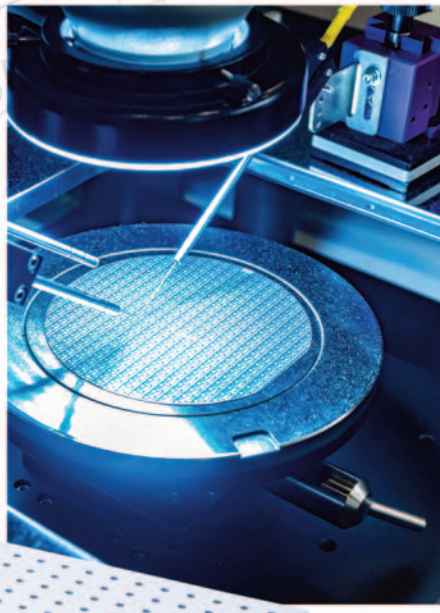
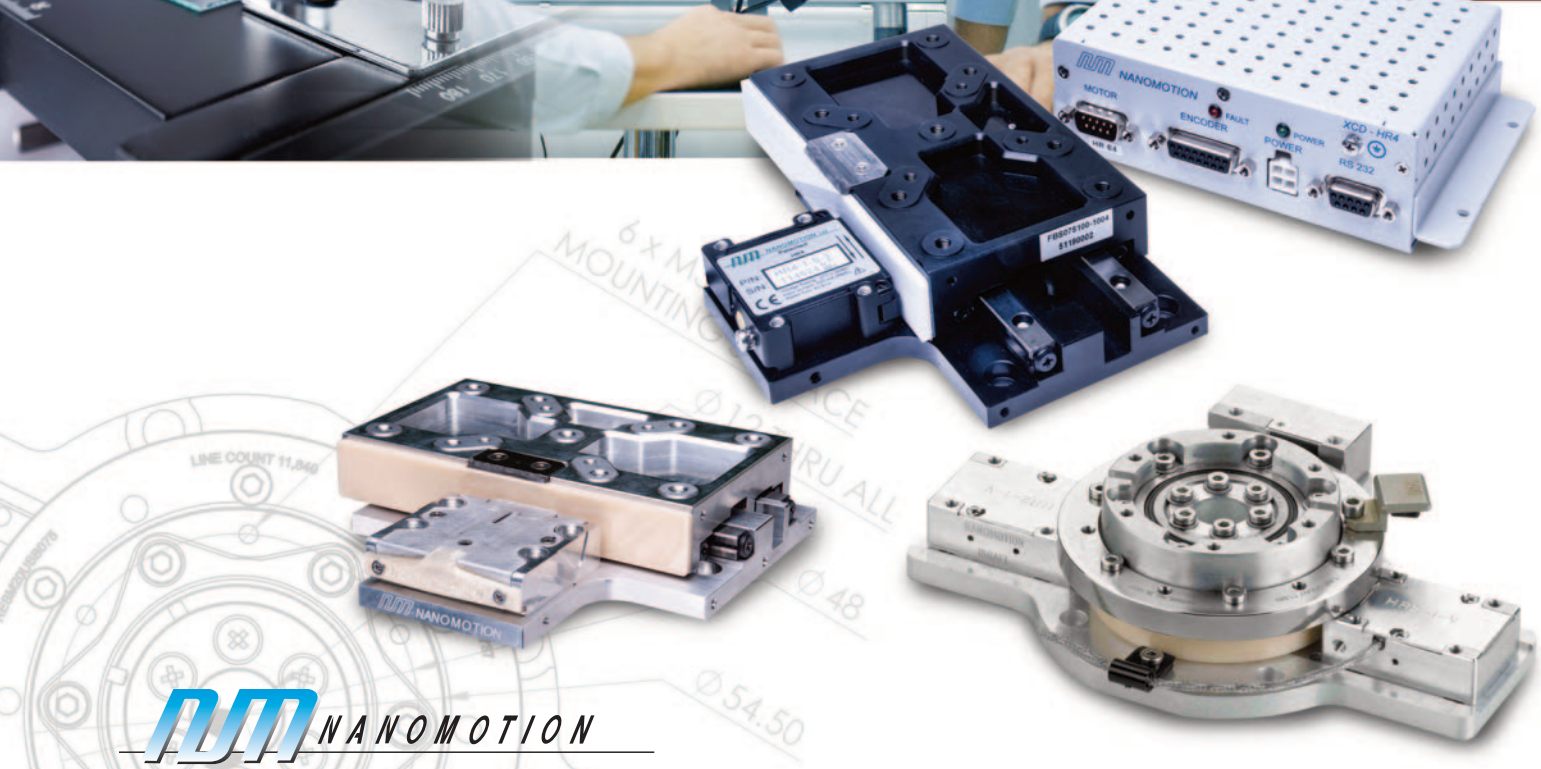
Standard Stages for Motion Control Applications

FB Stage Catalog

www.**nanomotion**.com





NANOMOTION

A Johnson Electric Company

Nanomotion designs and manufactures advanced motion systems, sub-systems modules and piezo motor/drive components.

The FB Series of standard stages are driven by Nanomotion's ultrasonic standing wave piezo motors, providing closed loop, servo motion with an optical encoder. The standard stages provide single and multi-axis motion performance for a wide range of applications in Semiconductor, Biomedical, and Instrumentation markets.

These compact stage configurations are provided in both standard atmospheric configurations as well as vacuum versions that can support clean operation to ISO Class 3 cleanliness. The modular design allows for easy mounting of axes, to each other, along with the use of standard angle brackets for Z mounting. All axes utilize precision crossed roller bearings with anti-migration and optical encoders for precision positioning requirements.

For applications not suitable to standard stage configurations, please feel free to contact Nanomotion's team of application engineers to learn about our custom stage capabilities.

PRODUCT FEATURES

- Precision standard stages for atmosphere and vacuum
- Linear stages for with travel up to 200mm travel
- Rotary stages for continuous motion
- Z-Wedge stage for pure vertical motion
- Goniometric stages for tip/tilt about a common pivot

Customized Solutions Give OEMs Unlimited Possibilities.

FBS050/020/050 Linear Stage

Mechanical Design Characteristics

MODEL	FBS050020	FBS050050
Stage Plate Material	Aluminum — Black Anodized	
Motor	HR4 Piezo, ultrasonic standing wave	
Bearing Type	Precision crossed rollers with anti-migration device	
Encoder	Linear optical encoder with gold tape scale	
Cable Lengths (m)	3m	
MTBF (hours)	30,000	
Stage Mass (g)	405g	550g
Carriage Moving Mass (g)	158g	230g
RoSH	Compliant	
Vacuum Compatible Options	High Vacuum (to 10^{-7} Torr) / UHV (to 10^{-10} Torr) available	

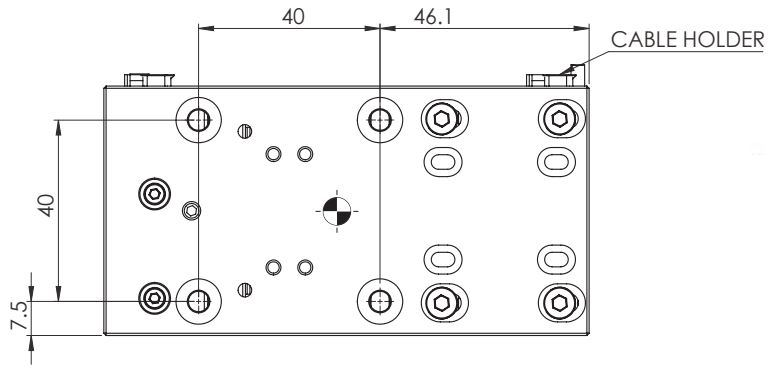
Performance Specifications

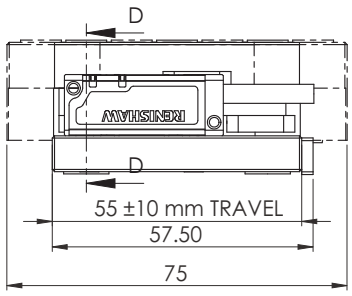
MODEL		FBS050020		FBS050050
Travel Range (mm)		20mm		50mm
Encoder Resolution	Standard	100nm		
	Optional	10nm		
Bi-directional Repeatability	Standard	1µm		
	Optional	100nm		
Absolute Accuracy	Standard	5µm		10µm
(Error mapping available)	Optional	2.5µm		7µm
Minimum Incremental	AC Mode	100nm		
Move Convergence	UHR Mode	5nm		
	DC Mode	<1nm		
Maximum Velocity		200mm/sec		200mm/sec
Straightness & Flatness		±4µm		±4µm
Pitch & Yaw		±40µrad		±40µrad
Load Capacity - Horizontal		1.8kg		1.8kg
Load Capacity - Vertical		0.4kg		0.3kg
Dynamic Stall Force		16N		16N
Motor Stiffness		1.7N/µ		1.7N/µ
Holding Force without Power		14N		

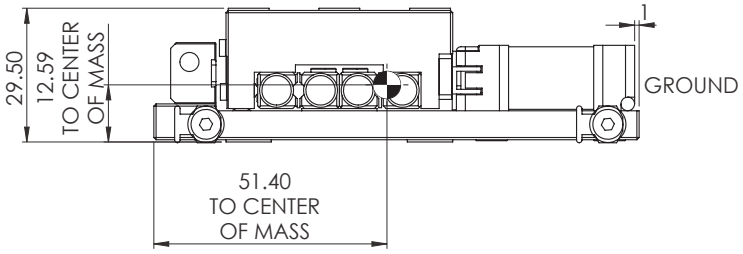
MECHANICAL DRAWINGS

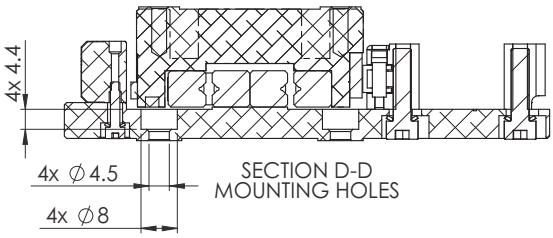
FBS0500020

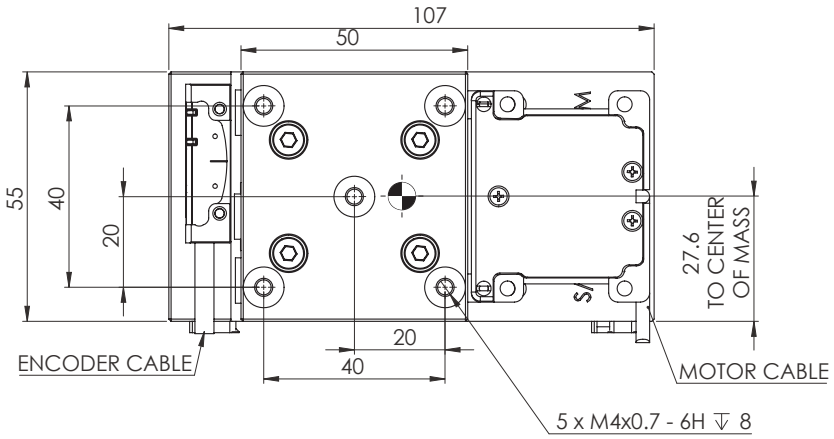
European View **Dimensions are Metric**











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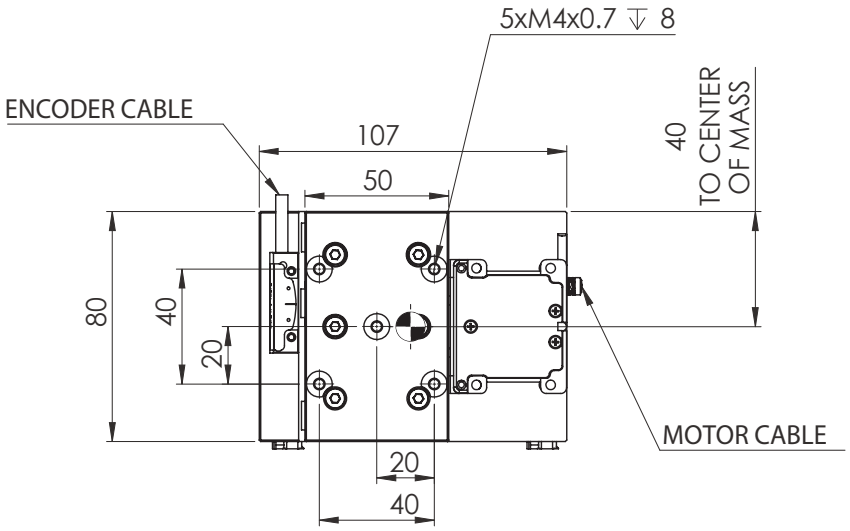
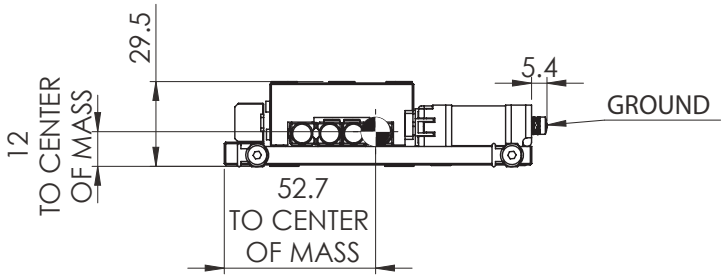
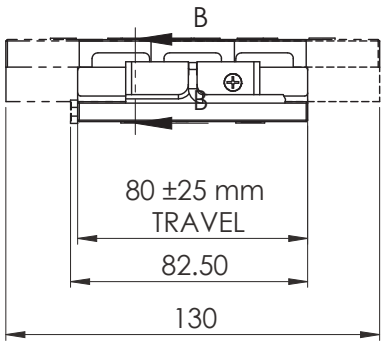
MECHANICAL DRAWINGS

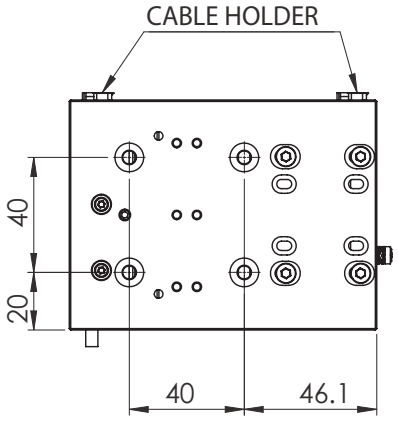
FBS0500050

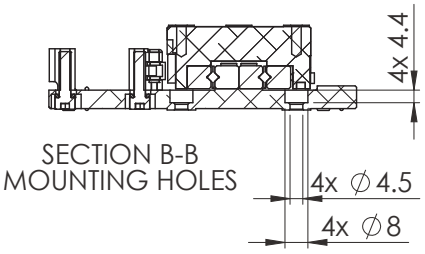
European View **Dimensions are Metric**











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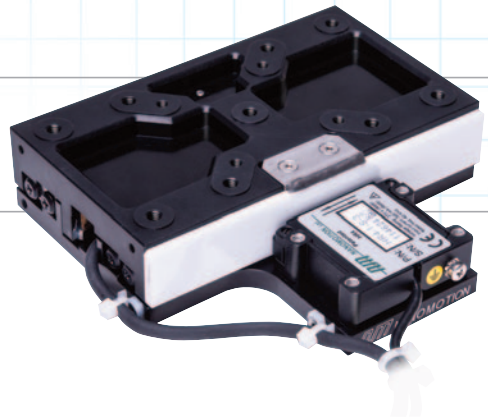
FBS075/040/060/100 Linear Stage



MECHANICAL DESIGN CHARACTERISTICS

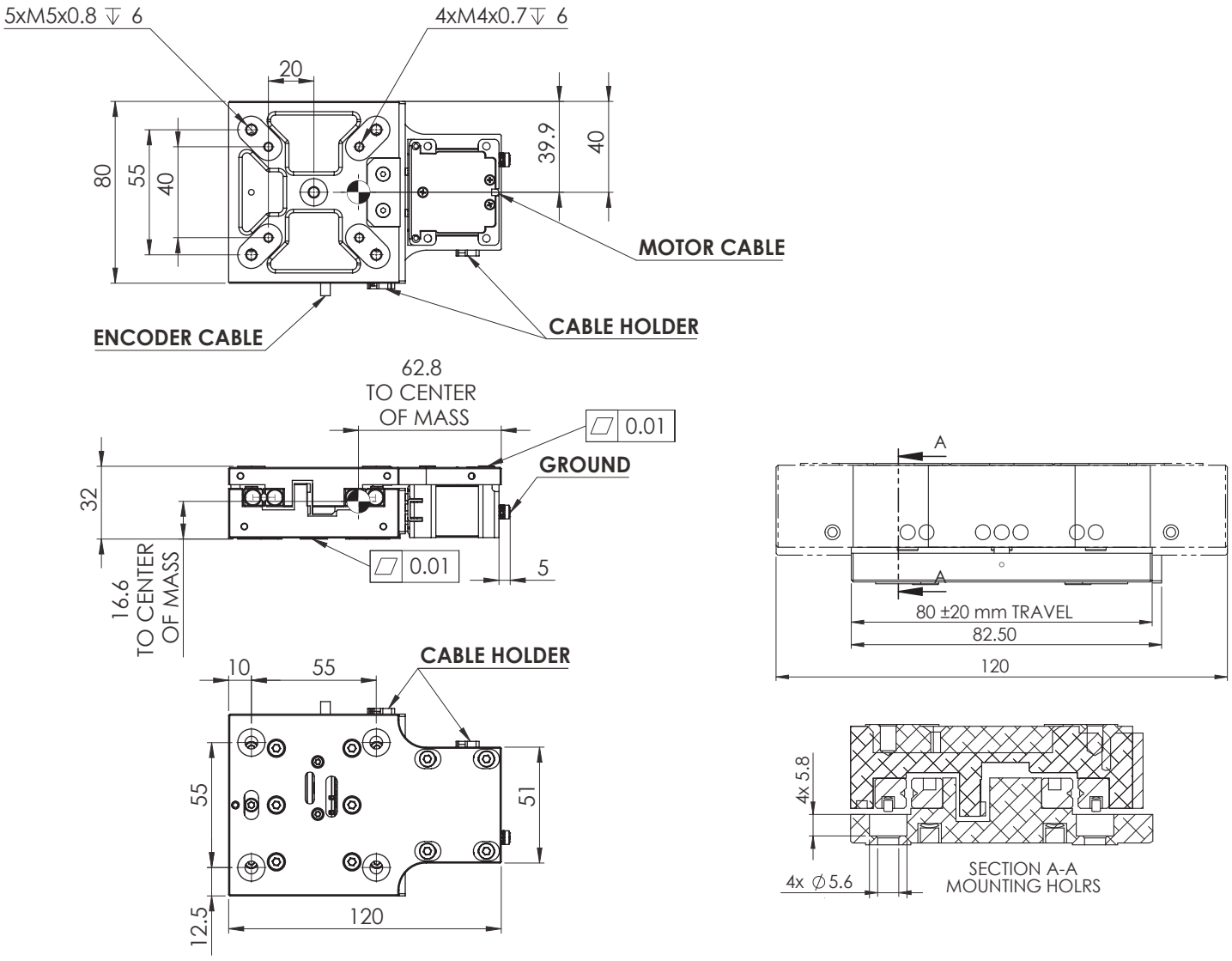
MODEL	FBS075040	FBS075060	FBS075100
Stage Plate Material	Aluminum — Black Anodized		
Motor	HR8 Piezo, ultrasonic standing wave		
Bearing Type	Precision crossed rollers with anti-migration device		
Encoder	Linear optical encoder with gold tape scale		
Cable Lengths (m)	3m		
MTBF (hours)	30,000		
Stage Mass (g)	727g	918g	1062g
Carriage Moving Mass (g)	284g	447g	445g
RoSH	Compliant		
Vacuum Compatible Options	High Vacuum (to 10^{-7} Torr) / UHV (to 10^{-10} Torr) available		

PERFORMANCE SPECIFICATIONS

MODEL		FBS075040	FBS075060	FBS075100
Travel Range (mm)		40mm	60mm	100mm
Encoder Resolution	Standard		100nm	
	Optional		10nm	
Bi-directional Repeatability	Standard		1µm	
	Optional		100nm	
Absolute Accuracy	Standard	6µm	8µm	10µm
(Error mapping available)	Optional	3µm	4µm	5µm
Minimum Incremental	AC Mode		100nm	
Move Convergence	UHR Mode		5nm	
	DC Mode		<1nm	
Maximum Velocity		200mm/sec	250mm/sec	250mm/sec
Straightness & Flatness		±4µm	±5µm	±5µm
Pitch & Yaw		±40µrad	±60µrad	±60µrad
Load Capacity - Horizontal		3.0kg	3.0kg	3.0kg
Load Capacity - Vertical		0.8kg	0.65kg	0.65kg
Dynamic Stall Force			32N	
Motor Stiffness			3N/µm	
Holding Force without Power			28N	

MECHANICAL DRAWINGS | FBS075040

European View **Dimensions are Metric**



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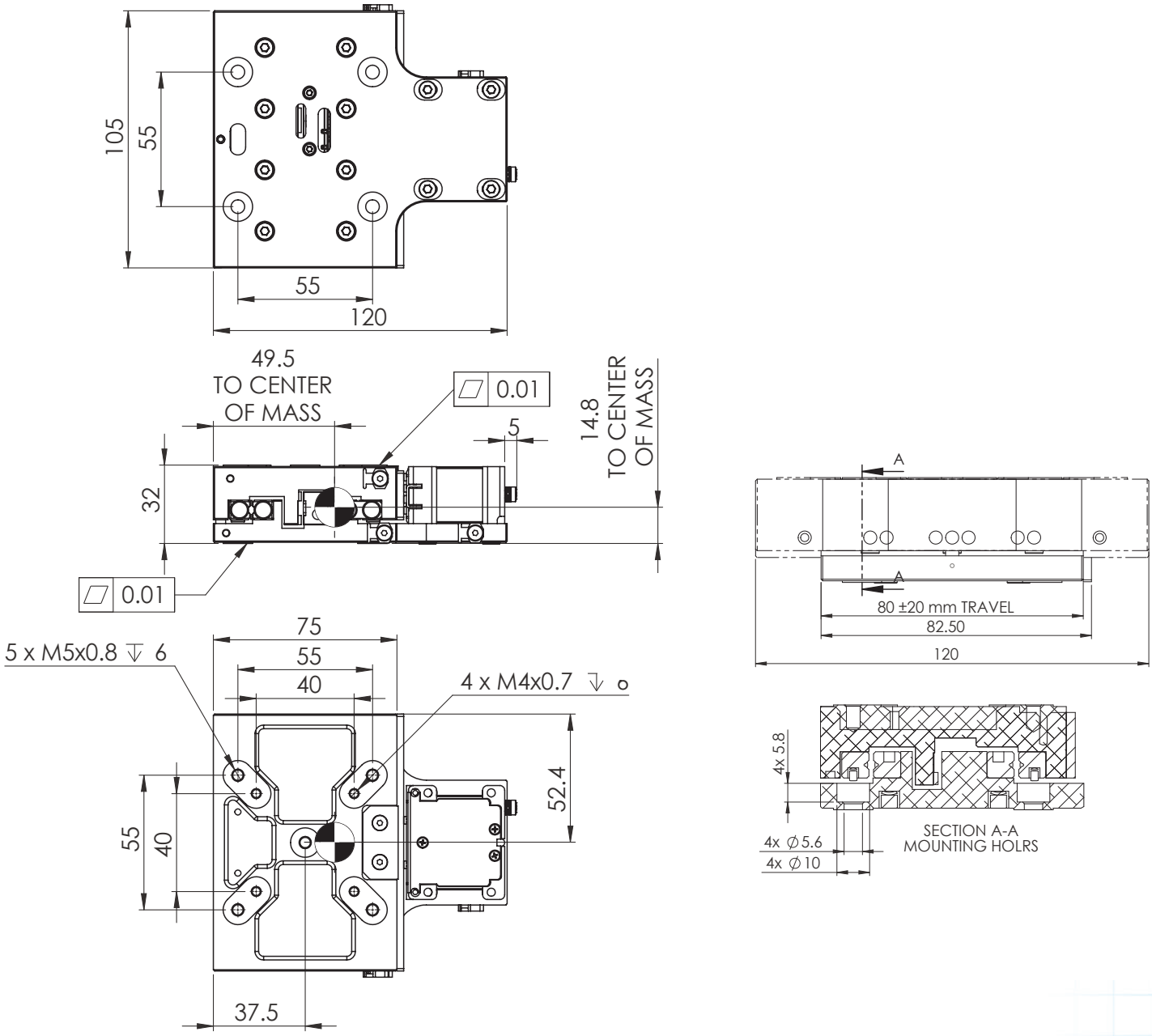
MECHANICAL DRAWINGS | FBS075060

European View **Dimensions are Metric**



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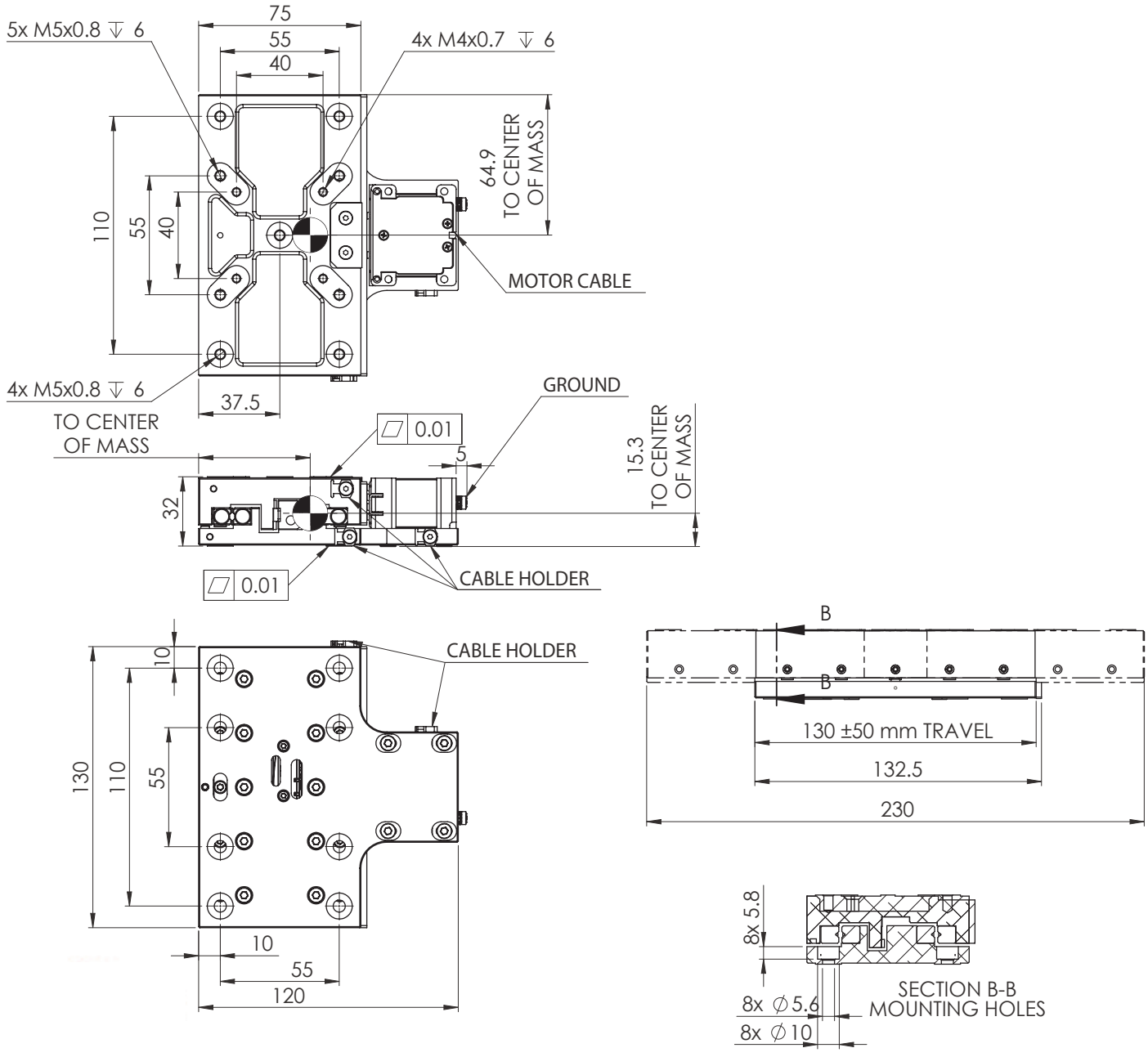
MECHANICAL DRAWINGS | FBS075100

European View **Dimensions are Metric**



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FBS100100

Linear Stage

Mechanical Design Characteristics

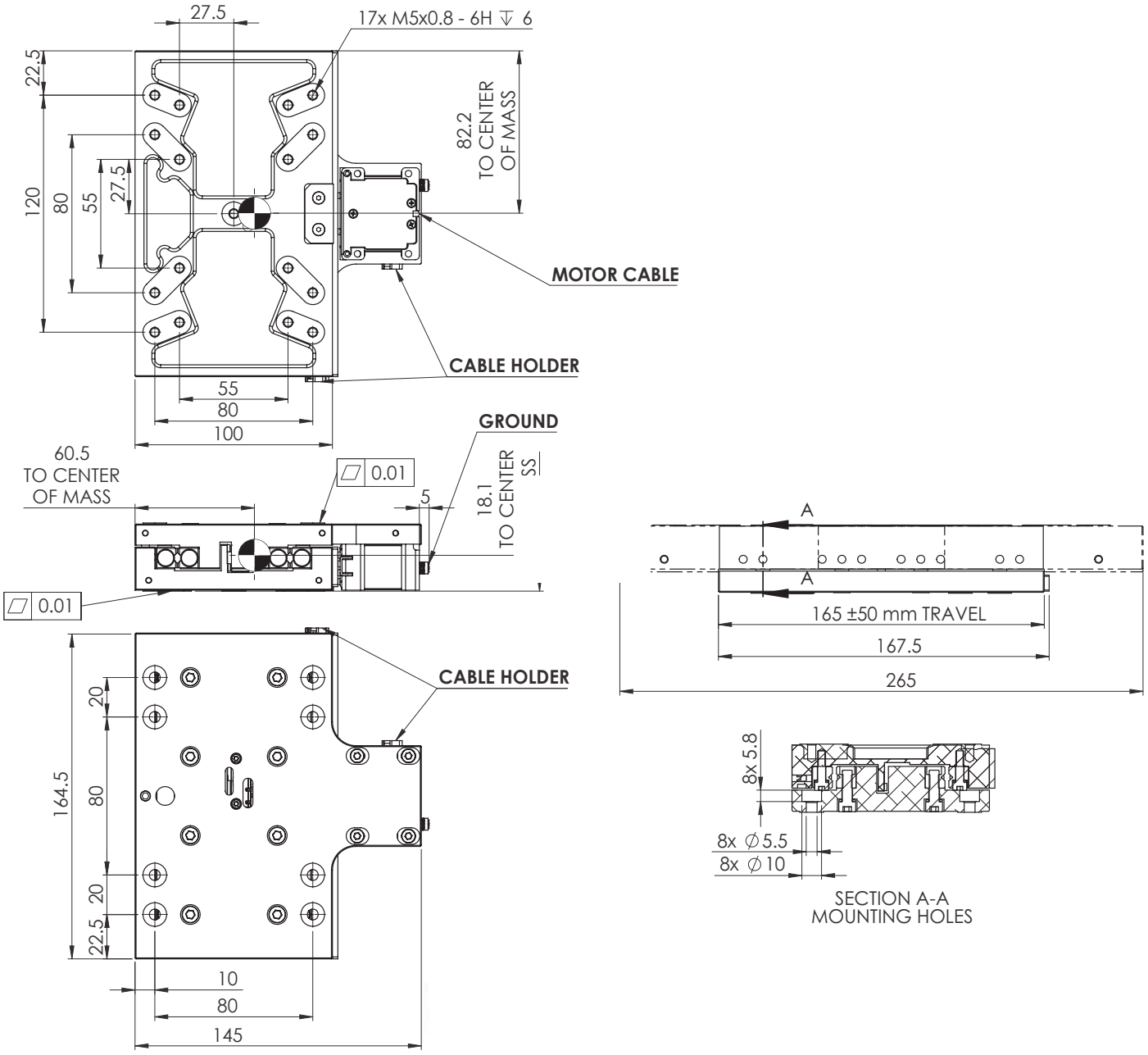
MODEL	FBS100100
Stage Plate Material	Aluminum — Black Anodized
Motor	HR8 Piezo, ultrasonic standing wave
Bearing Type	Precision crossed rollers with anti-migration device
Encoder	Linear optical encoder with gold tape scale
Cable Lengths (m)	3m
MTBF (hours)	30,000
Stage Mass (g)	1811g
Carriage Moving Mass (g)	710g
RoSH	Compliant
Vacuum Compatible Options	High Vacuum (to 10^{-7} Torr) / UHV (to 10^{-10} Torr) available

Performance Specifications

MODEL		FBS100100
Travel Range (mm)		100mm
Encoder Resolution	Standard	100nm
	Optional	10nm
Bi-directional Repeatability	Standard	1µm
	Optional	100nm
Absolute Accuracy	Standard	10µm
(Error mapping available)	Optional	7µm
Minimum Incremental	AC Mode	100nm
Move Convergence	UHR Mode	5nm
	DC Mode	<1nm
Maximum Velocity		250mm/sec
Straightness & Flatness		±4µmm
Pitch & Yaw		±50µrad
Load Capacity - Horizontal		2.7kg
Load Capacity - Vertical		0.4kg
Dynamic Stall Force		32N
Motor Stiffness		3N/µ
Holding Force without Power		28N

MECHANICAL DRAWINGS | FBS100100

European View **Dimensions are Metric**



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FBS150/150/200 Linear Stage

Mechanical Design Characteristics

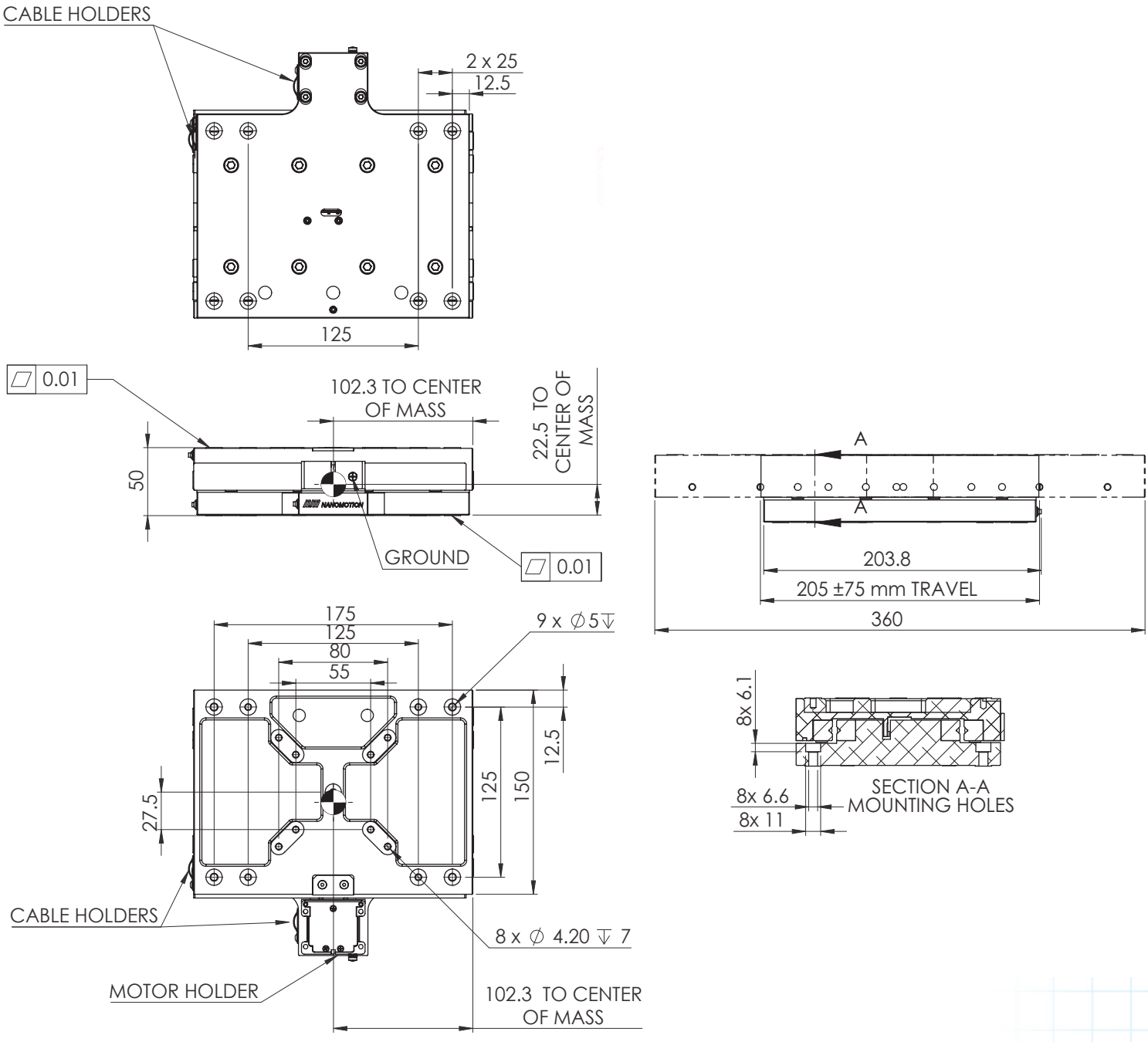
MODEL	FBS150150	FBS150200
Stage Plate Material	Aluminum — Black Anodized	
Motor	HR8 Piezo, ultrasonic standing wave	
Bearing Type	Precision crossed rollers with anti-migration device	
Encoder	Linear optical encoder with gold tape scale	
Cable Lengths (m)	3m	
MTBF (hours)	30,000	
Stage Mass (g)	4399g	5435g
Carriage Moving Mass (g)	1677g	2054g
RoSH	Compliant	
Vacuum Compatible Options	High Vacuum (to 10^{-7} Torr) / UHV (to 10^{-10} Torr) available	

Performance Specifications

MODEL		FBS150150	FBS150200
Travel Range (mm)		150mm	200mm
Encoder Resolution	Standard	100nm	
	Optional	10nm	
Bi-directional Repeatability	Standard	1µm	
	Optional	100nm	
Absolute Accuracy	Standard	12µm	15µm
(Error mapping available)	Optional	7µm	8µm
Minimum Incremental	AC Mode	100nm	
Move Convergence	UHR Mode	5nm	
	DC Mode	<1nm	
Maximum Velocity		200mm/sec	200mm/sec
Straightness & Flatness		±5µm	±5µm
Pitch & Yaw		±50µrad	±50µrad
Load Capacity - Horizontal		1.8kg	1.47kg
Load Capacity - Vertical		NA	NA
Dynamic Stall Force		30N	30N
Motor Stiffness		3N/µm	3N/µm
Holding Force without Power		28N	

MECHANICAL DRAWINGS | FBS150150

European View **Dimensions are Metric**



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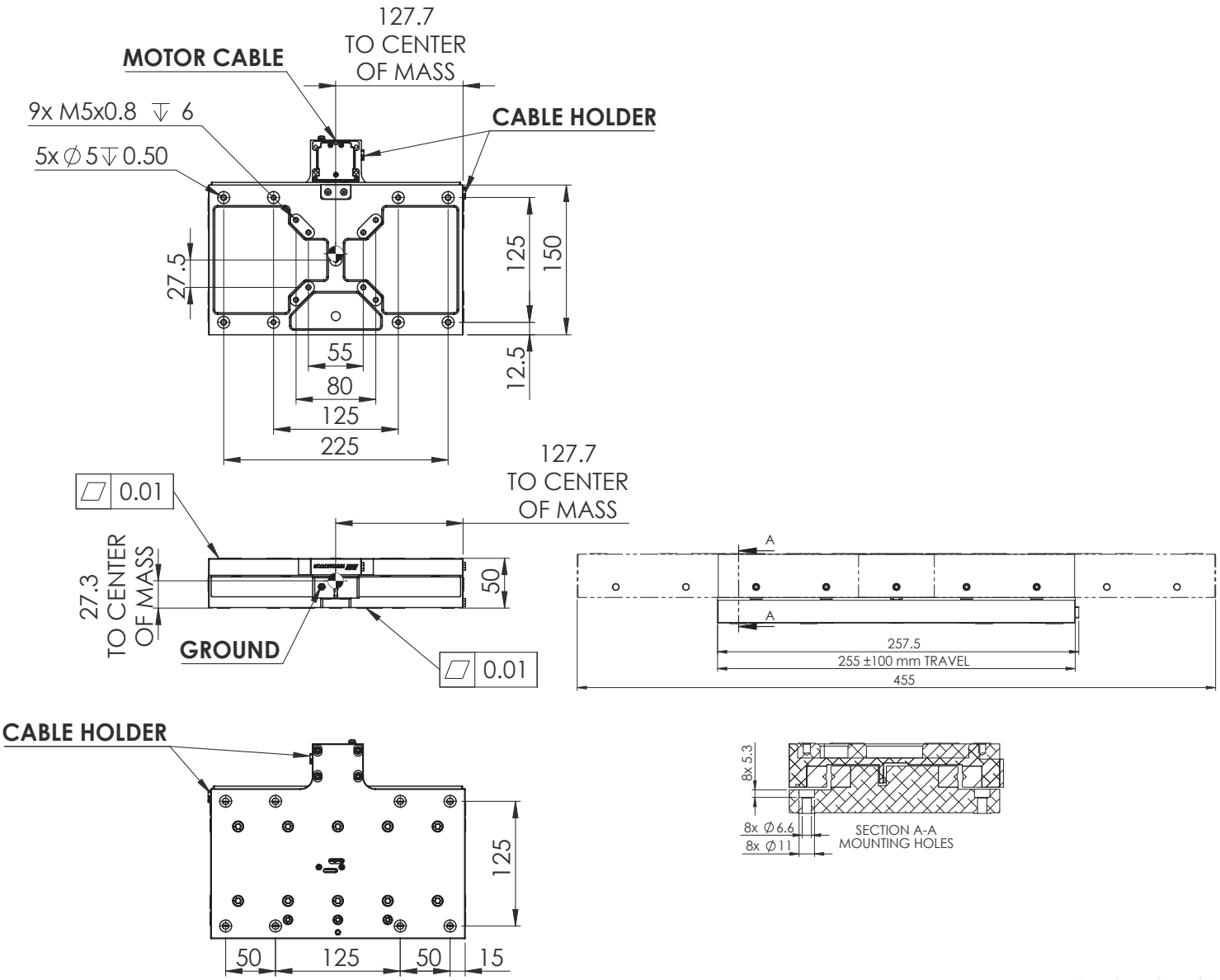

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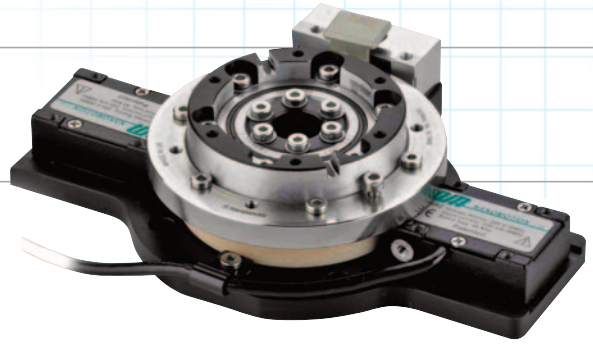
FRS060-360

Rotary Stage



Mechanical Design Characteristics

MODEL	FRS060-360
Stage Plate Material	Aluminum — Black Anodized
Motor	2 x HR2 Piezo, ultrasonic standing wave
Bearing Type	Precision crossed roller rotary bearing
Encoder	Linear optical encoder with metal ring
Cable Lengths (m)	3m
MTBF (hours)	30,000
Stage Mass (g)	581g
Moving Mass (g)	268g
Moving Inertia	0.102 gr-m^2
RoSH	Compliant
Vacuum Compatible Options	High Vacuum (to 10^{-7} Torr) / UHV (to 10^{-10} Torr) available

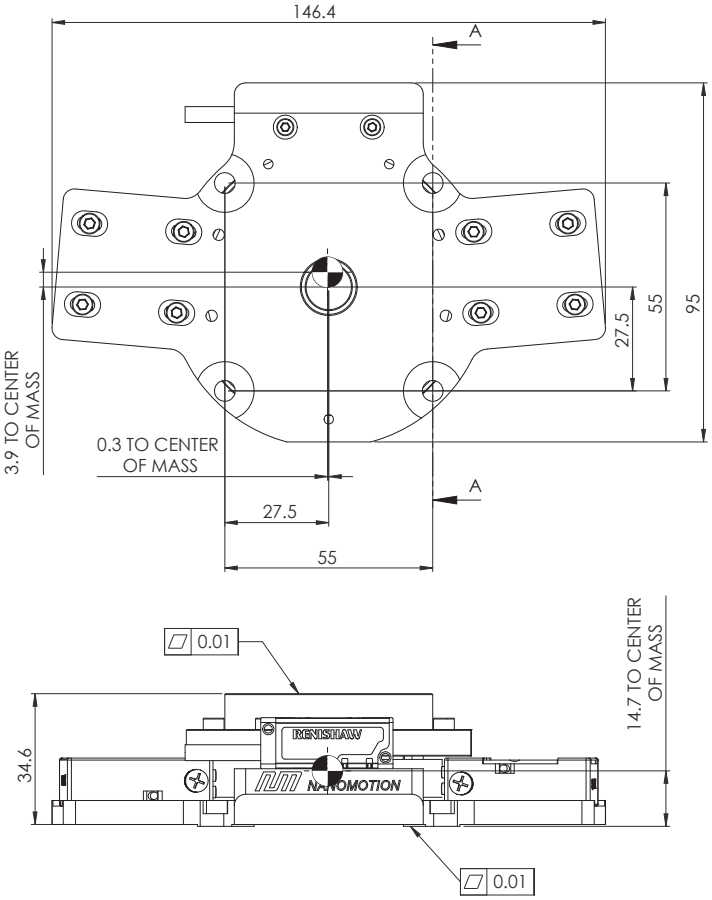
Performance Specifications

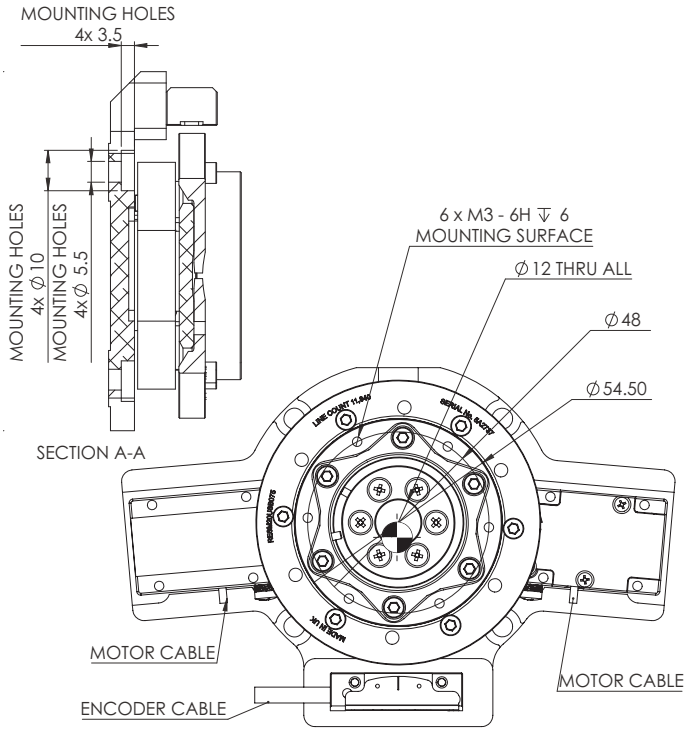
MODEL		FRS060360
Travel Range (mm)		n x 360
Encoder Resolution	Standard	5 arc sec.
	Optional	0.5 arc sec.
Bi-directional Repeatability	Standard	50 arc sec.
	Optional	5 arc sec.
Accuracy	Standard (arc sec.)	10 arc sec.
	Optional (arc sec.)	5 arc sec.
Maximum Velocity		8.3 rad/sec
Flatness		±5µm
Load Inertia Capacity		0.0035kg.m^2
Load Capacity - Moment		2kg
Dynamic Stall Force		0.96Nm
Stage Stiffness		0.0032 Nm/µrad
Holding Force without Power		0.86Nm

MECHANICAL DRAWINGS

FRS060-360

European View **Dimensions are Metric**





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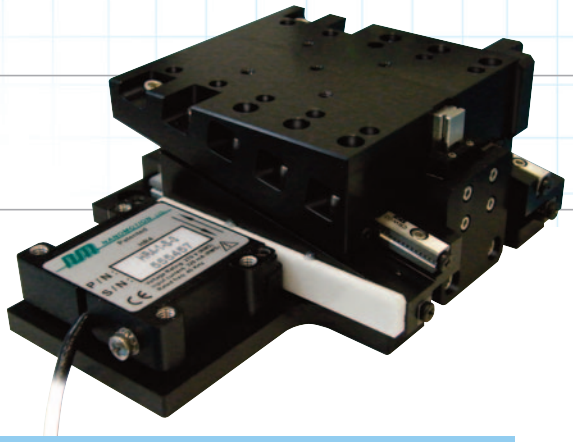
FZS0850100

Z Wedge Stage



Mechanical Design Characteristics

MODEL	FZS085010
Stage Plate Material	Aluminum — Black Anodized
Motor	HR8 Piezo, ultrasonic standing wave
Bearing Type	Precision crossed rollers with anti-migration device
Encoder	Linear optical encoder with gold tape scale
Cable Lengths (m)	3m
MTBF (hours)	30,000
Stage Mass (g)	1300g
Carriage Moving Mass (g)	310g
RoSH	Compliant
Vacuum Compatible Options	High Vacuum (to 10^{-7} Torr) / UHV (to 10^{-10} Torr) available

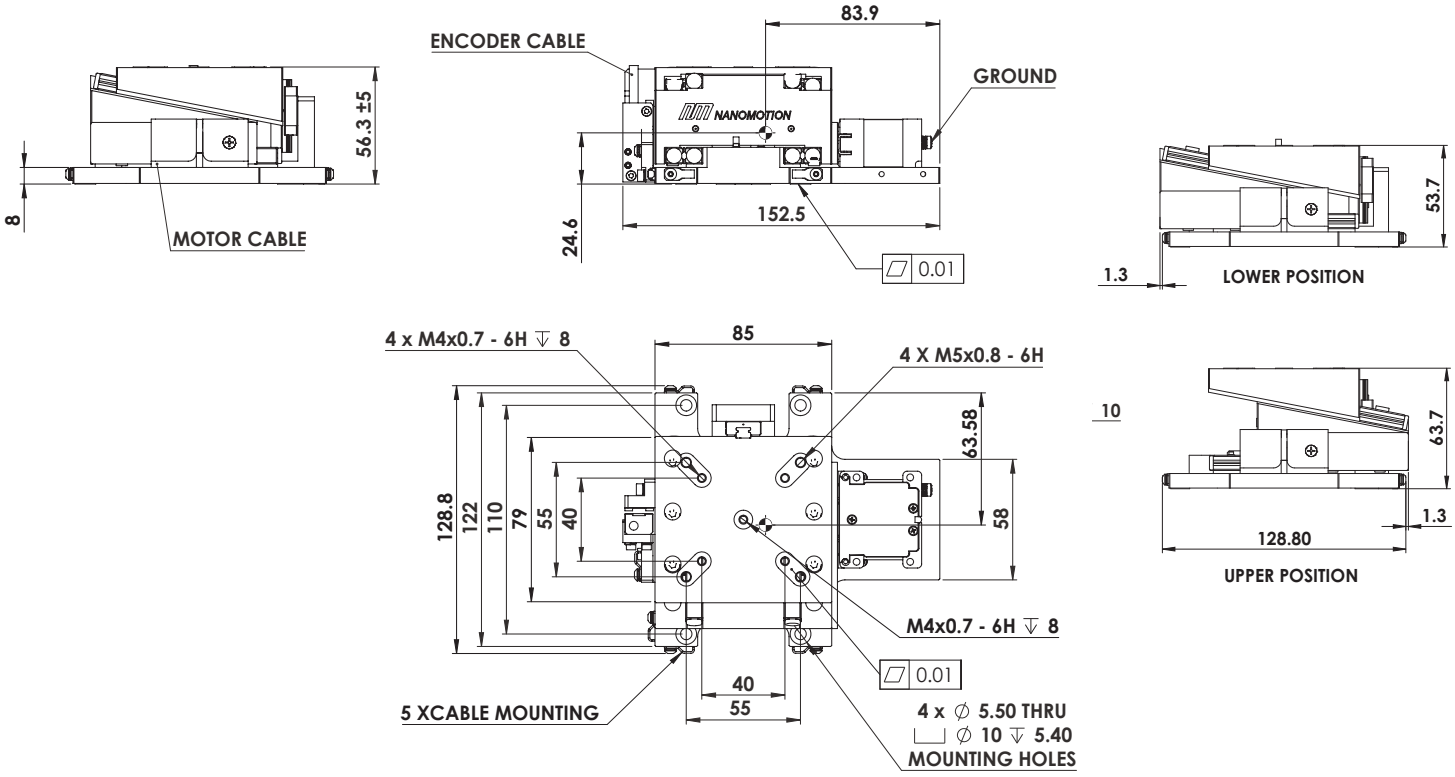
Performance Specifications

MODEL		FZS085010
Travel Range (mm)		10mm
Encoder Resolution	Standard	10nm
Bi-directional Repeatability	Standard	0.1µm
Accuracy	Standard	3µm
Minimum Incremental	AC Mode	100nm
Move Convergence	UHR Mode	5nm
(encoder & control dependant)	DC Mode	<1nm
Maximum Velocity (vertical)		50mm/sec
Straightness & Flatness		±2µm
Pitch & Yaw		±30µrad
Load Capacity		5kg
Dynamic Stall Force (N)		160N
Motor Stiffness (N/µ)		57N/µm
Holding Force without Power		150N

MECHANICAL DRAWINGS

FZS0850100

European View **Dimensions are Metric**



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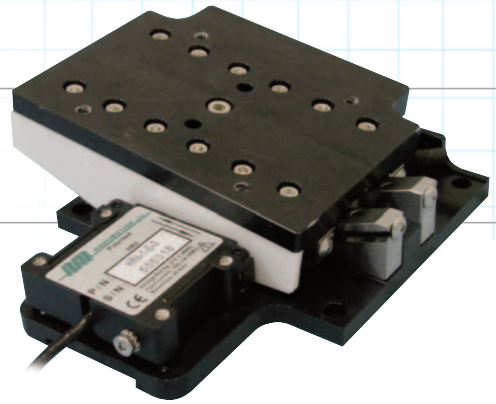
FGS100/125/160 Goniometer Stage



Mechanical Design Characteristics

MODEL	FGS100125	FGS100160
Stage Plate Material	Aluminum — Black Anodized	
Motor	HR4 Piezo, ultrasonic standing wave	
Bearing Type	Precision crossed rollers with anti-migration device	
Encoder	Linear optical encoder with gold tape scale	
Cable Lengths (m)	3m	
MTBF (hours)	30,000	
Stage Mass (g)	773g	842g
Carriage Moving Mass (g)	461g	423g
RoSH	Compliant	
Vacuum Compatible Options	High Vacuum (to 10^{-7} Torr) / UHV (to 10^{-10} Torr) available	

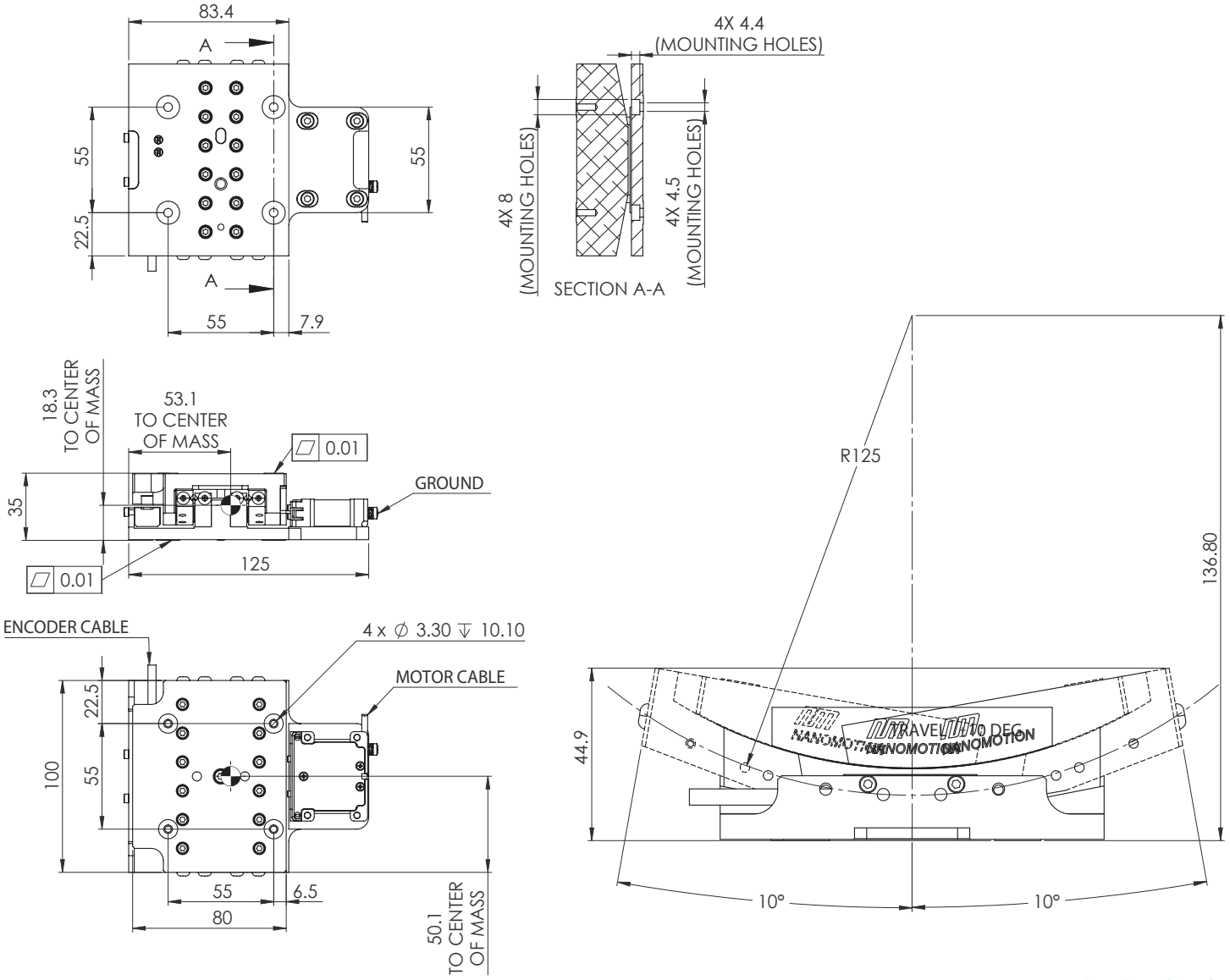
Performance Specifications

MODEL		FGS100125		FGS100160
Travel Range (deg)		±10°		±10°
Encoder Resolution	Standard	0.171 arc sec.		0.134 arc sec.
	Optional	0.0171 arc sec		0.0134 arc sec
Bi-directional Repeatability	Standard	2 arc sec.		
	Optional	0.2 arc sec.		
Minimum Incremental Move Convergence	AC Mode	0.165 arc sec.		0.128 arc sec.
	UHR Mode	0.0082 arc sec.		0.0064 arc sec.
	DC Mode	0.000165 arc sec.		0.000129 arc sec.
Maximum Velocity (deg/sec)		100 deg/sec		85 deg/sec
Load Capacity (kg)		3kg		3kg
Inertial Capacity ($kg.m^2$)		$0.0512kg.m^2$		$0.083kg.m^2$
Dynamic Stall Force		2040Nm		2600Nm
Motor Stiffness		0.045N* m/µrad		0.074N* m/µrad
Holding Force without Power		1836Nm		2340Nm

MECHANICAL DRAWINGS

FGS100125

European View **Dimensions are Metric**



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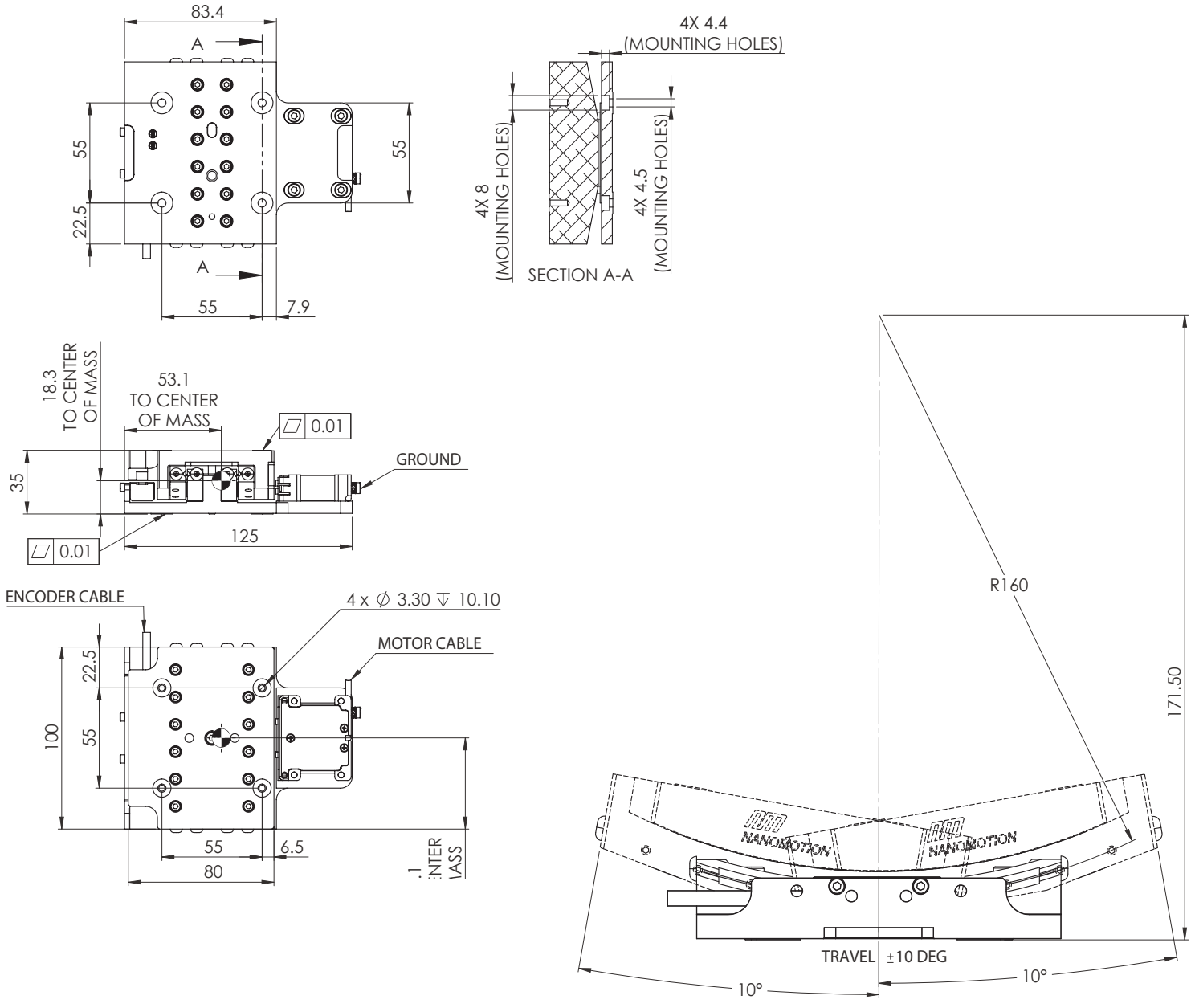
MECHANICAL DRAWINGS

FGS100160

European View **Dimensions are Metric**



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FB Series Wiring Configuration

Motor Wiring: 9 Pin D-type Female Connector

PIN	FUNCTION	DESCRIPTION
1	GND	System Ground
2	N.C.	With AB1A Driver — Phase
3	Motor - Up	White Wire — High Voltage Input
4	Motor - Common	Black Wire — High Voltage input for AB1A GND for AB5, AB2, AB4, XCD Controller/Driver
5	Motor-Down	Red Wire — High Voltage input
6	Motor Connected Safety Input	Short Pin 6 to Pin 1 — Enables Driver Open on Pin 6 — Disables Driver
7	GND	System Ground — Connected to Connector Hood
8	N.C.	Not Connected
9	N.C.	Not Connected

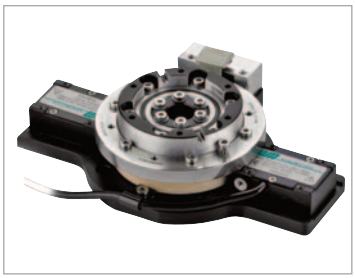
Encoder Wiring: 15 Pin D-type Male Connector

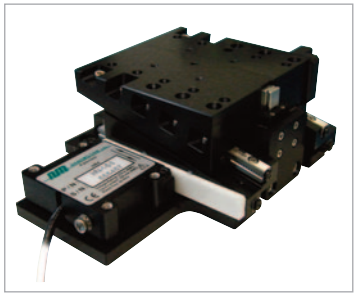
PIN	FUNCTION	DESCRIPTION
7,9	5v	Power
2,9	0v	Power
14	A+	Incremental Signals
6	A-	Incremental Signals
13	B+	Incremental Signals
5	B-	Incremental Signals
12	Z+/Q-	Reference Mark/Index
4	Z-/Q+	Reference Mark/Index
15	Shield	Inner Shield
Case	Shield	Outer Shield
1,3	N.C.	Not Connected
10,11	N.C.	Not Connected

FB Series Technical Section

Product Features

- Linear stages for 20mm to 200mm travel.
- Rotary Stage for continues motion
- Z-Wedge stage for 10mm travel
- Nanomotion's direct drive piezo motor with zero backlash and no hysteresis.
- Integrated 100nm (0.1μm) optical encoder.





Product Description

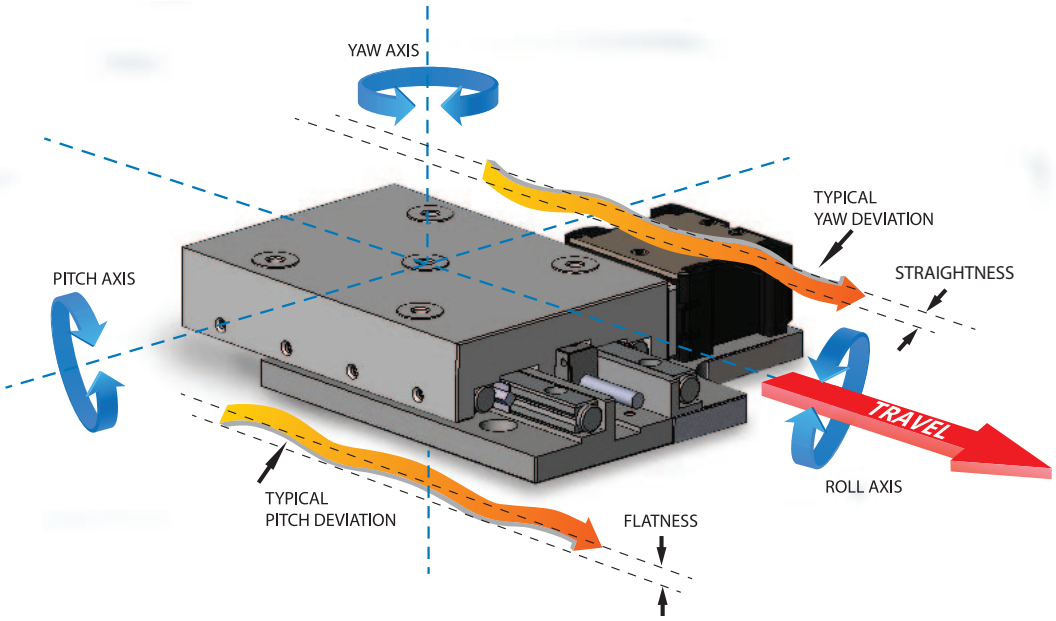
The FB Series of alignment stages are driven by Nanomotion's ultrasonic standing wave piezo motors, providing linear, rotary and vertical motion.

The FB Series of stages provide single and multi-axis motion performance for a wide range of applications in optical alignment, semiconductor, biomedical, and the analytical instrumentation markets. These compact stages are provided in both atmosphere and vacuum configurations and can support clean room operation to Class 10.

The FB Series is a modular design that allows for easy mounting for multi-axis applications. All FB Series stages are designed with precision optical encoders and precision crossed roller bearings, with the linear axes having an anti-migration device.

FB Series

Motion Accuracy



This illustration depicts the various elements that contribute to error. A given axis has linear errors, in the form of straightness & flatness and angular errors in the form of pitch, yaw & roll.

A linear axis has six degrees of freedom that can create potential errors in motion. There are 3 degrees of linear errors, considering the linear displacement (travel), Straightness of motion, & Flatness of motion. There are 3 degrees of angular error, which consist of Pitch, Yaw, and Roll.

1. The movement in the direction of translation, which is the actual motion displacement. This accuracy is governed by the precision of the feedback device and the ability of the motor/servo system to control the displacement of motion.
2. Straightness & Flatness are linear errors related to deviations in motion in a vertical plane or left/right plane.
3. Pitch & Yaw are angular errors that result in inclination (pitch) or twisting (yaw) of the moving surface, about the direction of travel.
4. Roll is an angular error that results in the tilting of the moving surface, off to the side, of the direction of motion.

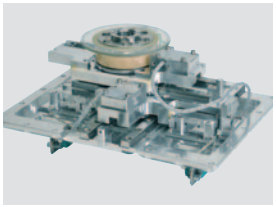
Nanomotion's FB Linear Series uses precision crossed roller bearings, yielding high stiffness, low friction and minimizing the linear and angular errors. The mounting surfaces for the bearings are precision machined aluminum, designed to reflect the bearing accuracy.

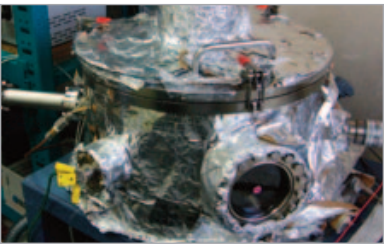
FB Series

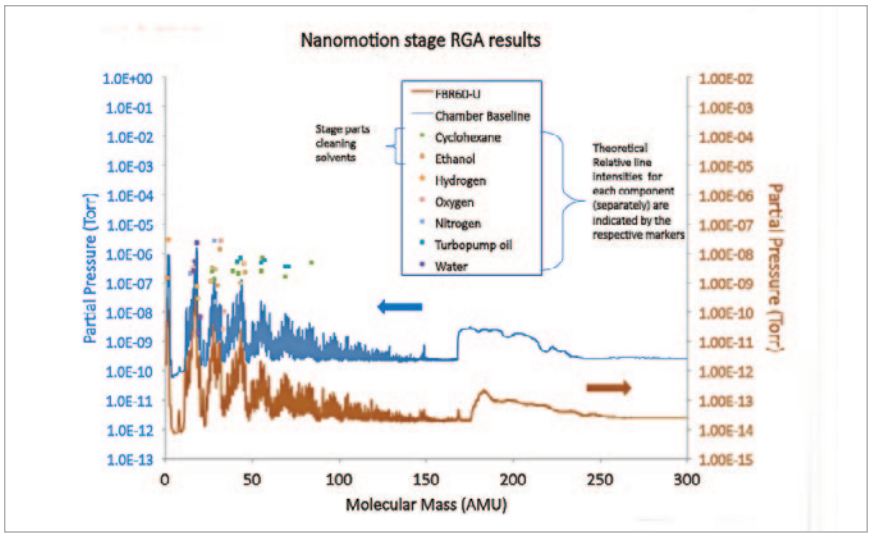
Vacuum & Ultra High Vacuum Compatibility & Cleanliness

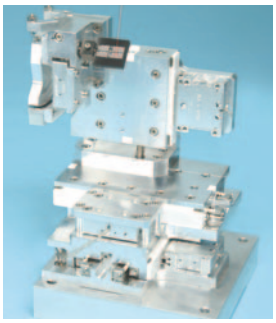
Nanomotion's infrastructure includes:

- Cleaning and baking equipment
- Residual Gas Analysis Equipment
- Cleanroom for assembly and testing
- Vacuum chambers for testing
- Particle counting









Nanomotion supports all vacuum/UHV applications with well established infrastructure for RGA analysis and performance testing in vacuum. Our cleanroom supports the assembly and testing of ultra-clean stages.

Nanomotion Motors & Stages are available in:
-V version for high vacuum (10^{-7} Torr)
-U version for Ultra High Vacuum (10^{-10} Torr)

Linear, rotary, tilt, and Z-wedge stages are configure specifically for vacuum / UHV environments, assembled and tested in a cleanroom, then packaged in dry air or nitrogen. Single and multi-axis assemblies are available to meet the most demanding motion requirements.

Nanomotion's motors and stages are available in vacuum and UHV compatible configurations, leveraging extensive research on materials, adhesives, and lubricants, providing high performance motion control. Motion systems are specifically designed and manufactured to meet the most stringent performance along with vacuum compatibility and cleanliness.

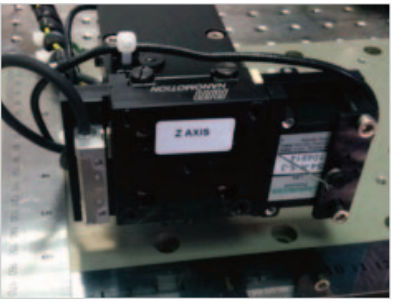
FB Series

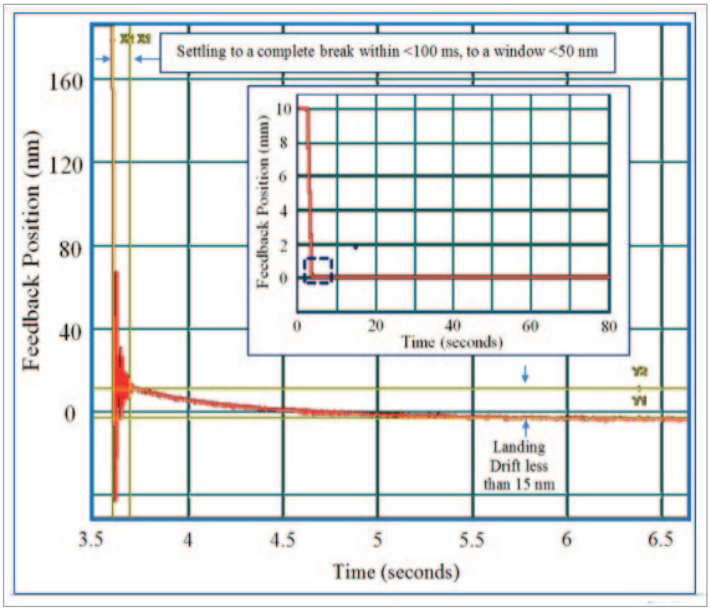
Move and Settle Motion Profiles & Braking

The ability to step and settle to a stable position is essential to many motion applications. Nanomotion's piezo stages have:

- zero backlash
- zero hysteresis
- no internal motor inertia
- faster response than traditional motor technology

The ability to accelerate an axis with Nanomotion's piezo motor technology is greatly enhanced as the inertia only comes from the moving load. Aside from an ultrasonic standing wave, there are no moving parts internal to the motor. The ability to stop (brake) and hold position with stability is also enhanced by the inherent friction of the ceramic tip working on a ceramic drive surface. These characteristics allow for optimum move and settle, along with the ultimate in position stability.



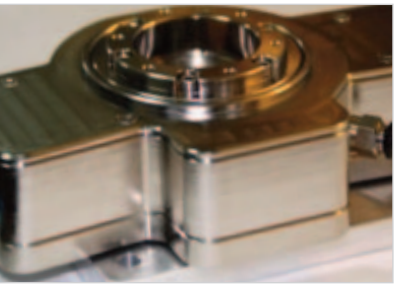


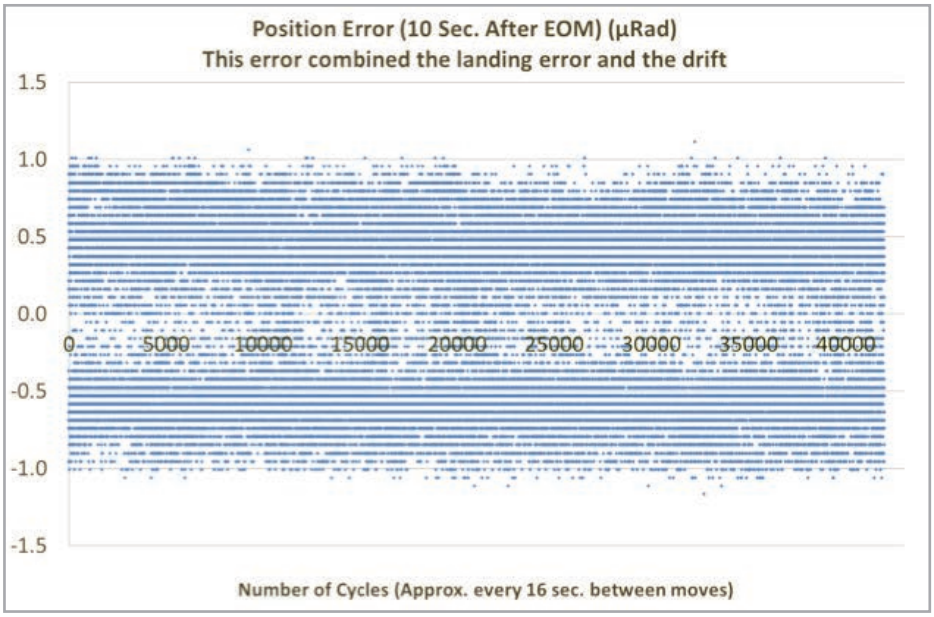
The motion profile reflects the position and velocity profile, reaching position stability at the end of the move command, settling to +/- 1 encoder count. The drift (position stability) is measured at <5nm per minute.

The ability to make more than 20 moves in 1 second, averaging 50msec, for move and settle, is demonstrated over 25 million cycles.

The motion profile below reflects the position and velocity profile, reaching position stability at the end of the move command, settling to +/- 1 encoder count. The drift (position stability) is measured at <5nm per minute.

Position Repeatability and Accuracy In The Direction of Motion





The graph above represents a test, simulating 5 years of operation service, moving 90°, 180°, 270°, 360° and back to home.

Accuracy in our normal servo mode (AC) is to 1µRad

Accuracy in our high resolution mode (DC) is to 0.1µRad

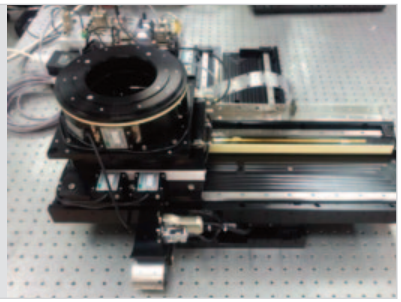
Position repeatability is to +/- 1 µRad

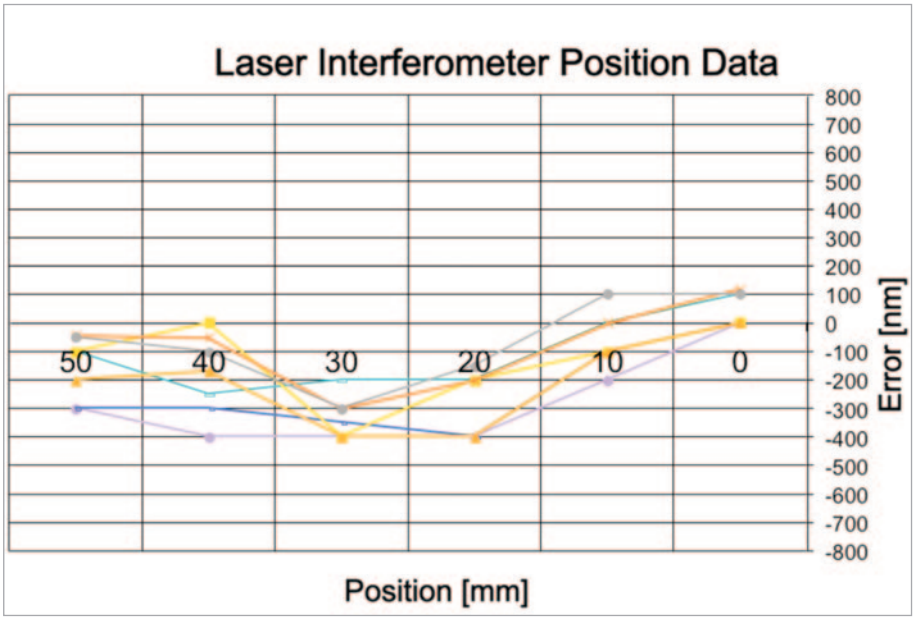
Position Repeatability and Accuracy In The Direction of Motion

There are many design and component factors that impact the ability to achieve position repeatability and accuracy.

All Nanomotion motion systems are closed loop with a position sensor. The position sensors vary in the available resolution and the absolute accuracy. In addition to the position sensors, design considerations that impact the systems stiffness, materials (thermal expansion) and bearing selection are all key factors in determining the precision of motion.

Nanomotion has extensive experience is system configurations ranging from 0.5nm resolution to 1µm resolution. Ultimately the position resolution will be a key factor in determining the position repeatability, as most systems will be repeatable to < 5 encoder counts. Actual errors in the position sensor can be factored out based on measurements with a laser interferometer or auto collimator, yielding standard accuracy in the sub-micron level and achievable accuracy in nanometer level.





Nanomotion utilizes metrology tools such as laser interferometry and auto collimators to validate all aspects of motion performance.

The long travel stage to the right and the graph below reflect an absolute position accuracy of 12 microns over 306mm. The position repeatability is 2 microns with a 0.1µm resolution encoder.

Increasing the encoder resolution can improve position repeatability.

Laser error mapping can improve position accuracy by adding correction points.

Application Data Sheet

Please use this as a guideline to the stage selection process

Name: _____

Company: _____

Phone: _____ Email: _____

Application Description Describe the application in text

_____

_____

_____

Operating Environment

Min/Max Operating Temperature _____ – [C/F]

Min/Max Storage Temperature _____ –_____ [C/F]

Pressure/Vacuum_____ [Torr]

Magnetic: ☐ Yes ☐ No

Cleanliness Class: _____

Other Environmental Considerations: _____

_____

_____

_____

Multi Axis Configurations

Choose configuration and define which axis is top of each other.

X _____

R _____

XR _____

XY _____

XZ _____

Example: Z mounted onto X with

ZR _____

XYZ _____

XYR _____

XYZ _____

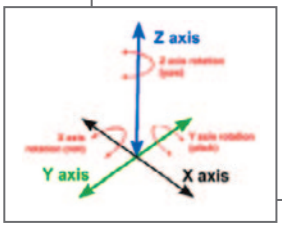
XYZR _____

R1R2 _____

Other _____

Number of Interpolated axes _____

Sketch If Required To Explain



Application Data Sheet

Please use this as a guideline to the stage selection process

Positioning Requirements

Repeatable The error returning to the same position _____ [nm/µ]

Absolute Accuracy The error from position zero to a target point. _____ [µm]

Typical Step Size _____ [nm/µm/mm]

Smallest Incremental Step _____ [nm/µm]

Encoder Resolution Nanomotion to define encoder resolution. _____ [nm/µm]

Motion Requirements– Maximum Travel per axis:

X _____ Y _____ Z _____ [mm]

R1 _____ R2 _____ [Degrees or Continuous]

Define: Constant Velocity (speed uniformity at what velocity and over what distance)

_____

Move and Settle (move distance and time)

_____

Load Requirements

Payload Mass _____ [Kg]

Thrust Force _____ [N]

Payload directly mounted to the stage surface ☐ Yes ☐ No

Distance from the stage surface to the CoG of the payload _____ [mm]

Please sketch on Axes Configuration chart for multi-axes configuration

Rotary Application, define moment of inertia _____ [kg.m^2]

Electrical

Main Power:☐ 12V☐ 24V ☐ 48V ☐ Battery _____ ☐ Other _____

Controller

Nanomotion: _____

Other Brand: _____

Controller Interface– Define specific requirements in communication protocol, packaging or interfacing with other devices:

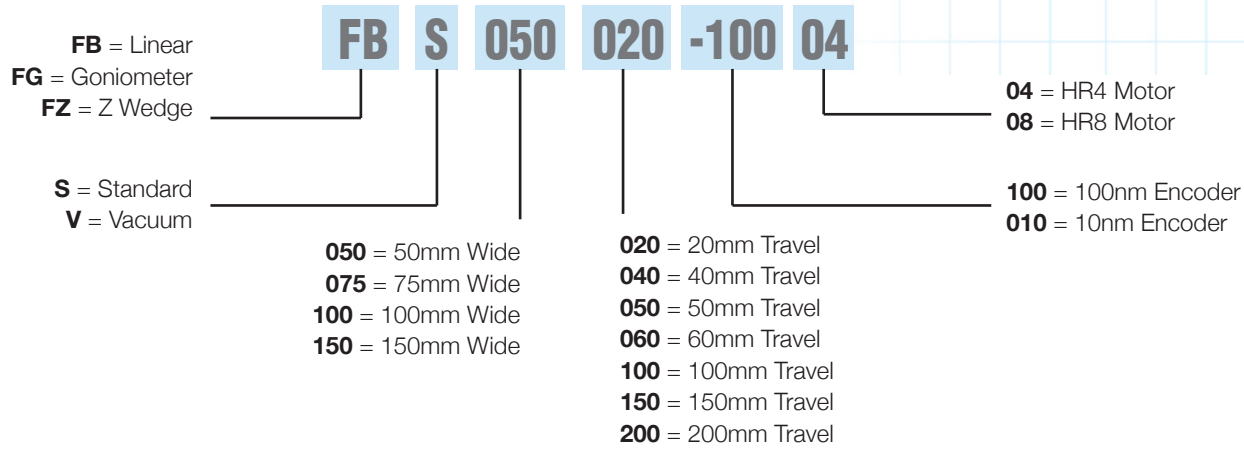
_____

_____

Motor Amplifier– Nanomotion to determine driver: _____

How To Order

FBS050020-10004



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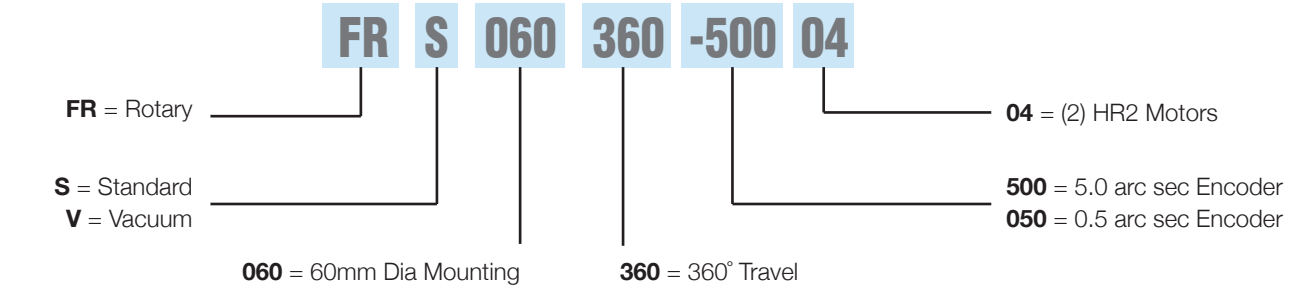

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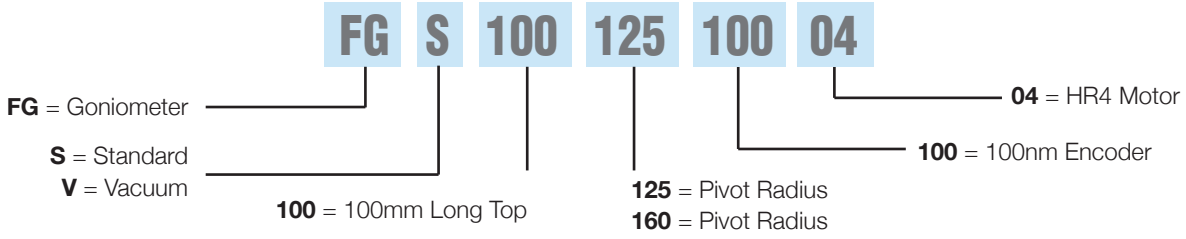

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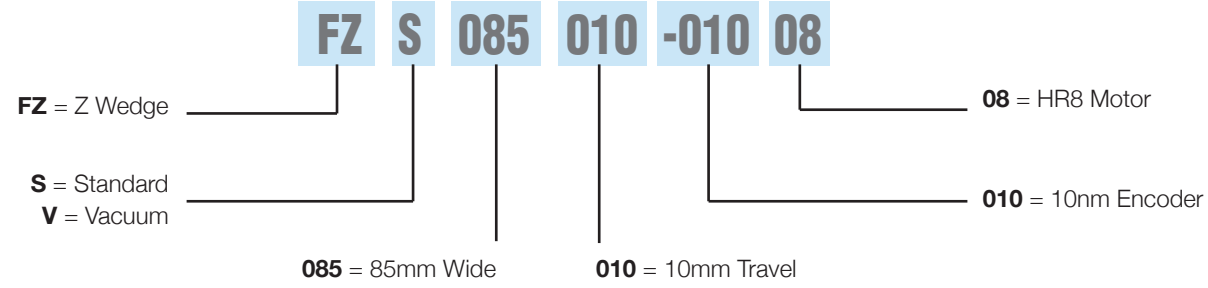

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