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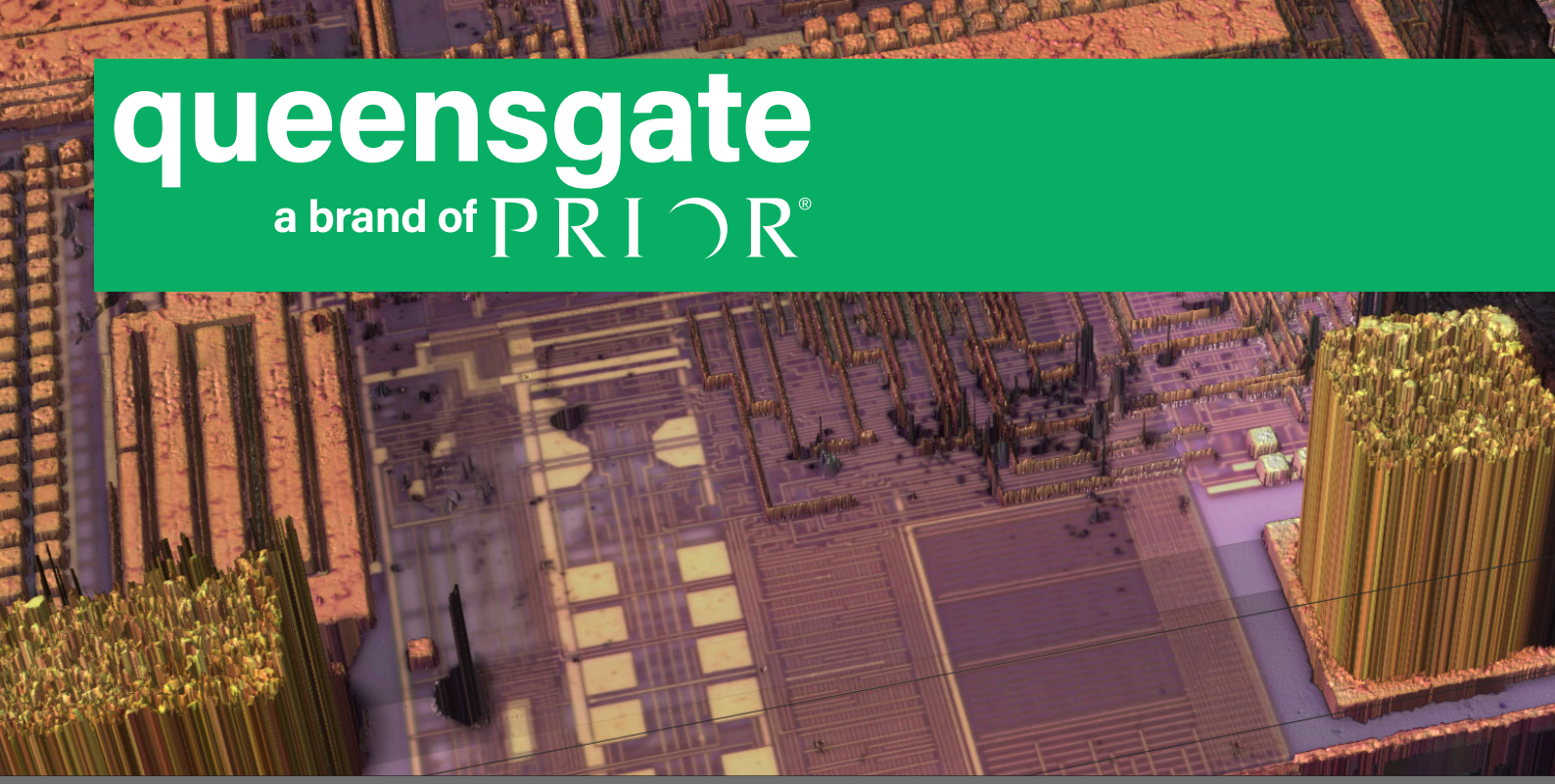

Global Leaders in Positioning Solutions for Nanotechnology

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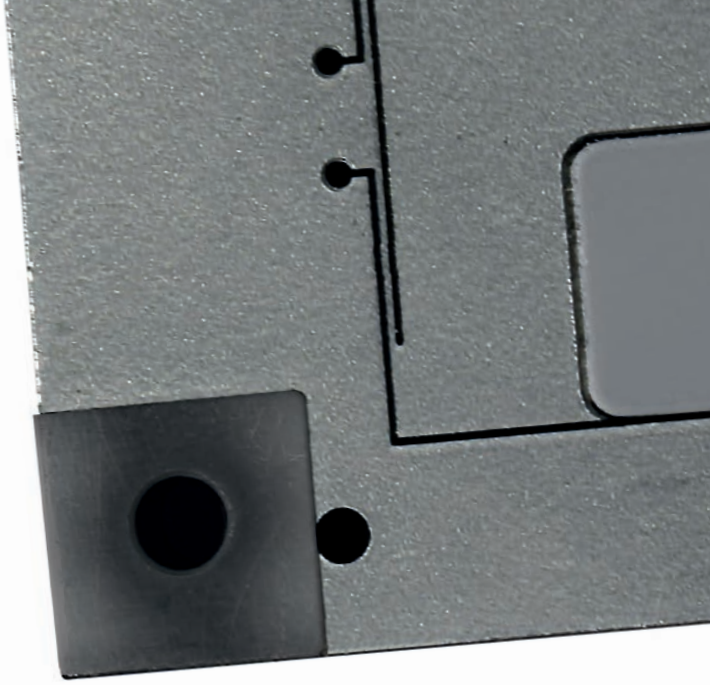

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“We have received what I believe is the best nanopositioner on the market.”

Ron Anderson
Managing Principal Engineer Seagate

Queensgate’s manufacturing is located in the new Epic Centre in Paignton, UK.

Queensgate Instruments was founded in 1979 and spun out of the ground breaking research in nanomotion at Imperial College in London. The company defined new levels of accuracy and performance in nanopositioning systems.

Queensgate’s early research and product developments proved to the world that it could play a major part in the research and development in various industries including biotechnology, medicine, astronomy, aerospace, semiconductors, mass computer storage devices, fiber optics, and optics. In 2018 the company was purchased by Prior Scientific Instruments Ltd., a global leader in the development and manufacture of precision motion, automation, and custom optical systems and components.

Queensgate offers a wide range of nanopositioning products and systems that includes stages, control electronics, precision displacement sensors, and software. Queensgate also offers custom products and solutions for the most challenging problems faced.

Queensgate’s team of engineers, based in Cambridge, UK, and our precision Piezo manufacturing facility in Paignton, UK are both ISO 9001:2015 certified and together produce the best of the next generation of nanopositioning products that are used around the world.

For more information on Queensgate and our range of products, please visit us at www.nanopositioning.com

Leaders in Nanopositioning

Experts in high speed, high precision applications

Queensgate systems are the products of choice when sub-nanometer resolutions and the best dynamic specifications are required.

Rugged, reliable and fast. Queensgate systems are used around the clock in demanding manufacturing environments, such as hard disk testing and lithography platforms. Scanning probe, confocal and super resolution microscopes also depend on Queensgate products as do many of the world's largest telescopes, satellites and even robotics systems on the International Space Station.

Products

Nanopositioning stages, single and multi-axis capability

- Piezo-driven, flexure-guided
- Capacitive feedback control to give precise positioning.
- Picometre resolution, repeatability and positional stability.
- Market leading dynamic performance

Microscope automation products

- Objective positioners
- Z stages

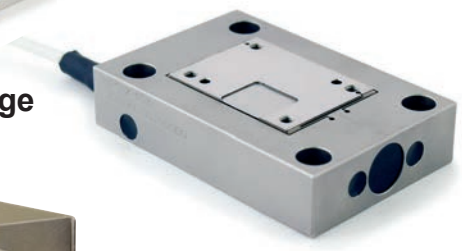
Preloaded precision piezo actuators for high loads and force

- Move loads of up to 60kg over full travel range at high bandwidths.
- Capacitive feedback control positioning with precision, speed and accuracy.

Capacitive sensors

- Providing positional feedback - ranges 20um to 11mm
- High resolution/ low noise - 7pm to 50nm
- High linearity of movement
- Repeatability < 1nm

XY Stage

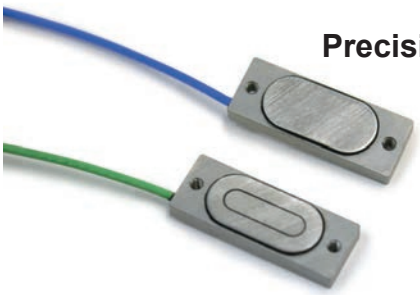


X Stage

Microscope Objective Positioner

Piezo Z Stage

Piezo Actuators



Precision Sensors

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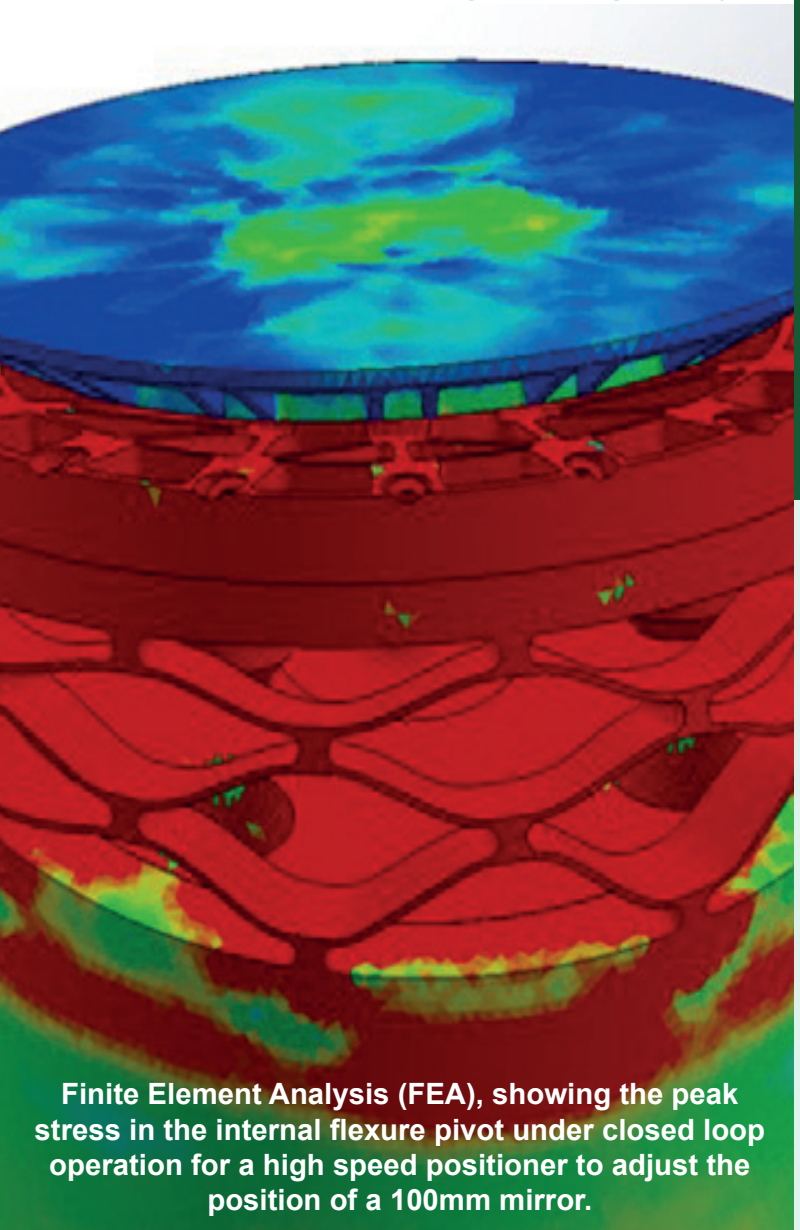
Designed for Peak Performance

Specializing in piezo driven flexure guided positioning stages, piezo actuators and capacitive sensors, Queensgate meets application, performance, quality and cost requirements. The company is committed to helping our customers decrease their test times and increase the yields of their products by consistently delivering the best performance for the price.

Queensgate engineers use the most advanced computer aided techniques to predict the behavior of stage designs, select the piezo stack, and choose the right materials to meet unique requirements and specifications.

Finite Element Analysis design to minimize stresses for stage longevity



Finite Element Analysis (FEA), showing the peak stress in the internal flexure pivot under closed loop operation for a high speed positioner to adjust the position of a 100mm mirror.

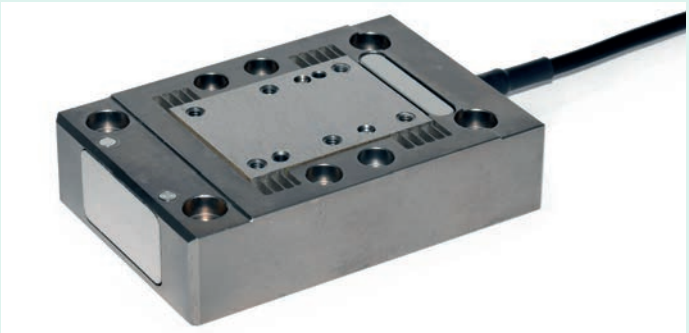
Integral Stage Flexure Hinges

- Amplify piezo motions
- Decouple off axis motion and strain
- Give pure single axis motion by preventing motion in other axes.

Patented Flexure Designs

for a high speed titanium stage for hard drive testing

- Resonant frequency 5700Hz
- Bandwidth greater than 2000Hz
- Noise less than 93pm measured using an interferometer, off axis, at the tip of a cantilever arm



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Unsurpassed Accuracy and Repeatability

Queensgate pioneered the use of **capacitive feedback sensors** for closed loop stages and actuators. Capacitive feedback sensors deliver the best positioning accuracy and repeatability.

Capacitive sensors provide superior:

- Resolution / low noise
- Stability / repeatability
- Linearity
- Highest bandwidths - speed
- Non-contact sensors are more independent of thermal influences when the stage is in operation - lowest drift.

The table below compares the performance of capacitive positioning sensors with other commonly used alternatives.

	Capacitive Positioning Sensors	Strain Gauge	Piezoresistive
Resolution	**<0.05nm**	1nm	<0.5nm
Linearity	**<0.01%**	0.5%	0.5%
Stability / Repeatability	**0.1nm**	15nm	>15nm
Bandwidth	**10KHz**	5KHz	5KHz

Piezo stages operating in open loop have variability in position of between 10 to 15 percent, Queensgate high performance stages operating in closed loop mode have a variability in position of less than 0.01%.

Selecting the Best Material

Queensgate selects the right material to deliver the performance required

- Material stiffness and density influence resonant frequency and hence bandwidth.
- Thermal expansion coefficient determines the movement of a particular point on the stage with respect to temperature.
- Loading impacts, the resonant frequency and therefore stiffer material will be required to deliver dynamic performance for higher loads.
- Material strength is also a factor for high loads and durability, material options include:
  - Stainless steel
  - Aluminum
  - Titanium
  - Super Invar

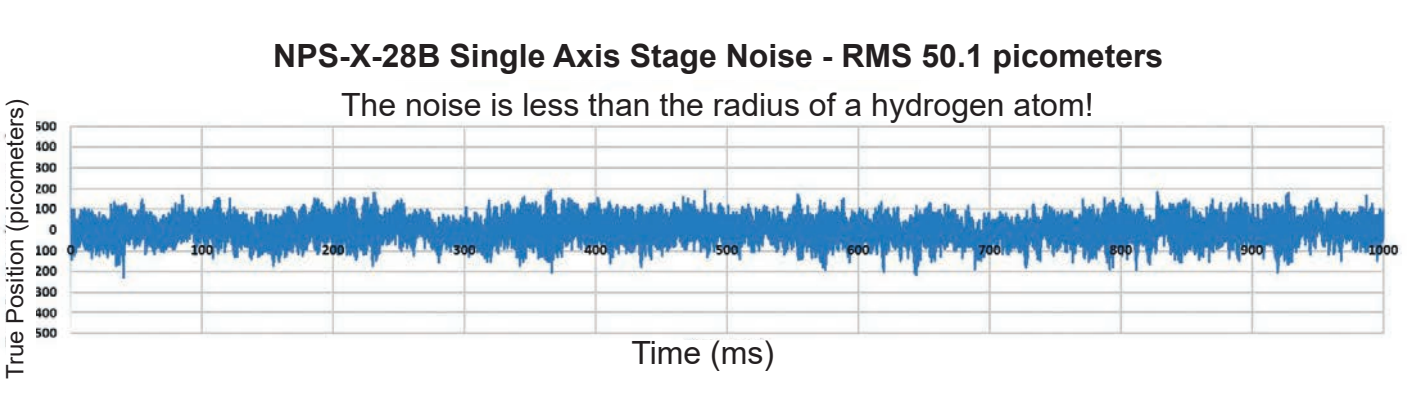
Digital Control Technology

Unparalleled precision with the best dynamic performance

Digital control provides flexibility of tuning to optimize a system for speed, resolution and payload. Queensgate standard controllers have the lowest electronic noise (low picometres levels) with high power; stages are driven faster and with greater precision and their position is updated every 20usec.

Queensgate systems are designed for unparalleled precision with dynamic performance. Stages can be driven at high bandwidths (3dB bandwidth) and at over 40% of their resonant frequency. Queensgate stages are often 4 to 5 times faster than competitive stages.

Picometer Performance



True position, using a laser interferometer, measured at the tip of a cantilevered arm mounted on the stage.

NanoScan NPC-D-6110 Series Single-channel Closed Loop Digital Controller

NanoScan NPC-D-6330 Series Three Axis Closed Loop Digital Controller

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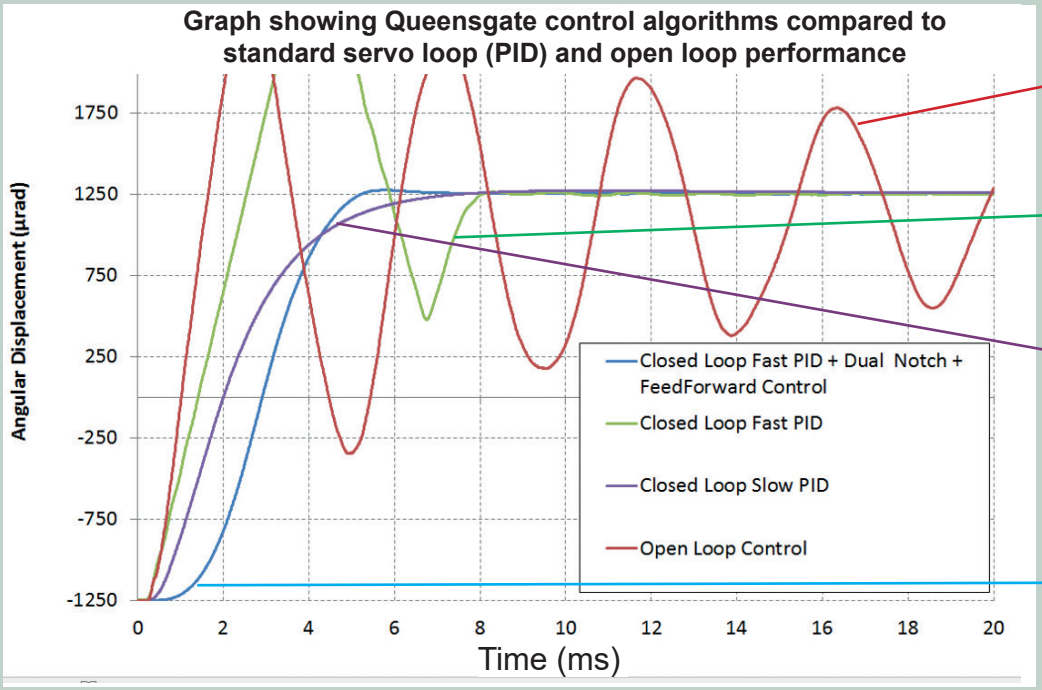
Enhanced Control Technology

A tool kit to deliver the best performance

Queensgate digital control electronics contribute significantly to stage performance:

- High order polynomial linearity functions optimize the linearity of movement for the best positional accuracy.
- Twin notch filters reduce the effect of first and second resonant frequencies on dynamic position.

Queensgate algorithms control speed and acceleration to minimize over shoot and system resonances to give the best step settle times. User selectable parameters allow for easy change of key parameters for specific applications.



Open loop control.
The system hasn't settled after 20ms

Fast servo loop (PID), the step is fast, there is significant overshoot and the step settle is > 8ms

On a slow setting there is little overshoot but again the step settle is ~7ms

Queensgate control algorithms reduce the settle time to ~5ms

Velocity Control, Acceleration Control and Active Damping

Velocity and acceleration control, quickly accelerate the stage to a highly stable steady state constant velocity. These ultra-smooth ramps can be used for applications such as focus stacking or focus bracketing. Active damping is another tool to better control the system excitation and it prevents the stage from resonating.

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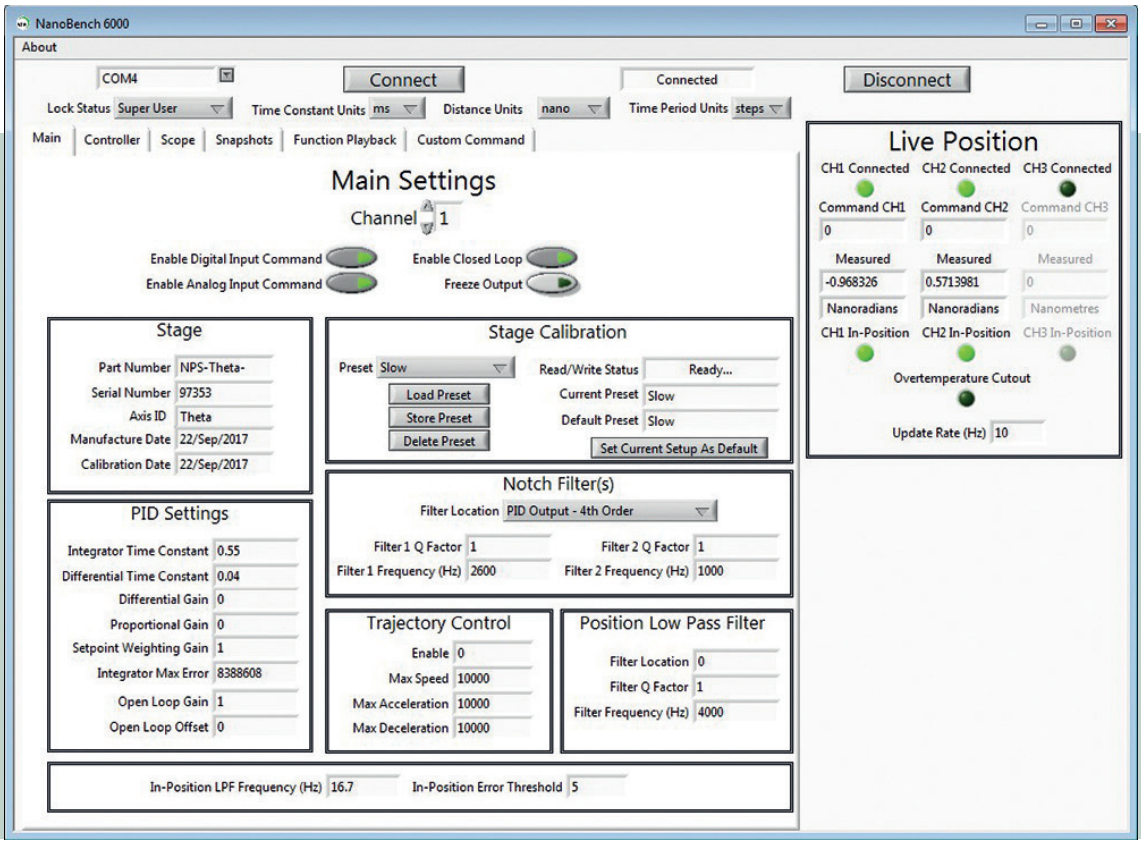
Flexibility and Ease of Use

Queensgate digital based servo control systems are designed to be easy to use and easy to interface. They offer a range of functionalities for application specific requirements, flexibility and usability.

Plug and Play:

The calibration data for the stage is held in an EEPROM in the stage connector. Controllers can be easily interchanged allowing field replacement where access to a stage is difficult, e.g. embedded in an instrument or operating in high vacuum.



Eight selectable PID settings

Typically systems are shipped with three factory settings optimized for the stage or application.
The additional settings can be populated with customer defined settings or used for further optimisation to deliver high resolution and high speed or cope with variable loads.

Programmable trigger inputs and outputs.

The trigger-out feature has adjustable criteria allowing external devices to be triggered. For example absolute position can be used to trigger a camera image when z stacking, eliminating rejected images. The trigger in allows external input to start. For example, a waveform.

Function play back

Allows play back of pre-programmed waveforms, such as raster scans and sine wave functions, etc.

Nanobench software

PC software allows users access to advanced capabilities such as servo loop (PID) optimization, function playback, waveform generation, trigger inputs and outputs and snapshot. These features can be accessed and controlled using OEM software.

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Custom Design and OEM

Queensgate has over 40 years of experience providing custom solutions where precision, accuracy and dynamic performance are required. The development process is very customer focused as the engineering teams work closely to understand the customer application and system requirements. Queensgate has decades of experience making custom/OEM nanopositioning solutions. With world leading in-house teams providing innovative expertise in all associated engineering disciplines, Queensgate is the perfect OEM partner for those looking to find new accurate and efficient solutions or new applications.

The company is ISO 9001 registered with a focus on high quality and project management to meet the performance specification on time and on budget.

bsi. ISO 9001 Quality Management

Custom system for Hard disk testing

Special high speed interface to provide protocol updates 120,000 times per second to servo out any oscillation

>2000Hz servo loop bandwidth
1 um step settle to 0.5nm error within 5ms.
Test and calibration performed with a cantilevered mass; < 90 pm noise measured at the cantilever tip with < 0.05% linearity error

Crystal bending in high energy X-ray beamline for imaging, diffraction and scattering

'It is stable, doesn't vibrate or shake and is happy working in a high radiation environment.'

- Principal beamline scientist from a leading synchotron facility

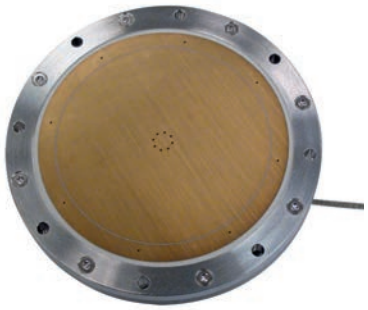
Custom Sensors

Challenge:

- Ultra High Vacuum (10^{-10} Torr)
- Non-magnetic construction
- Shielding from high electromagnetic interference
- Radiation stability
- Cryogenic operating conditions
- Range (>10mm)

Solution: NCG-1-AL-UHV

Feature	Application
Gold plated ceramic sensor	Construction Adhesive free – high reliability
UHV compatibility to 10^{-10} Torr.	Our standard range of metal UHV sensors are suitable for 10^{-9} Torr.
Radiation stability 10^7 Gy	Suitable for high radiation environment -rad hard. 10^7 Gy.
Variant available for use in a high magnetic field	Suitable for use in powerful magnetic fields.
Ceramic sensors are designed so they can be operated from -273 to +150 Degrees C	They can operate in systems requiring cryogenic temperatures, but also higher temperature environments. Also allows higher bakeout temperatures of +180 degrees for superior vacuum compatibility. Ease of handling where preconditioning necessary



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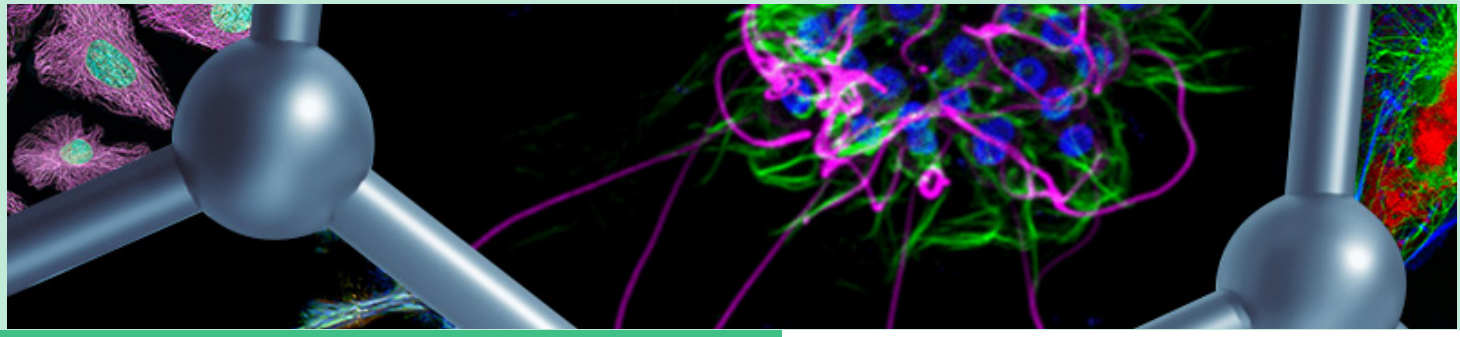
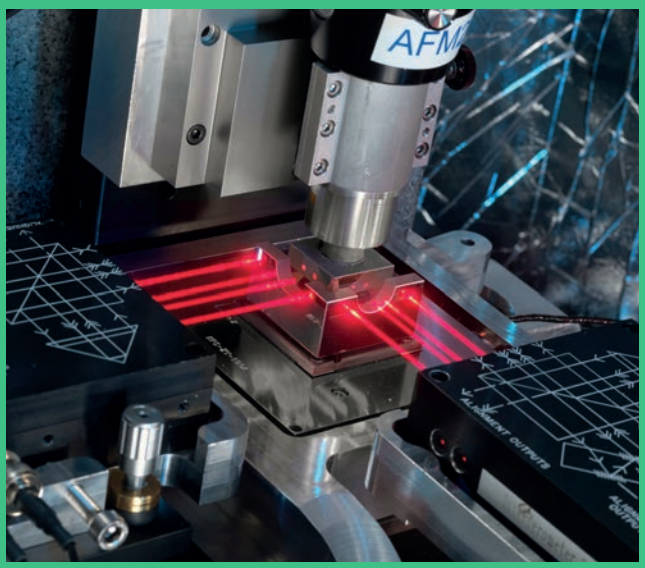
Applications

Queensgate systems deliver the best precision, accuracy and resolution for dynamic applications.



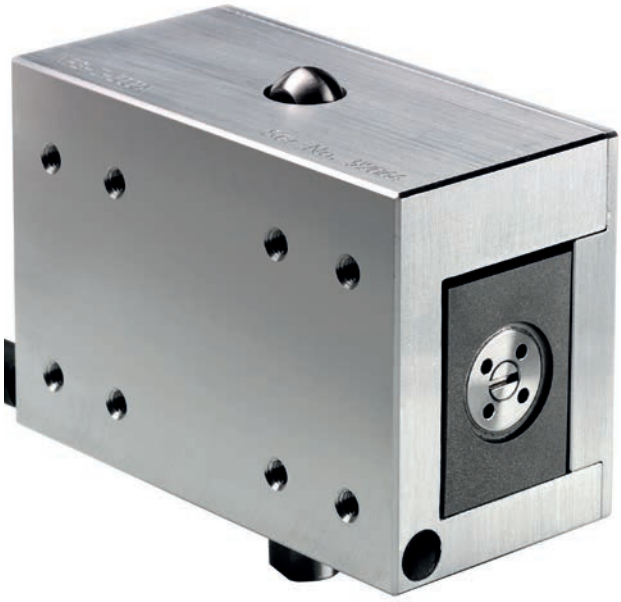
Nanopositioning Applications

- Precision manufacture and inspection (wafer inspection, lithography)
- Advanced scientific instruments and research (laser, x ray beam, mirror steering, interferometry, telescopes (ELT))
- Microscopy (sample scanning, 3D imaging)
- Advanced sensing (pressure, position, stress etc.)
- Photonic device manufacture
- Data storage (hard disk testing)
- Metrology
- Laser communication (point ahead mechanisms) and guidance
- Space based solutions since 1982



UHV (Ultra High Vacuum) Solutions

- UHV option guaranteed performance to 10^{-9} Torr
- Ultrasonic cleaning process
- No trapped voids or volumes
- Low out-gassing materials
- Individual Kapton cables with SMA or Sub-D bulkhead connections
- Plug and play interchangeability allowing easy controller replacement once installed
- Radiation prepared variants available
- Calibrated systems comprised of a closed loop piezo actuator/stage, airside extension cable, vacuum feedthrough and digital controller



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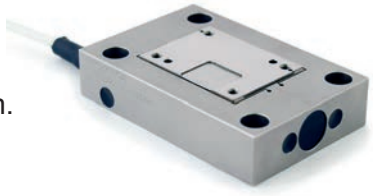
Product Range

Queensgate Instruments offers a wide range of Nanotechnology products for many different applications

Piezo Stages

Single Axis

Optimized for speed, resolution, precision and accuracy. Stages designed with picometre resolutions and the fastest settle times cover ranges; 15um, 20um and 28um. Longer range stages for speed, resolution and higher loads are available.



The Nanoscan OP400 objective positioners for inverted and upright microscopes are available for objective lenses up to 800g. The Nanoscan sample scanners in 400um and 600um versions have a super slim design with accessories for microtitre plates, slides and petri dishes.

Multi-axis Stages

XY and XYZ stages deliver the best resolutions; with choices of aluminum for speed and Super Invar for metrology applications. Z stages with or without an aperture are available. High performance tip/tilt stages are ideal for applications requiring high speed, ultra high precision positioning of mirrors.

Acuators

DPT-E actuators incorporate capacitive positioning sensors for operation in closed loop. Available as 110um, 50um and 20um versions they give the best precision, speed and accuracy. Specialist actuators for longer range operation or very high loads are available. The MTP range of UHV open loop actuators offer a very stiff design capable of generating blocking forces as high as 1000N. UHV versions of stages and actuators are available for operation up to 10^{-9} Torr.

Sensors

The Nanosensors™ are comprised of a target and a probe. The NX standard systems are made from aluminum or Super Invar and cover ranges from 20um to 2500um with resolutions down to 6 picometres. Custom variants of the NX series are available in round, rectangular and compact formats where space is a premium. UHV sensors and ceramic variants which are radiation hard are custom options.

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Queensgate Firsts

Continuous Innovation

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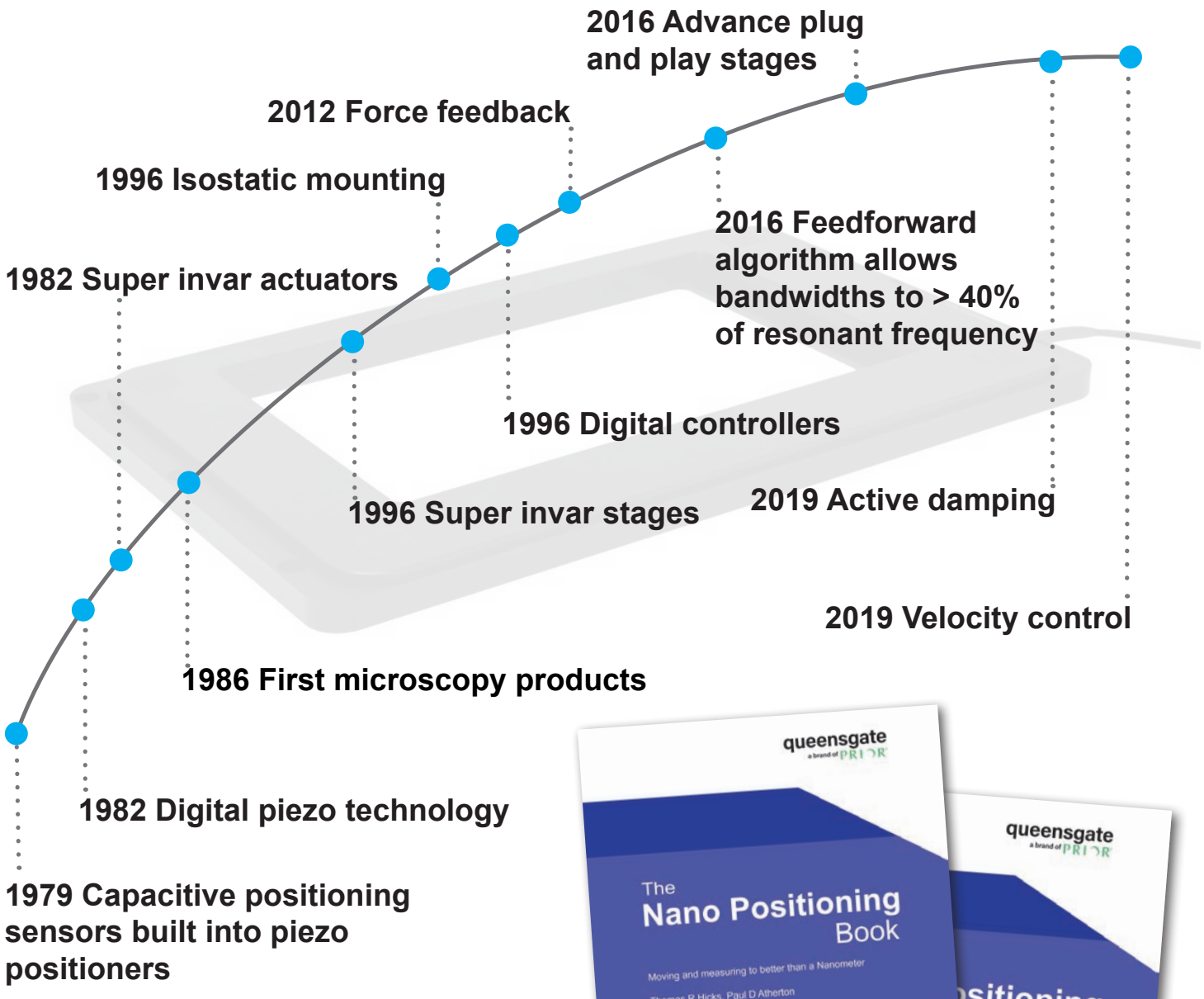

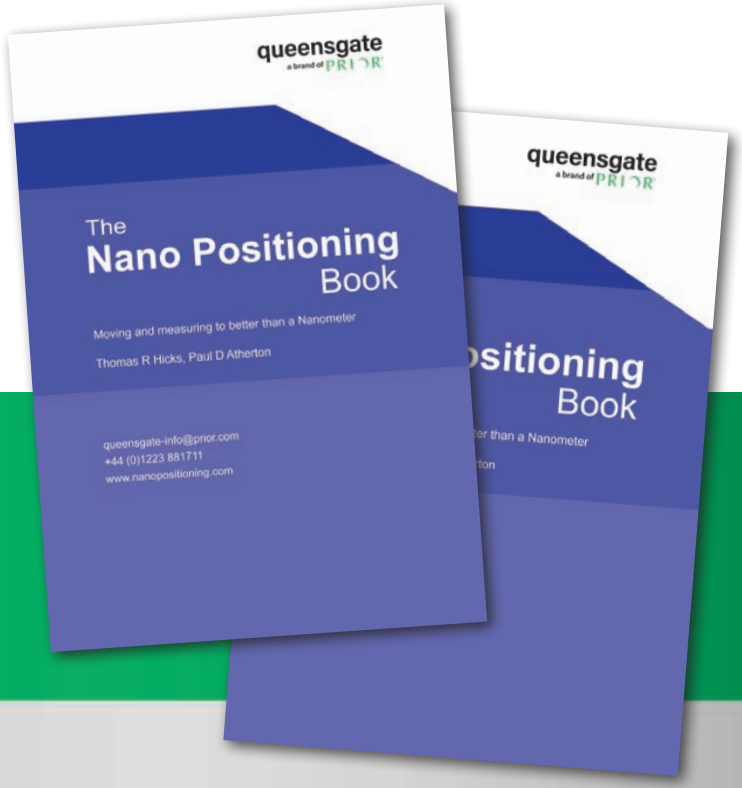

More information on our design principles, test and measurement are in The Nano Positioning Book available at:

https://www.nanopositioning.com/nanopositioning/the-nano-positioning-book

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