

Pacific Laser Equipment, Inc.

1SA-1000 User Manual



Name: 1SA-1000UM

Release: 1.21

Release Date: April 28, 2004

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1. Introduction

Product description

The 1SA-1000 is a unique piezo actuator driver.

It consist of is a precision high voltage amplifier with integrated servo controller electronics.

On the front panel the device offers manual control as well as an analog input for user control. All front panel connectors have the outer side connected to ground (GND).

The HV output connector will deliver up to -1200V (negative polarity) on the center pin.

For applications where PC control is necessary we suggest the use of a D/A card to generate the analog input voltage. Suggested manufacturers are Capital Equipment Corporation (CEC), Keythley Instruments and National Instruments (NI).

The actuator expansion can be visually monitored on the front panel digital display or through the analog monitor output, also available on the front panel through a BNC connector.

The equipment is pre-calibrated and the user seldom needs to adjust, one time, the “ZERO CALIBRATION” potentiometer on the front panel.

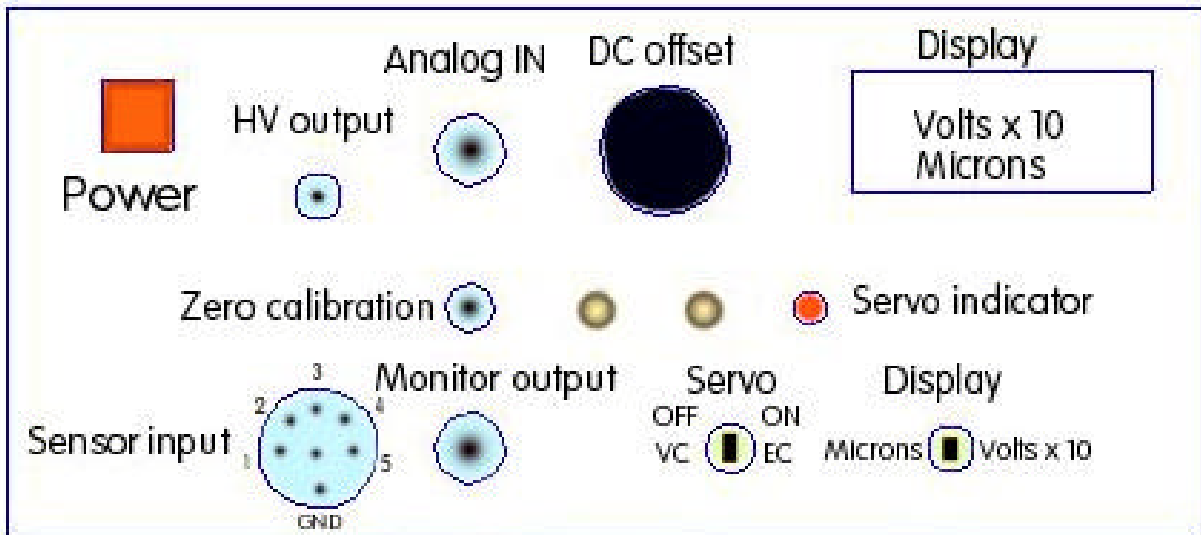
On the rear panel the user has access to the AC power plug and a slow-blow fuse.

Labels:

Rear panel two labels display the power requirements and the unit serial number.

Top cover the label shown bellow displays a “map” of the front panel controls and connectors.

Front panel the model number and company name are displayed.



Operation

Two operating modes can be selected from a front panel switch. Voltage Controlled (VC) or Expansion Controlled (EC). They are also referred as SERVO OFF (for VC) or SERVO ON (for EC).

In EC mode an analog input signal of +10 V causes the Piezo to expand to its nominal value and the monitor out should also measure +10V.

Most dynamic applications require the power amplifier to deliver a short peak current higher than the average value. This equipment is not designed for dynamic operation.

Manual Operation:

In VC mode the HV output can be controlled manually from 0 to -1200 VDC from the front panel DC- Offset Potentiometer.

Voltage Controlled Operation (VC-Mode)

In Voltage Control (VC) mode the closed loop position control circuit is bypassed and the system works like an amplifier. In this mode, the HV output is proportional to the Analog in signal input. The sensor electronics however works independently and outputs the actual piezo position even in VC mode if a sensor is connected to the unit.

The nominal input voltage range is 0 to +10 V for 0 to -1000 V output voltage range. For some applications where the full expansion capability of the piezo translators is needed the full output voltage range of 0 to -1200 V can be used.

The equivalent Analog IN voltage range is then 0 to +12 V.

For bipolar operation set the output with the external DC-Level potentiometer to an appropriate level (-500 V) and drive the input with +/- 5 V to get full expansion.

Expansion Controlled Operation (EC-Mode)

The 1SA-1000 has position sensor processing electronics on board.

Sensor controlled operation offers drift and hysteresis free positioning, which enables the expansion controlled (EC) mode.

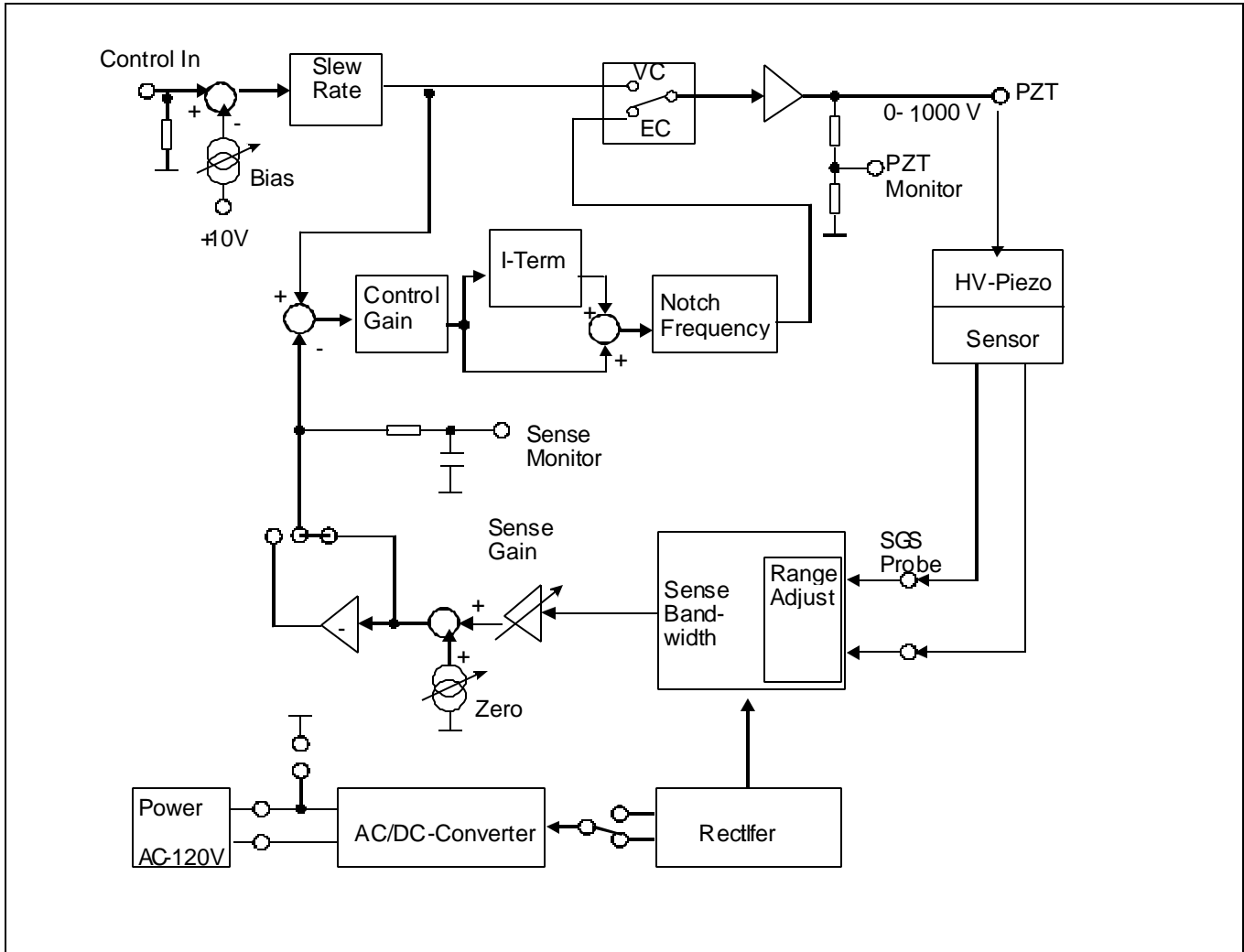
In EC mode, the expansion is directly proportional to the control input signal. The operating voltage for the piezo actuator may change in the range from 0 to -1200 V. If the actual expansion of the piezo can't match the commanded position defined by the control signal, the red overflow LED comes on, on the front panel.

Our standard calibration procedure assures that that the PZT reaches its nominal expansion value when the input control signal is +10 Volt.

Expansion Control (EC) mode supplies the amplifier with the output of the servo-controller and the piezo position is changed until the final position is reached. In this controlled mode the position is directly proportional to the input signal while the applied supply voltage is not.

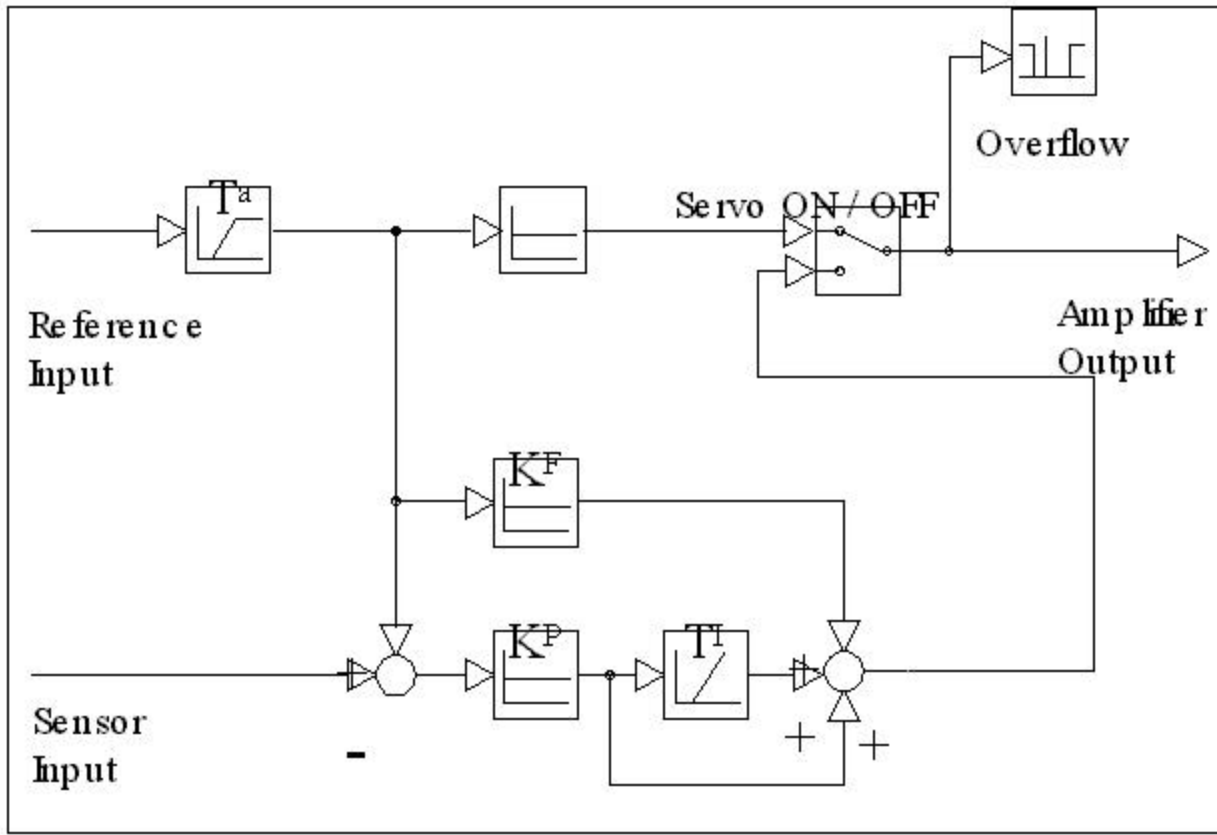
2. Block diagrams

2.1 General diagram



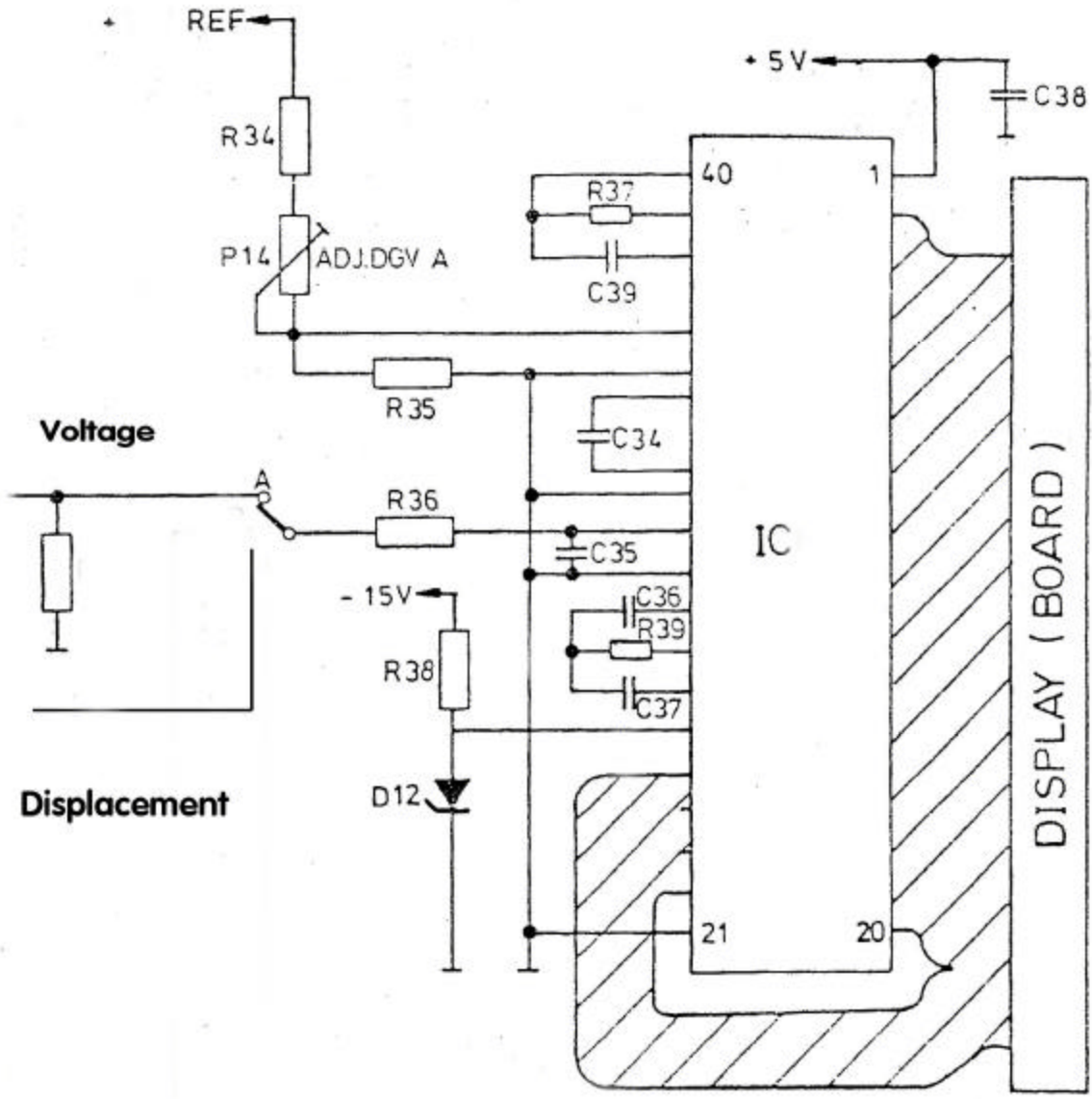
1-SA-1000 dwg.

2.2 Servo block diagram.



- T_A Slew rate limitation
- K_P Proportional term
- T_I Integration time constant
- K_F Feed forward (not installed by default)

2.3 Display



3. Blocks description

3.1 General

The system is composed of the following subassemblies.

Power supply. Providing regulated $\pm 12V @ 100mA$ and $+5V @ 500mA$ from AC 120V

High voltage amplifier. Provides 0 to $-1000VDC$ from $+12VDC$. Gain of $(-)$ 200.

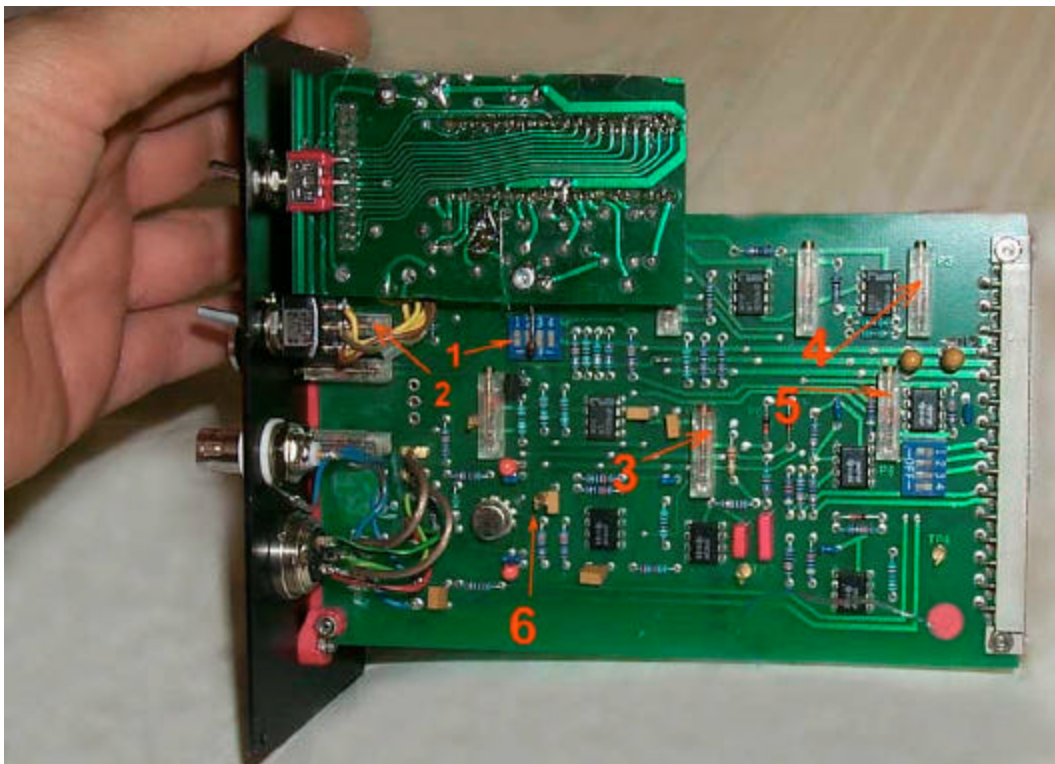
Servo controller. Specialized for SGS. Pre-calibrated with a matched piezo actuator.

Digital display. Calibrated for HV output reading $\times 10$ and displacement in microns.

3.2 Servo controller (Component Functions):

The servo controller shown in the picture below is specialized for strain gage sensors and has been pre-calibrated for the piezo actuator purchased with it.

The main adjusting potentiometers and dipswitches are listed with their function below.

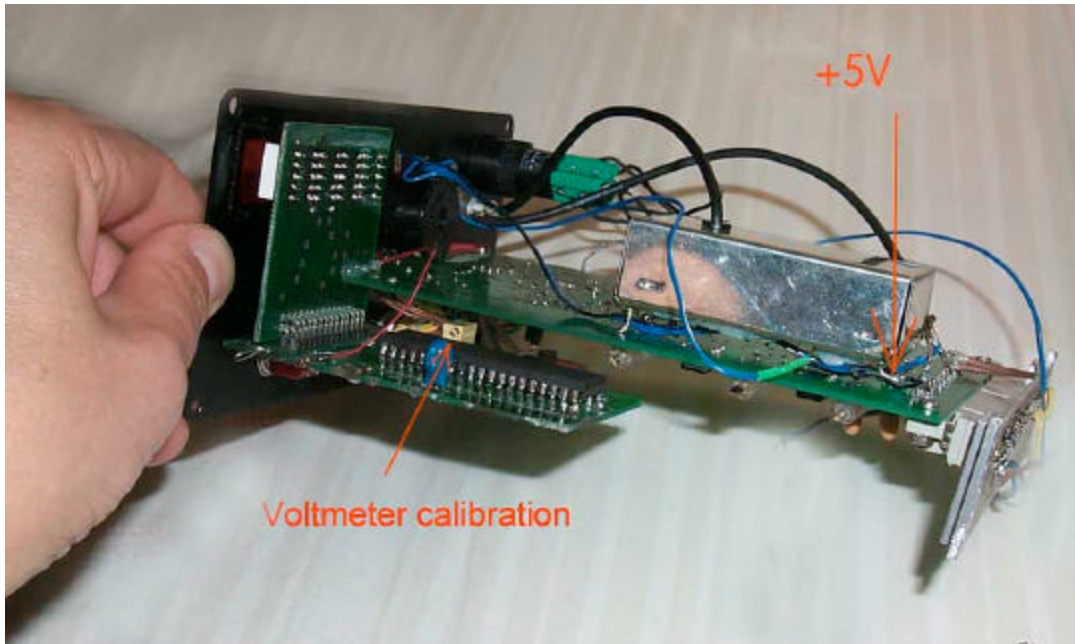


1. Voltage setting for SGS. At full expansion set to a voltage range between 4-6V on (6).
2. Sensor gain. Adjusted (in manufacturing) for nominal expansion on 10V analog input.
3. P-term. Adjusted (in manufacturing) so that the system will not self oscillate in EC.
4. Display offset. Adjusted in VC with 0V in so that the digital display reads 0V.
5. Monitor output. Adjusted for 0-10V on a displacement range of 0 to nominal expansion.
6. Test point for SGS excitation. See point (1).

3.3 Display

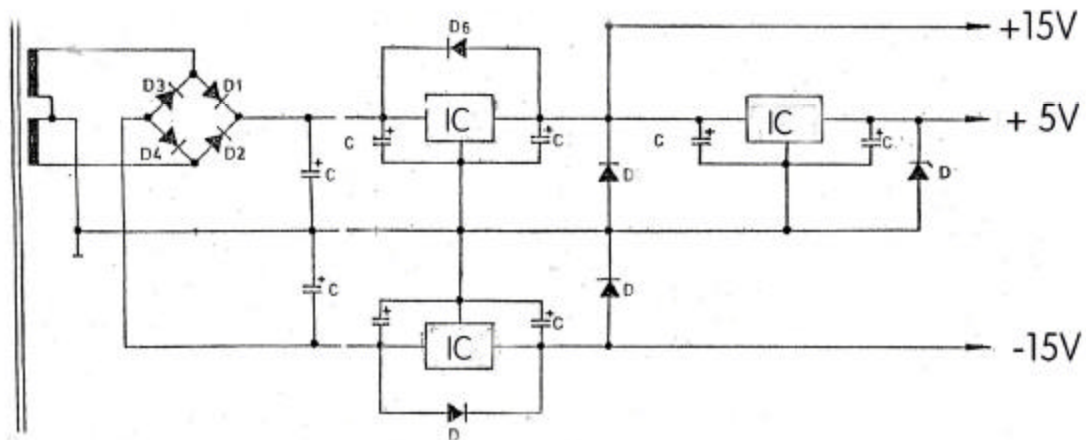
The display is built on a mixed signal processor from INTERSIL.
Part number ICL-7107.

The module inside this system will display $-100.0V$ at $-4V$ with the decimal point fixed at 100.0 regardless of the values displayed. The HV output voltage is therefore divided with a $20M\Omega/100K\Omega$ resistive voltage divider and than adjusted as shown in the picture bellow.

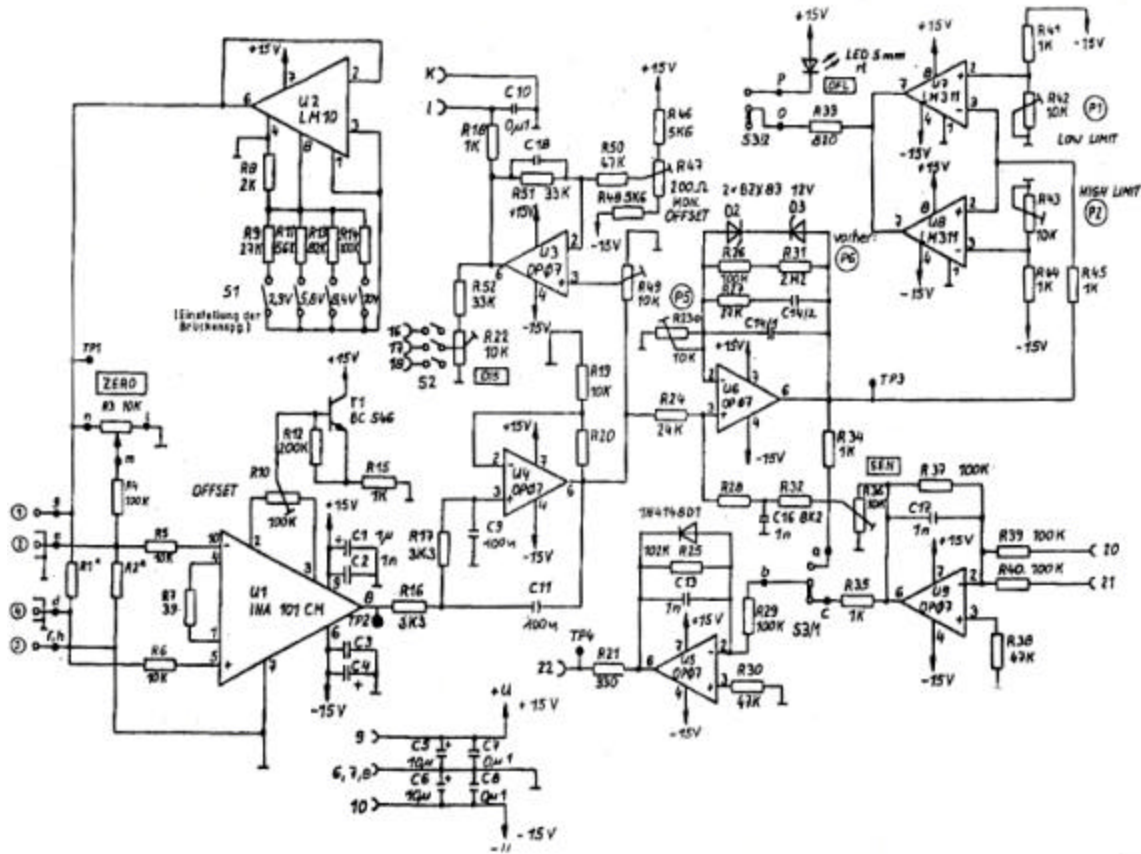


4. Schematics

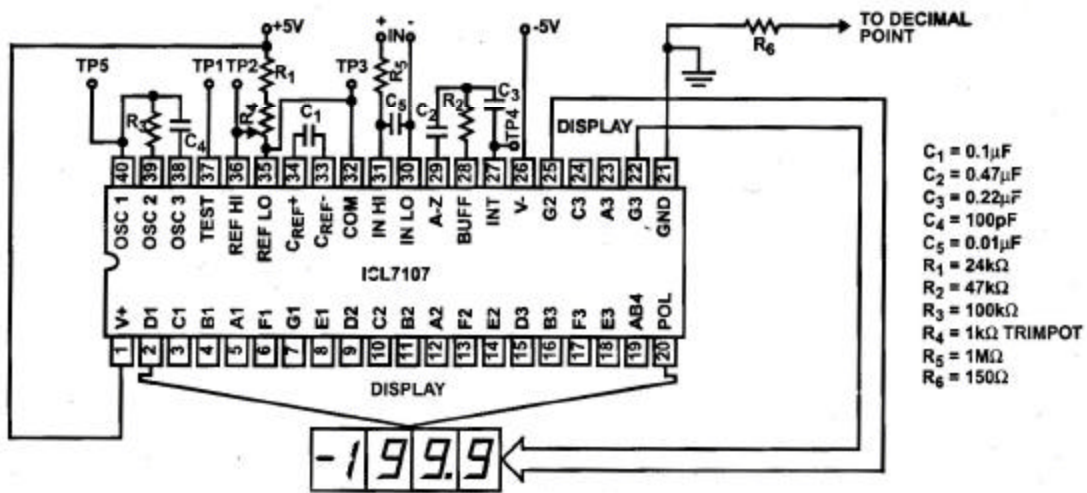
4.1 Power supply



4.2 Servo controller

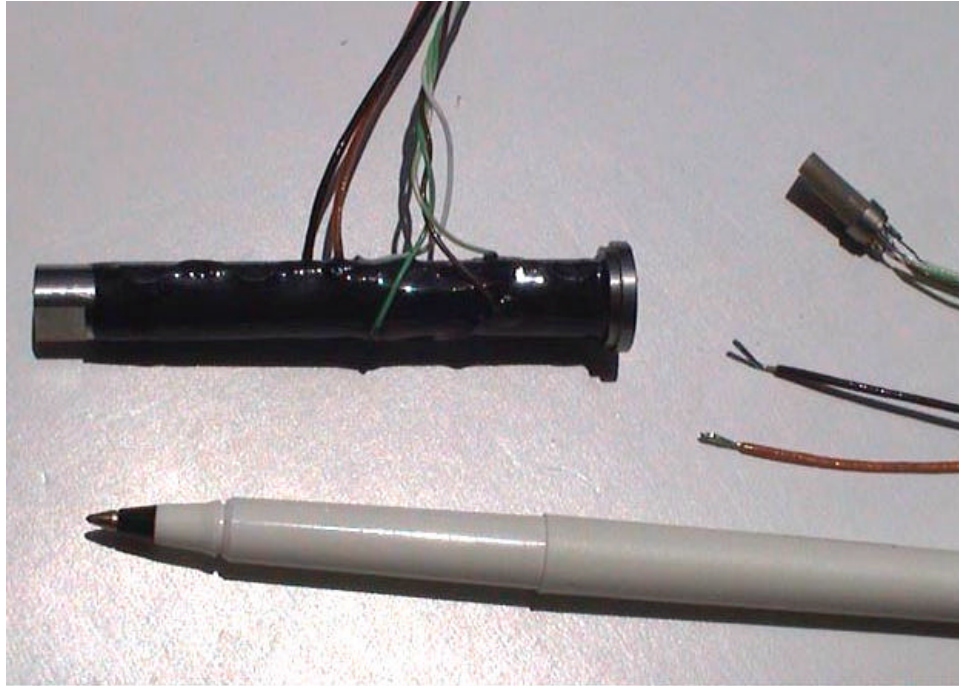


4.3 Digital display

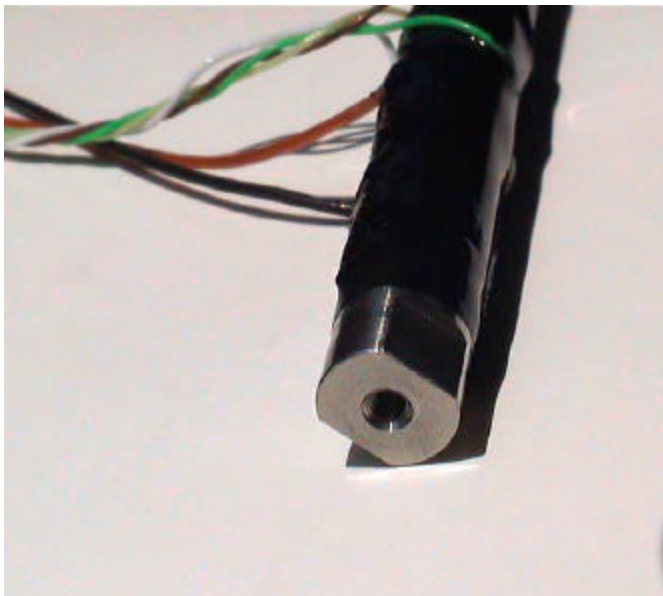


LED DIGITAL PANEL METER USING ICL7107

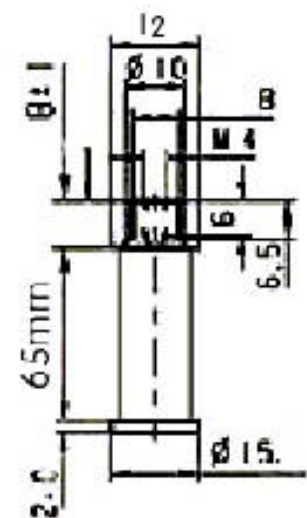
5. Piezo actuator



Side view



Top view



Thread

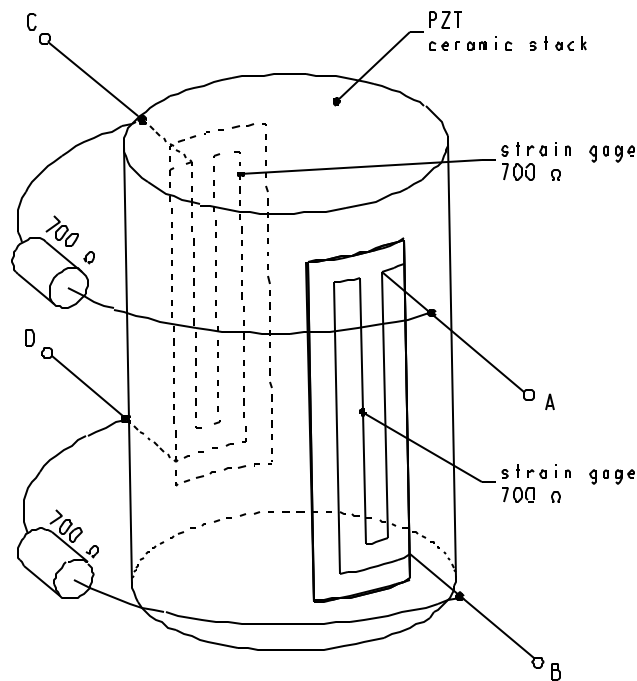
6. Strain Gage Sensors

Strain Gage Sensors (SGS) for piezo actuator applications use DC signals and consist of resistive films bonded to the ceramic piezoelectric actuator. The change in length of the piezo stack changes the resistance of the strain gage. The change is proportional to the change in displacement of the piezo actuator. Up to 4 strain gages are used in a bridge configuration for better stability and resolution.

Depending on the PZT model, either all four-bridge quadrants are active (full bridge) or two are active and the other two consist of fixed resistors (half bridge).

The Wheatstone bridge is balanced if all branches have the same resistance. The bridge becomes unbalanced if one or more resistances change due to expansion or contraction. Relative changes in length of 0.1% can be detected. At with 90µm nominal expansion the resolution is 90nm.

Wiring of SGS:



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7. Technical specs

7.1 Electronics

Output voltage range 0V to -1200V DC (negative polarity).

Position feedback from strain gage sensor (SGS).

Display: 3 ½ digit LED display.

Analog input: 0 to 10V for 0 to nominal actuator expansion (pre-calibrated).

Monitor out: 0 to 10V for 0 to nominal actuator expansion (pre-calibrated).

Servo controller: Proportional / integral term controller.

Power out: 3W continuous, 5W peak.

Static operation: The SGS offers long-term stability in the range of 90nm.

Dimensions: 8.5 x 6.15 x 3.1"

Power requirements: 120V AC, 100mA.

Dimensions: 8.5 x 6.15 x 3.092 inches

Enclosure material: Aluminum (Black anodized)

7.2 Piezo actuator type 90P1000 (Vacuum compatible to 10E-6 torr)

Displacement: 90 µm

Dimensions: L ~ 77mm, Dia ~ 12mm

Feedback sensor: Strain Gage Sensor (SGS)

Max. push force: 50N

Max. pull force: 1N

Max. bending moment: 0.1Nm

Max. twisting moment: 0.1Nm

8. Troubleshooting and test

Zero point calibration

To be adjusted in EC mode and 0V analog input and zero DC offset to $-5(0)V$ on the display.

High voltage output

Attention:

The HV output can reach $-1200V$. This is a dangerous voltage. A spark can jump 10mm.

Test in VC mode. At 10V analog input the display should read $-100(0)V$.

Monitor out

Can be tested in VC or EC mode.

At 90microns displayed on the digital display the voltage should be 10V.

At 0microns displayed on the digital display the voltage should be 0V.

SGS excitation

On pins 1 and 5 of the Sensor input connector on the front panel, the SGS excitation should be approximately 5V DC.

SGS integrity.

If the Wheatstone Bridge is interrupted the closed loop operation of the piezo actuator becomes impossible. This failure mode signals an imminent breakdown in the ceramics stack due to developing micro-cracks.

The resistance between the SGS connector pins can be measured and the values should be 700 or 1400 Ω or 500 and 700 Ω .

Piezo integrity.

Attention:

All piezo actuators are very fragile, they should be always treated like VERY BRITTLE.

A simple ohmmeter resistance test should read an average resistance higher than 2M Ω

This is a marginal value. Typical values are higher than that in the 8M Ω range.

A more accurate test is the current leakage test performed with the piezo at max. operating voltage and an Amp-meter in series in the HV circuit. A good value should be under 10 μA .

This is also a marginal value. Typical values are lower than that in the 4 μA range.

The current consumption increases to mA in dynamic operation of the actuator due to repeated charge /discharge cycles.

Applying reversed polarity on the piezo will depolarize the ceramics and cause failure.

Avoid high temperature directly applied to the ceramics. The max. spec. is 175°F.

Fuse

Check the main fuse on the rear panel. When replacing it, use slow-blow 120V, 100mA.

AC Power

Make sure that the power used is always 120V.

9. Calibration

Calibration graphs shown bellow for:
0-90µm expansion at 0-10V control input.

Linearity of expansion in percentage of the full range during expansion and retraction.

Piezo Actuator Calibration Document

Job Nr: #115

Control Document No.: 115

13:17:32 03-05-2002

Order Data

Customer:
Customer Ref No:
PLE Ref. No:

Actuator / Driver Data

PZT Model: 90P1000
Ser. No.: 115
Max. Oper. Voltage: -1200V
Max. Expansion: 90µm
Feed Back Sensor: SGS
Driver Model: 1SA-1000
Design Modifications: Standard
Option1:
Option2:

Measurement Setup

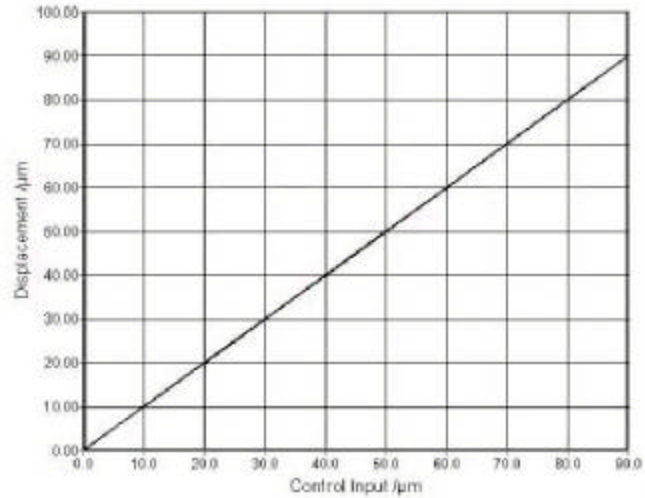
Measurement Device: HEIDENHEIN
Measurement Range: 500 µm
Min. Ctrl Input: 0.000 µm
Max. Ctrl Input: 90.000 µm
Step Size: 6.0 µm
Time Delay: 0.5 s
Temperature: 22.0 °C
Air Pressure: 989.0 mbar
Humidity: 60.0 %

Prog. ID: H-3.26
Tested by: KB

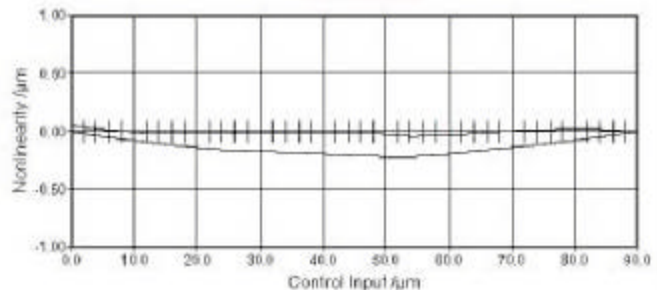
Measurement Results

Ctrl In /µm	Output + /µm	Output - /µm	nonlin /µm	nonlin /µm
0.000	0.059	0.110	0.000	0.001
6.000	6.048	6.074	-0.023	0.013
12.000	11.966	12.041	-0.027	-0.018
18.000	17.906	18.041	-0.129	-0.016
24.000	23.966	24.052	-0.169	-0.016
30.000	29.864	30.052	-0.175	-0.006
36.000	35.864	36.052	-0.188	-0.005
42.000	41.871	42.057	-0.201	-0.006
48.000	47.855	48.057	-0.219	-0.017
54.000	53.857	54.031	-0.229	-0.045
60.000	59.881	60.042	-0.197	-0.036
66.000	65.920	66.087	-0.169	-0.013
72.000	71.952	72.092	-0.139	0.016
78.000	77.969	78.100	-0.095	0.016
84.000	84.039	84.101	-0.047	0.017
90.000	90.068	90.081	0.009	0.000

Displacement Curves



Nonlinearity



10. Adendum

10.1 Connectors pin-out

Output voltage range 0V to -1200V DC (negative polarity) is sent through a coax cable with the center potential swings between 0 to -1200V. The shield is connected to the chassis of the electronics and to the ground of the power plug. The connectors are LEMO type and extension cables can be purchased if needed. The sensor connectors

10.2 Cable management

To use the system in a vacuum chamber one can cut the cable and solder it on the inside and the outside of the feed-through