High Precision
For Extreme Environments

attoMOTION

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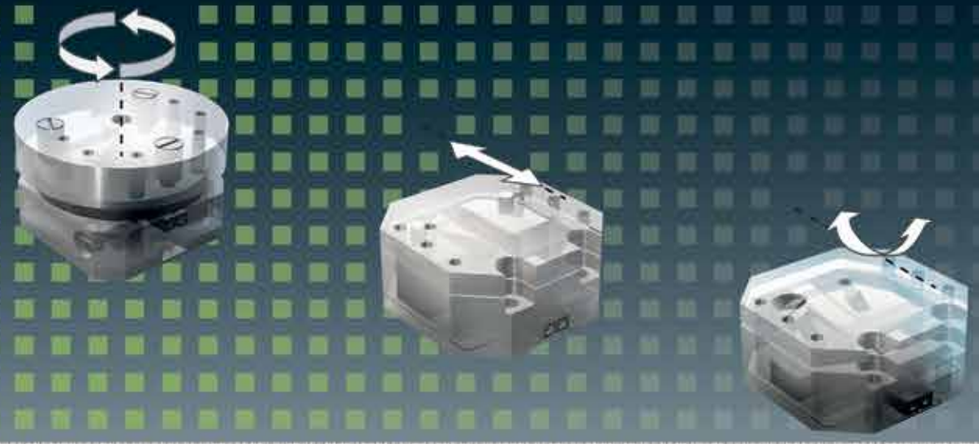

Premium Line

Linear Positioners | Goniometers | Rotators | Scanners

TOP 100
Top-Innovator 2013

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Premium Line Positioners

nanoprecise positioning in extreme environments

The great success of attocube's positioners is based on the unique combination of a patented driving technology, the powerful design, the selection of high quality materials, and the long experience of the attocube staff.
Premium Line positioners allow for reliable motion over centimeter ranges with the highest precision under extreme environmental conditions such as cryogenic temperatures, high magnetic fields, and ultra high vacuum.

The ANP portfolio comprises linear, rotational, and goniometric positioners and scanners – many of them with integrated position sensors for closed loop operation. Depending on the requirements, different sizes, travel ranges, and encoder options are available. The innovative design enables the assembling of several stages to positioning units with up to six degrees of freedom.

Extreme Environments

The non-magnetic ANP product line meets the challenge of nanoprecise, commercially available positioning systems working reliably under extreme environmental conditions. Suitable models are available for cryogenic temperatures, high and ultra high vacuum.

Closed Loop Control

Exact and repeatable positioning in absolute and relative terms is an easy task for all Premium Line positioners with implemented encoders. Depending on the positioner type and model up to two different encoder options are available: a resistive encoder optimized for cryogenic applications and an optoelectronic encoder interesting for applications at ambient temperatures.

Large Travel Ranges in Extreme Environments

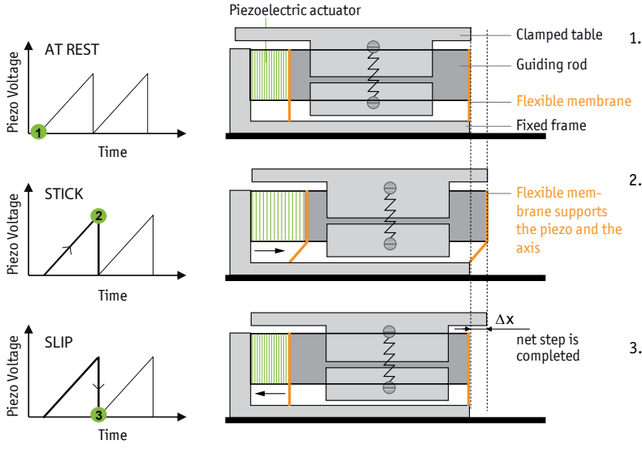
Positioners of the Premium Line take advantage of attocube's patented inertial drive technology, which is dedicated for use in extreme working environments. Controllable motion over centimeter ranges with small reproducible steps can also be achieved in cryogenic environments, where PZT piezo ceramics are usually limited to scanning ranges of only a few microns.

Multi Axis Operation

attocube's ANP positioners are available in a large variety of designs, sizes, and travel ranges. They can be stacked directly on top of each other and thus offer the highest flexibility for multi axis operation.

Working Principle

Working Principle - Coarse Positioners (ANP, ANR, ANG models)

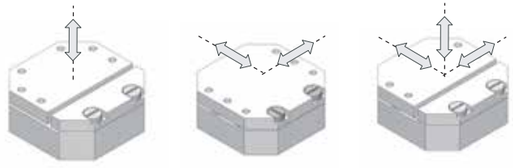


1. A guiding rod is firmly connected to a piezoelectric actuator while the moving table is clamped to it. The piezo is a passive element and expands its length proportional to applied voltages. The slip stick motion is based on the application of sawtooth shaped voltage pulses to the piezo.
2. During the slowly increasing voltage phase the clamped table sticks to the guiding rod and is moved over a distance Δx. The achieved expansion Δx is proportional to the applied maximum voltage. The typical minimum step size for ANP positioners is in the range of 50 nm at ambient conditions and 10 nm at cryogenic temperatures.
3. By applying the steep flank of the voltage pulse to the piezo, the guiding rod is accelerated very rapidly over a short period of time, so that the inertia of the clamped table overcomes friction. This way, the clamped table disengages from the accelerated rod and remains nearly stationary. The net step Δx is now completed.

By repeating this procedure the table can be moved over large distances with nanometer precision.

Working Principle – Scanners (ANS)

All ANS scanner units consist of a compact frame with integrated flexure structures. Depending on the scanner type, a set of suitable piezo stacks are implemented in the frame. By applying unipolar DC voltages to the piezo elements, the piezo itself is expanded. The flexures amplify this motion and samples mounted on an ANS scanner unit experience a scan motion much larger than for standard PZT scanners. The flexure structures of all ANS scanners are optimized for large scan ranges at cryogenic temperatures.



One-dimensional z scanner | Two-dimensional xy scanner | Three-dimensional xyz scanner

MAIN ADVANTAGES OF PREMIUM LINE POSITIONERS

- The positioners can be operated as coarse stepper and fine positioning units at the same time by either applying a sawtooth voltage pattern or a slowly changing DC voltage.
- All Premium Line positioners offer highest precision motion on the nanometer scale over centimeter travel ranges, even under extreme environmental conditions such as cryogenic temperatures, ultra high vacuum, and high magnetic fields .
- ANP positioning systems are available both as open loop versions as well as models with integrated encoders.

Working Environments

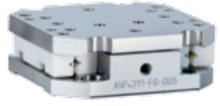
attocube's Premium Line positioners are designed for operation under extreme environmental conditions such as cryogenic temperatures down to the mK range and ultra high vacuum. ANP positioners are therefore qualified with six distinct environmental options: /RT, /HV, /UHV, /LT, /LT/HV, /LT/UHV.

All positioners are tested in their specified environment prior to shipment!

ANS Scanner

ANR Rotator

ANG Goniometer



ANP Linear Positioner

Working Temperature

- All ANP positioners are specified for working temperatures in the range of 0°C up to 100°C.
- All /UHV rated positioners withstand bake-out processes with temperatures up to 150°C.
- Positioners labeled with the /LT flag are dedicated for repeated cool-down procedures and offer reliable motion in cryogenic environments down to 10 mK.

Vacuum Compatibility

- All ANP positioners are specified for pressures ranging from ambient to 1E-4 mbar.
- Positioners qualified with a /HV flag are specified for high vacuum conditions up to 1E-8 mbar.
- /UHV rated positioners are compatible with ultra high vacuum conditions of up to 5E-11 mbar.

Magnetic Field Compatibility

- Premium Line positioners are intended for the use in high magnetic fields (current max. tested field: 31T).
- The actual compatibility depends on the positioner type.

Materials

- attocube's Premium Line positioners are manufactured from non-magnetic materials such as highly pure titanium and ceramics.
- As an upgrade option, ANP positioners can also be manufactured from copper beryllium (/CuBe).

Dedicated products for cryogenic environments

Material Upgrade Option: Copper Beryllium (/CuBe)

Cutting edge research at cryogenic temperatures is one of attocube's key markets. Extensive testing of all stages prior to shipment as well as ongoing development of new products for these environments is mandatory for a successful support of our customers. This offers them a chance to perform exciting, new experiments under challenging conditions. More and more highly sophisticated measurement techniques (e.g. STM, SQUID, or transport measurements) require ultra low temperatures in the mK regime.

As titanium becomes superconducting for temperatures lower than 400 mK and the application of magnetic fields is not always an option, attocube has dedicated considerable effort to find alternative materials for this community.
For all Premium Line positioners attocube thus offers a special upgrade option where the positioner bodies are manufactured from non-magnetic copper beryllium and are therefore ideally suited for all mK applications.

Titanium becomes superconducting for temperatures lower than 400 mK!

Thermal Coupling Device: ATC100

For cryogenic experiments, effective coupling of a positioner setup to a cold plate is essential. For all setups working without a He exchange gas atmosphere, aspects such as mechanical flexibility of the cooling braids as well as the cooling power itself need to be taken into consideration. In vacuum chambers as well as in dilution refrigerators and 3He-Systems, one has to rely on conductive cooling methods.
Standard attocube positioners are good thermal isolators due to a ceramic axis in the mechanical path connecting bottom and top part. For efficient cooling of a setup, one has to attach cooling braids to the top plate of the positioner stack and hence cool the attached load directly. Such a connection has to be mechanically flexible in order to still allow movement of the positioners.

attocube's dedicated thermal coupling device made from gold-plated copper, the ATC100, provides an easy-to-use solution available in three different lengths. It is directly compatible to all ANP101 positioner models allowing for a thermal conductivity of up to 25 mW/K.
As an upgrade option the ATC100 is also available with an integrated heater and temperature sensor. Si diodes are suitable for applications at temperatures ranging from 4K to 300K whereas the calibrated cernox sensor is specified for 1.4K up 325 K and is also compatible to high magnetic fields.

Article	Thermal Conductivity	Art.No.
ATC100/35	25 mW/K	1005260
ATC100/60	15 mW/K	1008437
ATC100/70	10 mW/K	1005253
ATC100/Si/35	25 mW/K	1009327
ATC100/Si/60	15 mW/K	1009326
ATC100/Si/70	10 mW/K	1009325
ATC100/Cer/35	25 mW/K	1009334
ATC100/Cer/60	15 mW/K	1009333
ATC100/Cer/70	10 mW/K	1009332

Product Quick Finder

choose your type of attocube's rotators

	Product Name	Description	Travel	Typical Min. Step Size	Size	Max.dyn. force
	ANPz30	linear, vertical stepper positioner	2.5 mm	50 nm (@ 300 K) / 10 nm (@ 4 K)	Ø 11; 12 mm	0.1 N (10 g)
	ANPx51 (/RES; /NUM models)	linear, horizontal stepper positioners (closed loop optional)	3 mm	50 nm (@ 300 K) / 10 nm (@ 4 K)	up to 15 x 19 x 9.2 mm	0.25 N (25 g)
	ANPz51 (/RES; /NUM models)	linear, vertical stepper positioners (closed loop optional)	2.5 mm	50 nm (@ 300 K) / 10 nm (@ 4 K)	up to 15 x 19 x 13.5 mm	0.5 N (50 g)
	ANPz51eXT (/RES; /NUM models)	linear, vertical stepper positioners (closed loop optional)	6 mm	50 nm (@ 300 K) / 10 nm (@ 4 K)	up to 15 x 19 x 17 mm	0.5 N (50 g)
	ANPx101 (/RES; /NUM models)	linear, horizontal stepper positioners (closed loop optional)	5 mm	50 nm (@ 300 K) / 10 nm (@ 4 K)	up to 24 x 28 x 11.5 mm	1 N (100 g)
	ANPz101 (/RES; /NUM models)	linear, vertical stepper positioners (closed loop optional)	5 mm	50 nm (@ 300 K) / 10 nm (@ 4 K)	up to 24 x 28 x 20 mm	2 N (200 g)
	ANPz101eXT12 (/RES; /NUM models)	linear, vertical stepper positioner with extended travel range (closed loop optional)	12 mm	50 nm (@ 300 K) / 10 nm (@ 4 K)	up to 24 x 28 x 32 mm	2 N (200 g)
	ANPx311 (/RES models)	linear, horizontal stepper positioner with integrated bearings (closed loop optional)	6 mm	100 nm (@ 300 K) / 20 nm (@ 4 K)	up to 30 x 34 x 10 mm	20 N (2 kg)
	ANPx321 (/RES; /NUM models)	linear, horizontal stepper positioner with integrated bearings (closed loop optional)	15 mm	100 nm (@ 300 K) / 20 nm (@ 4 K)	up to 40 x 47.5 x 11.5 mm	120 N (12 kg)
	ANPx341 (/RES; /NUM models)	linear, horizontal stepper positioner with integrated bearings (closed loop optional)	20 mm	100 nm (@ 300 K) / 20 nm (@ 4 K)	up to 45 x 47.5 x 11.5 mm	120 N (12 kg)
	ANGt50	compact goniometer for Θ-positioning	tilt: 7.2°	0.1 m° (@ 300 K) / 0.02 m° (@ 4 K)	15 x 15 x 10 mm	0.25 N (25 g)
	ANGp50	compact goniometer for Φ-positioning	tilt: 5.8°	0.1 m° (@ 300 K) / 0.02 m° (@ 4 K)	15 x 15 x 10 mm	0.25 N (25 g)
	ANGt101 (/RES; /NUM models)	goniometer providing Θ-positioning (closed loop optional)	tilt: 6.6°	0.1 m° (@ 300 K) / 0.02 m° (@ 4 K)	up to 24 x 28 x 11 mm	1 N (100 g)
	ANGp101 (/RES; /NUM models)	goniometer providing Φ-positioning (closed loop optional)	tilt: 5.4°	0.1 m° (@ 300 K) / 0.02 m° (@ 4 K)	up to 24 x 28 x 11 mm	1 N (100 g)

	Product Name	Description	Travel @ 300 K	Typical Min. Step Size	Size	Max. dyn. force
	ANR31	ultra compact rotator with vertical rotation axis	rotation: 360° endless	1 m° (@ 300 K) / 0.5 m° (@ 4 K)	ø10 x 7.5 mm	0.05 N (5 g)
	ANR51 (/RES models)	compact rotator with vertical rotation axis (closed loop optional)	rotation: 360° endless	1 m° (@ 300 K) / 0.5 m° (@ 4 K)	ø 20 x 9.5 mm	0.3 N (30 g)
	ANRv51 (/RES models)	compact rotator with horizontal rotation axis (closed loop optional)	rotation: 360° endless	1 m° (@ 300 K) / 0.5 m° (@ 4 K)	10 x 20 x 21 mm	0.2 N (20 g)
	ANR101 (/RES; /NUM models)	rotator with vertical rotation axis (closed loop optional)	rotation: 360° endless	1 m° (@ 300 K) / 0.5 m° (@ 4 K)	ø 30 x 18 mm	1 N (100 g)
	ANRv220 (/RES models)	rotator with horizontal rotational axis and ultra low wobble (closed loop optional)	rotation: 360° endless	1 m° (@ 300 K) / 0.5 m° (@ 4 K)	27 x 12 x 28.5 mm	1 N (100 g)
	ANR240 (/RES models)	rotator with vertical rotational axis, 1/2" aperture and ultra low wobble (closed loop optional)	rotation: 360° endless	1 m° (@ 300 K) / 0.5 m° (@ 4 K)	35 x 35 x 13.5 mm	2 N (200 g)
	ANSxy50	stand-alone, compact xy-scanner for 1" scanning probe setups	30 x 30 µm²	---	15 x 15 x 7 mm	0.5 N (50 g)
	ANSz50	stand-alone, compact z-scanner for 1" scanning probe setups	4.3 µm	---	15 x 15 x 6 mm	0.5 N (50 g)
	ANSxyz50	stand-alone, compact xyz-scanner for 1" scanning probe setups	30 x 30 x 4.3 µm³	---	15 x 15 x 13 mm	0.5 N (50 g)
	ANSxy100	stand-alone xy-scanner for 2" scanning probe applications with various scan ranges	up to 50 x 50 µm²	---	24 x 24 x 10 mm	1 N (100 g)
	ANSz100	stand-alone z-scanner for 2" scanning probe applications with various scan ranges	up to 50 µm	--- --- ---	24 x 24 x 10 mm	1 N (100 g)
	ANSxyz100	modular xyz-scanner for 2" scanning probe applications with various scan ranges	up to 50 x 50 x 24 µm³	---	24 x 24 x 10 mm	1 N (100 g)
	ANSx150	stand-alone x-scanner with large scan range at cryogenic temperatures	80 µm @ 300 K 125 µm @ 4 K	---	24 x 24 x 9 mm	1 N (100 g)

Closed Loop Control of ANP Positioners

optional position encoders for closed loop operation

With the introduction of encoded nanopositioner systems and the corresponding controller, the ANC350, exact and repeatable positioning in absolute and relative terms is now an easy task. The readout sensor detects the actual position which is communicated to the piezo controller. The ANC350 compares the actual position to the position setpoint and compensates for any error. For attocubes nanopositioners, the closed loop approach is executed in a sequential arrangement of stepping mode and fine positioning mode thus enabling highly precise positioning control over long travel ranges. It goes without saying that attocube offers suitable sets of closed loop systems which are compatible with extreme environments such as ultra high vacuum, high magnetic fields, and cryogenic temperatures.

Optoelectronic Encoder /NUM

The /NUM encoder system allows fully automated closed loop operation with a position resolution of 1 nm/10 µ°and a repeatability of 50 nm/400 µ°. This encoder option is suitable for ambient as well as UHV conditions and high magnetic fields up to 7T.

Resistive Encoder /RES

The resistive closed loop mode is the method of choice for applications at cryogenic temperatures, ultra high vacuum UHV and highest magnetic fields (current maximum field: 31T). It measures the absolute sample position with a position resolution of 200 nm/0.1 m° and a repeatability of 1 µm/1 m°.

Closed Loop Option /FPS

Outstanding precision is achieved by combining attocube's innovative, fiber-based interometer, the attoFPSensor, with standard open loop positioners. A 25 pm position resolution and 2 nm repeatability even at cryogenic temperatures, UHV conditions and high magnetic fields outrivals the specifications of any other encoder type.

Premium Line – Motion Control System

ANC300 and ANC350 motion controllers

ANC300

The ANC300 is the dedicated open loop piezo positioning controller which enables motion in step mode as well as in scan mode.
It offers a completely modular design with up to seven slots for stepping modules (ANM150), scanning module (ANM 200), or combined stepping and scanning modules (ANM300). The integrated touchscreen provides new ways of manual control. All functionalities are also accessible via USB 2.0 or Ethernet. LabView™ drivers and a programmable text-based console are included in the standard ANC300 software package.

ANC350

The ANC350 is attocube's multi-functional piezo controller which meets the highly demanding dynamic performance and accuracy requirements of multi-axis nanopositioning setups. The ANC350 enables closed loop control of attocube's nanopositioners with optoelectronic or resistive encoders. All functionalities are accessible via USB 2.0 or Ethernet. An extensive software support is provided including a DLL library as well as LabView™ and EPICS drivers.

EPICS, SPEC & TANGO DRIVERS AVAILABLE FOR THE ANC350!

EPICS is a set of software tools and applications which provide a software infrastructure for the use in building distributed control systems to operate devices such as particle accelerators, large scale experiments and major telescopes.

spec & Tango are UNIX-based software packages for instrument control and data acquisition widely used for X-ray diffraction at synchrotrons around the world, in universities, and national and industrial laboratories.

Applications and Technology Fields

overview

SEMICONDUCTOR RESEARCH

APPLICATIONS

- Positioning in micro assembly of optoelectronics
- Magnetic imaging with AFM/MFM, SHPM
- Wafer alignment
- High magnetic field studies
- Force measurements inside an SEM

PHOTONICS / LASER SYSTEMS

APPLICATIONS

- Mirror positioning
- Optical emission from carbon nanotubes
- Fiber alignment
- Beam steering and stabilization
- Cavity tuning

MICROSCOPY

APPLICATIONS

- High resolution vortex imaging of HTSCs
- NV color center experiments
- Precise coarse xyz positioning stages
- Micro-Raman spectroscopy on graphene
- Quantitative magnetic characterization on the nanoscale

SYNCHROTRON / BEAMLINE

APPLICATIONS

- Sample alignment on a crystallography beamline
- Tilt control
- Atomic Force Microscope for IR beamlines
- Nanofocusing parabolic refractive X-Ray lenses
- Micro-XRF spectrometer

CRYOGENICS

APPLICATIONS

- Low vibration measurements at high magnetic fields
- Micro photoluminescence
- Angle-dependent transport measurements
- Tuning of microwave cavities
- Optical spectroscopy on photonic crystals

HV & UHV APPLICATIONS

APPLICATIONS

- Laser cooling
- Quantum optomechanics
- Controlling electron emission in space and time
- Micromanipulator with an haptic interface
- SEM compatible probestation

METROLOGY

APPLICATIONS

- High precision, contactless measurement
- Distance control
- Adjustments of optics

SPACE APPLICATIONS

APPLICATIONS

- Rotation of optical components with ultra low wobble
- Precise lens alignment in high vacuum
- Laser interferometry
- Mirror alignment for multi system radiotelescopes

Glossary

precision and control

SENSOR RESOLUTION

The term sensor resolution or sensitivity indicates the smallest quantity detectable by a sensor. If the sensitivity is not fundamentally limited due to mechanical properties such as friction, the sensitivity is almost always bandwidth dependent. attocube specifies the resolution of optoelectronic (/NUM) sensors at a measurement bandwidth of 1 kHz.

SENSOR ACCURACY

The term sensor accuracy represents the absolute deviation of any measurement from a calibrated, metrologically traceable standard. The best accuracy is often obtained by interferometric sensors, facilitating well-known laser lines from thermally stabilized single mode gas lasers. Sensor accuracy does not necessarily relate to sensor sensitivity and repeatability, i.e. a sensor may provide a very high sensitivity and repeatability, yet lack a high accuracy.

SENSOR REPEATABILITY

The sensor repeatability represents the maximum (position) error when repeatably approaching a certain sensor value. At attocube, the sensor repeatability is measured in conjunction with an actual positioner,i.e. parameters such as minimum step size, thermal expansion, and resolution all contribute to the sensor repeatability. The repeatability for each closed loop positioner is determined by the value of the standard deviation (σ).

GUIDING ACCURACY

The guiding accuracy describes the deviation of the motion of a positioner from a purely linear behavior in terms of roll, θ_x, pitch, θ_y, and yaw, θ_z. Vertical and horizontal runouts are frequently also considered when referring to the term guiding accuracy. In real life, position sensors detect the motion of a positioner but do not provide real-time information on the guiding accuracy .

MINIMUM POSITIONER STEP SIZE

The minimum step size of a positioner is defined as the smallest repeatable motion which the positioner can achieve in coarse positioning mode. This parameter includes the positioner backlash.

OPEN LOOP POSITION CONTROL

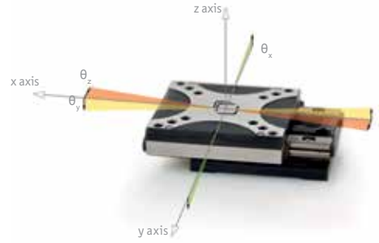
The open loop functionality of a positioner does not take advantage of a feedback loop in order to determine and control the actual position of a positioner. Depending on the number (frequency) of steps and the adjusted step size (voltage), a rough estimate of the actual position after any motion task can be deduced.

CLOSED LOOP POSITION CONTROL

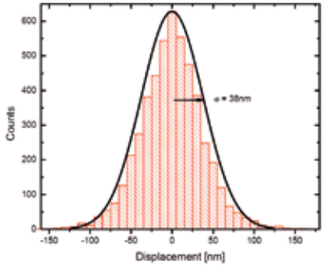
The closed loop functionality takes advantage of measuring the actual position of a positioner using an encoder. This position is then compared to a setpoint, where any difference between the two values is compensated for using a feedback loop. For attocube positioners equipped with an encoder, positioning setpoints can either be set in a software interface or on the front panel of the closed loop electronics (depending on type).

OPTOELECTRONIC POSITION SENSOR

This optoelectronic (/NUM) readout allows fully automated, closed-loop positioning operation with high resolution, compatible with ambient conditions, ultra high vacuum, and magnetic fields up to 7 T. It delivers a relative position to a reference with a sensor resolution of 10 nm and a repeatability of ± 50 nm. /NUM sensors are full integrated into the piezo stepper device.



Industrial Line positioners provide the highest guiding accuracy due to crossed roller bearings.



The figure above shows the histogram of the bidirectional repeatability measurements for a closed loop positioner with an optoelectronic encoder (/NUM).