3. Feedback controllers PosiCon 150/X

The “PosiCon” piezo positioning system is a complete system comprising all necessary electronic subsystems for closed loop piezo actuator control:

- position sensor signal amplifier stage
- feedback control logic
- piezo voltage amplifier
- piezo voltage rage: -30V/+150V

For feedback/closed loop operation, the piezo actuator must accept the voltage range of the PosiCon device and show option “position sensor” (see actuator’s data sheet).

A wide range of positioning applications are covered with respect to precision and response time. The amplifier stages provide semi-bipolar operation for largest stroke and feature lowest noise for highly stable positions together with a smooth reaction characteristic of the positioning system.

Dual use:
The PosiCon devices can be operated in “closed loop” or “open loop” mode.
The mode selection is done simply by a switch on the front panel.

3-channel PosiCon 150/3
The PosiCon-controllers are avaible as
single channel PosiCon 150/1
three channel PosiCon 150/3

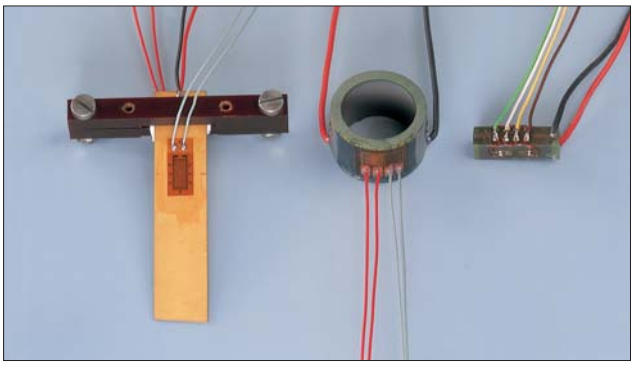
For multichannel devices, each channel can be set individually. In the “open loop” mode the PosiCon acts as simple piezo amplifier.
Position information is provided even in the “open loop” mode (see “Display” and “Monitor”).

What are the advantages of the feedback controlled PosiCon system

Piezoactuators stroke is measured by a position sensor (strain gage) applied directly onto the piezostack inside the casing:
Hereby the sensor detects all internal and external effects influencing the strain status of the stack:

The result is a

- **highly linear and reproducible motion of the actuator according the input reference signal (elimination of piezomaterials creep, hysteresis, nonlinearity).**
- **automatic selfcompensation for varying load forces, potentially changing the strain of a piezo stack: the PosiCon system shows virtually infinite stiffness (no change of strain under varying forces).**



Variety of piezoactuating components with surface mounted strain gauges.

- **Special thermally compensated strain gages are used which compensate even for a potential thermal expansion of the actuator.**

Functional elements, operation

“Open/closed loop” selector switch “Feedback”
Each channel of the PosiCon can be selected by a switch for “open loop” or “closed loop” operation.
In the “open loop” mode, the PosiCon behaves like a normal piezo amplifier.
Position detection remains active, so position information is provided via “LC-Display” and “Monitor”.

“Offset”

Closed loop operation:
A manual setting of the position can be done.
The position varies linearely with “Offset”, no hysteresis and creep.
Variations in position by varying load forces are compensated for automatically.
The “offset” setting is superimposed to external signals.
Open loop operation:
A manual setting of the output piezo voltage can be done.
The position of the actuator varies with “Offset” resulting in the normal open loop behaviour with hysteresis and creep.
The “offset” setting is superimposed to external signals.

LC-displays
for individual “µm” and “Volt” reading per channel

Zero-setting:
The starting point of piezo actuator’s action can depend on various side conditions like mounting forces, preloading etc.
To get a reasonable position read-out, each channel for the PosiCon can be set to “zero” individually by a potentiometer in the front panel.

Gain factor:
The amplifier gain factor of each channel of the PosiCon can be set individually by a switch to accept alternatively **5V or 10 V input signal** for full stroke action.

“Monitor”
Via BNC connectors on front and rear panel, analog signals are provided as real time information for position and piezovoltage for each channel individually.
Piezovoltage is reduced by a factor 1:1000.
Position is represented as a 5 V swing equivalent full stroke.

Sensor input:
The PosiCon unit requires a signal from a 4 active-element Wheatstone bridge for input.
This sensing element is usually applied to the piezo actuator (Option: position detection).
But the sensor can be attached to an external mechanism too.

Electrical connector, 4-pole LEMO 0S.304.

Piezovoltage output:
BNC.
Optionally, other connecting systems like LEMO 00 250 are available.

Output voltage:

PosiCon 150: –30V thru +150V/
max. current: 60 mA

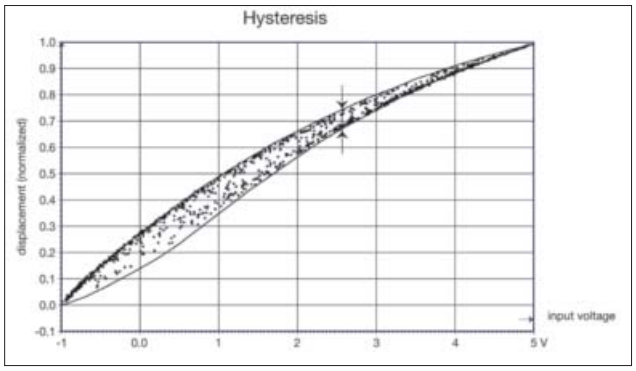
Calibration:
Calibration is only necessary to set the position read outs of the PosiCon (“µm”-LCD and “Monitor”) to the actuator performance.
Calibration is done at PIEZOMECHANIK factory and is valid for the distinct actuator-PosiCon combination.
Uncalibrated systems work in “closed loop” feedback mode too (compensation for hysteresis, creep etc.), only the position read outs are not valid.

Repeatability, Sensitivity
Precision means the tolerance range for hitting a wanted position upon application of the equivalent input signal.
A, for random access addressing of a position, the PosiCon system can show a repetition tolerance of about +/– 0.1%.
A 50 mm actuator can be operated within a +/– 50 nanometer tolerance field (residual hysteresis)
B, the repeatability is still better for cyclic motion profiles
C, the minimum resolvable relative shift in position is about 5 nm in the closed loop mode.

Precision positioning by piezoactuators

One **essential feature of a piezoceramic actuator** is its ability to make **infinitely small movements,** when a correspondingly small voltage signal is applied.This feature enables piezoactuators for ultraprecise positioning tasks (unlimited relative positioning sensitivity).

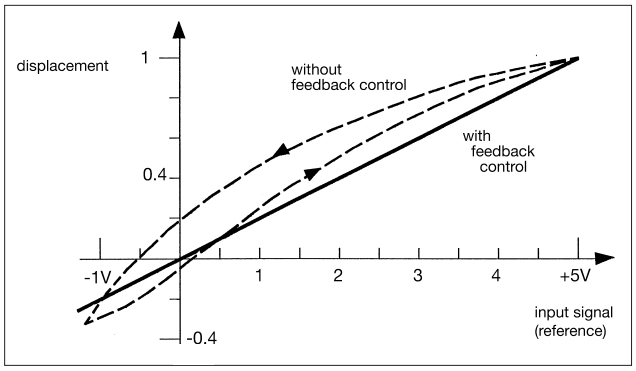
On the other hand, when a large change in the voltage signal is applied to a piezoactuator, the actual position stepwidth can be influenced by a lot of internal and external parameters acting onto the actuator, so that in the first instant, the relationship between voltage and the induced motion can only roughly be predicted. This can be easily demonstrated by applying a series of random voltage steps to a piezoactuator or by running a cycle over a distinct voltage range producing the wellknown hysteresis loop.



Open loop correlation of piezo actuator's position and driving voltage for a sequence of random voltage steps. The randomly generated sequence of points is filling up the area envelopped by the hysteresis cycle. Additionally the usual hysteresis cycle for a continuous full scale voltage variation is shown.

To get this information about the actual position, the actuator is combined with a suitable kind of position sensitive effect or sensor. "Suitable" means: sufficiently high in accuracy, repeatability, linearity.

By a feedback control logic, the real position of the actuator is permanently compared with the wanted position, defined by the magnitude of the input signal. When there is a difference between wanted (reference) and real position, the feedback control cancels it immediately out **(closed actuator-sensor loop operation)** and the systems settles at the perfect position.



Relation stroke – reference input voltage to a piezo-mechanical system in
A open loop operation (by standard amplifier or PosiCon in "feedback off" mode).
Result: typical piezoactuator nonlinear hysteresis characteristic. Hysteresis about 15 %
B closed loop operation of a PosiCon system together with an actuator with position sensor.
Result: linear characteristic with a residual hysteresis: order of magnitude 0.1 % of actuators maximum stroke.