

Electronics for piezoaction

Power supplies
Strain gage position detection
Closed loop positioning





Content



1.1 Analogue amplifiers SVR150/x

3

low power for ultra precision positioning
wide voltage range : -30 V / +150 V
very low noise



1.2 Analogue amplifier LE150/100

4

high power for enhanced dynamics
Unipolar output: 0V / +150 V
Low noise



2. Strain gage amplifier DMS.x

5

for operating precision strain gages e.g. for piezo based
precision positioning tasks



3. Feedback controllers PosiCon 150/x

8

for closed loop precision positioning, based on PIEZOMECHANIK strain gages
includes strain gage amplifier
feedback electronics
output -30V/+150 for max. stroke

On request

Electronics for -50V/+180V operating voltages up to +180V

SVR180/x -50V/+180V max. current 50 mA

LE180/080 0V/+180V max. current 800 mA

Electronics for even more power / higher current outputs
for highly dynamic piezo-excitation

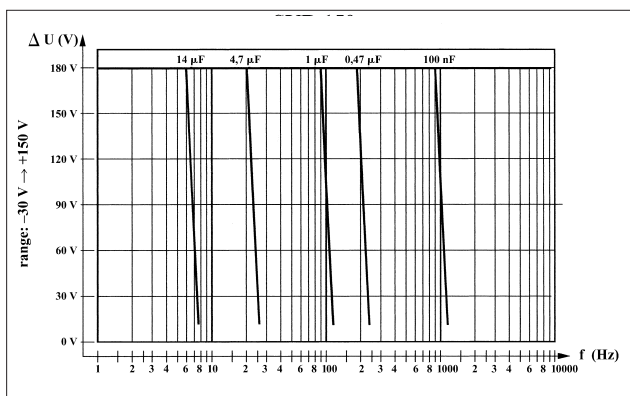


1.1 Analogue amplifiers SVR150/X



Max. semi-bipolar range
-30V/+150V
for maximum stroke/force generation

Very low noise
Manual setting of DC-offset
Variable attenuation for input signal matching
SVR150/1 single channel
SVR150/3 three independent channels



Input:
Signal: +/-5 V (+/-10 V with attenuation)
Impedance: 5 kOhms
Connector: BNC

Output:
Connector: BNC
Voltage total: -30 V thru +150 V
DC-Offset range: -30 V thru +150 V
Gain: 30 (without attenuation)
Max. current: 60 mA
Noise: 0.3 mVpp (for 4.7 μFarad load)
Display: LCD
Dimensions W x D x H (mm):
single channel: 165 x 200 x 65
3-channels: 260 x 320 x 155
Weight:
single channel: 1.75 kg
3-channels: 4.7 kg

On request

**SVR180/x output -50V/+180V
max. current 50 mA**

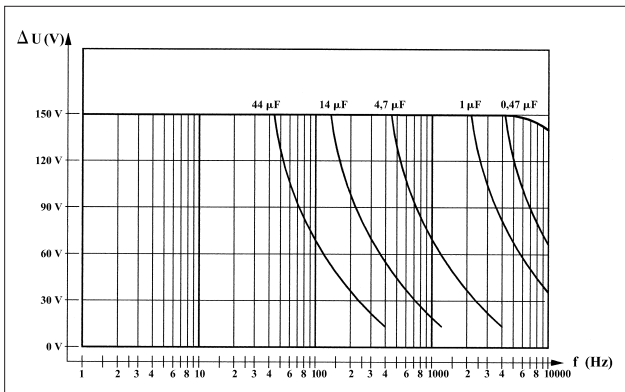


1.2 Analogue High Power Amplifier LE150/1



Voltage range
0V/+150V
Wide bandwidth up to 70 kHz
(depends on capacitive load)
Low noise

Manual setting of DC-offset
Variable attenuation for input signal matching
Single channel device



Input:
Signal: +/-5 V (+/-10 V with attenuation)
Impedance: 5 kOhms
Connector: BNC

Output:
Connector: BNC
Voltage total: 0 V thru +150 V
DC-Offset range: 0 V thru +150 V
Gain: 30 (without attenuation)
Peak current: 1200 mA
Average current: 350 mA
Noise: 20 mVpp (for 4.7 μFarad load)
Display: LCD
Dimensions W x D x H (mm):
260 x 320 x 165
Weight: 6.8 kg

On request

LE180/080 **output 0V/+180V**
max. current 800 mA



2. Strain gage amplifier DMS



Strain gage amplifiers DMS01 and DMS 03

DMS01

Single channel amplifier
W x D x H (mm) 120 x 120 x 60
weight 350 g

(power supply included)

DMS03

Triple channel amplifier
W x D x H (mm) 240 x 120 x 60
weight 550 g

(power supply included)

Accessories

- LEMO connectors 0S304 fitting to DMS signal input sockets
- 4-wire cables, shielded with one side LEMO 0S304 connector, 1 side blunt length 1.5 m (other lengths on request)
- 4-wire extension cables, shielded with LEMO 0S304 connector/coupler length 2 m, 3 m, 4 m



Strain and Position Detection

● Analog Signal Output:

0V/+5V equivalent piezo actuator's max. strain
Impedance: 1 kOhms
Connector BNC

● Readout

3 1/2 digit LC-display

Amplifier adjusts via mini-potentiometers

● Zero setting

The absolute length of a piezo stack varies with the preload conditions during mounting, thermal status etc.

Therefore a zero point setting procedure can be carried out for piezo actuator's operation to compensate for all mechanical offsettings during the installation of the actuator.

● Variable gain

The original signal height of a strain gage arrangement depends mainly on the strain gage characteristics (k-factor) and the number of active bridge elements (full bridge, half bridge, 2-quarter bridge etc).

The DMS-amplifiers shows a variable gain adjust for adapting the DMS output exactly to 0V / +5V range for a defined piezo stroke/strain.

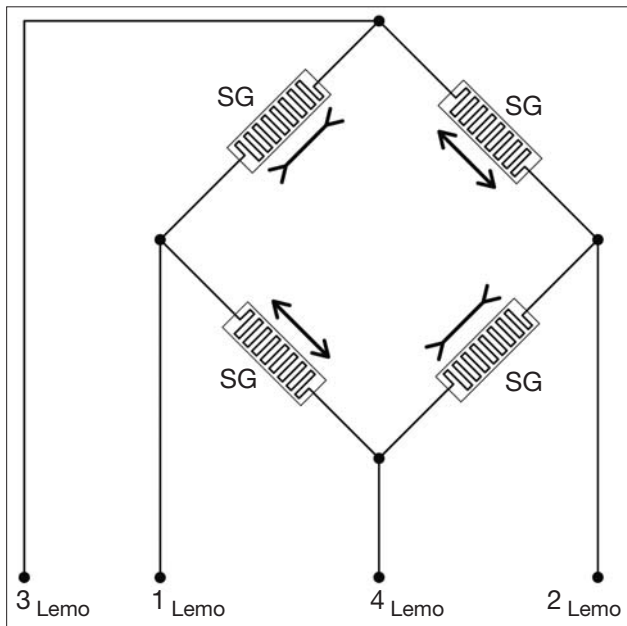
● Calibration of display for position readout in μm

A steady or slow varying position with sub-micrometer resolution is shown in terms of fractions of μm on a large LC-display.

A simple calibration procedure allows the user to adapt the readout to a distinct piezo actuator / sensor configuration.

Power supply:

12V



Schematic arrangement of a 4 active elements Wheatstone bridge

Contacts:

Connector LEMO 0S 304 pin-numbers or stranded wires/insulation color (for blunt ends)

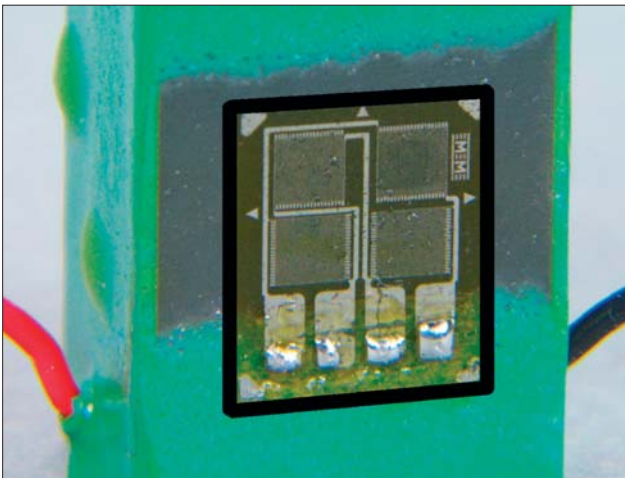
Supply voltage **in** bridge diagonal 1-2 / red-black
Signal **out** bridge diagonal 3-4 / white-green



Position Sensing by strain gages

Strain gage circuits produce very small signals in the mV and μV -range. A high quality amplifier like the DMS device is needed to convert this original signal into a reasonable standard analog output voltage level (e.g. 5 V) or other kind of usable information.

- All kinds of strain gages with a resistance of 350 Ohms up to 5 kOhms can be operated by the DMS amplifiers.
- The DMS amplifiers are a complete detection units comprising the strain gage electrical supply and the signal detection unit. No other attributes are necessary to run a strain gage measurement.
- The DMS 01 and 03 amplifiers show high resolution capability down to a strain variation $< 10^{-6}$.
- High dynamics with a 30 kHz bandwidth.
- The DMS amplifiers are stand-alone devices. This allows to locate the amplifiers rather near to the strain gage arrangement independently of other piezo-electronics. Hereby, any electrical noise pick up due to long distances from gage to amplifier is strongly reduced.
- ▶ Therefore, the strain gage amplifiers DMS are excellently suitable to be combined with piezo actuator borne strain gages for high resolution, high dynamic position monitoring.



4 active-elements strain gage-bridge configuration on a piezo stack Typical gage resistance: 1.2 kiloOhms.



Basic position control equipment. Piezo-actuator with strain gage position sensor. Position read out by DMS 01 unit. Piezo-actuator supply electronics SVR 150 (left).



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 range: -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 available as single channel PosiCon 150/1 three channel PosiCon 150/3

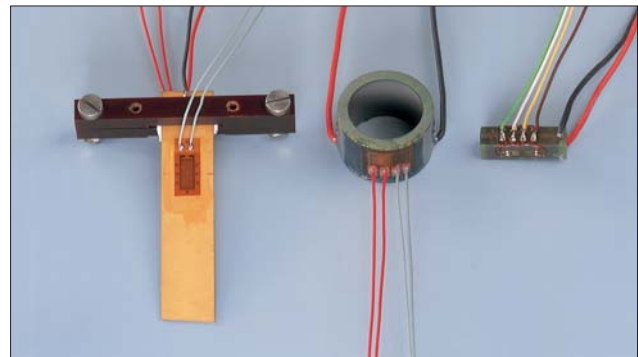
For multichannel devices, each channel can be set individually. In the “open loop” mode the PosiCon acts as simple piezo amplifier. Position information is provided even in the “open loop” mode (see “Display” and “Monitor”).

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 gauges 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 linearly 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 $\pm 0.1\%$.

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.

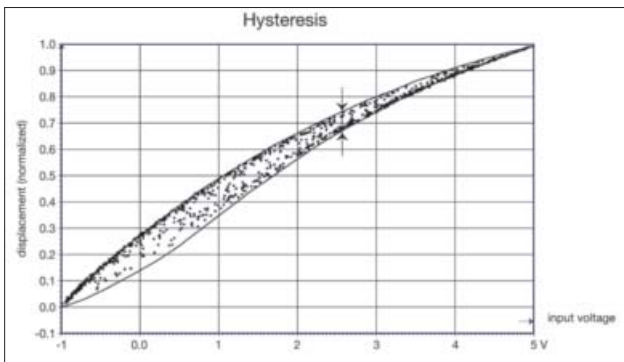


Precision positioning by piezoactuators

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.

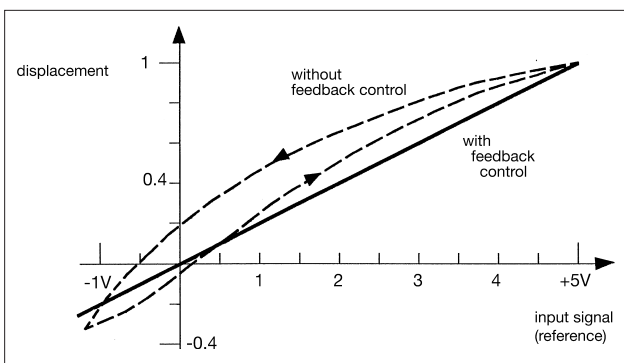


Open loop correlation of piezo actuator's position and driving voltage for a sequence of random voltage steps. The randomly generated sequence of points is filling up the area envelopped by the hysteresis cycle. Additionally the usual hysteresis cycle for a continuous full scale voltage variation is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



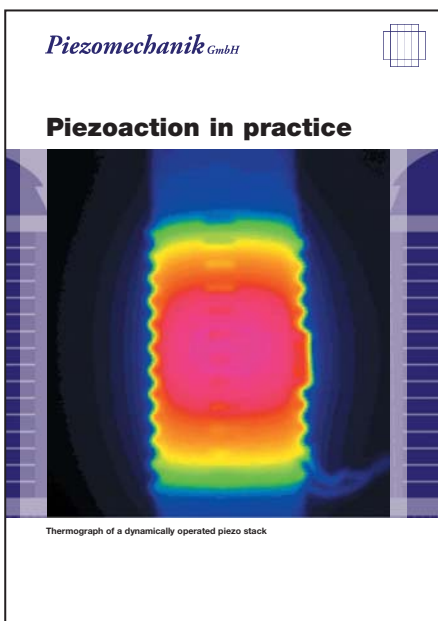
Piezo actuators

- Ranging from bare elements for space-saving designs up to contained versions
- Wide spectrum of size
- Suitable for exotic driving conditions.



Summary

A few basics about cofired monolithic piezo-ceramic actuators and chips regarding handling, properties, modifications, technology.



Extended

More details on PZT- actuating structures, operating parameters, design aspects, “must not”s and the interaction between PZT-actuators and attached mechanics as well as the importance of a well-adapted electronics to get the optimum performance out of your system.

PIEZOMECHANIK is a globally recognized supplier of first-class piezo systems.

Our actuator specialists are excellent connoisseurs of the current actuator scene. This allows you to point out certain intricacies of the topic, which you will not find in the usual company scripts.

PIEZOMECHANIK successfully provides advice and development contributions even for unorthodox piezoaktorian applications, some of which go far beyond the classical approaches.

We get for you from actuators what is really in it.



Piezomechanik · Dr. Lutz Pickelmann GmbH

Berg-am-Laim-Str. 64 · D-81673 Munich · Phone ++ 49/89/4 31 55 83 · Fax ++ 49/89/4 31 64 12
e-mail: info@piezomechanik.com · <http://www.piezomechanik.com>

