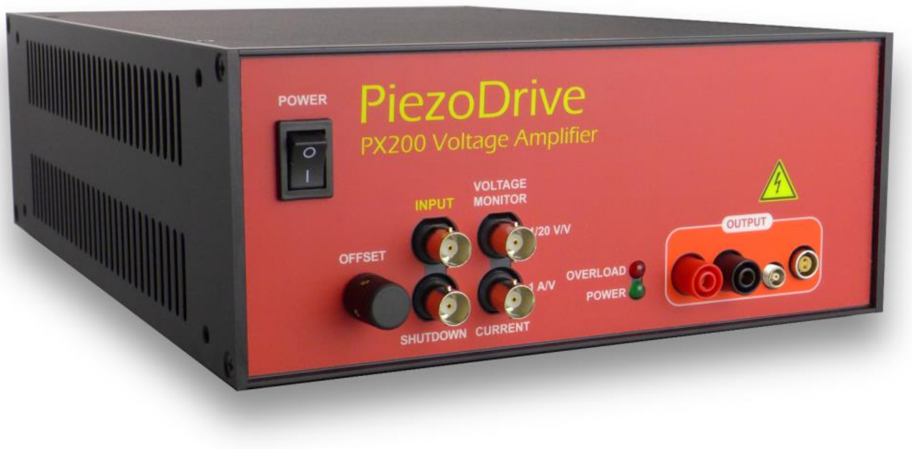


PX200 - 140 Watt Piezo Driver

Manual and Specifications

PiezoDrive Pty. Ltd.
www.piezodrive.com

Contents

1 Introduction

The PX200 is a high-power low-noise amplifier designed to drive unlimited capacitive loads from DC to 100 kHz. The output voltage range is user-selectable from $\pm$50V to +200V which provides a high degree of application flexibility. In particular, two amplifiers can be connected in bridge-mode to provide $\pm$200V with 280 Watts of power. The amplifier will deliver up to 4 Amps peak for sinusoidal operation, or up to 8 Amps for pulse applications

The amplifier is compact, light-weight, and can be powered from any mains supply. The output connectors include LEMO 00, LEMO 0B, and 4mm Banana Jacks so many commercially available piezoelectric actuators can be directly connected. The PX200 is suited to a wide range of applications including: electro-optics, ultrasonics, vibration control, nanopositioning systems, and piezoelectric motors.

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	+50V to +200V, $\pm$100V, -50V to +150V
RMS Current	1.5 Amps (3 Amps in 100V range)
Peak Current	2 Amps, 4 Amps, or 8 Amps
Gain	20 V/V
Slew Rate	35 V/us
Signal Bandwidth	390 kHz
Power Bandwidth	55 kHz (200 Vp-p sine-wave)
Max Power	140 W Dissipation
Offset	0V to Full Range with front panel adjustment
Load	Stable with any load
Noise	270 uV RMS (10uF Load, 0.03 Hz to 1 MHz)
Overload	Thermal and 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	LEMO 0B and LEMO 00 Sockets 4mm Banana Sockets
Power Supply	90 Vac to 250 Vac

Mechanical	
Environment	0 to 40°C (32 to 104°F) Non-condensing humidity
Dimensions	212 x 304.8 x 88 mm (8.35 x 12 x 3.46 in)
Weight	2 kg (4.4 lb)

4 Output Voltage Range

The desired voltage range should be identified when ordering. The following voltage ranges can be obtained with the correct combination of installed jumpers. Note that incorrect jumper settings may damage the amplifier.

The standard output voltage range is 0V to 200V. However, the amplifier can be supplied with any of the following voltage ranges by appending the order code with the voltage range code; for example, the standard configuration is PX200-V200. The voltage range jumper locations are labelled LK1 to LK8 on the PCB. Only three jumpers should be installed at any time.

Voltage Range	RMS Current	Code	+Supply	GND	-Supply
0V to +200	1.5 A	-V200	LK1	LK8	LK7
0V to +150	1.5 A	-V150	LK2	LK8	LK7
-50 to +100	1.5 A	-V50,100	LK1	LK3	LK6
-50 to +150	1.5 A	-V50,150	LK1	LK5	LK7
-100 to +100	1.5 A	-V100,100	LK1	LK3	LK7

Table 1. 200 Volt Range Configurations

In addition to the 200V ranges described above, three 100V ranges are also possible. These ranges have the benefit of twice the peak and RMS current, which enables higher frequency operation when driving low-voltage actuators.

Voltage Range	RMS Current	Code	+Supply	GND	-Supply
0V to +100	3.0 A	-V100	LK1	LK3	LK4
0V to +50	3.0 A	-V50	LK2	LK3	LK4
-50 to +50	3.0 A	-V50,50	LK2	LK3	LK6

Table 2. 100 Volt Range Configurations

The jumper settings can be modified by disconnecting the amplifier from mains power then removing the top panel to access the PCB board.

5 Output Current (200V Range)

In the 200V ranges, the standard output current is $\pm$2 Amps peak and 1.5 Amps RMS. This peak current is matched to the average current limit so that a sine-wave can be reproduced continuously at full current. However, for applications that require fast step changes in voltage, the amplifier can be configured in a pulse mode with 4 Amps or 8 Amps peak current limit. The maximum pulse time for each mode is listed in Table 3 and plotted against current in Figure 1.

The output current range can be configured by disconnecting the amplifier from mains power then removing the top panel. The following modes can them be obtained. 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 PX200-C2.

Peak Current	Code	Peak Limit	LK17	Overload Timer	Max Pulse Time
2 A	-C2	LK11	“B” Position	LK16 and LK18 Out	1 ms
4 A	-C4	LK12	“B” Position	LK16 and LK18 In	200 us
8 A	-C8	LK13	”B” Position	LK16 and LK18 In	100 us

Table 3. Current limit configuration in 200V range (Standard)

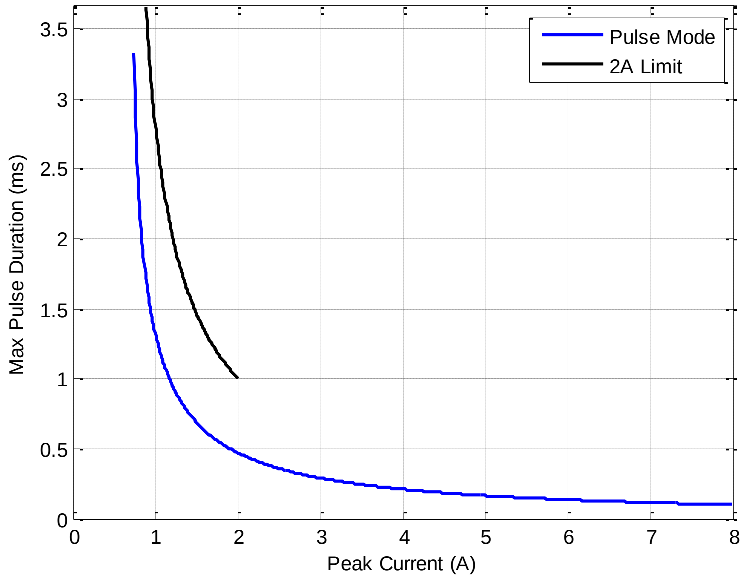


Figure 1. Maximum pulse time versus current

6 Output Current (100V Range)

In the 100V ranges, the output current can be doubled to ±4 Amps peak and 3 Amps RMS. For applications that require fast step changes in voltage, the amplifier can also be configured in a pulse mode with 8 Amps peak. The maximum pulse time is identical to the 200V range discussed above.

The output current range can be configured by disconnecting the amplifier from mains power then removing the top panel. The following modes can them be obtained. The amplifier can be supplied preconfigured to any current range by appending the order code with the current range code, for example, the 100V range and 4A current limit is PX200-V100-C4B.

Peak Current	Code	Peak Limit	LK17	Overload Timer	Max Pulse Time
4 A	-C4B	LK12	“A” Position	LK16 and LK18 Out	1 ms
8 A	-C8B	LK13	”A” Position	LK16 and LK18 In	100 us

Table 4. Current limit configuration in 100V range

7 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 is $I_{av+} = 0.7$ in the 200V range, the maximum frequency sine-wave, or power bandwidth of the PX200, is equal to

$$f = \frac{0.7}{V_{pp} C} ,$$

The above result is true for any periodic waveform such as triangular signals. In the 100V range, the power bandwidth is doubled. 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	Peak to Peak Voltage (200V Range)			
Cap.	200	150	100	50
10 nF	55 kHz	74 kHz	100 kHz	100 kHz
30 nF	55 kHz	74 kHz	100 kHz	100 kHz
100 nF	35 kHz	46 kHz	70 kHz	100 kHz
300 nF	11 kHz	15 kHz	23 kHz	46 kHz
1 uF	3.5 kHz	4.6 kHz	7.0 kHz	14 kHz
3 uF	1.1 kHz	1.5 kHz	2.3 kHz	4.6 kHz
10 uF	350 Hz	466 Hz	700 Hz	1.4 kHz
30 uF	116 Hz	155 Hz	233 Hz	466 Hz

Table 5. Power Bandwidth versus Load Capacitance (200V Range)

Load Cap.	Peak to Peak Voltage (100V Range) 100	75	50	25
10 nF	100 kHz	100 kHz	100 kHz	100 kHz
30 nF	100 kHz	100 kHz	100 kHz	100 kHz
100 nF	100 kHz	100 kHz	100 kHz	100 kHz
300 nF	46 kHz	62 kHz	93 kHz	100 kHz
1 uF	14 kHz	18 kHz	28 kHz	56 kHz
3 uF	4.6 kHz	6.2 kHz	9.3 kHz	18 kHz
10 uF	1.4 kHz	1.8 kHz	2.8 kHz	5.6 kHz
30 uF	466 Hz	622 Hz	933 Hz	1.8 kHz

Table 6. Power Bandwidth versus Load Capacitance (100V Range)

In the above tables, 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 35 V/uS which implies a maximum frequency of

$$f^{max} = \frac{35 \times 10^6}{\pi V_{pp}}$$

In the following figures, the maximum frequency periodic signal in the 200V and 100V range is plotted against the peak-to-peak voltage.

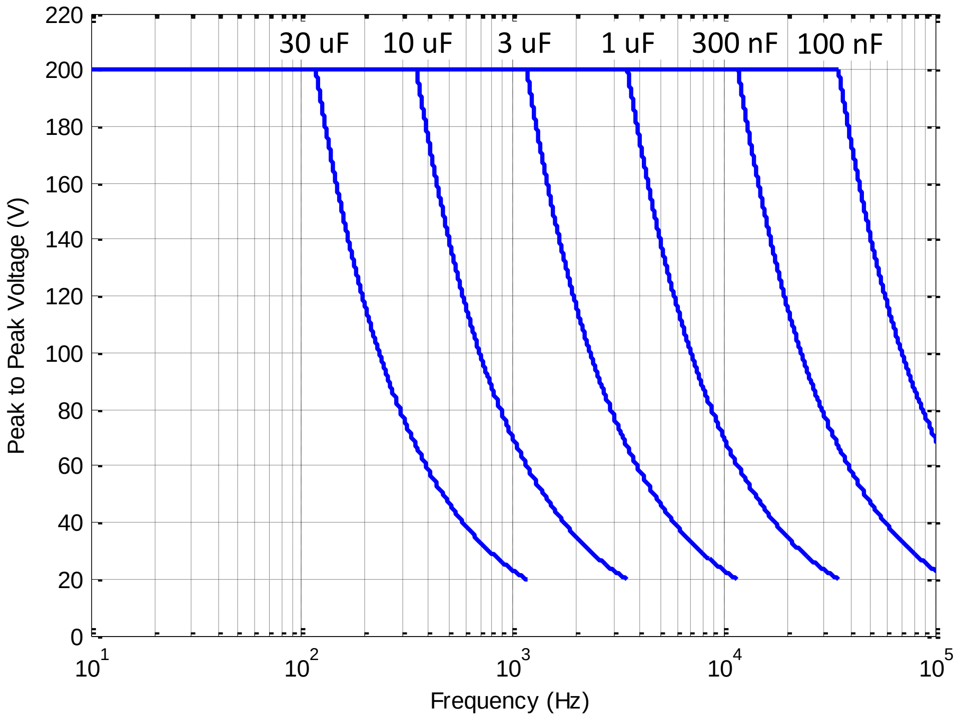


Figure 2. Power bandwidth versus voltage and load capacitance (200V Range)

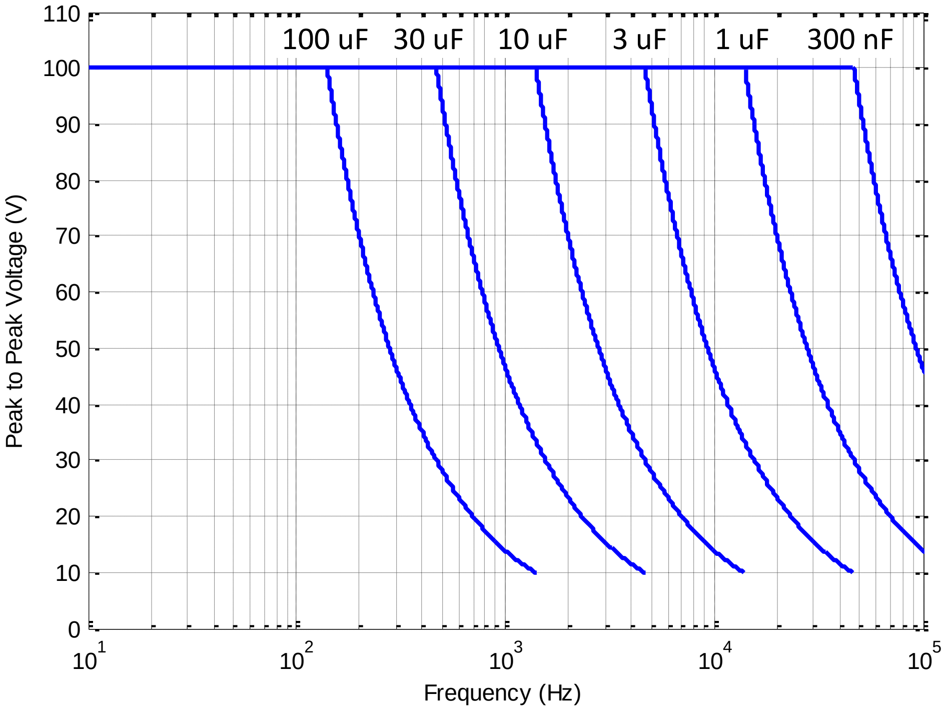


Figure 3. Power bandwidth versus voltage and load capacitance (100V Range)

8 Small Signal Bandwidth

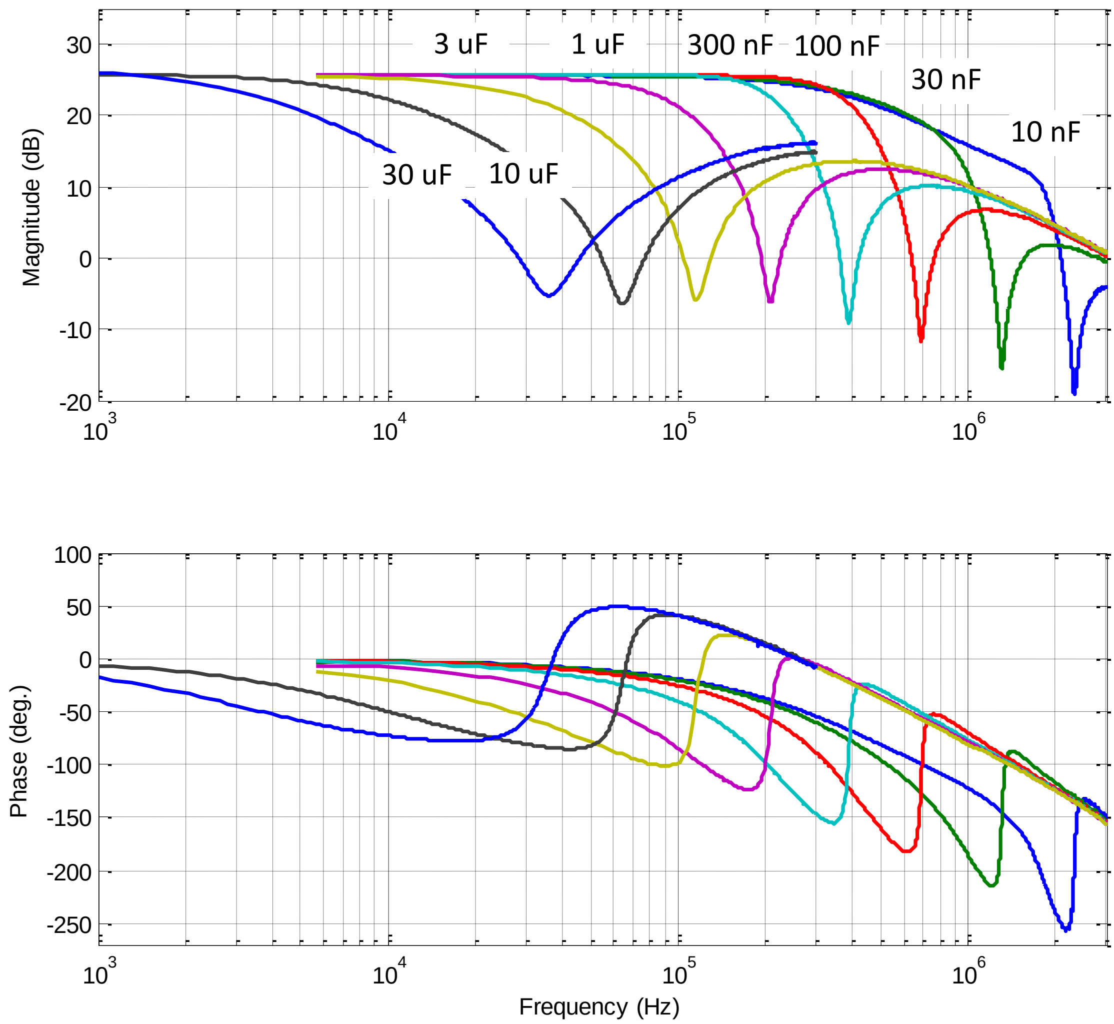


Figure 4. Small signal frequency response.

Load Cap.	Bandwidth
10 nF	393 kHz
30 nF	431 kHz
100 nF	367 kHz
300 nF	208 kHz
1 uF	88 kHz
3 uF	30 kHz
10 uF	9.3 kHz
30 uF	3.7 kHz
110 uF	1.3 kHz

Figure 5. Small signal bandwidth versus load capacitance (-3dB)

9 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 (20 Hz to 1 MHz) component 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 6. The RMS value is 173 uV with a peak-to-peak voltage of 960 uV.

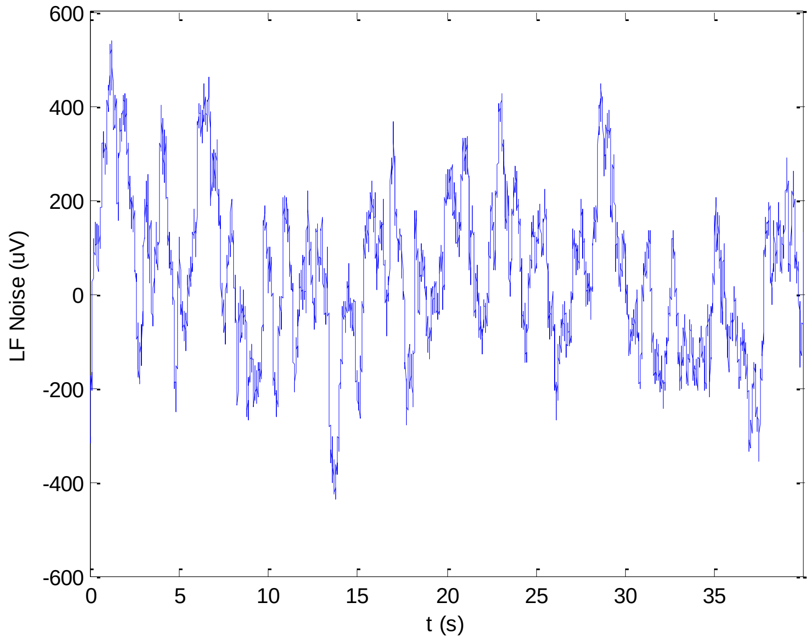


Figure 6. Low frequency noise from 0.03 Hz to 20 Hz. The RMS value is 173 uV, or 960 uVp-p.

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
10 nF	393 kHz	379 uV	417 uV
30 nF	431 kHz	382 uV	419 uV
100 nF	367 kHz	382 uV	419 uV
300 nF	208 kHz	326 uV	369 uV
1 uF	88 kHz	234 uV	291 uV
3 uF	30 kHz	214 uV	275 uV
10 uF	9.3 kHz	198 uV	263 uV
30 uF	3.7 kHz	187 uV	255 uV
110 uF	1.3 kHz	183 uV	252 uV

Table 7. RMS noise versus load capacitance (0.03 Hz to 1 MHz)

10 Input and Offset Configuration

The input stage is a differential amplifier with an input impedance of 27k. The input signal ground is permitted to float by up to 0.6V before it is clamped to the system ground.

The input stage is normally non-inverting; however, it can be configured as inverting by changing LK9 and LK10 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)		LK9 and LK10 Both "A"
Inverting	-INV	LK9 and LK10 Both "B"

Table 8. Input polarity configuration

The input offset source is also configurable. When LK21 is in the "A" 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 "B" 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, LK20 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.)		LK20 "A" Position
-100V to +200V Range	-OR2	LK20 "B" Position
Front panel source (def.)		LK21 "B" Position
PCB trim-pot source	-OS2	LK21 "A" Position

Table 9. Offset voltage source configuration

11 Gain

The standard voltage gain is 20 V/V. However, in the 100 Volt range, a gain of 10 may be more convenient. This can be achieved by removing LK14 and LK15. In this configuration, the voltage monitor sensitivity becomes 1/10 V/V.

12 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.

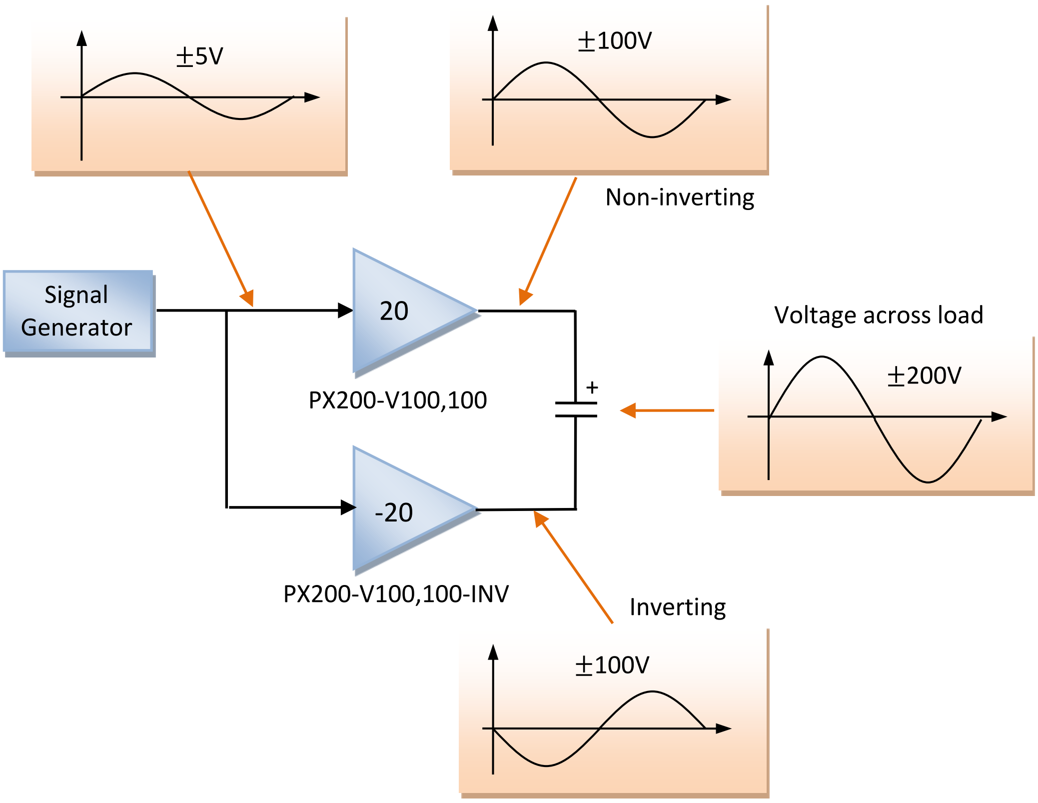


Figure 7. Bridged configuration for obtaining +/-200 V

13 Overload Protection

The Shutdown indicator will illuminate during a shutdown caused by a current overload or if the amplifier overheats as a result of excessive ambient temperature, poor air-flow, or fan failure. 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.

In addition to the internal shutdown triggers, the output stage of the amplifier can also be disabled by applying a positive voltage to the external shutdown connector (2V to +12V). The impedance of the external shutdown input is approximately 2.5 kΩ.

14 Output Connection Diagram

The actuator can be connected to the amplifier by either two 4mm banana plugs, a LEMO 00 coaxial connector, or a 2-way LEMO 0B connector. The LEMO 0B connector is recommended in high power applications. Preassembled LEMO cable assemblies are available from www.PiezoDrive.com

The mating plug for the LEMO 0B connector is a 2-Way straight cable plug. Ordering details and specifications are listed below. These parts can be obtained directly from www.mouser.com.

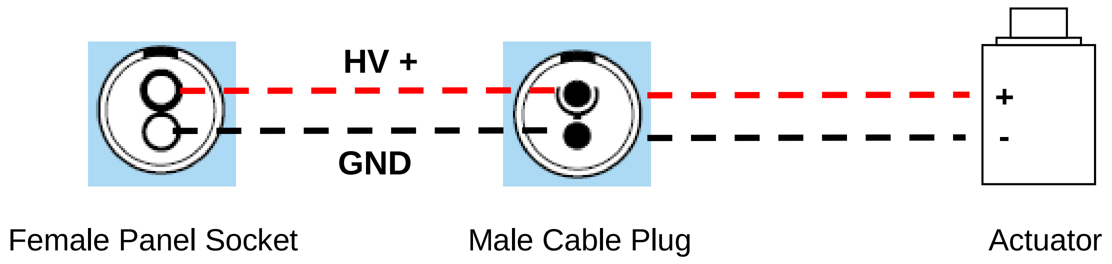
Plug	LEMO 0B 2-Way Straight Cable Plug
Crimp Terminal Version	*LEMO FGG.0B.302.CYCZ
Solder Tag Version	LEMO FGG.0B.302.CLAZ
Max Conductor Size	AWG22
Cable Collet	FGG.0B.742.DN
Cable Diameter	3.1mm – 4mm
Strain Relief Boot	GMA.0B.035.DN (3.5–3.9mm Cable)

*The crimp terminal plug requires a tool, if this is not available, the solder tag plug should be used.

A two conductor cable is required to connect the amplifier to a transducer. A recommended cable is the Belden 8451 cable. The specifications are listed below.

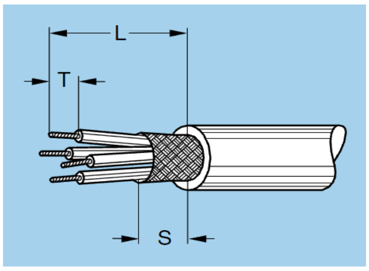
Cable	Belden 8451
Conductor Size	AWG22 (0.64mm diameter)
Resistance	53 mOhms/m
Capacitance	115 pF/m core–core, 220 pF/m core-shield
Outside Diameter	3.5mm

The actuator wiring diagram is shown below.



14.1 LEMO OB 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

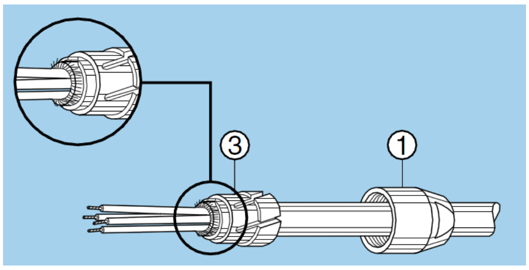
14.2 LEMO OB Plug Assembly

(Taken from LEMO 0B Series Cable Assembly Instructions)

1. Strip the cable as above

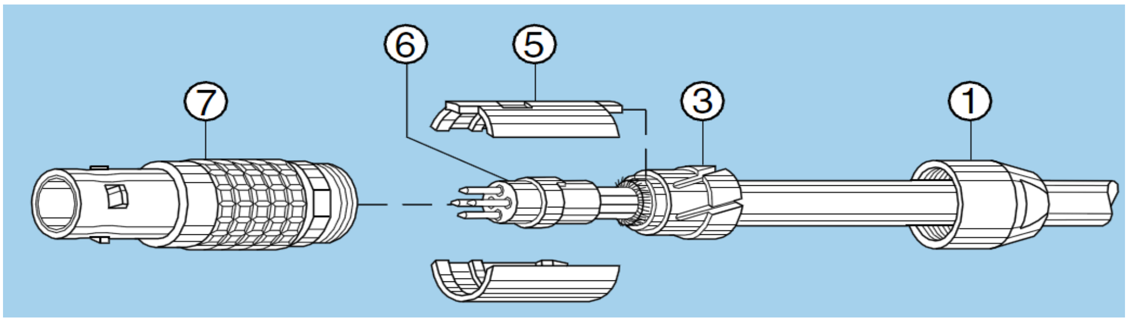
2. If the cable is shielded, fold the shield back over the cable

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,



15 Enclosure

The PX200 enclosure has a side air intake and rear exhaust. These vents should not be obstructed. If sufficient air-flow is not available, the amplifier will enter a thermal overload state as discussed in "Overload Protection".

The PX200 amplifiers can be bolted together in a side-by-side two-channel arrangement. With the addition of rack-mount handles, this configuration can be mounted into a standard 19-inch rack. A 19-inch rack-mount kit is also available for a single amplifier.

16 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.