

# N-725 PIFOC® High-Load Objective Scanner

## 1 mm Travel, Fast Response and Nanometer Precision



N-725 PIFOC® is the first piezo-objective drive with integrated NEXACT® Piezo Linear Motor, combining smooth motion, long travel ranges and fast response with extreme position stability

- **High Force & High-Dynamics for Positioning and Scanning of Large Objectives up to 29 mm Ø**
- **1 mm Travel for Applications with Large Penetration Depth**
- **Ideal for e. g. Two-Photon Microscopy**
- **Very Fast Response: 20 ms Step and Settle Time**
- **Self Locking at Rest, no Heat Generation, no Servojitter**
- **Drive Resolution < 1 nm, 20 nm Encoder Resolution**
- **Two Motion Modes: Continuous Nanostepping and High-Dynamics Analog Mode**
- **Compact Design: Ø 48 mm, 40.5 mm Height**
- **Frictionless, High-Precision Flexure Guiding System for Better Focus Stability**
- **QuickLock Thread Adapter for Simple Installation**

The N-725 PIFOC® is the first piezo objective nanopositioner equipped with a PiezoWalk® linear motor. This drive combines smooth motion, long travel ranges and fast step and settle with extreme position stability. Its exceptional stroke of 1 mm renders stepper motor positioners -often used as range ex-

tenders for piezo drives- unnecessary. The focussing plane can be selected in an extended range without any change of the mechanics. Together with a step and settle time of less than 20 ms this allows for higher throughput.

The large travel range is a big advantage for applications that have large optical penetration depth like two-photon microscopy where it allows to make use of the full working range of the objective and quickly scan through z stacks of up to 1 mm.

### 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.

### PiezoWalk® – the Multi-Functional Piezo Linear Motor

A great advantage characteristic of the NEXACT® drive principle is its dual-mode operating principle combining the best features of piezo motor designs, such as high resolution, high force and high speed into one compact unit. At the target position the drive requires no current and generates no heat while providing long-term, nanometer stability. This autolocking feature also completely eliminates servo jitter as it occurs with other closed-loop motors. Since motion is solely caused by the nanometer precise motion of clamped piezo actuators, there is no wear to limit the lifetime. When operated in closed-loop, excellent velocity control is achieved.

See p. 1-12 for further information on NEXACT® PiezoWalk® technology.

### Controller and Drive Electronics Optimized for the Application

NEXACT® actuators require special drive electronics to control the complex stepping sequences. The E-861 includes complete NEXACT® servo controller with low-noise drivers and a powerful DSP. It also comes with ample software for easy integration and highly effective computer control. For applications which do not require the highest resolution, the E-862 lower-priced drive electronics can be ordered.

The products described in this document are in part protected by the following patents: German Patent No. P4408618.0

### Ordering Information

**N-725.1A**  
PIFOC® Piezo Nanofocusing Z-Drive with NEXACT® Linear Motor, 1 mm, Linear Encoder, 20 nm Resolution, for QuickLock Thread Adapters

#### Accessories

QuickLock Thread Adapters: see figure

**P-721.90Q**  
Extens. Tube, 12.5 mm, Thread W0.8 x 1/36"

**P-721.91Q**  
Extens. Tube, 12.5 mm, Thread M25 x 0.75

**P-721.92Q**  
Extens. Tube, 12.5 mm, Thread M26 x 0.75

**P-721.93Q**  
Extens. Tube, 12.5 mm, Thread M27 x 0.75

**P-721.94Q**  
Extens. Tube, 12.5 mm, Thread M28 x 0.75

**P-721.95Q**  
Extens. Tube, 12.5 mm, Thread M32 x 0.75

**P-721.96Q**  
Extens. Tube, 12.5 mm, Thread M26 x 1/36"

**P-721.98Q**  
Extens. Tube, 12.5 mm, Thread M19 x 0.75

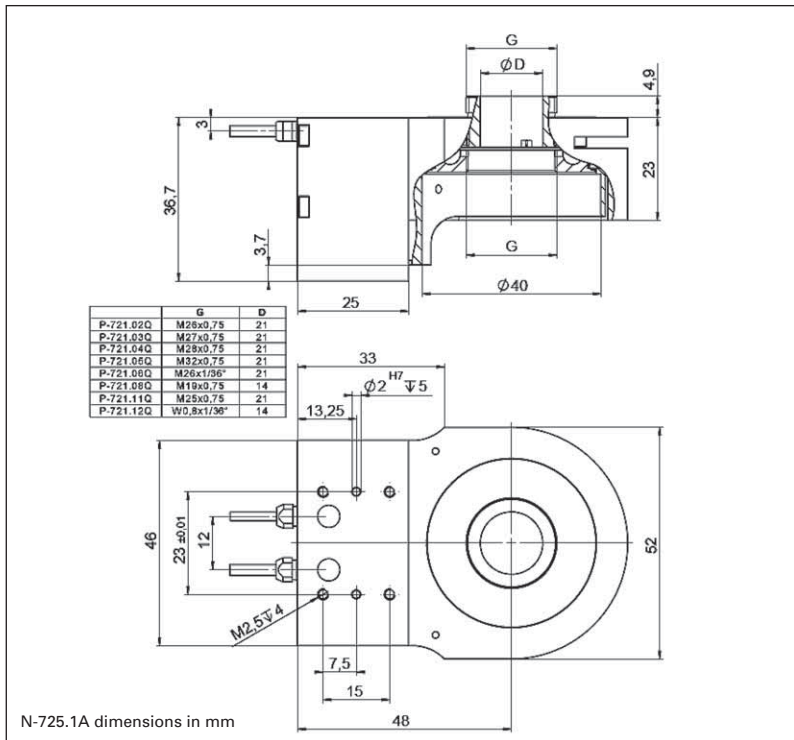
**Ask about custom designs!**

### Scanner for Higher Resolution and Higher Loads

PI offers a range of related PIFOC® objective scanners with different specifications. The P-725 models e. g. (s. p. 2-28) offer resolutions of less than one nanometer. For larger loads and dynamic scanning applications the models P-726 (s. p. 2-32) and P-725.DD (s. p. 2-30) are also available with travel ranges of up to 100 µm.

### Application Examples

- 3-D Imaging
- Screening
- Autofocus systems
- Microscopy
- Confocal microscopy
- Surface structure analysis
- Wafer inspection



## Technical Data

|                                 |  |
|---------------------------------|--|
| <b>Model</b>                    | <b>N-725.1A</b>  |
| Active axes                     | Z  |
| <b>Motion and positioning</b>   |  |
| Travel range                    | 1 mm   |
| Integrated sensor               | Linear encoder   |
| Sensor resolution               | 20 nm *  |
| Travel range in analog mode     | 7 µm   |
| Closed-loop resolution          | 20 nm *  |
| Linearity, closed-loop          | 0.1%   |
| Bidirectional repeatability     | 50 nm  |
| Rotation (X, Y) typ.            | 15 µrad / 100 µm   |
| Step and Settle (200 nm), typ.  | 20 ms  |
| Max. velocity                   | 10 mm/s*   |
| <b>Mechanical properties</b>    |  |
| Stiffness in motion direction   | 0.5 N/µm   |
| Max. push / pull force (active) | 10 N   |
| <b>Drive properties</b>         |  |
| Drive type                      | NEXACT® linear drive   |
| Operating voltage               | -10 V to +45 V   |
| <b>Miscellaneous</b>            |  |
| Operating temperature range     | 0 to 50°C  |
| Material                        | Aluminium  |
| Mass                            | 440 g  |
| Cable length                    | 1.5 m  |
| Connector                       | HD sub-D connector, 15-pin                                     |
| Recommended controller          | E-861.1A1 Controller for NEXACT® Linear Drives and Positioners |

\* With E-861. Depending on drive electronics.

Linear Actuators & Motors

Nanopositioning / Piezoelectrics

Piezo Flexure Stages / High-Speed Scanning Systems

Linear

Vertical & Tip/Tilt

2- and 3-Axis

6-Axis

Fast Steering Mirrors / Active Optics

Piezo Drivers / Servo Controllers

Single-Channel

Multi-Channel

Modular

Accessories

Piezoelectrics in Positioning

Nanometrology

Micropositioning

Index



### Easy System Set-up, Comprehensive Software Package

All parameters can be set and checked via software. For system setup and configuration the versatile PIMikroMove user-interface software is included. Interfacing to custom software is facilitated with LabView drivers and DLLs.

### Scanners for Higher Resolution and Larger Loads

PI offers a range of related PIFOC® objective scanners with different specifications. The P-725 models e.g. (s.p. 2-28) offer resolutions of less than one nanometer. For larger loads

and dynamic scanning applications the models P-726 (s.p. 2-32) and P-725.DD (s.p. 2-30) are also available with travel ranges of up to 100 µm.

### NEXACT® PiezoWalk® Technology

See page 1-12 for further information.

The products described in this document are in part protected by the following patents:  
German Patent No. P4408618.0

## Technical Data

|                                 |   |
|---------------------------------|---|
| <b>Model</b>                    | <b>ND72Z9LAQ</b>  |
|                                 | Long-travel objective scanning system, incl. controller   |
| Active axes                     | Z   |
| <b>Motion and positioning</b>   |   |
| Travel range                    | 1 mm  |
| Integrated sensor               | Linear encoder  |
| Sensor resolution               | 20 nm   |
| Linearity, closed-loop          | 0.1 %   |
| Bidirectional repeatability     | 50 nm   |
| Runout (X, Y) typ.              | 15 µrad / 100 µm  |
| Step and settle (200 nm) typ.   | 20 ms   |
| Max. velocity                   | 10 mm/s   |
| <b>Mechanical properties</b>    |   |
| Stiffness in motion direction   | 0.5 N/µm  |
| Max. push / pull force (active) | 10 N  |
| Drive resolution                | < 1 nm  |
| <b>Drive properties</b>         |   |
| Drive type                      | NEXACT® linear drive  |
| <b>Controllers</b>              |   |
| Communication interfaces        | USB 1.0, RS-232 (9-pin (m) sub-D)   |
| I/O ports                       | 4 analog/digital in, 4 digital out (TTL)  |
| User software                   | PIMikroMove®, PI Terminal   |
| Software drivers                | GCS-DLL, LabVIEW Driver   |
| Supported functionality         | Digital setting of the control parameters on-the-fly; start-up macro; data recorder for recording parameters such as motor input voltage, velocity, position or position error; internal safety circuit: watchdog timer |
| <b>Miscellaneous</b>            |   |
| Operating temperature range     | 0 to 50 °C  |
| Material Scanner                | Aluminum  |
| Weight                          | 440 g (scanner), 1.1 kg (controller)  |
| Cable length to controller      | 1.5 m   |
| Dimensions controller           | 206 x 130 x 66 mm (including mounting rails)  |

# 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  $\mu\text{m}$
- 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  $\mu\text{m}$ ), 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  $\mu\text{m}$  (closed-loop)
  - 2 Travel Range 250  $\mu\text{m}$  (closed-loop)
  - 4 Travel Range 400  $\mu\text{m}$  (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.

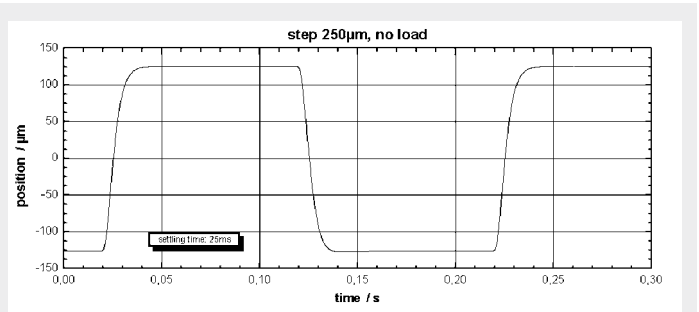
Open-loop models are available for applications where fast response and very high resolution are essential. Here, specifying or reporting absolute position values is either not required or is handled by external sensors, such as interferometers, vision system or photodiode PSD (position sensitive detector).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



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

### Application Examples

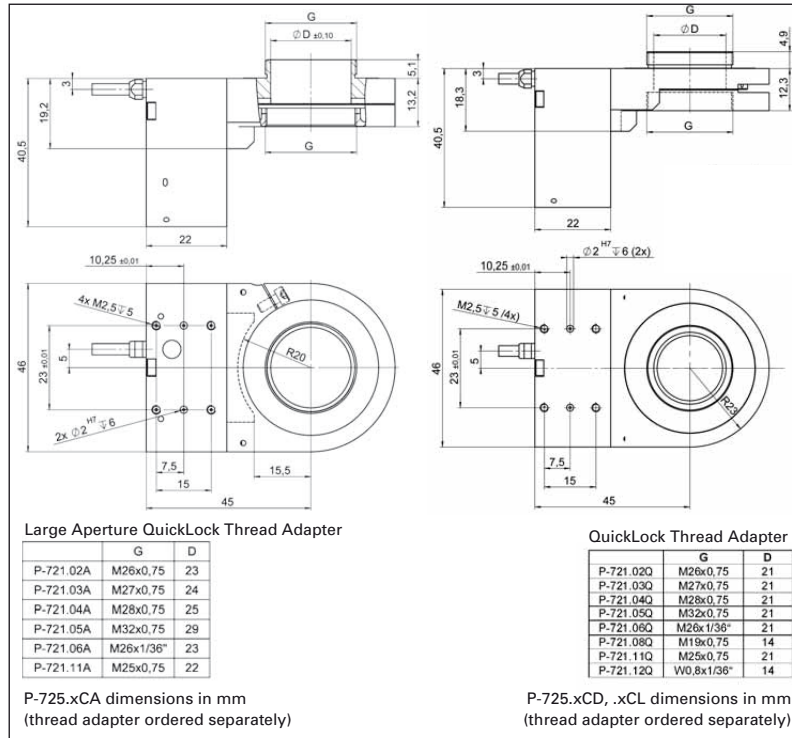
- 3D-Imaging
- Screening
- Interferometry
- Metrology
- Disc-drive-testing
- Autofocus systems
- Confocal microscopy
- Biotechnology
- Semiconductor testing

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<br>P-725.1CD<br>P-725.1CA          | P-725.2CL<br>P-725.2CD<br>P-725.2CA          | P-725.4CL<br>P-725.4CD<br>P-725.4CA          | P-725.x0L<br>open-loop<br>version | Units        | Tolerance       |
|--|--|--|--|-----------------------------------|--------------|-----------------|
| Active axes                                  | Z  | Z  | Z  | Z                                 |              |                 |
| <b>Motion and positioning</b>                |  |  |  |                                   |              |                 |
| 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 $\Theta_x$                            | 1  | 6  | 10   | as P-725.xCL                      | µrad         | typ.            |
| Runout $\Theta_y$                            | 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.            |
| <b>Mechanical properties</b>                 |  |  |  |                                   |              |                 |
| 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.            |
| <b>Drive properties</b>                      |  |  |  |                                   |              |                 |
| 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%            |
| <b>Miscellaneous</b>                         |  |  |  |                                   |              |                 |
| 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<br>others:<br>Sub-D special | CL-version: LEMO<br>others:<br>Sub-D special | CL-version: LEMO<br>others:<br>Sub-D special | LEMO<br>(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