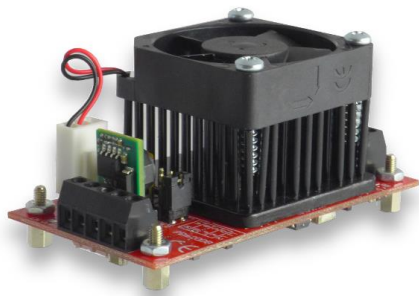


## PDm200 V9

### High Performance Piezo Driver



The PDm200 is a high-performance power supply and linear amplifier module for driving piezoelectric actuators. The output voltage range can be switched between bipolar or unipolar modes with a range of 100V, 150V, or 200V. Up to  $\pm 400V$  can be achieved in the bridged configuration. In the unipolar mode, the negative output range is fixed at -30V for use with stack actuators.

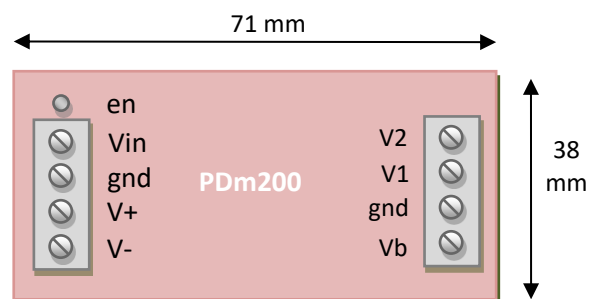
The PDm200 can drive stack actuators; standard piezoelectric actuators; two wire benders; and three-wire piezoelectric benders requiring a bias voltage.

Compatible Actuators	
Stack Actuators	60V to 200V
Plates and Tubes	up to $\pm 200V$
Two Wire Benders	up to $\pm 200V$
Three Wire Benders	0 to 200V with 200V bias $\pm 100V$ with $\pm 100V$ bias

The PDm200 is suited to a wide range of applications including: Electro-optics, ultrasound, vibration control, nanopositioning systems, and piezoelectric motors.

The PDm200 is protected against current overload and excessive temperature. It can be mounted to a base with four M2.5 screws or. The PCB mounting version is supplied with headers for direct mounting onto a host motherboard.

Specifications	
Power Supply	$\pm 12 V$ to +34 V
Max Unipolar Output	-30V to 200 V
Max Bipolar Output	$\pm 200 V$ ( $\pm 400 V$ bridge mode)
Peak Output Current	300 mA
RMS Output Current	120 mA ( $\pm 100 V$ Output)
Power Bandwidth	63 kHz (100 Vp-p)
Signal Bandwidth	200 kHz
Slew Rate	20 V/us
Dimensions	71 x 38 mm
Weight	50 g
Gain	20 V/V
Input Impedance	200 k $\Omega$
Input Offset	$\pm 10$ mV
Load	Any
Overload	Thermal and current overload protection
Noise	<1 mV RMS (1uF Load)
Environment	0 to 60°C (32 to 140°F) Non-condensing humidity
Quiescent Current	100 mA (7.5 mA in Shutdown)



Inputs		Outputs	
en	Enable	V2	Low Noise Output
Vin	Input Signal	V1	High Speed Output
gnd	Ground	gnd	Ground
V+	Positive Supply	Vb	Bias Voltage
V-	Negative Supply		

Figure 1. Connection diagram

## Operation

The system block diagram is illustrated in Figure 2. A power converter generates a unipolar or bipolar supply. The output voltage range is controlled by the voltage selector jumpers.

The amplifier has a gain of 20 and an input voltage range of  $\pm 10$  V. The load is connected directly to the high-speed output (V1) or through a filter (V2) which reduces the noise and bandwidth. In most applications, the V2 output is recommended.

A variable bias supply is also available for piezoelectric bender applications. The default bias voltage is 200 V but lower voltages can be achieved by adding a resistor.

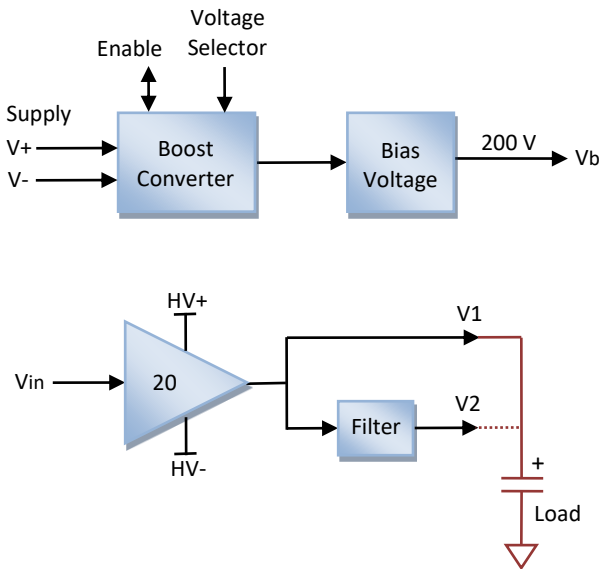


Figure 2. PDM200 Block Diagram

## Configuration

The PDM200 is configurable to suit a wide range of power supply and output voltage ranges. The output voltage range is selected by two jumpers marked L1 and L2, as shown below. Each jumper has four possible positions marked by the letters A to D and E to H.

In the unipolar output mode, the negative output range is fixed at -30 V and the jumper L2 is always in the 'E' position. The correct position for the L1 jumper is listed below for different power supply voltages.

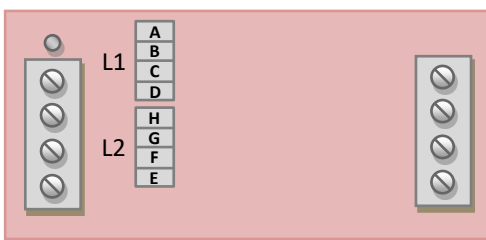


Figure 3. Jumper Locations

Output		Power Supply Voltage			
Max	Min	$\pm 12$ to $\pm 14$	$\pm 15$ to $\pm 17$	+24V* to 30	+30V* to 34
200 V	-30 V		D		D
150 V	-30 V	D	C	D	C
120 V	-30 V	C	B	C	B
100 V	-30 V	B	A	B	A

Table 1. Unipolar jumper configuration (L2 = E)

\*With a single supply, the negative output voltage range is reduced from -30 V to -20 V.

In bipolar output mode, the correct positions for the L1 and L2 jumpers are listed in below in Table 2.

In the  $\pm 200$  V mode, the low-noise output (V2) is recommended. See the section on "Stability" for more details.

Output Voltage		Power Supply Voltage			
Max	Min	$\pm 12$ to $\pm 14$ V	$\pm 15$ to $\pm 17$ V	+24 V to 30V	+30 V to 34
200 V	-200 V		D,H		D,H
150 V	-150 V	D,H	C,G	D,H	C,G
100 V	-100 V	B,F	A,F	B,F	A,F

Table 2. Bipolar jumper configuration

The PDM200 can also be used in lower voltage applications; however, the output current may be reduced. The corresponding low-voltage jumper positions are listed below.

Output Voltage		Power Supply Voltage	
Max	Min	$\pm 12$ to $\pm 14$ V	+12 V to 15 V
80 V	-30 V	A,E	
80 V	0 V		D,E
60 V	-60 V		D,H

Table 3. Low voltage jumper configurations

## Output Current

The peak output current is approximately 300 mA and the maximum average output current is approximately

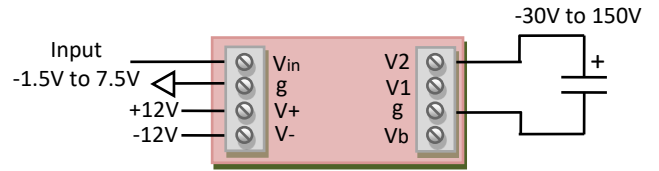
$$I_{av} = \frac{0.45 \times V_s}{V_{out}} - 0.01,$$

where  $V_s$  is the differential supply voltage e.g. 30V, and  $V_{out}$  is the differential output voltage range e.g. 400 V. The average DC current is the average current flowing in either the positive or negative direction. For a sine wave, the average current is related to RMS current by

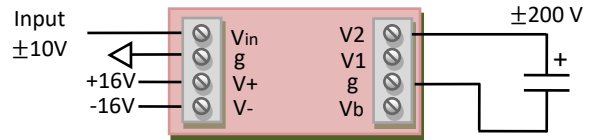
$$I_{av} = \frac{\sqrt{2}}{\pi} I_{rms}.$$

The PDM200 calculator can be used to estimate the maximum input and output current for a given supply voltage and output voltage range. Some common values are tabulated below.

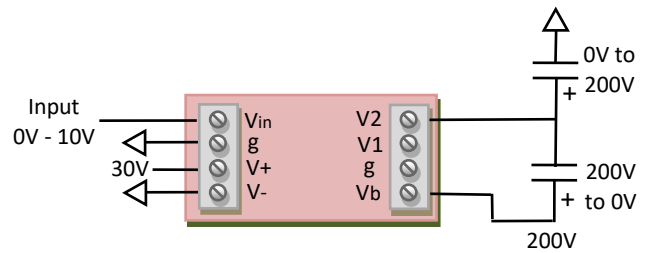
## Example Applications



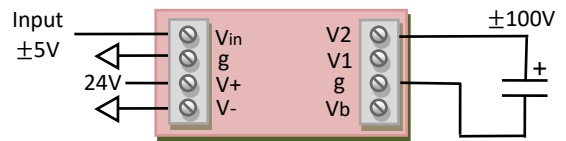
150 V Piezo stack driver. Jumpers in D and E positions.



±200 V Piezo driver. Jumpers in D and H positions.



200 V Three-wire bender driver with bias.  
Jumpers in D and E positions.



±100 V Piezo driver. Jumpers in D and E positions.

Voltage Range	RMS Current	Average Current
-30 V, +150 V	144 mA	65 mA
-30 V, +200 V	108 mA	49 mA
-100 V, +100 V	128 mA	58 mA
-200 V, +200 V	53 mA	24 mA

Table 4. Average output current for ±15V supply

## Supply Current

The maximum supply current is 0.5 A at full load. For a partial load, the supply current is

$$I_{in} = \frac{P_{in}}{V_s},$$

where the required input power is

$$P_{in} = 1.33 V_{out}(0.01 + I_{av}),$$

where  $V_{out}$  is the differential output voltage range and  $I_{av}$  is the average output current.

## Application Notes

The amplifier input  $V_{in}$  should not be left floating as it will drift towards a supply rail. However, in applications where the input may float, a 1 k $\Omega$  resistor (1206 size) can be mounted at the location "Rin", the input impedance is now 1 k $\Omega$ .

## Heat Dissipation

At full power, the worst-case heat dissipation is approximately 15 W which is dissipated by the heatsink and fan.

During normal operation the heat dissipation can be estimated by multiplying the required supply current and the differential supply voltage.

When the heat dissipation is less than 5W, the module fan can be removed. A high-performance passive heatsink is also available (PDM200-Fanless).

Note that the power dissipation in the +/-200V output range is always greater than 5 W so forced air cooling is a requirement.

With the passive cooling option, the thermal impedance of the PDM200 from junction to ambient is approximately 10 °C/W. An air-flow of 100 LFM or greater is required when more than 5 W is dissipated continuously. The PDM200 will shut down when the heat-sink reaches 70 °C

## Power Bandwidth

The maximum frequency with a capacitive load is most easily determined from the online calculator at <https://www.piezodrive.com/modules/pdm200/>.

With a capacitive load, the power bandwidth is limited by the average output current. The maximum frequency sine wave is

$$f_{pwr} = \frac{I_{av}}{V_{L(p-p)}(C_L + 3.9nF)}$$

The power bandwidth for a range of load capacitance values is listed below.

Load (uF)	Peak to Peak Voltage			
	100 V	200 V	300 V	400 V
0.01	67625	17626	8393	4317
0.03	27729	7227	3441	1770
0.1	9047	2358	1123	577
0.3	3093	806	384	197
1	936	244	116	60
3	313	82	39	20
10	94.0	24.5	11.7	6.0
30	31.3	8.2	3.9	2.0

Table 5. Power bandwidth (Hz) for a capacitive load

In the following figures, the maximum peak-to-peak voltage is plotted against frequency for a range of capacitive loads.

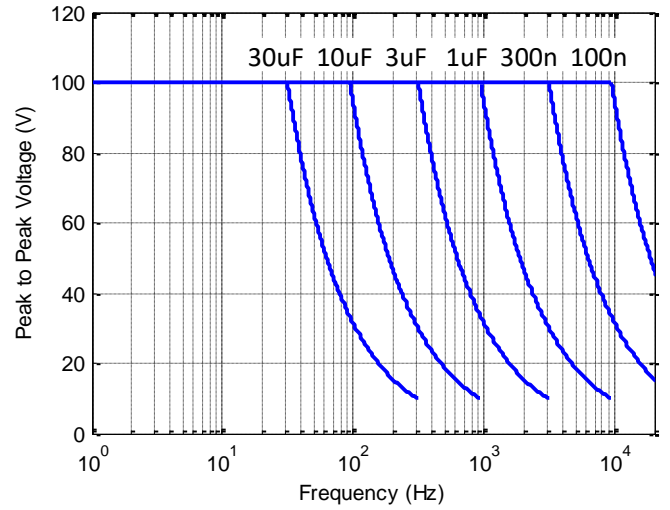


Figure 4. 100 V range power bandwidth

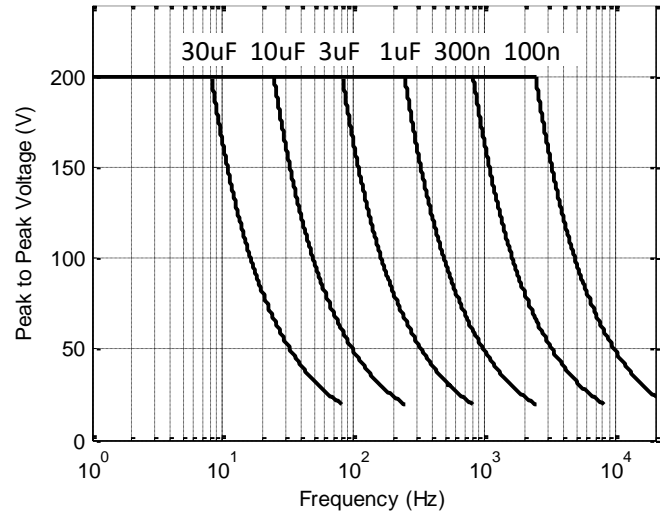


Figure 5. 200 V range power bandwidth

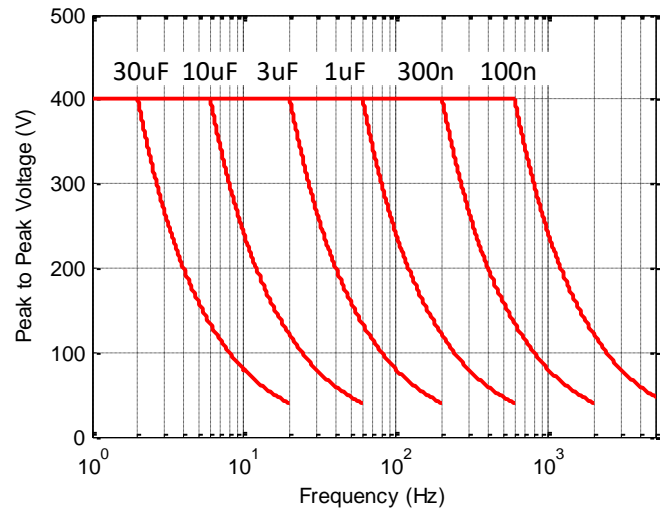


Figure 6. 400 V range power bandwidth

The power bandwidth is primarily related to the average current limit as described above. However, when operating at full range, e.g. ±200 V, with the minimum supply voltage, e.g. ±15 V, the power supply droop can distort the top of a signal. This effect can be reduced by increasing the supply voltage.

## Signal Bandwidth

With a load capacitance greater than 100 nF, the small signal bandwidth is

$$f_{bw} = \frac{1}{63 C_L}$$

With a load capacitance less than 100 nF, the small signal bandwidth is approximately 200 kHz.

The bandwidth of the low noise output (V2) is approximately 5% of the high speed output, that is,

$$f_{bw} = \frac{1}{1445 C_L}$$

The small signal bandwidth for a range of capacitive loads is listed in Table 6.

Load Capacitance	High Speed Bandwidth	Low Noise Bandwidth
10 nF	200 kHz	49 kHz
30 nF	200 kHz	20 kHz
100 nF	158 kHz	6.6 kHz
300 nF	52 kHz	2.3 kHz
1 uF	15 kHz	690 Hz
3 uF	5.2 kHz	230 Hz
10 uF	1.5 kHz	69 Hz
30 uF	530 Hz	23 Hz

Table 6. Small signal bandwidth

## Noise

The output of the PDm200 contains a small amount of switching noise from the boost converter and random noise from the high-voltage amplifier. With a  $\pm 15$  V supply and  $\pm 100$  V output range, the RMS noise is listed in Table 7.

Load Cap	High Speed Output	Low Noise Output
10 nF	4.1 mV*	1 mV*
100 nF	1.3 mV*	0.3 mV*
1 uF	1.3 mV	0.3 mV
10 uF	0.42 mV	0.1 mV

Table 7. RMS noise

For applications requiring extremely low noise, an output resistor resistance can be used to reduce the effective bandwidth, which is approximately

$$f_{bw} = \frac{1}{2\pi RC_L}$$

where  $C_L$  is the load capacitance. The recommended bandwidth is low-noise applications is 100 Hz.

The noise measurements were performed with the input shorted and the fan disabled. The noise may increase

when significant current is drawn from the output due to ripple from the boost converter.

\*For load capacitances of 100nF or smaller, the low-noise output (V2) is recommended.

## Stability

In the  $\pm 200$  V range, oscillation can occur with some load capacitances when the output voltage is very close to the negative rail (-190V). This problem can be eliminated by using the low-noise output (V2). Alternatively, a 330pF 25V 0603 capacitor can be soldered on top of R14 which reduces the bandwidth to approximately 3 kHz and will avoid oscillation. This capacitor can be installed before delivery if necessary.

## Bias Output

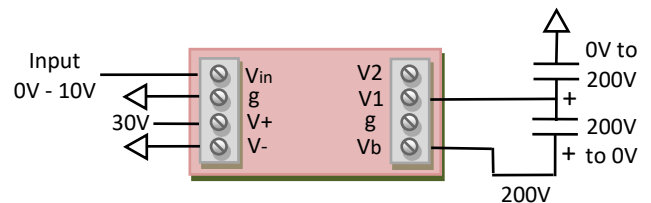
The bias output (Vb) provides a fixed +200 V output for driving 200 V three-wire actuators like benders that require a bias voltage. Actuators that require a  $\pm 100$  V bias can also be driven in this configuration as this is electrically identical.

Lower bias voltages can also be achieved by adding a 1206 resistor to the location "Rb". The resulting bias voltage is

$$V_b = 5 + \frac{196.08 \times R_b}{R_b + 1M\Omega}$$

For example, if  $R_b$  is 2.7 M $\Omega$ ,  $V_b = 148$  V.

The bias output can sink or source an average current of 10 mA. However, there is no protection so care must be taken not to exceed the current limit. If more than 10 mA is required, the primary output of a second PDm200 can be used to generate the bias.



200 V Three-wire bender driver with bias, using D and E jumpers.

## Enable / Shutdown

The Enable pin is a high impedance signal that floats 5V above the negative supply rail. It can be pulled to the negative supply rail to disable the amplifier. The voltage on this pin can also be monitored to check the status of the amplifier. Any monitoring circuit should have an input impedance of greater than 200 k $\Omega$ . A high level voltage on the enable pin indicates a normal status while a low level indicates a thermal shutdown.

The recommended enable circuits for unipolar and bipolar supplies are shown below. Any small signal transistors are suitable, e.g. BC817 and BC807.

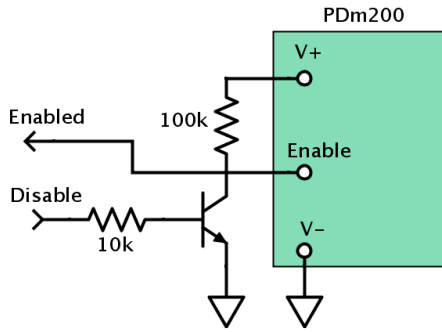


Figure 7. Enable circuit for unipolar supply (V- is grounded)

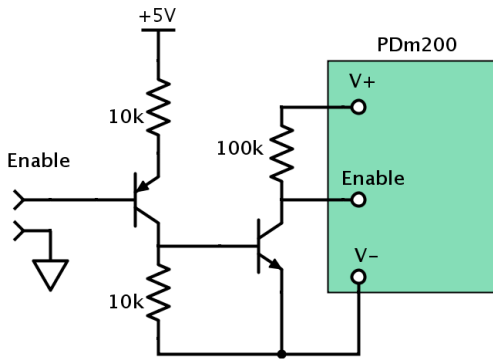


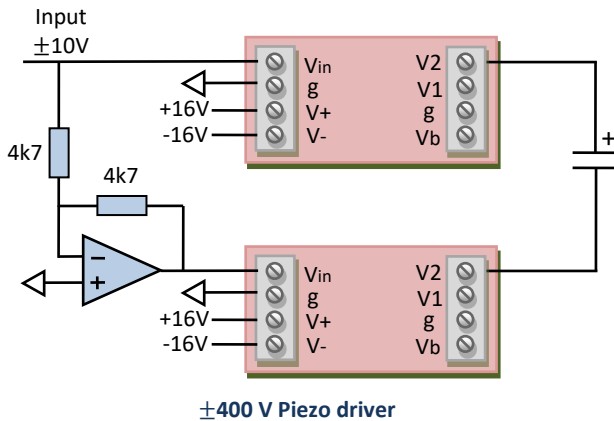
Figure 8. Enable circuit for bipolar supply

## Overload Protection

The PDM200 is protected against over-current and thermal overload. If the PCB temperature exceeds 70 °C the amplifier will be disabled until the temperature reduces.

## Bridge Configuration

The output voltage range can be doubled by driving the load in a bridged configuration as shown below. Both amplifiers should be configured for  $\pm 200V$  operation.



The power bandwidth for this configuration can be calculated by considering only one amplifier and doubling the effective capacitance.

## Safety

This device produces hazardous potentials and should be used by suitably qualified personnel. Do not operate the device when there are exposed conductors.



Parts of the circuit will store charge so precautions must also be taken when the device is not powered

## Dimensions

The mounting posts accept an M2.5 screw. For the PCB mounting version (PDM200-PCB), a schematic and footprint library is available for Altium Designer, contact [info@piezodrive.com](mailto:info@piezodrive.com) to receive the file.

## Warranty

PDM200 devices are tested prior to delivery. There is no warranty period.

## Contact / Support

[info@piezodrive.com](mailto:info@piezodrive.com)

## Revision History

Date	Rev	By	Changes
02/02/23	R5	KB	Updated dimensions
09/01/23	R4	KB	Updated Figure 9
20/11/21	R3	KB	Simplified equation for Vb
16/01/21	R2	KB	Temp range updated

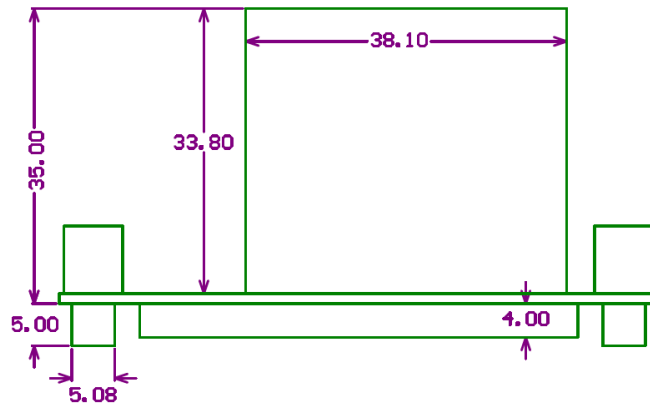
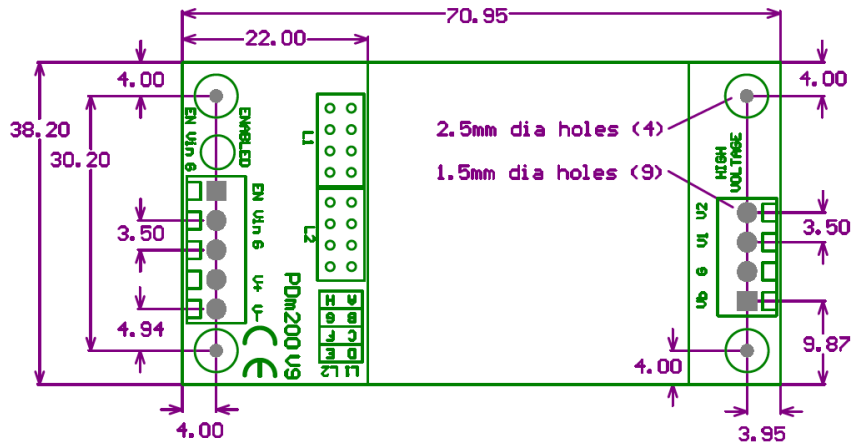


Figure 9. Dimensions (mm)