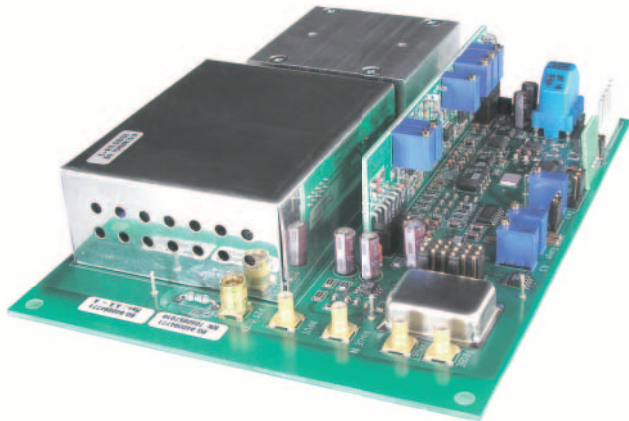


Precision Motion Control



OEM piezo controller card. The piezo control voltages are generated on-board, operation only requires a stabilized voltage between 12 and 24 V

Closed-loop PI piezo controllers feature:

- High linearity
- Positioning with sub-nanometer accuracy
- Excellent long-term stability
- Noise approx. 1 mV (RMS value)
- Low power consumption
- Notch filter for higher bandwidth
- Output voltages adapted to various piezo actuators and piezo drives
- Analog interfaces for fast direct commanding in real time
- Short-circuit strength

Flexible Controllers to Match the Mechanics

PI offers the world's largest portfolio of precision motion technologies for positioning in the accuracy range from one micrometer down to below one nanometer. Fast settling or extremely smooth low speed motion, high positional stability, high resolution and high dynamics – the requirements placed on piezo mechanisms vary greatly and need drivers and controllers with a high degree of flexibility. PI provides a broad spectrum of piezo electronics from versatile general purpose controllers to highly specialized devices. Units come in different levels of integration from customized OEM boards and a plug & play bench-top devices to modular controllers to scalable to almost any number of axes.

Piezo mechanisms directly respond to the smallest change in the drive voltage with a change in displacement. Response times of a few microseconds are possible, depending on the mechanical design and the performance of the piezo controller.

In static operation, i.e. when a certain position is held, the stability of the power supply is also decisive because piezo actuators react even to the minutest change in voltage with a motion. Therefore, noise or drifting must be avoided as much as possible.

This high-performance piezo controller delivers peak power of up to 6 kW. A digital interface module offers extended functionalities, such as data recorder and function generator

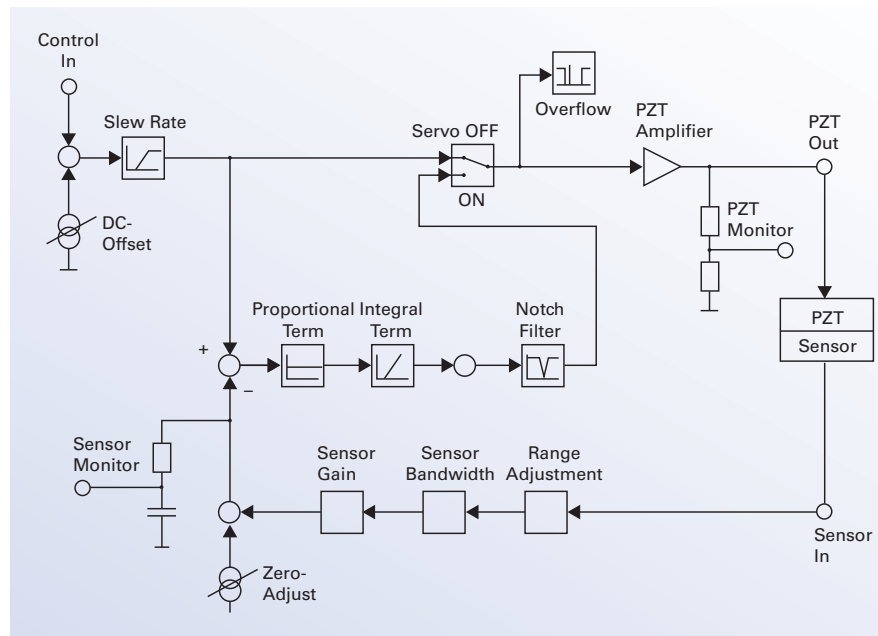


Optimized Control Design Improves System Properties

The performance of a piezo mechanism not only depends on the mechanical design but also largely on the capabilities of its controller. PI's low-noise, drift-free piezo amplifiers ensure optimum stability and resolution. High bandwidth allows for rapid response times and high scanning frequencies.

Closed-loop position control compares the target position with the information provided by the position feedback sensor (actual value) and automatically compensates for nonlinearity, hysteresis and drift.

The servo-control part of most analog piezo controllers manufactured by PI is identical: A proportional integral control loop specifically optimized for piezo operation. One or more adjustable notch filters considerably improve usable bandwidth and dynamics because resonances are suppressed before they can affect the system stability. In digital controllers, optimized control algorithms further minimize settling times and increase bandwidth and stability. High-end closed-loop piezo positioning systems can achieve a repeatability down to the sub-nanometer range and bandwidths to 10 kHz.



Block diagram of a typical closed-loop piezo controller

Resolution in Closed-Loop and Open-Loop Control

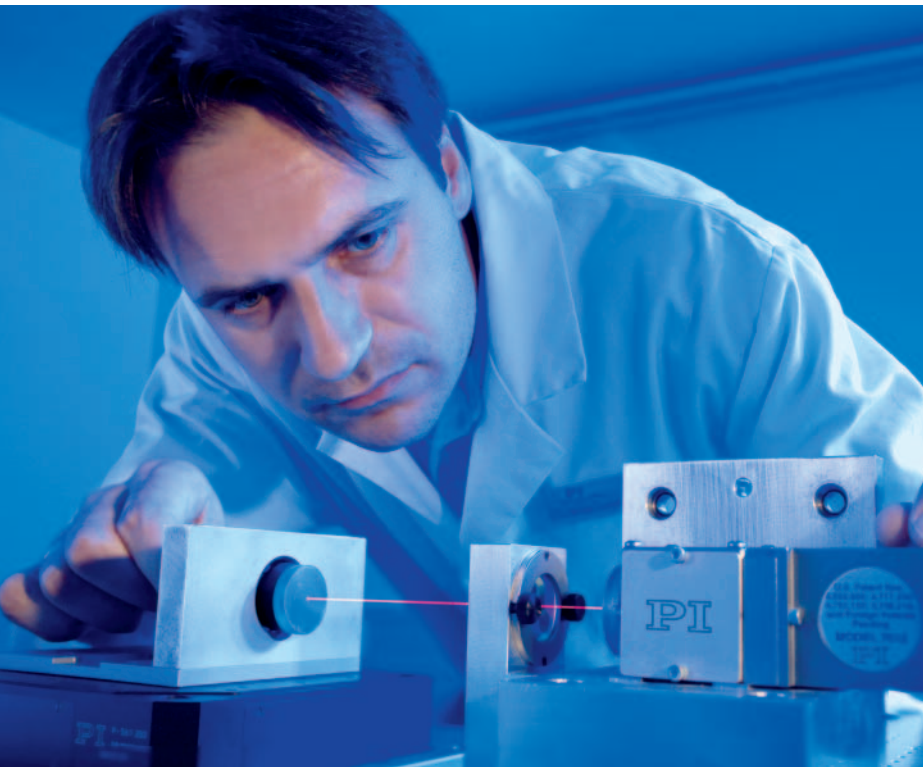
Closed-loop piezo systems guarantee higher linearity and repeatability than open-loop systems. The position resolution of piezo actuators and flexure-based piezo mechanisms is not limited by friction but influenced by electrical noise at the sub-nanometer level.

Because of the additional sensor and the servo circuit, the noise is slightly higher in closed-loop operation compared to open-loop control, where only the piezo amplifier contributes to electrical noise. If high-quality components are used, sub-nanometer positional noise levels are possible in closed-loop operation. Capacitive position sensors achieve the best resolution, linearity and stability.

Advantages and Disadvantages of Position Control

Most precision positioning applications greatly benefit from closed-loop control. When maximum bandwidth is crucial, open-loop may be worth a consideration: A closed-loop controller always operates in the linear range of voltages and currents. Since the peak current is limited in time and is therefore nonlinear, it cannot be used for a stable selection of control parameters. As a result, position control limits the bandwidth and does not allow for pulse-mode operation. In switching applications, it may not be possible to attain the necessary positional stability and linearity with position control. Open-loop operation may be a better choice here with linearization obtained by means of charge-controlled amplifiers or by numerical correction methods.

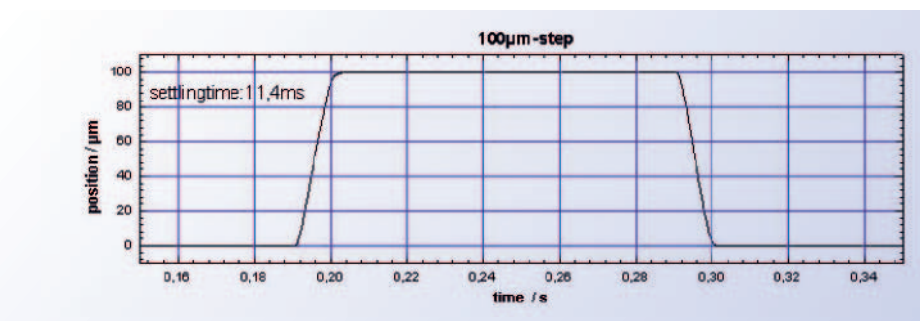
In closed-loop operation, the maximum safe operating frequency is also limited by the phase and amplitude response of the system. Rule of thumb: The higher the resonant frequency of the mechanical system, the higher the control bandwidth can be set. The sensor bandwidth and performance of the servo (digital or analog, filter and controller type, bandwidth) also limit the operating bandwidth of the positioning system.



Standardized Measurements Logs: The Good Feeling When Your Expectations Are Met

Nanopositioning systems are an essential but costly component in applications. PI therefore individually tests and optimizes the static and dynamic parameters of every system. The measurement log is delivered with the system. The customer can thus retrace the performance of the system at delivery and which system components belong together at any time.

PI continually invests in improving the testing methods and testing equipment in order to be able to supply systems of even higher quality. Closed-loop nanopositioning systems are tested exclusively with high-quality calibrated interferometers. The test laboratories are insulated against seismic, electromagnetic and thermal effects, temperature stability is better than 0.25°C in 24 hours. PI thus sets the standard in the testing and specification of nanopositioning products.



Highly dynamic, closed-loop nanopositioning system: A piezo scanner achieves the full travel range of 100 µm in only a few milliseconds

Controller Tuning

To optimize the system performance, information about the application is required, such as the desired operating frequency, step-and-settle, the size and weight of the payload, or the spring constant of a preload in relation to which the piezo actuator is operated.



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