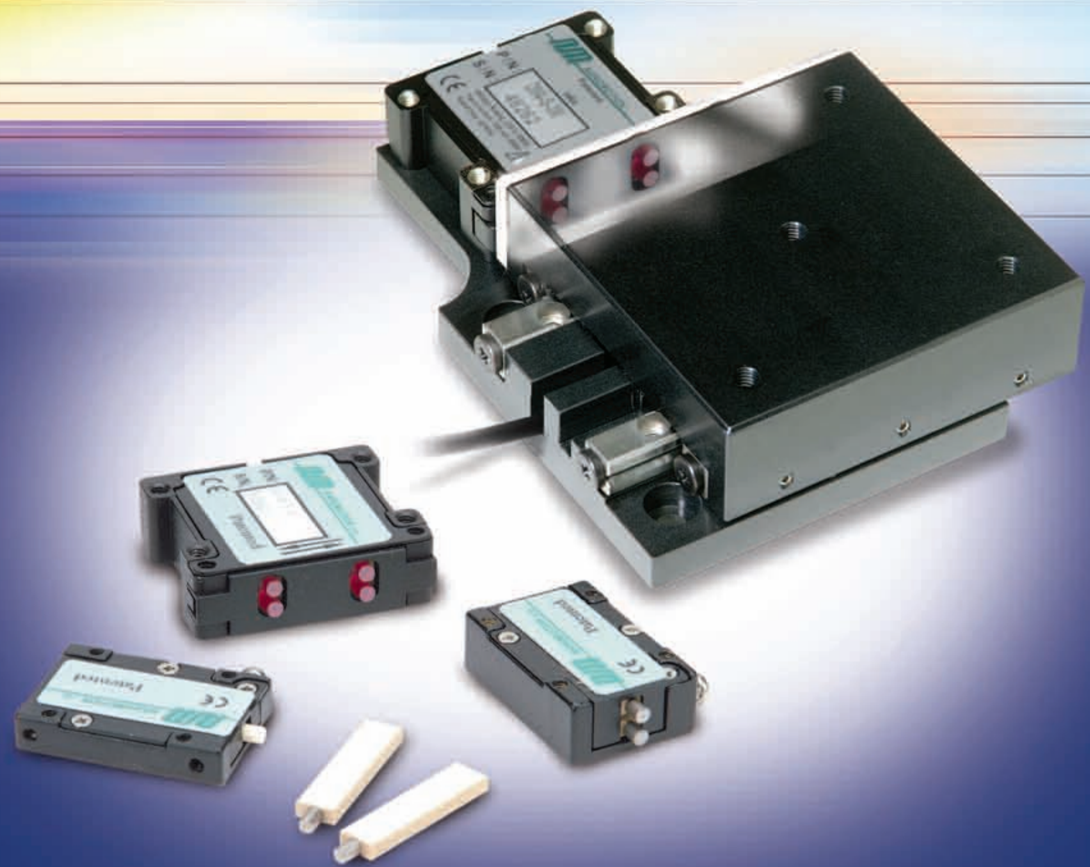




Precision Motion Control



NM CERAMIC SERVO MOTORS
by Nanomotion

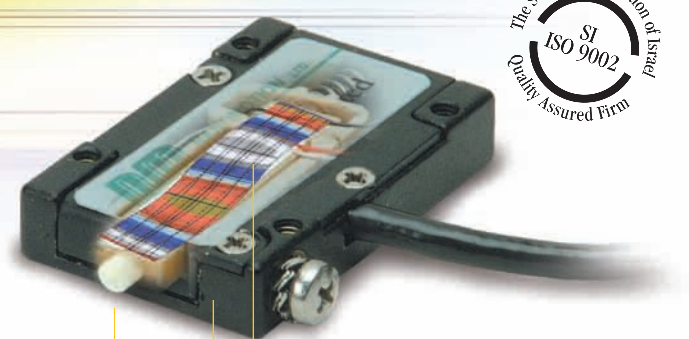
A Johnson Electric Company

Based on the principles of ultrasonic standing waves in piezoelectricity, Nanomotion introduces its most advanced series of electronic motors, operating similarly to DC servo motors with the high resolution and dynamic performance of piezo actuators.

Nanomotion... A Breakthrough Technology

As the leading manufacturer of piezo-electric motors for precision motion control applications, Nanomotion's product line ranges from single element motors for actuation, to larger motors for driving typical stages. Nanomotion motors operate with no intrinsic magnetic fields and no moving parts. The motors provide unlimited travel in a compact package, with the ability to achieve unmatched precision for linear or rotary motion.

Nanomotion's motors have been successfully applied in diverse applications, using our standard housed motors for motion control positioning in industrial automation to simply applying a piezoelectric element embedded in consumer products. Regardless of the packaging, Nanomotion brings a unique drive solution to any motion requirement.



By pressing the ceramic finger tip against a ceramic strip a driving force is exerted on a linear or rotary stage, creating motion.

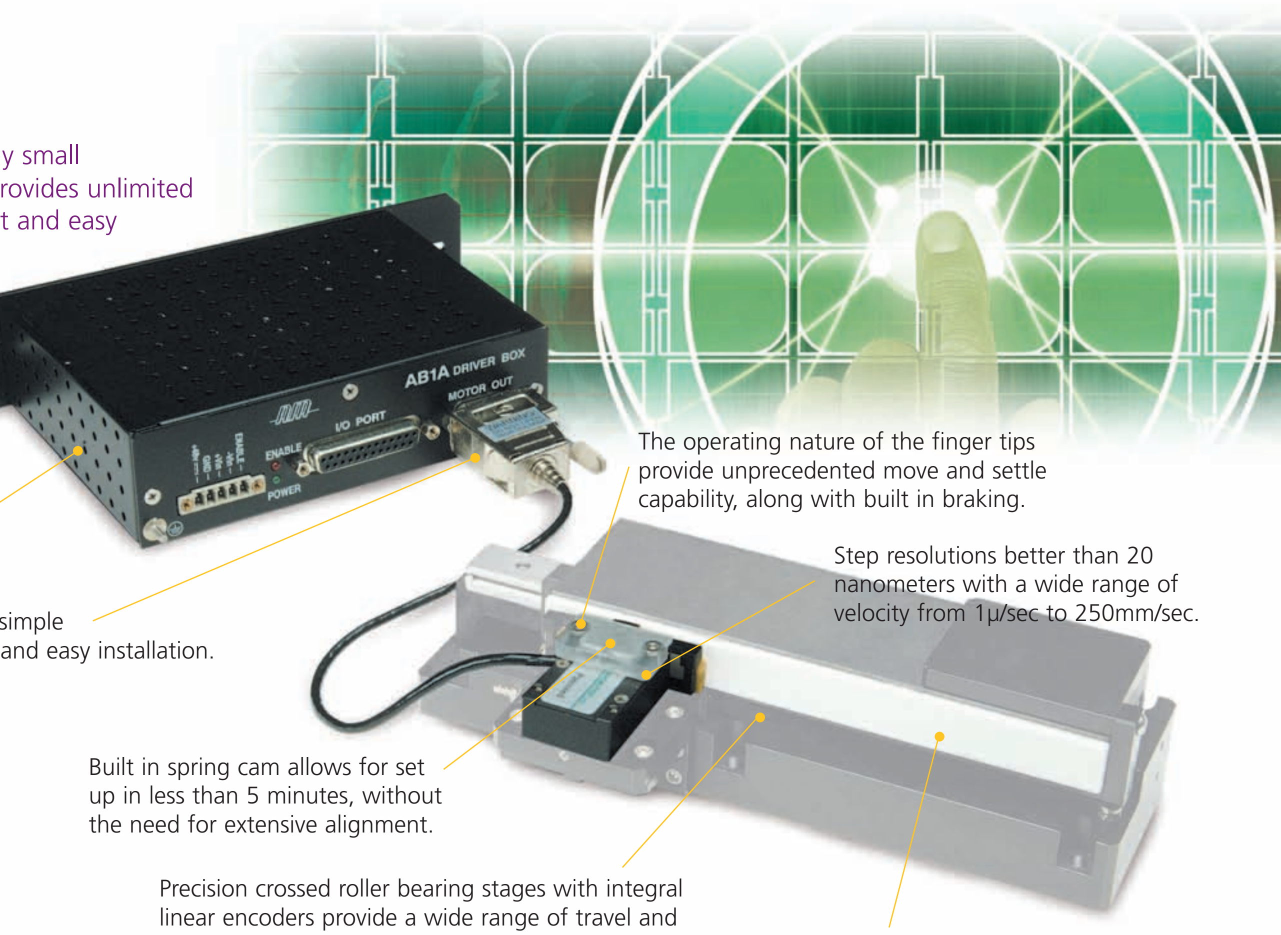
The simultaneous excitation of the longitudinal extension and transverse bending modes creates two dimensional acoustic waves resulting in a small elliptical path at the finger tip.

When the driving voltage is not applied, the compression of the finger tip to the ceramic maintains holding torque on the motion device. Unlike other braking devices, there is no position shift or hysteresis in the Nanomotion motor.

Table of Contents

Nanomotion's unique motor & stage technology makes it well suited to applications in:

- Semiconductor & Flat Panel Equipment
  - Normal Environments to Ultra-High Vacuum
- Fiber Optics Manufacturing and Dynamic Components
- Storage Media Manufacturing and Test Equipment
- Bio-Medical and Pharmaceutical Manufacturing
- Metrology
- General Automation



Nanomotion motors and FB stages are available in a wide range of configurations and are compatible with all standard servo controls.

Nanomotion Motors and FB Stages For The Semiconductor Market

Standard Motors:
- Clean Room Applications

Vacuum and Non-Magnetic Motors:
- E-Beam and Ion Beam Applications

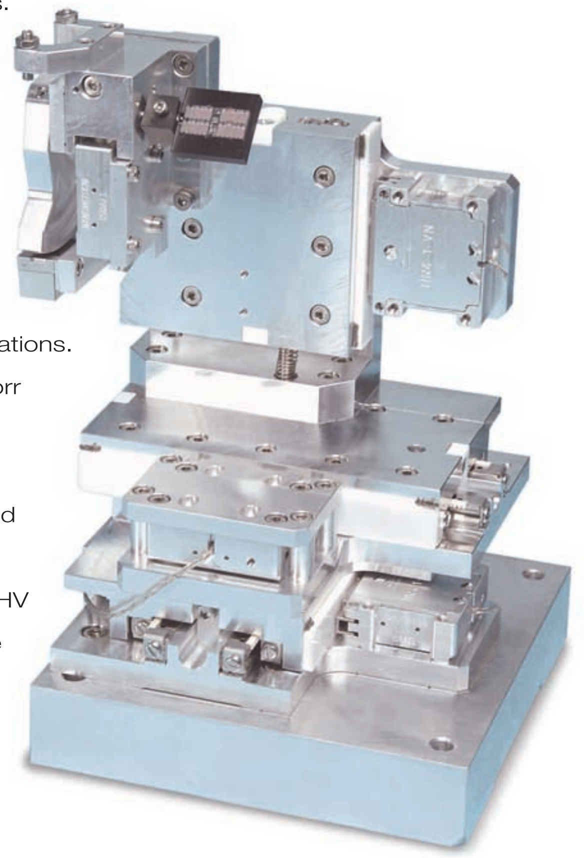
Vacuum Compatible Motors:
- High Vacuum and UHV Applications

Standard and Vacuum Compatible FB Stages:
- Precision linear and rotary stages for clean room and vacuum environments
- Custom stage designs for open frame and small footprints
- Well-suited to use in E-Beam and Ion Beam chambers

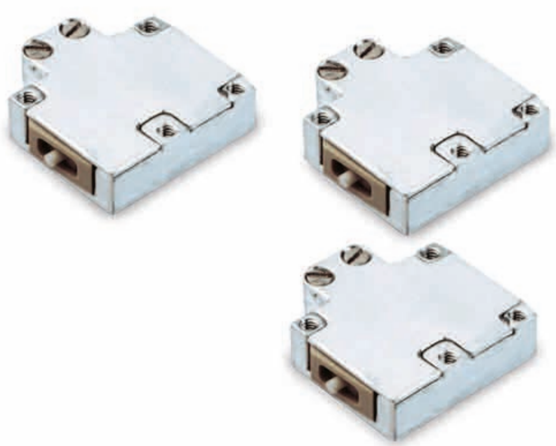
XYZT UHV Stage for Laser / Ion Beam Micromachining of Semicon Devices

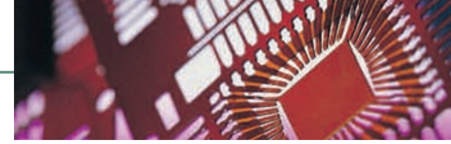
This 4 axis motion system provides X/Y/Z and Theta motion for laser or Ion Beam machining of semiconductor chips or MEMs devices. The stage construction is UHV compatible to 10^{-10} Torr and has non-magnetic motors.

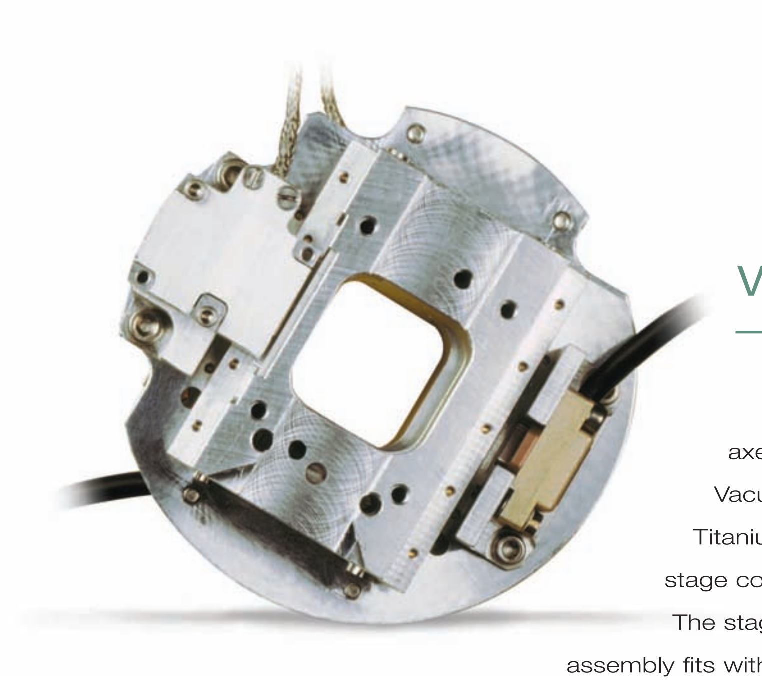
Each linear axis uses 50nm resolution linear encoders and the theta axis positions to 1 arc second. This stage can operate up to 200mm/sec.



Nanomotion manufactures a wide variety of vacuum and UHV motors for Semiconductor applications. Our vacuum motors, for environments up to 10^{-7} Torr are also available in non-magnetic configurations. These motors have no magnetic materials and no intrinsic magnetic field, and are ideal for E-Beam and Ion Beam applications, where magnetic motion can disturb the direction of the beam. Nanomotion's UHV motors are inherently non-magnetic and compatible to 10^{-10} Torr.







Vacuum / Non-Magnetic Stage

A dual axis stage providing 10mm travel in X and Y axes uses Nanomotion's ST motors, in a Ultra High Vacuum compatible and non-magnetic configuration. Titanium bearings provide for a completely non-magnetic stage construction.

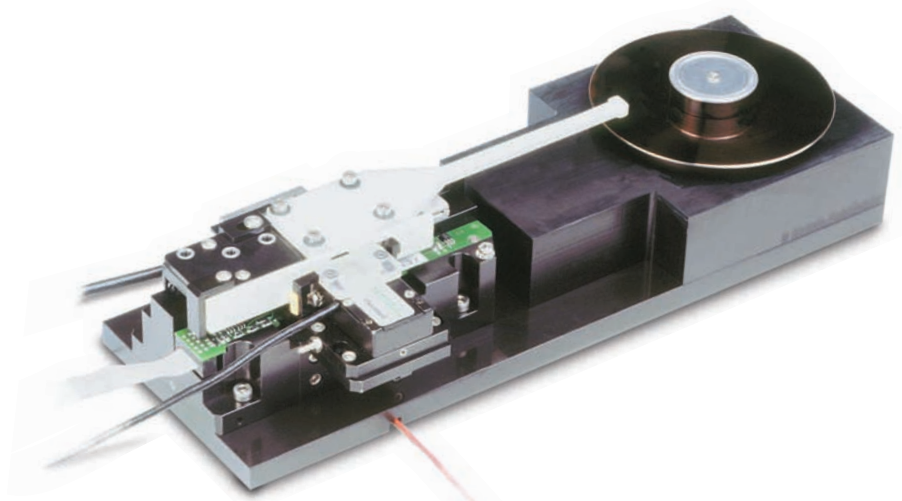
The stages use a 50nm resolution encoder and the entire assembly fits within a 75mm diameter.

Data Storage Certification Process

A single axis linear stage is used for track certification of a hard disk. The stage uses Nanomotion LS4 motors and a 100nm resolution linear encoder. (5nm optional)

Step sizes range from 1µ to 15µ in less than 10msec, settling to 200nm.

The stage operates in a class 100 clean room environment, on a 24/7 basis. Several hundred units have accumulated billions of cycles over the past several years.



Nanomotion Motors and FB Stages For The BioMedical Market

Non-magnetic Motors:

- MRI Applications

Standard Motors:

- Microscope Stages
- Auto Focus Axes
- High Throughput Screening
- Clean Room Assembly Applications

Vacuum Motors:

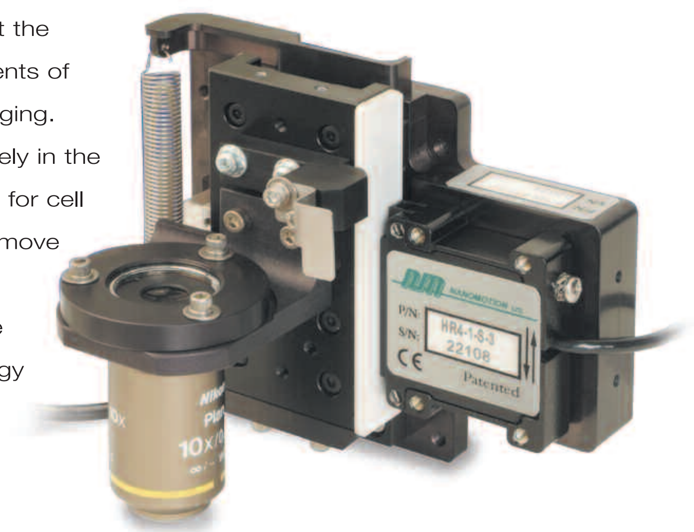
- Laser & Mass Spectrometer Applications

Precision Stages for Bio and Pharma Markets:

- Linear stages for auto focus in cell analysis
- Linear and rotary stages for sample manipulation

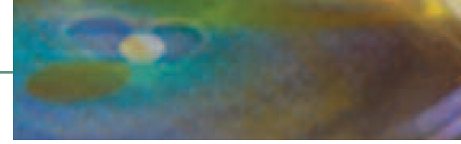
Auto Focus & Scanning Stages for Cell Imaging and Virtual Microscopy

Nanomotion's auto focus stage is designed specifically for use in vertical orientation, with the dynamic performance to meet the demanding requirements of focusing on the fly. The stage uses a spring counterbalance to offset the load, and manage the demanding requirements of following Cell Terrain, during high speed imaging. Nanomotion's stages are also used extensively in the horizontal Step & Repeat or Scan on-the-fly, for cell imaging. The ability to provide high speed move & settle as well as smooth constant velocity offers the highest motion performance in the smallest footprint. While the stage technology can provide long travel, it can make focus moves in the range of 1 to 10 microns in 5 milliseconds, settling to 100nm.



Features

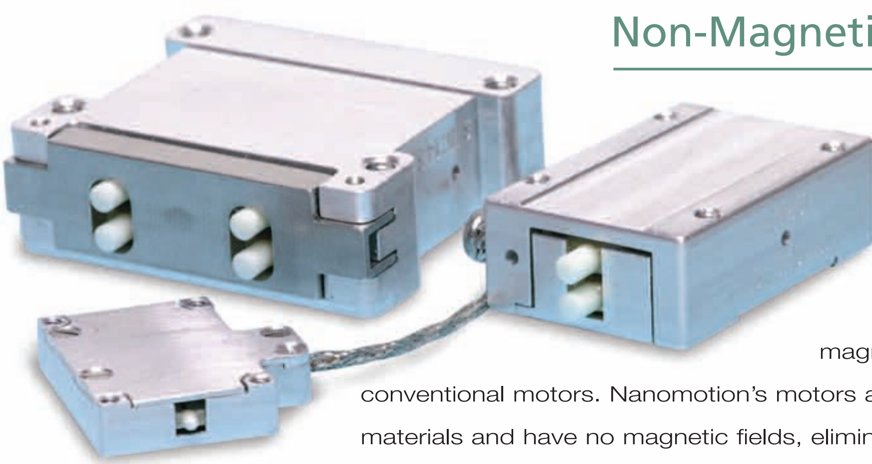
- Ceramic Servo Motor with Travel to 25mm
- High Resolution from 10nm to 100nm (1nm optional)
- Zero Backlash with Direct Drive
- High Speed Move & Settle for Focusing Operation
- Superior Position Stability and Zero Power Consumption at Rest
- Position Holding without Power Provides Optical Stability and Reduces Thermal Drift
- Easy Add-on Mounting to Standard Microscopes



Proteomics and Drug Development

High speed multi-axis systems use Nanomotion ceramic servo motors to provide the utmost in speed and performance, while maintaining an exceptionally small machine footprint.

Whether controlling the position of the dispensing head or actuating a series of syringes, Nanomotion provides compact, light weight motors that can operate in a lab environment.



Non-Magnetic Motors for MRI

MRI manipulators and robotics use Ceramic Servo Motors to control position while the MRI machine is on. The MRI creates an exceptionally high magnetic field preventing the use of conventional motors. Nanomotion's motors are provided with NO magnetic materials and have no magnetic fields, eliminating the potential for artifacts on the display screen.

HR Series

Nanomotion's HR Series motors range in size from a single element (providing 0.4kg of force) to an eight element motor (providing 3.2kg of force). The HR series is capable of driving both linear and rotary stages. The HR series motors have a wide dynamic range of speed, from several microns per second to 250mm/sec and can easily mount to traditional low friction stages or other devices. The unique operating characteristics of the HR Series motors provide inherent braking and the ability to eliminate servo dither when in a static position.

Features

- Unlimited Travel
- Wide Dynamic Velocity Range
  - From 1μ/sec to 250mm/sec
- Excellent Move & Settle
- Step Resolutions to 10nm
- No Intrinsic Magnetic Field
- No External Magnetic Field Sensitivity (for Non-Magnetic Version)
- Vacuum Versions Available

CE Approved

Motor Performance Specifications

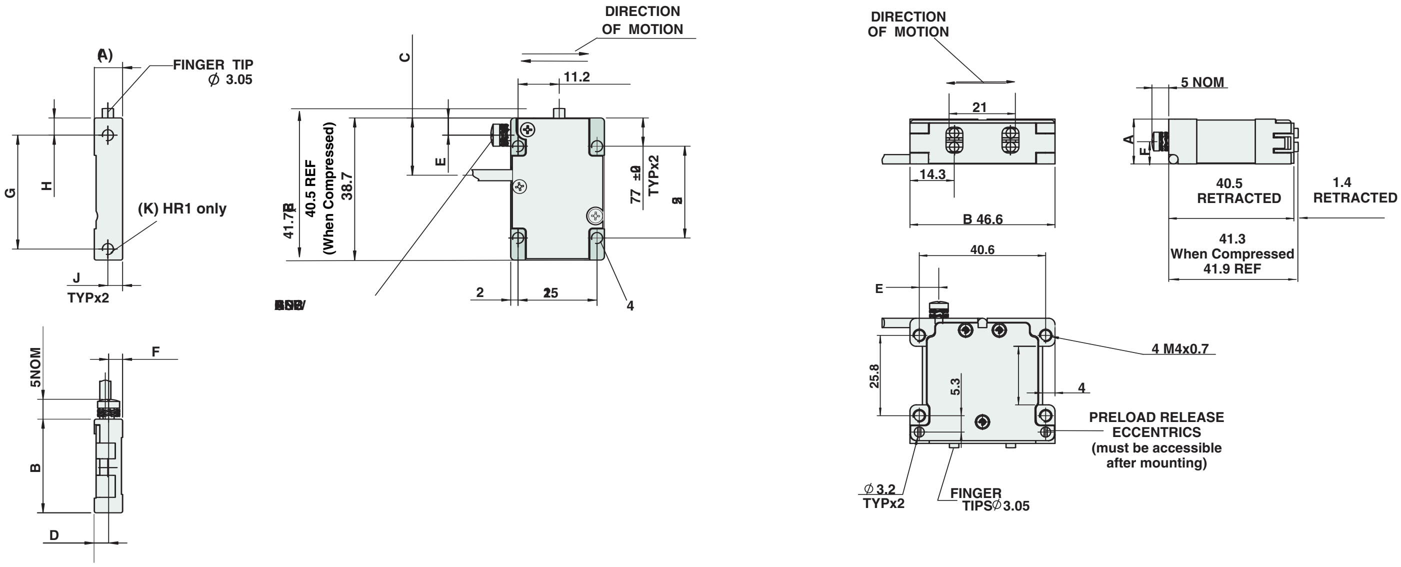
	Max Velocity (mm/sec)	Dynamic Stall Force (N)	Static Hold Force (N)	Static Stiffness (N/μ)	Preload on Stage (N)	Kf Force Constant (N/Volt Commanded)
HR1	250	4	3.5	1	18	.75
HR2	250	8	7	1.8	36	1.5
HR4	250	16	14	2.8	72	3
HR8	250	32	28	3.8	144	6

Note: All motor performance data is based on using Nanomotion ceramic motors and amplifiers.

Environmental

operating temperature:	0 to 50° C
storage:	-20°C to +70°C
humidity:	0 to 80%, non condensing
-V vacuum motors:	to 10^{-7} torr after bake out
-U ultra-high vacuum motors:	to 10^{-10} torr after bake out
max bake out temperature:	120°C for -V motors, 140°C for -U motors

Dimensions (European View)



	A Motor Height	B Motor Width	C Cable Exit	D	E Gnd Screw	F Gnd Screw	G Side Mtg	H Side Mtg	J Side Mtg	K Screw Type	Motor Weight (Grams)
HR1-1-S	8	25.7	15.6	4.7	4.7	3.8	31	4.7	4	M3x0.5	30
HR1-1-V	8	25.7	15.6	4.7	4.7	3.8	31	4.7	4	M3x0.5	20
HR1-1-U	7.7	25.5	NA	NA	4	4	NA	NA	NA	NA	20
HR2-1-S	12.7	25.7	15.6	9.7	4.7	6	NA	NA	NA	NA	60
HR2-1-V	12.7	25.7	15.6	9.7	4.7	6	NA	NA	NA	NA	40
HR2-1-U	12.7	25.5	NA	NA	4	6	NA	NA	NA	NA	40
							Terminal Mtg for U motors				
HR4-1-S	14.4	46.6	Bottom Back		9.3	7.2	NA	NA	NA	NA	73
HR4-1-V	14.4	46.6	Left or Right		9.3	7.2	NA	NA	NA	NA	73
HR4-1-U	14.9	46.6	NA	NA	NA	NA	NA	NA	6	NA	73
HR8-1-S	23.3	46.6	Bottom Back		9	12	NA	NA	NA	NA	170
HR8-1-V	23.3	46.6	Left or Right		9	12	NA	NA	NA	NA	120
HR8-1-U	23.8	46.6	NA	NA	NA	NA	NA	NA	12	NA	120

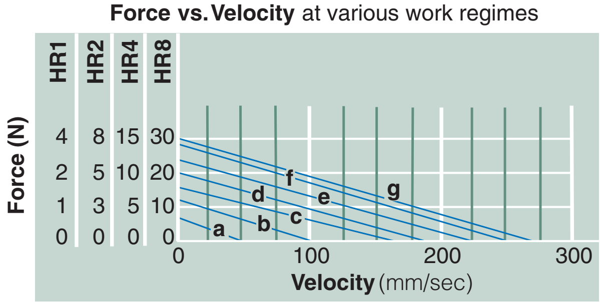
Note: All dimensions in mm

-S motors are Standard
-V motors are Vacuum Rated to 10^{-7}, Torr (use VN for Vacuum & Non-Magnetic)
-U motors are Vacuum Rated to 10^{-10}, Torr and are Non-Magnetic
-N motors are Non-Magnetic, for MRI environments

Envelope of Performance

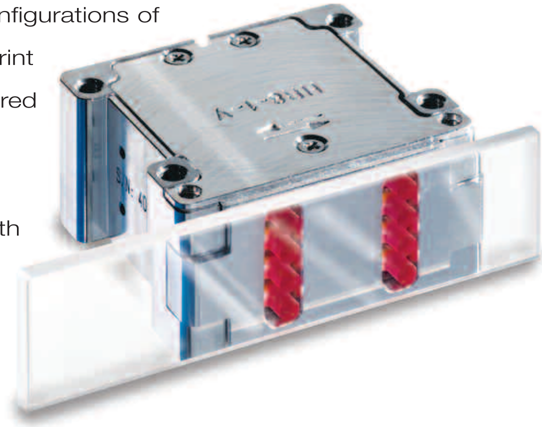
curve	25°C duty cycle	25°C max. continuous operation time	50°C duty cycle	50°C max. continuous operation time	Vacuum duty cycle	Vacuum max. continuous operation time
a	100%	—	100%	—	100%	—
b	100%	—	100%	—	44%	184
c	100%	—	92%	137	26%	107
d	100%	—	62%	93	17%	72
e	78%	67 seconds	47%	70	13%	55
f	56%	62 seconds	33%	50	9%	39
g	50%	56 seconds	30%	45	8%	35

Force vs. Velocity at various work regimes



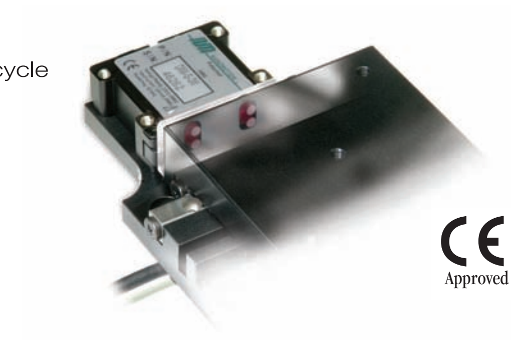
The DuraMotor provides the utmost in durability through the use of new and improved materials for the motor tip and drive strip. Designed for the most demanding applications, the DuraMotor provides exceptional levels of cleanliness and motor life with low particle generation.

The DuraMotor series is available in the standard configurations of DM1, 2, 4 and 8 element motors with the identical footprint of the equivalent HR series. The DuraMotor series is offered with a unique family of DuraStrips and DuraDisks, and is compatible with all standard Nanomotion amplifiers. The DuraMotor supports linear, rotary, and tilt applications with the same benefits of unlimited travel, built-in holding/braking without power consumption and a wide bandwidth of velocity.



Features

- Demanding Move & Settle profiles with high duty cycle
- High speed motion profiles
- Vacuum & UHV configurations available
- Wide dynamic range of velocity
  - From 1µm/sec to 250mm/sec



Motor Performance Specifications

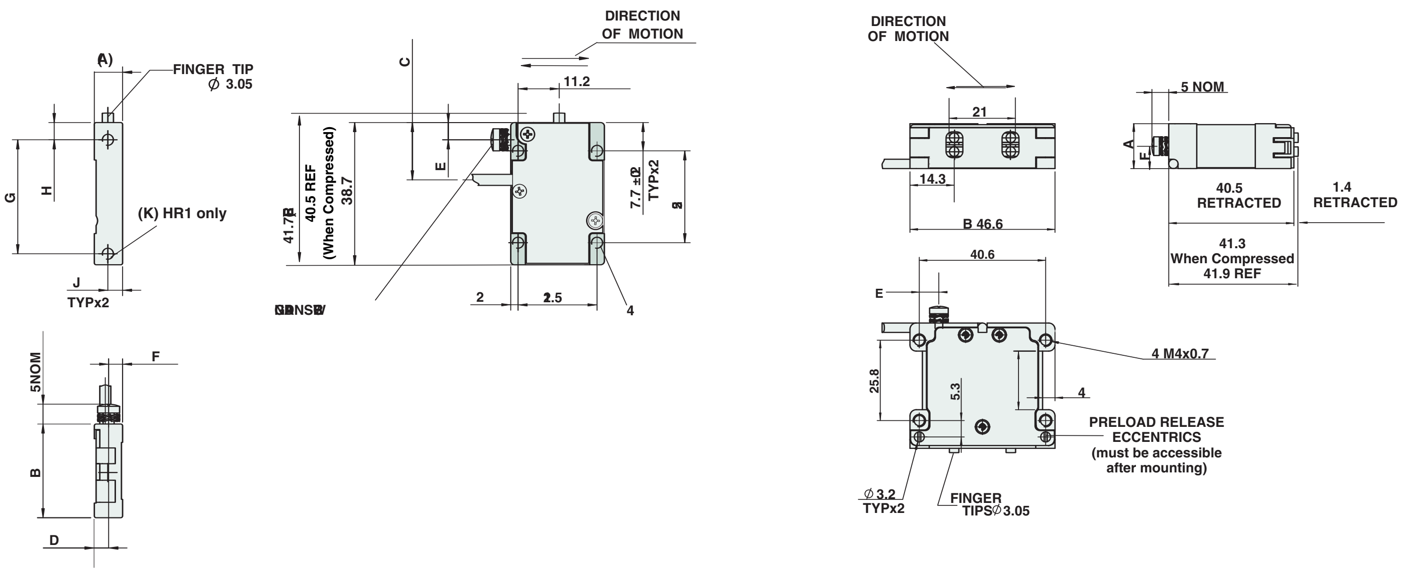
	Max Velocity (mm/sec)	Dynamic Stall Force (N)	Static Hold Force (N)	Static Stiffness (N/µ)	Preload on Stage (N)	Kf Force Constant (N/Volt Commanded)
DM1	**250**	**4**	**3.5**	**1**	**18**	**.75**
DM2	**250**	**8**	**7**	**1.8**	**36**	**1.5**
DM4	**250**	**16**	**14**	**2.8**	**72**	**3**
DM8	**250**	**32**	**28**	**3.8**	**144**	**6**

Note: All motor performance data is based on using Nanomotion Drive Surface, motors and amplifiers.

Environmental

operating temperature:	0 to 50° C
storage:	-20°C to +70°C
humidity:	0 to 80%, non condensing
-V vacuum motors:	to 10^{-7} torr after bake out
-U ultra-high vacuum motors:	to 10^{-10} torr after bake out
max bake out temperature:	120°C for -V motors, 140°C for -U motors

Dimensions (European View)



	A Motor Height	B Motor Width	C Cable Exit	D	E Gnd Screw	F Gnd Screw	G Side Mtg	H Side Mtg	J Side Mtg	K Screw Type	Motor Weight (Grams)
DM1-1-S	8	25.7	15.6	4.7	4.7	3.8	31	4.7	4	M3x0.5	30
DM1-1-V	8	25.7	15.6	4.7	4.7	3.8	31	4.7	4	M3x0.5	20
DM1-1-U	7.7	25.5	NA	NA	4	4	NA	NA	NA	NA	20
DM2-1-S	12.7	25.7	15.6	9.7	4.7	6	NA	NA	NA	NA	60
DM2-1-V	12.7	25.7	15.6	9.7	4.7	6	NA	NA	NA	NA	40
DM2-1-U	12.7	25.5	NA	NA	4	6	NA	NA	NA	NA	40
							Terminal Mtg for U motors				
DM4-1-S	14.4	46.6	Bottom Back		9.3	7.2	NA	NA	NA	NA	73
DM4-1-V	14.4	46.6	Left or Right		9.3	7.2	NA	NA	NA	NA	73
DM4-1-U	14.9	46.6	NA	NA	NA	NA	NA	NA	6	NA	73
DM8-1-S	23.3	46.6	Bottom Back		9	12	NA	NA	NA	NA	170
DM8-1-V	23.3	46.6	Left or Right		9	12	NA	NA	NA	NA	120
DM8-1-U	23.8	46.6	NA	NA	NA	NA	NA	NA	12	NA	120

Note: All dimensions in mm

-S motors are Standard

-V motors are Vacuum Rated to 10^{-7}, Torr (use VN for Vacuum & Non-Magnetic)

-U motors are Vacuum Rated to 10^{-10}, Torr and are Non-Magnetic

-N motors are Non-Magnetic, for MRI environments

Envelope of Performance

curve	25°C duty cycle	25°C max. continuous operation time	50°C duty cycle	50°C max. continuous operation time	Vacuum duty cycle	Vacuum max. continuous operation time
a	100%	—	100%	—	100%	—
b	100%	—	100%	—	44%	184
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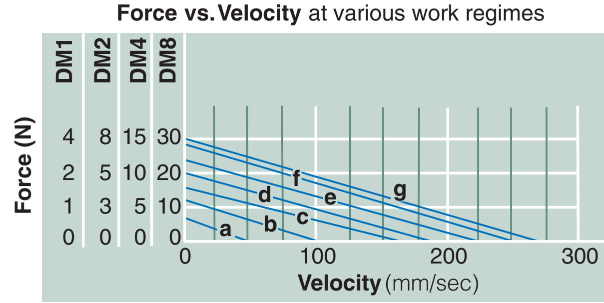
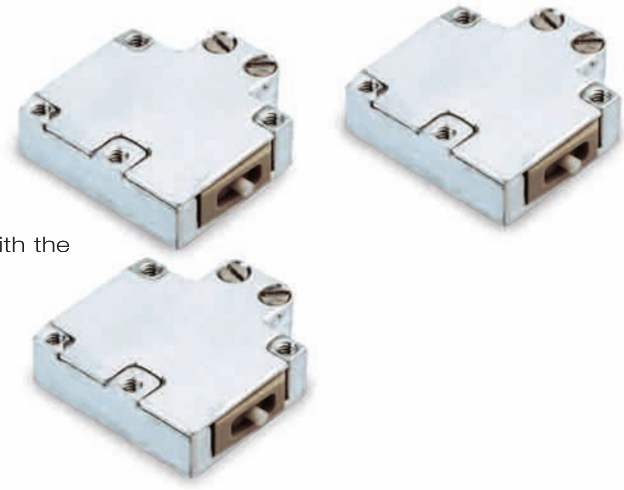
Force vs. Velocity at various work regimes



ST Motor

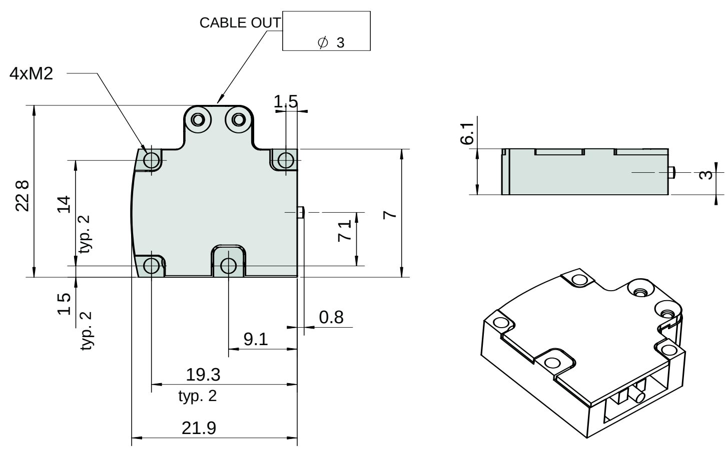
The ST Series Piezoelectric Motor is the smallest motor of its kind. The ST provides high resolution motion control for linear or rotary devices in a fraction of the space of traditional mechanisms. The ST is ideal for small stepping as well as continuous travel, with the ability to make step increments in the tens of nanometers and the ability to operate at speeds up to 250mm/sec.



Features

- The Smallest Standard Piezo-Electric Package
- Unlimited Travel
- Wide Dynamic Velocity Range - from 1µm/sec to 250mm/sec
- Excellent Move & Settle
- Standard and Low Speed Version for High Resolution
- No Intrinsic Magnetic Field
- No External Magnetic Field Sensitivity

Dimensions (European View)



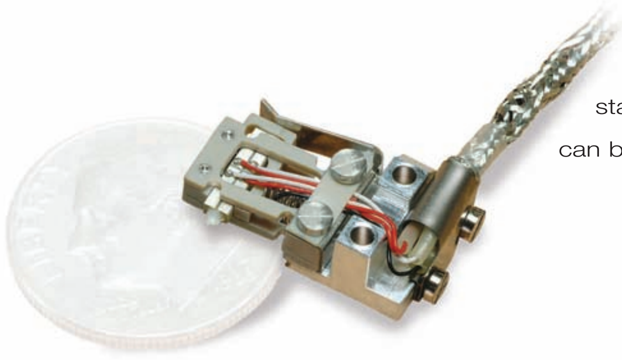
Motor Performance Specifications

	max velocity (mm/sec)	dynamic stall force (N)	static hold force (N)	static stiffness (N/µ)	preload on stage (N)	Kf Force Constant (N/Volt Commanded)
ST-1-S	250	1.2	1	.15	8	.1
ST-1-V	250	1.2	1	.15	8	.1

Note: All Dimensions are in mm.

Environmental

operating temperature:	0 to 50˚ C
storage:	-40˚C to +70˚C
humidity:	0 to 80%, non condensing

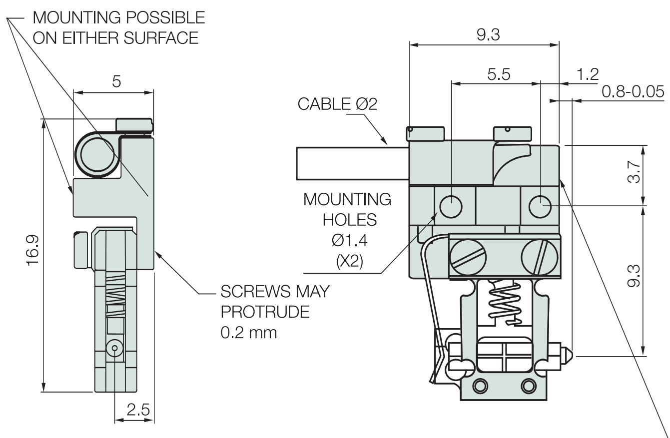


Nanomotion's MM motor is the smallest industrial motor of its kind that provides unlimited linear or rotary motion, with 0.17N of driving force and velocity up to 220mm/sec.

The MM motor works with Nanomotion's standard AB4 amplifier and any servo controller, and can be integrated into most bearing structures.

Features

- Exceptionally small dimensions
- Excellent move and settle characteristics
- Suitable for high vacuum environments
- Inherent brake at power off
- Unlimited travel
- Wide dynamic velocity range– from 100 micron/sec to 220 mm/sec
- No intrinsic magnetic field
- High resolution
- Nominal lifetime– 20,000 hours under nominal operating conditions



Motor Performance Specifications

	Max Velocity (mm/sec)	Dynamic Stall Force (mN)	Static Hold Force (mN)	Static Stiffness (Nμ)	Preload on Stage (N)	Kf Force Constant (mN/Volt Commanded)	Kv Force (N • sec/m)
MM-1-S-1.5	220	170	160	0.04	0.9	25 to 35	0.5 to 0.8
MM-1-V-1.5	220	170	160	0.04	0.9	25 to 35	0.5 to 0.8

Note: All motor performance data is based on using Nanomotion ceramic motors and amplifiers

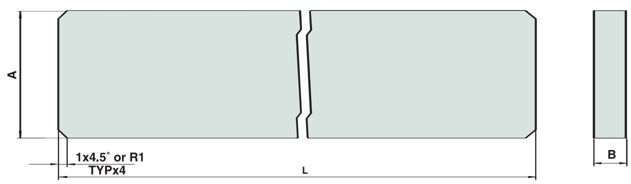
Environmental

operating temperature:	0 to 50˚ C
storage	-40˚C to +70˚C
humidity	0 to 80%, non condensing
residual magnetism	0.27 nT
vacuum compatibility	1E – 7 torr. guaranteed after baking
max bake out temperature	24Hr @ 120˚C

Drive Strips

Nanomotion manufactures and supplies ceramic drive strips, DuraStrips and CCS ceramic coated steel for all motor types. Standard strips, rings and disks are available in a wide variety of sizes and shapes. Nanomotion can also provide custom drive strips/rings for different application requirements.

The mating drive surface is critical to the motor's performance. All specifications are based on using Nanomotion's drive surfaces. Most of Nanomotion's standard drive strips are provided with vacuum compatible, double sided tape for easy mounting. The motor user manual defines the proper mounting procedure.



*Mounted with Double Sided Tape

Strips

	for use with	a	b	standard lengths**			
standard ceramic							
CS-10-1.5-200	ST, HR1	10	1.5	200	–	–	–
CS-10-3-XXX***	HR1, HR2, HR4	10	2.7	200	250	300	350
CS-20-3-XXX	HR8	20	2.7	200	250	300	350
dura strip							
DS-10-3-XXX***	DS1, DS2, DS4	10	2.7	200	250	300	350
DS-20-3-XXX	DS8	20	2.7	200	250	300	350
ceramic coated steel							
CCS-20-5-XXX	HR1, HR2, HR4, HR8	20	4.8	500	1000	1500	2000

Note: * All ceramics are provided with double sided tape. Please specify in your order form if otherwise required.
** For special lengths, consult factory for pricing and availability
*** The XXX represents the required length of the ceramic strip; 50, 100, and 150mm are available as standard.

Note: All dimensions are in mm

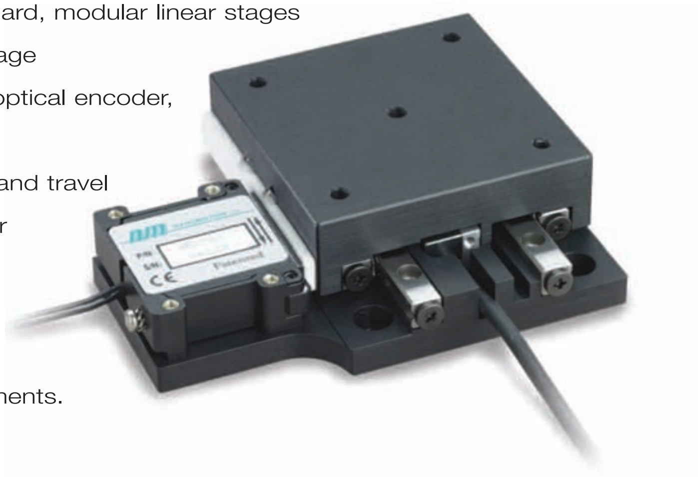
Rings & Disks

	motor preload	od	id	thickness
rings				
CR-12-9-5-X	a = axial, r = radial, ra = radial axial	12	9	5
CR-40-32-10-X*	a = axial, r = radial, ra = radial axial	40	32	10
CR-60-40-10-X	a = axial, r = radial, ra = radial axial	60	40	10
CR-100-80-10-X	a = axial, r = radial, ra = radial axial	100	80	10

Note: * The X represents the motor preload required for the ceramic ring, a = axial, r = radial, ra = radial axial

disks				
CD-146-114-1.5	axial	146	114	1.5
CD-192-60-5	axial	192	60	5
CD-192-150-5	axial	192	150	5

Nanomotion manufactures many other ring and disk sizes. Please contact us for non-standard sizes.



The FB Series product line is a family of standard, modular linear stages available for single and multi-axis applications. The stage configuration utilizes crossed roller bearings, a linear optical encoder, and Nanomotion's ceramic servo motors.

The stages are offered in a wide range of widths and travel lengths and can be combined in X/Y or X/Y/Z or other multi-axis configurations. Encoder resolutions can be varied to achieve a range of performance criteria and there are different size motors for each cross-section to meet necessary force/acceleration requirements.

Features

- Compact stage design with low profile
- Direct drive motor with simple, robust construction
- Linear encoder mounted in the center for optimum positioning
- Easily configurable in multi-axis
- Wide range of slide size, travels and motor size

Stage Configurations

series	Width	Motor Options	Standard Travels
FB050	50mm	HR2 OR HR4	20mm, 50mm, 75mm
FB075	75mm	HR4 OR HR8	40mm, 60mm, 100mm, 150mm
FB100	100mm	HR4 OR HR8	60mm, 100mm, 150mm
FB150	150mm	HR4 OR HR8	100mm, 150mm, 200mm

Note: Travel lengths to 300mm available in the FB100 and FB150 configurations.

Encoders
Standard encoder resolution is 0.1µm
Optional resolutions: 1µm, 0.5µm, 50nm, 10nm
Optional limits and home sensor (FB050 is home only)

Available Mountings
X/Y
X/Z using angle bracket
X/Y/Z using angle bracket

Performance Specifications

	FB050	FB075	FB100	FB150
straightness & flatness	2.5µm/25mm travel	2.5µm/25mm travel	2.5µm/25mm travel	1.5µm/25mm travel
maximum load capacity (in kg)				
20mm travel	2			
40mm travel		5		
50mm travel	5			
60mm travel		5	10	
75mm travel	7			
100mm travel		7	12	20
150mm travel		10	12	25
200mm travel				25

Motor Performance Specifications

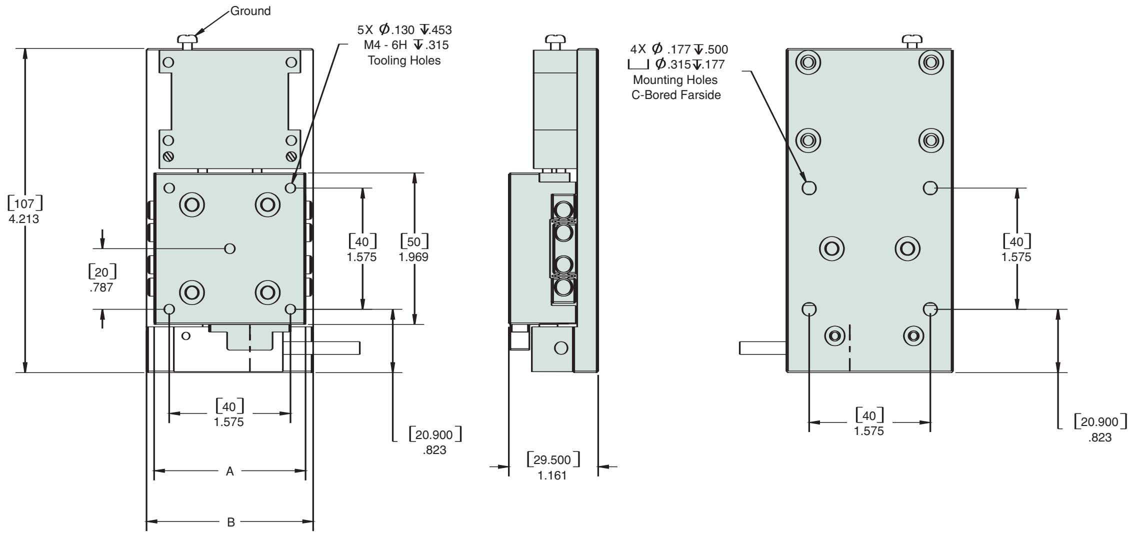
driving force (in N)	FB050	FB075	FB100	FB150
HR2	8			
HR4	16	16	16	16
HR8		30	30	30

static holding force (in N)	FB050	FB075	FB100	FB150
HR2	3.5			
HR4	12	12	12	12
HR8		25	25	25

position repeatability	FB050	FB075	FB100	FB150
0.1µm standard	±0.5µm			
10nm optional	±50nm			
50nm optional	±200nm			
0.5µm optional	±2µm			
1.0µm optional	±3µm			

Features

- Compact stage design with low profile
- Direct drive motor with simple, robust construction
- Linear encoder mounted in the center for optimum positioning
- Easily configurable in multi-axis
- Wide range of slide size, travels and motor size



Motor Performance Specifications

	Travel (mm)	A (mm)	B (mm)	Dynamic Stall Force (N)	Stage Mass (g)	Moving Mass (g)
FB050-020-0.1M2	20	50	55	8	385	150
FB050-020-0.1M4	20	50	55	16	400	150
FB050-050-0.1M2	50	75	80	8	595	226
FB050-050-0.1M4	50	75	80	16	610	226
FB050-075-0.1M4	75	100	105	16	700	400

Note All standard FB stages are provided with .1µm resolution linear encoders.

Encoder Options

part suffix	**resolution**
-1.0M	.1µm Optional
-0.5M	.5µm Optional
-50N	50nm Optional
-10N	10nm Optional

Features

- Compact stage design with low profile
- Direct drive motor with simple, robust construction
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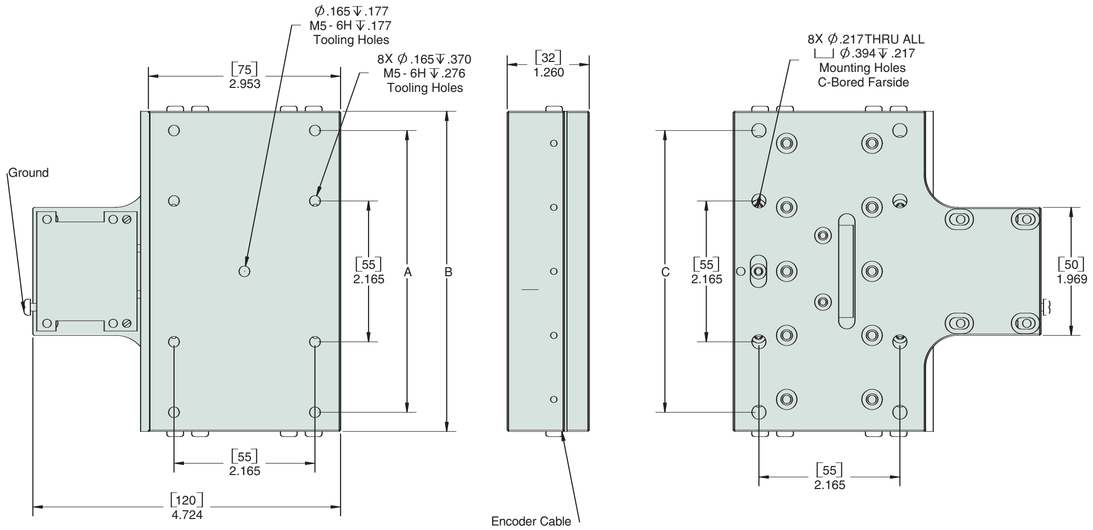


Motor Performance Specifications

	Travel (mm)	A (mm)	B (mm)	C (mm)	Dynamic Stall Force (N)	Stage Mass (g)	Moving Mass (g)
FB075-040-0.1M4	**40**	**n/a**	**75**	**n/a**	**16**	**650**	**302**
FB075-060-0.1M4	**60**	**n/a**	**100**	**n/a**	**16**	**920**	**405**
FB075-060-0.1M8	**60**	**n/a**	**100**	**n/a**	**32**	**1035**	**412**
FB075-100-0.1M4	**100**	**110**	**125**	**110**	**16**	**1125**	**505**
FB075-100-0.1M8	**100**	**110**	**125**	**110**	**32**	**1230**	**515**
FB075-150-0.1M4	**150**	**160**	**175**	**160**	**16**	**1515**	**710**
FB075-150-0.1M8	**150**	**160**	**175**	**160**	**32**	**1620**	**720**

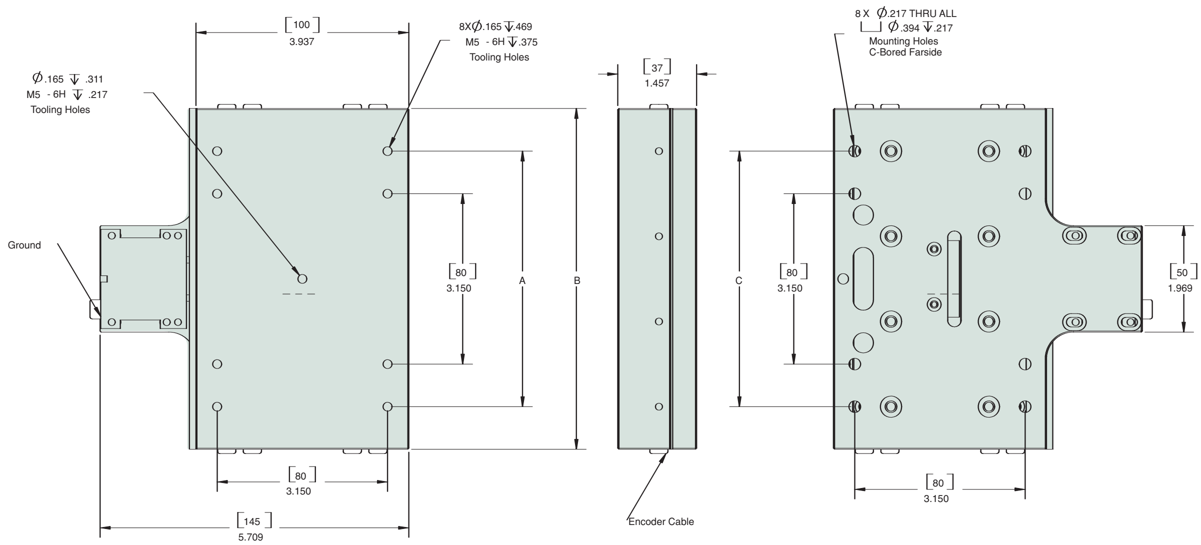
Note All standard FB stages are provided with .1µm resolution linear encoders.

Encoder Options

part suffix	**resolution**
-1.0M	.1µm Optional
-0.5M	.5µm Optional
-50N	50nm Optional
-10N	10nm Optional

Features

- Compact stage design with low profile
- Direct drive motor with simple, robust construction
- Linear encoder mounted in the center for optimum positioning
- Easily configurable in multi-axis
- Wide range of slide size, travels and motor size



Motor Performance Specifications

	Travel (mm)	A (mm)	B (mm)	C (mm)	Dynamic Stall Force (N)	Stage Mass (g)	Moving Mass (g)
FB100-060-0.1M4	60	n/a	120	n/a	16	1580	690
FB100-060-0.1M8	60	n/a	120	n/a	32	1690	700
FB100-100-0.1M4	100	120	160	120	16	2040	920
FB100-100-0.1M8	100	120	160	120	32	2145	930
FB100-150-0.1M8	150	160	200	160	32	2625	1160

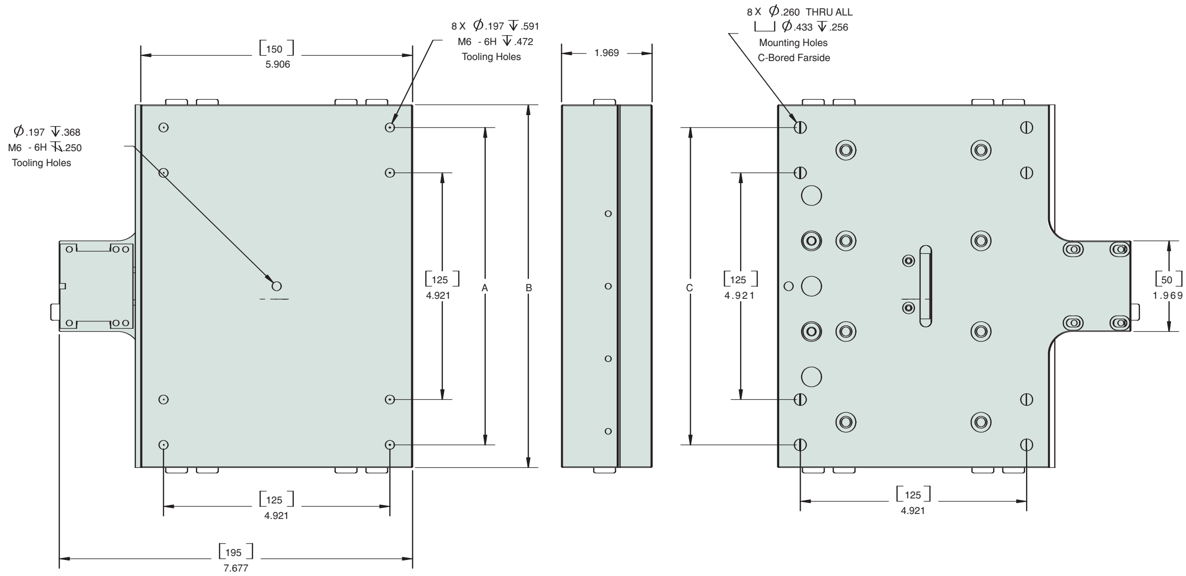
Note All standard FB stages are provided with .1µm resolution linear encoders.

Encoder Options

part suffix	resolution
-1.0M	.1µm Optional
-0.5M	.5µm Optional
-50N	50nm Optional
-10N	10nm Optional

Features

- Compact stage design with low profile
- Direct drive motor with simple, robust construction
- Linear encoder mounted in the center for optimum positioning
- Easily configurable in multi-axis
- Wide range of slide size, travels and motor size



Motor Performance Specifications

	Travel (mm)	A (mm)	B (mm)	C (mm)	Dynamic Stall Force (N)	Stage Mass (g)	Moving Mass (g)
FB0150-100-0.1M8	**100**	**n/a**	**150**	**n/a**	**32**	**3940**	**1600**
FB150-150-0.1M8	**150**	**175**	**200**	**175**	**32**	**5095**	**2125**
FB150-200-0.1M8	**200**	**225**	**250**	**225**	**32**	**6275**	**2660**

Note All standard FB stages are provided with .1μm resolution linear encoders.

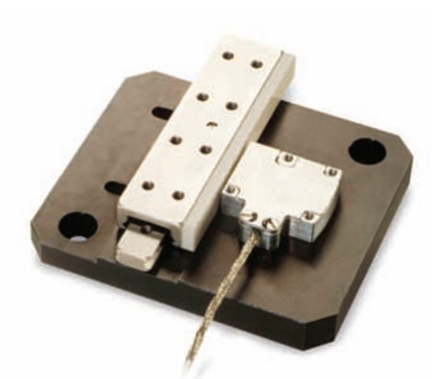
Encoder Options

part suffix	**resolution**
-1.0M	.1μm Optional
-0.5M	.5μm Optional
-50N	50nm Optional
-10N	10nm Optional

Unique Motion Solutions

Miniature stages are available in open loop (shown here) or closed loop configurations, utilizing Nanomotion's ST motor and a 15mm wide slide assembly.

The ST motor will drive this stage with up to 1.3N force with a maximum velocity of 250mm/sec and completely unlimited travel.



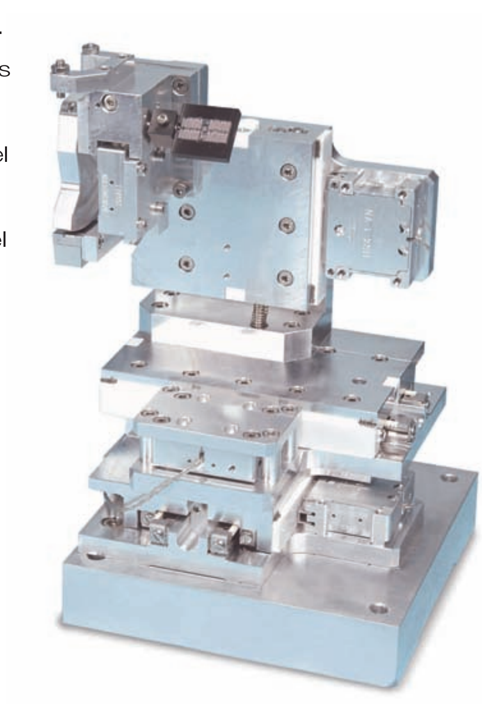
This long travel, closed loop actuator is easily configured for motion up to 4 meters in length.

The assembly consists of a profile linear rail with recirculating ball bearings mounted to an aluminum extrusion. A linear tape scale encoder is used for position feedback and the stage is driven with an HR8 motor providing 40N of force.

This assembly utilizes Nanomotion's new CCS, ceramic coated steel drive strip which is designed for long travel applications.

A four axis vacuum rated assembly, providing motion in X/Y/Z and Theta orientations, is used for laser etching.

The assembly is vacuum rated to 10^{-7} Torr and uses non-magnet motors. The Z axis uses a spring counter balance to offset the vertical load and all stainless steel crossed roller axes use an anti-migration device in the bearing structure. This assembly provides 40mm travel in X & Y axes, 25mm travel in Z and up to 90 degrees in Theta.



Nanomotion offers 5 types of amplifiers to facilitate best performance of the motors.

AB1A- is the standard, heavy duty amplifier, widely used.

AB1A-3U- a board level AB1A amplifier card, in 3U format for motherboard interface.

AB2- facilitates additional ultra high resolution capabilities (UHR), down to 1 nanometer, using the unique DC mode.

AB4- a compact amplifier, powered by 12V supply.

AB5- the innovative linearized amplifier, yields excellent motion performance with any standard controller firmware.

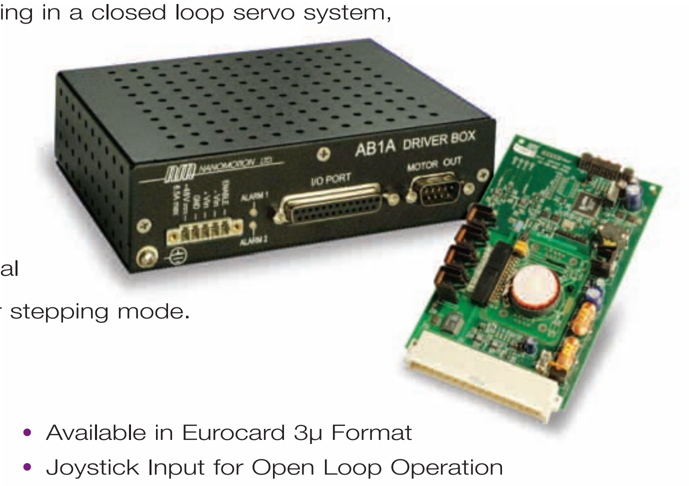
AB5-3U- a board level AB5 amplifier card, in 3U format for motherboard interface.

	AB1A	AB1A-3U	AB2	AB4	AB5	AB5-3U
unique functionality	nanomotion basic	board level 3U format	dc mode for ultra high resolution	compact amplifier package	linear response, operates with standard servo	linear response operates with standard servo
supply voltage (vdc)	48	48	24	12	24	24
packaging	Panel mount box	Board level 3U format	Panel mount box	Small panel mount box	Panel mount box	Board level 3U format
max # of HR elements (1)	32	32	16	4	32	32
max motor cable length (3)	15	15	20	20	20	20
input signals (2)	±10vdc	±10vdc	±10vdc	±10vdc SPI Digital	±10vdc	±10vdc
modes of operation	Velocity Step Gate	Velocity Step Gate	Velocity Step Gate UHR position	Velocity Step Gate	Velocity Step Gate	Velocity Step Gate

	AB1A, AB1A-3U		AB2, AB5, AB5-3U		AB4	
	regular cable	low capacitance cable	regular cable	low capacitance cable	regular cable	low capacitance cable
1HR element	0.5 to 5	0.5 to 8	0.5 to 10	0.5 to 20	0.5 to 10	0.5 to 20
2HR elements	0.5 to 5	0.5 to 8	0.5 to 10	0.5 to 20	0.5 to 10	0.5 to 20
4 HR elements	0.5 to 10	0.5 to 15	0.5 to 10	0.5 to 20	0.5 to 10	0.5 to 20
8 HR elements	0.5 to 10	0.5 to 15	0.5 to 10	0.5 to 20	NA	NA
16 HR elements	0.5 to 10	0.5 to 15	0.5 to 10	0.5 to 20	NA	NA
32 HR elements	0.5 to 10	0.5 to 15	0.5 to 10 (AB5)	0.5 to 20 (AB5)	NA	NA
1 ST element	3	3	NA	0.5 to 10	NA	0.5 to 10m
2 LS elements	0.5 to 5	NA	NA	NA	NA	NA
4 LS elements	0.5 to 5	NA	NA	NA	NA	NA
8 LS elements	0.5 to 5	NA	NA	NA	NA	NA

AB1A Amplifiers

The AB1A amplifier is a single axis digital driver that can run one or multiple Nanomotion motors in parallel. While operating in a closed loop servo system, the driver works as a velocity amplifier, receiving a +/- 10 volt analog command from the controller. The controller signal translates into AC voltage at 39.6 kHz to run the motor. In an open loop mode the amplifier can receive a signal from an external joystick, providing motion in a continuous or stepping mode.

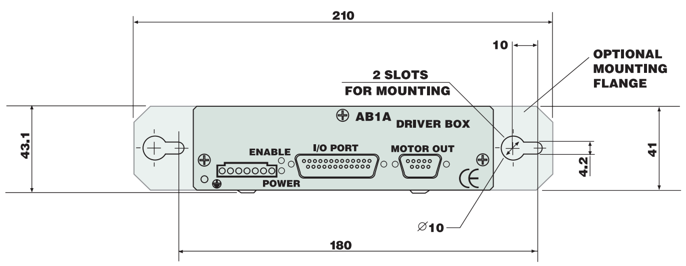


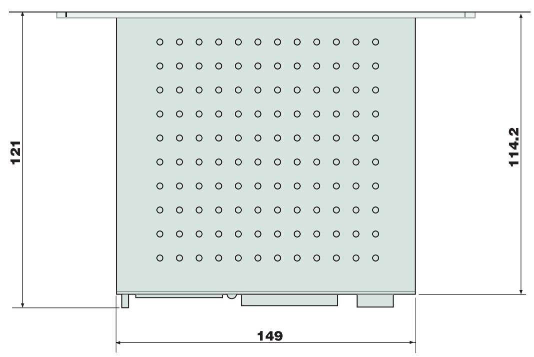
Features

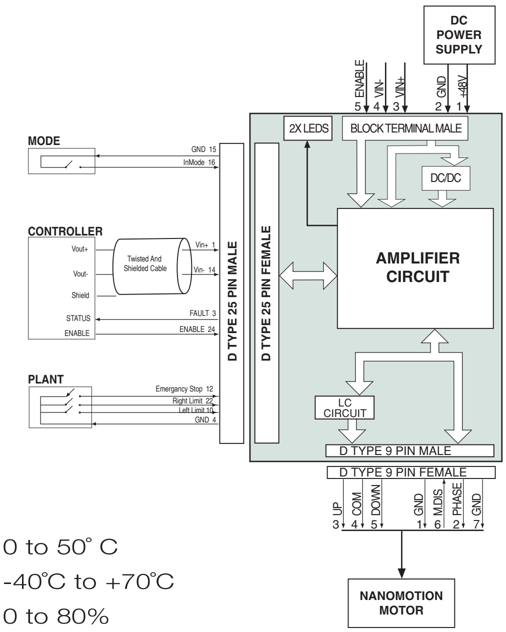
- Digital Drive Handles Up to 32 Elements
- +/- 10V Input from Servo Control
- 2 Optically Isolated Limits
- Available in Eurocard 3µ Format
- Joystick Input for Open Loop Operation
- Card Interface is 48 Pin 3 Row Connector

Amplifier Specifications

driving capability:	up to 32 elements (4 HR8 motors)
Analog Control Input	
input voltage range:	+/-10V
input impedance:	10 KΩ
input low pass filter:	2.7 KHz
input sampling resolution:	10 bits







Environmental

operating temperature:	0 to 50˚ C
storage temperature:	-40˚C to +70˚C
humidity:	0 to 80%

Electrical

power input:	+48Vdc±5%
max motor output:	270 to 280Vrms
power consumption w/o load:	+48Vdc/0.125A
power consumption with max load:	+48Vdc/6.5Amax

The AB2 amplifier combines the normal Velocity mode of the AB1A amplifier, for servo operation, with the DC mode, for Ultra-High resolution positioning. The DC mode treats the motor as a traditional piezo actuator, providing the ability to make discrete moves at the 1 nanometer level.

The DC mode uses the same ±10v analog signal from the controller output and translates it to a ±300 nanometer position move capability, with 1 nanometer resolution. This function can be operated in an open loop or closed loop manner. The switching between the Velocity mode and DC mode is done seamlessly through a discrete input signal.

Features

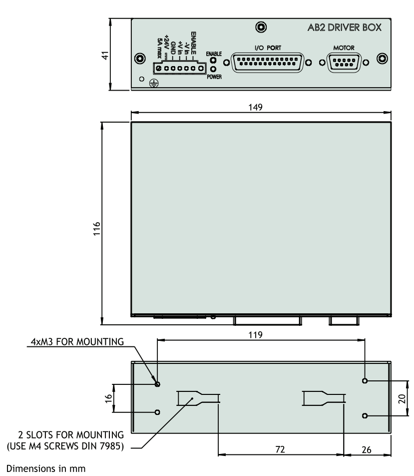
- Ultra High Resolution Capability using DC Mode
- Digital Drive Handles 16 HR Motor Elements
- Requires 24Vdc Supply Input
- Cable Length up to 20m
- Over Current and Over Voltage Protection

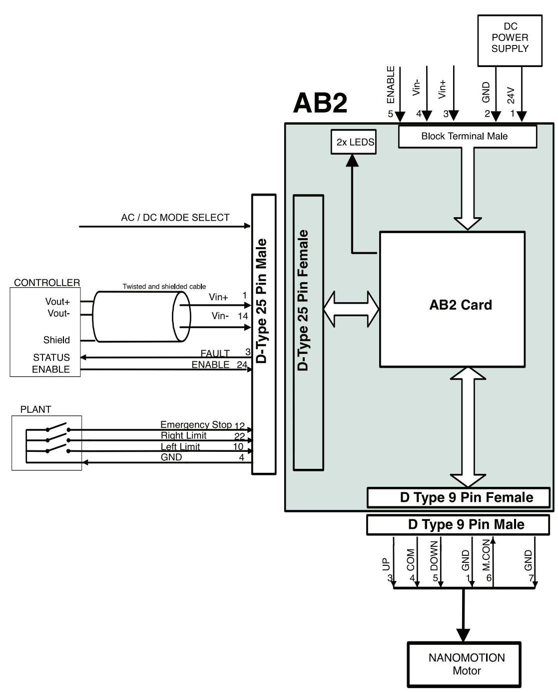
Environmental

operating temperature:	0 to 50° C
storage:	-40°C to +70°C
humidity:	up to to 80%, non condensing

Electrical

power supply input:	+24 Vdc ±5% (stabilized)
max motor output voltage:	280 Vrms
power consumption without load:	+24 Vdc/200 mA
power consumption with max load:	+24 Vdc/5A





The AB4 amplifier offers the same performance as the AB1A, in a reduced package. The AB4 operates off of 12vdc supply input and can drive up to 4 HR motor elements total, either (1) 4 element HR motor, or multiple HR motors totaling 4 elements.

The AB4 is the smallest standard motor amplifier and is provided with a 26-pin rear connector (26 pin, two row header). This connector provides access to all functionality (motor, power inputs, limits, and I/O functions), making it easy to integrate. Additional motor and power inputs are available with standard connections on the front.

Features

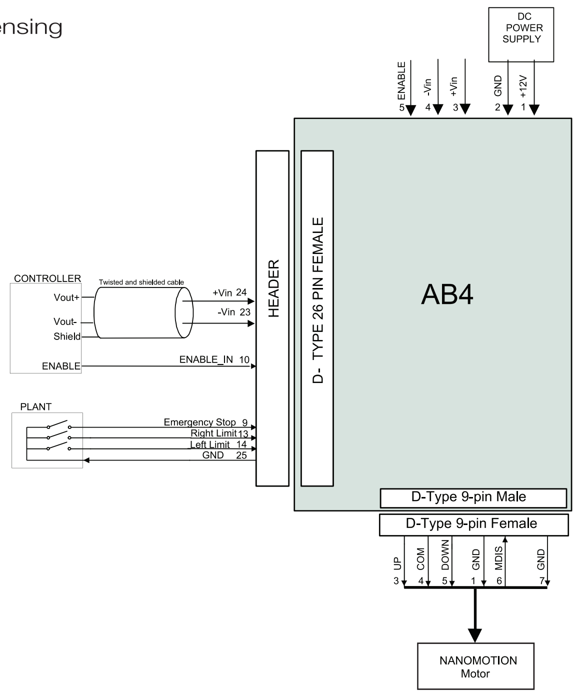
- Exceptionally compact mounting
- 12Vdc supply input
- Drives up to 4 HR motor elements
- Cable length up to 20m
- Over current and over voltage protection

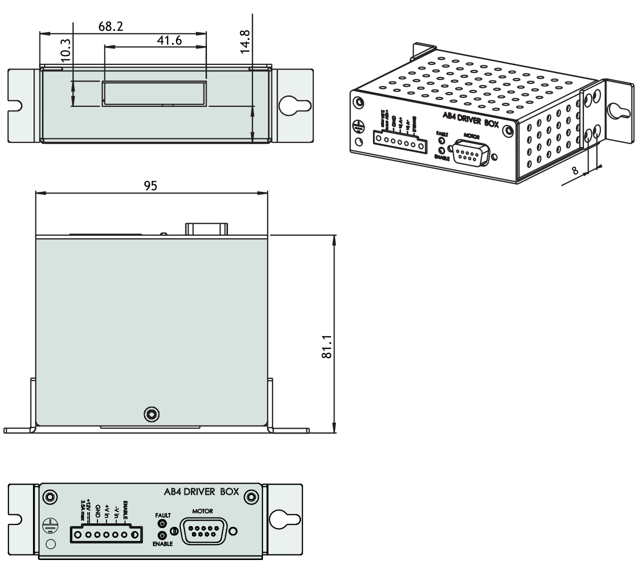
Environmental

operating temperature:	0 to 50° C
storage:	-40°C to +70°C
humidity:	up to to 80%, non condensing

Electrical

power supply input:	+12 Vdc ±5% (stabilized)
max motor output voltage:	280 Vrms
power consumption without load:	+12 Vdc/300 mA
power consumption with max load:	+12 Vdc/3.5A



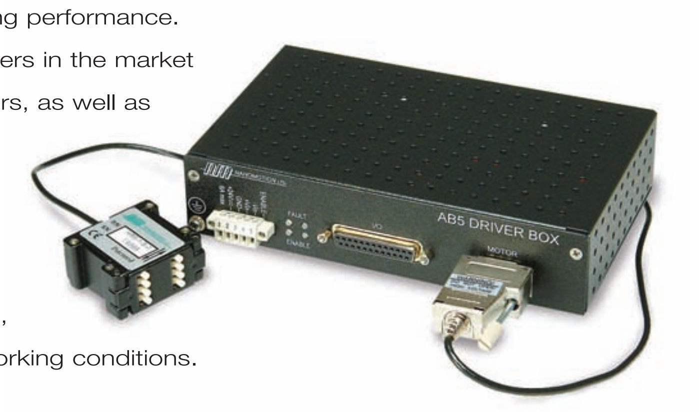


Dimensions in mm

The AB5 amplifier revolutionizes the driving concept for Nanomotion ceramic servo motors, enabling a frictionless and smooth motion throughout the entire velocity range. At stop the inherent brake is activated, maintaining the many advantages of brake at power off. Consequently the control scheme is simplified, facilitating the use of any low cost servo controller to achieve outstanding performance.

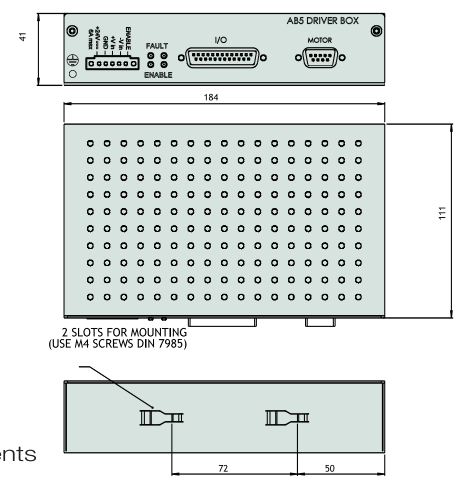
As a result the whole range of controllers in the market place can be used with Nanomotion motors, as well as generic control algorithms. No custom algorithm is needed to be used with Nanomotion motors.

In addition, exceptional control performance is achieved at servo systems, showing robust performance at various working conditions.



Features

- Compatible with any Servo Controller
- Linear Velocity Response at Full Command Range
- Brake On or Brake Off Upon Command
- Drives Up to 32 HR Motor Elements
- 24 Vdc Supply Input



Dimensions in mm

Motor Performance Specifications

driving capability:	up to 32 HR motor elements

Analog Control Input

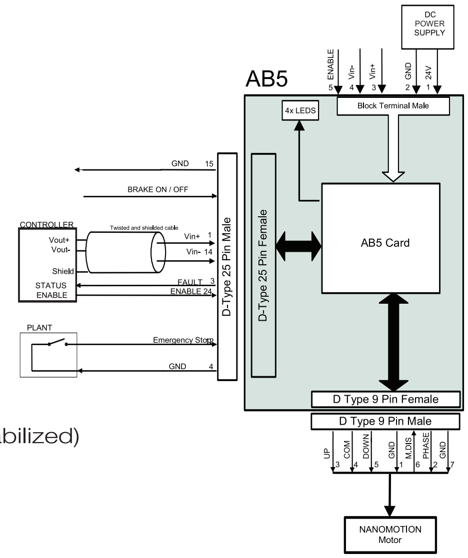
input voltage range:	±10V
input impedance:	10KΩ
input low pass filter:	2.7 Khz
input sampling resolution:	10 bits + direction

Environmental

operating temperature:	0 to 50° C
storage:	-40°C to +70°C
humidity:	up to to 80%, non condensing

Electrical

power input:	+24 Vdc ±5% (stabilized)
power consumption without load:	24 Vdc/200 mA
power consumption with max load:	24 Vdc/10A



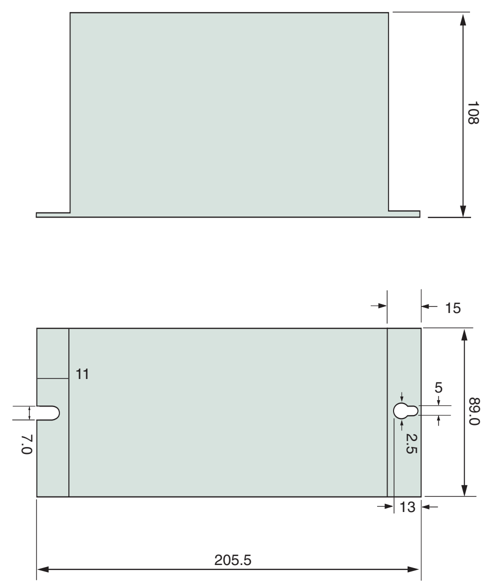
Single Axis Drive Control SB1291 NM

The SB1291 NM combines a single axis AB1A amplifier combined with a single axis, high performance, digital servo control card. This offers complete stand alone operation in a compact package with a high performance controller that is easy to use. The SB1291 NM comes complete with user interface software for the ease of application development and the ability to store preset programs.

Contact Nanomotion for Dual Axis Version

Features

- Digital control with velocity and position loop sampling at 20kHz sampling rate
- Programmable operation for motion in position, velocity, manual joystick, and Master-Slave modes
- RS232 communication interface
- Comprehensive C Libraries for DOS and most Windows configurations
- Drive control can be provided with AB2 for nanometer positioning



Dimensions & Specifications

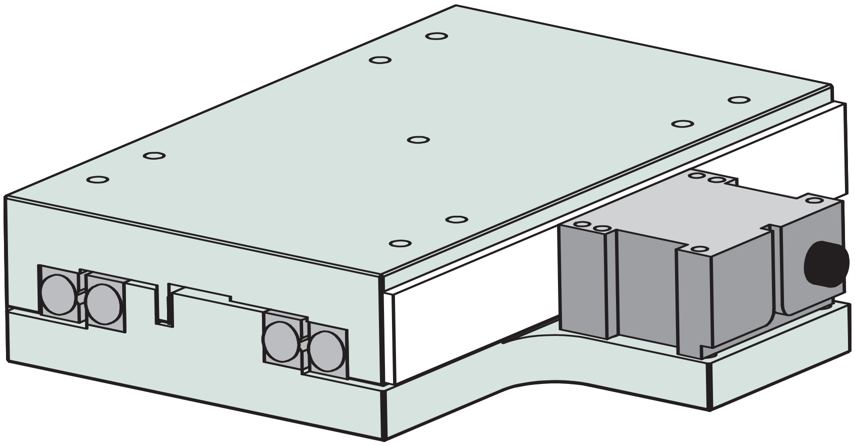
communication:	RS232. Baud Rate up to 57600
encoder:	Two channel, +5VDC TTL compatible, 4MHz max, optically isolated
analog input:	1 input ±10V, 12 bit resolution
safety input:	End of travel limits & E Stop, optically isolated
inputs/outputs:	(8) optically isolated inputs 5 or 24V
	(8) optically isolated outputs 5 or 24V 50mamp per output
electrical input:	48Vdc ±5%

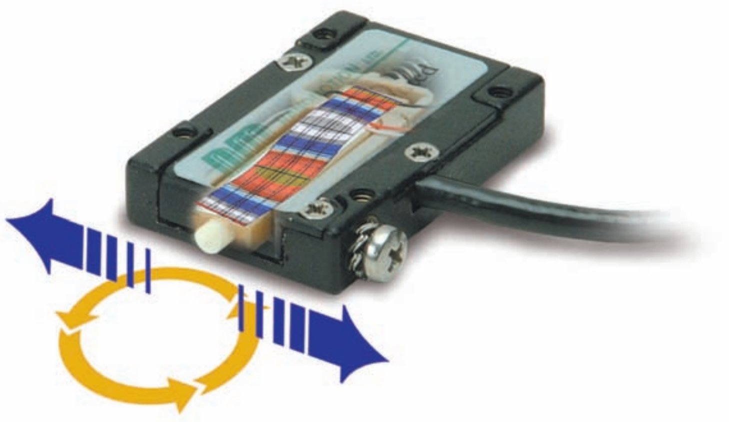
Technical Guidelines for Using Nanomotion Motors

Nanomotion motors provide direct drive performance for linear or rotary motion. Motion is transmitted through the contact of a finger pushing on a drive strip. The 'friction pair' is specifically selected to yield optimum performance with minimal wear, currently achieving 40,000 hours of operation and working in environments up to Class 10 clean rooms.

To yield the maximum performance benefits of Nanomotion's ceramic servo motors, it is important to understand the operating characteristics of the piezo ceramic elements and the impact that it has on the mechanical structure.

As a direct drive, the Nanomotion motor is sized by the basic principles of F=MA (plus the resistance of the bearing structure & the force of gravity if on an incline or vertical). While this is a basic sizing method, one must calculate the maximum speed and force necessary to meet the application performance requirements and size the motor properly, operating within the defined EOP (Envelop of Performance).





Managing Normal Force and Stage Stiffness

In addition to the motor sizing, Nanomotion's motor exerts a normal force into the bearing structure in the direction that the motor is mounted and preloaded. This normal force is 5 times the driving force of the motor. Because of this force, it is optimum if the motor can be mounted on the centerline of the bearing structure. Nanomotion motors are in successful operation with:

- Crossed roller linear and rotary bearings
- Recirculating linear guides & shaft bearings.
- Linear and rotary air bearings.
- Angular contact & radial rotary bearings

A key design criteria is the bearing stiffness and preload, to assure successful operation of the motor. A good target value is 40N/micron of bearing stiffness. For less precise applications that do not require 20,000 hours of life, a lower stiffness number is acceptable. For more precise applications, operating in production environments, a minimum stiffness of 50N/micron should be targeted. These stiffness values are easily achieved with conventional bearings on the market today.

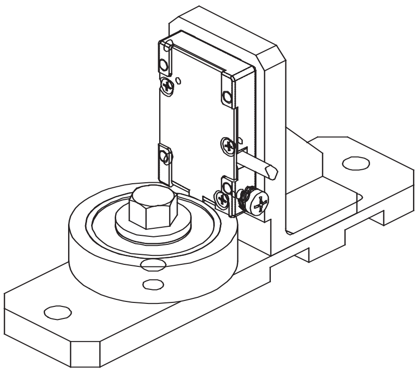
For example, an HR1 motor provides 1 lb (4.4N) of thrust, and will create 5 lbs (22N) force into the bearing structure, perpendicular to motion. In addition to the normal force, there is the potential for higher acceleration forces that are placed in the same direction, impacting the bearing. Acceleration forces can be 2 to 3 times greater than the normal force.

The most common linear bearings used in precision motion are crossed rollers and linear recirculating guides. While ball bushings and air bearings are acceptable technologies, they are in the minority.

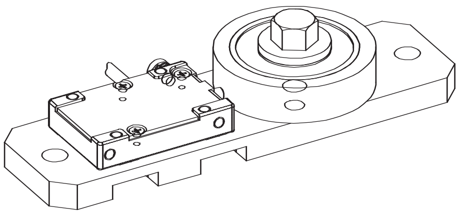
Rotary applications with Nanomotion motors are quite common as the direct drive motor can eliminate worm gears, belts and other rotary transmissions. In rotary applications there is design flexibility to apply the motor axially, driving on the flat surface of a disk, or radially, driving on the circumference of a ring.

Rotary Bearings

Typical Axial Mounting



Typical Radial Mounting



As with linear bearings, the bearing stiffness is critical to the performance of the Nanomotion motor. Moreover, a single motor applied axially will induce a moment load on the bearing whereas a single motor applied radially will induce a side load on the bearing structure. In many rotary applications it is appropriate to consider the use of two smaller motors, mounted 180º apart to maintain a balanced load on the bearing. Mounting two motors that are not 180º apart, with a slightly different angle, can also help to maintain a preload on the bearing and have a positive impact.

In evaluating rotary bearings, there are 3 common types that are utilized in rotary stages:

- Rotary crossed roller
- Angular contact
- Deep groove radial

While the same stiffness criteria apply to rotary applications, 50N/μm, each bearing offers different operating characteristics. The selected bearing should be fully evaluated for its specific load rating and stiffness in the appropriate directions.

Mechanical Mounting Tolerance

The Nanomotion motor is constructed with a spring behind each motor element. This spring is designed to provide a preload (normal force) as well as allow for mounting inaccuracies. The spring can compensate for 'out of parallel' conditions up to 50µm (.002").

All of the bearing types discussed provide linear accuracies well within these tolerances, but the machined mounting surfaces will contribute to linear accuracy. It should, however, be achievable to control linear straightness to 50µm in a precision motion system.

For systems that require ultrahigh resolution (below 100nm) and smooth constant velocity, it is important to maintain tighter tolerances on the straightness of motion, to optimize the servo performance.

Mechanical Assembly Procedures and Safeguards

WARNING: NEVER OPERATE THE MOTOR UN-LOADED,
WITHOUT PRELOAD AGAINST A NANOMOTION DRIVE STRIP.

Proper mounting procedures are described in each motor manual, with preload being set by a shim (provided with ST, HR1 & HR2 motors), or a cam (internal to the HR4 & HR8 motors). The motor should be mounted perpendicular to travel, with the arrows on the motor label indicating the direction of travel.

In applications utilizing the HR4 & HR8 motors, it is important to avoid compressing the motor against the ceramic strip, prior to engaging the cams. This additional force will result in a higher that expected preload. If there is a concern about controlling the force during mounting it is acceptable to use a shim, when the fingertips are in a retracted position, up to 15µm thickness. This will assure that the motor elements are not 'over compressed' against the drive strip.

Always make sure the mechanical travel does not permit the motor fingers to become disengaged from the ceramic drive strip. The fingertips should remain in a compressed state at all times.

Most Nanomotion provided drive strips have a 3M acrylic tape bonded to them. Nanomotion can provide the specification on the tape for those customers who require it. When applying the ceramic with the tape, make sure there are no air bubbles and the ceramic strip is applied to a clean surface. After adhering the drive strip, secure it with two drops of epoxy, per the instructions in the manual, to prevent any motion in sheer.

Sizing Example:

Requirements:

Total moving mass (moving part of stage plus payload), M = 1Kg

Travel, X = 0.01 m (horizontal orientation)

Total move time, T = 0.1 sec (not including settling time)

Motion profile: trapezoidal, accelerate for 1/3 of the total time, move a constant velocity for 1/3 of the total time, decelerate for 1/3 of the total time

Calculate:

Acceleration / deceleration, A = 4.5 * X / T^2 = 1 * 0.01 / 0.1^2 = 4.5 m/sec^2

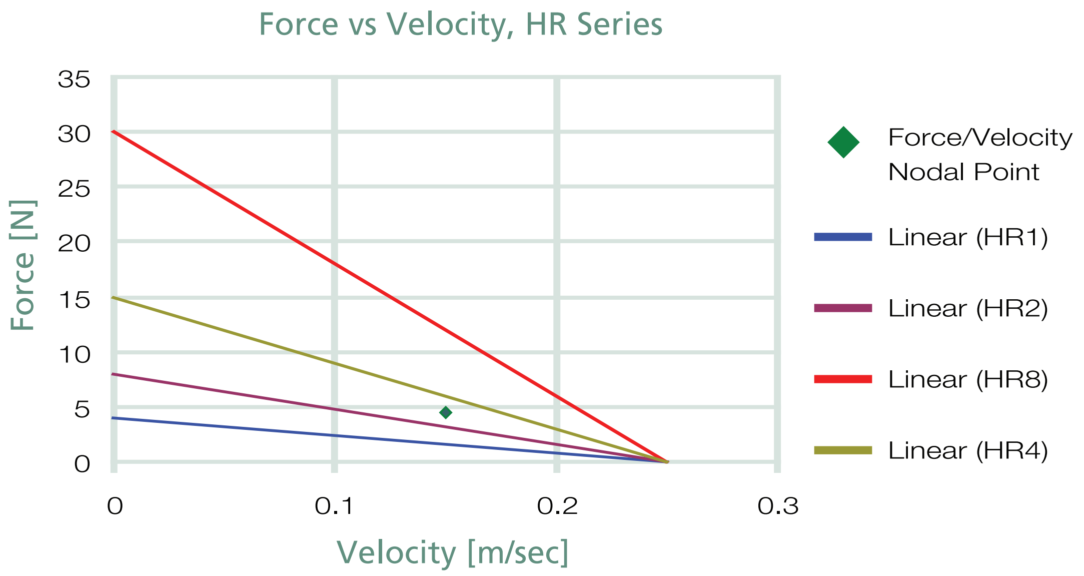
Maximum velocity, V = 1.5 * X / T = 1.5 * 0.01 / 0.1 = 0.15 m/sec

Acceleration force, Fa = M * A = 1 * 4.5 = 4.5 N

Add additional forces (bearing friction, load force, gravity/inclination, etc.) to obtain total force Ft. Let's neglect in this example.

Plot the point {Ft,V} on the Force/Velocity curves. See figure below.

Select the motor whose curve is above the {Ft,V} point. In this case it would be an HR4.



Settling Time

The achievable settling time is mainly dictated by the damping of the motor and the natural frequency of the system. A typical number of three cycles is required for the motor damping to damp the system vibration along the motion axis, so the settling time will be roughly according to the following formula:

Ts = 3/Fr

Where Fr is the natural frequency of the system, and is calculated according to the following formula:

$$Fr = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$$

Where:

K - stiffness of the motor in Newton/meter

m - mass of the moving part in Kg

If the desired natural frequency is higher than the one calculated for a given configuration, adding another motor in parallel or in tandem will increase the system's natural frequency due to the increased stiffness. The combined stiffness of several motors is the algebraic sum of the stiffness of the individual motors. One should recalculate the natural frequency using the combined stiffness of the motors. It is worthwhile to note that the effective motor stiffness increases under close loop operation.

Driving vertically with a motor that actuates based on friction requires specific consideration to the static load, separate from the dynamic force. As a rule of thumb, each 4.4N element can drive 120 grams vertically. Beyond this a counter balance should be considered. This can be in the form of a spring, a continuous force gas spring, or opposing weight.

Electrical Interface

Nanomotion's motors run at resonant frequency and are sensitive to the capacitance of the electrical circuit. Changing cable lengths will affect the total capacitance. There are guidelines provided in Nanomotion's catalog and manuals as to the acceptable cable lengths.

In addition to the cable length from the motor to the amplifier, caution should be used if third party cable is used. Nanomotion provides motors with specific low capacitance cable at:

Standard motors: 64pF/foot

Vacuum motors: 13pF/foot

If the capacitance of the electrical circuit is too high, the full performance of the motor will not be realized. Nanomotion can provide guidelines for testing capacitance.

Quick Reference– Getting Started

Verify proper stage mechanics with preloaded bearings and appropriate stiffness.

Follow Nanomotion's motor mounting guidelines for preloading and motor orientation with respect to travel & verify that ceramic strip has two drops of epoxy.

Connect the ground wire from the motor to the amplifier.

Verify the connection (jumper) between power supply return and the controller's analog ground.

Condition the motor before tuning, per Motor Installation Manual (Always recondition the motor each time it is disengaged from the ceramic strip).

After conditioning, wipe the ceramic with a clean cloth and IP alcohol without disengaging the motor.

Use "Abort on Position Error" (or other safety mechanism) and appropriate torque limit during initial integration and conditioning. Do not exceed 5v and 50% duty cycle.

Avoid prolonged operation in an unstable condition (excessive vibration) during tuning process.

Consult with Nanomotion with any questions during the set up process.

- Do not operate the motor in an un-loaded (un-mounted) condition
- Do not exceed the duty cycle limits when operating the motor (see Motor Installation Manual)
- Do not allow the motor tips to leave contact with the ceramic strip during operation (Use mechanical hard stops)
- Do not remove the cover of the motor (High Voltage Inside)
- Do not immerse the motor in any liquids

Ordering Guide

Motors

HR 1- 1- S- 3

motor type	# of elements	configuration	operating environment	cable length
HR DM (DuraMotor) LS ST MM	1 2 4 8	1	S = Standard V = Vacuum (10^{-7}) N = Non-Magnetic VN = Vac & Non Mag U = Ultrahigh Vacuum (10^{-10})	-0 for U (500mm flying leads) 3= 3 meters 10= 10 meters (custom cable lengths are available, contact factory)

Amplifiers

AB5- HR- E4-

amplifier type	motor type	# of elements
AB1A-2a ABIA-3U AB2 AB4 AB5 AB5-3U	HR (HR or DM) LS ST MM	E1 E2 E4 E8 E16 E32

Ceramics

CS 20- 3- 200

drive surface type	strip width	strip thickness	strip length
CS (ceramic strips) DS (DuraStrip) CCS (ceramic coated steel)	10 (10mm wide) 15 (15mm wide) 20 (20mm wide) 25 (25mm wide)	1.5 (1.5mm thick) 3 (2.7mm thick) 5 (5.2mm thick) -for CCS only	050 (50mm) 100 (100mm) 150 (150mm) 200 (200mm) 250 (250mm) 300 (300mm) 350 (350mm) 400 (400mm) 500 (500mm) 600 (600mm)

ring type	ring outside diameter - inside diameter - ring height	
CR (ceramic rings)	12-9-5	(12mm outside diameter)
	40-32-10	(40mm outside diameter)
	60-40-10	(60mm outside diameter)
	80-60-10	(80mm outside diameter)
	100-80-10	(100mm outside diameter)

disk type	disk outside diameter - inside diameter - disk thickness	
CD (ceramic disks)	146-114-1.5	(146mm outside diameter)
	192-60-5	(192mm outside diameter)
	192-150-5	(192mm outside diameter)

for non-standard strip/ring/disk sizes, please contact the factory.

NM CERAMIC SERVO MOTORS
by Nanomotion

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