10 Things to Consider
When Acquiring a Nanopositioning System

npoint

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There are many factors to consider when looking for nanopositioning piezo stages. This article will help explain some items that are important when looking at different stages and systems. Those who are new to the world of nanopositioning, please contact us with any additional questions.

This article explains flexure-based piezoelectric stages. The advantages of such a system include:

- Frictionless motion
- High stiffness
- High-speed motion
- Small parasitic errors

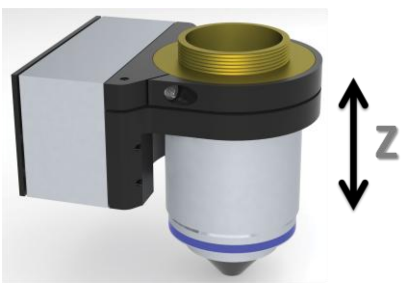
The major disadvantage of piezo stages are their limited range of motion. While some designs have travel of up to 2mm most stages typically move a few hundred microns.

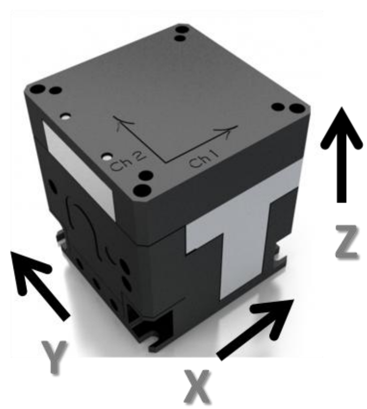
1. Travel Range

Travel range is the maximum distance a stage can move in a single axis. One of the most important things to note when considering travel range is the tradeoff between position noise and maximum travel distance. The position noise of a stage will often increase with larger travel distance. It is important to consider what the maximum travel requirement will be for a stage and compare the desired position noise to determine what if any, tradeoffs should be made. If longer travel is desired, it is also important to note that speed may also be compromised. While stages are designed for different purposes, as a rule of thumb when speed and resolution are important it is best to chose a stage with shorter travel ranges.

2. Axes of Motion

It is important to consider how many axes of motion are required for your application. Take a look at what planes of movement are most important. Nanopositioning systems have X, Z, XY, XYZ, and tip/tilt motion associated. Also consider the travel range necessary for each axis of movement. Some examples can be seen below.





3. Controller

When choosing the controller that best fits your needs, first consider the number of axes that the stage will have. A controller must be selected with an equal amount channels to axes of the stage. An example would be a XYZ stage would require a 3-channel controller. Each channel of the controller is used to communicate the necessary details to one axis of the stage. Controllers are available with up to six axes or more.

A controller is necessary for closed-loop control. It provides feedback to the piezo every 24 microseconds at the same time the sensor provides position data to ensure the stage is moving to the commanded position. A piezo driver can be used for applications where open-loop control is only required. Open-loop control can be used for applications where the user "closes the loop" or in applications where accuracy and hysteresis are not an issue. Piezos can experience creep and hysteresis so commanded position could be off 10% or more without closed-loop control.

PC software can be used along with the DSP controller to get the most out of a nanopositioning system. PID controls along with advanced control software allow a reduction in settling time with a load necessary to the application. If you are interested in learning more about advanced control settings please watch this video on Control Loop Tuning.

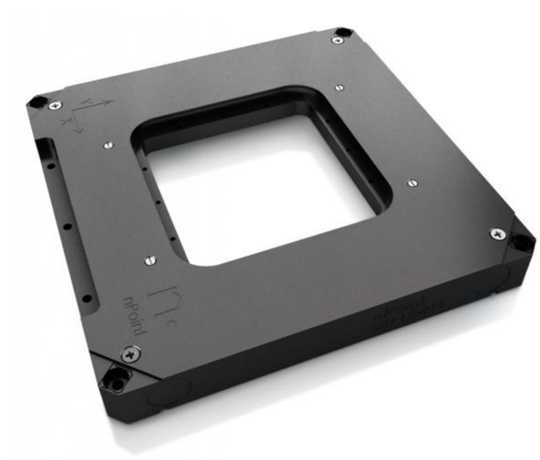
4. System Interface

There are multiple ways in which to communicate with a controller. The simplest way to command a stage to reach and maintain a position or to scan is by using the BNC analog inputs of the controller. Each channel is equipped with analog control and sensor monitor BNC connectors. A voltage range of -10V to 10V ensures that the maximum travel distance is used. Stages can also be calibrated for other input ranges as well.

The system can also be interfaced via USB, Digital I/O, or high speed parallel port. The nPoint USB interface uses FTDI drivers compatible with many programming languages. The user can perform a variety of functions via the USB interface such as commanding position, reading the actual position (sensor signal) and changing control parameters when required. The digital I/O can assign different triggering functions to the 9-pin interface through the front panel software. The high speed interface offers communication with the controller at full loop speed. This allows the user to set the position and read sensor data for up to six channels every 24 microseconds at 20 bit resolution.

5. Stage Footprint/Aperture

The size and shape of a stage is very important to choosing the right system for your needs. Consider how the stage will be integrated in the system. Some stages are designed for certain functions like moving a microscope objective while others are designed solely for AFM applications. Be sure to look at the physical size of the stage to determine if it will fit within the design requirements of the particular application. Some stages are available with common sample holders for standard microscope slides and petri dishes. If an aperture is required for microscopy applications make sure that the aperture is large enough to best fit your requirements.



6. Position Noise

Position noise is the amplitude of the stage movement when it is trying to maintain position at a certain control-loop bandwidth. The control-loop bandwidth varies from stage to stage. A common bandwidth that nPoint uses to measure the noise at is approximately one tenth the resonant frequency of the stage. This measure is commonly used to define the resolution of nanopositioners and it is typically dominated by the sensor noise. If you interface with the nPoint controllers via the analog input you need to make sure that your voltage command is not noisy so that you maintain the high resolution (low noise) capability of the nPoint nanopositioning systems.

7. Settling Time

Settling time is the time it takes for a stage to move to a commanded position and settle to within 2% of its final value of the step size. A small signal step response reflects the dynamic characteristics of the system in greater detail. The time is takes to step 1 micrometer is a common measure used. It is important to note the difference between rise time and settling time. Rise time is the time it takes for the nanopositioning system to move from 10% of the commanded position to 90%. This time is often much quicker than settling time and while it does discuss the relative speed at which a stage can step it does not take into affect the time it takes to for the stage to "settle" in its desired position. When a large step is used, i.e equal to the full travel range of the stage, then the settling time is limited by the current output capability of the controller.

8. Sensor

A position sensor is necessary to provide closed-loop control for the nanopositioning system. There are different types of sensors that can be used to provide the measuring feedback to eliminate inherent issues with piezos such as non-linearity and hysteresis. Three common types of sensors include capacitive, strain gage, and LVDT. Each has advantages for certain applications. Capacitive sensors provide the highest accuracy and linearity. Strain gages are often used in lower cost applications where resolution may not be as critical.

9. Resonant Frequency

The first (or lowest) resonant frequency per axis is typically specified for a nanopositioner. The resonant frequency could be of the mode along the motion axis or along other axes including rotation and other complex modes. In general, the higher the resonant frequency of a system, the higher the stability and the wider working bandwidth the system will have. The resonant frequency of a stage is reduced when load on the stage is increased. When selecting a nanopositioner to move large samples it is important to understand how the resonant frequency will change when the nanopositioner is loaded.

10. Stage Operating Conditions

It is important to consider the conditions which your nanopositioning system will be operating. Piezo stages can be made from various materials such as invar, stainless steel, titanium and aluminum. Piezo stages can operate in UHV and environments that require non magnetic positioning. Stages are designed with particular applications in mind and are made out of materials accordingly. Custom stages can be designed for unique applications and choosing stage material is an important part of the process.

Questions? Please contact us or visit www.nPoint.com