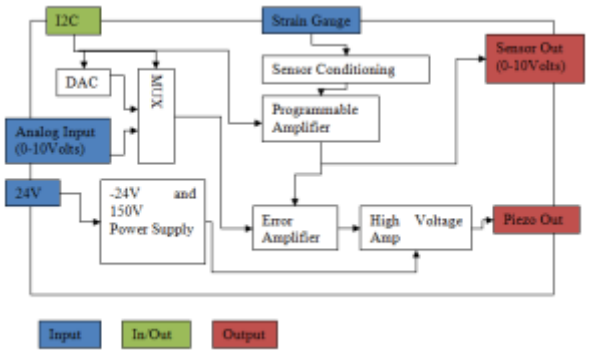
ASIs Drive Electronics(ADEPT) for 3rd Party Piezo Actuators

ASIs Drive Electronics for Piezo Topplate (ADEPT) and actuators can drive and control 3rd party piezo stages and actuators with little or no modifications. The card is actuator agnostic and needs only a single factory calibration to be paired with an actuator.



Features

- Onboard step up regulator that converts 24VDC to -24VDC and 150VDC
- ADEPT can drive piezo stacks with capacitance load of 9uF to 12uF at 10-20Hz. Expect lower frequency response if used to drive actuators with higher capacitive loads.
- Designed for use with strain gauges as positional feedback. Strain gauges need to be in half bridge configuration i.e. one flexing/strained and the other unflexing/unstrained or counter strained.
- Capable of accepting positional input from multiple sources
  - A 0-10V analog signal
  - A Serial command from a PC or other devices
  - And the Knob on the MS2000/TG-1000 controller
- Piezo actuator position can also be read thru multiple methods
  - A 0-10V analog signal thru sensor out
  - MS2000/TG-1000 controller can be queried with a serial command
  - Or can be read out from the LCD display(MS2000 only).
- The ADEPT card can be operated either in
  - Closed Loop Mode, the card uses strain gauges as positional sensors to accurately position the actuator with nanometers precision.
  - Open Loop Mode, the card applies and maintains a voltage proportional to the user input and ignores the strain gauge feedback .
- MS2000 controller can house only one ADEPT card
- TG-1000 controller can house multiple ADEPT cards, each card be addressed and controlled individually.

Connectors/Interface

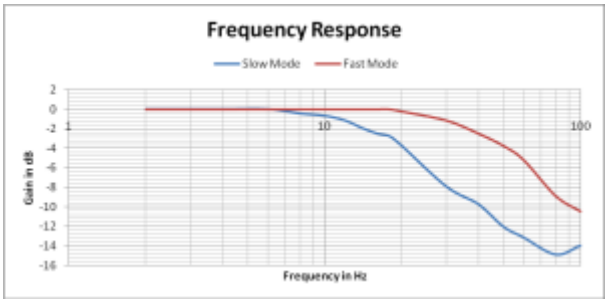
Pin	**DB 9 connector To Piezo Actuator**
1	Voltage to Piezo Actuator , between -24V to 140V
2	Piezo Actuator ground
3	Strain Gauge ground
4	Flexing/strained strain gauge
5	Unflexing/unstrained strain gauge
6,7,8,9	Ground
Coax Connectors	
EXT IN	0-10V Analog signal, used as input when operated in external input mode
Sensor OUT	A 0-10V analog signal put out by the ADEPT card that represents the position of the Piezo

*Pin outs can be modified on request

Compatible Piezo Stack Specification

The ADEPT card is designed to work with piezo stacks rated for 150V or higher. The card can be connected to a single piezo stack or multiple stacks in parallel. Connect the positive terminal of the piezo stack to pin 1 and negative end to pin 2 of the ADEPT cards DB9 connector.

The Frequency response of the ADEPT card connected in parallel to three piezo stacks of 3uF i.e. 9uF is shown below. When driving higher capacitive loads, expect the frequency response of the ADEPT card to be lower.



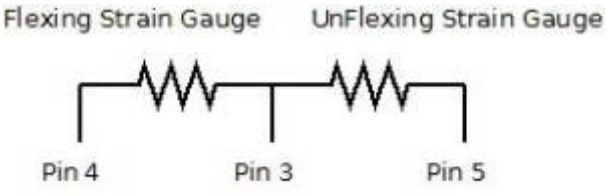
An example of a compatible piezo stack is Noliac's SCMAP04 series.

Note: We found that operating the piezo at only 75%-80% of their rated voltage ie getting required maximum travel at only 75%-80% of piezo's maximum rated voltage results in piezo with longer lifetimes and increased reliability.

Compatible Strain Gauges

The ADEPT card uses resistive strain gauges for positional feedback of the actuator. The card expects the strain gauges to be in half bridge configuration. One strain gauge flexing connected to pin 4, another unflexing or counter strained connected to Pin 5, and both the strain gauges connected to pin 3 of the ADEPT cards DB9 connector. The flexing strain gauge should be installed in such a way that it experiences a change in mechanical strain as the piezo stack expands and contracts. The unflexing should be installed close to the flexing strain gauge but in such a way it is immune to any change in

mechanical strain or it sees the counter strain experienced by the flexing strain gauge as the piezo stack travel.



The strain gauge conditioning circuit on the ADEPT card applies a current of 1ma to 2ma on both the strain gauges. As the gauges are electrically resistive in nature they develop a voltage, this voltage is applied to a differential instrumentation amplifier and the voltage put out by the amplifier is proportional to the difference in strain between the flexing and unflexing strain gauges, thus the position of the actuator can be calculated.

This differential configuration makes the sensor very robust to temperature fluctuations , wear and tear , parasitic effects, ageing etc.

When installed on the actuator the two strain gauge 's electrical resistance should be very close. A mismatch of 30-80 ohm (for 400 ohm strain gauges) and 100-200 ohms (for 1500 ohm strain gauges) can be corrected onboard the ADEPT card. Any higher and the card will not be able to compensate, which may lead to false readings. We recommend using semiconductor strain gauges as they are available in matched pairs and are sensitive to small changes in strain. The card is compatible with strain gauge of resistance between 300ohm to 1.5K ohms.

Micron's Backed semiconductor strain gauges are an example of ADEPT card compatible strain gauges.

Calibration

When an ADEPT card and a piezo actuator are first paired together they need to be calibrated for proper operation. Calibration compensates for strain gauge mismatch, non linearity and variation in gauge factor.

Strain Gauge mismatch compensation

For accurate sensor feedback, the strain gauges must show equal electrical resistance at a point in the actuator’s travel range. However due to manufacturing variances and installing technique there will always be a resistive mismatch between the strain gauges. The ADEPT card's sensor conditioning circuit has a digital potentiometer that can be adjusted to compensate for the mismatch. The routine to adjust this potentiometer is done by the MS2000/TG-1000 controller every time the controller is turned on or on user request. The MS2000/TG-1000 controller will always make sure that the two strain gauges are always matched.

This calibration can be performed in the field or at the factory thru a serial command (PZC) without any additional equipment. Once set, the parameter is saved in non volatile memory onboard the card.

Please refer to the piezo card's user manual on how to use the PZC command.

Refer to the Setting Strain Gauge Manually section to find how to adjust strain gauge manually.

Setting Feedback Gain

ADEPT card interprets the position of the actuator by measuring the electrical resistance of the strain gauges which is proportional to mechanical strain experienced by them. Gauge factor or strain factor of a strain gauge is the ratio of relative change in electrical resistance to the mechanical strain. This gauge factor for strain gauges varies slightly from unit to unit. To compensate for this the gain of the feedback amplifier can be adjusted using a digital potentiometer.

This parameter only needs to be set once and the setting is saved into a non-volatile memory on the card. This parameter will not change with wear and tear or ageing. Only if the ADEPT card is paired with a different actuator this setting has to be deduced and set again. To Deduce the feedback amplifier gain the ADEPT card has to be connected to the piezo actuator, then using a high resolution length gauge like Heidenhain length gauges[3], this setting can be manually deduced and set or a special controller(which ASI can provide) can find and set this automatically.

This setting must be set at the factory as it requires additional equipment. Once set ,the gain is saved in a non volatile memory onboard the card.

Refer to the Setting Strain Gauge Manually section to find how to adjust this manually.

Strain Gauge non Linearity Compensation

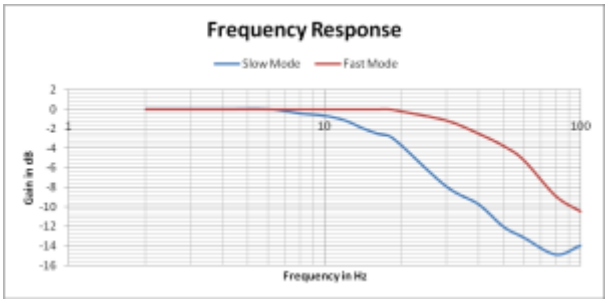
For small changes in mechanical strain the strain gauges electrical resistance changes linearly, however for larger changes in mechanical strain the strain gauges electrical resistance changes non linearly, which may lead to false reading. The ADEPT cards addresses this with help of the non linearity compensation circuit onboard, which is set through the screw potentiometer.

The position of the screw potentiometer depends on the range of mechanical strain the strain gauge might experience, once this setting has been deduced for an actuator it can be applied to other ADEPT cards that will be paired with similar actuators too.

Adjustable Error Amp Gain (only in ADEPT Rev L2+)

In Adept Cards Rev L2+ we added a slower gain network for error amp to help reduce ringing and oscillations. User can pick to stay with the Regular error amp gain or pick this new slower gain network by setting a Jumper.

Graph below shows the change in frequency response.



Refer to TN147: Changing Piezo Drive Card's Fast Slow Compensation

Setting Strain Gauge Manually

You need: A MultiMeter set to voltage connected to Sensor out of ADEPT

- The Piezo Magnifiers are preloaded at 65V, i.e. at 65V the Magnifier is straight, It requires more voltage for the magnifier to swing upwards then downwards. So we apply voltages slightly less than 65V to zero the strain gauges. We suggest 35V. We will call this the zeroing pt. This is usually 15% off the center.
- Set ADEPT to open loop mode [`PZ Z=2` for MS2000 or `<Card Addr#>PZ Z=2` for TG-1000], to avoid hysteresis first move to the lower limit then come back to the zeroing pt. (just a convention so that we always zero the strain gauges the same way)
- For 100um piezo
  - `M z=-500` (assuming z is the piezo axis)
  - [after a second]
  - `M z=150` (is the 35V pt)
- For 150um piezo
  - `M z=-750` (assuming z is the piezo axis)
  - [after a second]
  - `M z=225` (is the 35V pt)
- For 300um piezo
  - `M z=-1500` (assuming z is the piezo axis)
  - [after a second]
  - `M z=450` (is the 35V pt)
- For 500um piezo
  - `M z=-2500` (assuming z is the piezo axis)
  - [after a second]
  - `M z=750` (is the 35V pt)

• Now set the `PZ X=#` [`PZ X=#` for MS2000, or `<Card Addr#>PZ X =#` for TG-1000]such that sensor out is as close to 5V as possible. PZ X cmd sets the digital potentiometer that offsets the

current in the nonflexing strain gauge so that voltage on both the strain gauges is equal. When sensor out is 5V, both the strain gauges have same voltage across them. • Strain Gauge offset calibration is done.

• Please refer to the piezo card's user manual on how to use the PZ Z and PZ X command.

Setting Feedback Gain Manually

Using a Length gauge like Heidenhain length gauges

1. Ensure the piezo's range is correctly set with the CCA X command for the MS2000 or the PR command for TG-1000.
2. First perform the Setting Strain Gauge Manually steps, then perform this calibration.
3. Put the piezo back in open loop mode with the PZ Z=2 command, [PZ Z=2 for MS2000 or <Card Addr#>PZ Z=2 for TG-1000]
4. Move the piezo using the knob such that the Heidenhain plunger registers a set distance. Say 30microns, move the knob so that the position of the Heidenhain plunger has changed by 30microns.
5. You should see a corresponding change on sensor out. In a 100um piezo system, 1V represents 10um, in a 300um system 1V represents 30um. So if you have a 100um system, you should see that the sensor out has changed exactly by 3V, if not then set PZ Y=# [PZ Y=# for MS2000, or <Card Addr#>PZ Y=# for TG-1000] so it is that. PZ Y cmd sets the digital Potentiometer that sets the gain of the feedback stage. By adjusting the gain so that the sensor out has changed by 3V, you have taught the ADEPT card that 1V=10ums.
6. Once you found the right PZ Y value the calibration is complete.
7. Put the piezo back in closed loop mode with the PZ Z=0 command, [PZ Z=0 for MS2000 or <Card Addr#>PZ Z=0 for TG-1000] and try out the calibration. PZ X & Y settings are saved to a non volatile memory on the ADEPT card. The first step of calibration ie zeroing strain gauges is checked for and done every time the MS2000 is powered on.

Using a Microscope's focus knob

This procedure uses measuring the voltage on the Sensor Out port on the ASI controller or Adept Card versus the known correlation between the Sensor Out Voltage, Piezo Moment, and the Gain value.

An object is selected and put into focus. The voltage on the sensor out port is noted for the position. Using the correlation of 1 volt = a set distance of travel, the z position is moved via the microscope fine focus knob a set distance. Then the controller is used to move the piezo device so as to re-establish focus. The gain setting is then adjusted, so the voltage output of the Sensor Out port establishes the 1 volt = set distance relationship

1) Use the serial command PZC X, To ensure the adept card Offset value is aligned.
2) Note: Information on the serial commands is in the piezo user manual.
3) Ensure the Controller is in Open Loop Mode by giving the serial command PZ Z=2, you can verify the mode by giving the PZ Z? command.[PZ Z=2 for MS2000 or <Card Addr#>PZ Z=2 for TG-1000]
4) Ensure you are not at the limits of the piezo travel. To go to the center of travel, issue the M Z=0 serial command or give a quick press to the Home button on the ASI controller.

5) Pick an object in vision of the microscope and focus on the object, using the microscope fine focus knob, coming in from one direction to reduce backlash error. It is important to be able repeatedly focus to the same position.
6) Attach a Voltmeter to the Sensor OUT BNC port on the back of the controller and note the voltage at this focus position.
7) Pick the appropriate distance from the chart below, using the microscopes fine focus knob, move the set distance.

Max Travel	Set Distance
100um	20um
150 um	30um
200 um	40um
300 um	60um
500 um	100um

8) Using the focus knob on the ASI controller, refocus on the object that was selected in step 5. Attempting to repeat the same focus as was achieved in step 5 is essential.
9) Note: When the gain is properly aligned, a move of the distance given in the above chart will result in a 2vdc change on the sensor out. Until the gain is set properly, the voltage change will not be 2 vdc.
10) Using the PZ Y= and PZ Y? commands, adjust the gain value to get the voltage on the Sensor OUT port to show a 2V change from the voltage noted in step 4.
11) Note: On some piezo devices one direction works better than the other for this procedure. If you are having difficulties getting a 2 volt change, try moving the set distance in the opposite direction when doing step.
12) The alignment is now complete. The settings made with the serial PZ Y= command are automatically saved on non-volatile memory when the command is given. You will not need to adjust the settings again unless you use the controller with a different piezo device.

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