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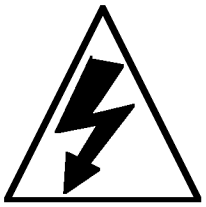
OPERATING INSTRUCTIONS
12/12/12

EPA-008

Linear Amplifier with Integral HV Power Supply



HIGH VOLTAGES MAY BE PRESENT AT THE OUTPUT OF THIS UNIT. All Operating personel should use extreme caution in handling these voltages and be thoroughly familiar with this manual.

NOTE: This is a new product and specifications are subject to change. If any questions arise concerning its operation or capabilities please contact Piezo Systems, Inc.

SERVICE AND WARRANTY

ALL PIEZO SYSTEMS, INC. products are warranted against defective materials and workmanship. This warranty applies for a period of time one year from the date of delivery to th original purchaser. Any instrument that is found not to meet these standards within the warranty period will be repaired or replaced. No other warranty is expressed or implied

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1.0 GENERAL DESCRIPTION

The EPA-008 is a very compact high voltage linear non-inverting amplifier designed to be convenient for both bench top experimentation and OEM installation. It requires only a single 15V DC power input, yet will accept +/- 10 V ground referenced input and produce +/- 180 V ground referenced output. No external high voltage power supplies are required.

It is designed to be used as a high voltage drive source for various piezoelectric actuating devices and servo applications in the DC to 1500 Hz frequency range.

2.0 SAFETY PRECAUTIONS

WARNING!

WHILE THE EPA-008 IS POWERED ON IT IS ALWAYS POSSIBLE THAT EITHER AN INTENTIONAL OR UNINTENTIONAL INPUT WILL RESULT IN THE APPEARANCE OF +/-180 V DC AT THE OUTPUT TERMINALS AND ON ANY WIRES ATTACHED TO THE OUTPUT TERMINALS

For safe operation, always remember to follow all of the following guidelines:

All leads connected to output terminals should be insulated with an insulation rating of at least 600 V.

Secure all output wires at both ends at all times, do not permit them to dangle unattached. Do not leave portions of bare wire exposed where they can be touched by yourself or others.

If the EPA-008 is being used as a benchtop amplifier, the area where it is placed should not be cluttered with conductive items such as pliers, screwdrivers, loose resistors, capacitors, inductors, prototyping wire, etc. They can wander into the output terminals causing both sparks and shock hazards.

3.0 SETUP

Check to see that the EPA-008 amplifier arrived in good condition.

The amplifier should be ready for operation when it is unpacked. If it appears to have been damaged in shipment, make a claim with the carrier, and notify Piezo Systems, Inc. immediately.

A quick out-of -the box setup and check of functionality can be made as follows:

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SETUP - Cont'd

MATERIALS: EPA-008 & AC power adapter, sinusoidal signal generator, oscilloscope.

Referring to Fig. 1,

1. Turn signal generator output down to zero, then connect signal generator output via wires to the screw terminals marked "Signal Input" on the I/O Panel of the EPA-008. Be sure that the signal generator ground is connected to the screw terminal marked "GND".

2. Connect oscilloscope probe via wires to the screw terminals marked "Amplifier Output" on the I/O Panel of the EPA-008. Be Sure that the oscilloscope ground clip is attached to the terminal marked "GND". Make all connections both mechanically secure and electrically safe.

   DURING THE REMAINDER OF THE TEST, DO NOT TOUCH THE OUTPUT TERMINALS OR ANY WIRE OR FASTENER WHICH IS CONNECTED TO THEM.

3. Plug in the power connector of the AC adapter (15 V DC, center positive, supplied with the unit) into the EPA-008, and then plug in the AC adapter to a 115V AC outlet. The the green indicator LED should shine brightly and steadily (indicating that 15 V DC power is getting to the amplifier) and the cooling fan should come on.

4. Set signal generator output for 100 Hz sine wave signal of amplitude 1 V peak, and observe the oscilloscope signal from the output terminals. It should be 20 V peak.

5. Now raise signal generator amplitude to 10 V peak, and make sure that the output voltage is 200 V peak on the oscilloscope. NOTE: This test is done under "no load " conditions, consequently the observed output will exceed the rated output of 180 V peak and exhibit s slight "flattening" of the tops of the sinusoidal output waveform. This is normal.

6. Mantaining the 10 V input, vary the frequency 10 Hz to 1000 Hz and make sure that amplitude and sinusoid appearance of the output remain unchanged.

7. After completing the above test, turn input voltage to zero, and remove the 15 V DC power connection and/or unplug the AC adapter from the 115VAC receptacle.

When the EPA-008 passes the above check-out, it can be assumed to be in working order.

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4.0 OPERATION

4.1 0 SUPPLYING POWER TO THE EPA-008 - TWO METHODS

SAFETY NOTE

START WITH UNIT TURNED OFF

It is good safety practice to leave the EPA-008 in the POWER OFF state while making connections to either the output or the input. This protects both you and your intended electrical load from unwanted surprise exposure to high voltage.

4.1.1 Supplying power via the screw terminals (OEM installation)

For the case when permanent installation of the EPA-008 is desired, a set of screw terminals for DC input is provided on the POWER PANEL (See Fig. 1). The input voltage must be between 13 VDC and 18 VDC with 800 mA current capacity. The green LED indicator comes on to indicate that the EPA-008 has input power.

NOTE:

TO AVOID DAMAGE TO THE UNIT PROPER INPUT POLARITY MUST BE OBSERVED !.

4.1.2 Supplying power from the AC adapter (for Benchtop Experimentation)

At one end of the EPA-008 on the POWER PANEL (See Fig. 1) there is a DC power input receptacle which can be used for any AC adapter which has a CENTER POSITIVE jack and output rating of 13 - 18 VDC @ 800 mA. The green LED indicator comes on to indicate that the EPA-008 has input power.

This mode of supplying power is most convenient for benchtop experimentation where minimum setup time and flexibility of EPA-008 placement on the benchtop are real advantages.

4.2 SIGNAL INPUT & GROUNDING

Input to the unit is made by a connecting wires to the screw terminal connector on the I/O PANEL at one end of the unit (see Fig. 1). This is a low voltage only input for +/- 10 V peak referenced to the EPA-008's ground. The EPA-008 is equipped with input protection, however input overvoltage should be avoided if possible, particularly if the voltage source is capable of delivering more than 0.5 Watt. AC, DC, or superposed

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AC and DC signals (e.g. from a computer D/A board) can be used.

NOTE: The ground terminals for signal input, the High Voltage output, and the 13 V DC power input are electrically common.

4.30 HV OUTPUT

4.31 BASIC CONNECTIONS

Output from the EPA-008 appears at two screw terminals on the I/O PANEL of the EPA-008 (see Fig. 1). The terminal marked "HV" is the high voltage output, and the terminal marked "GND" is the ground reference terminal which is electrically common with the Signal Input GND terminal.

MAKE SURE UNIT IS OFF, then connect the load between the HV and GND terminals.

4.32 USE OF OSCILLOSCOPE FOR MONITORING

If you wish to monitor the output voltage on an oscilloscope, it is good practice to always place the ground lead on the GND output terminal.

If you wish to monitor the current passing through the load, you may use any non contacting clip-around probe, but it is safest to clip it around the lead attached to the GND terminal. You can also insert a current sense resistor in series with the load near the GND terminal and observe the voltage drop across it with an oscilloscope.

4.33 OUTPUT CURRENT LIMITATIONS AND PROTECTION

Fig.2 gives a graphical summary of the useful output voltage and current regimes for the EPA-008. This graph should be used to determine whether the amplifier is capable of driving a given load safely.

Depending on the driving frequency, a single piezo transducer can present an extremely variable load to an amplifier. At low frequencies they appear as a simple pure capacitance, while at a strong mechanical resonance or a very high drive frequency they can appear as a very low impedance (e.g. 10 Ohms).

Current limit circuitry is installed in the EPA-008 to avoid damage due to excessive current flow. The current limit is the type referred to as "simple current limit" in which the amplifier does not allow its output current to rise above approximately 30 mA. In the event of a short circuit at the output, the EPA-008 would simply supply 30 mA of flow at nearly zero volts output. If the short were removed, the current limit would cease to be active, and the output voltage would instantly jump back to its original value.

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4.34 USE OF A 'SAFETY RESISTOR'

When experimenting with High Voltage piezoelectric actuators it is recommended that some resistance (say 1 KOhm to 10 KOhm) be added in series with the actuator during initial setup and checkout. This prevents damage to your transducer due to electrical arcs and/or fast risetime high voltage swings from intermittent short-circuits in the region of the actuator.

After the fundamental setup has been confirmed to work, the safety resistor can be reduced in value or removed to improve performance.

4.35 USE OF AC COUPLING

The EPA-008 is provided with DC coupling to allow maximum flexibility in piezo drive applications (i.e., creating AC, DC, or AC output with DC bias). If your applications never require a DC output component, placing a capacitor in series with the INPUT TERMINAL will prevent a steady state DC high voltage output from appearing in response to an unintentional DC input such as a DSP or A/D converter output offset.

NOTE:The capacitor must be a non-polar type.

The following guideline can be used to choose the value of input capacitor used for AC input coupling:

$(2*pi*f*C)^{-1} < 1000$ ohm

where C is the coupling capacitance
f is the lowest operating frequency you will be using
pi = 3.14159265358979

4.36 LOADS

The EPA-008 is designed and tested to be stable for high voltage drive into piezoelectric loads such as bending elements, extension elements, and piezo stacks.

In general, piezoelectric actuators (e.g. vibrational control servos and sound sources) appear as simple series/parallel combinations of capacitors and resistors when operated at frequencies away from mechanical resonances. The EPA-008 will work with piezo loads in this frequency region, and also with pure capacitive loads of any value and pure resistance loads of any value.

Near structural mechanical resonances piezoelectric actuators have equivalent circuits consisting of various series-parallel arrangements of capacitors, inductors, and

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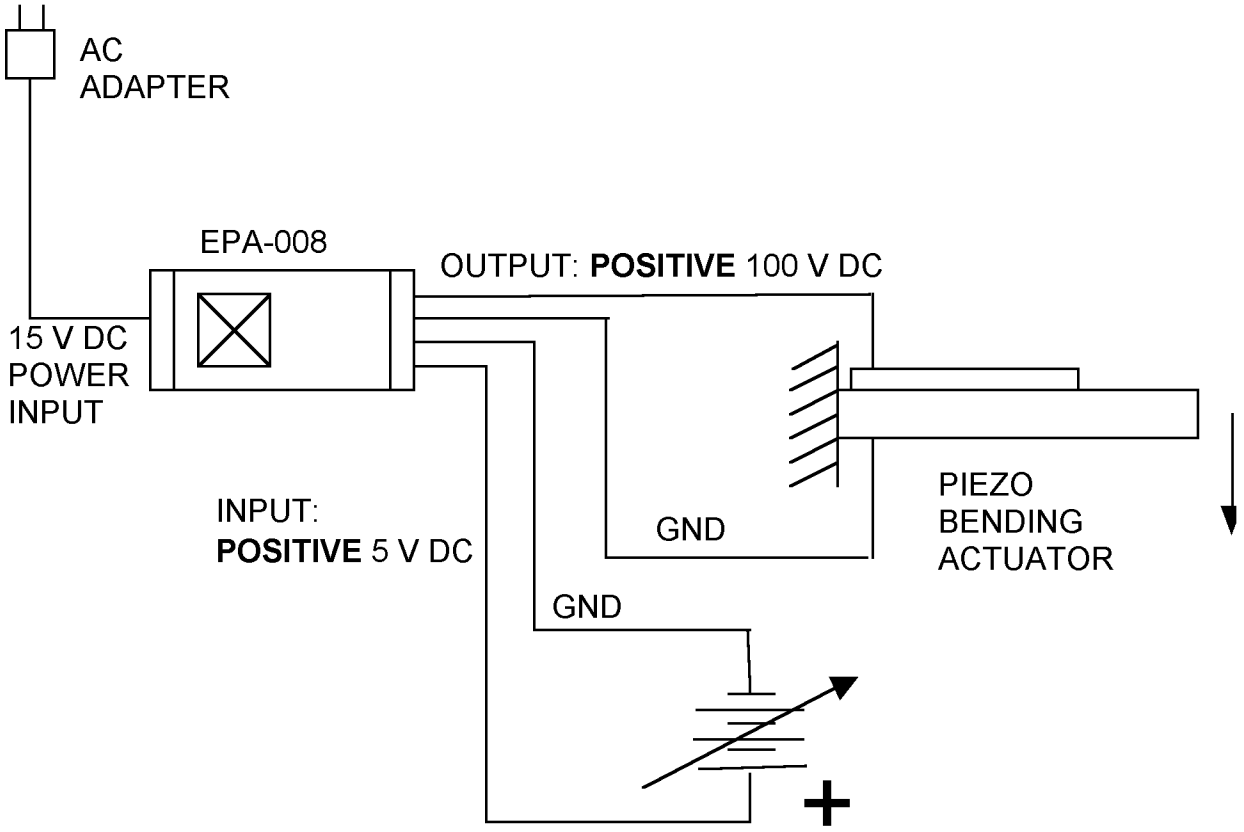
resistors. Within its current capacity, the EPA-008 will drive piezo loads over the entire region of resonance. The EPA-008 is not recommended for driving pure inductive loads (e.g. low resistance coils or permanent magnet speakers).

5.0 MECHANICAL MOUNTING (OEM)

The EPA-008 is small enough and light enough to be bolted directly to the bottom or side of an OEM product case.

A mechanical drawing of the EPA-008 case is provided in Fig. 3. It has a convenient mounting flange with six through-holes for 6-32 screws (see Fig. 3 for hole pattern). The flange may be bolted or riveted flush to a wall (no standoffs required).

6.0 DIAGRAMS of TYPICAL APPLICATIONS for the EPA-008



OPEN LOOP DC DRIVE FOR POSTIONING

(INPUT SOURCE MAY BE MANUALLY ADJUSTED POTENTIOMETER, OPAMP OUTPUT, OR D/A CONVERTER OUTPUT.)

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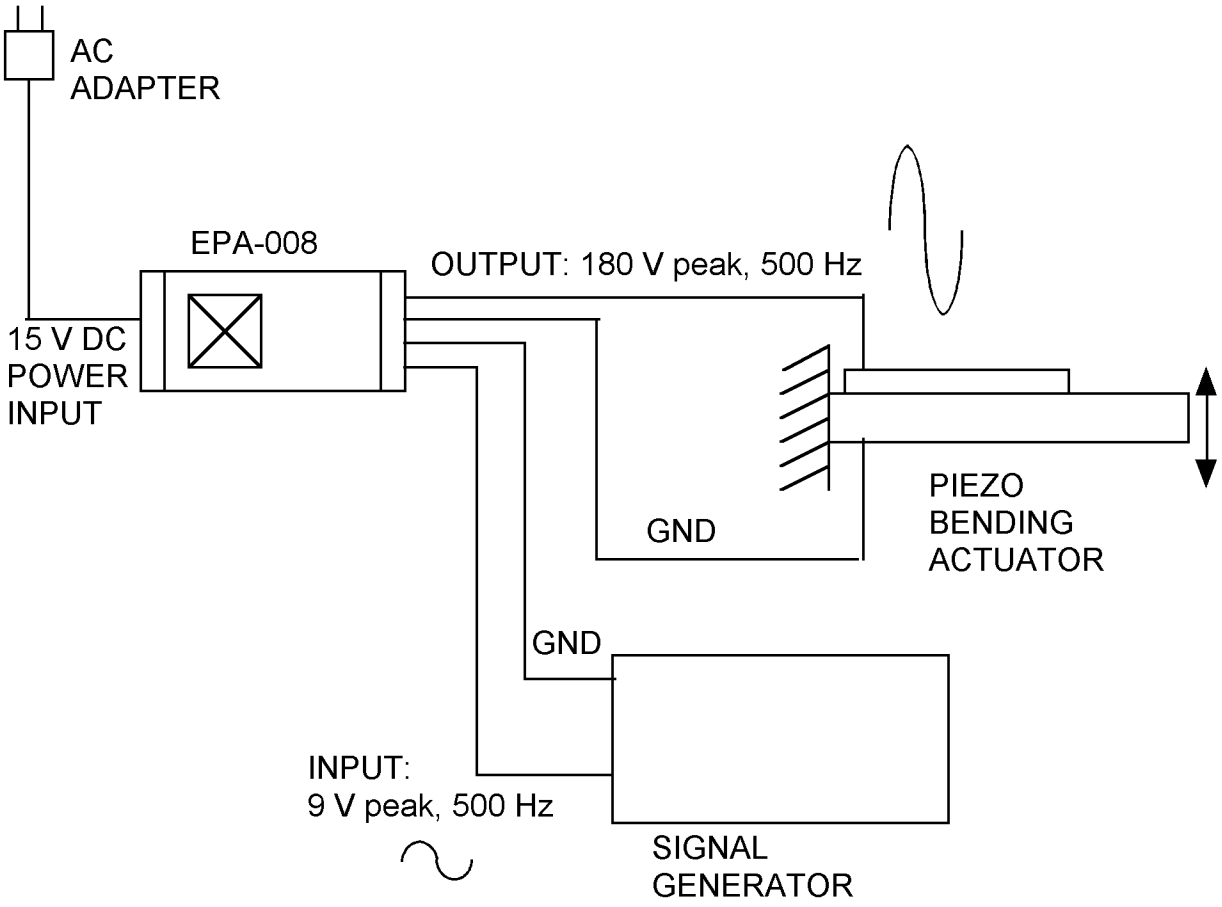

OPEN LOOP AC DRIVE FOR SOUND OR VIBRATION SOURCE

(NOTE: OUTPUT SIGNAL IS IN PHASE WITH INPUT)

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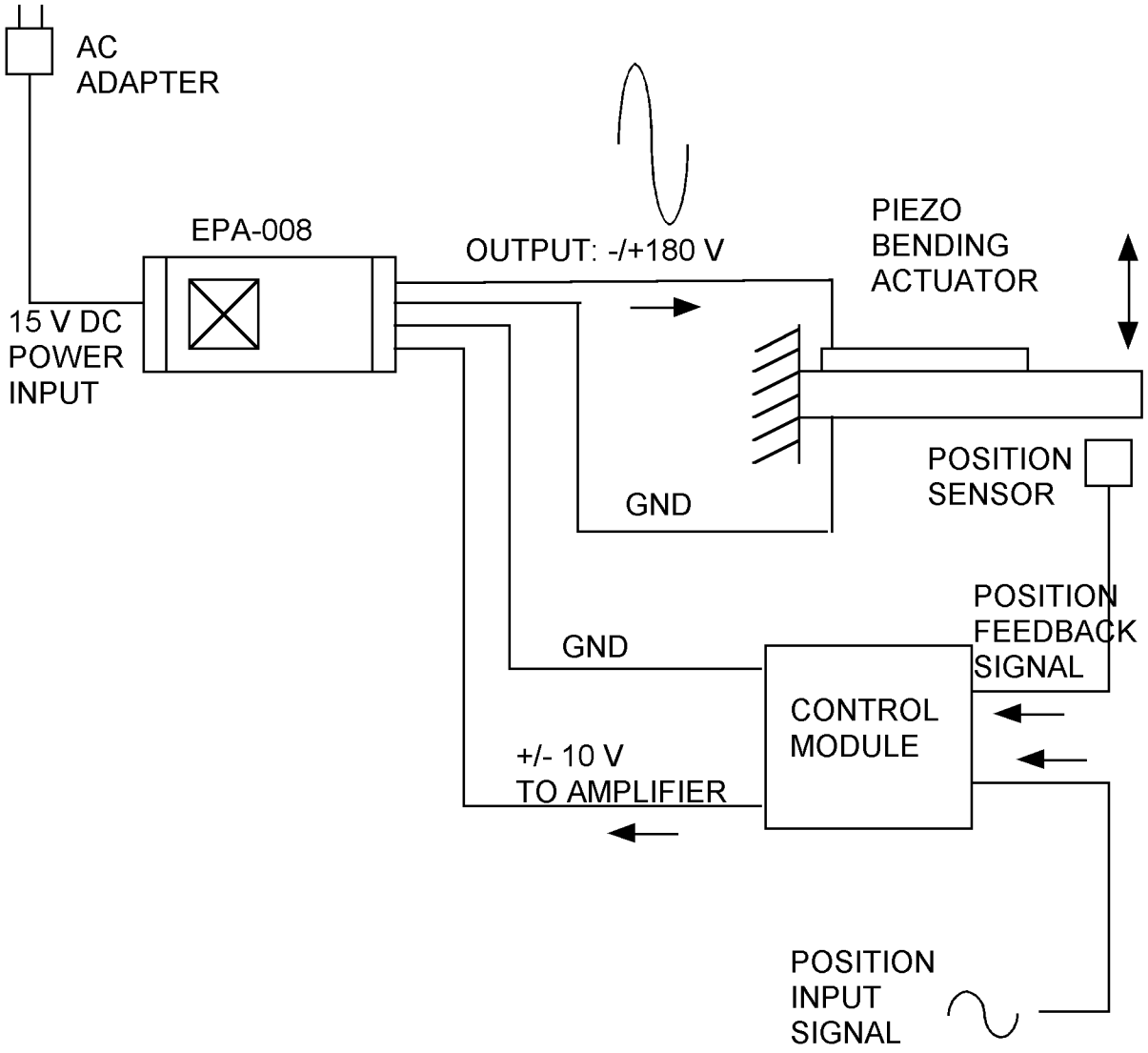

CLOSED LOOP POSITION CONTROL

THE CONTROL MODULE ACCEPTS BOTH AN INPUT POSITION COMMAND AND A POSITION FEEDBACK SIGNAL, PROCESSES THEM WITH SOME ALGORITHM, AND THEN SENDS OUT A VOLTAGE SIGNAL TO THE AMPLIFIER. (THE CONTROL MODULE CAN BE BE BASED ON ANALOG CIRCUITRY, DEDICATED MICROPROCESSOR OR A MATLAB CONTROLLER WITH AN D/A OUTPUT)

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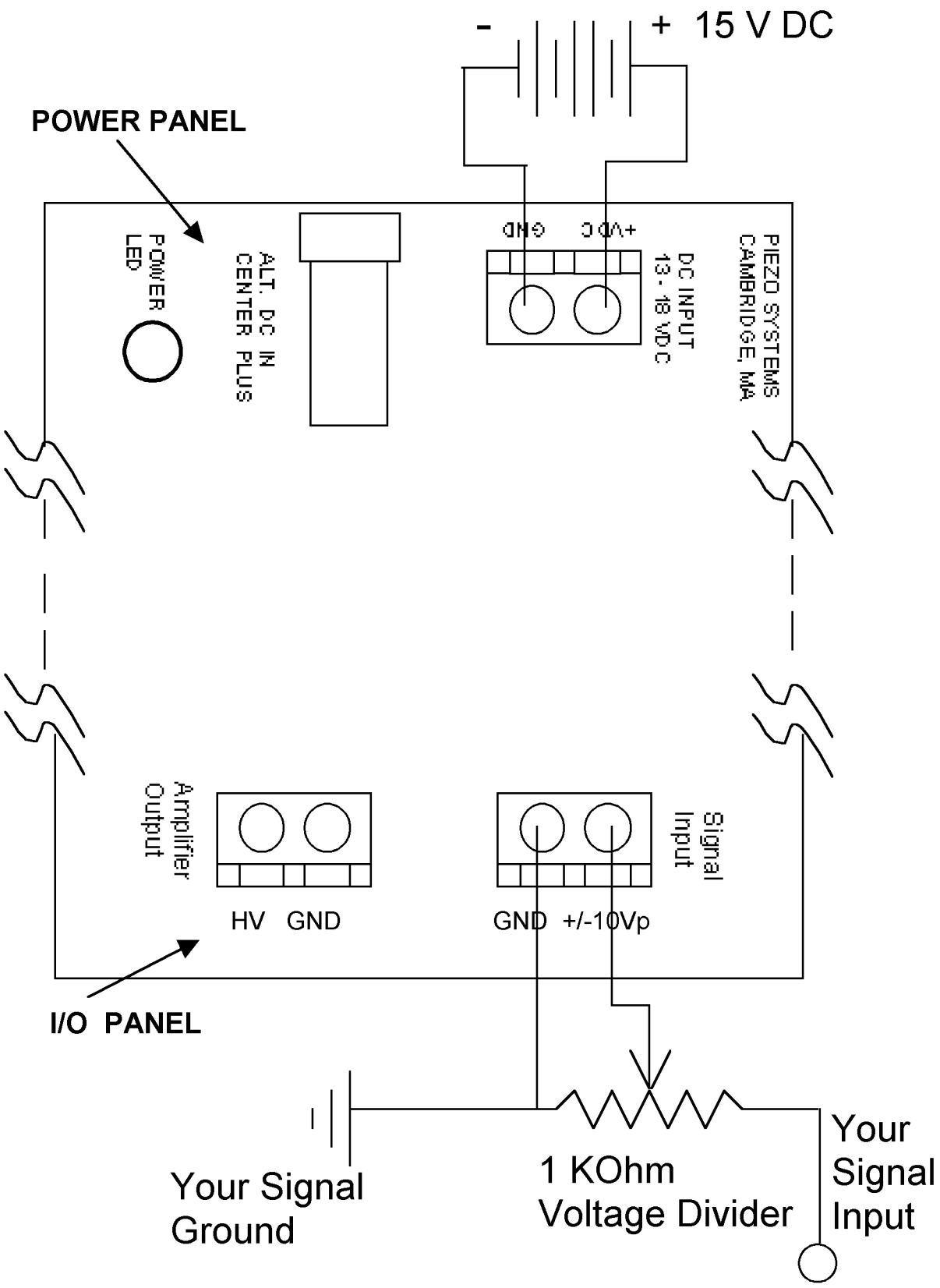

WIRING THE EPA-008 FOR VARIABLE GAIN

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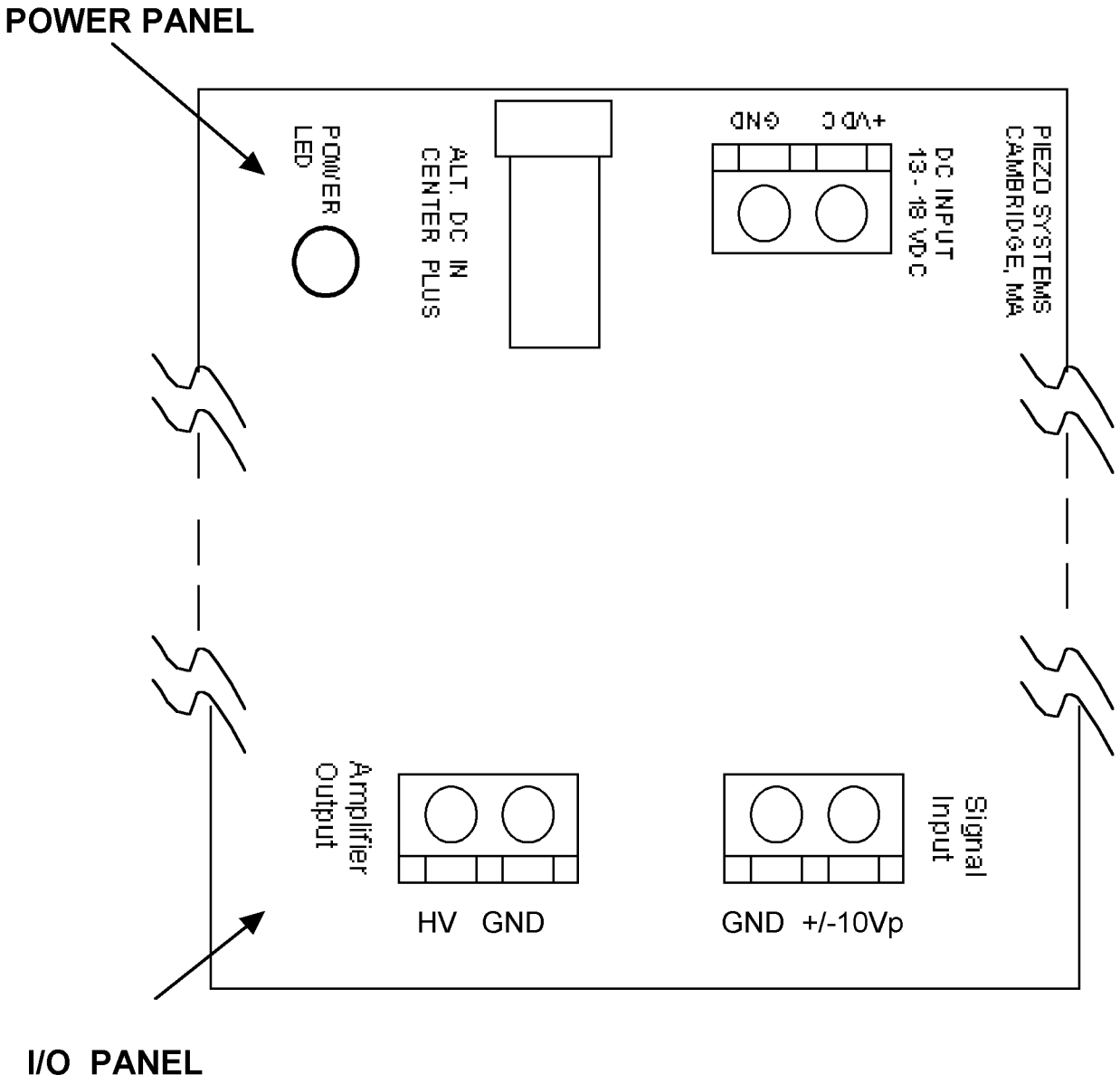

Fig. 1 EPA-008 ELECTRICAL CONNECTIONS

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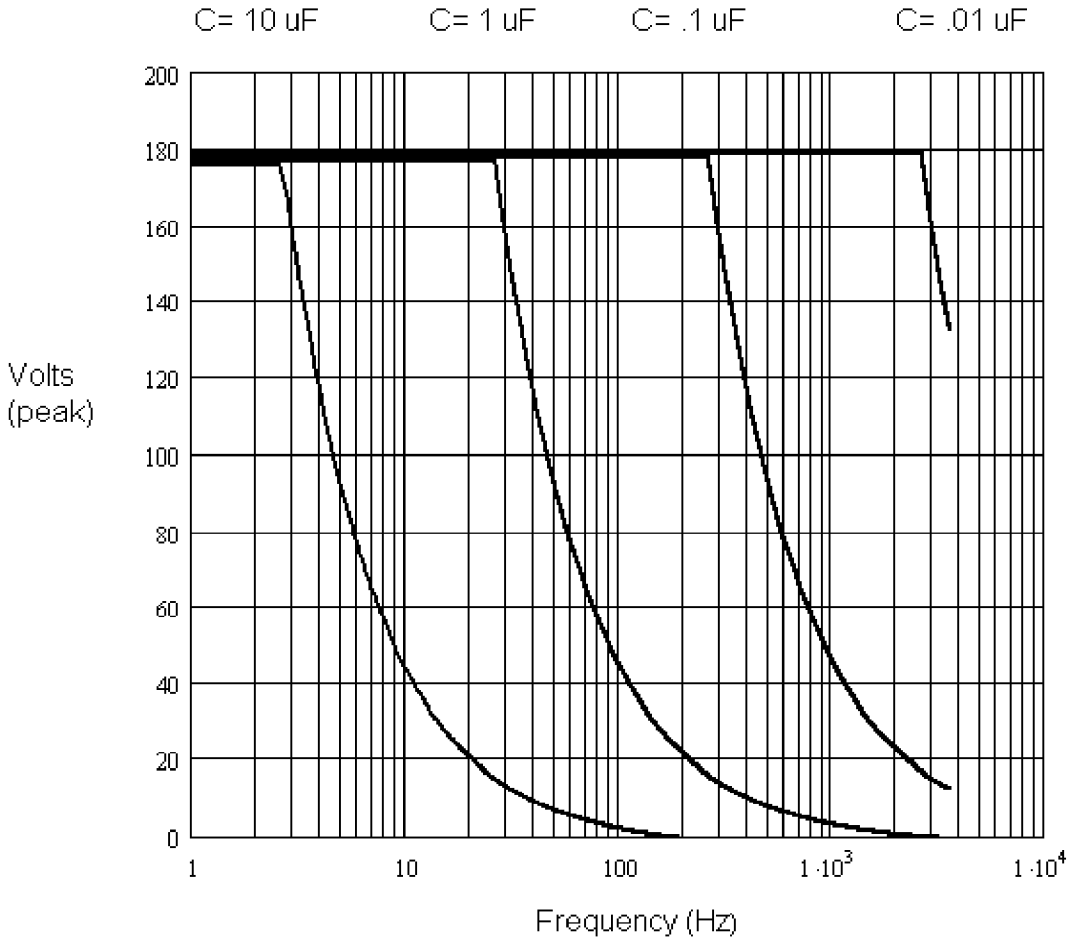

Fig. 2 EPA-008 Peak Output Voltage vs. Frequency for Various Capacitive Loads (Based on 30 mA current limit & sinusoidal waveform)

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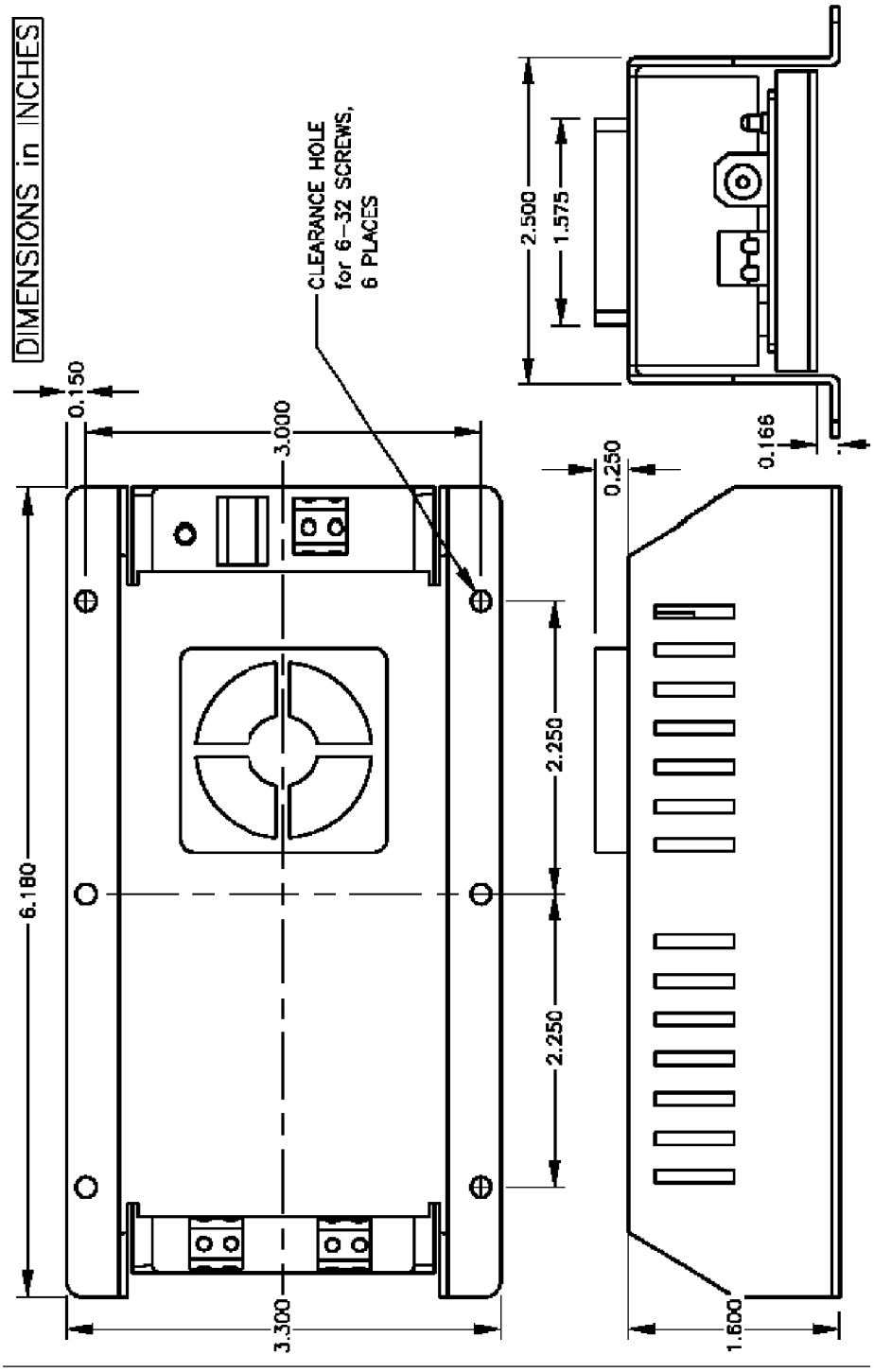

Fig. 3 EPA-007 CASE DIMENSIONS

SPECIFICATIONS **July 20 2004**

MODEL EPA-008 LINEAR AMPLIFIER with INTEGRAL HV POWER SUPPLY

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MODEL EPA-008 SPECIFICATIONS

Amplifier Polarity:	Non-inverting type, output in phase with input
Weight:	9 oz (256 g)
Overall Size:	1.825 in. H x 6.18 in. L x 3.3 in. W
Maximum Input Voltage:	+/- 10 V
Maximum Input DC Component:	+/- 10 V
Maximum Output Voltage:	+/- 180 V
Maximum Output Current::	+/- .030 A peak (.021 A RMS)
Output ripple	70 mV rms
Permissible Loads:	PIezo, Capacitive, Resistive (Not recommended for purely inductive loads)
Open Circuit Frequency Response:	0 Hz to 3 KHz, Flat
Full Power Bandwidth:	0 Hz to 1.5 KHz, Flat
Voltage Gain:	Fixed, x 20 +/-5%
Input Coupling:	DC coupled
Input Impedance:	10 KOhm
Output Coupling :	DC coupled
Circuit Protection:	Simple current limit, approximately 30mA
Short circuit endurance:	Indefinite
Power Source:	+13 V DC to +18V DC @ 800 mA
Current Draw	475 mA no load 725 mA full load
Cooling:	Internal Brushless DC fan
Isolation:	Ground terminals for signal input, High Voltage output, and 15 V DC power input are electrically common.

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