

P-722
P-723

PIFOC® Microscope Objective NanoPositioners & Scanners

Application Examples

- Scanning interferometry
- Surface structure analysis
- Disk-drive testing
- Autofocus systems
- Confocal microscopy
- Biotechnology
- Semiconductor test equipment

- Remotely Positions Objectives with nm Resolution
- Travel to 350 µm
- Precision Trajectory Control
- Settling Time 20-30 msec
- Compatible with Universal Imaging Software

P-722/P-723 PIFOC® microscope objective NanoPositioners are fast and compact drive units which can be mounted on most microscopes. The units are screwed between the turret and the objective, providing a positioning and scanning range of up to 350 µm with nanometer resolution while extending the optical path by only 13 mm (infinity-corrected microscope required; extension tubes are available to adjust path lengths of other objectives on the turret). The standard thread is $W0.8 \times 1/36"$, for alternate threads see Ordering Information. For smaller positioning ranges see models P-720 & P-721 (page 2-10).

Open- & Closed-Loop Models

In open-loop operation, the vertical position of the objective is roughly proportional to the drive voltage (see p. 4-11 in the "Tutorial: Piezoelectrics in Positioning" section for behavior of open-loop piezos). The open-loop models P-722.00 / P-723.00 are ideal for tracking applications where the position is controlled by data provided by an external sensor (e.g. optical displacement sensor, a CCD camera,



P-722 Objective NanoPositioners, front and side view, shown with objective (not included)

etc.). The closed-loop versions allow for absolute position control, high linearity and repeatability based on an integrated position feedback sensor.

A special PIFOC® for moving the complete **microscope turret** rather than an objective is available on request.

Working Principle

PIFOC® positioners are equipped with low-voltage piezoelectric drives (0 to 100 V) integrated into a sophisticated flexure guiding system. The force exerted by the piezo drive pushes a flexure parallel-gram via an integrated motion amplifier. The wire-EDM-cut flexures are FEA modeled for zero stiction/friction, ultra-high resolution and exceptional guiding precision.

Notes

See the "PZT Control Electronics" section for our comprehensive line of low-noise modular and OEM control electronics for computer and manual control.

Ordering Information

P-722.00

PIFOC® Objective Positioner & Scanner,
200 μm , Thread $W0.8 \times 1/36''$

P-722.07

PIFOC Objective Positioner & Scanner,
200 μm , Specify Thread (P-722.01 - .08)

P-722.10

PIFOC® Objective Positioner & Scanner,
200 μm , LVDT, $W0.8 \times 1/36''$

P-722.17

PIFOC® Objective Positioner & Scanner,
200 μm , LVDT, Specify Thread
(P-722.01 - .08)

P-723.00

PIFOC® Objective Positioner & Scanner,
350 μm , Thread $W0.8 \times 1/36''$

P-723.07

PIFOC® Objective Positioner & Scanner,
350 μm , Specify Thread (P-722.01 - .08)

P-723.10

PIFOC® Objective Positioner &
Scanner, 350 μm , LVDT, $W0.8 \times 1/36''$

P-723.17

PIFOC® Objective Positioner & Scanner,
350 μm , LVDT, Specify Thread
(P-722.01 - .08)

Custom Designs for Volume Buyers

Optional Threads for

P-722.07/17 & P-723.07/17:

P-722.01

Thread $M25 \times 0.75$ for P-722.07/17,
P-723.07/17

P-722.02

Thread $M26 \times 0.75$ for P-722.07/17,
P-723.07/17

P-722.03

Thread $M27 \times 0.75$ for P-722.07/17,
P-723.07/17

P-722.04

Thread $M28 \times 0.75$ for P-722.07/17,
P-723.07/17

P-722.05

Thread $M32 \times 0.75$ for P-722.07/17,
P-723.07/17

P-722.06

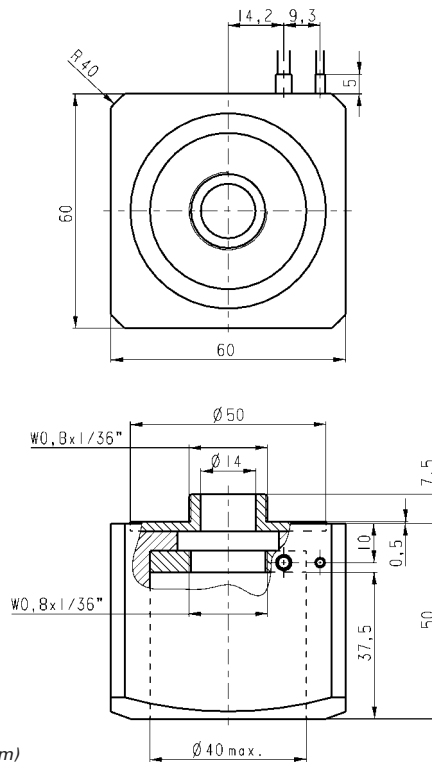
Thread $M26 \times 1/36''$ for P-722.07/17,
P-723.07/17

P-722.08

Thread $M19 \times 0.75$ for P-722.07/17,
P-723.07/17

Objective Extension Tubes:

see P-720/P-721 Ordering Information
(page 2-10)



P-722, P-723
dimensions (in mm)

Technical Data

Models	P-722.00	P-722.10	P-723.00	P-723.10	Units	Notes see p. 2-44
Max. objective diameter	39	39	39	39	mm	
Open-loop travel @ 0 to 100 V	200	200	350	350	$\mu\text{m} \pm 20\%$	A2
Closed-loop travel \geq	-	200	-	350	μm	A5
Integrated feedback sensor	-	LVDT	-	LVDT		B
Closed-loop / open-loop ** resolution \leq	- / 2	10 / 2	- / 3	10 / 3	nm	C1
Closed-loop linearity (typ.)	-	0.1	-	0.1	%	
Full-range repeatability (typ.)	-	± 40	-	± 60	nm	C3
Stiffness	0.38	0.38	0.32	0.32	$\text{N}/\mu\text{m} \pm 20\%$	D1
Push/pull force capacity (in operating direction)	20 / 20	20 / 20	20 / 20	20 / 20	N	D3
Tilt (θ_x, θ_y) (typ.)	15	15	25	25	μrad	E1
Electrical capacitance	7.8	7.8	11.1	11.1	$\mu\text{F} \pm 20\%$	F1
* Dynamic operating current coefficient (DOCC)	4.8	4.8	3.9	3.9	$\mu\text{A}/(\text{Hz} \times \mu\text{m})$	F2
Unloaded resonant frequency	300	300	150	150	$\text{Hz} \pm 20\%$	G2
Resonant frequency @ 150 g load	180	180	100	100	$\text{Hz} \pm 20\%$	G3
Operating temperature range	- 20 to 80	- 20 to 80	- 20 to 80	- 20 to 80	$^{\circ}\text{C}$	H2
Voltage connection	VL	VL	VL	VL		J1
Sensor connection	-	L	-	L		J2
Weight (with cables)	400	410	410	420	$\text{g} \pm 5\%$	
Body material	Al	Al	Al	Al		L
Recommended driver/controller (codes explained p. 6-46)	G, C, (A)	H, E	G, C, (A)	H, E		

* Dynamic Operating Current Coefficient in μA per hertz and μm .

Example: Sinusoidal scan of $30 \mu\text{m}$ at 10 Hz requires approximately 1.4 mA drive current (P-722).

** Resolution of PZT NanoPositioners is not limited by friction or stiction. Noise equivalent motion with E-503 amplifier.

P-725

PIFOC® Long Range Microscope Objective Positioners & Scanners with Capacitive Sensors



P-725.2CL with QuickLock option
P-721.12Q for W0.8 x 1/36" threads and objective.

- **Scans and Positions Objectives with Sub-nm Resolution**
- **High Linearity and Stability with Direct-Measuring Capacitive Sensors**
- **Travel to 500 μm**
- **Most-Compact Unit with Direct Metrology**
- **Enhanced Guiding Precision for Better Focus Stability**
- **Fast Response & Settling Time**
- **Compatible with Metamorph™ Imaging Software**
- **QuickLock Adapter for Easy Attachment**

P-725s are long-range-travel additions to our PIFOC® family of microscope objective nanofocussing devices. Despite the increased travel ranges (up to 500 μm) the units are 20% shorter than the P-721 series (page 2-10), while providing sub-nanometer resolution. The long travel range is achieved with a newly designed, friction-free and extremely stiff flexure system which also offers high guiding accuracy and rapid settling.

P-725 PIFOCs® are screwed between the turret and the objective, extending the optical path by only 12.5 mm (infinity-corrected microscope required; extension tubes are available to adjust path lengths of other objectives on the turret).

Superior Accuracy Through Direct-Motion-Metrology Capacitive Feedback Sensors

P-725s are equipped with direct-measuring capacitive po-

sition sensors. Unlike conventional indirect systems, they measure the position rather than strain in the actuator / guiding system. Capacitive sensors are absolute-measuring devices and show none of the periodic errors found in incremental linear encoders. This permits motion linearity of better than 0.03% and resolution in the sub-nanometer range. This technique, combined with the inherent precision of the non-contact, two-plate capacitive sensor and the temperature-compensated design, results in higher linearity scans, and provides superior responsiveness, resolution, repeatability and stability at the nanometer level.

Fastest Step-and-Settle: 25 Milliseconds for 250 Microns

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

A variety of analog and digital controllers (OEM, bench-top and rackmount) are available to drive the units. The P-725.xCD model can be operated with the new E-665 servo-controller through an analog or RS-232 interface or the E-750 high-speed digital NanoAutomation® controller (see page 6-12). This controller also features a number of options such as high-throughput PIO (parallel I/O) or fiber link interfacing and InputShaping® signal processing for even faster settling.

Ordering Information

P-725.1CL
PIFOC® Objective Positioner & Scanner, 100 μm , Capacitive Sensor, LEMO Connectors, for QuickLock Thread Adapters

P-725.1CD
PIFOC® Objective Positioner & Scanner, 100 μm , Capacitive Sensor, Sub-D connector, for QuickLock Thread Adapters

P-725.2CL
PIFOC® Objective Positioner & Scanner, 250 μm , Capacitive Sensor, LEMO Connectors, for QuickLock Thread Adapters

P-725.2CD
PIFOC® Objective Positioner & Scanner, 250 μm , Capacitive Sensor, Sub-D connector, for QuickLock Thread Adapters

P-725.4CL (Preliminary Data)
PIFOC® Objective Positioner & Scanner, 400 μm , Capacitive Sensor, LEMO Connectors, for QuickLock Thread Adapters

P-725.4CD (Preliminary Data)
PIFOC® Objective Positioner & Scanner, 400 μm , Capacitive Sensor, Sub-D connector, for QuickLock Thread Adapters

Custom Designs for Volume Buyers

<http://www.pi.ws>
info@pi.ws

Increased Lifetime with New Piezoceramic

The P-725 PIFOC® units are driven with PI Ceramic's PICMA high-performance, multilayer piezo ceramic actuators. These newly designed and highly optimized drives are more robust than conventional piezo actuators, and feature superior lifetime in dynamic and static applications. Because guidance and sensors are all frictionless and maintenance-free, PIFOC® systems achieve exceptional levels of reliability.

Working Principle

PIFOC® positioners are equipped with high-performance piezoelectric drives integrated in a sophisticated flexure guiding system. The force exerted by the piezo drive pushes a flexure parallelogram via an integrated motion amplifier. The wire-EDM-cut flexures are FEA modeled for zero stiction/friction, high resolution and exceptional guiding precision. An integrated, direct-measuring, non-contact, two-plate capacitive position sen-

Application Examples

- Scanning interferometry
- Surface structure analysis
- Disk drive testing
- Autofocus systems
- Confocal microscopy
- Biotechnology
- Semiconductor test equipment

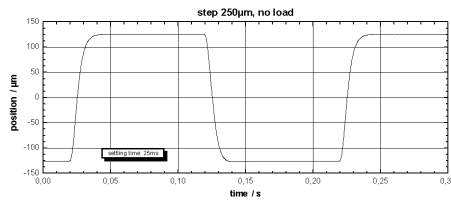
sor provides the highest possible resolution, linearity and stability in closed-loop operation.

QuickLock

The new QuickLock thread adapter options allow

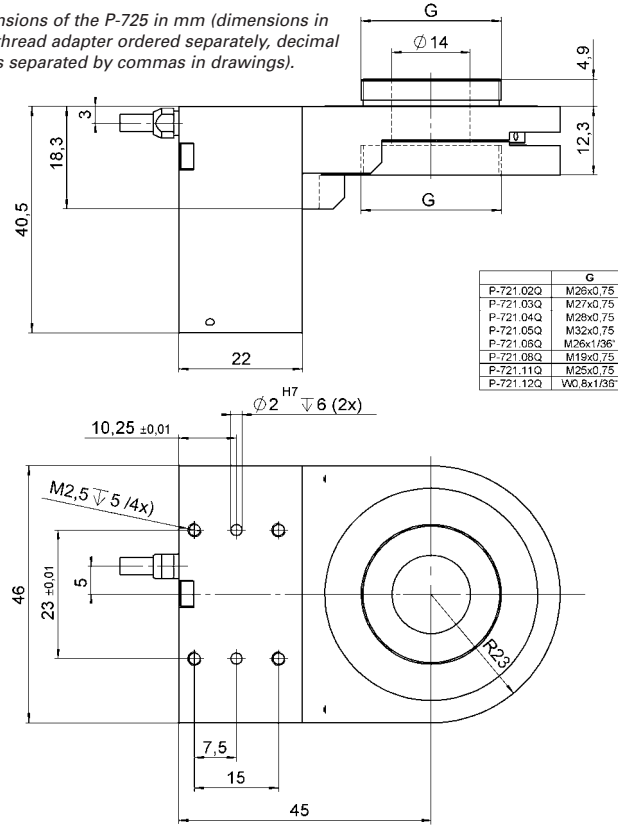
- Easy attachment of the PIFOC® to the microscope.
- Flexible use of different thread adapter options with one PIFOC® nanofocussing device.

After the thread adapter is screwed into the microscope, the PIFOC® is attached to the adapter with the QuickLock system in the desired position. Mounting does not require rotation of the PIFOC® unit, so there are no cable twisting issues. Be sure to order the required thread adapters separately: the basic P-725 PIFOC® units do not include any QuickLock thread adapters.



25 ms for a 250 µm step-top dynamic performance of the P-725.2CL PIFOC.

Dimensions of the P-725 in mm (dimensions in mm, thread adapter ordered separately, decimal places separated by commas in drawings).



Technical Data

Models	P-725.1CL, P-725.2CL, P-725.1CD	P-725.2CD	P-725.4CL, Units P-725.4CD Preliminary Data	Notes see page 2-44
Max. objective diameter	39	39	39	mm
Min. Open-loop travel @ -20 to 120 V	150	330	500	µm ±20%
Closed-loop travel	100	250	400	µm
Integrated feedback sensor	Capacitive	Capacitive	Capacitive	B
Closed-loop ** resolution	0.65	0.75		nm
Closed-loop linearity (typ.)	0.03	0.03		%
Full-range repeatability (typ.)	±5	±5		nm
Stiffness	0.25	0.2		N/µm ±20%
Push/pull force capacity (in operating direction)	100 / 20	100 / 20		N
Tilt (θ _x) (typ.)	1	6		µrad
Tilt (θ _y) (typ.)	20	45		µrad
Lateral runout (Y) (typ.)	40	40		nm
Electrical capacitance	4.2	6.0		µF ±20%
* Dynamic operating current coefficient (DOCC)	4.0	2.5		µA/(Hz × µm)
Unloaded resonant frequency	530	330		Hz ±20%
Resonant frequency @ 120 g load	205	180		Hz ±20%
Resonant frequency @ 200 g load	160	140		Hz ±20%
Operating temperature range	-20 to 80	-20 to 80		°C
Voltage connection	P-725.xCL: VL; P-725.xCD: D			J1
Sensor connection	P-725.xCL: 2 × C; P-725.xCD: D			J2
Weight (with cables)	215 (230)	230 (245)		g ±5%
Body material	Al	Al	Al	L
Recommended driver/controller (codes explained p. 6-46)	H, M, F	H, M, F	H, M, F	

* Dynamic Operating Current Coefficient in µA per hertz and µm.

Example: Sinusoidal scan of 30 µm at 10 Hz requires approximately 1.4 mA drive current.

** Resolution of PZT NanoPositioners is not limited by friction or stiction. Noise equivalent motion with E-503 amplifier.

Notes

QuickLock Thread adapters

P-721.11Q

QuickLock Thread Adapter
M25 × 0.75

P-721.12Q

QuickLock Thread Adapter
W0.8 × 1/36"

P-721.02Q

QuickLock Thread Adapter
M26 × 0.75

P-721.03Q

QuickLock Thread Adapter
M27 × 0.75

P-721.04Q

QuickLock Thread Adapter
M28 × 0.75

P-721.05Q

QuickLock Thread Adapter
M32 × 0.75

P-721.06Q

QuickLock Thread Adapter
M26 × 1/36"

P-721.08Q

QuickLock Thread Adapter
M19 × 0.75

Objective Extension Tubes

P-721.90Q

Objective extension tube,
12.5 mm, thread W0.8 × 1/36"

P-721.91Q

Objective extension tube,
12.5 mm, thread M25 × 0.75

P-721.92Q

Objective extension tube,
12.5 mm, thread M26 × 0.75

P-721.93Q

Objective extension tube,
12.5 mm, thread M27 × 0.75

P-721.94Q

Objective extension tube,
12.5 mm, thread M28 × 0.75

P-721.95Q

Objective extension tube,
12.5 mm, thread M32 × 0.75

P-721.96Q

Objective extension tube,
12.5 mm, thread M26 × 1/36"

P-721.98Q

Objective extension tube,
12.5 mm, thread M19 × 0.75



P-721.12Q QuickLock thread adapter, exploded view with microscope objective and PIFOC®. Mounting tools are included.