

PIFOC® Long Range Objective Scanning System

High-Dynamics Sub-Nanometer Piezo Drive; Controller & Software



PIFOC® long range objective scanning system with QuickLock thread adapter and controller (objective not included)

- **Complete System with Controller: High Performance Digital Servo Software Configurable Parameters**
- **Travel Ranges to 400 µm**
- **Scans and Positions Objectives with Sub-nm Resolution**
- **Frictionless, High-Precision Flexure Guiding System for Better Focus Stability**
- **Higher Linearity and Stability Through Digital Control and Direct Metrology with Capacitive Sensors**
- **Clear Aperture up to 29 mm Ø, QuickLock Adapter for Easy Attachment**
- **Interfaces: USB, RS-232 and Analog**
- **Extensive Software Support, Compatible with MetaMorph Imaging Software**

The PIFOC® piezo objective scanner systems include a high precision piezo mechanism and a custom-tuned compact digital controller. This combination

provides higher performance at reduced costs. The piezo mechanisms combine large travel ranges of up to 400 µm with extreme position stability. The in-

tegrated, frictionless and stiff piezo flexure guiding system and the sophisticated digital servo, ensure high stiffness, fast response and minimal settling times. Highly parallel motion with minimum tilt improve image quality. Nevertheless, the focusing systems are extremely compact.

The settling time of less than 20 ms increases the throughput and allows rapid Z-stack acquisition.

For applications which need a particularly large clear aperture a version with a 29 mm diameter threaded insert is available.

Digital Controller for Automated Scans

Included in the delivery is a digital controller which opens up the possibilities of digital control for piezo-driven nanopositioning systems for the same price as analog controllers. The advantage: higher precision and simpler operation. The controller can also be used for applications which provide analog control signals: as a standard, a broadband analog input is provided as well as the two digital interfaces.

Flexibility: Software Configurable Servo Parameters

All servo controllers require

Ordering Information

PD72Z2CAA
Fast PIFOC® Piezo Nanofocusing Z-Drive, 250 µm, Capacitive Sensor, M32 Large Aperture QuickLock Thread Adapters, Digital Controller with USB, RS-232

PD72Z2CAQ
Fast PIFOC® Piezo Nanofocusing Z-Drive, 250 µm, Capacitive Sensor, M25 QuickLock Thread Adapters, Digital Controller with USB, RS-232

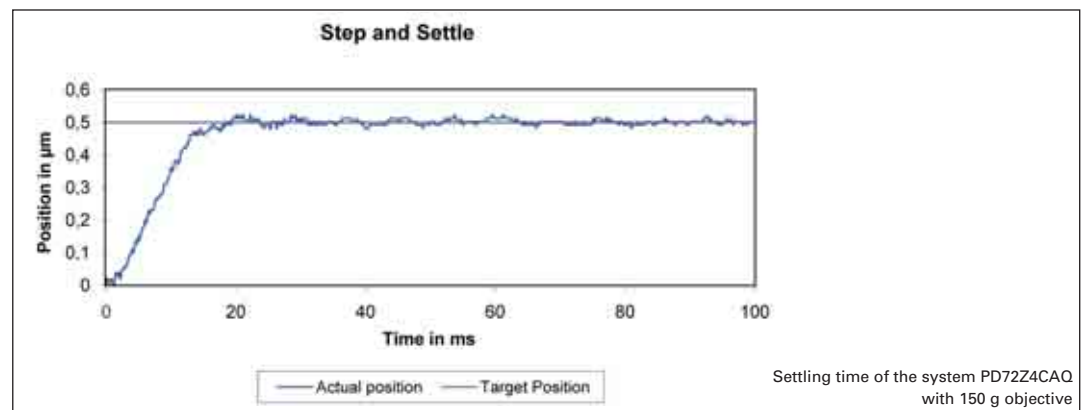
PD72Z4CAA
Fast PIFOC® Piezo Nanofocusing Z-Drive, 400 µm, Capacitive Sensor, M32 Large Aperture QuickLock Thread Adapters, Digital Controller with USB, RS-232

PD72Z4CAQ
Fast PIFOC® Piezo Nanofocusing Z-Drive, 400 µm, Capacitive Sensor, M25 QuickLock Thread Adapters, Digital Controller with USB, RS-232

tuning and adjustment of servo parameters for optimum performance (e.g. as a result of changes to the load or the motion profile). With a digital controller, all adjustments are carried out by simple software commands and the resulting motion or transient characteristics can be viewed, analyzed and further optimized immediately with the provided software. It is also possible to switch between previously

Application Examples

- Microscopy
- Confocal microscopy
- 3D Imaging
- Screening
- Autofocus systems
- Surface analysis
- Wafer inspection
- Multi-Photon Spectroscopy



found sets of parameters when the controller is in operation. Since jumpers and potentiometers no longer have to be set manually, system integration becomes much more straightforward.

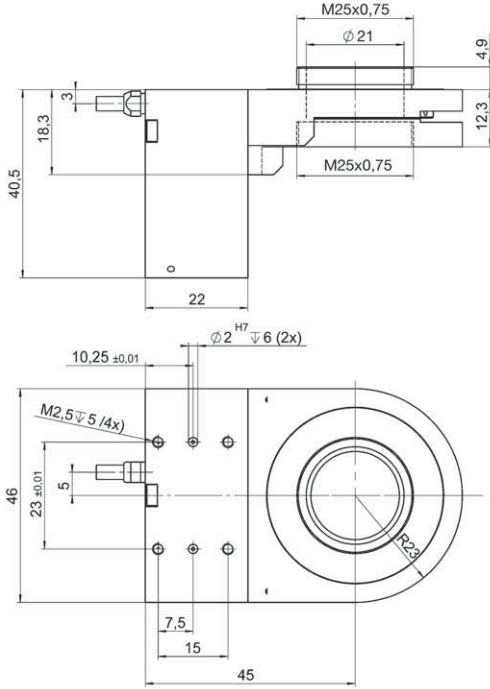
Easy System Setup, Comprehensive Software

All parameters can be set and checked by software. System setup and configuration is done with the included user-interface

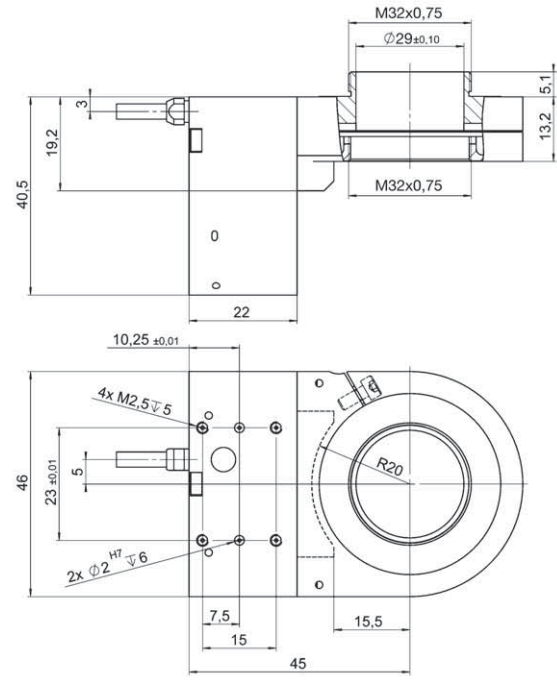
software. Interfacing to custom software is facilitated with included LabVIEW drivers and DLLs. Drivers for MetaMorph and μ Manager are available.

Technical Data

Model	PD72Z2CAA PD72Z2CAQ	PD72Z4CAA PD72Z4CAQ	Units	Tolerance
Active axes	Z	Z		
Motion and positioning				
Integrated sensor	Capacitive	Capacitive		
Closed-loop travel	250	400	μm	
Closed-loop resolution	1.5	2.5	nm	typ.
Linearity, closed-loop	0.06	0.06	%	typ.
Repeatability	± 5	± 5	nm	typ.
Runout θ_X	6	10	μrad	typ.
Runout θ_Y	45	45	μrad	typ.
Crosstalk in X	20	60	nm	typ.
Crosstalk in Y	40	60	nm	typ.
Settling time (0.5 μm step to 5 % accuracy, 150 g)	15	20	ms	typ.
Mechanical properties				
Stiffness in motion direction	0.17	0.12	N/ μm	$\pm 20\%$
Unloaded resonant frequency	330	230	Hz	$\pm 20\%$
Resonant frequency @ 150 g	140	120	Hz	$\pm 20\%$
Push/pull force capacity in motion direction	100 / 20	100 / 20	N	Max.
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Controller				
	Digital controller for single-axis piezo nanopositioning systems			
Processor	DSP 32-bit floating point, 150 MHz			
Communication interfaces	USB, RS-232			
Linearization	5th order polynomials			
Amplifier power	10 W (<5 ms); 5 W (>5 ms)			
I/O Connector	HD-Sub-D 26-pin, 1 Analog input 0 to 10 V, 1 Sensor monitor 0 to 10 V, 1 digital input (LVTTTL, programmable), 5 digital outputs (LVTTTL, 3 predefined, 2 programmable)			
User software	PIMikroMove, NanoCapture			
Software drivers	LabVIEW drivers, DLLs			
Supported functionality	Digital setting of the control parameters, wave generator, data recorder, auto zero, trigger I/O; Compatible to MetaMorph, μ Manager			
Display	Status LED, overflow LED			
Miscellaneous				
Operating temperature range	10 to 50 °C			
Material scanner	Aluminum			
Weight	0.23 kg (scanner), 0.5 kg (controller)			$\pm 5\%$
Cable length to controller	1.5 m			
Dimensions controller	160 x 96 x 33 mm			



PD72ZxCAQ with M25 QuickLock thread adapters, dimensions in mm



PD72ZxCAA with M32 large aperture QuickLock thread adapters, dimensions in mm

P-725 PIFOC® Long-Travel Objective Scanner

High-Precision Positioner / Scanner for Microscope Objectives



P-725.2CL with QuickLock option
P-721.12Q for W0.8 x 1/36" threads
and objective (QuickLock adapter
and objective not included)

- Travel Ranges to 460 μm
- Significantly Faster Response and Higher Lifetime than Motorized Z-Stages
- Scans and Positions Objectives with Sub-nm Resolution
- Direct Metrology with Capacitive Sensors for Highest Linearity
- Parallel Precision Flexure Guiding for Better Focus Stability
- Compatible with MetaMorph Imaging Software
- Outstanding Lifetime Due to PICMA® Piezo Actuators
- QuickLock Adapter for Easy Attachment
- Clear Aperture up to 29 mm \varnothing

P-725 PIFOC® nanofocus systems are long-travel (up to 460 μm), high-speed, piezo-driven microscope objective nanofocusing/scanning devices. The innovative, frictionless, flexure guiding system provides enhanced precision for superior focus stability with fast response for rapid settling and scanning. Despite the larger travel range, they are 20 % shorter than P-721 units (p. 2-25) while providing sub-nanometer reso-

lution. For applications which require a particularly high resolution, such as the two photon spectroscopy, there are versions which allow a free aperture of up to 29 mm in diameter.

Superior Accuracy With Direct-Metrology Capacitive Sensors

PI's proprietary capacitive sensors measure position directly and without physical contact. They are free of friction and hysteresis, a fact which, in combination with the positioning resolution of well under 1 nm, makes it possible to achieve very high levels of linearity. Further advantages of direct metrology with capacitive sensors is the high phase fidelity and the high bandwidth of up to 10 kHz.

Open-loop models are available for applications where fast response and very high resolution are essential. Here, specifying or reporting absolute position values is either not required or

Ordering Information

P-725 PIFOC® Piezo Nanofocusing Z-Drive for Long Scanning Ranges

- 1 Travel Range 100 μm (closed-loop)
- 2 Travel Range 250 μm (closed-loop)
- 4 Travel Range 400 μm (closed-loop)

P-725.

- CA Capacitive Sensor, Sub-D Connectors, for Large Aperture QuickLock Thread Adapters
- CD Capacitive Sensor, Sub-D Connectors, for QuickLock Thread Adapters
- CL Capacitive Sensor, LEMO Connector, for QuickLock Thread Adapters
- 0L No Sensor, LEMO Connectors, for QuickLock Thread Adapters, Travel Range see Data Table

Accessories

QuickLock Thread Adapters s. fig.,
Extension Tubes for Objectives s. www.pi.ws

is handled by external sensors, such as interferometers, a vision system or photodiode PSD (position sensitive detector). These models retain the inherent piezo advantages such as high resolution and speed.

Open-loop models are available for applications where fast response and very high resolution are essential. Here, specifying or reporting absolute position values is either not required or is handled by external sensors, such as interferometers, vision system or photodiode PSD (position sensitive detector). These models retain the inherent piezo advantages as high resolution and speed.

Simple Installation with QuickLock Thread Options

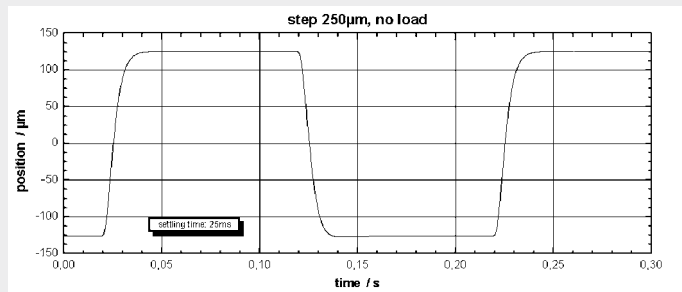
The PIFOC® is mounted between the turret and the objective with the QuickLock thread adapter. After threading the adapter into the turret, the QuickLock is affixed in the desired position. Because the PIFOC® body need not to be rotated, cable wind-up is not an issue.

High Reliability and Long Lifetime

The compact PIFOC® systems are equipped with preloaded PICMA® high-performance piezo actuators which are integrated into a sophisticated, FEA-modeled, flexure guiding system. The PICMA® actuators feature

Application Examples

- 3D-Imaging
- Screening
- Interferometry
- Metrology
- Disc-drive-testing
- Autofocus systems
- Confocal microscopy
- Biotechnology
- Semiconductor testing



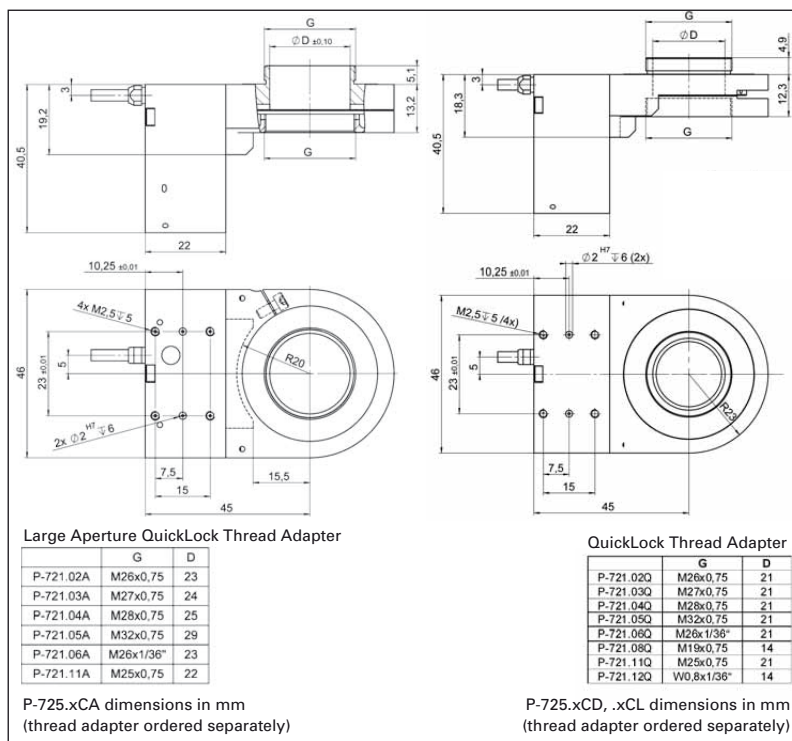
Fastest step and settle: The P-725.2CL can perform a 250 μm step to 1 % accuracy in only 25 ms (no load; 50 ms with a load of 150 g. With E-665.CR controller)

cofired ceramic encapsulation and thus offer better performance and reliability than conventional piezo actuators. Actuators, guidance and sensors are maintenance-free and not subject to wear, and thus offer an extraordinary reliability.

Scanner for Higher Dynamics and Higher Loads

PI offers a series of related PIFOC® objective scanners with different specifications. For higher loads and dynamic scanning applications the models P-726 (s.p. 2-32) and P-725.DD (s.p. 2-30) featuring a stroke of up to 100 µm are available.

Alternatively, the sample can be moved into focus: The P-737 piezo Z-nanopositioner features a large aperture to hold a variety of sample holders.



Technical Data

Model	P-725.1CL P-725.1CD P-725.1CA	P-725.2CL P-725.2CD P-725.2CA	P-725.4CL P-725.4CD P-725.4CA	P-725.x0L open-loop version	Units	Tolerance
Active axes	Z	Z	Z	Z		
Motion and positioning						
Integrated sensor	Capacitive	Capacitive	Capacitive	-		
Open-loop travel, -20 to +120 V	150	330	460	as P-725.xCL	µm	min. (+20%/-0%)
Closed-loop travel	100	250	400	-	µm	calibrated
Open-loop resolution	0.3	0.4	0.5	as P-725.xCL	nm	typ.
Closed-loop resolution	0.65	0.75	1.25	-	nm	typ.
Linearity, closed-loop	0.03	0.03	0.03	-	%	typ.
Repeatability	±5	±5	±5	-	nm	typ.
Runout Θ_x	1	6	10	as P-725.xCL	µrad	typ.
Runout Θ_y	20	45	45	as P-725.xCL	µrad	typ.
Crosstalk in X	20	20	60	as P-725.xCL	nm	typ.
Crosstalk in Y	20	40	60	as P-725.xCL	nm	typ.
Mechanical properties						
Stiffness in motion direction	0.23	0.17	0.12	as P-725.xCL	N/µm	±20%
Unloaded resonant frequency	470	330	230	as P-725.xCL	Hz	±20%
Resonant frequency @ 150 g	185	140	120	as P-725.xCL	Hz	±20%
Push/pull force capacity in motion direction	100 / 20	100 / 20	100 / 20	as P-725.xCL	N	Max.
Drive properties						
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	as P-725.xCL		
Electrical capacitance	4.2	6.2	6.2	as P-725.xCL	µF	±20%
Dynamic operating current coefficient	5.2	3.1	1.9	as P-725.xCL	µA/(Hz · µm)	±20%
Miscellaneous						
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum		
Max. objective diameter	39	39	39	39	mm	
Mass	0.215	0.23	0.23	as P-725.xCL	kg	±5%
Sensor / voltage connection	CL-version: LEMO others: Sub-D special	CL-version: LEMO others: Sub-D special	CL-version: LEMO others: Sub-D special	LEMO (no sensor)		

Recommended controller / amplifier
 CL-versions:
 E-610 servo controller / amplifier (p. 2-110); E-500 modular piezo controller system (p. 2-142) with E-505 high-performance amplifier module (p. 2-147) and E-509 controller (p. 2-152)
 CD/CA-versions:
 E-621 controller module (p. 2-160), E-625 servo controller, bench-top (p. 2-114), E-665 display servo controller, with digital interface, bench-top (p. 2-116)
 Single-channel digital controller:
 E-753 (bench-top) (p. 2-108), E-709

PIFOC® Objective Scanning System 2000 μm

NANOMETER RESOLUTION AND FAST STEP-AND-SETTLE



ND72Z2LAQ

- Complete system with digital controller, software and M32 threaded QuickLock insert
- 2000 μm travel range
- Objective positioning with nm resolution
- Highly dynamic step-and-settle for Z stacks
- Further thread adapters as optional accessory

PIFOC® objective scanning system for microscopy

Optimized for large travel ranges and fast step-and-settle with step sizes to 3 μm . Compact design and QuickLock thread adapters for easy integration in all standard microscopes. Ideally suited for 2-photon microscopy and all applications where a large travel range is required

Digital controller

All control parameters can be set and optimized via software. Trace Memory allows for displaying the path-time diagram on the host PC. Implemented macro functionality for carrying out measurement tasks, even without constant connection to the host PC

High resolution sensor

High-resolution, optical linear encoder for direct metrology with sub nm resolution for stable and precise position control

System with controller and software

The compact E-861.1A1 digital servo piezo controller is included in the delivery. Digital servos allow adaptation of all control parameters on the fly, by software. Control is possible via USB and RS-232. Supports PIMikroMove, NanoCapture. PI General Command Set (GCS). Drivers for LabVIEW, shared libraries for Windows and Linux. Compatible with μ Manager, MetaMorph and MATLAB

Fields of application

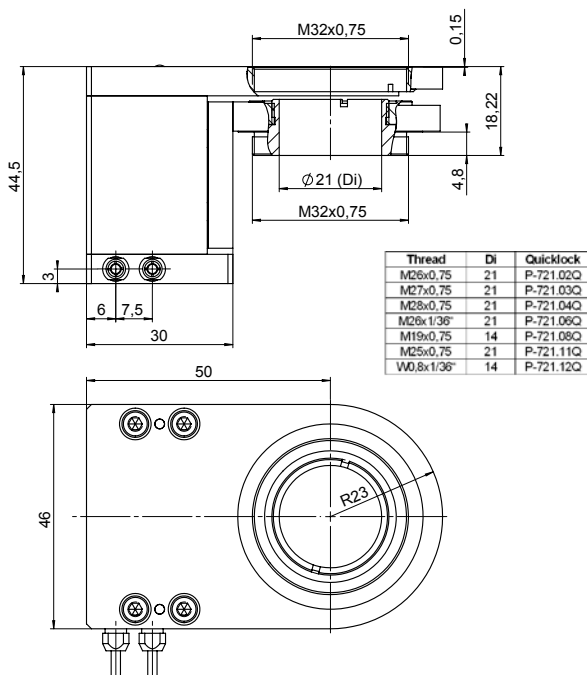
2-photon microscopy, confocal microscopy, 3D imaging, laser technology, interferometry, biotechnology, micro-manipulation, autofocus for large travel ranges

Accessories

M32 thread adapter included in delivery. Other threaded inserts available as option, see data table

	ND72Z2LAQ	Unit	Tolerance
Active axes	Z		
Motion and positioning			
Integrated sensor	Optical linear encoder		
Closed-loop travel	2000	µm	
Min. incremental motion, closed-loop	5	nm	typ.
Mechanical properties			
Step-and-settle time for a 3 µm step at 200 g payload, 100 nm settling band	<20	ms	
Recommended load*	700	g	max.
Drive properties			
Piezoceramics	NEXACT®		
Miscellaneous			
Operating temperature range	15 to 40	°C	
Material	Aluminium		
Mass	290	g	±5 %
Cable length	1.5	m	±10 mm
Piezo controller	E-861 digital servo (included in delivery)		
Communication interfaces	USB, RS-232		
Connector (motor)	HD Sub-D 15-pin		
Connector (sensor)	HD Sub-D 15-pin		
I/O connector	4× digital input (TTL, programmable) 4× digital output (TTL, programmable)		
Command set	PI General Command Set (GCS)		
User software	PIMikroMove®		
Software drivers	LabVIEW driver, dynamic libraries for Windows and Linux. Supports MATLAB, MetaMorph, µManager.		
Supported functionality	Wave generator, data recorder, macro programming		
Controller dimensions	160 mm × 96 mm × 33 mm		

Ask about custom designs!



N-725.2A with M32 threaded insert, dimensions in mm