# pr.Amplifier – PiezoRobotics Piezo Amplifier

The PiezoRobotics' pr.Amplifier is a high-voltage power supply and linear voltage amplifier for driving high capacitive loads such as piezoelectric ceramics at high frequencies. It is the next generation of a high-performance and low-cost amplifier module, with user friendly connectors inspired from consumer electronics, while maintaining the quality of a laboratory equipment. The pr.Amplifier converts a small-amplitude audio-type input signal into a unipolar output voltage of amplitude up to 350 $V_{p\text{-}p}$, by means of a high-voltage boost converter and a linear amplifier. This is useful in piezoelectric applications that require high voltage and high current drive, such as broadband active vibration control and ultrasonic generators.

## Key Features

- Power supply over USB-C PD
- Low input voltage, up to 350 $V_{p\text{-}p}$ output voltage
- Output current up to 0.5 $A_{0\text{-}p}$
- 40 kHz Bandwidth


## Technical Specifications

| Specifications | Value | Notes |
|---|---|---|
| Supply Voltage | 20 $V_{DC}$ over USB-C PD 3.0 | |
| Quiescent Current | 0.4 A | Quiescent Power = 8 W |
| Gain | 126 (42 dB) | @ 1kHz (see plot) |
| Slew Rate | 50 V/µs | |
| Input Voltage Range | ±1.4 $V_{0\text{-}p}$ (1.0 $V_{RMS}$) | bipolar input |
| Input DC Offset | 0 $V_{DC}$ | fixed |
| Output Voltage Range | 0 – 350 $V_{p\text{-}p}$ (123.7 $V_{RMS}$) | unipolar output |
| Output DC Offset | 175 $V_{DC}$ | fixed |
| Output Current Range | 0 – 0.5 $A_{0\text{-}p}$ (0.354 $A_{RMS}$) | continuous |
| Output Power to Load | 44 W maximum | see power limitations below |
| Load Impedance | Unlimited | |
| Bandwidth | 40 kHz | |
| Output Noise | 72 $mV_{RMS}$ | noise below 1 MHz |
| Power Connector | USB Type-C PD (Power Delivery) | minimum 65 W / 3.25 A |
| Input Signal Connector | 3.5 mm mini audio jack plug | |
| Output Connector | BNC | |
| Dimensions | 141 x 86 x 48 mm | |
| Operating Temperature | -25°C to +40°C | |
| Weight | 0.38 kg | |

## Applications

Active Vibration Control, Vibration Condition Monitoring, Piezoelectric Ultrasonic Actuators, Ultrasonic Wave Generators.

## Electrical Connection

The pr.Amplifier can be powered by a standard USB-C connector and a commercial USB Power Delivery (PD) charger or power supply with an existing output voltage of 20 $V_{DC}$ and a power rating of at least 65 W or a minimum output current of 3.25 A (100 W / 5 A maximum and recommended). The low-voltage analog input signal is connected through a 3.5 mm audio jack and can be generated by a standard line level source. After amplification, the high-voltage analog output signal can be connected to the piezoelectric load through a standard BNC cable.

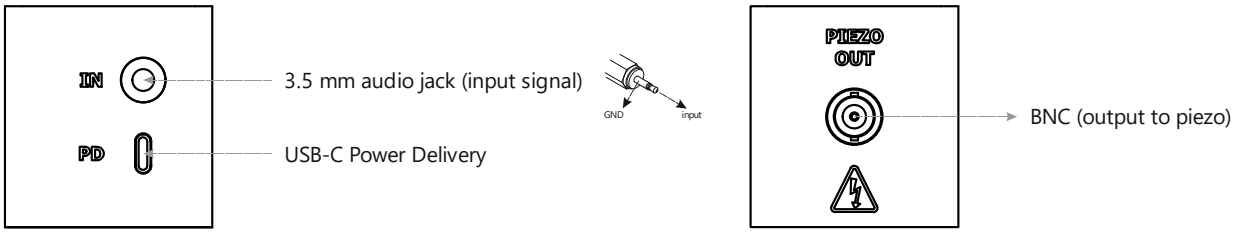


Figure 1. Power and analog signals connections

## Operation

The pr.Amplifier contains a DC/DC high-voltage boost converter, which generates a fixed 350 $V_{DC}$ from the 20 $V_{DC}$ supply voltage. The high-voltage non-inverting linear amplifier has an input voltage range from -1.4 V to +1.4 V with a gain of 42 dB. The load is connected between the output and ground. Bipolar output voltages up to ±175 $V_{0\text{-}p}$ are possible with an external AC coupling capacitor.

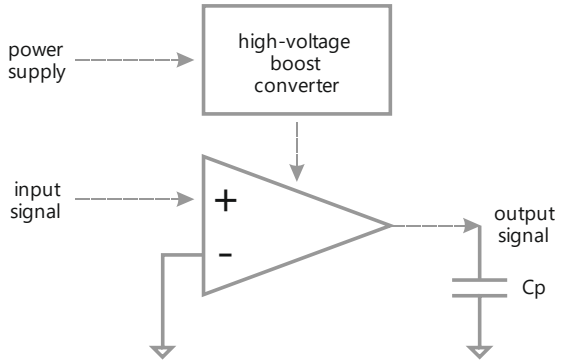


Figure 2. Principle of operation of the linear amplifier

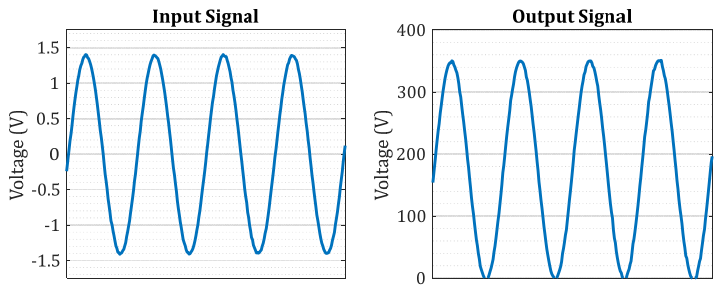


Figure 3. Time domain input and output signals

## Small Signal Bandwidth

The frequency response of the amplifier with no-load condition is given by the measured plot below:

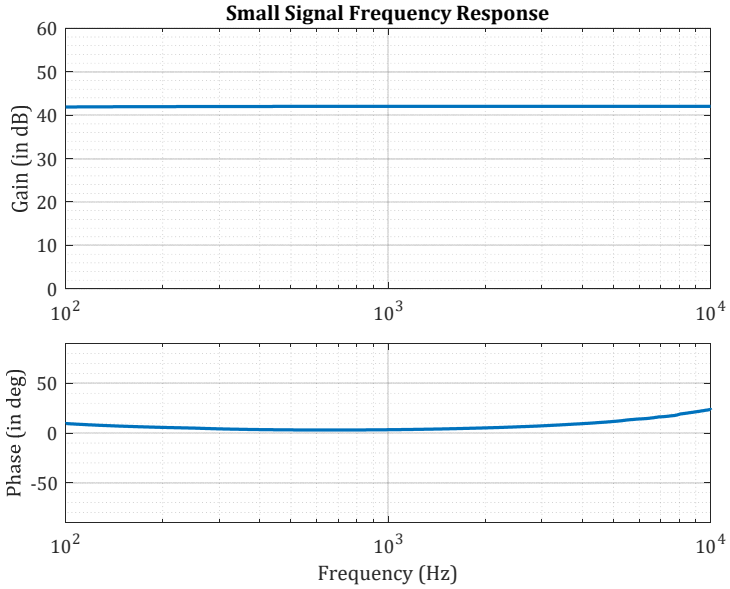


Figure 4. Measured small signal frequency response

## Output Current and Power Limitations

Considering a sine wave input signal, the peak electrical current required to drive a capacitive or piezoelectric load is given by the following equation:

$$I_{0-p} = \pi V_{p-p} C_p f$$

where $V_{p\text{-}p}$ is the peak-to-peak output voltage, $C_p$ is the effective capacitance of the load and $f$ is the sine wave frequency.

The pr.Amplifier has an internal limiting circuit allowing a maximum output current of 0.5 $A_{0\text{-}p}$. Nevertheless, using the formula above, or preferably by measuring the actual output current to the

piezoelectric load, the user should carefully choose the values of $C_p$, $V_{p\text{-}p}$ and $f$ in order not to exceed the output voltage, current and power maximum ratings. The average power delivered to load can be calculated with measured output voltage and current using the following equation:

$$P_{load} = V_{RMS} I_{RMS} = V_{p-p} I_{0-p} / 4$$

The actual maximum output power possibly delivered to the load depends on several parameters such as circuit temperature, boost voltage, signal waveform and load impedance (phase between output voltage and current). The input power supplied to the amplifier can be up to several times higher than the output power supplied to the load.

## Overload Protection and Safety

Each pr.Amplifier is individually tested. The measured small signal frequency response is provided with each delivery. The pr.Amplifier has an internal limitation on output voltage and output current, but not on output power. Excessive internal temperatures may damage the amplifier permanently. An external cooling fan is recommended for high power applications.

## Dimensions

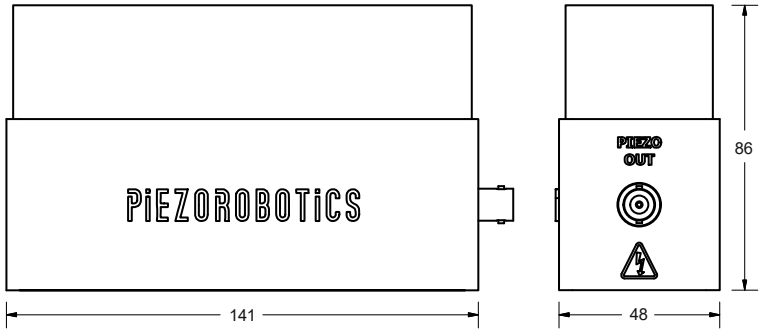


Figure 5. Dimensions of the pr.Amplifier

## Customization

PiezoRobotics has the capability to customize the pr.Amplifier according to your specific application and requirements. We can modify any electrical specification, dimensions, connectors or other parameters, and integrate it with your own electronics and piezo system. We also guarantee much lower prices for high volume purchases. Please contact us for further details.

## Package Content

1 x pr.Amplifier