

# Technote: Miniature Voice Coil Stage with Counterbalance

Ideal for Scanning, Measuring, Imaging, Alignment



- 40x50mm footprint
- 8 mm travel, 2g acceleration
- 5nm resolution, direct-measuring encoder for superior accuracy and repeatability
- Optional counterbalance
- Very compact footprint
- Direct drive motor for efficient, dynamic performance
- Crossed-roller bearings for true straightness and flatness

Figure 1a. V-121 Rendering Fig 1b. V-121.006A1Z with optional objective holder and microscope objective

## Application

When space is limited and speed, high accuracy, and long service life are critical, compact voice-coil-driven stages provide an excellent solution. PI designed the V-121 direct-drive stages for applications such as fast focusing, scanning, and nanopositioning, with the option to use in any orientation and in XY or XYZ assemblies. An integrated counterbalance is available for vertical operation to offset the weight force, maximizing dynamics and keeping the motor cool when at rest.

Despite its matchbox-like dimensions, V-121 linear stages offer superior travel accuracy, flatness, and performance compared to bigger stages. With a powerful, non-cogging, direct drive motor, the V-121 linear stage family performs well in production environments. The ultra-precision cross roller bearings are intended to be low maintenance for the life of the stage.

## Direct drive motors for higher-dynamics and friction-free, maintenance-free operation

The direct drive voice coil linear motor driving the V-121 stage family transfers force directly to the motion platform. This eliminates backlash that can result from mechanical components like gears and screws in the drivetrain. Ideal for high-velocity, high-acceleration applications, these motors feature a maintenance-free, frictionless design, ensuring longevity in demanding 24/7 operations. The controller's current limit settings allow easy motor disablement, preventing damage to the stage or the application.

## Crossed roller bearings improve load capacity, accuracy and lifetime

Crossed roller bearings offer a superior level of smoothness, straightness, and flatness, close to air bearing performance. By replacing the point contact of ball bearings with a line contact, rollers become considerably stiffer, requiring less preload. This reduction in friction enables smoother running and higher accuracy. Crossed roller bearings can also support more direct loads and moment loads. The anti-creep mechanism prevents roller drift, enhancing reliability. Cleanroom grease is applied for low-maintenance operation.

## High-resolution encoder

V-121 stages are equipped with incremental sin/cos linear encoders that measure position with utmost accuracy directly at the motion platform, enhancing linearity and ensuring immunity to mechanical play and elastic deformation of indirect measuring methods. A home signal is built in to initiate the stage.

## Choosing the right precision linear stage and motion controller

Selecting the right linear stage is pivotal for optimal performance in high-precision motion applications, such as semiconductor inspection and photonics alignment. Factors such as resolution, guiding accuracy, and repeatability must be carefully considered. For their minute size, these linear stages offer excellent geometric accuracy (flatness, straightness, pitch, and yaw), along with 50-nanometer bi-directional repeatability. With high dynamic properties, including up to 2g acceleration, these compact motorized stages are ideal for 24/7 automation of highly accurate positioning tasks required for micro-assembly, alignment, or mass production of precision devices.

Partnered with PI's A-800 series motion controllers, these stages achieve unparalleled motion performance. PI's EtherCAT®-based controllers offer remarkable flexibility, facilitating the seamless integration of third-party equipment compatible with EtherCAT®. Advanced algorithms in the A-8xx series motion controllers, such as PILOT allow for higher dynamics with reduced motor currents, virtually increasing the motor's force constant. Choose the compact V-121 for precision, reliability, and efficiency in your motion applications.

## Accessories and options

- Magnetic counterbalance for vertical use.
- Single or multi-axis, ACS motion controllers and servo drives, integrated or distributed.
- Cables compatible with the A-8xx series, ACS-powered controllers.
- Multi-axis assemblies.

## Application fields

Precision micro-assembly. Research. Biotechnology. General Automation. Device assembly. Laser Micro-processing. Pick and place. Photonics Alignment and Assembly.

## Ordering Information

### V-121.006A1

Linear Motor Cross-Roller Bearing Stage, 45mm Wide, 8 mm Travel, Analog SIN/COS Encoder

### V-121.006A1Z

Linear Motor Cross-Roller Bearing Stage, 45mm Wide, 8 mm Travel, Analog SIN/COS Encoder, Magnetic Z Counterbalance

## Controllers and Cables

Part Number	Description
A-81x Series	ACS based controllers (2, 4 axis versions, various configurations) with medium power
A-82x Series	ACS based controllers (4, 6, 8 axis versions, various configurations) with high power
C-414	PIMag® Motion Controller

## Preliminary Specifications

Motion	V-121.006A1	V-121.006A1Z	Unit	Tolerance
Active axes	X - axis	Z-Axis		
Travel range	8		mm	max
Acceleration, unloaded	20		Max.	m/s <sup>2</sup>
Pitch <sup>(1)</sup>	100		μrad	max.
Yaw <sup>(1)</sup>	100		μrad	max.
Straightness <sup>(1)</sup>	1.0		μm	max.
Flatness <sup>(1)</sup>	1.0		μm	max.
Bidirectional repeatability	± 0.05		μm	max.
Positioning accuracy, calibrated <sup>(2)</sup>	± 1		μm	max.

Mechanical	V-121.006x1 V-121.006A1Z	Unit	Tolerance
Bearing	Ultra-precision, cross-roller bearing		
Stage Footprint	40 x 50	mm	
Motion platform	40 x 42	mm	
Stage Height	18	mm	
Load capacity <sup>(3)</sup>	15	N	max.
Counterbalance force	9	N	Max.
Moving mass, unloaded	80	g	typ.
Overall mass	200	g	typ.
Carriage and Base Materials	Steel, Black Chrome Plating		

Drive properties	V-121.006x V-121.006A1Z	Unit	Tolerance
Drive type	Direct Drive Motor		
Drive voltage	24	V DC	Min.
Peak force	13.5	N	max.
Continuous force	4.5	N	
Peak Current	3	A	max.
Nominal Current, RMS	1.0	A	max.
Force constant	4.5	N/A	typ.
Motor constant	1.42	N/vW	typ.
Resistance, phase-phase	10	Ω	±10%
Inductance, phase-phase	6.1	mH	±10%
Back EMF, phase-phase	4.5	V/m/s	±10%
Linear Velocity <sup>(3)</sup>	0.5	m/s	max.
Acceleration <sup>(3)</sup>	20	m/s <sup>2</sup>	max.

### NOTES

<sup>(1)</sup> Dependent on the quality of the mounting surface, the payload, orientation, and external forces that act on the stage. Please contact PI for application-specific parameters. The specified values are static (no rotary motion during measuring) and without load.

<sup>(2)</sup> The specified values are without error compensation. The positioner must be ordered with a controller from PI to reach better accuracy values, usually 2-3 times the repeatability values. Accuracy values assume short-term duration and do not consider the long-term effects of thermal drift on the stage.

<sup>(3)</sup> Can be limited by imbalance of the payload or the controller and the drive. Horizontal orientation.

Measurement Sensor	V-121.xA1
Integrated sensor	Incremental encoder
Sensor signal type	Sin/cos, 1 V peak-peak
Sensor resolution period	20μm
Reference point switch	1 at center of travel

Miscellaneous	V-121.x1
Encoder/Motor Connector	DB15 (male)
Operating Temp Range	5 to 50 °C
Recommended Controller	A-81x Series A-82x Series
Cable Length	1.5 m