

NM3D Nanomanipulator

DTI's NM3D is a state-of-the-art 3-axis nanomanipulator system, whose combination of extremely high resolution (0.4 nm), long term stability (drift less than 2 nm/hour @ 20°C) and long travel (10 mm) is unprecedented in the field. At the heart of the design is an advanced piezoelectric rotary motor, integrated with a digital signal processor (DSP) programmable joystick controller. When the motor is deenergized, it provides an automatic solid brake on movement, with almost undetectable backlash and drift. The design of the NM3D makes it ideal for a variety of biomedical, microelectronic and optical applications.

NM3D Key Features

- ❑ *Extended travel range - 10 mm*
- ❑ *Compact size & economical*
- ❑ *Ultra-low drift - <2 nm per hour @20°C*
- ❑ *Superior XYZ resolution (less than 0.4 nm)*
- ❑ *PiezoThrust - For smooth membrane penetration*
- ❑ *Variable speed of movement - 0.5 nm/sec to 500 µm/sec*
- ❑ *State-of-the-art DSP design with programmable joystick controller*
- ❑ *Ideal for many applications requiring precise controlled nano/micropositioning*

Operation

The experimental tool or probe, such as a microelectrode, is clamped into the universal holder that is mounted on the side of the NM3D. The clamp accommodates a range of tool/probe sizes and diameters (3 mm to 15 mm) and can also rotate vertically (90°). The vertical rotation enables the angle of approach of the tool/electrode to be manually altered. The NM3D itself is mounted on a rotary base plate, which enables the whole nanomanipulator instrument to be rotated through 360° in the horizontal plane. The base assembly has been designed to be compatible with both metric and imperial sized plates, vibration free tables, optical benches, and a wide range of micromanipulator stands.

Control over the XYZ movement of the NM3D is achieved using a joystick controller. The speed and direction of movement is proportional to the degree of displacement of the joystick handle. If the joystick is deflected fully the nanomanipulator will move at maximum speed (500 µm/sec); which is ideal for rapidly approaching a target of interest under a microscope. If the joystick is deflected gently, the nanomanipulator will move slowly in nanometer increments, which is ideal for the final and precise approach to the exact target site. The joystick can control each axis independently, or all three axes simultaneously.

A New 3-Axis Piezoelectric Nanomanipulator with Ultra-Low Drift and Programmable Joystick



Description

The NM3D nanomanipulator works by converting the rotary motion of an advanced piezoelectric motor (fitted onto each axis of the nanomanipulator) into linear motion. A combination of high torque, variable speed and high angular resolution enables the piezoelectric motor to be used in either continuous or stepper mode. These characteristics facilitate a smooth transition, without degradation in intrinsic performance, from an angular step of less than 5 µrad to continuous motion, and a range of angular velocities, from 5 µrad/sec up to 60 rev/min. This translates into a linear resolution of 0.4 nm and a linear range of velocities from 0.5 nm/sec to 500 µm/sec for each axis of the NM3D.

Additional benefits of the NM3D design include the elimination of heat dissipation, the use of non-ferrous and non-magnetic components, ultra-low electrical noise and low supply voltage (12 VDC), which together make the NM3D ideal for very sensitive applications (e.g. delicate electrophysiological recordings).

Variable PiezoThrust™

A third joystick function, the PiezoThrust™ mode, allows for the rapid penetration of biological membranes using glass or metal microelectrodes. The PiezoThrust is typically employed with the microelectrode positioned very close to the cell membrane. During a PiezoThrust the micropipette rapidly accelerates (e.g. 5 m/sec²) towards the membrane, which it penetrates. The high acceleration enables the microelectrode to puncture the membrane without damaging the surrounding membrane. The depth of penetration can be varied (e.g. 0.5 µm to 5 µm).

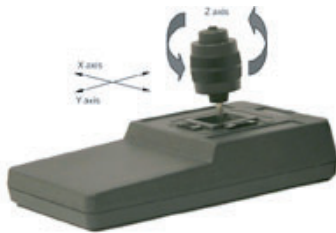
Elimination of the “Stick-Slip” Effect

The “Stick/Slip” is one of the major factors, which limits nanometer resolution and hence the performance of traditional nanopositioners/manipulators. The effect is due to the fact that in mechanical systems the coefficient of static friction is greater than the coefficient of dynamic friction. When a force is applied to drive a system which is at rest, the initial movement is slightly delayed on the applied force. Simply, there is no movement until the force overcomes the static friction. At this point, there is a finite jump (stick/slip) in position; the greater the coefficient of static friction, the greater the initial stick/slip. This effect limits the achievable resolution in position control.

The NM3D overcomes the stick/slip effect using the unique combination of the piezoelectric motor and DSP control. Any angular position of the rotor is locked by the self-decelerating torque of the motor. The same force locks the whole friction system of the nanomanipulator. To limit the effect of any jump when initiating motion the unlocking process must occur almost instantaneously (within 10-100 μ sec). NM3D’s DSP core has been designed to implement a step formation within 2-10 μ sec/ μ rad. This timing results in an angular step of the motor in the nanometer range, which translates immediately into an equivalent linear step eliminating measurable static friction effects.

Programmable DSP Joystick Controller

The joystick controller is supplied ready to use, pre-programmed with default settings. PC-based configuration software included with the controller enables the user to re-program the controller settings via USB port, providing complete user control of the NM3D’s response characteristics. Once programmed, the NM3D operates as a standalone device. No host computer is required.



Ordering Information

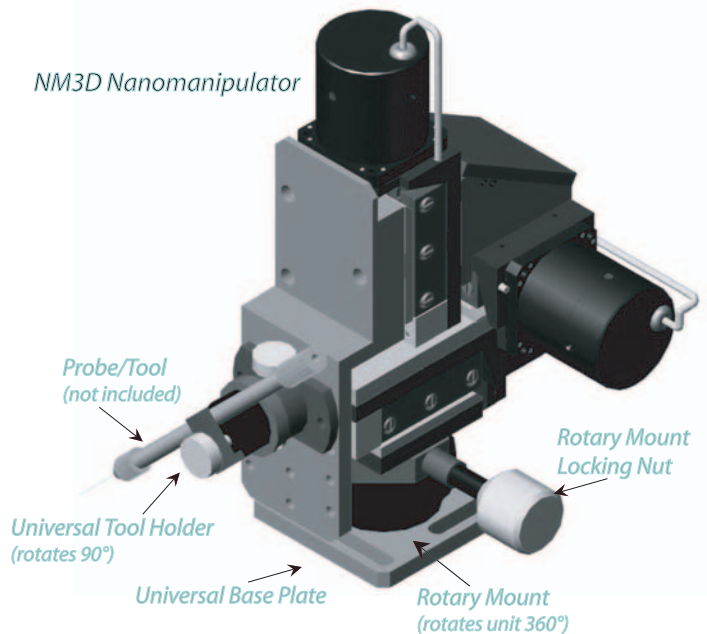
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Description: NM3D Nanomanipulator System (includes joystick controller, universal headstage adapters (2), cable, 110/240 VAC to 12 VDC adapter).

Digital Signal Processor (DSP) Design

An integral part of the NM3D system is the controller, which is embedded into the joystick controller. The internal architecture of controller and joystick is based entirely on digital signal processing (DSP) technology, therefore enabling a wide dynamic range and a very high resolution to be achieved. The complete system is highly compact and portable and operates from a 12 Volt DC power supply (110/240 VAC to 12 VDC adapter included).

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Technical data

Travel Range	10 mm
Design Resolution	0.4 nm
Min. Linear Increment	< 0.4 nm
Long-term Drift	<2 nm per hour @20°C
Unidirectional Repeatability	< 0.4 nm
Bi-directional Repeatability	< 0.5 μ m
Backlash	< 0.5 μ m
Hysteresis	< 0.5 μ m
Roll ((α)) / per 1 mm	< 25 μ rad
Pitch ((β)) / per 1 mm	< 25 μ rad
Yaw ((γ)) / per 1 mm	< 25 μ rad
Max. Velocity	500 μ m/sec
Reaction Time – demand to max velocity	< 0.3 msec
Velocity Range (Stepped – Continuous)	(0.5 nm/sec to 500 μ m/sec)
Response Time	10 μ sec
PiezoThrust (Acceleration)/(Depth)	(0.5 m/sec ² to 5 m/sec ²)/(0.5 μ m to 5 μ m)
Max Load – Capacity	3 kg
Max. Push/Pull Force	15/50 N
Max. Lateral Force	100 N
Supply Voltage	12 V
Nominal Power Consumption	1 W
Maximum Power Consumption (per axis)	4 W
Dimensions NM3D (mm)	198 (h) x 123 (w) x 115 (d)
Dimensions Joystick Controller (mm)	40 (h) X 120 (w) x 200 (d)
Weight NM3D/Joystick controller	1.5 kg/0.5 kg

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