

# 5-Axis Air Bearing Stage – XYZ-Tip-Tilt

High-Performance, True Planar XY with Low Profile ZTT Nanopositioning System



## A-725

- Ideal for multi-axis scanning and nanopositioning
- XY travel range from 100×100 to 300×400mm, Z-θX-θY travel range: 5mm × 2°×2°
- True planar XY base stage with low profile integrated ZTT, platform diameter of 250mm
- Load capacity up to 8 kg

The A-725 five-axis precision motion stage combines a true planar XY base stage ([A-311](#)) with a low-profile parallel-kinematics Z-θX-θY module ([A-523](#)). The moving platform of the planar stage glides over a common reference plane in both the X and Y directions, significantly improving geometric accuracy compared to conventional stacked XY stages with mechanical bearings. The low-profile Z tip/tilt stage, along with the cable management system, is integrated directly on top of the planar stage. All five axes are directly driven by three-phase linear motors. The efficient, compact design features a low center of gravity and offers significant advantages for machines with limited installation space.

### Product overview

The moving platform of the planar stage glides over a common reference plane in both the X and Y directions, significantly improving geometric accuracy compared to conventional stacked XY stages with mechanical bearings. The low-profile Z tip/tilt stage, along with the cable management system, is integrated directly on top of the planar stage. All five axes are directly driven by three-phase linear motors. The efficient, compact design features a low center of gravity and offers significant advantages for machines with limited installation space.

### Direct Drive with 3-Phase Linear Motors

The ironless three-phase linear motors transmit the drive force directly to the moving platform, eliminating mechanical contact, friction, and wear. This direct-drive design enables high velocities and accelerations while ensuring long service life and minimal maintenance. Because the motors contain no iron in the moving forcer, there is no magnetic cogging caused by interaction with the permanent magnets. The result is exceptionally smooth motion with minimal velocity ripple, even at very low speeds, as well as vibration-free operation at high speeds. The absence of cogging also simplifies servo tuning, improves control linearity, and enables highly precise positioning with freely adjustable drive force.

### Control

PI's ACS-based motion controllers and drives provide advanced motion control algorithms that maximize dynamic performance while compensating for system errors. Every A-725 system is fully configured, wired, and tested by PI, including servo tuning optimized for the customer's specific payload and application requirements. The result is a turnkey, ready-to-install precision motion system that reduces integration effort and enables rapid deployment.

### Accessories and options

- Air filter sets and air preparation kit (version with vacuum generation required for models from 300 mm travel range)
- Encoder
- Multi-axis motion controller and direct drives
- Machine bases
- Best performance is achieved when mounted on optional granite base plate and vibration isolation system

### Application fields

PIglide air-bearing nanopositioning systems are ideally suited for high-precision motion applications such as semiconductor inspection, laser processing, microscopy, metrology, and high-speed scanning. The integrated Z-θX-θY stage enables precise focus, height, and angular alignment, making it ideal for applications requiring nanometer-level positioning and alignment, including wafer inspection, silicon photonics, optical component positioning, flat-panel display inspection, maskless lithography, advanced packaging, and MicroLED manufacturing. The noncontact air bearing design eliminates friction, wear, and particle generation, making the system ideally suited for cleanroom and other contamination-sensitive environments.

# Specifications

Motion	Unit	Tolerance	A-725.100B1	A-725.150B1	A-725.200B1	A-725.300B1	A-725.400B1
Active axes			X   Y   Z   $\theta$ X   $\theta$ Y	X   Y   Z   $\theta$ X   $\theta$ Y	X   Y   Z   $\theta$ X   $\theta$ Y	X   Y   Z   $\theta$ X   $\theta$ Y	X   Y   Z   $\theta$ X   $\theta$ Y
Travel range in X	mm		100	150	200	300	400
Travel range in Y	mm		100	150	200	300	300
Travel range in Z	mm		5	5	5	5	5
Rotation range in $\theta$ X	°		2	2	2	2	2
Rotation range in $\theta$ Y	°		1.6	1.6	1.6	1.6	1.6
Acceleration in X, unloaded	m/s <sup>2</sup>	Max.	27.5	27.5	27.5	10	10
Acceleration in Y, unloaded	m/s <sup>2</sup>	Max.	13	11	10	10	10
Acceleration in Z, unloaded	m/s <sup>2</sup>	Max.	10	10	10	10	10
Maximum velocity in X, un-load.	mm/s		2000	2000	2000	1000	1000
Maximum velocity in Y, un-load.	mm/s		2000	2000	2000	1000	1000
Maximum velocity in Z, unloaded	mm/s		200	200	200	200	200
Orthogonality	$\mu$ rad	Typ.	$\pm$ 12.5	$\pm$ 12.5	$\pm$ 12.5	$\pm$ 10	$\pm$ 25
Straightness error E_XY	$\mu$ m	Max.	$\pm$ 0.25	$\pm$ 0.25	$\pm$ 0.5	$\pm$ 1	$\pm$ 1
Straightness error E_YX	$\mu$ m	Max.	$\pm$ 0.25	$\pm$ 0.25	$\pm$ 0.5	$\pm$ 1	$\pm$ 1
Flatness error E_ZX	$\mu$ m	Max.	$\pm$ 0.25	$\pm$ 0.5	$\pm$ 0.75	$\pm$ 1.5	$\pm$ 1.5
Flatness error E_ZY (flatness)	$\mu$ m	Max.	$\pm$ 0.25	$\pm$ 0.5	$\pm$ 0.75	$\pm$ 1.5	$\pm$ 1.5
Angular error E_AY (pitch)	$\mu$ rad	Max.	$\pm$ 10	$\pm$ 10	$\pm$ 12.5	$\pm$ 20	$\pm$ 20
Angular error E_BX (pitch)	$\mu$ rad	Max.	$\pm$ 10	$\pm$ 10	$\pm$ 12.5	$\pm$ 20	$\pm$ 20
Angular error E_CX (yaw)	$\mu$ rad	Max.	$\pm$ 5	$\pm$ 5	$\pm$ 5	$\pm$ 10	$\pm$ 10
Angular error E_CY (yaw)	$\mu$ rad	Max.	$\pm$ 5	$\pm$ 5	$\pm$ 5	$\pm$ 10	$\pm$ 10
Yaw (Rotational crosstalk in $\theta$ X with motion in Z)	$\mu$ rad	Typ.	$\pm$ 25	$\pm$ 25	$\pm$ 25	$\pm$ 25	$\pm$ 25
Pitch (Rotational crosstalk in $\theta$ Y with motion in Z)	$\mu$ rad	Typ.	$\pm$ 25	$\pm$ 25	$\pm$ 25	$\pm$ 25	$\pm$ 25

Positioning	Unit	Tolerance	A-725.100B1	A-725.150B1	A-725.200B1	A-725.300B1	A-725.400B1
Positioning accuracy in X, calibrated	$\mu$ m	Typ.	$\pm$ 0.2	$\pm$ 0.2	$\pm$ 0.2	$\pm$ 0.2	$\pm$ 0.2
Positioning accuracy in X, uncalibrated	$\mu$ m	Typ.	$\pm$ 1.5	$\pm$ 2	$\pm$ 2.5	—	—
Positioning accuracy in Y, calibrated	$\mu$ m	Typ.	$\pm$ 0.2	$\pm$ 0.2	$\pm$ 0.2	$\pm$ 0.2	$\pm$ 0.2
Positioning accuracy in Y, uncalibrated	$\mu$ m	Typ.	$\pm$ 1.5	$\pm$ 2	$\pm$ 2.5	—	—
Positioning accuracy in Z, calibrated	$\mu$ m	Typ.	$\pm$ 0.5	$\pm$ 0.5	$\pm$ 0.5	$\pm$ 0.5	$\pm$ 0.5
Positioning accuracy in $\theta$ X, uncalibrated	$\mu$ rad	Typ.	$\pm$ 15	$\pm$ 15	$\pm$ 15	$\pm$ 15	$\pm$ 15
Positioning accuracy in $\theta$ Y, uncalibrated	$\mu$ rad	Typ.	$\pm$ 15	$\pm$ 15	$\pm$ 15	$\pm$ 15	$\pm$ 15
Bidirectional repeatability in X	$\mu$ m	Max.	0.1	0.1	0.1	0.1	0.1
Bidirectional repeatability in Y	$\mu$ m	Max.	0.1	0.1	0.1	0.1	0.1
Bidirectional repeatability in Z	$\mu$ m	Typ.	0.25	0.25	0.25	0.25	0.25
Bidirectional repeatability in $\theta$ X	$\mu$ rad	Typ.	8	8	8	8	8
Bidirectional repeatability in $\theta$ Y	$\mu$ rad	Typ.	8	8	8	8	8
Reference switch						—	
Limit switches						—	
Integrated sensor						Absolute linear encoder	
Sensor signal						BISS-C	
Sensor signal period	$\mu$ s					—	
Sensor resolution	nm					1	
Minimum incremental motion in Z	$\mu$ m	Typ.	0.01	0.01	0.01	0.01	0.01
Minimum incr. motion in $\theta$ X	$\mu$ rad	Typ.	0.06	0.06	0.06	0.06	0.06
Minimum inc. motion in $\theta$ Y	$\mu$ rad	Typ.	0.06	0.06	0.06	0.06	0.06

Drive properties	Unit	Tolerance	A-725.100B1	A-725.150B1	A-725.200B1	A-725.300B1	A-725.400B1
Drive type			Ironless 3-phase linear motor				
			X   Y				
Nominal voltage	V		48	48	48	48	48
Peak voltage	V		80	80	80	80	80
Nominal current, RMS	A	Typ.	3.2	3.2	3.2	2.9	2.9
Peak current, RMS	A	Typ.	6.9	6.9	6.9	10	10
Drive force in X	N	Typ.	39	39	39	58	58
Drive force in Y	N	Typ.	39	39	39	58	58
Peak force in X	N		85	85	85	200	200
Peak force in Y	N		85	85	85	200	200
Force constant	N/A		12.3	12.3	12.3	19.9	19.9
Resistance phase-phase	$\Omega$	Typ.	3.6	3.6	3.6	5.6	5.6
Inductance phase-phase	mH		1.24	1.24	1.24	1.8	1.8
Back EMF phase-phase	V-s/m	Max.	10.1	10.1	10.1	16	16
Pole pitch N-N	mm		30	30	30	30	30
			Z   $\theta$ X   $\theta$ Y				
Nominal voltage	V		24	24	24	24	24
Peak voltage	V		60	60	60	60	60
Nominal current, RMS	A	Typ.	1.4	1.4	1.4	1.4	1.4
Peak current, RMS	A	Typ.	2.8	2.8	2.8	2.8	2.8
Force constant	N/A		5.9	5.9	5.9	5.9	5.9
Resistance phase-phase	$\Omega$	Typ.	5.2	5.2	5.2	5.2	5.2
Inductance phase-phase	mH		1	1	1	1	1
Back EMF phase-phase	V-s/m	Max.	4.2	4.2	4.2	4.2	4.2
Pole pitch N-N	mm		19.66	19.66	19.66	19.66	19.66

Mechanical properties	Unit	Tolerance	A-725.100B1	A-725.150B1	A-725.200B1	A-725.300B1	A-725.400B1
Material			Hardcoat aluminum, stainless steel mounting hardware				
Permissible push force in XY	N	Max.	80	80	80	80	80
Permissible push force in Z	N	Max.	147	147	147	147	147
Moved mass in X, unloaded	g		3000	3000	3000	4000	4000
Moved mass in Y, unloaded	g		5500	5500	6500	12500	15000
Guide			Air bearing with air preload				
Overall mass	kg		22.7	26.7	30.7	56.2	63.2

Miscellaneous	Unit	Tolerance	A-725.100B1	A-725.150B1	A-725.200B1	A-725.300B1	A-725.400B1
Operating temprange	$^{\circ}\text{C}$		+15 to +25				
Connector			D-sub 9W4 (m)				
Sensor connector			X   Y: D-sub 15 (m) Z   $\theta$ X   $\theta$ Y: HD D-sub 26 (m)				
Operating pressure	kPa		X   Y: 415 to 485 (60 to 70 psi) Z   $\theta$ X   $\theta$ Y: 515 to 585 (75 to 85 psi)				
Air consumption	L/min	Max.	X   Y: 56 Z   $\theta$ X   $\theta$ Y: 84				
Air quality			Clean (filtered up to 1.0 $\mu\text{m}$ or better) - ISO 8573-1 class 1   Oil free - ISO 8573-1 class 1   Dry (-15 $^{\circ}\text{C}$ dew point) - ISO 8573-1 class 3				
Recommended controllers / drivers			A-814 (four axes), A-82x (4 / 6 / 8 axes)				
Air connector			One-touch fitting for tubing with 6 mm outer diameter				

Note on straightness and angular errors: Dependent on the flatness of the surface, on which the stage is mounted.

Note on velocity and acceleration: It can be limited by payload, controller, or drive performance.

Note on permissible push force: Assumes that the payload center of gravity is centered no more than 50 mm above the motion platform. The stage is designed for horizontal operation only.

Note on sensor resolution: Assumes a 4096x interpolation. Contact PI for the use of other factors.

Note on positioning accuracy: Improved accuracy can be obtained with controller-based error compensation. The stage must be ordered with a controller from PI to reach these values.

Accuracy values assume short duration and do not consider the long-term effects of thermal drift on the stage. Note on moved

mass in Y: Value includes upper axis (X)

Note on operating pressure: To protect the stage against damage, it is recommended to connect an air pressure sensor to the Motion-Stop input of the controller. All specifications apply per axis, if not otherwise described.

Note on travel and rotation ranges: The travel range in Z and the rotation areas in  $\theta$ X and  $\theta$ Y depend on each other. The values in the table show the maximum travel range for each axis, when all other axes are at the reference position. If one axis has reached its maximum position, movement of the other axes is not possible.

Note on acceleration and velocity: The given values are valid in an unloaded state.

Note on positioning accuracy: The calibrated accuracy can only be achieved with a controller-driven error compensation. The stage must be ordered with a controller from PI to reach these values.

Accuracy values assume short duration and do not consider the long-term effects of thermal drift on the stage.

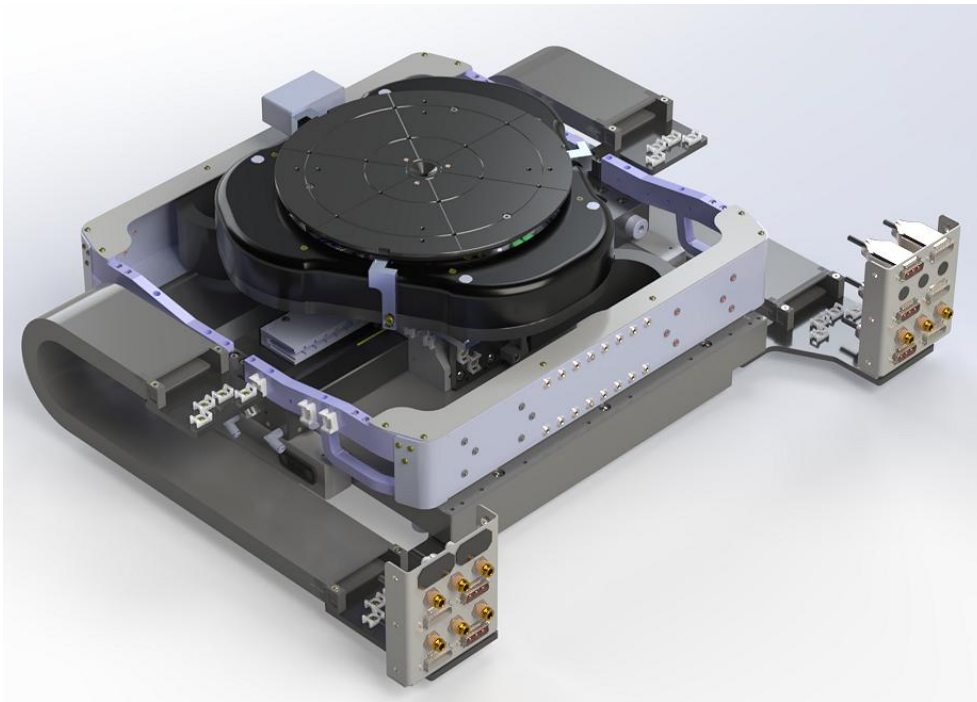
Note on minimum incremental motion: Is directly related to the system stability (servo jitter); this depends on the servo drive used. The position stability can be improved by using ServoBoost™ PLUS on an ACS SPiiPlus controller.

Note on the nominal and peak voltages and the nominal and peak currents: The given values apply per motor. The stage contains three motors.

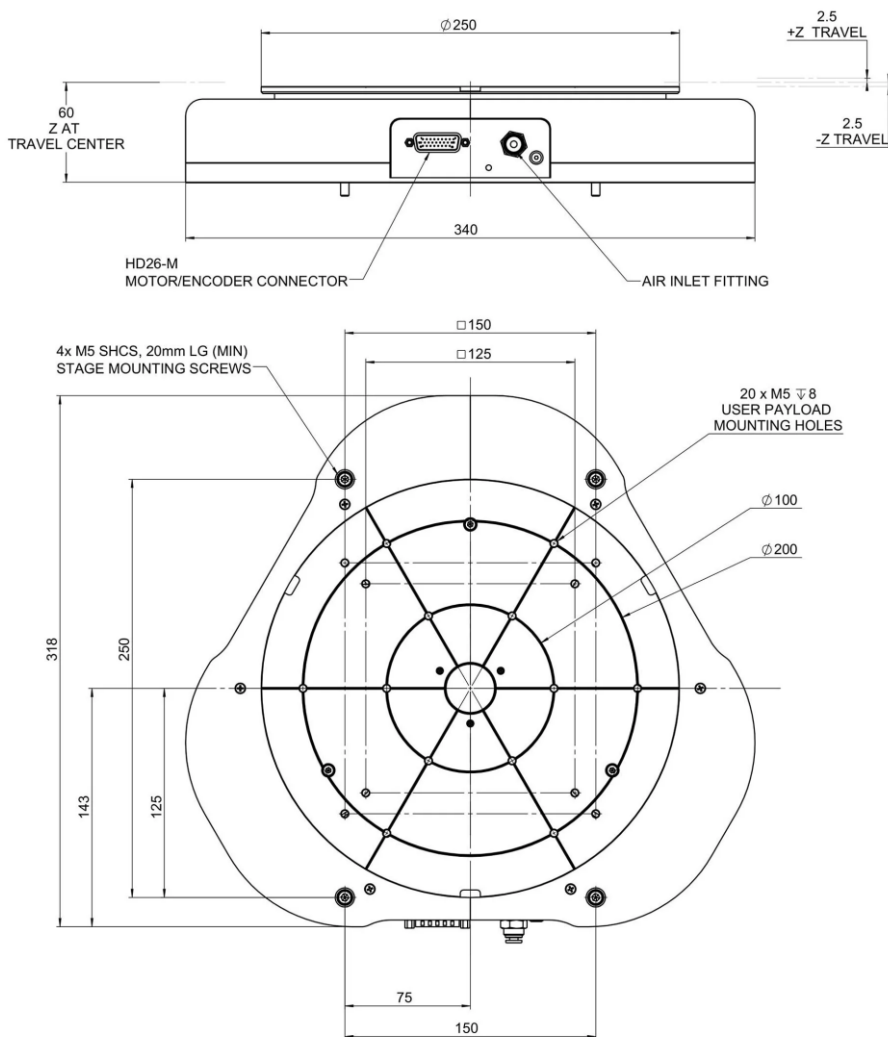
Note on the permissible push force: Assumes an operating pressure of 480 kPa of the air bearings. The stage is designed for horizontal operation only.

Note on the operating pressure: To protect the stage against damage, it is recommended to connect an air pressure sensor to the E-Stop input of the controller.

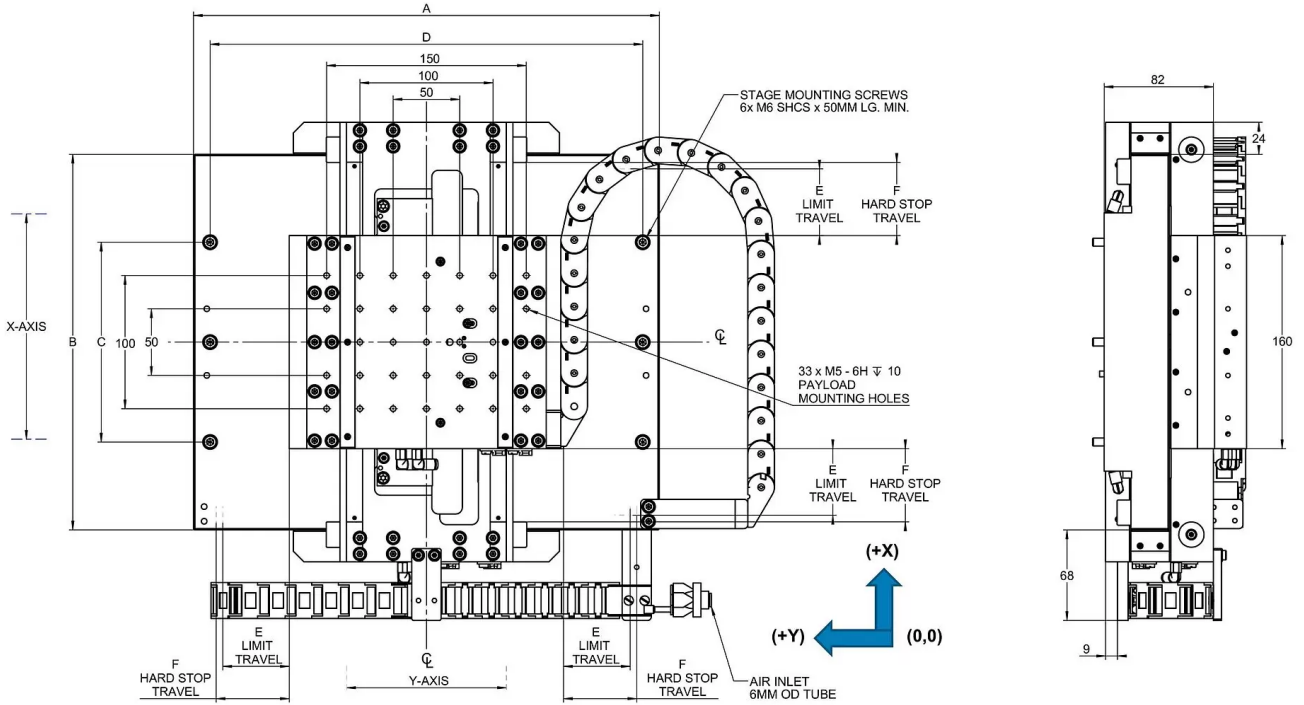
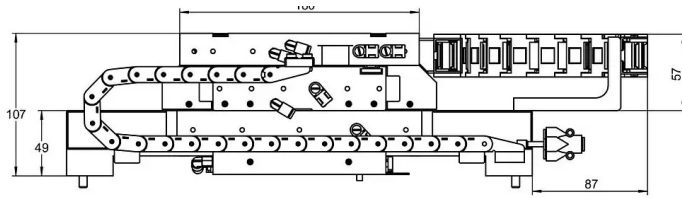
At PI, technical data is specified at 22  $\pm$ 3  $^{\circ}\text{C}$ . Unless otherwise stated, the values are for unloaded conditions. Some properties are interdependent. The designation "typ." indicates a statistical average for a property; it does not indicate a guaranteed value for every product supplied. During the final inspection of a product, only selected properties are analyzed, not all. Please note that some product characteristics may deteriorate with increasing operating time.



A-725, connector-side view



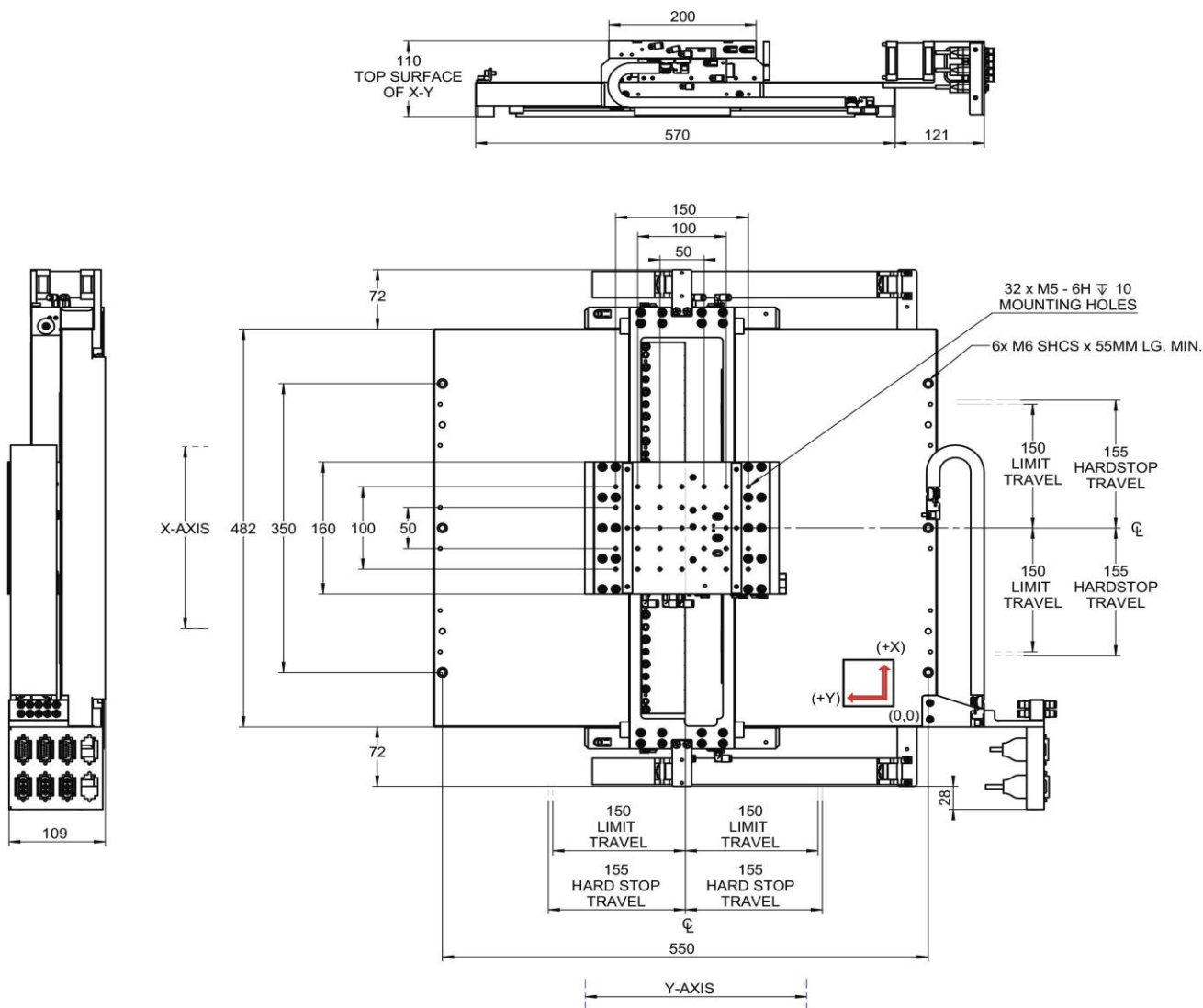
Dimensions of the [A-523 parallel-kinematics Z-tip-tilt module](#) (in mm)



MODEL	Travel	A	B	C	D	E	F	Moving Mass (x-axis)	Moving Mass (y-axis)	Total Mass
A-311.AXX	100mm x 100mm	350	282	150	325	50	55	3kg	6.5kg	18.5kg
A-311.BXX	150mm x 150mm	400	332	200	375	75	80	3kg	7.5kg	22.5kg
A-311.CXX	200mm x 200mm	450	382	250	425	100	105	3kg	8.5kg	27.5kg

A-311XXX

Dimensions of the planar XY base stage for the 100x100, 150x150 and 200x200mm travel range models:  
[A-311.Axx \(100mm\)](#), [A-311.Bxx \(150mm\)](#), [A-311.Cxx \(200mm\)](#), dimensions in mm



Dimensions of the planar XY base stage for the 300x300 and 300x400mm travel range models: [A-311.FXx \(300x300mm\)](#), [A-311.GXx \(300x400mm\)](#), dimensions in mm

## Ordering Information

### A-725.100B1

5-Axis Air Bearing Stage, 100x100mm XY, 5mm x 2°x 2° Z-Tip-Tilt, Echairs

### A-725.150B1

5-Axis Air Bearing Stage, 150x150mm XY, 5mm x 2°x 2° Z-Tip-Tilt, Echairs

### A-725.200B1

5-Axis Air Bearing Stage, 200x200mm XY, 5mm x 2°x 2° Z-Tip-Tilt, Echairs

### A-725.300B1

5-Axis Air Bearing Stage, 300x300mm XY, 5mm x 2°x 2° Z-Tip-Tilt, Echairs

### A-725.400B1

5-Axis Air Bearing Stage, 300x400mm XY, 5mm x 2°x 2° Z-Tip-Tilt, Echairs