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NanoSensors

NX/NZ NanoSensor®

The NanoSensor® is a non-contact position measuring system based on the principle of capacitance micrometry. Two sensor plates, a Target and a Probe, form a parallel plate capacitor.

The spacing of these two plates can be measured using the appropriate electronic controller, to better than 0.1nm, with a range up to 1.25mm, a frequency response up to 10KHz and linearity down to 0.02%. Because the NanoSensor is a non-contact method, it is free of hysteresis. No power is dissipated at the point of measurement.

NXD1

Key features

- Features
- Sub nanometer position resolution
- Zero hysteresis
- Linearity error down to 0.02%
- Bandwidth up to 5kHz
- Super Invar versions available
- Vacuum compatible options

Applications

- Stage control
- Microscopy
- Structural deformation
- Vibration control
- Materials testing
- Precision engineering
- Metrology
- Active Optics
- Precision Beam Steering
- Space Station Robot Arm

Suggested controllers

The NS2000 is a single channel stand-alone electronic module for driving the NX NanoSensor® series. It operates by measuring the change in capacitance of a parallel plate capacitor and outputs an analogue voltage proportional to the NanoSensor® gap. The voltage output varies linearly between -5V and +5V as the sensor gap changes from 50% to 150% of the nominal NanoSensor® gap. Its compact size, stand-alone operation and high resolution makes this ideal for upgrading existing systems where NanoPositioning is required.

The NS-A-1100 is Queensgates latest Single Channel stand alone control module. Fundamentally working in the same manner as the NS2000, its main differences are a -10V to +10V output and customer specified, factory set range and bandwidth (100Hz, 1kHz, 10kHz options).

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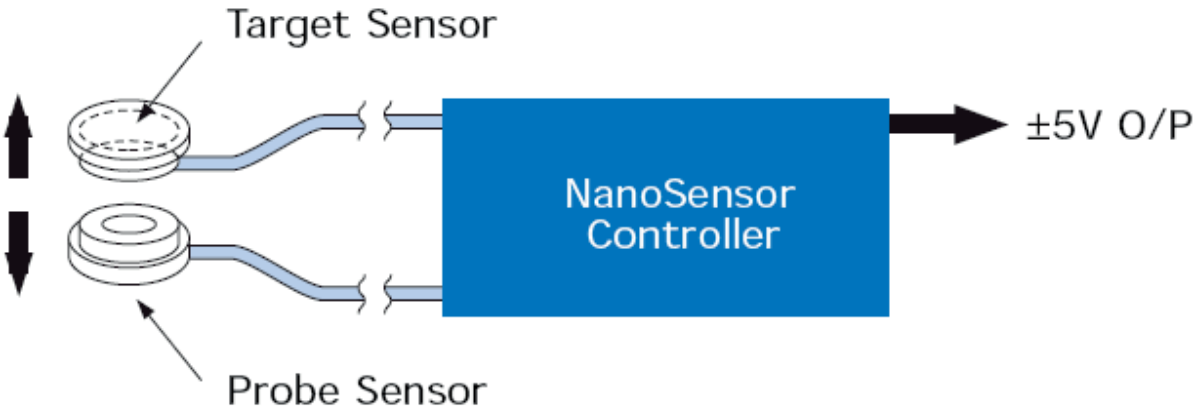
NanoSensors NX/NZ NanoSensor®



Using the NanoSensor®

The two plates of a NanoSensor are mounted facing each other with an air gap (G) equal to the measuring range. One plate is secured to a fixed reference, the other secured to the moving part to be measured. The sensor measures displacement over the region 0.5G to 1.5G, for example a 100μm range sensor is mounted with a 100μm nominal gap and operates from 50μm to 150μm. For optimum performance the sensor faces should be mounted parallel to each other.

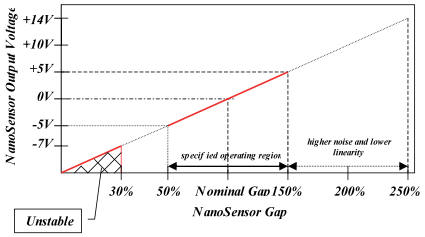
Each sensor can be used over two different measuring ranges denoted -L for long range and –S for short range, with 2pF and 10pF capacitances respectively. For example the NXC sensor can be used to measure a 500µm range with a noise level of 75pm rms Hz$^{-½}$ or to measure a 100μm range with a noise level of 5pm rms Hz$^{-½}$. The –L or –S operation is determined by the electronic controller and is user selectable. The measurement bandwidth is also user selectable at 50Hz, 500Hz or 5kHz.

Choosing a NanoSensor®

As a general rule, choose the sensor that matches the range to be measured; NXD for large measuring range, NXB for small measuring range. Short range sensors have lower noise than long range sensors. The NXB sensor has the lowest noise (0.001nm rms Hz$^{-½}$) and the shortest range (20μm). For low noise measurements choose the shortest appropriate range sensor.

The large gap sensors have large areas; if space is limited choose a short range sensor and note that the square and rectangular shapes have thin profiles. For the highest linearity choose a large gap sensor and use over a small part of the full range, e.g. <0.005% linearity error is achievable over 100μm range using an NXC1-L (normal range 500μm).

Super Invar sensors have the advantage over Aluminium of extremely low coefficient of thermal expansion. The thermal expansion of Super Invar is typically 0.3ppm K^{-1}, 50 times less than that of Aluminium.



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NanoSensor® noise

To calculate the noise for a certain range and bandwidth, multiply the vertical axis, noise in units of nm rms per root Hertz, by the square root of the bandwidth – e.g. for NXC sensors, 100μm range at 500Hz has an rms noise level of 0.1nm. Note that the measuring range is equal to the gap (stand off) between the plates.

NanoSensor® Linearity error

The graph shows an example of a linearity error plot for the NXC1-AL sensor. The linearity error in this example is < 0.01%. This is achieved without electronic compensation. Electronic compensation of the NanoSensors is not required because they are designed to be extremely linear and below 0.1% the linearity error is dominated by the parallelism of the mounting surfaces. Please contact Queensgate for details on calibrating your sensors in-situ and compensating linearity error to better than 0.2%.

Linearity error & tilt

The NanoSensor® performance is insensitive to tilt or non-parallel plates. However, for the highest linearity the parallelism of the plates needs to be less than two milliradians. Note, for a given tolerance the effect of the tilt is lower when the gap (range) is larger.

Scale factor & tilt

The scale factor is also affected by the parallelism of the plates. A tilt of one milliradian causes a change of 0.5% in scale factor. The graph opposite 'Scale Factor v. Tilt' is a plot for the 100μm range sensor, longer range sensors are much less sensitive to tilt.

Cable length

The standard cable length is 1m and the maximum cable length is 10m. Please note that noise increases with cable length. The increase in noise is approximately 20% per meter of cable. Extension cables are available in 1m, 2m or 3m lengths (order codes ECX01LL, ECX02LL, ECX03LL respectively).

Thermal drift

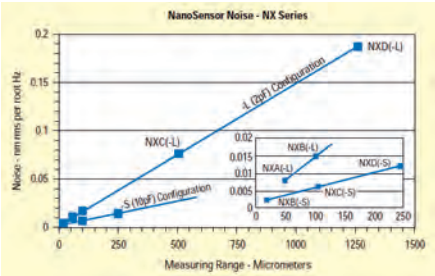
The thermal drift can be separated into electronic drift, which is a property of the controller and its environment, and sensor drift due to thermal expansion of the sensors in thickness and in area. This can be readily calculated using the coefficient of thermal expansion of Aluminum (22×10^{-6} K^{-1}) or Super Invar ($0.3 \times 10^{-6} K^{-1}$) as appropriate. The effect of the thickness change can be minimised using compensating materials, leaving only the change in area.

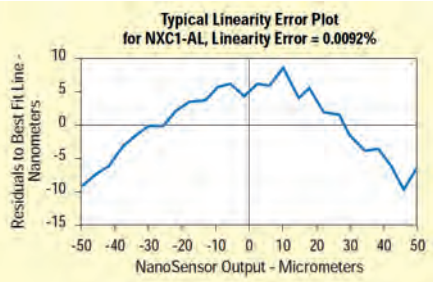
Vacuum compatibility

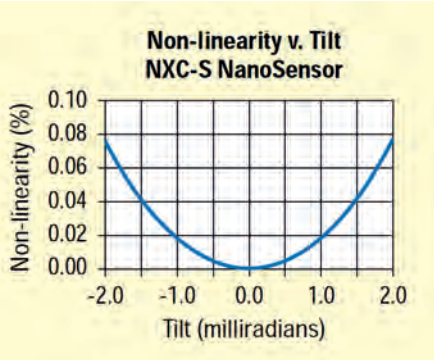
Vacuum compatible NanoSensors® are available - please specify '–UVAC' when ordering. The vacuum compatible version is typically good to 10^{-9}Torr and can be baked out at up to 100°C. Please contact Queensgate to discuss specific applications.

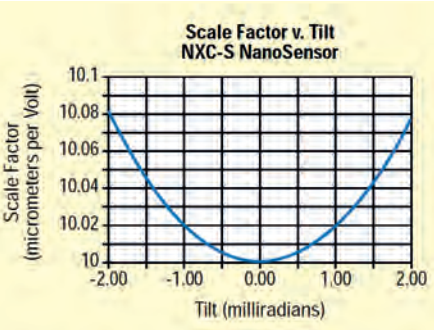
Custom sensors

Custom Sensors can be designed for many different applications. Please contact Queensgate to discuss specific applications.









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NanoSensors NX NanoSensor®

Specification

Parameter		Value						Units	Comments
Static physical									
Variant		NXB		NXC		NXD			
Active area		22.5		113		282		mm^2	
Material		AL	SI	AL	SI	AL	SI		Note 1
Dynamic physical (Typical values)									
Thermal drift		230	3	230	3	230	3	nm K^{-1}	Note 2
Short range –S (10pF)	Range	20		100		250		µm	
	Nominal scale factor	2		10		25		µm/V	
	Noise	<0.001		<0.005		<0.013		nm_{rms} $Hz^{-½}$	
	Linearity error	<0.08		<0.05		<0.06		%	Note 3
Long range –L (2pF)	Range	100		500		1,250		µm	
	Nominal scale factor	10		50		125		µm/V	
	Noise	<0.015		<0.075		<0.188		nm_{rms} $Hz^{-½}$	
	Linearity error	<0.08		<0.03		<0.06		%	Note 3
Operating temperature	Controller	+10 to +50						°C	
	Sensor	-273 to +100						°C	
Storage temperature		0 to +70						°C	
Relative humidity		5 to 95 (non-condensing)						%	
Operating pressure	-UVAC	10^{-9}						τ	

Notes

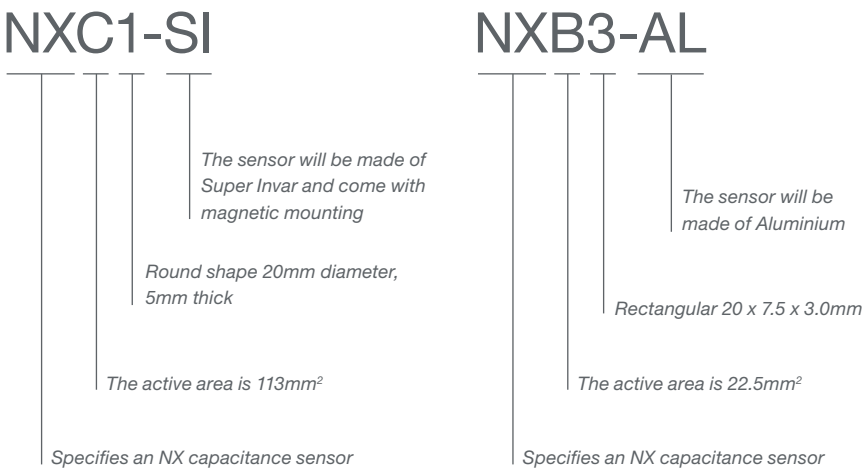
1. Aluminium (AL) and Super Invar (SI) material available on all variants. Alternative materials, e.g. Stainless Steel or Titanium can be used. Please consult Queensgate.
2. This is the thickness contribution only. It does not include the area effect.
3. Linearity error can be dominated by the parallelism of the sensor faces; particularly for short range sensors.

Ordering information

The NX NanoSensors® are available in three sizes, up to three different shapes and two materials. The size is indicated by letters, B (smallest) to D (largest). The larger the sensor the longer the range. The shape is indicated by numbers, 1 (round), 2 (square) and 3 (rectangular). The shape does not affect performance.

All NX series sensors are available in Aluminium and Super Invar (0.3ppm K^{-1}). The round Super Invar sensor has an optional magnetic base. Alternative materials are available please consult Queensgate.

Example order codes



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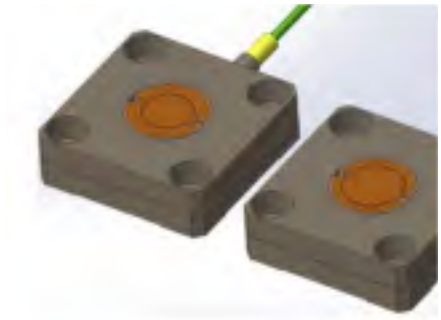
NanoSensors NZ NanoSensor®

The NZ Series NanoSensors operate on exactly the same principle as the NX Series. Their difference lies in the materials used and construction techniques employed. These have been selected and developed to achieve the ultimate in thermal stability.

NZ Series NanoSensors are constructed from Zerodur and Super Invar and, with the absence of adhesives, this makes them thermally very stable and suitable for cryogenic applications.



NZ

Specification

Parameter		Value			Units	Comments
Static physical						
Variant		NZB	NZC	NZD		
Active area		22.5	113	282	mm^2	
Material		Zerodur/SI	Zerodur/SI	Zerodur/SI		Note 1
Dynamic physical (Typical values)						
Thermal drift		1.5	1.5	1.5	$nm\ K^{-1}$	Note 2
Operating temperature	Controller	+10 to +50			°C	
	Sensor	-273 to +100			°C	

Notes
1. This is the sensor thickness contribution only, it does not include any area effect.
2. Sensor head only can be used at cryogenic temperatures.

All other parameters are as per NX Series NanoSensors.

Ordering information

The NZ NanoSensors® are available in three sizes and one shape. The size is indicated by letters, B (smallest) to D (largest).The larger the sensor, the longer the range. The shape is indicated by number, 2 (square).

Example order code

NZC2

Square shape

The active area is 113mm²
Size is 31mm x 31mm x 6mm (each sensor)

Specifies an NZ capacitance sensor
Zerodur & Super Invar

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