

NTS NanoDirect series

(Model NTS100)

New Generation of Nanopositioning Piezoelectric Translation Stages with Long Travel Distance

Current Challenges in Nanopositioning

In recent years the field of nanopositioning has been able to offer unprecedented resolution in the single digit nanometer range (e.g. approximately 1 nm). However, despite the technological advances, all current commercial piezoelectric translators (PZTs) used for nanopositioning suffer from one very important disadvantage – they have a very limited travel range (typically 5-200 μm). By comparison, stages that use alternative motorized systems, such as DC or stepper motors, offer extended travel ranges (10-100 mm), but provide relatively low resolution (typically 0.1 μm or worse). This makes them inadequate for nanopositioning applications. Another significant limitation of the current PZT nanopositioning systems is a relatively large drift (between 1000 and 2000 nm/hour @ 20°C), which clearly undermines positioning repeatability and accuracy. Most often the drift is related to inaccuracies associated with the applied voltage during nanopositioning.

The solution

The NTS NanoDirect is a state-of-the-art software-controlled nanopositioning system, which resolves these problems by combining unprecedented resolution of 0.4 nm with a travel range of up to 100 mm and long-term stability in open loop mode of less than 2 nm drift/hour @ 20°C. Hence the NTS NanoDirect provides a travel range similar to a conventional stepper motor, but more than 250-times the resolution and up to 1000-times better drift stability.

There are three NTS stage models available offering varying extended ranges of travel; NTS10 (10 mm), NTS20 (20 mm) and NTS100 (100 mm). The NTS NanoDirect system is ideal for a range of applications, including: **Photonics, Fibre Optics, Metrology, Test Equipment, Micro/nanomachining and Biomedicine.**

Piezoelectric motor properties

The NTS stage works on the principle of converting the rotary motion of a highly advanced piezoelectric motor into linear motion of the stage. The combination of high torque, variable speed, and high angular resolution using a shaft-mounted 4000 counts/revolution optical encoder, enables the piezoelectric motor to be used in either continuous or stepper mode, therefore providing accurate angular positioning. When the piezoelectric motor is de-energized, it operates as a position holder (brake) with practically undetectable backlash and drift.



The NTS100 Nanopositioning Translation stage

NTS100 Key Features

- Motion Increment less than 0.4 nm
- Travel Distance 100 mm
- Travel Velocity up to 2000 $\mu\text{m/s}$
- Wide Velocity Range (6 orders)
- Continuous or Stepping Mode
- AutoLock (Self-Locking) when the unit is de-energized
- Acceleration Time to Maximum Velocity less 0.3 ms
- Response Time 50 μsec
- Open-Loop and Close-Loop Modes
- Feedback through a High Resolution Optical Encoder
- Long-term Drift in Open Loop less than 2nm per hour @ 20°C
- Ideal for Nanomotion and Nanopositioning
- High Reliability
- DSP Multichannel Controller

These characteristics facilitate a smooth transition from an angular step of 1 arc sec to continuous motion, a wide range of angular velocities, from 1 arc sec/s up to 60 rev/min (equivalent to about 6 orders of magnitude dynamic range).

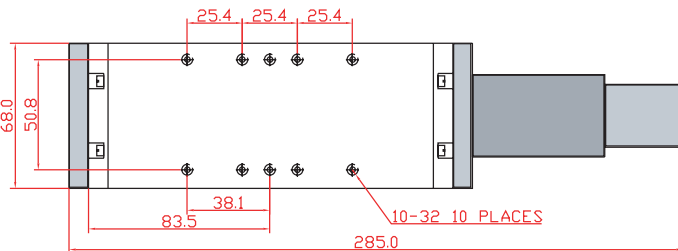
An additional benefit of the piezomotor design is the elimination of heat dissipation in the steady-state mode, which makes the NTS positioners ideal in a number of critical applications (e.g. vacuum applications etc.).

A further advantage of the design is the absence of any positional change in the holding mode, a feature of conventional mechanical motor brakes. The long-term stability of the NTS series is less than 2 nm/hour drift @ 20°C.

Elimination of the “Stick/Slip” Effect

The “Stick/Slip” is one of the major factors, which limits resolution. The effect is caused by the fact that the coefficient of static friction is greater than the coefficient of dynamic friction. When a driving force is applied to a nano-positioner, movement from rest is slightly delayed on the applied force. Initially, with finite force, there is no movement until the force exceeds the static friction. At this point there is a jump in position. Only “frictionless” devices such as solid-state actuators (piezo actuators), exhibit zero measurable friction and therefore provide resolution superior to “classical” mechanical positioners in the sub-micron to sub-nanometer range.

However, the NTS series overcomes the “Stick/Slip Effect” due to the unique start-stop characteristic of the rotary piezoelectric motor. Any angular position of the rotor is “locked” (held) by the self-decelerating torque of the motor. The same force “locks” the whole friction system of the translation stage. To limit the effect of any jump when initiating motion the unlocking process must occur almost instantaneously (with a time constant in the range of 10-100 μ sec). The incorporated piezoelectric motor has been designed to implement a step formation within 50-60 μ sec per 1 arc sec. This timing results in an angular step of the motor in the nano-range, which translates immediately into an equivalent linear step eliminating any static friction effects.



Technical drawings of the NTS100 stage dimensions in mm

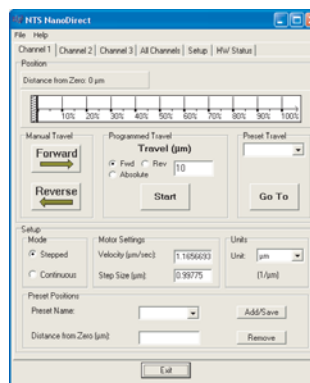
★ NTS nanositioning stages can be arranged into various multi-channel configurations (e.g. XY, XYZ) using a range of available adapters and universal mounting plates.

An optional joystick can be connected to the NTS NanoDirect controller to enable precise simultaneous control of up to 3 NTS stages.



NTS NanoDirect Controller

An integral part of the NTS NanoDirect system is the NTS NanoDirect controller (available in either 1, 2 or 3-channel configurations). The internal architecture of the NTS NanoDirect controller is based entirely on digital signal processing (DSP) therefore enabling a wide dynamic range and a very high measurement accuracy to be achieved. The system is highly portable and operates from a 12 Volt DC power supply.



The NTS NanoDirect controller provides the communication and control link between the NTS Stage and Windows2000/XP operating software. The computer/laptop monitor displays simple menus and prompts the operator to select or enter parameters for the chosen mode of operation. The software processes the digitised input signal and applies the operator-selected information for real-time display and control.

Technical data

Travel Range ~ NTS100	100 mm
Design Resolution	0.2 nm
Min. Linear Increment	< 0.4 nm
Unidirectional Repeatability	< 0.4 nm
Bi-directional Repeatability	< 0.5 μ m
Backlash	< 0.5 μ m
Hysteresis	< 0.5 μ m
Pitch (θ_x) / per 10 mm	< 5 arc. Sec.
Yaw (θ_z) / per 10 mm	< 5 arc. Sec.
Max./Nom. Velocity	500/250 μ m/s
Reaction Time – demand to maximum velocity	< 0.3 ms
Velocity Range (Stepped – Continuous)	6 orders (0.5 nm/s to 250 μ m/s)
Response Time	10 μ sec
Max Load –Capacity	3 kg
Max. Push/Pull Force	30/30 N
Max. Lateral Force	100 N
Encoder Resolution	4000 counts/rev.
Drive Screw Pitch	0.5 mm/rev.
Supply Voltage	12 Volt
Nominal Power Consumption	1 W
Length ~ NTS100	280 mm
Weight	1.792 kg
Long Term Stability – Drift	Less than 2 nm /hour @ 20 ^o C
Recommended Controller	NTS NanoDirect series 1, 2 or 3 channel

For further information and OEM inquiries please contact Discovery Technology International or your local distributor



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