PiezoDrive

PD200 – 60 Watt Voltage Amplifier

Manual and Specifications

PiezoDrive Pty. Ltd.
www.piezodrive.com

Contents

1 Introduction

The PD200 is a high bandwidth, low-noise linear amplifier for driving piezoelectric actuators. The output voltage range can be switched between bipolar or unipolar modes with a range of 200V, -50V to +150V, or ±100V. Up to ±200V can be achieved in the bridged configuration.

The PD200 can drive unlimited capacitive loads such as stack actuators; standard piezoelectric actuators; two wire benders; and three-wire piezoelectric benders requiring a 200V bias voltage.

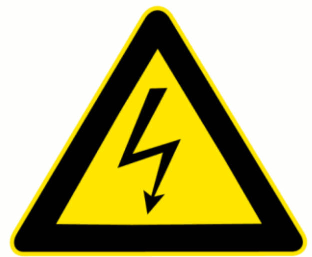
Compatible Actuators	
Stack Actuators	100V, 120V, 150V, 200V
Plates and Tubes	up to ± 100V
Two Wire Benders	up to ± 100V
Three Wire Benders	0 to 200V with 200V bias ± 100V with ± 100V bias

The PD200 is highly user configurable with jumpers for options such as the voltage range, polarity, and gain control. Two potentiometers are also provided to limit the positive and negative voltages to any arbitrary value between zero and full range. Due to the extensive configuration options, the PD200 is suited to a wide range of applications including electro-optics, ultrasound, vibration control, nanopositioning systems, and piezoelectric motors.

There are four output connectors including Lemo 00, Lemo 0B, BNC, and screw terminals that allow the direct connection to almost any commercially available piezoelectric actuator, including those from PI, Piezomechanic, PiezoSystems, etc.

2 Warnings / Notes

This device produces hazardous potentials and should be used by suitably qualified personnel under the supervision of an observer with appropriate first-aid training. Do not operate the device when there are exposed conductors.



High-Voltage

3 Specifications

Electrical				
Output Voltage Ranges	+200V	+150V	-50 to 150V	±100V
RMS Current	570 mA			
Peak Current	2 Amps or 10 Amps			
Gain	20 V/V			
Slew Rate	150 V/us			
Signal Bandwidth	680 kHz			
Power Bandwidth	230 kHz (200 Vp-p sine-wave)			
Max Power	60 W Dissipation			
Offset	0V to Full Range with front panel adjustment			
Load	Stable with any load			
Noise	665 uV RMS (10uF Load)			
Overload	Over-current protection			
Analog Outputs	Voltage monitor 1/20 V/V (BNC) Current monitor 1 V/A (BNC)			
Analog Input	Signal input (BNC, Z_{in} = 27k)			
Output Connectors	BNC, LEMO 00, LEMO 0B, 4mm Banana Sockets			
Power Supply	90 Vac to 250 Vac			

Mechanical	
Environment	0 to 40°C (32 to 104°F) Non-condensing humidity
Dimensions	275 x 141 x 64 mm (10.8 x 5.5 x 2.5 in)
Weight	1 kg (2.2 lb)

4 Output Voltage Range

The output voltage range can be configured by disconnecting the amplifier from mains power then removing the top panel. The following voltage ranges can be obtained with the correct combination of installed jumpers. Note that incorrect jumper settings may destroy the amplifier.

The standard output voltage range is 0V to 200V. However, the amplifier can be supplied with any voltage range by appending the order code with the voltage range code, for example, the standard configuration is PD200-V200. The voltage range jumper locations are labelled with the LP, LG, and LN prefixes on the PCB.

Voltage Range	Code	LP	LG	LN	LK10 and LK12
0V to +200	-V200	LP1	LG3		Position A
0V to +150	-V150	LP2	LG3		Position A
0V to +100	-V100	LP2	LG2		Position A
0V to +50	-V50	LP2	LG1		Position A
-50 to +50	-V50,50	LP2	LG1	LN1	Position B
-50 to +100	-V50,100	LP2	LG2	LN2	Position B
-50 to +150	-V50,150	LP1	LG2	LN2	Position B
-100 to +100	-V100,100	LP1	LG1	LN2	Position B

Table 1. Voltage range configuration (Standard)

5 Output Current Range

The standard peak output current is ±2 Amps; however, for applications that require very fast step changes in voltage, the amplifier can be configured in pulse mode with a 10 Amp current limit. The maximum pulse time for each mode is listed in Table 2 and plotted against current in Figure 1.

The output current range can be configured by disconnecting the amplifier from mains power then removing the front and top panel. The amplifier can be supplied preconfigured to any current range by appending the order code with the current range code, for example, the standard configuration is PD200-C2.

Peak Current	Code	Peak Limit	Overload Timer	Max Pulse Time
2 A	-C2	LK16	LK19 and LK20 Out	1 ms
10 A	-C10	LK18	LK19 and LK20 In	100 us

Table 2. Current range configuration (Standard)

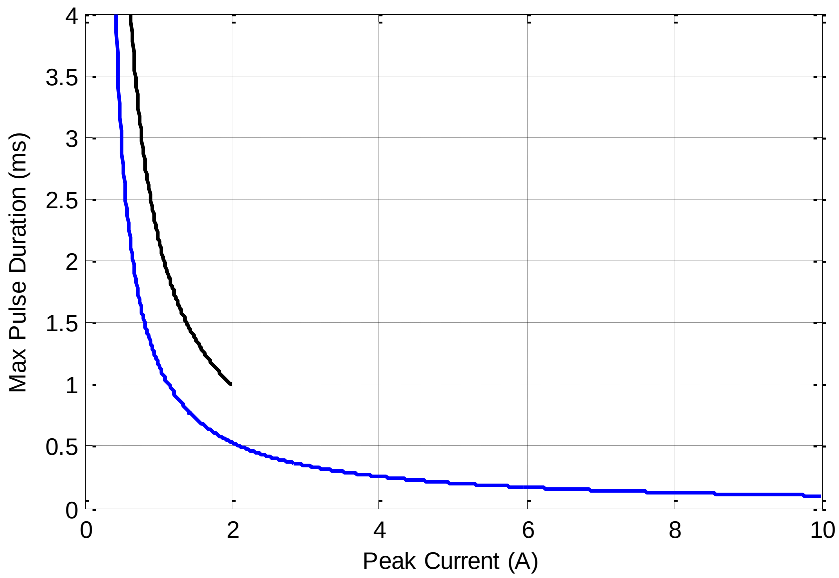


Figure 1. Maximum pulse time versus current

6 Power Bandwidth

With a capacitive load, the peak load current for a sine-wave is

$$I_{pk} = \pm V_{pp} \pi C f$$

where V_{pp} is the peak-to-peak output voltage, C is the load capacitance and f is the frequency. Given a peak current limit I_{pk}, the maximum frequency is therefore $f = I_{pk}/V_{pp}\pi C$. However, the PX200 is protected by both peak and average current limits. The average current I_{av+} is defined as the average positive or negative current. For example, for a sine-wave

$$I_{av+} = \frac{1}{2\pi}\int_0^{\pi} I_{pk}\sin(\theta)\,d\theta = \frac{I_{pk}}{2\pi}[-cos]_0^{\pi} = \frac{I_{pk}}{\pi} \;.$$

Therefore, for a sine-wave $I_{av+} = I_{pk}/\pi$. Since the average current limit of the PD200 is fixed at $I_{av+} = 0.26$ A, the maximum frequency sine-wave, or power bandwidth of the PX200, is equal to

$$f = \frac{0.26}{V_{pp} C}.$$

The above result is true for any periodic waveform such as triangular signals. The RMS current for a sine-wave can also be related to the average current,

$$I_{av} = \frac{\sqrt{2}}{\pi}\, I_{rms}\,.$$

The power bandwidths for a range of load capacitance values are listed below.

Load Cap.	Peak to Peak Voltage 200	150	100	50
No Load	230 kHz	310 kHz	470 kHz	520 kHz
10 nF	130 kHz	173 kHz	260 kHz	520 kHz
30 nF	43 kHz	58 kHz	87 kHz	173 kHz
100 nF	13 kHz	17 kHz	26 kHz	52 kHz
300 nF	4.3 kHz	5.8 kHz	8.7 kHz	17 kHz
1 uF	1.3 kHz	1.7 kHz	2.6 kHz	5.2 kHz
3 uF	430 Hz	570 Hz	870 Hz	1.7 kHz
10 uF	130 Hz	170 Hz	260 Hz	520 Hz
30 uF	43 Hz	57 Hz	87 Hz	170 Hz

Table 3. Power Bandwidth versus Load Capacitance

In the above table, the frequencies limited by slew-rate are marked in green while the frequencies limited by signal bandwidth are marked in blue. The slew-rate is approximately 150 V/uS which implies a maximum frequency of

$$f^{max} = \frac{150 \times 10^6}{\pi V_{pp}}$$

In the following figure, the maximum frequency periodic signal is plotted against the peak-to-peak voltage.

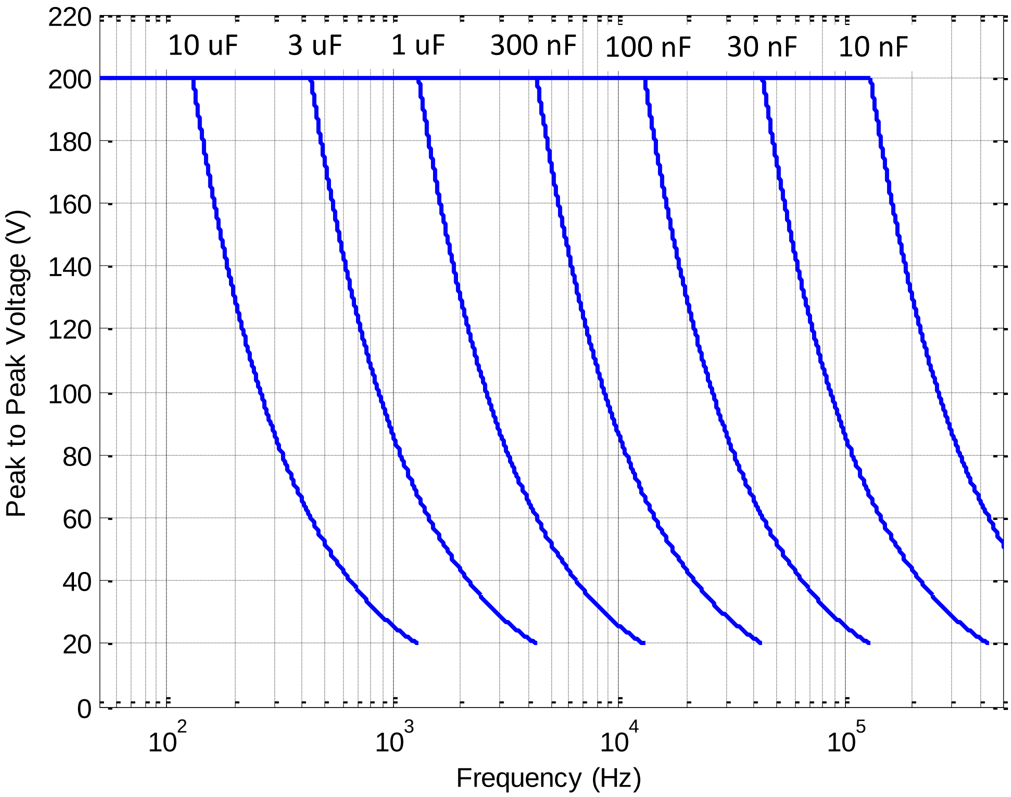


Figure 2. Power bandwidth versus voltage and load capacitance

7 Small Signal Bandwidth

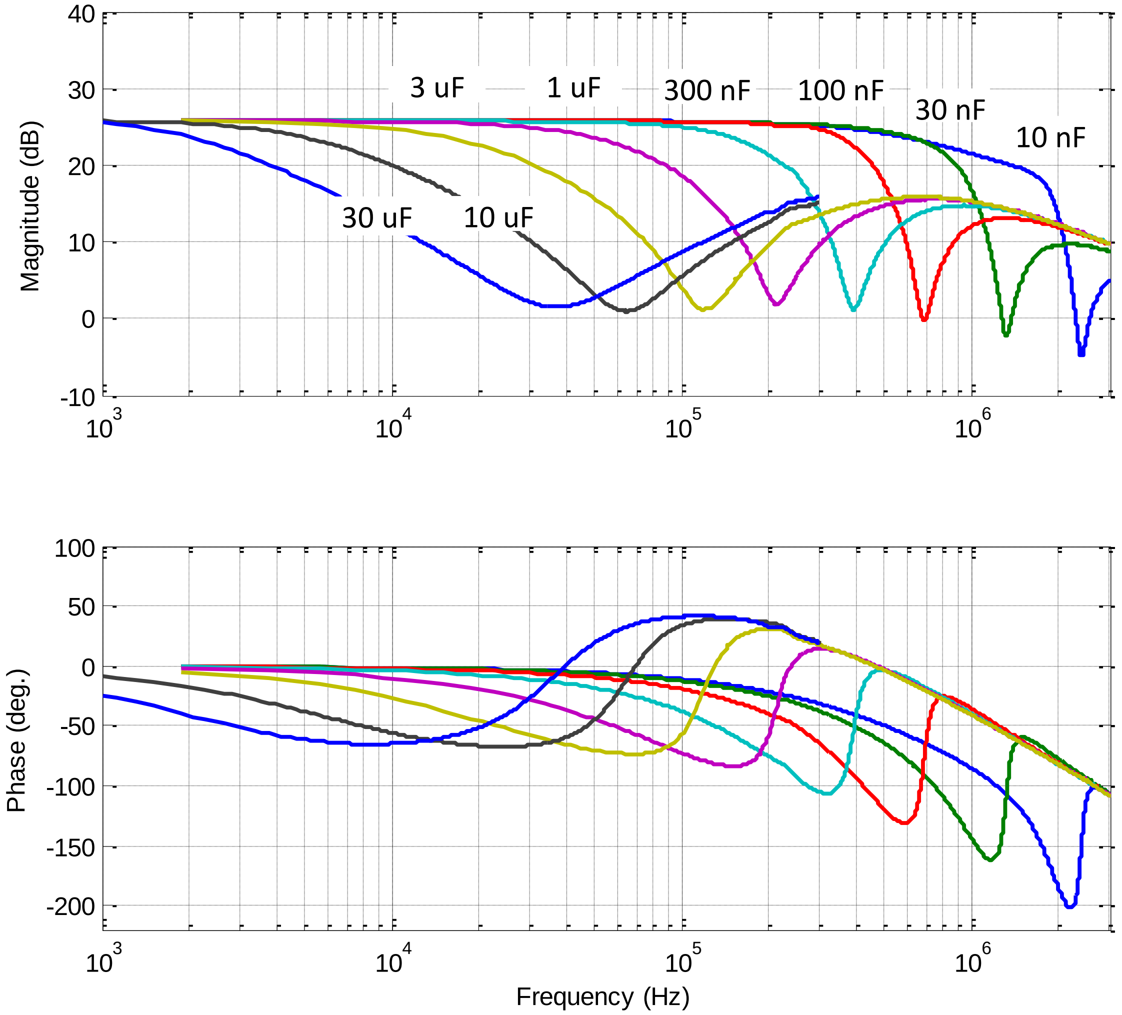


Figure 3. Small signal frequency response.

Load Cap.	Bandwidth
No Load	684 kHz
10 nF	759 kHz
30 nF	720 kHz
100 nF	388 kHz
300 nF	172 kHz
1 uF	60 kHz
3 uF	21 kHz
10 uF	6.4 kHz
30 uF	2.4 kHz
110 uF	940 Hz

Figure 4. Small signal bandwidth versus load capacitance (-3dB)

8 Noise

The output noise contains a low frequency component (0.03 Hz to 20 Hz) that is independent of the load capacitance; and a high frequency component (20 Hz to 1 MHz) that is inversely related to the load capacitance. Many manufacturers quote only the AC noise measured by a multimeter (20 Hz to 100 kHz) which is usually a gross underestimate.

The noise is measured with an SR560 low-noise amplifier (Gain = 1000), oscilloscope, and Agilent 34461A Voltmeter. The low-frequency noise is plotted in Figure 5. The RMS value is 650 uV with a peak-to-peak voltage of 4.3 mV. The noise level is approximately equal to the least significant bit of a 16-bit digital-to-analog converter.

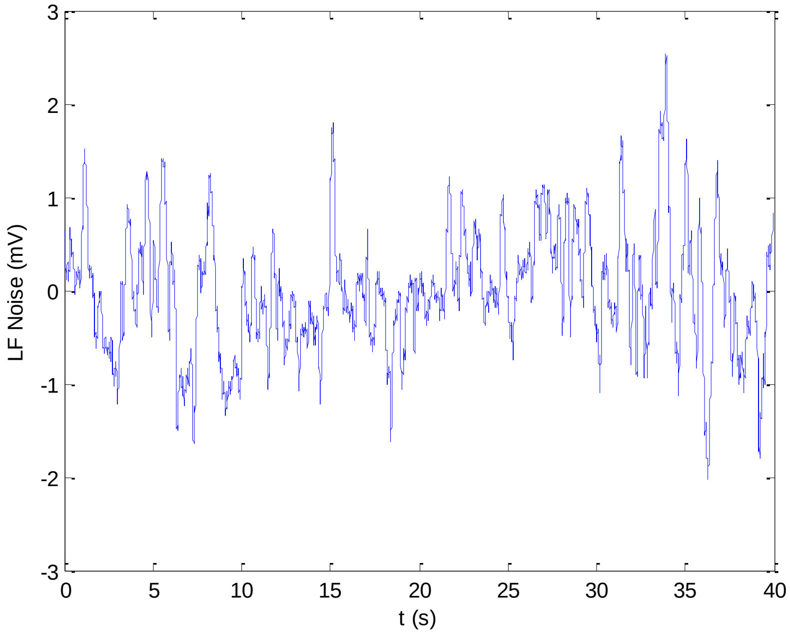


Figure 5. Low frequency noise from 0.03 Hz to 20 Hz. The RMS value is 650 uV, or 4.3 mVp-p.

The high frequency noise (20 Hz to 1 MHz) is listed in the table below versus load capacitance. The total noise from 0.03 Hz to 1 MHz is found by summing the RMS values, that is $\sigma = \sqrt{\sigma_{LF}^2 + \sigma_{HF}^2}$.

Load Cap.	Bandwidth	HF Noise RMS	Total Noise RMS
No Load	684 kHz	240 uV	698 uV
10 nF	759 kHz	241 uV	698 uV
30 nF	720 kHz	243 uV	699 uV
100 nF	388 kHz	234 uV	696 uV
300 nF	172 kHz	171 uV	677 uV
1 uF	60 kHz	133 uV	668 uV
3 uF	21 kHz	115 uV	665 uV
10 uF	6.4 kHz	112 uV	665 uV
30 uF	2.4 kHz	98 uV	662 uV
110 uF	940 Hz	85 uV	660 uV

Table 4. RMS noise versus load capacitance (0.03 Hz to 1 MHz)

9 Input and Offset Configuration

The input stage is normally non-inverting; however, it can be configured as inverting by changing LK14 and LK15 to their "B" position. The default jumper position is "A" which is marked with a white bar on PCB overlay. The amplifier can be supplied with an inverting input by appending the order code with –INV.

Input Configuration	Code	Link Positions
Non-inverting (default)		LK14 and LK15 Both "A"
Inverting	-INV	LK14 and LK15 Both "B"

Table 5. Input polarity configuration

The input offset source is also configurable. When LK21 is in the "B" position, the offset is derived from the on-board trim-pot R15, which is adjustable from zero to full-scale. The default configuration for LK21 is in the "A" position where the offset voltage is derived from the front-panel potentiometer.

The standard offset voltage range is from zero volts to full-scale; however, for applications that require negative offset voltages, LK13 can be moved from the "A" to "B" position. In the "B" position, the offset range is from -100V to full-scale.

Offset Configuration	Code	Link Positions
0V to +200V Range (def.)		LK13 "A" Position
-100V to +200V Range	-OR2	LK13 "B" Position
Front panel source (def.)		LK21 "A" Position
PCB trim-pot source	-OS2	LK21 "B" Position

Table 6. Offset voltage source configuration

10 Bridged Mode

In bridged mode, two amplifiers are connected in series to double the output voltage range and power. To obtain ±200V at the load, the amplifiers are configured as illustrated below. Both amplifiers are configured in the ±100V range and the lower amplifier is also inverting. A ±5V signal applied to both inputs will develop ±200V at the output.

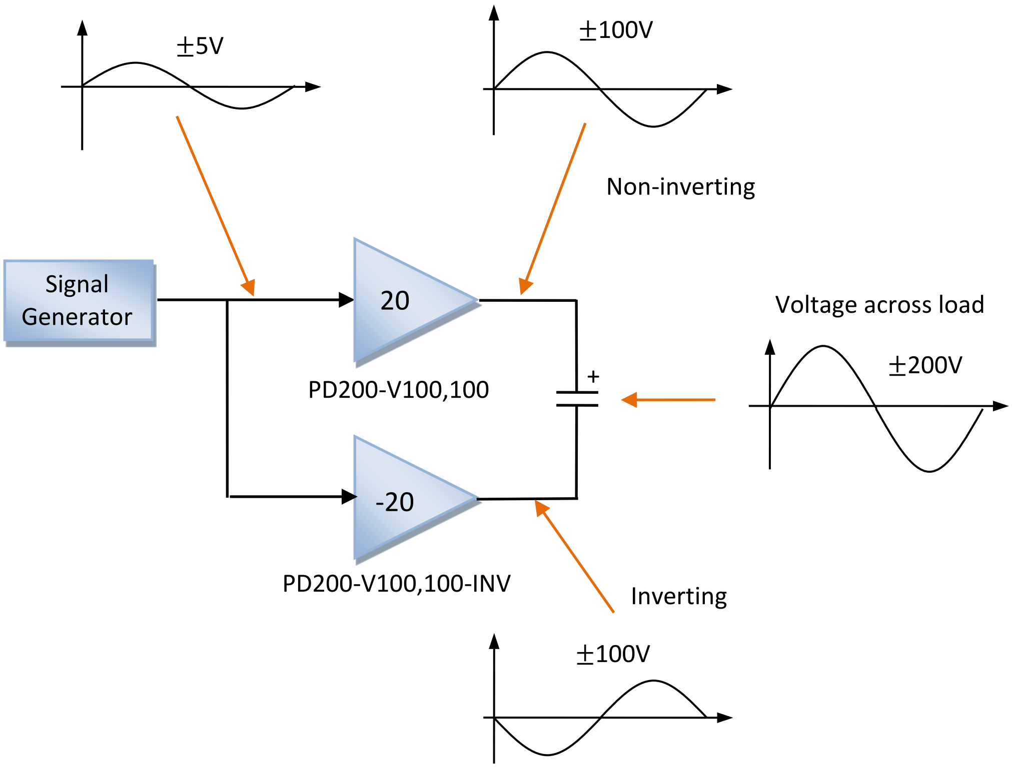


Figure 6. Bridged configuration for obtaining +/-200 V

11 Overload Protection

The Shutdown indicator will illuminate during a shutdown caused by an average current overload. During shutdown, the amplifier output current is limited to a few mA and may float to the high or low voltage rail if the load impedance is high or capacitive.

When the amplifier is turned on, the overload protection circuit is engaged by default and will take approximately three seconds to reset.

12 Output Connections

An actuator can be connected to the amplifier by either screw terminals or the LEMO 00, LEMO 0B, or BNC connectors. The recommended connectors are listed below. The full connector part number will depend on the diameter of the cable and desired strain relief.

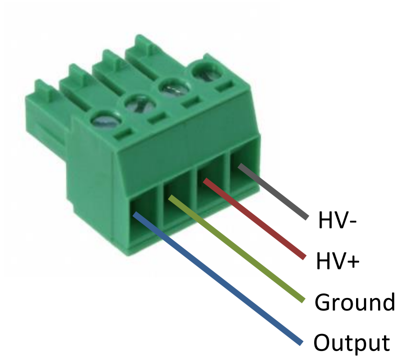
Output	Recommended Connector	Manufacturer	PCB Connector
BNC	Any BNC Connector	TE	1-1634613-0
Terminals	20020004-D041B01LF	FCI	20020110-D041A01LF
LEMO 00	FFA.00.250	LEMO	EPL.00.250
LEMO 0B	FGG.0B.302	LEMO	EPG.0B.302

Table 7. Output connectors

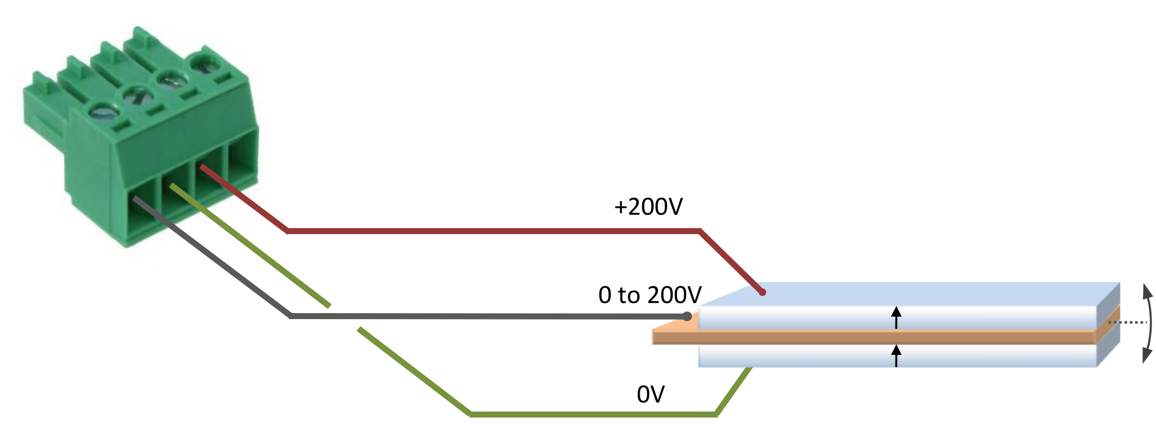
The LEMO 0B connector is recommended in high power applications. Preassembled LEMO cable assemblies are available from www.PiezoDriveOnline.com

12.1 Screw Terminals

The plug-in screw terminal has contacts for the output voltage, ground, and the positive and negative high-voltage supply rails, which are useful when driving piezoelectric bender actuators.

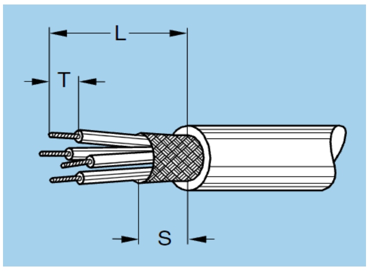


Bender actuators can be driven with a single bias voltage, for example 200 V, or bipolar bias voltages, for example $\pm$ 100 V. The 200 V unipolar configuration is illustrated below.



12.2 LEMO 0B Cable Preparation

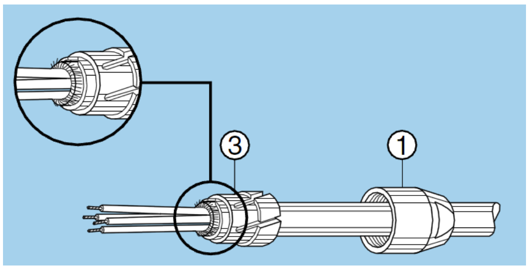
(Taken from LEMO 0B Series Cable Assembly Instructions)



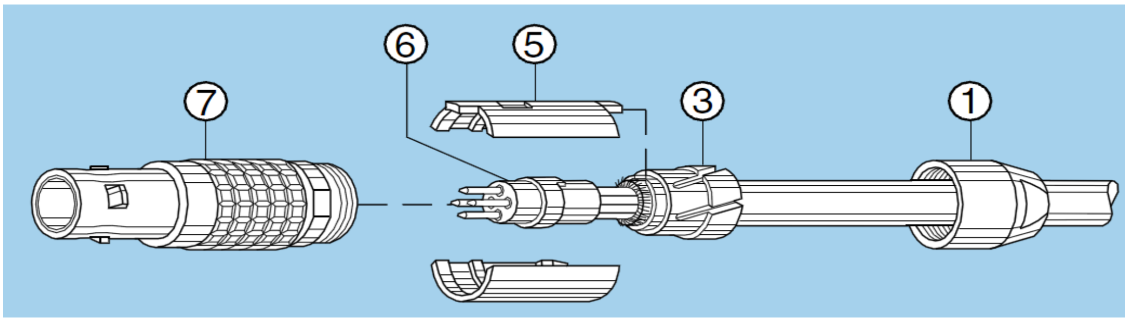
Solder			Crimp		
L	S	T	L	S	T
13.0	7	3.0	17.0	7	4.0

12.3 LEMO 0B Plug Assembly

(Taken from LEMO 0B Series Cable Assembly Instructions)



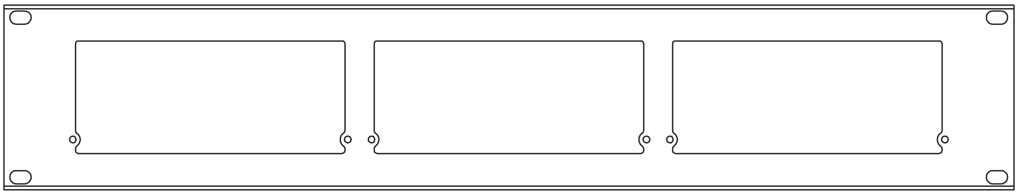
1. Strip the cable as above
2. If the cable is shielded, fold the shield back over the cable
3. Slide the strain relief, collet nut (1) and collet (3) onto the cable.
4. Solder or crimp the conductors onto the contacts.
5. Assemble the plug,



13 Enclosure

The PD200 enclosure has a side air intake and rear exhaust. These vents should not be obstructed.

The PD200 amplifiers can be rack-mounted in a three channel arrangement as shown below. The rack panel (19-inch X 2U) is supplied separately and requires some user assembly to mount between one and three channels. The rack order code is PD200-RackPanel.



14 Warranty

PiezoDrive amplifiers are guaranteed for a period of 3 months. The warranty does not cover damage due to misuse or incorrect user configuration of the amplifier.