
<i>NANO-BIO2</i>	18
<i>NANO-MAX50</i>	19
<i>NANO-M250</i>	20
<i>NANO-T SERIES</i>	21
<i>NANO-PDQ SERIES</i>	22
<i>NANO-LP SERIES</i>	23
<i>NANO-M350</i>	24
<i>NANO-M3Z</i>	25
<i>NANO-ALIGN3</i>	26
<i>NANO-MAN5</i>	27
<i>NANO-ALIGN</i>	28
<i>NANO-VIEW™</i>	29
<i>ACTIVE OPTICS</i>	
<i>NANO-F100</i>	31
<i>NANO-MTA SERIES</i>	32
<i>NANO-THETA</i>	33

VACUUM COMPATIBLE SYSTEMS

NANO-UHV50 34
NANO-UHV100 35
NANO-MAN5 36

HIGH SPEED/LARGE LOAD SYSTEMS

NANO-MTA SERIES 37
NANO-PDQ SERIES 38
NANO-MAX50 39
NANO-Z100 40
NANO-OP SERIES 41
NANO-P SERIES 42
NANO-MZ 43

MICROSCOPY APPLICATIONS

NANO-Z100 44
NANO-BIO2 45
NANO-LP SERIES 46
NANO-VIEW™ 47

ALIGNMENT APPLICATIONS

NANO-MTA SERIES 49
NANO-ALIGN3 50
NANO-ALIGN 51
NANO-M3Z 52
NANO-MAN5 53

CONTROLLERS AND OPTIONS

NANO-DRIVE™ 54
NANO-DRIVE™ OPTIONS 55
CUSTOM SOLUTIONS 56

NOTES ON NANOPositionING 58

TECHNICAL INFORMATION 59

SALES 60

TERMS AND CONDITIONS OF SALE 61

About Mad City Labs, Inc.

On-line Catalog.

Complete part specifications and drawings.

Custom Nanopositioning Systems.

Our technical staff offers innovative and efficient solutions for your nanopositioning needs.

Interested in OEM?

Call for competitive pricing.

New Product Releases.

We are continually adding to our product line.

Check our website for the most current product information.

Competitive Pricing

Mad City Labs, Inc. is committed to maintaining competitive prices.

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Superior Support - Real Live People!

Sick of voicemail? At Mad City Labs, Inc. you can speak directly to the appropriate support personnel.

Our sales and technical staff are experienced scientists and engineers with extensive experience in many facets of R & D, not just nanopositioning systems. Got a question? Pick up the phone and talk to one of our friendly support staff.

Important Notice to Purchaser

All technical information and recommendations related to Mad City Labs, Inc. products made in this catalog are based on information believed to be reliable. Before utilizing the product, the users should determine the suitability of the product for its intended use. The user assumes all risks and liability whatsoever in connection with such use.

NANO-VIEW™

Product Description

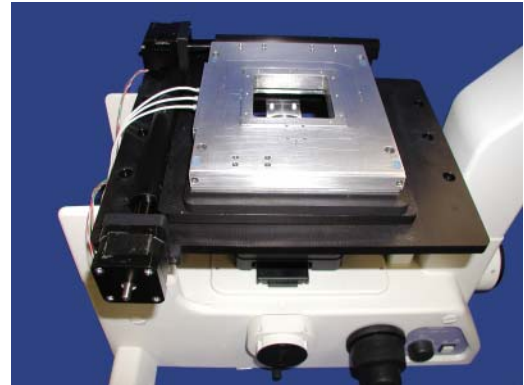
The *Nano-View™* is a fully integrated positioning system for use with most inverted optical microscopes¹ that offers long range linear positioning in two dimensions, combined with a high resolution nanopositioner. The *Nano-View™* is comprised of a motor driven two axis linear motion stage and an ultra-low profile, high resolution nanopositioning system. The micropositioning stage has integrated encoders and offers up to 1" (25 mm) travel per axis with an encoder resolution of 20 nm. The minimum step size is 95.25 nm with a step repeatability of 50 nm.

The nanopositioning systems employed in the *Nano-View™* are high precision with the lowest profile commercially available. Travel ranges extend up to 200 microns per axis (X,Y and Z) with single nanometer resolution or better under closed loop control. As with all Mad City Labs, Inc. nanopositioning systems they are designed for minimum parasitic motion and feature integrated sensors for absolute position measurement.

The *Nano-View™* is designed to be controlled by standard National Instruments control boards and is fully compatible with user written LabView™ software, offering greater flexibility.

The *Nano-View™* is the complete nanometer scale positioning system for single molecule spectroscopy and high resolution microscopy applications.

¹ Olympus IX Series, Nikon TE Series inverted microscopes, Leica DMIRB and Zeiss Axiovert Series. Other inverted and upright microscope models subject to special order.



Above: Nano-View™ 100-3

Highlights

- ◆ *Fully integrated positioning system.*
- ◆ *High precision long range motion up to 1" (25 mm).*
- ◆ *High performance two and three axis nanopositioners.*
- ◆ *Sub-nanometer precision*
- ◆ *Accurate position tracking via encoders (MicroStage)*
- ◆ *Integrated position sensors (Nanopositioner)*
- ◆ *Retrofitted to your inverted microscope*
- ◆ *High Speed data acquisition available.*
- ◆ *Compatible with National Instruments control boards and user written LabView™ Software.*
- ◆ *Suitable for demanding microscopy applications.*

Standard Configuration

- ◆ *Two axis stepper motor MicroStage.*
- ◆ *Two or Three Axis Closed Loop Nanopositioning System.*
- ◆ *Integrated Linear encoders (MicroStage).*
- ◆ *Micro-Drive controller.*
- ◆ *Nano-Drive™ controller.*
- ◆ *National Instruments NI7334 motion control board*

NANO-VIEW™

Specifications: Nanopositioner

Number of axes	2 or 3
Range of motion (XY)	100 or 200 μm
Range of motion (Z)	100 or 200 μm
Resolution (100/200 μm)	0.67/1.3 nm
Resonant frequency (X-axis)	450 Hz
Resonant frequency (Y-axis)	350 Hz
Resonant frequency (Z-axis)	2300 Hz
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al or Invar
Control Electronics	Nano-Drive™

Specifications: MicroStage

Number of axes	2
Range of motion	up to 1" (25 mm)
Step Size	95.25 nm
Step repeatability	50 nm
Encoder resolution	20 nm
Body Material	Anodized Al
Control electronics	Micro-Drive™

Ordering Information:

Nano-View™100/200 - # axes - Option

Example: Nano-View™100 -3-HS describes a Nano-View system with a 3 axis 100 micron (per axis) nanopositioner with the high speed data acquisition option.

- Please specify brand and model of inverted microscope.

- Some options are exclusive, please consult with your sales representative.

Available Options

- NV162

Two axis 16 bit digital interface for use with Nano-Drive™ controller. National Instruments PCI-DIO96 and R1005050 cable included. LabView™ compatible.

- NV163

Three axis 16 bit digital interface for use with Nano-Drive™ controller.

-NV164

Four axis 16 bit digital interface for use with Nano-Drive™ controller.

- NV202

Two axis 20 bit digital interface for use with Nano-Drive™ controller. National Instruments PCI-DIO96 and R1005050 cable included. LabView™ compatible.

-NV203

Three axis 20 bit digital interface for use with Nano-Drive™ controller.

-NV204

Four axis 20 bit digital interface for use with Nano-Drive™ controller.

- HS

High speed data acquisition via parallel port for four axes. Acquisition at speeds of 100 kHz simultaneously for 4 axes. Includes 2 PXI6534 boards, PXI1002 crate and shielded cables. LabView™ compatible.

- F100E

Objective lens nanopositioning system with encoder. Range of motion is 100 microns in Z with sub-nanometer accuracy. Encoder must be installed by trained personnel. Includes analog controller.

- 5NM

Upgrade to 5nm linear encoders on the MicroStage

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

NANO-ALIGN

Product Description

The *Nano-Align* is a five axis nanopositioning system with sub-nanometer/sub-microradian accuracy under closed loop control. The low profile design of the *Nano-Align* allows it to be easily integrated into existing instrumentation, e.g. microscopes, probe assemblies. With an extended range of motion in Z, the *Nano-Align* is ideal for demanding applications which require long range travel, sub nanometer accuracy and three dimensions of motion. In addition, the *Nano-Align* has 1.2 milliradians of tip/tilt in θ_x, θ_y with sub-microradian resolution. The *Nano-Align* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-Align* is also offered as a three axis system and can be constructed from specialty materials such as invar.

Highlights

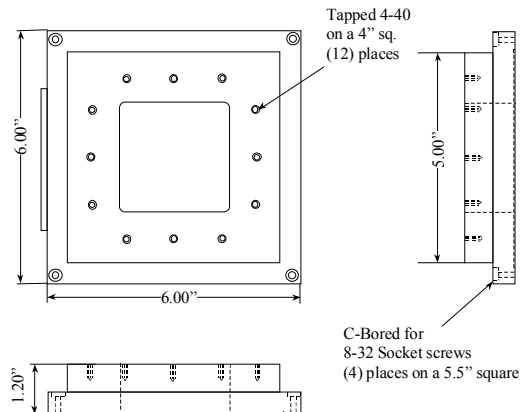
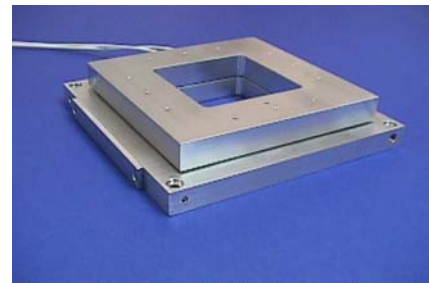
- ◇ Easy integration into existing instrumentation
- ◇ Low profile 1.20"
- ◇ 100 μm x 100 μm x 50 μm (x, y, z).
- ◇ Sub-nanometer positioning.
- ◇ 1.20 mrad (θ_x, θ_y).
- ◇ Sub-microradian resolution .
- ◇ Large through hole (2.6"x2.6") for inverted objective lens.
- ◇ Extended ranges of motion available.

All dimensions in inches unless otherwise stated.

Technical Specifications (Aluminum)

Range of motion (XY)	100 μm x 100 μm
Range of motion (Z)	50 μm
Range of motion (θ_x, θ_y)	1.2 mrad x 1.2 mrad
Resolution (XY/Z/ θ)	0.67 nm/0.33 nm/ 0.01 μrad
Resonant Frequency (XY)	200 Hz
Resonant Frequency (Z)	1.5 kHz
θ_{roll} (XY typical)	5 μrad
θ_{pitch} (XY typical)	5 μrad
θ_{yaw} (XY typical)	10 μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al or Invar
Control electronics	<i>Nano-Drive</i> TM

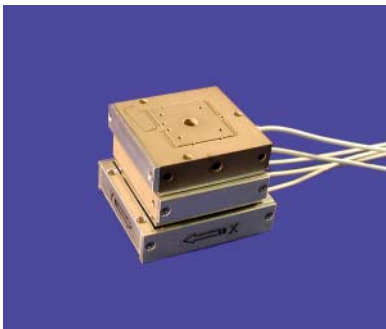
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



NANO-MAN5

Product Description

The *Nano-Man5* is a five axis nanopositioning system constructed from titanium or invar with sub-nanometer/sub-microradian accuracy under closed loop



control. The compact design of the *Nano-Man5* allows it to be easily integrated into existing instrumentation for applications such as nanolithography, SEM and active optics. The *Nano-Man5* is ideal for demanding applications which require parallel motion, sub nanometer accuracy and three linear axes of motion. In addition, the *Nano-Man5* has 1 milliradian of tip/tilt in θ_x , θ_y with sub-microradian resolution. The *Nano-Man5* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-Man5* is also available as a three axis system, the *Nano-M350* or *Nano-M3Z*, and vacuum compatible models.

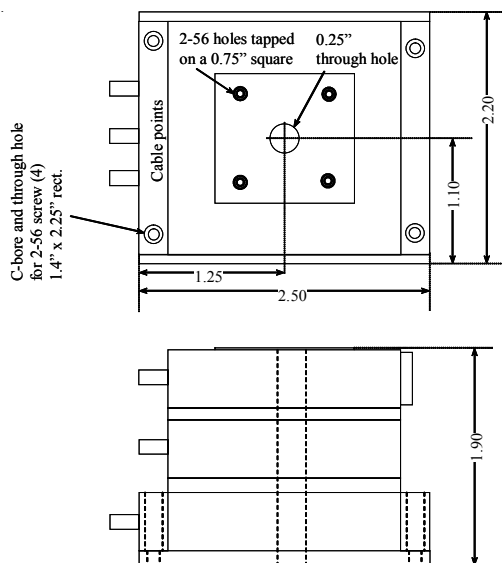
Highlights

- ◇ Easy integration into existing instrumentation
- ◇ Compact Design
- ◇ $50 \mu\text{m} \times 50 \mu\text{m} \times 20 \mu\text{m}$ (x, y, z).
- ◇ Sub-nanometer positioning.
- ◇ 1 mrad (θ_x, θ_y).
- ◇ Sub-microradian resolution .
- ◇ Vacuum compatible models available

Technical Specifications

Range of motion (XY)	50 μm x 50 μm
Range of motion (Z)	25 μm
Range of motion (θ_x, θ_y)	1 mrad x 1 mrad
Resolution (XY/Z/ θ)	0.32 nm/0.13 nm/1 μrad
Resonant Frequency (X)	1 kHz
Resonant Frequency (Y)	700 Hz
Resonant Frequency (Z)	> 1 kHz
θ_{roll} (XY typical)	< 5 μrad
θ_{pitch} (XY typical)	< 5 μrad
θ_{yaw} (XY typical)	< 10 μrad
Recommended load (horizontal)*	0.2 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al/Ti or Invar
Control electronics	<i>Nano-Drive</i> TM

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

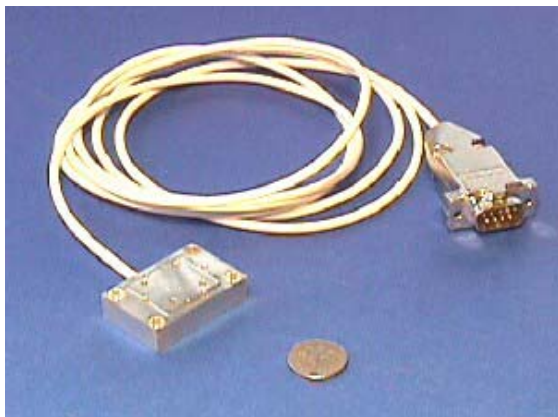


All dimensions in inches unless otherwise stated.

NANO-MINI

Product Description

The *Nano-Mini* is one of the smallest flexure guided nanopositioning stages available. Designed for optimum performance on a small footprint, this stage uses an innovative mini-cross section multilayer piezo ceramic which allows for a stiff stage to translate 10 microns with angstrom precision. This unique design makes it ideal for applications in precision metrology and microscopy. The *Nano-Mini* includes a piezo-resistive sensor for absolute position measurement and sub-nanometer accuracy. Available in titanium or invar.



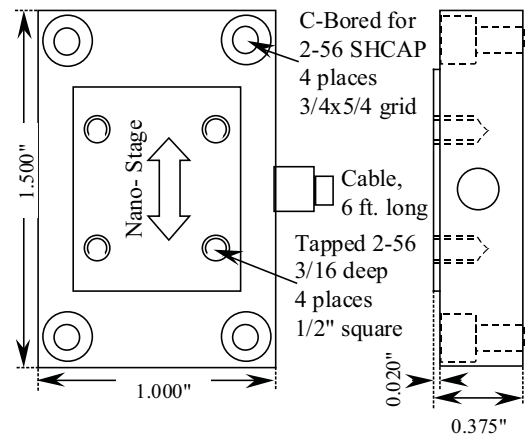
Highlights

- ◇ Ultra small footprint 1"×1.5".
- ◇ Fiber optic alignment.
- ◇ Optical positioning.
- ◇ Stackable for XY scanning and positioning.
- ◇ Micro and nano-manufacturing.
- ◇ Angstrom precision.
- ◇ Available in titanium or invar.

Technical Specifications

Range of motion	10 μm
Resolution	0.06 nm
Voltage range	-5V to +150V
Resonant frequency	1.5 kHz \pm 20%
Resonant frequency @ 50g load	650 Hz \pm 20%
Stiffness	1 N/ μm \pm 20%
θ_{roll} (typical)	2 μrad
θ_{pitch} (typical)	2 μrad
θ_{yaw} (typical)	5 μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.15 kg
Body material	Ti or Invar
Control electronics	Nano-Drive™

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

NANO-OP SERIES

Product Description

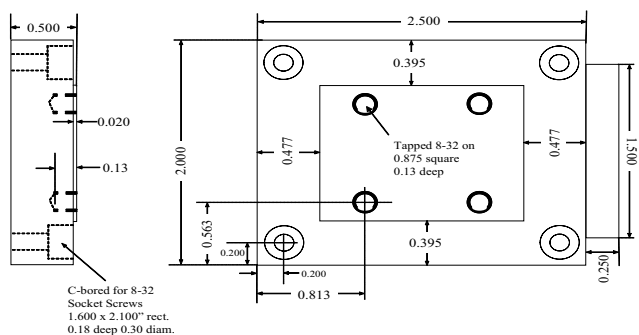
The *Nano-OP Series* is a range of ultra high accuracy positioning stages designed for sub-nanometer positioning applications, which demand a high degree of repeatability with a large carrying capacity. The *Nano-OP Series* can be easily incorporated into any optical or measurement system due to their compatibility with standard optical fixtures. The *Nano-OP Series* is available in aluminum, invar, or titanium, and includes integrated piezo-resistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. These stages can be used as single axis positioners or stacked for uncoupled two or three axis nanopositioning. The *Nano-OP Series* is available with motion ranges of 30 μm , 65 μm and 100 μm .



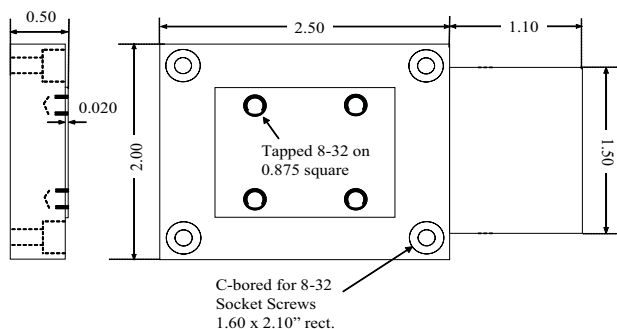
Technical Specifications

Range of motion (Nano-OP30)	30 μm
Range of motion (Nano-OP65)	65 μm
Range of motion (Nano-OP100)	100 μm
Resolution	0.2/0.43/0.67 nm
Voltage range	-5V to +150V
Resonant frequency	4 kHz \pm 20%
Resonant frequency @ 100g load	2 kHz \pm 20%
Stiffness	3 N/ μm \pm 20%
θ_{roll} (typical)	2 μrad
θ_{pitch} (typical)	2 μrad
θ_{yaw} (typical)	2 μrad
Recommended load (horizontal)*	1.0 kg
Recommended load (vertical)*	0.5 kg
Body material	Al, Invar or Titanium
Control electronics	<i>Nano-Drive</i> TM

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



Above: Dimensions of Nano-OP30



Above: Dimensions of Nano-OP65

Highlights

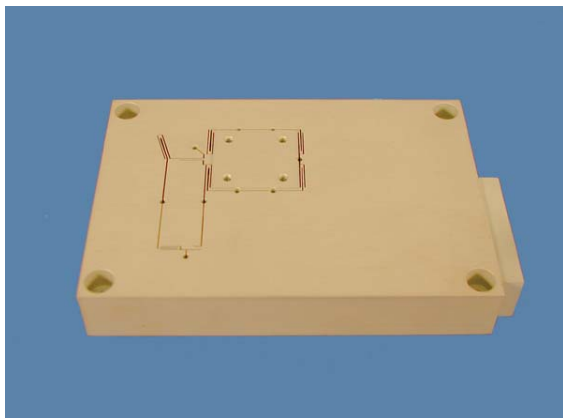
- ◆ Stiff, large load capacity.
- ◆ Stackable for 2 or 3 axis nanopositioning.
- ◆ Sub-nanometer positioning accuracy.
- ◆ Available with 30 μm , 65 μm and 100 μm .
- ◆ Available in aluminum, invar, or titanium.

All dimensions in inches unless otherwise stated.

NANO-LR200

Product Description

The *Nano-LR200* is designed to provide long range translation with a minimum amount of coupled motion. This combination of a stiff translational stage with minimal parasitic motion and long range scanning capability is made possible through the use of PZT multilayer actuators with 4 times the normal stiffness. A piezoresistive sensor is included for absolute position measurement and nanometer accuracy. The *Nano-LR200* is ideally suited for applications that require extreme parallelism, such as metrology, AFM and MEMS.



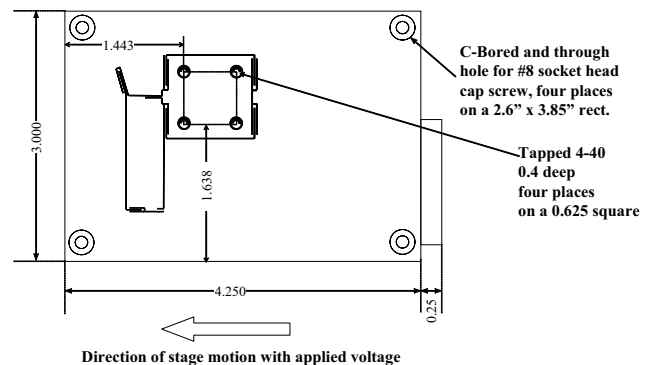
Highlights

- ◇ Long range scanner with 200µm of motion.
- ◇ Less than 5 nm out of plane motion.
- ◇ Stackable for XY scanning and positioning.
- ◇ Wafer scanning and alignment.
- ◇ Surface metrology.
- ◇ Micro manipulation.
- ◇ Nanometer precision.

Technical Specifications

Range of motion	200 µm
Resolution	1.3 nm
Voltage range	-5V to +150V
Resonant frequency	500Hz±20%
Resonant frequency @ 100g load	200Hz±20%
Stiffness	0.2 N/µm±20%
θ_{roll} (typical)	< 5 µrad
θ_{pitch} (typical)	< 5 µrad
θ_{yaw} (typical)	< 10 µrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Mass	0.5 kg
Body material	Al
Control electronics	<i>Nano-Drive™</i>

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

NANO-P SERIES

Product Description



The *Nano-P Series* is piezo actuated, closed loop, linear translators that incorporate a unique flexure hinge design. The flexure hinge is machined entirely from a single block of high strength titanium using an advanced electrical discharge machining process. This hinge, available for the first time on a tubular nanopositioner, ensures the highest degree of repeatability, torque and load capability. Unlike similar products on the market, no belleville springs are used in the construction of the *Nano-P Series*. The guiding mechanism is a true flexure spring, having no contacting parts moving relative to each other. The *Nano-P Series* is constructed from invar and titanium for the best combination of thermal stability and mechanical strength, making it ideal for the most demanding microscopy, positioning and metrology applications. The *Nano-P Series* is available in three standard ranges of motion with integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. Custom systems available.

Highlights

- ◇ Up to 100 microns motion
- ◇ True guided motion
- ◇ Millisecond response
- ◇ Integrated piezoresistive sensors for superior performance
- ◇ Closed loop control.
- ◇ Sub-nanometer resolution.

Technical Specifications

Voltage range -5V to +150V
Body material Ti/Invar
Control electronics *Nano-Drive™/Nano-Drive™85*

Nano-P15

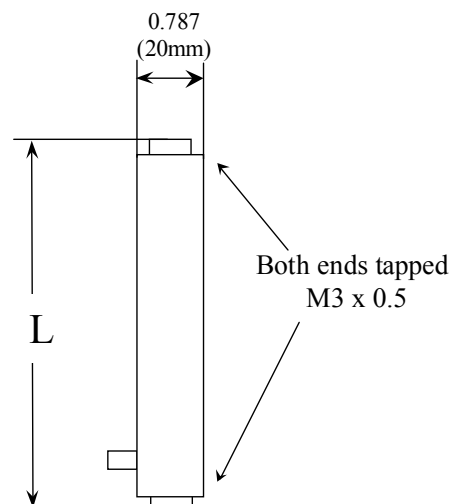
Range of motion 15µm
Resolution 0.1 nm
Length 1.7"

Nano-P35

Range of motion 35µm
Resolution 0.23 nm
Length 3.1"

Nano-P70

Range of motion 70µm
Resolution 0.47 nm
Length 5.5"



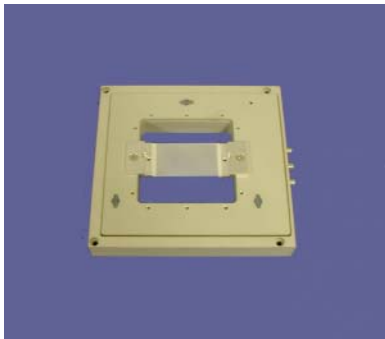
All dimensions in inches unless otherwise stated.

NANO-Z100

Product Description

The *Nano-Z100* is a single axis nanopositioning system with integrated position sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The low profile design of the *Nano-Z100* allows it to be integrated into existing instrumentation where space is restricted. With a generous center aperture this system is ideal for demanding imaging and microscopy applications such as high speed confocal microscopy that require long range travel and sub nanometer precision and repeatability.

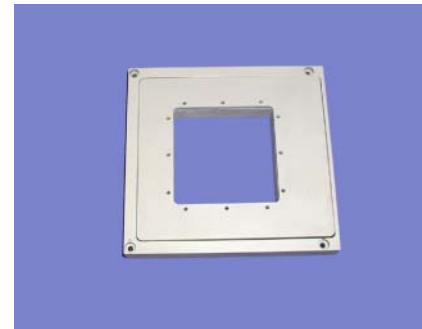
The *Nano-Z100HS* is also available for high speed applications that require typical step responses of 3-4ms and sub-nanometer accuracy.



Technical Specifications

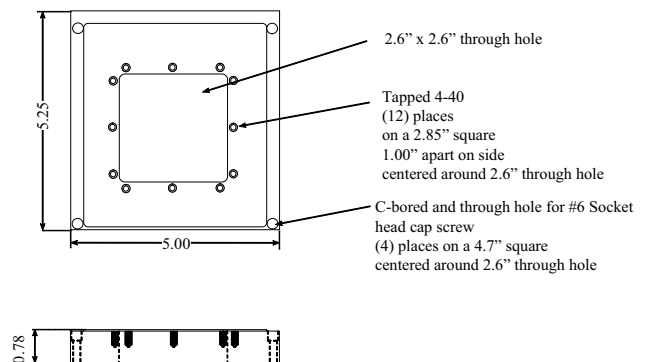
Range of motion (Z)	100 μm
Resolution	0.67 nm
Resonant frequency	> 1 kHz
Stiffness	1.0 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load* (horizontal)	0.5 kg
Body Material	Aluminum
Control electronics	<i>Nano-Drive</i> TM / <i>Nano-Drive</i> TM 85

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



Highlights

- ◇ Engineered to retrofit to most microscopes.
- ◇ Low profile 0.78"
- ◇ Sub-nanometer positioning.
- ◇ Large through hole (2.6"x 2.6") for inverted objective lens.
- ◇ Available constructed from aluminum, invar or titanium.
- ◇ Extended ranges of motion available.

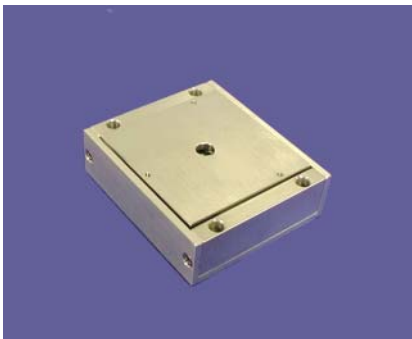


All dimensions in inches unless otherwise stated.

NANO-MZ

Product Description

The *Nano-MZ* is a compact single axis nanopositioning system with integrated position sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The compact design of the *Nano-MZ* allows it to be integrated into existing instrumentation where space is restricted. The *Nano-MZ* is ideal for demanding applications which require high precision and sub nanometer accuracy. The *Nano-MZ* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-MZ* is available for high speed applications (*Nano-MZHS*) and as a vacuum compatible model.



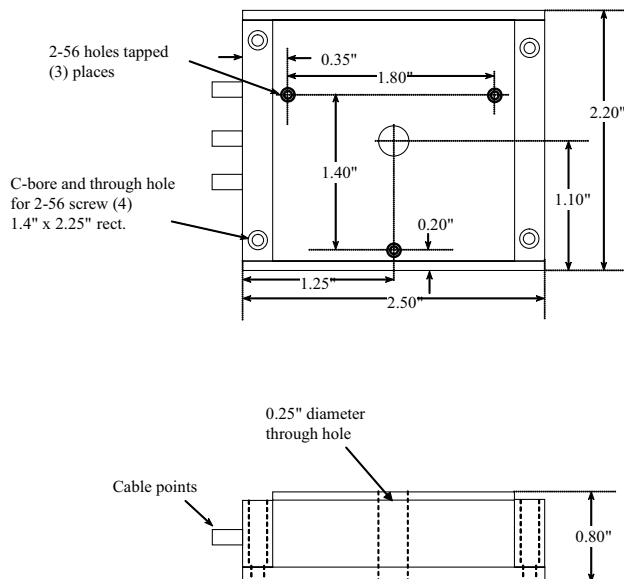
Highlights

- ◇ Compact Design.
- ◇ Low profile 0.8"
- ◇ Sub-nanometer positioning.
- ◇ Available constructed from invar or aluminum.
- ◇ Vacuum compatible models available.
- ◇ High speed models available.

Technical Specifications

Range of motion (Z)	25 μm
Resolution	0.16 nm
Resonant frequency	> 1 kHz
Stiffness	1.0 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load* (horizontal)	0.5 kg
Body Material	Al or Invar
Control electronics	<i>Nano-Drive</i> TM / <i>Nano-Drive</i> TM 85

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

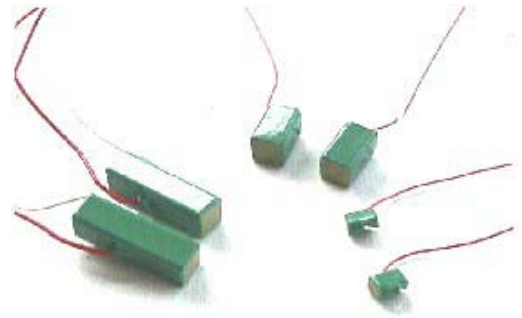


All dimensions in inches unless otherwise stated.

PIEZOACTUATORS

Product Description

The PZT range of products are individual piezoactuators, ready to use in a variety of applications. In most cases, these items are in stock and can be delivered overnight. These low voltage multilayer actuators have variable cross sections and displacements up to 18 μm . These actuators are easily bonded together in larger stacks for greater displacement.



Technical Specifications

	PZT1	PZT2	PZT3	PZT4	PZT5	PZT6
<i>Length (mm)</i>	5	10	20	10	20	20
<i>Cross Section (mm × mm)</i>	3.5 × 4.5	3.5 × 4.5	3.5 × 4.5	6.5 × 6.5	6.5 × 6.5	12 × 12
<i>Max. Voltage (V. DC)</i>	150	150	150	150	150	150
<i>Displacement (μm)</i>	4.6 ± 1.5	9.1 ± 1.5	18.4 ± 1.5	9.1 ± 1.5	17.4 ± 2.0	18.4 ± 3.5
<i>Capacitance ($\mu\text{F} \pm 20\%$)</i>	0.1	0.18	0.36	0.75	1.4	5.4
<i>Resonant Frequency (kHz)</i>	276	138	69	138	69	69
<i>Generated Force (N)</i>	200	200	200	850	850	3500
<i>Tensile Strength (N)</i>	20	20	20	100	100	400
<i>Young's Modulus (N/m)</i>	4.4×10^{10}	4.4×10^{10}	4.4×10^{10}	4.4×10^{10}	4.4×10^{10}	4.4×10^{10}
<i>Temperature Range ($^{\circ}\text{C}$)</i>	$^{-}25$ to $^{+}85$	$^{-}25$ to $^{+}85$	$^{-}25$ to $^{+}85$	$^{-}25$ to $^{+}85$	$^{-}25$ to $^{+}85$	$^{-}25$ to $^{+}85$

MICROSTAGE

Product Description

The *MicroStage* is a precision stepper motor driven micropositioning system for use with optical microscopes¹. The *MicroStage* offers long range linear positioning in two dimensions with high resolution and repeatability due to the integrated linear encoders that are a standard feature. The *MicroStage Series* offers high stability with less than 5nm drift after 150 micron step (Figure 1 below).

The *MicroStage-20E* offers up to 25 mm travel per axis with a step resolution of 20 nm and a minimum step size of 95 nm. The *MicroStage-5E* offers up to 25mm travel per axis with a step resolution of 5nm and a minimum step size of 25nm

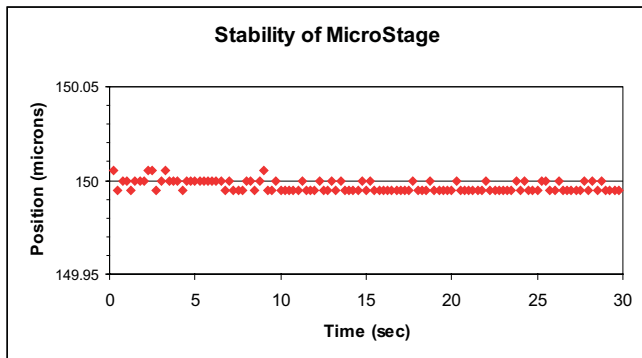


Figure 1: Stability of MicroStage Series

The *MicroStage* employs the National Instruments 7334 motion control board which offers an open architecture for implementing customized motion control. Using the Flex Motion software provided, the user has a high level of flexibility to program and execute complex motion parameters with ease.

¹ Olympus IX Series, Nikon TE Series, Leica DMIRB and Zeiss Axiovert Series.
Other inverted and upright microscope models subject to special order.

Highlights

- ◆ High precision long range motion up to 25 mm
- ◆ Accurate position tracking via integrated encoders
- ◆ National Instruments 7334 Motion Control Board
- ◆ Programmable for complex motion control tasks.
- ◆ LabView Compatible
- ◆ High stability, less than 5nm drift
- ◆ Compatible with Mad City Labs, Inc. nanopositioning systems.
- ◆ Suitable for demanding microscopy applications.
- ◆ Retrofitted to your inverted microscope
- ◆ I/O upgrade option available.

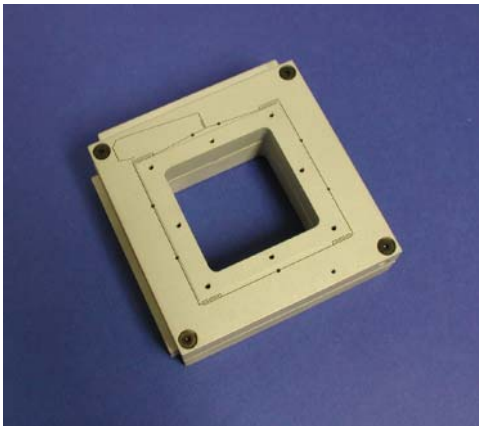
Specifications: MicroStage-20E/5E

Number of axes	2
Range of motion	up to 25 mm
Step Size	95/25 nm
Step resolution	20/5 nm
Body Material	Anodized Al
Control electronics	Micro-Drive™

NANO-H SERIES

Product Description

The *Nano-H Series* is a compact long range 2-axis positioning stage with sub-nanometer accuracy. The large through hole makes the *Nano-H Series* ideal for applications requiring transmitted beams, or the mounting of bulky components such as multiple fibers, optics, and metrology probes. Includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy. The *Nano-H Series* is also available in custom ranges of motion and can be constructed from aluminum, invar or titanium.



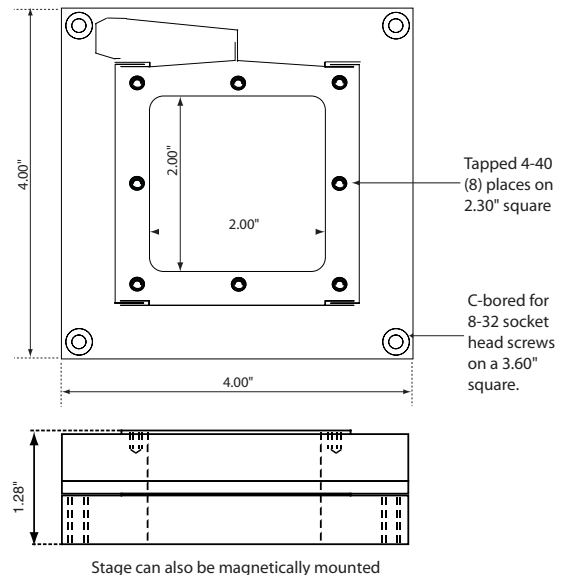
Highlights

- ◇ Large through hole (2"×2") for inverted objective lens
- ◇ Available in custom ranges of motion.
- ◇ Sub-nanometer accuracy.
- ◇ Available in aluminum, invar or titanium.
- ◇ Single molecule detection.
- ◇ AFM
- ◇ Affordable closed loop nanopositioning.

Technical Specifications

Range of motion (<i>Nano-H100</i>).....	100 μm x 100 μm
Range of motion (<i>Nano-H50</i>).....	50 μm x 50 μm
Resolution (100/50)	0.67/0.33 nm
Voltage range	-5V to +150V
Resonant frequency (X).....	500 Hz
Resonant frequency (Y).....	250 Hz
Stiffness	1.0 N/μm
θ_{roll} (typical)	5μrad
θ_{pitch} (typical)	5μrad
θ_{yaw} (typical)	10μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body material	Al or Invar
Control electronics	<i>Nano-Drive™</i>

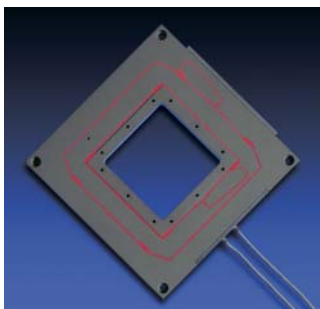
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

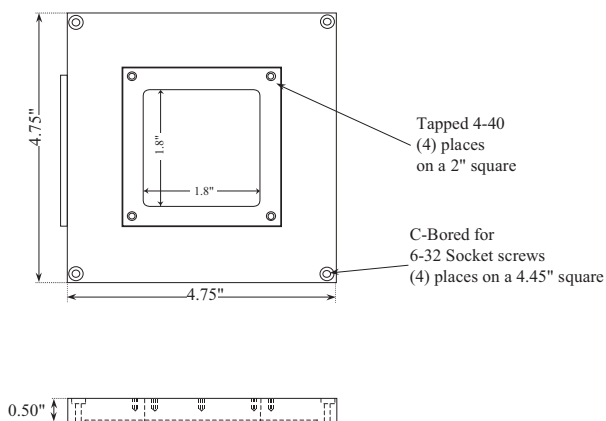
NANO-BIO2

Product Description



The *Nano-Bio2* is an ultra low profile two axis nanopositioning system with sub-nanometer accuracy under closed loop control. With its low profile design the *Nano-Bio2* is easily integrated into

existing inverted microscopes, AFM and other instrumentation where space is limited. The large center aperture allows the *Nano-Bio2* to accommodate the lens cone of most major microscope manufacturers. The *Nano-Bio2* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop feedback control. This system is available in the following models: *Nano-Bio2200*, *Nano-Bio2* and the *Nano-Bio2M*. The *Nano-Bio2M* when combined with an additional interface unit is a plug and play add on for instruments using Veeco NanoScope controllers.



Above: Technical drawing for Nano-Bio2M (Invar/Ti only)
Right: Technical drawing for Nano-Bio2 and Nano-Bio2200.
Note: 0.6" height for Al , 0.5" height for invar/ Ti models.

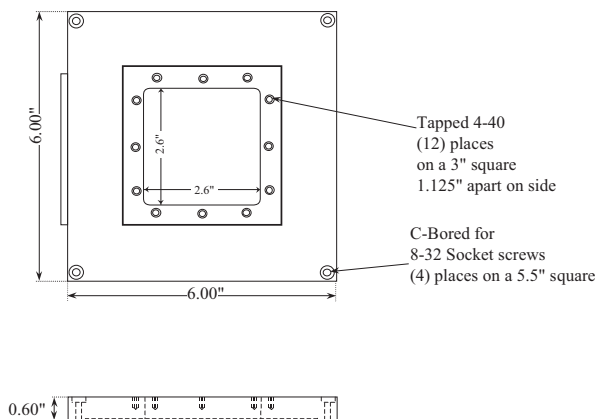
Technical Specifications

Range of motion (<i>Nano-Bio2200</i>)	200 μ m x 200 μ m
Range of motion (<i>Nano-Bio2</i>)	100 μ m x 100 μ m
Range of motion (<i>Nano-Bio2M</i>)	50 μ m x 50 μ m
Resolution (200/100/50)	1.3/0.67/0.33 nm
Resonant frequency (X)	500 Hz
Resonant frequency (Y)	300 Hz
Stiffness	1.0 N/mm
θ_{roll} (typical)	5 μ rad
θ_{pitch} (typical)	5 μ rad
θ_{yaw} (typical)	10 μ rad
Body Material	Al or Invar
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Control electronics	<i>Nano-Drive</i> TM

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

Highlights

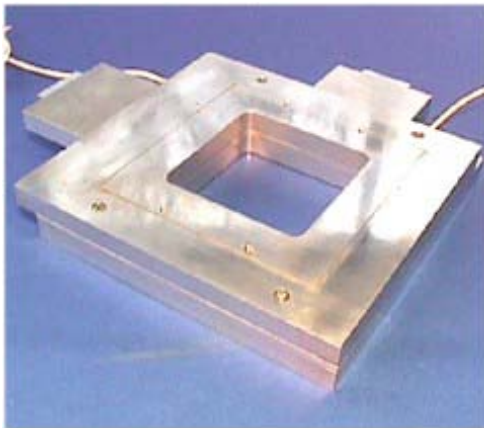
- ◇ Lowest profile available.
- ◇ Compatible with AFM
- ◇ Closed loop, sub-nanometer positioning.
- ◇ Engineered to retrofit to most microscopes.



NANO-MAX50

Product Description

The *Nano-Max50* is a two axis nanopositioning stage with sub-nanometer accuracy. The *Nano-Max50* is designed to accurately position large loads, such as cryostats, under optical microscopes. The low profile and extra large aperture allows the *Nano-Max50* to be easily integrated into any existing optical microscope. As with all our nanopositioning systems, the *Nano-Max50* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. Increased range of motion is available.



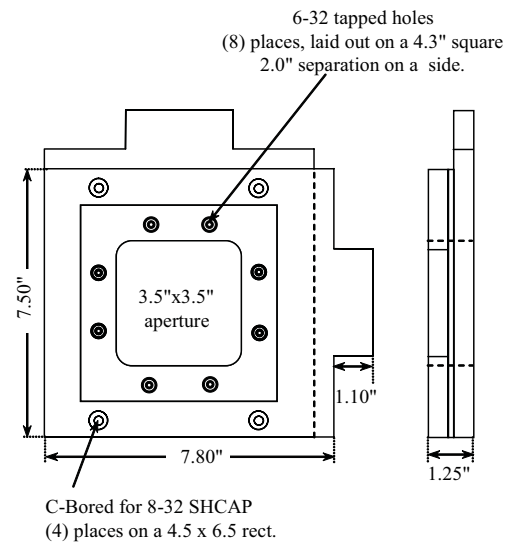
Highlights

- ◇ Precision cryostat positioning.
- ◇ Large load capacity.
- ◇ Low profile design.
- ◇ Generous 3.5" x 3.5" through hole.
- ◇ Low temperature optical microscopy.
- ◇ Low temperature spectroscopy.
- ◇ Quantum dot research.
- ◇ Inexpensive modifications available.

Technical Specifications

Range of motion	50 μm x 50 μm
Resolution	0.33 nm
Voltage range	-5V to +150V
Resonant frequency (X)	1500 Hz
Resonant frequency (Y)	1000 Hz
Stiffness	> 5 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load (horizontal)*	5 kg
Body material	Al
Control electronics	Nano-Drive™/Nano-Drive™85

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

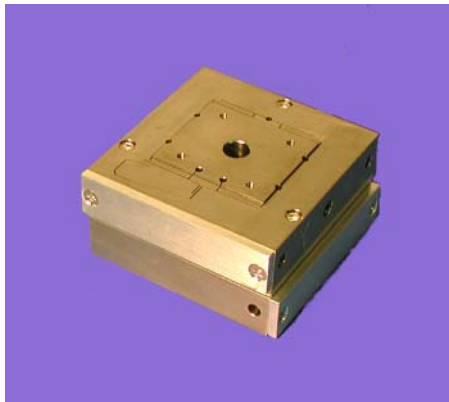


All dimensions in inches unless otherwise stated.

NANO-M250

Product Description

The *Nano-M250* is a compact two axis nanopositioning system constructed from titanium or invar with sub-nanometer accuracy under closed loop control. The compact design of the *Nano-M250* allows it to be easily integrated into existing instrumentation for applications such as nanolithography, SEM and active optics. The *Nano-M250* is ideal for demanding applications which require parallel motion and sub nanometer accuracy. The *Nano-M250* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-M250* is also available in high vacuum and ultra high vacuum compatible models.



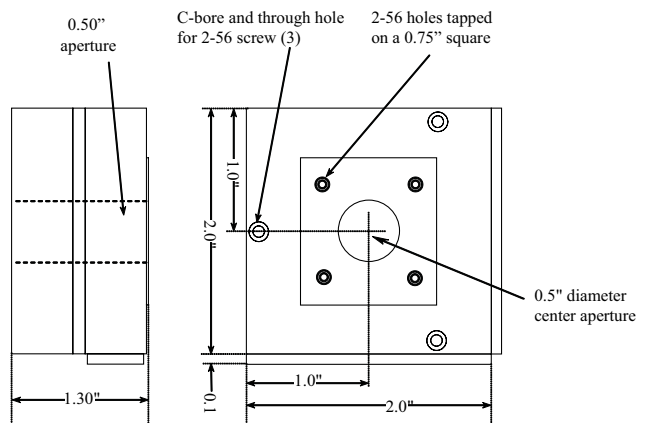
Highlights

- ◆ Easy integration into existing instrumentation
- ◆ Compact Design
- ◆ 50 μm x 50 μm (X, Y).
- ◆ Sub-nanometer positioning.
- ◆ Vacuum compatible models available

Technical Specifications

Range of motion	50 μm x 50 μm
Resolution	0.33 nm
Resonant Frequency (X)	1 kHz
Resonant Frequency (Y)	700 Hz
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
θ_{roll} (Typical)	< 5 μrad
θ_{pitch} (Typical)	< 5 μrad
θ_{yaw} (Typical)	< 10 μrad
Body Material	Ti or Invar
Control electronics	<i>Nano-Drive</i> TM

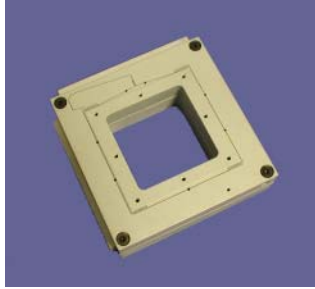
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

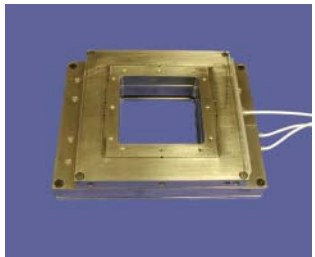
NANO-T SERIES

Product Description



The *Nano-T Series* are multi-axis nanopositioning systems with sub-nanometer accuracy constructed from aluminum or invar. The *Nano-T Series* is available with up to 200

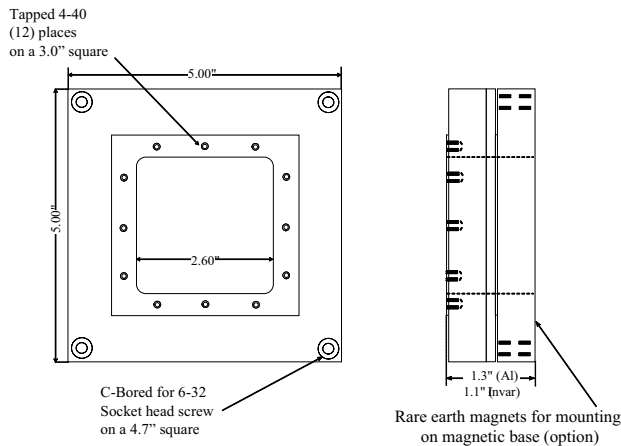
microns in X and Y, up to 50 microns in Z, and a generous center aperture to accommodate lenses and probes without compromising performance. As with all Mad City Labs, Inc.



systems they feature integrated position sensors and closed loop control for absolute position measurement. The *Nano-T Series* are priced competitively

and available as two or three axis models.

Two axis: *Nano-T11, Nano-T22* **Three axis:** *Nano-T112, Nano-T115, Nano-T222, Nano-T225*



Photos

Top: *Nano-T11 (Aluminum)*, Bottom: *Nano-T115 (Invar)*

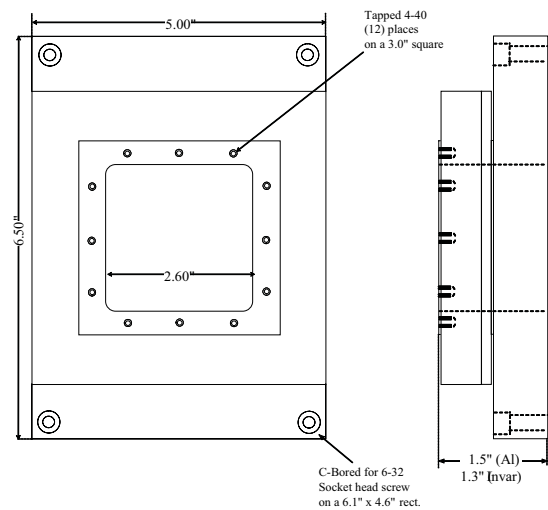
Technical Drawings

Above: *Nano-T (2 axis)*, Right: *Nano-T (3 axis)*

Technical Specifications

Range of motion (X)	100 μ m/200 μ m
Range of motion (Y)	100 μ m/200 μ m
Range of motion (Z)	20 μ m/50 μ m
Resolution (200/100/50/20)	1.3/0.67/0.33/0.13 nm
Resonant frequency (X)	450 Hz
Resonant frequency (Y)	350 Hz
Resonant frequency (Z)	> 1kHz
Stiffness	1.0 N/mm
θ_{roll} (typical)	5 μ rad
θ_{pitch} (typical)	5 μ rad
θ_{yaw} (typical)	10 μ rad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Aluminum or Invar
Control electronics	<i>Nano-Drive™</i>

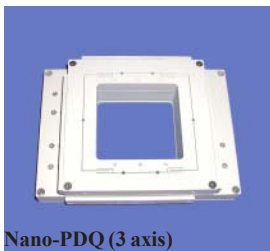
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

NANO-PDQ SERIES

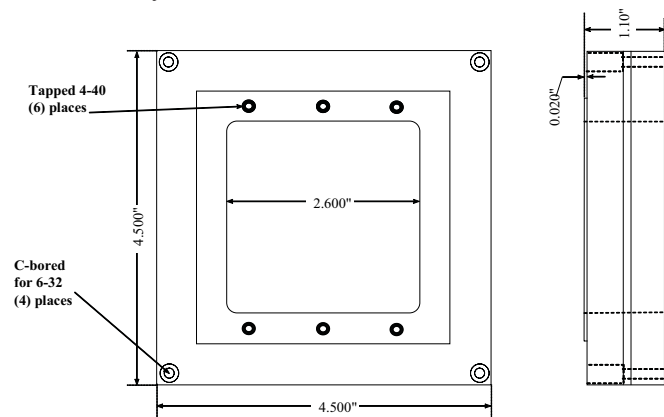
Product Description



Nano-PDQ (3 axis)

The *Nano-PDQ Series* are high speed multi-axis precision nanopositioning systems with sub-nanometer accuracy under closed loop control. The *Nano-PDQ*

Series offers a compact footprint with a large center aperture while still offering fast performance with a resonant frequency greater than 1kHz. This makes it ideal for applications such as photo bleaching and the calibration of optical traps (via Stokes fluid drag measurements). The *Nano-PDQ Series* are also ideal for applications that demand high rates of scanning or large load capacity. When used with the *Nano-Drive™85* controller full amplitude scan rates of 400Hz are achievable, better than 10 times the speed of comparable systems! The *Nano-PDQ Series* features parallel, uncoupled motion in two or three axes and fully integrated piezoresistive sensors for absolute position measurement and sub-nanometer precision when operated under closed loop control using the *Nano-Drive™* family of controllers.



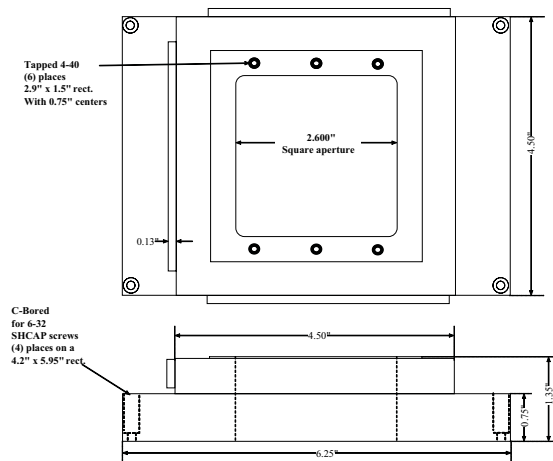
Above: Nano-PDQ (2 axis), Right: Nano-PDQ (3 axis)

All dimensions in inches unless otherwise stated.

Technical Specifications

Range of motion (X)	50 μ m/75 μ m
Range of motion (Y)	50 μ m/75 μ m
Range of motion (Z)	50 μ m
Resolution (50/75 μ m)	0.33/0.5 nm
Resonant Frequency (X,Y)	2.5 kHz
Resonant Frequency (Z)	1.5 kHz
Scanning Speed (full amplitude)	up to 400 Hz
Stiffness	3.0 N/ μ m
θ_{roll} (typical)	5 μ rad
θ_{pitch} (typical)	5 μ rad
θ_{yaw} (typical)	10 μ rad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al, Invar or Titanium
Controller	<i>Nano-Drive™/Nano-Drive™85</i>
Two Axis: Nano-PDQ250, NanoPDQ275, Nano-PDQ250HS, Nano-PDQ275HS	
Three Axis: Nano-PDQ350, Nano-PDQ375, Nano-PDQ350HS, Nano-PDQ375HS	

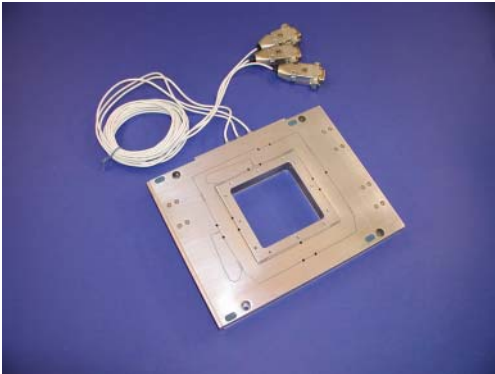
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



NANO-LP SERIES

Product Description

The *Nano-LP Series* are ultra-low profile three axis nanopositioning systems with sub-nanometer accuracy. The ultra-low profile design of the *Nano-LP Series* allows it to be integrated into existing instrumentation where space is restricted, such as inverted optical microscopes. With extended ranges of motion, the *Nano-LP Series* is ideal for demanding microscopy applications which require long range travel, sub nanometer accuracy and three dimensions of motion. The *Nano-LP Series* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy. The *Nano-LP Series* is available constructed from aluminum, invar or titanium.



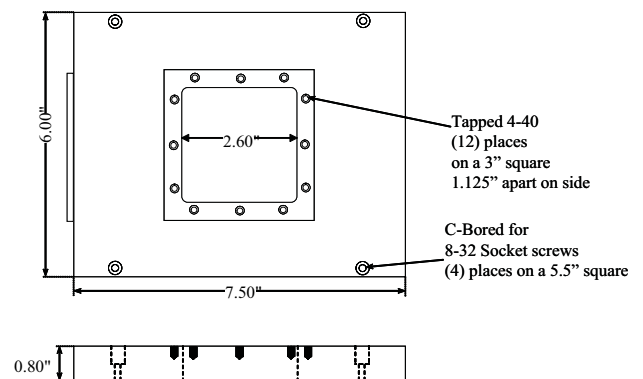
Highlights

- ◆ Engineered to retrofit to most microscopes.
- ◆ Lowest profile nanopositioner available.
- ◆ Long range motion
- ◆ Sub-nanometer positioning.
- ◆ Large through hole (2.6" x 2.6")
- ◆ Available constructed from aluminum, invar or titanium.
- ◆ Single molecule detection.

Technical Specifications

Range of motion (<i>Nano-LP100</i>)	100 x 100 x 100 μ m
Range of motion (<i>Nano-LP200</i>)	200 x 200 x 200 μ m
Resolution (200/100)	1.3 / 0.67 nm
Resonant frequency (X)	450 Hz
Resonant frequency (Y)	350 Hz
Resonant frequency (Z)	1000 Hz
Stiffness	1.0 N/ μ m
θ_{roll} (typical)	5 μ rad
θ_{pitch} (typical)	5 μ rad
θ_{yaw} (typical)	10 μ rad
Recommended load (horizontal)*	0.5 kg
Body Material	Al, Invar or Ti
Control electronics	<i>Nano-Drive</i> TM

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

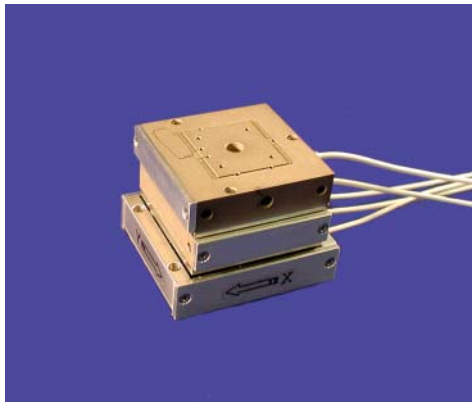


All dimensions in inches unless otherwise stated.

NANO-M350

Product Description

The *Nano-M350* is a compact three axis nanopositioning system constructed from titanium or invar with sub-nanometer accuracy under closed loop control. The compact design of the *Nano-M350* allows it to be easily integrated into existing instrumentation for applications such as nanolithography, SEM and active optics. The *Nano-M350* is ideal for demanding applications which require parallel motion and sub nanometer accuracy. The *Nano-M350* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-M350* is also available in high vacuum and ultra high vacuum compatible models.



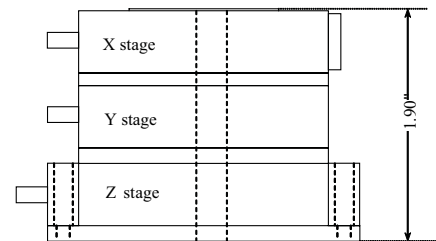
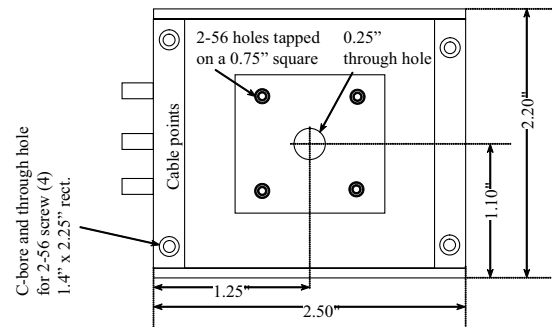
Highlights

- ◆ Easy integration into existing instrumentation
- ◆ Compact Design
- ◆ 50 μm x 50 μm x 25 μm (x, y, z).
- ◆ Sub-nanometer positioning.
- ◆ Vacuum compatible models available

Technical Specifications

Range of motion (X)	50 μm
Range of motion (Y)	50 μm
Range of motion (Z)	25 μm
Resolution (50/25)	0.33/ 0.17 nm
Resonant Frequency (X)	1 kHz
Resonant Frequency (Y)	700 Hz
Resonant Frequency (Z)	> 1 kHz
θ_{roll} (Typical)	< 5 μrad
θ_{pitch} (Typical)	< 5 μrad
θ_{yaw} (Typical)	< 10 μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al/Ti or Invar
Control electronics	<i>Nano-Drive</i> TM

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

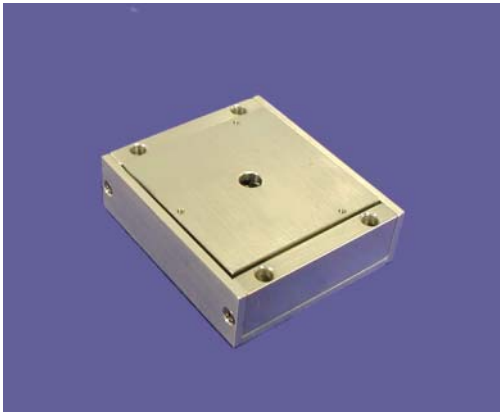


All dimensions in inches unless otherwise stated.

NANO-M3Z

Product Description

The *Nano-M3Z* is a triple axis nanopositioning system with sub-nanometer accuracy constructed from invar or aluminum. The compact design of the *Nano-M3Z* allows it to be integrated into existing instrumentation where space is restricted. The *Nano-M3Z* is ideal for demanding applications which require high precision, alignment capabilities, and sub nanometer accuracy. The *Nano-M3Z* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-M3Z* is also available as a vacuum compatible model.



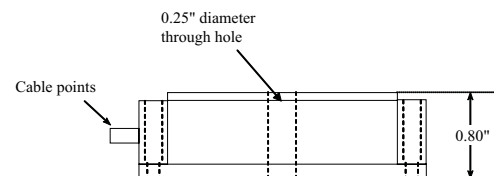
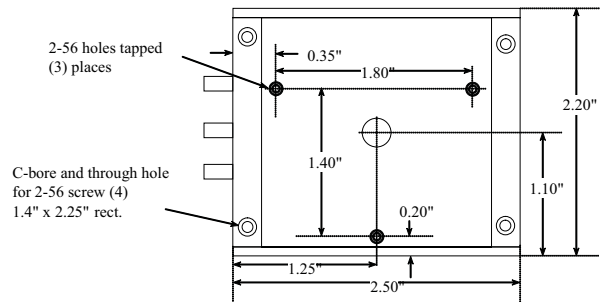
Highlights

- ◆ *Ideal for alignment applications.*
- ◆ *Compact Design*
- ◆ *Sub-nanometer positioning.*
- ◆ *Minimal parasitic motion*
- ◆ *Vacuum compatible models available*
- ◆ *Sub-microradian positioning.*

Technical Specifications

Range of motion (Z)	25 μm
Range of motion (θ_x)	1 mrad
Range of motion (θ_y)	1 mrad
Resolution	0.16 nm
Resonant frequency	> 1 kHz
Stiffness	1.0 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load* (horizontal)	0.5 kg
Recommended load* (vertical)	0.2 kg
Body Material	Al or Invar
Control electronics	<i>Nano-Drive™</i>

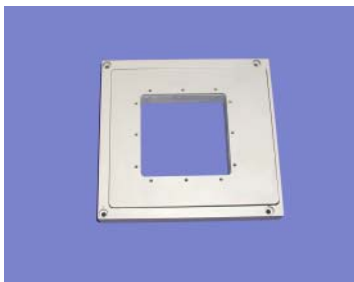
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

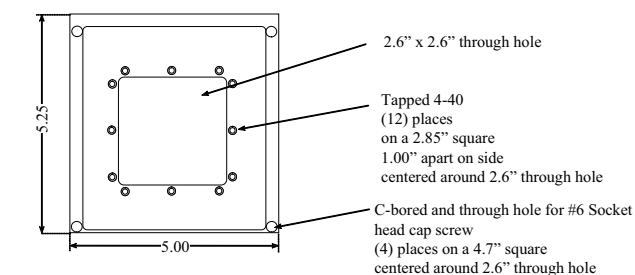
NANO-ALIGN3

Product Description



The *Nano-Align3* is a triple axis nanopositioning system with sub-nanometer accuracy constructed from aluminum. The low profile design of the *Nano-Align3*

allows it to be integrated into existing instrumentation where space is restricted. With a generous center aperture this system is ideal for demanding microscopy applications which require long range travel, alignment capabilities, and sub nanometer accuracy. The *Nano-Align3* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-Align3* is also available constructed from invar, super invar, or titanium



All dimensions in inches unless otherwise stated.

Technical Specifications

Range of motion (Z)	100 μm
Range of motion (θ_x)	2 mrad
Range of motion (θ_y)	2 mrad
Resolution (Z, θ)	0.67 nm/ 0.02 μrad
Resonant frequency	> 1 kHz
Stiffness	1.0 N/ μm
Recommended load* (horizontal)	0.5 kg
Recommended load* (vertical)	0.2 kg
Body Material	Al, Invar or Ti
Control electronics	<i>Nano-Drive</i> TM / <i>Nano-Drive</i> TM 85

* *These are recommended loads, larger load requirements should be discussed with our engineering staff.*

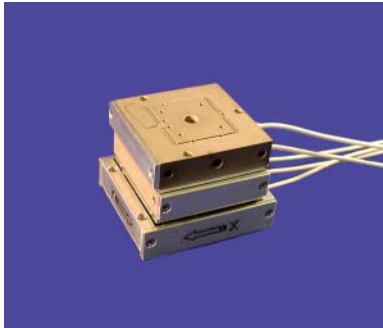
Highlights

- ◇ *Engineered to retrofit to most microscopes.*
- ◇ *Low profile 0.78"*
- ◇ *Sub-nanometer positioning.*
- ◇ *Large through hole (2.6"x2.6") for inverted objective lens.*
- ◇ *Available constructed from aluminum, invar or titanium.*
- ◇ *Extended ranges of motion available.*

NANO-MAN5

Product Description

The *Nano-Man5* is a five axis nanopositioning system constructed from titanium or invar with sub-nanometer/sub-microradian accuracy under closed loop



control. The compact design of the *Nano-Man5* allows it to be easily integrated into existing instrumentation for applications such as nanolithography, SEM and active optics. The *Nano-Man5* is ideal for demanding applications which require parallel motion, sub nanometer accuracy and three linear axes of motion. In addition, the *Nano-Man5* has 1 milliradian of tip/tilt in θ_x, θ_y with sub-microradian resolution. The *Nano-Man5* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-Man5* is also available as a three axis system, the *Nano-M350* or *Nano-M3Z*, and vacuum

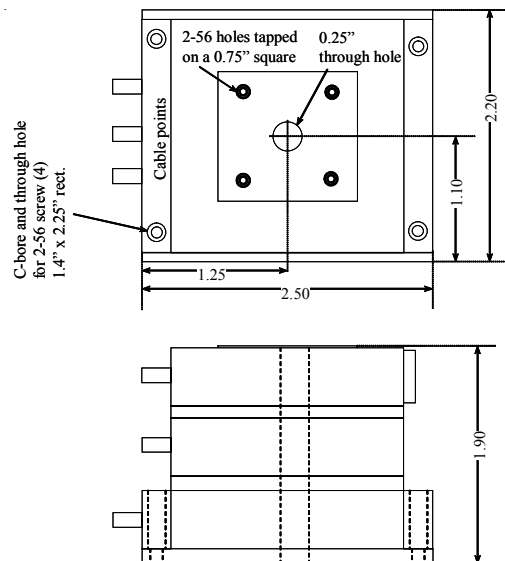
Highlights

- ◇ Easy integration into existing instrumentation
- ◇ Compact Design
- ◇ $50 \mu\text{m} \times 50 \mu\text{m} \times 20 \mu\text{m}$ (x, y, z).
- ◇ Sub-nanometer positioning.
- ◇ 1 mrad (θ_x, θ_y).
- ◇ Sub-microradian resolution .
- ◇ Vacuum compatible models available

Technical Specifications

Range of motion (XY)	50 μm x 50 μm
Range of motion (Z)	25 μm
Range of motion (θ_x, θ_y)	1 mrad x 1 mrad
Resolution (XY/Z/ θ)	0.32 nm/0.13 nm/1 μrad
Resonant Frequency (X)	1 kHz
Resonant Frequency (Y)	700 Hz
Resonant Frequency (Z)	> 1 kHz
θ_{roll} (XY typical)	< 5 μrad
θ_{pitch} (XY typical)	< 5 μrad
θ_{yaw} (XY typical)	< 10 μrad
Recommended load (horizontal)*	0.2 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al/Ti or Invar
Control electronics	<i>Nano-Drive</i> TM

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

NANO-ALIGN

Product Description

The *Nano-Align* is a five axis nanopositioning system with sub-nanometer/sub-microradian accuracy under closed loop control. The low profile design of the *Nano-Align* allows it to be easily integrated into existing instrumentation, e.g. microscopes, probe assemblies. With an extended range of motion in Z, the *Nano-Align* is ideal for demanding applications which require long range travel, sub nanometer accuracy and three dimensions of motion. In addition, the *Nano-Align* has 1.2 milliradians of tip/tilt in θ_x, θ_y with sub-microradian resolution. The *Nano-Align* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-Align* is also offered as a three axis system and can be constructed from specialty materials such as invar.

Highlights

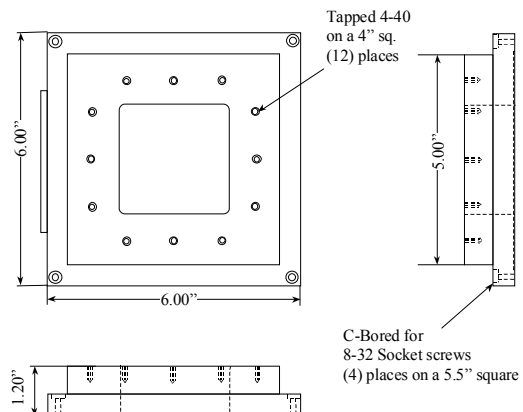
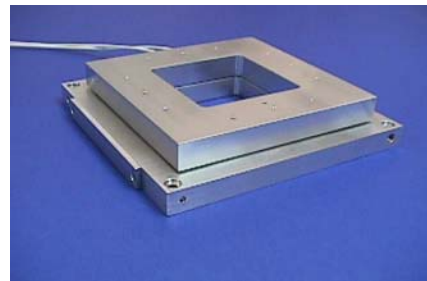
- ◆ Easy integration into existing instrumentation
- ◆ Low profile 1.20"
- ◆ 100 μm x 100 μm x 50 μm (x, y, z).
- ◆ Sub-nanometer positioning.
- ◆ 1.20 mrad (θ_x, θ_y).
- ◆ Sub-microradian resolution .
- ◆ Large through hole (2.6"x2.6") for inverted objective lens.
- ◆ Extended ranges of motion available.

All dimensions in inches unless otherwise stated.

Technical Specifications (Aluminum)

Range of motion (XY)	100 μm x 100 μm
Range of motion (Z)	50 μm
Range of motion (θ_x, θ_y)	1.2 mrad x 1.2 mrad
Resolution (XY/Z/ θ)	0.67 nm/0.33 nm/ 0.01 μrad
Resonant Frequency (XY)	200 Hz
Resonant Frequency (Z)	1.5 kHz
θ_{roll} (XY typical)	5 μrad
θ_{pitch} (XY typical)	5 μrad
θ_{yaw} (XY typical)	10 μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al or Invar
Control electronics	<i>Nano-Drive</i> TM

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



NANO-VIEW™

Product Description

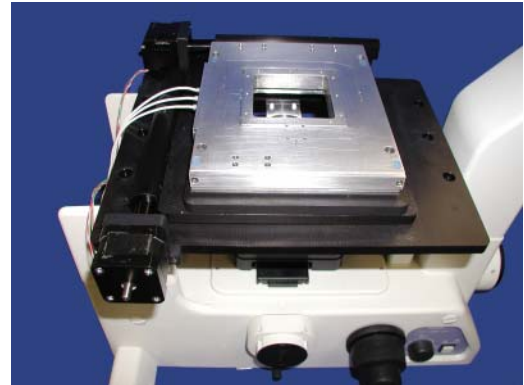
The *Nano-View™* is a fully integrated positioning system for use with most inverted optical microscopes¹ that offers long range linear positioning in two dimensions, combined with a high resolution nanopositioner. The *Nano-View™* is comprised of a motor driven two axis linear motion stage and an ultra-low profile, high resolution nanopositioning system. The micropositioning stage has integrated encoders and offers up to 1" (25 mm) travel per axis with an encoder resolution of 20 nm. The minimum step size is 95.25 nm with a step repeatability of 50 nm.

The nanopositioning systems employed in the *Nano-View™* are high precision with the lowest profile commercially available. Travel ranges extend up to 200 microns per axis (X,Y and Z) with single nanometer resolution or better under closed loop control. As with all Mad City Labs, Inc. nanopositioning systems they are designed for minimum parasitic motion and feature integrated sensors for absolute position measurement.

The *Nano-View™* is designed to be controlled by standard National Instruments control boards and is fully compatible with user written LabView™ software, offering greater flexibility.

The *Nano-View™* is the complete nanometer scale positioning system for single molecule spectroscopy and high resolution microscopy applications.

¹ Olympus IX Series, Nikon TE Series inverted microscopes, Leica DMIRB and Zeiss Axiovert Series. Other inverted and upright microscope models subject to special order.



Above: Nano-View™ 100-3

Highlights

- ◆ *Fully integrated positioning system.*
- ◆ *High precision long range motion up to 1" (25 mm).*
- ◆ *High performance two and three axis nanopositioners.*
- ◆ *Sub-nanometer precision*
- ◆ *Accurate position tracking via encoders (MicroStage)*
- ◆ *Integrated position sensors (Nanopositioner)*
- ◆ *Retrofitted to your inverted microscope*
- ◆ *High Speed data acquisition available.*
- ◆ *Compatible with National Instruments control boards and user written LabView™ Software.*
- ◆ *Suitable for demanding microscopy applications.*

Standard Configuration

- ◆ *Two axis stepper motor MicroStage.*
- ◆ *Two or Three Axis Closed Loop Nanopositioning System.*
- ◆ *Integrated Linear encoders (MicroStage).*
- ◆ *Micro-Drive controller.*
- ◆ *Nano-Drive™ controller.*
- ◆ *National Instruments NI7334 motion control board*

NANO-VIEW™

Specifications: Nanopositioner

Number of axes	2 or 3
Range of motion (XY)	100 or 200 μm
Range of motion (Z)	100 or 200 μm
Resolution (100/200 μm)	0.67/1.3 nm
Resonant frequency (X-axis)	450 Hz
Resonant frequency (Y-axis)	350 Hz
Resonant frequency (Z-axis)	2300 Hz
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al or Invar
Control Electronics	Nano-Drive™

Specifications: MicroStage

Number of axes	2
Range of motion	up to 1" (25 mm)
Step Size	95.25 nm
Step repeatability	50 nm
Encoder resolution	20 nm
Body Material	Anodized Al
Control electronics	Micro-Drive™

Ordering Information:

Nano-View™100/200 - # axes - Option

Example: Nano-View™100 -3-HS describes a Nano-View system with a 3 axis 100 micron (per axis) nanopositioner with the high speed data acquisition option.

- Please specify brand and model of inverted microscope.

- Some options are exclusive, please consult with your sales representative.

Available Options

- NV162

Two axis 16 bit digital interface for use with Nano-Drive™ controller. National Instruments PCI-DIO96 and R1005050 cable included. LabView™ compatible.

- NV163

Three axis 16 bit digital interface for use with Nano-Drive™ controller.

-NV164

Four axis 16 bit digital interface for use with Nano-Drive™ controller.

- NV202

Two axis 20 bit digital interface for use with Nano-Drive™ controller. National Instruments PCI-DIO96 and R1005050 cable included. LabView™ compatible.

-NV203

Three axis 20 bit digital interface for use with Nano-Drive™ controller.

-NV204

Four axis 20 bit digital interface for use with Nano-Drive™ controller.

- HS

High speed data acquisition via parallel port for four axes. Acquisition at speeds of 100 kHz simultaneously for 4 axes. Includes 2 PXI6534 boards, PXI1002 crate and shielded cables. LabView™ compatible.

- F100E

Objective lens nanopositioning system with encoder. Range of motion is 100 microns in Z with sub-nanometer accuracy. Encoder must be installed by trained personnel. Includes analog controller.

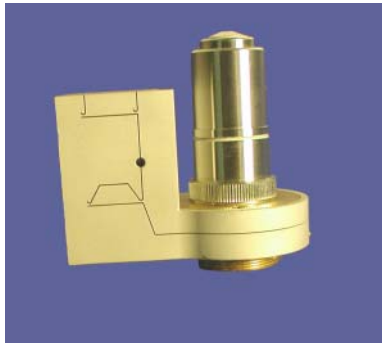
- 5NM

Upgrade to 5nm linear encoders on the MicroStage

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

NANO-F100

Product Description



The *Nano-F100* is a focusing element nanopositioner with 100 microns of travel and sub-nanometer accuracy under closed loop control.

The *Nano-F100* offers an alternative for z-motion in microscopy applications, or in applications to compensate for thermal expansion. It can be used as a stand-alone item or in conjunction with other Mad City Labs, Inc. nanopositioning systems. The *Nano-F100* is constructed from aluminum and brass with integrated piezoresistive sensors and quick mount adapter for ease of use. The quick mount adapter screws directly into the microscope separately from the Nano-F100. The Nano-F100 clamps directly onto the quick mount adapter with the no rotation. The brass threads of both the adapter and the specific microscope thread are interchangeable. The *Nano-F100* is compatible with all microscopes. Please specify your microscope model at time of order.

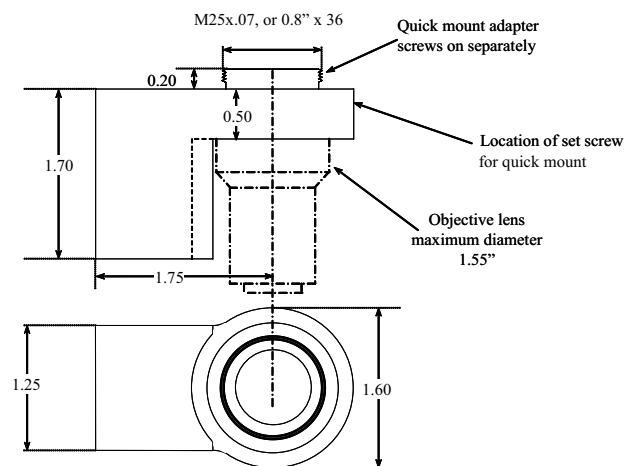
Highlights

- ◇ Compact design.
- ◇ 100 μm travel (z)
- ◇ Quick mount connector
- ◇ Sub-nanometer positioning.
- ◇ Compatible with other Mad City Labs, Inc. nanopositioning systems.
- ◇ Compatible with all microscopes.

Technical Specifications

Product Name (Olympus).....	Nano-F100-0.8
Product Name (Nikon)	Nano-F100-25
Range of motion (Z)	100 μm
Resolution	0.67 nm
Resonant Frequency	>1kHz
Stiffness	1.0 N/ μm
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al/Brass
Control electronics	<i>Nano-Drive</i> TM

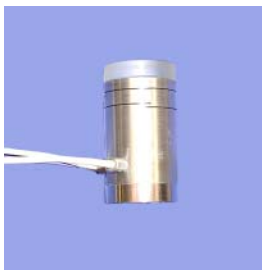
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

NANO-MTA SERIES

Product Description



The *Nano-MTA Series* are single and two axis piezoelectric mirror tilt actuator for laser beam steering.

With sub-microradian resolution the *Nano-MTA Series* is ideal for applications in optical disk

manufacturing, laser beam steering and tracking and laser beam scanning. Piezoresistive sensors are included for absolute measurement and sub-microradian accuracy under closed loop control. The *Nano-MTA Series* is compatible with either the *Nano-Drive™* or *Nano-Drive™85* controllers. Both controllers include sensor electronics, proportional integral feedback control, and 150V amplifier. The *Nano-MTA Series* when used with a *Nano-Drive™85* controller is capable of speeds of 1kHz full amplitude. This makes the *Nano-MTA Series* ideal for high speed scanning applications.

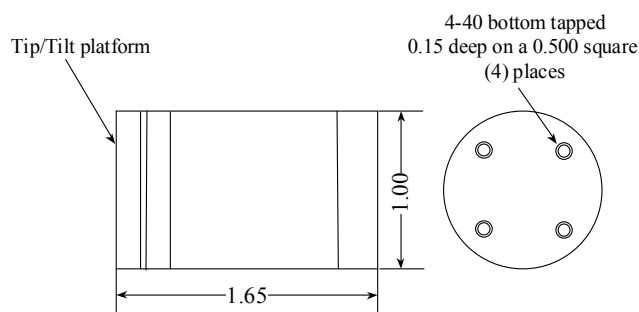
Highlights

- ◇ Up to 5 milliradians motion.
- ◇ Sub-microradian resolution.
- ◇ Speeds up to 1kHz full amplitude available
- ◇ True decoupled motion.
- ◇ Mountable in any orientation.
- ◇ Integrated position sensors.
- ◇ Available in aluminum or invar.
- ◇ Increased range of motion and custom design available.

Technical Specifications

Range of motion (per axis).....	2.0 mrad
Resolution	0.02 μ rad
Range of motion (extended)	5.0 mrad
Resolution	0.04 μ rad
Resonant frequency (unloaded).....	5 kHz \pm 20%
Scanning Speed	1kHz
Optics	2.0"
Body material	Al or Al/Invar
Control electronics	<i>Nano-Drive™/Nano-Drive™85</i>
Footprint (Standard).....	1.0"(Diameter) x 1.65"

Models available: Nano-MTA (single axis), Nano-MTA2 (2 axis), Nano-MTAX (extended range), Nano-MTA2X, add -HS for high speed models.

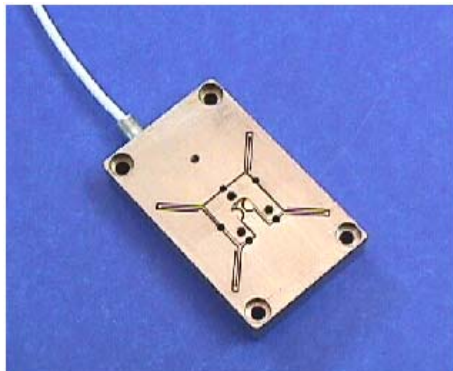


All dimensions in inches unless otherwise stated.

NANO-THETA

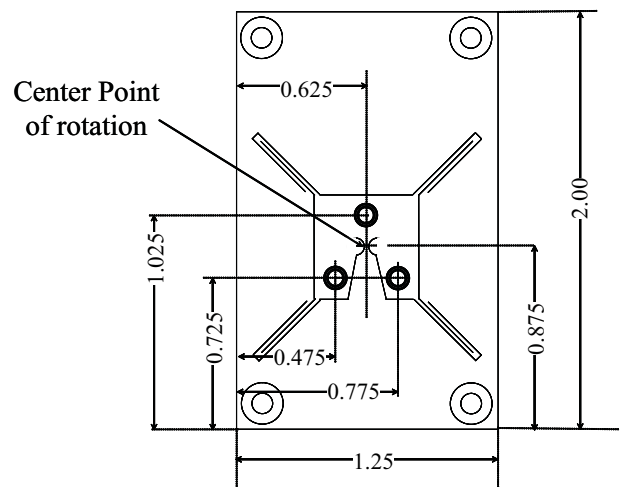
Product Description

The *Nano-Theta* is a piezo-actuated rotation stage for mask alignment and laser beam steering. With sub- μ rad resolution the *Nano-Theta* is ideal for applications in lithography, optical disk manufacturing, laser beam steering and tracking and laser beam scanning. The innovative design of the *Nano-Theta* incorporates a readily accessible and well-defined axis of rotation which allows a mirror to be mounted so that it is co-planar with the axis of rotation. A piezoresistive sensor is included for absolute measurement and sub-microradian accuracy.



Technical Specifications

Range of motion	2.0 mrad
Resolution	0.02 μ rad
Resonant frequency (unloaded)	2 kHz \pm 20%
Body material	Al or Invar
Control electronics	<i>Nano-Drive</i> TM



All dimensions in inches unless otherwise stated.

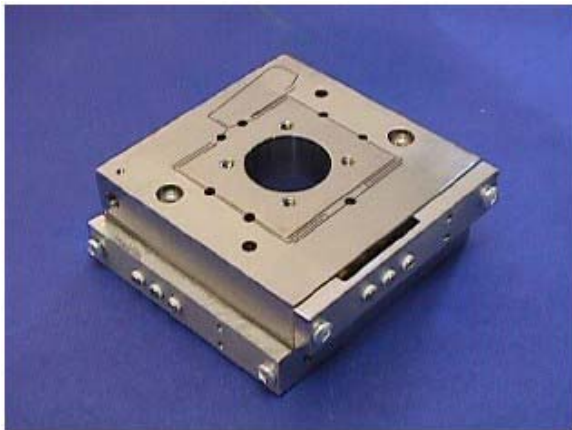
Highlights

- ◇ 2.0 mrad range.
- ◇ 0.02 μ rad resolution.
- ◇ Accessible & well defined axis of rotation.
- ◇ Available in invar or aluminum.
- ◇ Mountable in any orientation.
- ◇ Integrated position sensor.
- ◇ Custom designs available.
- ◇ Vacuum compatible versions available

NANO-UHV50

Product Description

The *Nano-UHV50* is a two axis UHV compatible nanopositioning system with sub-nanometer accuracy constructed from invar. Made entirely from UHV compatible materials, the *Nano-UHV50* is bakeable to 120°C for vacuum applications in the 10⁻¹⁰ Torr range. As with all our nanopositioning systems, the *Nano-UHV50* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy. Footprint modifications available by custom order.



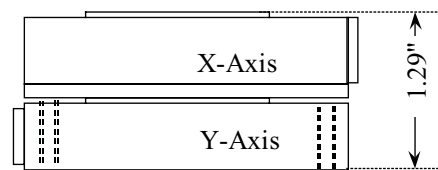
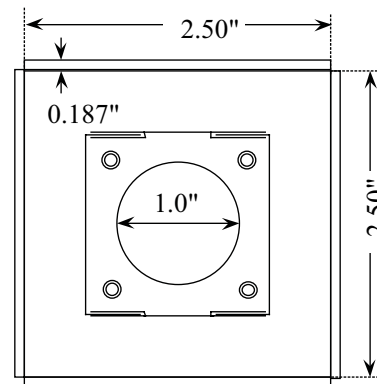
Highlights

- ◆ Built entirely from UHV compatible materials.
- ◆ Bakeable to 120°C.
- ◆ Invar construction.
- ◆ X-ray, VUV, and optical microscopy.
- ◆ Surface metrology.
- ◆ UHV atomic scale microscopy.
- ◆ 1" diameter through hole.

Technical Specifications

Range of motion	50 x 50 μm
Resolution	0.33 nm
Voltage range	-5V to +150V
Resonant frequency (X)	500 Hz
Resonant frequency (Y)	250 Hz
Stiffness	0.5 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Mass	800 g
Body material	Invar
Control electronics	<i>Nano-Drive™</i>

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

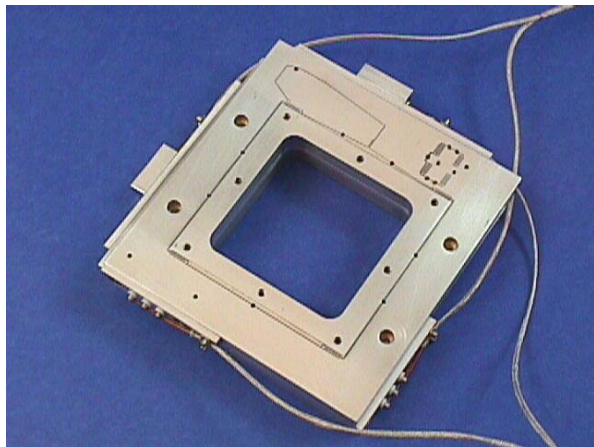


All dimensions in inches unless otherwise specified.

NANO-UHV100

Product Description

The *Nano-UHV100* is a two axis UHV compatible nanopositioning stage with sub-nanometer accuracy. Made entirely from UHV compatible materials, the *Nano-UHV100* can be baked to 120°C for vacuum applications in the 10⁻¹⁰ Torr range. As with all our nanopositioning systems, the *Nano-UHV100* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy. The *Nano-UHV100* is constructed from titanium and entirely UHV compatible.



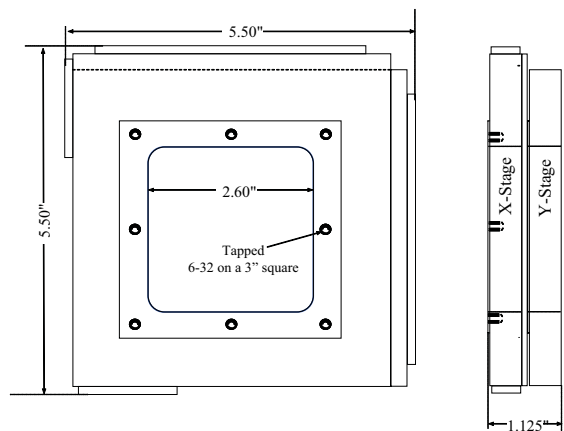
Highlights

- ◆ Built entirely from UHV compatible materials.
- ◆ Bakeable to 120°C.
- ◆ Titanium construction.
- ◆ X-ray, VUV, and optical microscopy.
- ◆ Surface metrology.
- ◆ UHV atomic scale microscopy.
- ◆ 2.6" x 2.6" through hole.

Technical Specifications

Range of motion	100 x 100 μm
Resolution	0.67 nm
Voltage range	-5V to +150V
Resonant frequency (X-Axis)	500 Hz
Resonant frequency (Y-Axis)	250 Hz
Stiffness	1.0 N/μm
θ _{roll} (typical)	5μrad
θ _{pitch} (typical)	5μrad
θ _{yaw} (typical)	10μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Titanium
Control electronics	<i>Nano-Drive™</i>

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

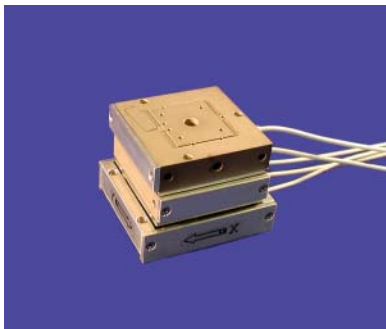


All dimensions in inches unless otherwise specified.

NANO-MAN5

Product Description

The *Nano-Man5* is a five axis nanopositioning system constructed from titanium or invar with sub-nanometer/sub-microradian accuracy under closed loop



control. The compact design of the *Nano-Man5* allows it to be easily integrated into existing instrumentation for applications such as nanolithography, SEM and active optics. The *Nano-Man5* is ideal for demanding applications which require parallel motion, sub nanometer accuracy and three linear axes of motion. In addition, the *Nano-Man5* has 1 milliradian of tip/tilt in θ_x, θ_y with sub-microradian resolution. The *Nano-Man5* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-Man5* is also available as a three axis system, the *Nano-M350* or *Nano-M3Z*, and vacuum

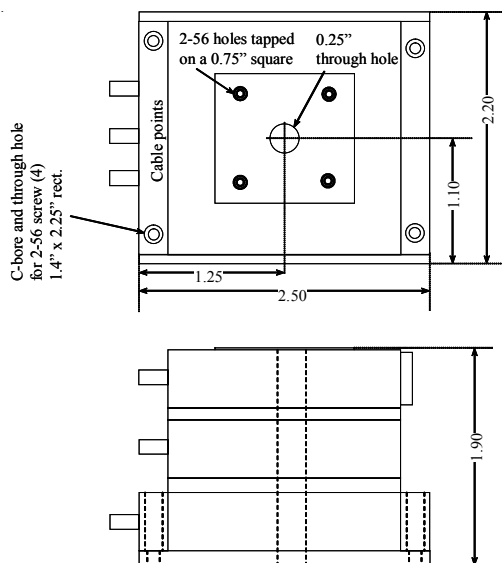
Highlights

- ◇ Easy integration into existing instrumentation
- ◇ Compact Design
- ◇ $50 \mu\text{m} \times 50 \mu\text{m} \times 20 \mu\text{m}$ (x, y, z).
- ◇ Sub-nanometer positioning.
- ◇ 1 mrad (θ_x, θ_y).
- ◇ Sub-microradian resolution .
- ◇ Vacuum compatible models available

Technical Specifications

Range of motion (XY)	50 μm x 50 μm
Range of motion (Z)	25 μm
Range of motion (θ_x, θ_y)	1 mrad x 1 mrad
Resolution (XY/Z/ θ)	0.32 nm/0.13 nm/1 μrad
Resonant Frequency (X)	1 kHz
Resonant Frequency (Y)	700 Hz
Resonant Frequency (Z)	> 1 kHz
θ_{roll} (XY typical)	< 5 μrad
θ_{pitch} (XY typical)	< 5 μrad
θ_{yaw} (XY typical)	< 10 μrad
Recommended load (horizontal)*	0.2 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al/Ti or Invar
Control electronics	<i>Nano-Drive</i> TM

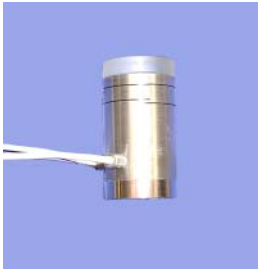
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

NANO-MTA SERIES

Product Description



The *Nano-MTA Series* are single and two axis piezoelectric mirror tilt actuator for laser beam steering. With sub-microradian resolution the *Nano-MTA Series* is ideal for applications in optical disk

manufacturing, laser beam steering and tracking and laser beam scanning. Piezoresistive sensors are included for absolute measurement and sub-microradian accuracy under closed loop control. The *Nano-MTA Series* is compatible with either the *Nano-Drive™* or *Nano-Drive™85* controllers. Both controllers include sensor electronics, proportional integral feedback control, and 150V amplifier. The *Nano-MTA Series* when used with a *Nano-Drive™85* controller is capable of speeds of 1kHz full amplitude. This makes the *Nano-MTA Series* ideal for high speed scanning applications.

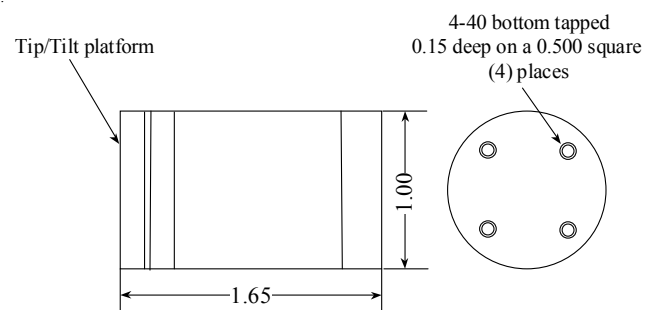
Highlights

- ◇ Up to 5 milliradians motion.
- ◇ Sub-microradian resolution.
- ◇ Speeds up to 1kHz full amplitude available
- ◇ True decoupled motion.
- ◇ Mountable in any orientation.
- ◇ Integrated position sensors.
- ◇ Available in aluminum or invar.
- ◇ Increased range of motion and custom design available.

Technical Specifications

Range of motion (per axis).....	2.0 mrad
Resolution	0.02 μ rad
Range of motion (extended)	5.0 mrad
Resolution	0.04 μ rad
Resonant frequency (unloaded).....	5 kHz \pm 20%
Scanning Speed	1kHz
Optics	2.0"
Body material	Al or Al/Invar
Control electronics	<i>Nano-Drive™/Nano-Drive™85</i>
Footprint (Standard).....	1.0"(Diameter) x 1.65"

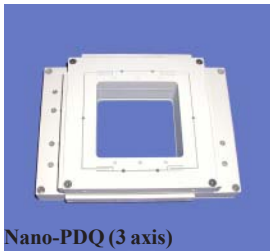
Models available: Nano-MTA (single axis), Nano-MTA2 (2 axis), Nano-MTAX (extended range), Nano-MTA2X, add -HS for high speed models.



All dimensions in inches unless otherwise stated.

NANO-PDQ SERIES

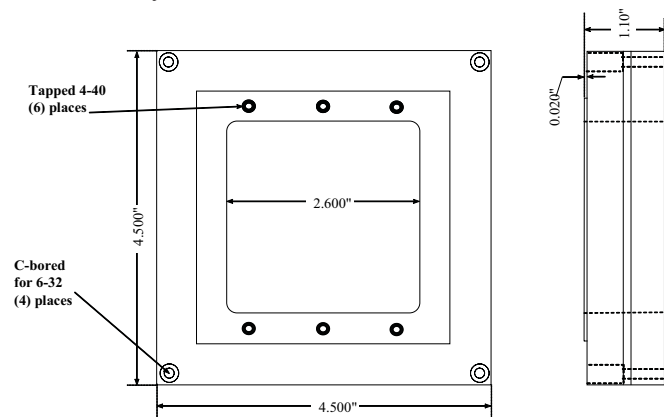
Product Description



Nano-PDQ (3 axis)

The *Nano-PDQ Series* are high speed multi-axis precision nanopositioning systems with sub-nanometer accuracy under closed loop control. The *Nano-PDQ*

Series offers a compact footprint with a large center aperture while still offering fast performance with a resonant frequency greater than 1kHz. This makes it ideal for applications such as photo bleaching and the calibration of optical traps (via Stokes fluid drag measurements). The *Nano-PDQ Series* are also ideal for applications that demand high rates of scanning or large load capacity. When used with the *Nano-Drive™85* controller full amplitude scan rates of 400Hz are achievable, better than 10 times the speed of comparable systems! The *Nano-PDQ Series* features parallel, uncoupled motion in two or three axes and fully integrated piezoresistive sensors for absolute position measurement and sub-nanometer precision when operated under closed loop control using the *Nano-Drive™* family of controllers.



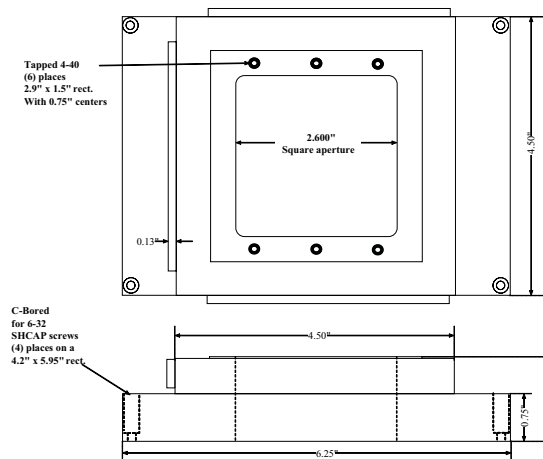
Above: Nano-PDQ (2 axis), Right: Nano-PDQ (3 axis)

All dimensions in inches unless otherwise stated.

Technical Specifications

Range of motion (X)	50 μ m/75 μ m
Range of motion (Y)	50 μ m/75 μ m
Range of motion (Z)	50 μ m
Resolution (50/75 μ m)	0.33/0.5 nm
Resonant Frequency (X,Y)	2.5 kHz
Resonant Frequency (Z)	1.5 kHz
Scanning Speed (full amplitude)	up to 400 Hz
Stiffness	3.0 N/ μ m
θ_{roll} (typical)	5 μ rad
θ_{pitch} (typical)	5 μ rad
θ_{yaw} (typical)	10 μ rad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al, Invar or Titanium
Controller	<i>Nano-Drive™/Nano-Drive™85</i>
Two Axis: Nano-PDQ250, NanoPDQ275, Nano-PDQ250HS, Nano-PDQ275HS	
Three Axis: Nano-PDQ350, Nano-PDQ375, Nano-PDQ350HS, Nano-PDQ375HS	

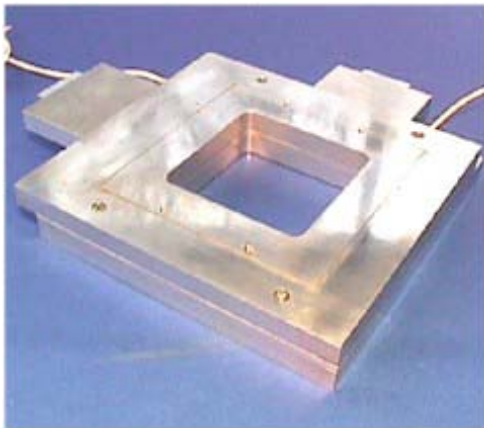
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



NANO-MAX50

Product Description

The *Nano-Max50* is a two axis nanopositioning stage with sub-nanometer accuracy. The *Nano-Max50* is designed to accurately position large loads, such as cryostats, under optical microscopes. The low profile and extra large aperture allows the *Nano-Max50* to be easily integrated into any existing optical microscope. As with all our nanopositioning systems, the *Nano-Max50* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. Increased range of motion is available.



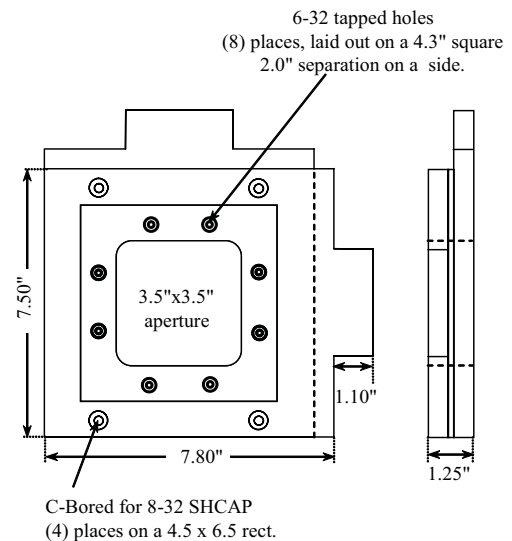
Highlights

- ◇ Precision cryostat positioning.
- ◇ Large load capacity.
- ◇ Low profile design.
- ◇ Generous 3.5" x 3.5" through hole.
- ◇ Low temperature optical microscopy.
- ◇ Low temperature spectroscopy.
- ◇ Quantum dot research.
- ◇ Inexpensive modifications available.

Technical Specifications

Range of motion	50 μm x 50 μm
Resolution	0.33 nm
Voltage range	-5V to +150V
Resonant frequency (X)	1500 Hz
Resonant frequency (Y)	1000 Hz
Stiffness	> 5 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load (horizontal)*	5 kg
Body material	Al
Control electronics	Nano-Drive™/Nano-Drive™85

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



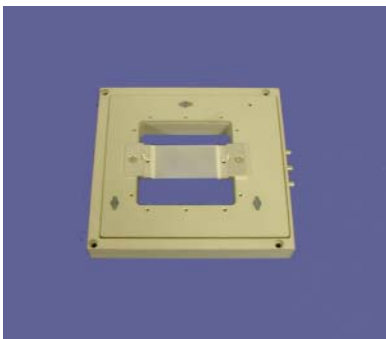
All dimensions in inches unless otherwise stated.

NANO-Z100

Product Description

The *Nano-Z100* is a single axis nanopositioning system with integrated position sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The low profile design of the *Nano-Z100* allows it to be integrated into existing instrumentation where space is restricted. With a generous center aperture this system is ideal for demanding imaging and microscopy applications such as high speed confocal microscopy that require long range travel and sub nanometer precision and repeatability.

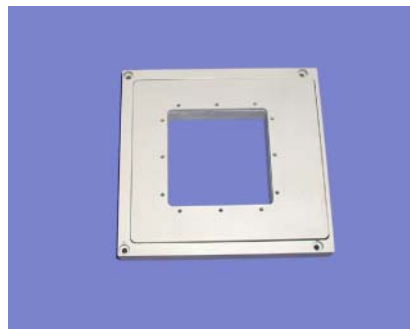
The *Nano-Z100HS* is also available for high speed applications that require typical step responses of 3-4ms and sub-nanometer accuracy.



Technical Specifications

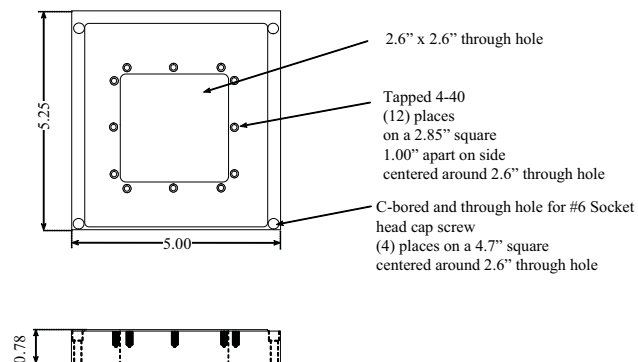
Range of motion (Z)	100 μm
Resolution	0.67 nm
Resonant frequency	> 1 kHz
Stiffness	1.0 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load* (horizontal)	0.5 kg
Body Material	Aluminum
Control electronics	<i>Nano-Drive</i> TM / <i>Nano-Drive</i> TM 85

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



Highlights

- ◆ Engineered to retrofit to most microscopes.
- ◆ Low profile 0.78"
- ◆ Sub-nanometer positioning.
- ◆ Large through hole (2.6"x 2.6") for inverted objective lens.
- ◆ Available constructed from aluminum, invar or titanium.
- ◆ Extended ranges of motion available.

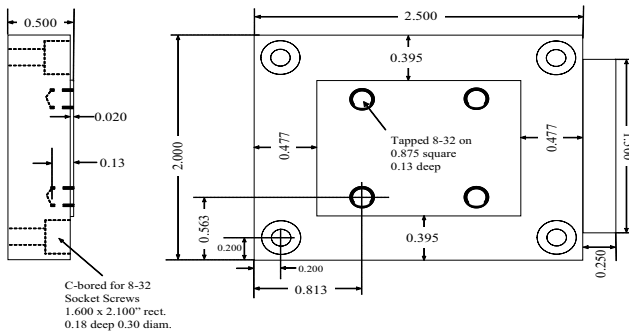


All dimensions in inches unless otherwise stated.

NANO-OP SERIES

Product Description

The *Nano-OP Series* is a range of ultra high accuracy positioning stages designed for sub-nanometer positioning applications, which demand a high degree of repeatability with a large carrying capacity. The *Nano-OP Series* can be easily incorporated into any optical or measurement system due to their compatibility with standard optical fixtures. The *Nano-OP Series* is available in aluminum, invar, or titanium, and includes integrated piezo-resistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. These stages can be used as single axis positioners or stacked for uncoupled two or three axis nanopositioning. The *Nano-OP Series* is available with motion ranges of 30 μm , 65 μm and 100 μm .



Above: Dimensions of Nano-OP30

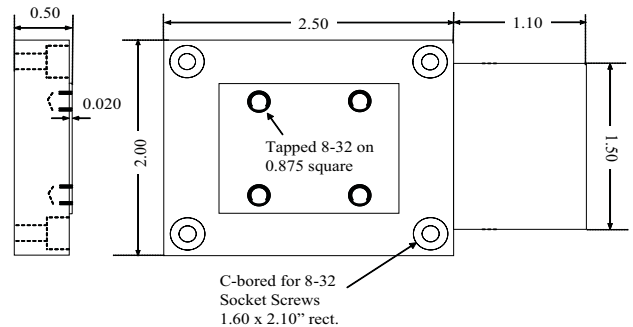
Highlights

- ◆ Stiff, large load capacity.
- ◆ Stackable for 2 or 3 axis nanopositioning.
- ◆ Sub-nanometer positioning accuracy.
- ◆ Available with 30 μm , 65 μm and 100 μm .
- ◆ Available in aluminum, invar, or titanium.

Technical Specifications

Range of motion (Nano-OP30)	30 μm
Range of motion (Nano-OP65)	65 μm
Range of motion (Nano-OP100)	100 μm
Resolution	0.2/0.43/0.67 nm
Voltage range	-5V to +150V
Resonant frequency	4 kHz \pm 20%
Resonant frequency @ 100g load	2 kHz \pm 20%
Stiffness	3 N/ μm \pm 20%
θ_{roll} (typical)	2 μrad
θ_{pitch} (typical)	2 μrad
θ_{yaw} (typical)	2 μrad
Recommended load (horizontal)*	1.0 kg
Recommended load (vertical)*	0.5 kg
Body material	Al, Invar or Titanium
Control electronics	Nano-Drive™

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



Above: Dimensions of Nano-OP65

All dimensions in inches unless otherwise stated.

NANO-P SERIES

Product Description



The *Nano-P Series* is piezo actuated, closed loop, linear translators that incorporate a unique flexure hinge design. The flexure hinge is machined entirely from a single block of high strength titanium using an advanced electrical discharge machining process. This hinge, available for the first time on a tubular nanopositioner, ensures the highest degree of repeatability, torque and load capability. Unlike similar products on the market, no belleville springs are used in the construction of the *Nano-P Series*. The guiding mechanism is a true flexure spring, having no contacting parts moving relative to each other. The *Nano-P Series* is constructed from invar and titanium for the best combination of thermal stability and mechanical strength, making it ideal for the most demanding microscopy, positioning and metrology applications. The *Nano-P Series* is available in three standard ranges of motion with integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. Custom systems available.

Highlights

- ◇ Up to 100 microns motion
- ◇ True guided motion
- ◇ Millisecond response
- ◇ Integrated piezoresistive sensors for superior performance
- ◇ Closed loop control.
- ◇ Sub-nanometer resolution.

Technical Specifications

Voltage range -5V to +150V
Body material Ti/Invar
Control electronics *Nano-Drive™/Nano-Drive™85*

Nano-P15

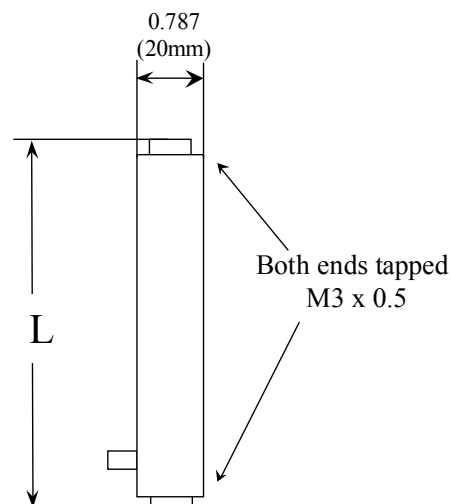
Range of motion 15µm
Resolution 0.1 nm
Length 1.7"

Nano-P35

Range of motion 35µm
Resolution 0.23 nm
Length 3.1"

Nano-P70

Range of motion 70µm
Resolution 0.47 nm
Length 5.5"

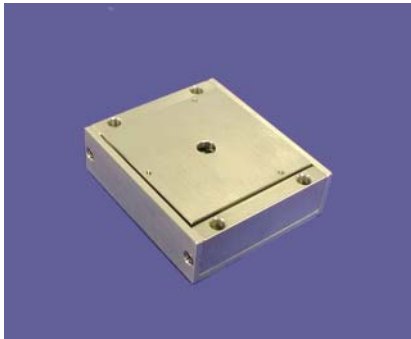


All dimensions in inches unless otherwise stated.

NANO-MZ

Product Description

The *Nano-MZ* is a compact single axis nanopositioning system with integrated position sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The compact design of the *Nano-MZ* allows it to be integrated into existing instrumentation where space is restricted. The *Nano-MZ* is ideal for demanding applications which require high precision and sub nanometer accuracy. The *Nano-MZ* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-MZ* is available for high speed applications (*Nano-MZHS*) and as a vacuum compatible model.



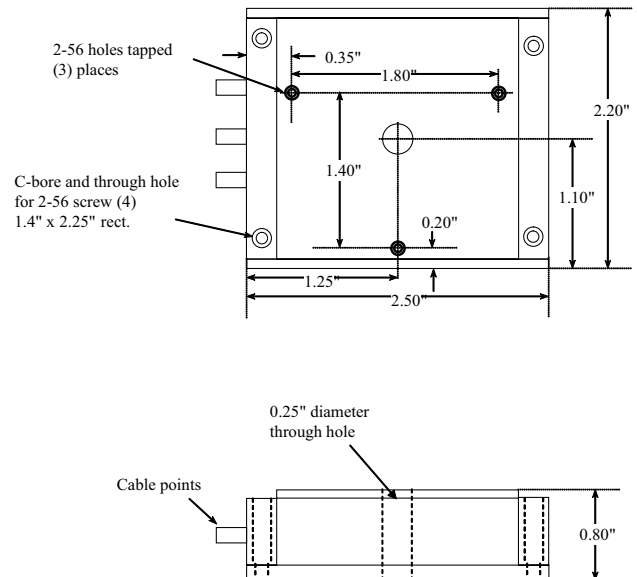
Highlights

- ◇ Compact Design.
- ◇ Low profile 0.8"
- ◇ Sub-nanometer positioning.
- ◇ Available constructed from invar or aluminum.
- ◇ Vacuum compatible models available.
- ◇ High speed models available.

Technical Specifications

Range of motion (Z)	25 μm
Resolution	0.16 nm
Resonant frequency	> 1 kHz
Stiffness	1.0 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load* (horizontal)	0.5 kg
Body Material	Al or Invar
Control electronics	<i>Nano-Drive</i> TM / <i>Nano-Drive</i> TM 85

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



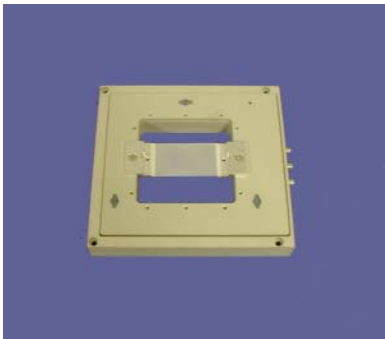
All dimensions in inches unless otherwise stated.

NANO-Z100

Product Description

The *Nano-Z100* is a single axis nanopositioning system with integrated position sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The low profile design of the *Nano-Z100* allows it to be integrated into existing instrumentation where space is restricted. With a generous center aperture this system is ideal for demanding imaging and microscopy applications such as high speed confocal microscopy that require long range travel and sub nanometer precision and repeatability.

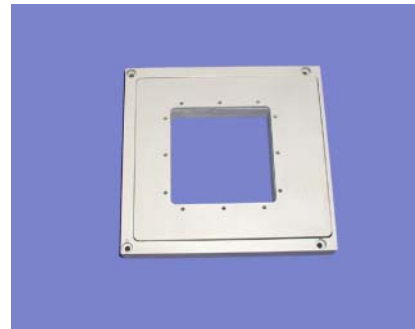
The *Nano-Z100HS* is also available for high speed applications that require typical step responses of 3-4ms and sub-nanometer accuracy.



Technical Specifications

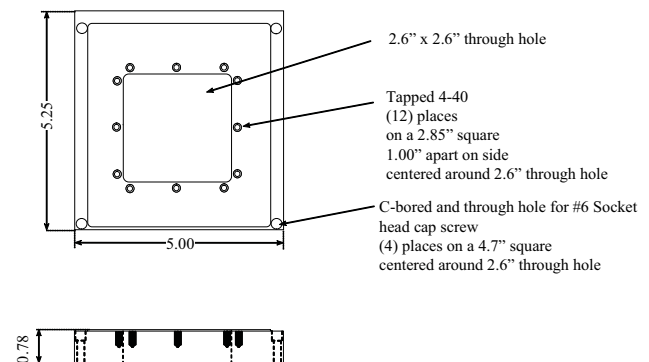
Range of motion (Z)	100 μm
Resolution	0.67 nm
Resonant frequency	> 1 kHz
Stiffness	1.0 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load* (horizontal)	0.5 kg
Body Material	Aluminum
Control electronics	<i>Nano-Drive</i> TM / <i>Nano-Drive</i> TM 85

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



Highlights

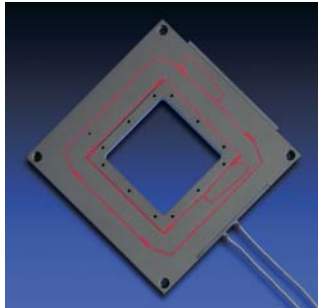
- ◆ Engineered to retrofit to most microscopes.
- ◆ Low profile 0.78"
- ◆ Sub-nanometer positioning.
- ◆ Large through hole (2.6"x 2.6") for inverted objective lens.
- ◆ Available constructed from aluminum, invar or titanium.
- ◆ Extended ranges of motion available.



All dimensions in inches unless otherwise stated.

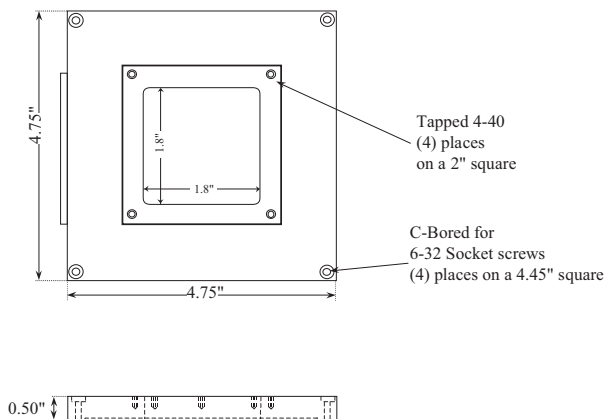
NANO-BIO2

Product Description



The *Nano-Bio2* is an ultra low profile two axis nanopositioning system with sub-nanometer accuracy under closed loop control. With its low profile design the *Nano-Bio2* is easily integrated into

existing inverted microscopes, AFM and other instrumentation where space is limited. The large center aperture allows the *Nano-Bio2* to accommodate the lens cone of most major microscope manufacturers. The *Nano-Bio2* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop feedback control. This system is available in the following models: *Nano-Bio2200*, *Nano-Bio2* and the *Nano-Bio2M*. The *Nano-Bio2M* when combined with an additional interface unit is a plug and play add on for instruments using Veeco NanoScope controllers.



Above: Technical drawing for Nano-Bio2M (Invar/Ti only)

Right: Technical drawing for Nano-Bio2 and Nano-Bio2200.

Note: 0.6" height for Al , 0.5" height for invar/ Ti models.

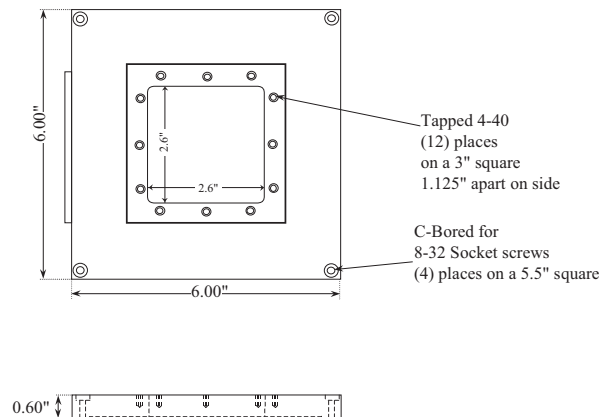
Technical Specifications

Range of motion (<i>Nano-Bio2200</i>)	200 μm x 200 μm
Range of motion (<i>Nano-Bio2</i>).....	100 μm x 100 μm
Range of motion (<i>Nano-Bio2M</i>)	50 μm x 50 μm
Resolution (200/100/50).....	1.3/0.67/0.33 nm
Resonant frequency (X).....	500 Hz
Resonant frequency (Y).....	300 Hz
Stiffness	1.0 N/mm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Body Material	Al or Invar
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Control electronics	<i>Nano-Drive™</i>

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

Highlights

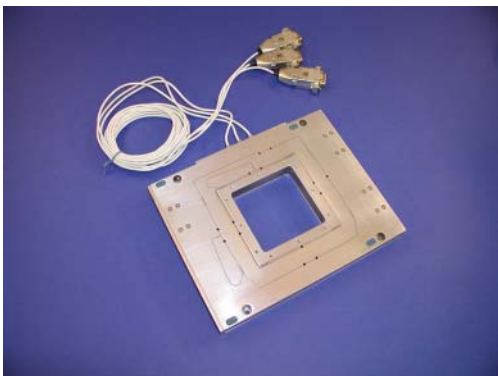
- ◆ Lowest profile available.
- ◆ Compatible with AFM
- ◆ Closed loop, sub-nanometer positioning.
- ◆ Engineered to retrofit to most microscopes.



NANO-LP SERIES

Product Description

The *Nano-LP Series* are ultra-low profile three axis nanopositioning systems with sub-nanometer accuracy. The ultra-low profile design of the *Nano-LP Series* allows it to be integrated into existing instrumentation where space is restricted, such as inverted optical microscopes. With extended ranges of motion, the *Nano-LP Series* is ideal for demanding microscopy applications which require long range travel, sub nanometer accuracy and three dimensions of motion. The *Nano-LP Series* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy. The *Nano-LP Series* is available constructed from aluminum, invar or titanium.



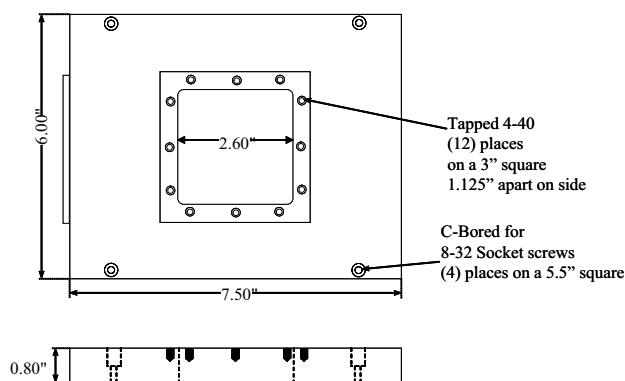
Highlights

- ◆ Engineered to retrofit to most microscopes.
- ◆ Lowest profile nanopositioner available.
- ◆ Long range motion
- ◆ Sub-nanometer positioning.
- ◆ Large through hole (2.6"x 2.6")
- ◆ Available constructed from aluminum, invar or titanium.
- ◆ Single molecule detection.

Technical Specifications

Range of motion (<i>Nano-LP100</i>)	100 x 100 x 100 μm
Range of motion (<i>Nano-LP200</i>)	200 x 200 x 200 μm
Resolution (200/100)	1.3 / 0.67 nm
Resonant frequency (X)	450 Hz
Resonant frequency (Y)	350 Hz
Resonant frequency (Z)	1000 Hz
Stiffness	1.0 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load (horizontal)*	0.5 kg
Body Material	Al, Invar or Ti
Control electronics	<i>Nano-Drive™</i>

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

NANO-VIEW™

Product Description

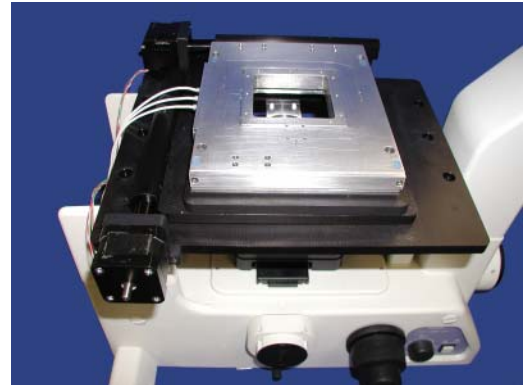
The *Nano-View™* is a fully integrated positioning system for use with most inverted optical microscopes¹ that offers long range linear positioning in two dimensions, combined with a high resolution nanopositioner. The *Nano-View™* is comprised of a motor driven two axis linear motion stage and an ultra-low profile, high resolution nanopositioning system. The micropositioning stage has integrated encoders and offers up to 1" (25 mm) travel per axis with an encoder resolution of 20 nm. The minimum step size is 95.25 nm with a step repeatability of 50 nm.

The nanopositioning systems employed in the *Nano-View™* are high precision with the lowest profile commercially available. Travel ranges extend up to 200 microns per axis (X,Y and Z) with single nanometer resolution or better under closed loop control. As with all Mad City Labs, Inc. nanopositioning systems they are designed for minimum parasitic motion and feature integrated sensors for absolute position measurement.

The *Nano-View™* is designed to be controlled by standard National Instruments control boards and is fully compatible with user written LabView™ software, offering greater flexibility.

The *Nano-View™* is the complete nanometer scale positioning system for single molecule spectroscopy and high resolution microscopy applications.

¹ Olympus IX Series, Nikon TE Series inverted microscopes, Leica DMIRB and Zeiss Axiovert Series. Other inverted and upright microscope models subject to special order.



Above: Nano-View™ 100-3

Highlights

- ◆ *Fully integrated positioning system.*
- ◆ *High precision long range motion up to 1" (25 mm).*
- ◆ *High performance two and three axis nanopositioners.*
- ◆ *Sub-nanometer precision*
- ◆ *Accurate position tracking via encoders (MicroStage)*
- ◆ *Integrated position sensors (Nanopositioner)*
- ◆ *Retrofitted to your inverted microscope*
- ◆ *High Speed data acquisition available.*
- ◆ *Compatible with National Instruments control boards and user written LabView™ Software.*
- ◆ *Suitable for demanding microscopy applications.*

Standard Configuration

- ◆ *Two axis stepper motor MicroStage.*
- ◆ *Two or Three Axis Closed Loop Nanopositioning System.*
- ◆ *Integrated Linear encoders (MicroStage).*
- ◆ *Micro-Drive controller.*
- ◆ *Nano-Drive™ controller.*
- ◆ *National Instruments NI7334 motion control board*

NANO-VIEW™

Specifications: Nanopositioner

Number of axes	2 or 3
Range of motion (XY)	100 or 200 μm
Range of motion (Z)	100 or 200 μm
Resolution (100/200 μm)	0.67/1.3 nm
Resonant frequency (X-axis)	450 Hz
Resonant frequency (Y-axis)	350 Hz
Resonant frequency (Z-axis)	2300 Hz
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al or Invar
Control Electronics	Nano-Drive™

Specifications: MicroStage

Number of axes	2
Range of motion	up to 1" (25 mm)
Step Size	95.25 nm
Step repeatability	50 nm
Encoder resolution	20 nm
Body Material	Anodized Al
Control electronics	Micro-Drive™

Ordering Information:

Nano-View™100/200 - # axes - Option

Example: Nano-View™100 -3-HS describes a Nano-View system with a 3 axis 100 micron (per axis) nanopositioner with the high speed data acquisition option.

- Please specify brand and model of inverted microscope.

- Some options are exclusive, please consult with your sales representative.

Available Options

- NV162

Two axis 16 bit digital interface for use with Nano-Drive™ controller. National Instruments PCI-DIO96 and R1005050 cable included. LabView™ compatible.

- NV163

Three axis 16 bit digital interface for use with Nano-Drive™ controller.

-NV164

Four axis 16 bit digital interface for use with Nano-Drive™ controller.

- NV202

Two axis 20 bit digital interface for use with Nano-Drive™ controller. National Instruments PCI-DIO96 and R1005050 cable included. LabView™ compatible.

-NV203

Three axis 20 bit digital interface for use with Nano-Drive™ controller.

-NV204

Four axis 20 bit digital interface for use with Nano-Drive™ controller.

- HS

High speed data acquisition via parallel port for four axes. Acquisition at speeds of 100 kHz simultaneously for 4 axes. Includes 2 PXI6534 boards, PXI1002 crate and shielded cables. LabView™ compatible.

- F100E

Objective lens nanopositioning system with encoder. Range of motion is 100 microns in Z with sub-nanometer accuracy. Encoder must be installed by trained personnel. Includes analog controller.

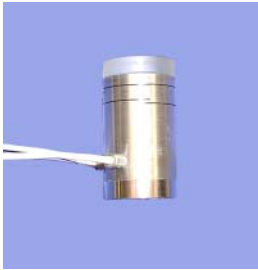
- 5NM

Upgrade to 5nm linear encoders on the MicroStage

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

NANO-MTA SERIES

Product Description



The *Nano-MTA Series* are single and two axis piezoelectric mirror tilt actuator for laser beam steering. With sub-microradian resolution the *Nano-MTA Series* is ideal for applications in optical disk

manufacturing, laser beam steering and tracking and laser beam scanning. Piezoresistive sensors are included for absolute measurement and sub-microradian accuracy under closed loop control. The *Nano-MTA Series* is compatible with either the *Nano-Drive™* or *Nano-Drive™85* controllers. Both controllers include sensor electronics, proportional integral feedback control, and 150V amplifier. The *Nano-MTA Series* when used with a *Nano-Drive™85* controller is capable of speeds of 1kHz full amplitude. This makes the *Nano-MTA Series* ideal for high speed scanning applications.

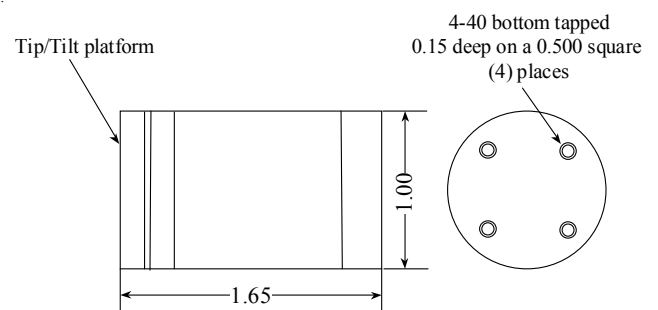
Highlights

- ◇ Up to 5 milliradians motion.
- ◇ Sub-microradian resolution.
- ◇ Speeds up to 1kHz full amplitude available
- ◇ True decoupled motion.
- ◇ Mountable in any orientation.
- ◇ Integrated position sensors.
- ◇ Available in aluminum or invar.
- ◇ Increased range of motion and custom design available.

Technical Specifications

Range of motion (per axis).....	2.0 mrad
Resolution	0.02 μ rad
Range of motion (extended)	5.0 mrad
Resolution	0.04 μ rad
Resonant frequency (unloaded).....	5 kHz \pm 20%
Scanning Speed	1kHz
Optics	2.0"
Body material	Al or Al/Invar
Control electronics	<i>Nano-Drive™/Nano-Drive™85</i>
Footprint (Standard).....	1.0"(Diameter) x 1.65"

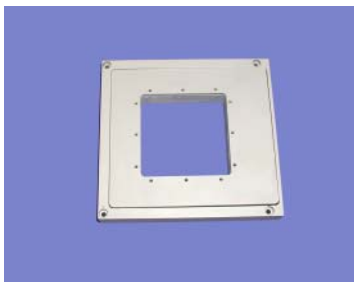
Models available: Nano-MTA (single axis), Nano-MTA2 (2 axis), Nano-MTAX (extended range), Nano-MTA2X, add -HS for high speed models.



All dimensions in inches unless otherwise stated.

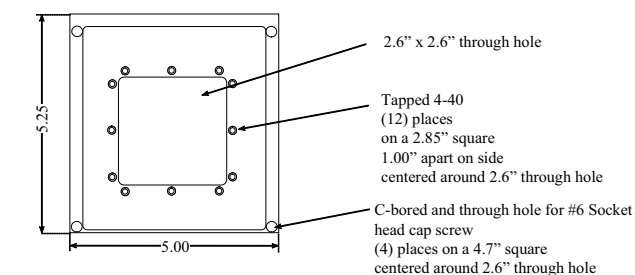
NANO-ALIGN3

Product Description



The *Nano-Align3* is a triple axis nanopositioning system with sub-nanometer accuracy constructed from aluminum. The low profile design of the *Nano-Align3*

allows it to be integrated into existing instrumentation where space is restricted. With a generous center aperture this system is ideal for demanding microscopy applications which require long range travel, alignment capabilities, and sub nanometer accuracy. The *Nano-Align3* includes piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-Align3* is also available constructed from invar, super invar, or titanium



All dimensions in inches unless otherwise stated.

Technical Specifications

Range of motion (Z)	100 μm
Range of motion (θ_x)	2 mrad
Range of motion (θ_y)	2 mrad
Resolution (Z, θ)	0.67 nm/ 0.02 μrad
Resonant frequency	> 1 kHz
Stiffness	1.0 N/ μm
Recommended load* (horizontal)	0.5 kg
Recommended load* (vertical)	0.2 kg
Body Material	Al, Invar or Ti
Control electronics	<i>Nano-Drive</i> TM / <i>Nano-Drive</i> TM 85

* *These are recommended loads, larger load requirements should be discussed with our engineering staff.*

Highlights

- ◇ *Engineered to retrofit to most microscopes.*
- ◇ *Low profile 0.78"*
- ◇ *Sub-nanometer positioning.*
- ◇ *Large through hole (2.6"x2.6") for inverted objective lens.*
- ◇ *Available constructed from aluminum, invar or titanium.*
- ◇ *Extended ranges of motion available.*

NANO-ALIGN

Product Description

The *Nano-Align* is a five axis nanopositioning system with sub-nanometer/sub-microradian accuracy under closed loop control. The low profile design of the *Nano-Align* allows it to be easily integrated into existing instrumentation, e.g. microscopes, probe assemblies. With an extended range of motion in Z, the *Nano-Align* is ideal for demanding applications which require long range travel, sub nanometer accuracy and three dimensions of motion. In addition, the *Nano-Align* has 1.2 milliradians of tip/tilt in θ_x, θ_y with sub-microradian resolution. The *Nano-Align* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-Align* is also offered as a three axis system and can be constructed from specialty materials such as invar.

Highlights

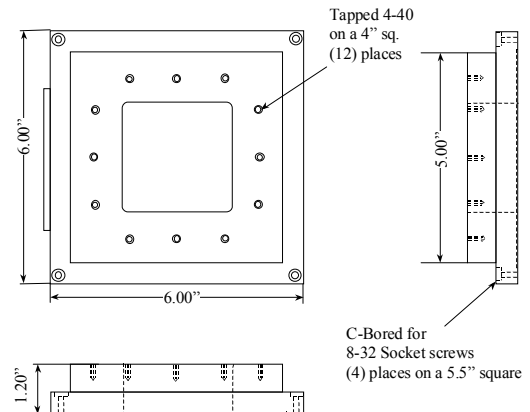
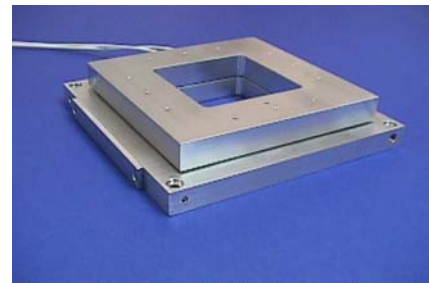
- ◇ Easy integration into existing instrumentation
- ◇ Low profile 1.20"
- ◇ 100 μm x 100 μm x 50 μm (x, y, z).
- ◇ Sub-nanometer positioning.
- ◇ 1.20 mrad (θ_x, θ_y).
- ◇ Sub-microradian resolution .
- ◇ Large through hole (2.6"x2.6") for inverted objective lens.
- ◇ Extended ranges of motion available.

All dimensions in inches unless otherwise stated.

Technical Specifications (Aluminum)

Range of motion (XY)	100 μm x 100 μm
Range of motion (Z)	50 μm
Range of motion (θ_x, θ_y)	1.2 mrad x 1.2 mrad
Resolution (XY/Z/ θ)	0.67 nm/0.33 nm/ 0.01 μrad
Resonant Frequency (XY)	200 Hz
Resonant Frequency (Z)	1.5 kHz
θ_{roll} (XY typical)	5 μrad
θ_{pitch} (XY typical)	5 μrad
θ_{yaw} (XY typical)	10 μrad
Recommended load (horizontal)*	0.5 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al or Invar
Control electronics	<i>Nano-Drive</i> TM

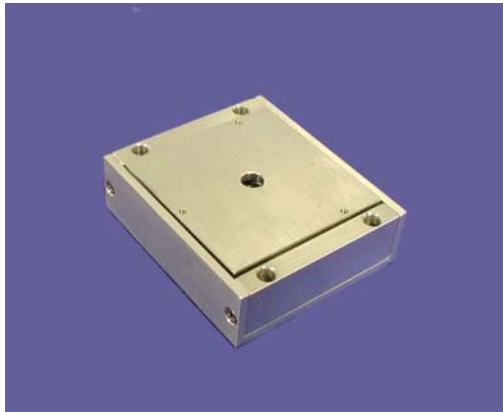
* These are recommended loads, larger load requirements should be discussed with our engineering staff.



NANO-M3Z

Product Description

The *Nano-M3Z* is a triple axis nanopositioning system with sub-nanometer accuracy constructed from invar or aluminum. The compact design of the *Nano-M3Z* allows it to be integrated into existing instrumentation where space is restricted. The *Nano-M3Z* is ideal for demanding applications which require high precision, alignment capabilities, and sub nanometer accuracy. The *Nano-M3Z* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-M3Z* is also available as a vacuum compatible model.



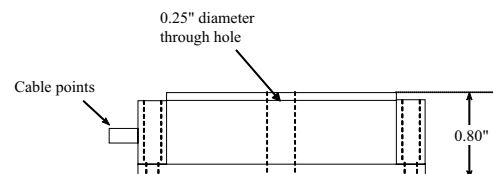
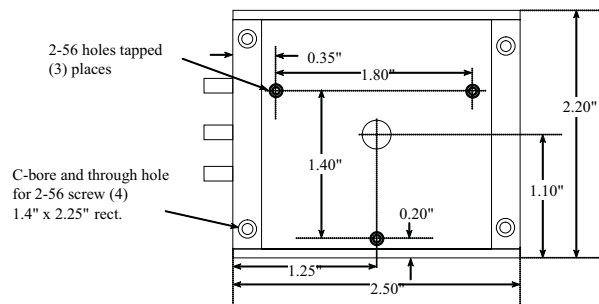
Highlights

- ◆ *Ideal for alignment applications.*
- ◆ *Compact Design*
- ◆ *Sub-nanometer positioning.*
- ◆ *Minimal parasitic motion*
- ◆ *Vacuum compatible models available*
- ◆ *Sub-microradian positioning.*

Technical Specifications

Range of motion (Z)	25 μm
Range of motion (θ_x)	1 mrad
Range of motion (θ_y)	1 mrad
Resolution	0.16 nm
Resonant frequency	> 1 kHz
Stiffness	1.0 N/ μm
θ_{roll} (typical)	5 μrad
θ_{pitch} (typical)	5 μrad
θ_{yaw} (typical)	10 μrad
Recommended load* (horizontal)	0.5 kg
Recommended load* (vertical)	0.2 kg
Body Material	Al or Invar
Control electronics	<i>Nano-Drive™</i>

* These are recommended loads, larger load requirements should be discussed with our engineering staff.

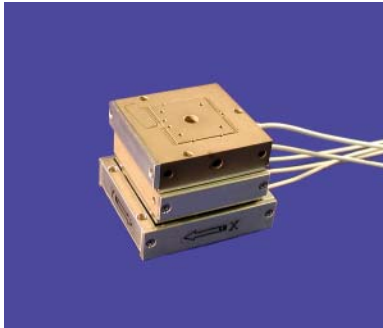


All dimensions in inches unless otherwise stated.

NANO-MAN5

Product Description

The *Nano-Man5* is a five axis nanopositioning system constructed from titanium or invar with sub-nanometer/sub-microradian accuracy under closed loop



control. The compact design of the *Nano-Man5* allows it to be easily integrated into existing instrumentation for applications such as nanolithography, SEM and active optics. The *Nano-Man5* is ideal for demanding applications which require parallel motion, sub nanometer accuracy and three linear axes of motion. In addition, the *Nano-Man5* has 1 milliradian of tip/tilt in θ_x, θ_y with sub-microradian resolution. The *Nano-Man5* includes integrated piezoresistive sensors for absolute position measurement and sub-nanometer accuracy under closed loop control. The *Nano-Man5* is also available as a three axis system, the *Nano-M350* or *Nano-M3Z*, and vacuum

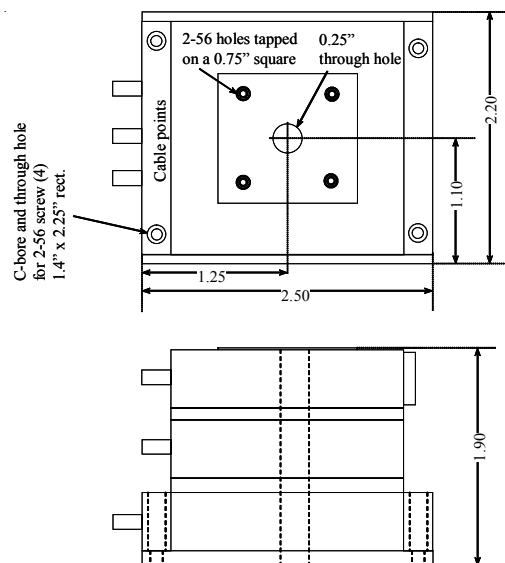
Highlights

- ◇ Easy integration into existing instrumentation
- ◇ Compact Design
- ◇ $50 \mu\text{m} \times 50 \mu\text{m} \times 20 \mu\text{m}$ (x, y, z).
- ◇ Sub-nanometer positioning.
- ◇ 1 mrad (θ_x, θ_y).
- ◇ Sub-microradian resolution .
- ◇ Vacuum compatible models available

Technical Specifications

Range of motion (XY)	50 μm x 50 μm
Range of motion (Z)	25 μm
Range of motion (θ_x, θ_y)	1 mrad x 1 mrad
Resolution (XY/Z/ θ)	0.32 nm/0.13 nm/1 μrad
Resonant Frequency (X)	1 kHz
Resonant Frequency (Y)	700 Hz
Resonant Frequency (Z)	> 1 kHz
θ_{roll} (XY typical)	< 5 μrad
θ_{pitch} (XY typical)	< 5 μrad
θ_{yaw} (XY typical)	< 10 μrad
Recommended load (horizontal)*	0.2 kg
Recommended load (vertical)*	0.2 kg
Body Material	Al/Ti or Invar
Control electronics	<i>Nano-Drive</i> TM

* These are recommended loads, larger load requirements should be discussed with our engineering staff.



All dimensions in inches unless otherwise stated.

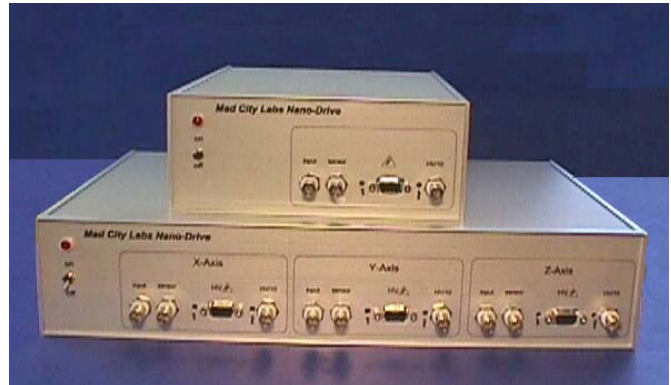
NANO-DRIVE™

Product Description

The *Nano-Drive™* Series of controllers are the complete electronic package for sub-nanometer positioning. All *Nano-Drive™* controllers include a low noise, low drift amplifier, absolute position control, bandwidth selection, and closed loop feedback. Offered with either an analog or digital interface and in single and multi-axis versions with standard bandwidth selection (200 Hz, 100 Hz and 20 Hz) and others by request. The *Nano-Drive™* is also available as a stand alone circuit board for OEM or custom applications. The analog input is via a front panel BNC, as are the sensor position signal, and HV/10 signal. The feedback circuit is configured for a 0-10V command signal or other ranges by request (see options). The AR-10 option (-10V to +10V command signal) is compatible with Digital Instruments Bioscope/Nanoscope IV controllers when interfaced to a breakout box (see options). The closed loop feedback ensures that the displacement, as a function of input voltage, is highly linear. The closed loop feedback system also eliminates the positioning errors due to creep and hysteresis in the piezoactuator.

Highlights

- ◇ Closed Loop Servo/Drivers for all Mad City Labs nanopositioning systems.
- ◇ Higher current models for high speed.
- ◇ Proportional-Integral feedback.
- ◇ Wide range of options available
- ◇ 16 bit and 20 bit digital interfaces available.
- ◇ Digital interfaces National Instruments compatible.
- ◇ USB interface available



Above: Single axis and three axis *Nano-Drive™* controllers with standard analog interface.

MODEL	OUTPUT VOLTAGE	CURRENT	NOISE ⁽¹⁾
<i>Nano-Drive™</i>	-5V to +150V	0.15 A	1 mV
<i>Nano-Drive™85</i>	-5V to +150V	0.5 A	1 mV
<i>Nano-Drive™170</i>	-5V to +150V	1.0 A	1 mV
<i>Nano-Drive™450</i>	-5V to +150V	3.0 A	1 mV
<i>Nano-Drive™900</i>	-5V to +150V	6.0 A	1 mV

(1) Measured at 200 Hz, corresponds to 1 part in 10^5 positional noise (0.67nm for 100 micron range of motion). Positional noise is further reduced by lowering bandwidth.

NANO-DRIVE™ OPTIONS

As a complement to our nanopositioning systems, we offer a wide range of options. If you are interested in specific details for any of the options listed, please contact us.

OPTIONS	DESCRIPTION	NOTES
<i>DI16-x</i>	16 bit digital interface for Nano-Drive™ controller. (x) indicates number of axes. Enables user to command controller via parallel port and user written software.	Customer must purchase National Instruments parallel port board PCI-DIO96 and R1005050 cable. <i>e.g. DI16-2 is a 16 bit digital interface for the Nano-Drive™2</i>
<i>DI20-x</i>	20 bit digital interface for Nano-Drive™ controller. (x) indicates number of axes. Enables user to command controller via parallel port and user written software.	Customer must purchase National Instruments parallel port board PCI-DIO96 and R1005050 cable. <i>e.g. DI20-3 is a 20 bit digital interface for the Nano-Drive™3</i>
<i>NV16-x</i>	16 bit digital interface for the Nano-View™ system. (x) indicates the number of axes. Enables user to command controller via parallel port and user written software.	National Instruments boards and cables supplied. <i>For ordering information see Nano-View™ in this catalog.</i>
<i>NV20-x</i>	20 bit digital interface for the Nano-View™ system. (x) indicates the number of axes. Enables user to command controller via parallel port and user written software.	National Instruments boards and cables supplied. <i>For ordering information see Nano-View™ in this catalog.</i>
<i>DBW</i>	Digital bandwidth control option. Permits the user to change the bandwidth via software.	All controllers come with 3 bandwidth settings, generally 5, 20 and 200Hz.
<i>CBW</i>	Custom bandwidth option. The customer can specify 3 bandwidth selections at the time of ordering.	Bandwidth selections may be limited based on customer supplied information regarding planned usage of the system.
<i>RM</i>	Rack mount for Nano-Drive™ controller	
<i>SO</i>	Scan offset potentiometer for the Nano-Drive™.	
<i>AR-5</i>	+5V to -5V input scan range for the Nano-Drive™.	
<i>AR-6</i>	+6V to -6V input scan range for the Nano-Drive™.	
<i>AR-10</i>	+10V to -10V input scan range for the Nano-Drive™.	Compatible with Digital Instruments NanoScope/BioScope. Must order VBOB option (see below).
<i>HS</i>	High Speed data acquisition via parallel port for 4 axes. Acquisition of speeds of 100 kHz simultaneously.	Includes National Instruments PXI6534 cards, PXI crate and shielded cables. <i>For ordering information see Nano-View™ in this catalog.</i>
<i>F100E</i>	Objective lens nanopositioning system with encoder for use with Nano-View™. Offers 100 microns of travel with sub-nanometer accuracy.	<i>For ordering information see Nano-View™ in this catalog.</i>
<i>USB</i>	USB interface	
<i>OCL</i>	Front panel open loop/closed loop switch	
<i>VBOB</i>	Veeco Breakout box	Compatible with Veeco NanoScope controllers. Must be ordered with AR-10 option.
<i>CBOB</i>	Breakout box for compatibility with external instrumentation	Specifications must be supplied by customer.

CUSTOM SOLUTIONS



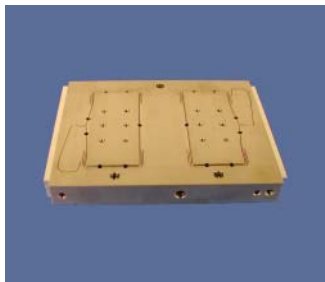
While our product line offers a wide variety of nan positioning systems, we understand that many applications require custom solutions.

Whether your problem is footprint size, range of motion, or environmental issues our

design engineers can assist you in solving your custom nan positioning needs. Our engineering team has extensive



experience in UHV instrumentation, optical spectroscopy and nanotechnology. We have assisted many users with custom solutions that meet their needs ranging from



R&D to industrial processes. Our engineering team has over 50 years collective experience in scientific instrumentation design, with our specialty areas being ultra-high vacuum applications and optical spectroscopy/microscopy. Consult with our staff about YOUR research needs and get solutions fast.



Do you need a Custom Solution?

- ◇ **Is there a standard product close to your needs?**
We can modify standard products quickly with modest price increases to get the correct solution for your needs.
- ◇ **Do you have specific experimental conditions that may impact on nan positioning performance?**

Conditions such as ultra-high vacuum, temperature variation, high load, or high speed can affect the optimum performance of a nan positioning system.

Please consult our technical sales staff to discuss your application in detail.

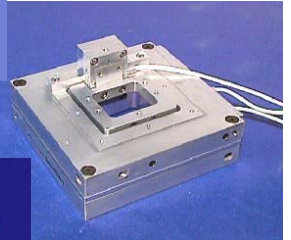
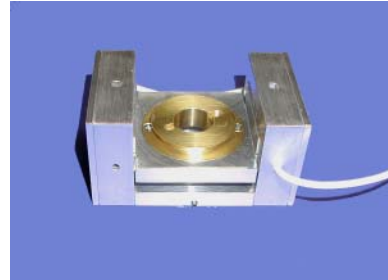
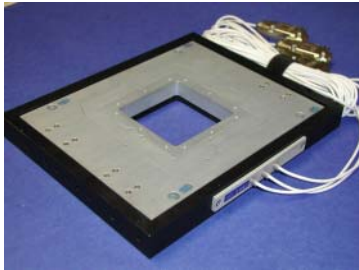
The Mad City Labs, Inc. Advantage

- ◇ Sales and Technical staff with direct research experience
- ◇ Prompt and courteous technical support. Engineering staff are available to discuss issues with customers over the phone.
- ◇ Competitive pricing. We match or better competitive bids on comparable systems.
- ◇ Fast delivery times. In stock items in 15 days, non stock items in 30 to 45 days.
- ◇ Fast repair times. Typical repair turnarounds of 1 week within the contiguous United States.
- ◇ Custom design. Specify your parameters and we do the rest. See “Purchasing Hints” on the next page.
- ◇ High quality products at affordable prices.

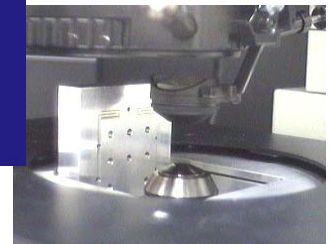
CUSTOM SOLUTIONS

Purchasing Hints

Are you thinking about buying a nanopositioner? The checklist below incorporates the commonly asked questions during the purchasing process.



- ◇ How many axes of motion do you need?
- ◇ Range of motion per axis?
- ◇ Resolution and repeatability per axis?
- ◇ How much load? (maximum, typical and minimum)
- ◇ How fast do you want to move? It's useful to have approximate values for the maximum, typical and minimum loads.
- ◇ Are you going to be scanning continuously or step wise motion?
- ◇ What are the ideal physical dimensions of the stage (length, width, height)?
- ◇ Do you require a center aperture?
- ◇ Are there any physical interfacing issues, such as retrofitting to existing instrumentation?
- ◇ Are there environmental conditions that may impact the nanopositioning system, such as UHV, humidity, large magnetic fields?
- ◇ Do you require computer control, i.e. digital interface?
- ◇ What is your budget?



Some Handy Tips

- ◇ Prioritize the specifications of your system. For instance, is the range of motion the single most important parameter for your application?
- ◇ Always have ideal values for your system and "I can live with it" values.
- ◇ Be prepared to give a brief description of your application. Our technical sales staff are experienced scientists and can offer a variety of solutions as well as flag potential problem areas .

NOTES ON NANOPositionING

General Application. Our nanopositioning systems are useful for any application which demands precision and reproducibility at the nanometer level. These applications include numerous types of microscopy, nano-alignment, micro- and nano-manufacturing, testing, robotics and positioning.

Piezoactuator. Our nanopositioning systems are activated using multilayered piezo actuators. These actuators are made from PZT which expands when a voltage is applied to it. This expansion is nearly linear in applied voltage, but hysteresis (~8%) and creep (~1%) are problems. As the PZT expands it twists and corkscrews.

Coupled motions. The twisting and corkscrewing of the PZT gives rise to unwanted motions which can best be described by the standard angles of roll, pitch, and yaw. To visualize these unwanted motions, think of an airplane which is traveling in the translation direction. Roll is a rotation about fuselage, pitch is the airplane diving, and yaw is a rotation about the vertical axis. Excessive roll, pitch, or yaw in a nanopositioning system leads to devastating positioning errors. This is why piezoactuators by themselves are poor nanopositioning devices for any range of motion greater than a few microns.

Flexure guided motion. To overcome the coupled motion problems associated with PZT actuators, all of our nano-systems are designed using electric discharge machined flexure stages. Flexure stages are unique in that they give slip-stick free motion. They also, by proper design, restrict the stage to move in only one direction. This effectively decouples the unwanted motion in the PZT actuators and results in a pure translation.

Resolution. Since there is no quantum principle affecting the lattice spacing in the PZT, the step resolution of our nanopositioning stages is dependent upon the resolution of the input voltage to the *Nano-Drive™* when run in open loop mode. When run in closed loop mode the resolution is dependent on the sensor and driver noise level.

Closed loop vs. open loop. In open loop mode, the driver determines the motion of the nano-stage simply by amplifying the input voltage. The position of the nano-stage includes errors due to creep and hysteresis. In closed loop mode, the input voltage is compared to the output voltage from a position sensor. Using a proportional-integral feedback loop, the driver output is continuously adjusted so that the sensor signal matches the input signal to the driver. Since the sensor signal is proportional to the absolute position, the position of the nano-stage is linear to the driver input voltage. The effects of creep and hysteresis are eliminated. The choice of closed loop vs. open loop is dependent upon application. When hysteresis and creep are not important, such as when maximizing an alignment signal or when an external sensor is used, then the economy of an open loop system is beneficial. Closed loop systems are necessary in any two or three dimensional imaging application.

Piezoresistive Position Sensors. We use ultra sensitive temperature compensated solid state piezoresistors for position measurement. These devices achieve step resolutions of 0.1nm with a positioning linearity of 0.05% (Visit our website for more information).

Response and Speed. Mad City Labs nanopositioning systems operate in the low to very high speed range. The useable bandpass is typically $\frac{1}{3}$ to $\frac{1}{10}$ the resonant frequency.

Load capacity. The load capacities quoted in the catalog are conservative. Much larger loads can be moved but special care must be taken. If your application demands a larger load it would be beneficial to discuss the details with our engineering staff.

TECHNICAL INFORMATION

Position Sensors

The position sensor is the most critical element in any closed loop nanopositioning system. Mad City Labs nanopositioning systems use low impedance piezoresistors. Piezoresistors are solid state devices that can be thought of as ultra sensitive strain sensors. They make a highly linear, ultra precise, and temperature compensated position sensor when appropriately integrated into a flexure guided nanopositioning stage.

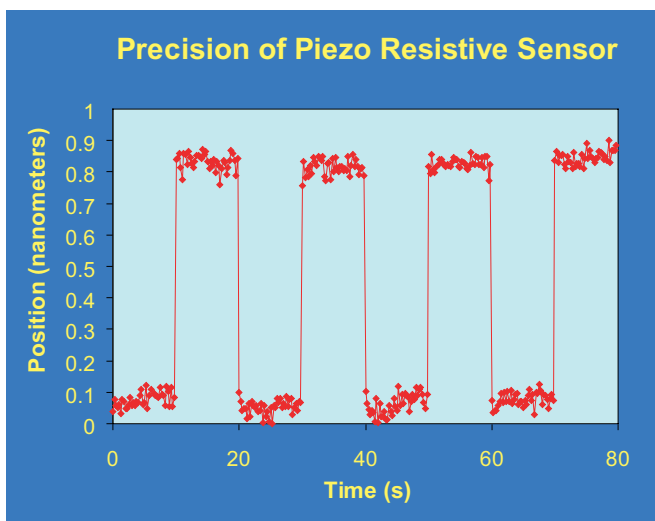


Figure 1. Shown is the typical step response for a nanopositioner based on a piezoresistive sensor. The noise comes primarily from the electronics, so the overall contribution of position noise from the sensor is negligible.

Linearity

The accuracy and reproducibility of any piezoactuator driven nanopositioning stage depends on the linearity and sensitivity of the stage. The linearity and sensitivity of a stage are different depending on the operation mode, open or closed loop. When operated in the open loop mode, the hysteresis and creep of the piezoactuator determine the linearity, which is typically 8%. This nonlinearity is due to hysteresis in the piezoactuator.

The linearity is greatly improved when operating in closed loop mode. In closed loop operation, a control circuit compares the input signal to a signal from a position sensitive detector. The control circuit continuously adjusts the driver voltage to ensure that the input signal matches the position signal. The linearity of a nanopositioning stage, when operated in closed loop mode depends on the *linearity of the position sensitive detector*. Mad City Labs, Inc. nanopositioning stages use semiconductor piezoresistors for position sensitive detectors. These detectors have a linearity of better than 0.05%. The closed loop linearity of a Mad City Labs nanopositioning stage is shown below. The linearity measured is better than 0.05%.

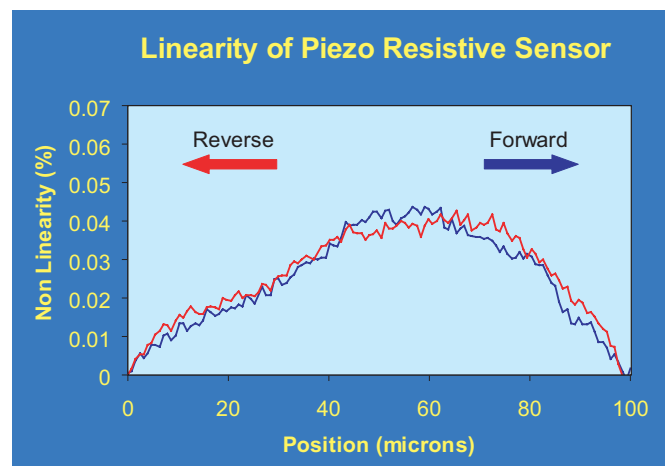


Figure 2. For one system, measured non-linearity is less than 0.05%. No look up table or high order polynomial was used to correct for nonlinearities.

For further technical information please visit our website and click on "Technical Information" or download our paper on Piezoresistive Sensors.

SALES

Mad City Labs, Inc. is committed to providing superior sales and technical support through our U.S. office and worldwide representatives. Please contact your local representative for assistance and pricing. Territories without representation should contact our U.S. office directly. We will continue to add representatives to serve our customers better. Please check our website for updates.

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WEB	www.laseranalytik.de	www.lot-oriel.it	www.lastek.com.au	
TERRITORY	Germany Austria Switzerland The Netherlands	Italy	Australia New Zealand	India

TERMS AND CONDITIONS OF SALE

1. Price. Quoted prices on the products are exclusive of all sales, excise and other taxes, and exclusive of freight, installation, handling and storage charges, any or all of which, as applicable will be added to the invoice as a separate charges to be paid by the Buyer or otherwise charged as indicated in these Terms and Conditions. Prices are effective for all purchase orders received from Buyer within 60 days of the date of Mad City Labs, Inc.'s formal price quotation, and thereafter subject to changes. Mad City Labs, Inc. reserves the right to increase prices in cases where modifications requested by the Buyer give rise to additional costs. Verbal price estimates are not binding.

2. Payment Terms. Buyer agrees to pay the total amount shown as due on each invoice within 30 days after the date of such invoice notwithstanding any repairs, corrections or adjustments that may have to be made. Special orders for products pursuant to Buyer specifications, are subject to payment of 50% of quoted price at time of acceptance of purchase order. Invoices will be dated as of date of shipment except if products are stored at Buyers request for more than 30 days beyond completion of their manufacture, in which case, invoices will be dated as of the date of product completion. Mad City Labs, Inc. shall reserve the right to charge interest at a rate not in excess of 18% per annum (but in no event more than the amount permitted by applicable law) upon any sum not paid by the due date. Mad City Labs, Inc. shall be entitled to collect from Buyer for all expenses of collection, including attorneys' fees.

3. Delivery. Terms shall be FOB Mad City Labs, Inc. premises, Madison, Wisconsin, for delivery by Federal Express (or similar carrier) with all freight charges, including special handling charges of carrier, paid by Buyer. Buyer shall bear all risk or loss or damage upon delivery of products to carrier at point of shipment, Madison Wisconsin.

4. Delays. Mad City Labs, Inc. is not liable for any delay in the performance of orders or contracts, or in the delivery or shipment of products, or any damages suffered by Buyer by reason of such delay, when such delay is, directly or indirectly, caused by or in any manner arises from, fires, floods, earthquakes, accidents, Acts of God, governmental interference or embargoes, strikes, labor difficulties, shortage of labor, fuel, power, materials or supplies, transportation delays or any other cause or caused beyond its control. All orders or contracts are given and accepted with the understanding that they are subject to Mad City Labs, Inc.'s ability to obtain materials from manufacturers and suppliers and are subject to manufacturing schedules and government regulations that may be in effect from time to time. Failure to meet a delivery date shall not give cause to either cancellation of the order, or liability on the part of Mad City Labs, Inc. Mad City Labs, Inc. may elect to make partial shipments.

5. Title. Upon issuance of Buyer's purchase order and Mad City Labs, Inc. acceptance thereof, Buyer thereby shall be considered to have granted to Mad City Labs, Inc. a security interest in all products delivered to secure the payment of invoiced amounts due. Buyer agrees to execute and deliver to Mad City Labs, Inc., upon request, UCC financing statements and other documents reasonably requested by Mad City Labs, Inc. to perfect its security interest in the products.

6. Cancellations and Change Orders. Accepted purchase orders can be cancelled or changed only with Mad City Labs, Inc.'s written consent and upon terms that will indemnify Mad City Labs, Inc. against all losses, costs and damages it sustains directly or indirectly related to the cancellation or change. All special orders are non-cancellable and non-changeable.

7. Inspection and Rejection. All products shall be examined by Buyer upon receipt of Buyer. If products are damaged upon receipt or do not conform to agreed specifications, products shall not be moved from point of delivery, and a written claim must be filed with Mad City Labs, Inc. within 5 business days of date of delivery. Upon receipt of a written claim for damaged or nonconforming products, Mad City Labs, Inc. will notify Buyer in writing if products are to be returned, or if products will be repaired or if a credit will be issued. Whether products are returned or repaired or whether a credit is issued, is within Mad City Labs, Inc.'s full and complete discretion, subject to the limited warranty set forth below, and shall be Buyer's sole remedy at law or equity.

8. Limited Warranty: Disclaimer. Mad City Labs, Inc. warrants that for a period of 1 year following the date of delivery to Buyer Mad City Labs, Inc. products shall conform to the specifications, drawings or other written descriptions contained in any purchase order and shall be free from defects in material and workmanship. This limited warranty applies to the initial purchaser only and may be acted upon only by the initial purchaser. Buyer's sole remedy and Mad City Labs, Inc.'s exclusive liability for a breach of this limited warranty shall be, at Mad City Labs, Inc.'s option, the repair or replacement of the nonconforming product or part thereof. This limited warranty does not cover normal wear and tear and shall not apply to any product which has been damaged or misused or modified, altered or repaired by any party other than an authorized representative of Mad City Labs, Inc.

THE FOREGOING LIMITED WARRANTY IS IN LIEU OF ANY OTHER WARRANTY, WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL (INCLUDING ANY WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE OR NON-INFRINGEMENT.)

TERMS AND CONDITIONS OF SALE

9. IN NO EVENT SHALL MAD CITY LABS, INC. BE LIABLE TO BUYER FOR SPECIAL, INCIDENTAL, CONSEQUENTIAL, EXEMPLARY, PUNITIVE, OR OTHER INDIRECT DAMAGES, OR FOR LOSS OF PROFITS, LOSS OF DATA OR LOSS OF USE DAMAGES, ARISING OUT OF THE MANUFACTURE, SALE, SUPPLYING OR FAILURE OR DELAY IN SUPPLYING OF THE PRODUCTS OR THE SERVICES RELATED THERETO, WHETHER BASED UPON WARRANTY, CONTRACT, TORT, STRICT LIABILITY OR OTHERWISE, SHALL NOT EXCEED THE PRICE PAID FOR THE PRODUCT.

10. Controlling Provisions. To the extent there is a conflict between these Terms and Conditions of Sale and Buyer's purchase order, these Terms and Conditions of Sale shall be controlling.

11. Termination. Each purchase order issued by Buyer in connection with Mad City Labs, Inc.'s quotation is subject to acceptance by Mad City Labs, Inc. If Buyer defaults in the payment of any sum due Mad City Labs, Inc. or commits any other breach of any of the terms or conditions herein or if there is a material change in the ownership or financial conditions of the Buyer which is considered unsatisfactory to Mad City Labs, Inc., then Mad City Labs, Inc. may, without prejudice to any other rights which may have accrued or which may accrue to it, whether under contract or at law or equity, refuse to accept any purchase order and may terminate any order immediately.

12. Governing Law. Any contract between the parties shall be construed and governed in accordance with the laws of the State of Wisconsin.

13. Mad City Labs, Inc.'s Property. All specifications, drawings, tools, jigs, dies, fixtures, materials, equipment and other items furnished by Mad City Labs, Inc., or the cost of which is charged against this order shall be confidential and shall be and remain the property of Mad City Labs, Inc.. The sale of products by Mad City Labs, Inc. to Buyer shall not be construed as a license of any trade secret right, trademark, patent or copyright.

14. Patents. The Buyer agrees to defend, indemnify and hold Mad City Labs, Inc. and its distributors and dealers in, and users of the products of Mad City Labs, Inc. harmless against any and all losses, damages or liabilities arising out of any demand, claim, action, litigation or judgement (each, a "Claim") involving infringement or alleged infringement of the U.S. and/or foreign patent by any product furnished hereunder.

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