Digital Controllers Provide Precision, Dynamics and Ease of Operation

Digital piezo controllers have several advantages over analog servo circuits: Linearity and settling behavior can be specifically influenced by digital algorithms allowing much greater flexibility than analog circuits. The result is higher precision and better dynamic performance.

Linearization of the Electronics

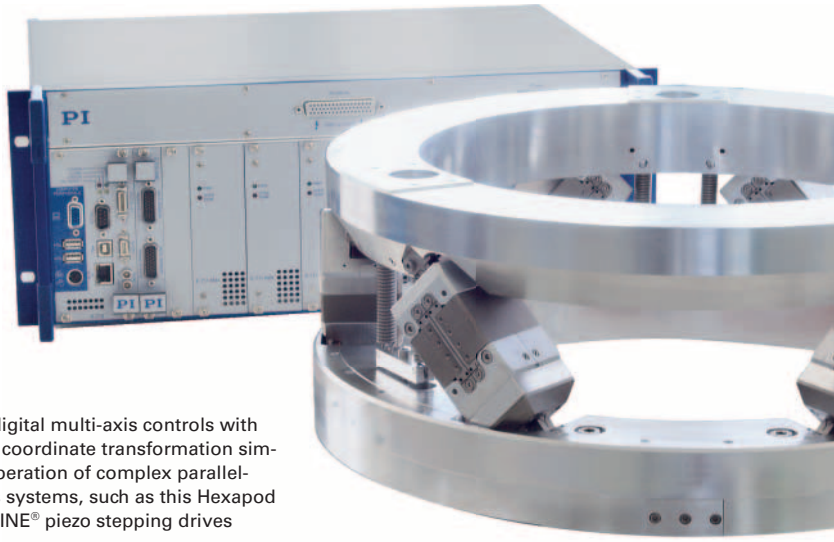
With digital servo controllers it is possible to upload calibration data quickly and remotely. PI piezo stages can store optimized parameters in an ID chip. With this combination, controllers and mechanics can be swapped without performance losses, because the controller recognizes the mechanics and reads specific linearization and calibration data when it is powered up.

Controllers and Servo Techniques

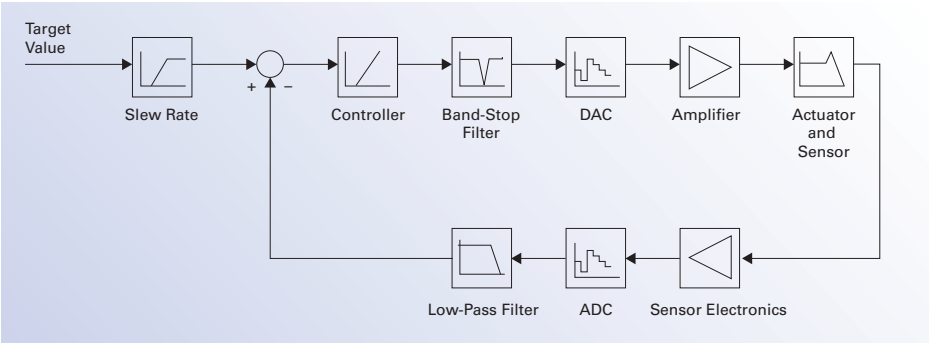
The task of a servo loop is to correct deviations between the actual position and the target position. Commonly, this is done with P-I (proportional-integral) controllers. Depending on the application, however, advanced control techniques in combination with linearization algorithms can yield better results. Digital filters avoid undesired mechanical excitation, suppress noise and, with that, increase the resolution and system bandwidth.

Linearization of the Mechanical System

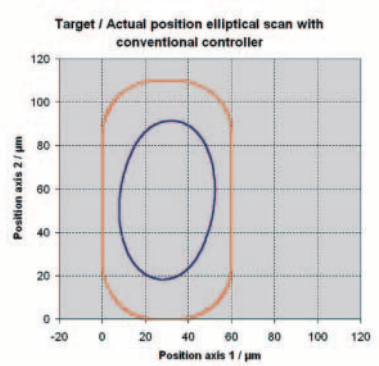
The linearity of the entire system is one criterion for its positioning accuracy. Piezo actuators typically show a nonlinearity of 10 to 15%, which has to be compensated by the control loop. Digital controllers use higher-order polynomials to reduce the motion nonlinearity to values below 0.001%, which, for a typical travel range of 100 µm, corresponds to an accuracy of one nanometer and better.



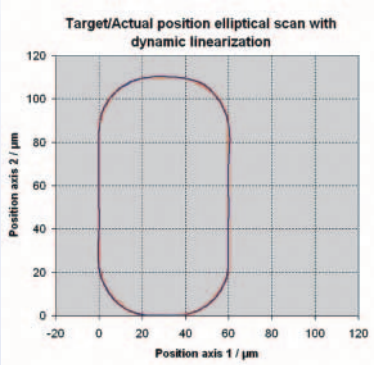
Modular, digital multi-axis controls with integrated coordinate transformation simplify the operation of complex parallel-kinematics systems, such as this Hexapod with NEXLINE® piezo stepping drives



Block diagram of a digital piezo servo controller



Elliptical scan (for laser micro bore applications) with an XY piezo scanning stage and conventional PID controller. The outer curve shows the desired position, the inner curve shows the actual motion



The same scan as before but with a DDL controller. The tracking error is reduced to a few nanometers, target and actual position cannot be distinguished in the graph

Dynamic·Linearization: Following a Moving Target

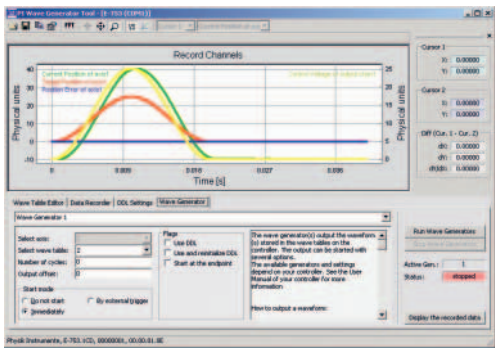
Dynamic digital linearization (DDL) reduces the dynamic tracking errors of periodic trajectories. This is relevant for scanning applications, where a specific position must be identified on the fly and later be approached with high precision, or for applications where a trajectory must be followed at very high speed with minimum deviation for processing steps.

Additional Functions of Digital Controllers

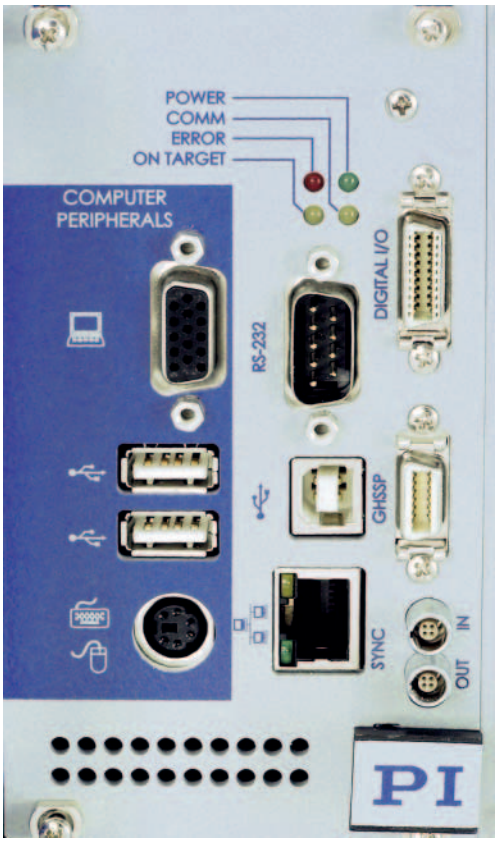
Computing power and memory size which go hand in hand with digital controllers allow useful additional functions to be implemented.

- Software access to all motion parameters and the graphic display of the results
- Coordinate transformation for parallel kinematics for simple control in Cartesian coordinates
- Macro memory to store and retrieve motions which can be triggered externally
- Function generator and waveform memory for the retrieval of predefined trajectories and the generation of customized waveforms
- Data recorders record sensor and control data for subsequent processing
- The ID chip permits the flexible exchange of controllers and nanopositioners without the need to retune the operational parameters

Not all controllers provide the above-listed functions. The individual ranges of functions are listed in the relevant datasheets.



Complex motion profiles can be generated, saved and implemented with the function generator



The standard interfaces for digital nanopositioning controllers are RS-232, USB and TCP/IP. Additionally, PI offers digital I/O lines, options for analog interfaces and real-time PIO

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