Micromechatronics Inc.
200 Innovation Blvd., Suite 155 ; State College, PA 16803-6602, USA
Phone: (814) 861-5688 ; Fax: (814) 861-1418. www.mmech.com

PDUS200 200W Ultrasonic Driver

Manual and Specifications

Micromechatronics, Inc.
www.mmech.com

1 Warnings / Notes

1) This device produces hazardous potentials and should only 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

2 Specifications

Electrical	
Frequency	1 to 100 kHz (Pure Sine-wave)
Output Voltage	±100 V
Output Current	±4 A
Transducer Power	200 W
Bandwidth	100 kHz
Slew Rate	35 V/us
Gain	15 V/V
Overload	Thermal and over current protection
Analog Outputs	Voltage and current monitors
Analog Inputs	Signal input (±7.5 V) Auxiliary monitor input (±10 V)
Output Connectors	LEMO 0B Socket 4mm Banana Sockets
Power Supply	90 Vac to 250 Vac

Mechanical	
Environment	-40 to 60°C (-40 to 140°F) Non-condensing humidity
Dimensions	212 x 304.8 x 88 mm
Weight	2 kg

Digital	
USB	USB 2.0
Frequency Resolution	1 mHz
Phase Resolution	0.1 Degrees
Sampling Rate	1 MHz
Available Signals	Voltage, current, auxiliary
Amplifier Shutdown	USB or Digital (Via BNC)

3 Software Manual

3.1 Main Window

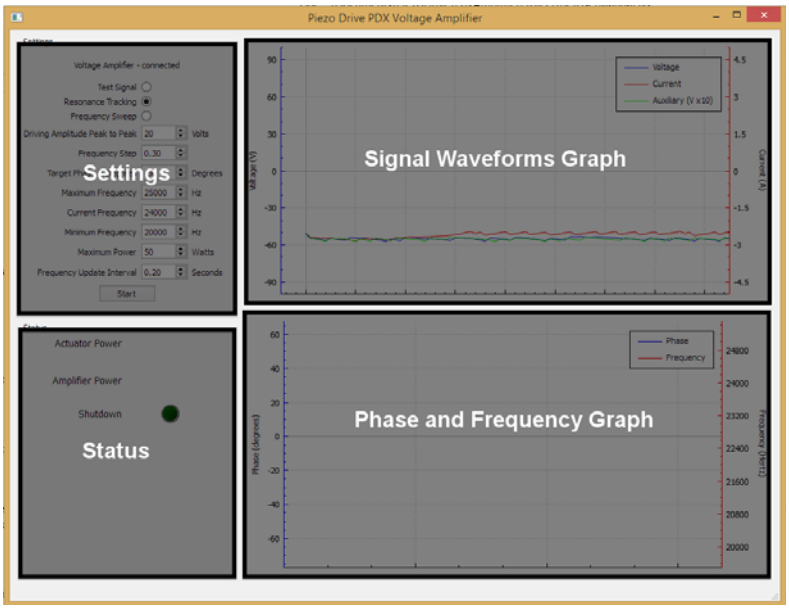


Figure 1. Main software window

The main window is comprised of four sections, the

- Settings control panel,
- Amplifier status panel,
- Signal waveforms graph, and
- Phase and frequency graph.

3.1.1 Overview

The amplifier is controlled by the settings control panel, which is comprised of the mode buttons, the numeric parameters, and the Start/Stop button. The available setting depends on the mode and whether the amplifier is started or stopped.

Most of the settings can be controlled by multiple input methods:

- clicking the controls in the widget
- the up, down, page up, and page down keyboard keys
- the mouse scroll wheel
- numeric text input.

3.1.2 Status

The Status section of the Main Window reports the power being dissipated by the actuator and the amplifier, and the amplifier shutdown indicator.

Actuator Power

The Actuator Power is calculated by

$$P_{act} = \frac{1}{N}\sum_{n=0}^{N}(v_n - V_{av}) \times (i_n - I_{av})$$

where v_n and i_n are the samples of voltage and current and V_{av} and I_{av} are the average (DC) values. N is chosen to include an integer number of the waveform periods.

The amplifier power is calculated by

$$P_{amp} = P_{total} - P_{act}$$

where P_{total} is

$$P_{total} = V_s \times I_s$$

where V_s is the total supply voltage (200V) and I_s is supply current which is calculated by averaging the rectified output current

$$I_s = \frac{1}{N}\sum_{n=0}^{N} |i_n|$$

Shutdown

The shutdown indicator is activated when the amplifier has entered a shutdown state due to a current overload or when the temperature of the amplifier exceeds 100 ºC (212 ºF). In the shutdown state, the amplifier output is switched to high-impedance.

3.2 Plot Windows

The user can interact with the plot windows with a number of controls.

3.2.1 Graph Scale

The scale of an axis can be controlled by clicking it then moving the mouse scroll wheel. The limits of the axis can also be adjusted by clicking and dragging. To de-select an axis, the user can left-click on the graph area. The graphs auto-scale by default but this is disabled once the user has made a manual adjustment. To re-enable autoscaling the user can double click the axis to enable auto-scaling.

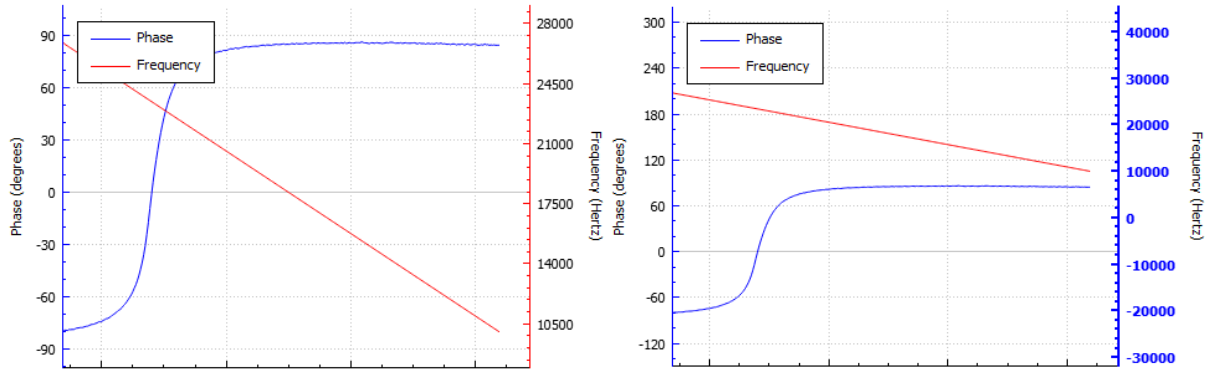


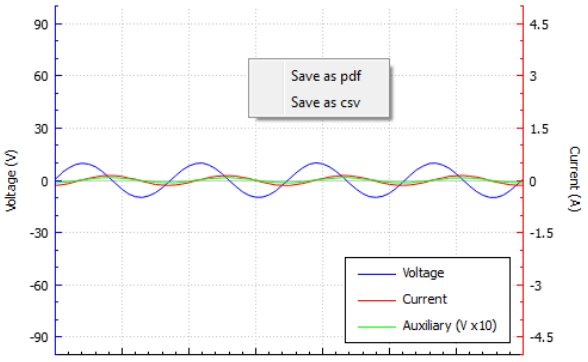
Figure 2. An example where the scale and offset of the phase and frequency plot is manually controlled

3.2.2 Legend Position

To adjust the legend position, right-click the legend and select a new position.

3.2.3 Exporting Graph Data

To export a graph, right-click the graph area select either 'Save as PDF' or 'Save as CSV', then select the file location.



3.2.4 Notes on Graph Functions

- The x-axis of the Phase and Frequency graph is fixed and cannot be selected or adjusted.
- Auto-scaling is not disabled for the Actuator Impedance or Auxiliary Transfer Function graphs while the sweep is active. The graph is auto-scaled until the sweep is complete.

3.3 Test Signal Mode

The amplifier operates in Test Signal mode when the Test Signal button is selected. In this mode the amplifier generates a sine wave output with the amplitude and frequency set in the settings control panel. The controls that are available in this mode are:

- **Driving Amplitude Peak to Peak** controls the peak-to-peak voltage of the drive signal. It can take integer values between 0V and 200V.

- **Maximum Frequency** controls the frequency limits of the Current Frequency and can be set between the Minimum Frequency and 100 kHz. If this value is adjusted below the Current Frequency, the Current Frequency is adjusted to comply with the Maximum Frequency setting.

- **Current Frequency** can be set to an integer value between the Minimum Frequency and Maximum Frequency.

- **Minimum Frequency** can be set to an integer value between 1 kHz and the Maximum Frequency. If this value is adjusted above the Current Frequency, the Current Frequency is adjusted to comply with the Minimum Frequency.

- **Maximum Power.** If the power dissipated in the actuator is greater than this value, the actuator power reading in the status panel changes to bold red text to alert the user.

- **Start/Stop button.** Enables/disables the signal generator.

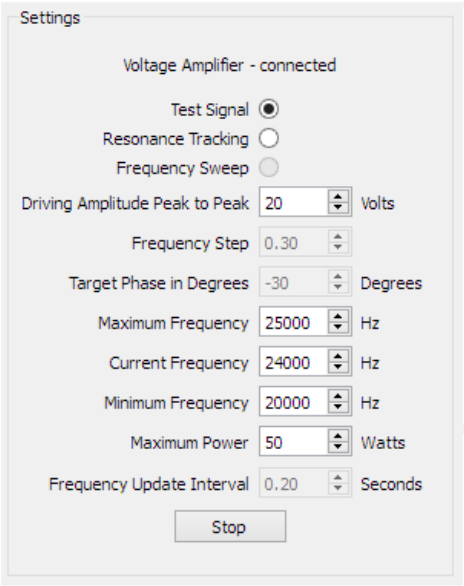


Figure 3. The settings control panel

The above settings can be adjusted whether the amplifier is stopped or started. The user can also switch between Test Signal and Resonance Tracking when the amplifier is stopped or started.

3.4 Resonance Tracking Mode

In this mode the amplifier adjusts the frequency of the drive voltage to maintain a target phase between the drive voltage and drive current. All of the controls described above are available in resonance tracking mode, with the addition of:

- **Frequency Step** controls the rate of change in the frequency adjustment. The next frequency is calculated by

$$f_{k+1} = f_k + \text{Freq. Step} \times (\text{Target Phase} - \text{Current Phase})$$

  High values of Frequency Step cause the drive frequency to adjust more quickly but may be less stable. The Frequency Step can be set between 0.01 and 10.0.

- **Target Phase** of the current relative to the drive voltage. This is equivalent to the phase of the admittance, which is the inverse of impedance. Negative values indicate a current lag (inductive), and positive values indicate a current lead (capacitive)

- **Frequency Update Interval** sets the minimum amount of time that the amplifier will wait between frequency updates. Longer intervals allow the transient response to settle before the next phase measurement, at the expense of update rate.

3.5 Frequency Sweep Mode

In the frequency sweep mode, the impedance of the transducer is measured from the set Minimum to Maximum frequency. Since many ultrasonic actuators exhibit a non-linear resonance at high-power, the frequency is swept in both directions. 500 points are recorded in both directions, therefore the resolution is controlled by the Maximum and Minimum Frequency. During the frequency sweep, there is a fixed 200ms delay between measurements to allow for the decay of transients between frequency changes, this results in 5 measurements per second and a total sweep time of 200 seconds.

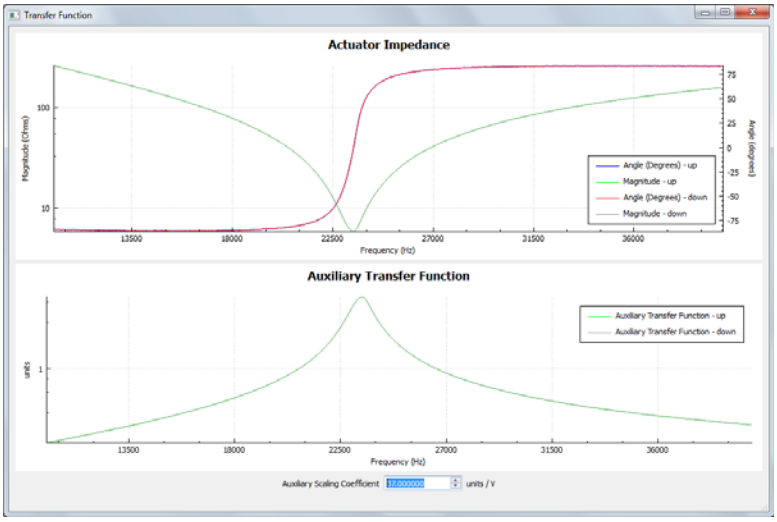


Figure 4. The frequency sweep window

In the Frequency Sweep mode, the available controls are:

- **Driving Amplitude Peak to Peak**
- **Maximum Frequency**
- **Minimum Frequency**
- **Start/Stop button**.

In addition to the impedance measurement, the transfer function between the voltage and an auxiliary signal can also be measured simultaneously by applying the auxiliary signal to the front panel. Typical signals include the acceleration, velocity, or displacement. A scaling coefficient is available below the Auxiliary Transfer Function plot which allows the vertical scale to be equated to the sensor gain.

3.5.1 Dynamic Range

The dynamic range of the frequency response measurement is 12-bit relative to the full-scale range of the current measurement, which is ± 5 Amps. Therefore, the minimum detectable current is ± 3 mA. Furthermore, in order to allow grounded transducers, the internal current measurement is performed on the “high-side” of the load which is subject to a large common-mode signal. The common-mode rejection ratio of the current measurement is approximately -80 dB at 100 kHz. This may also limit the detection of small currents when large voltages and high frequencies are encountered.

Due to the limited dynamic range, the PDUS200 will not accurately measure anti-resonances in the impedance transfer function where very little current is flowing. Precise measurement of the system anti-resonances is best performed using a shunt resistor to ground and a dedicated spectrum, or network analyzer.

The minimum detectable signal in the auxiliary transfer function is ± 5 mV.

4 Hardware Manual

4.1 Output Connection Diagram

The actuator can be connected to the amplifier by either two 4mm banana plugs or a 2-way LEMO 0B socket (LEMO EGG.0B.302.CLL). Preassembled LEMO cable assemblies are available from www.mmech.com

The mating plug is a LEMO 0B 2-Way Straight Cable Plug. Ordering details and specifications are listed below. These parts can be obtained directly from www.mouser.com

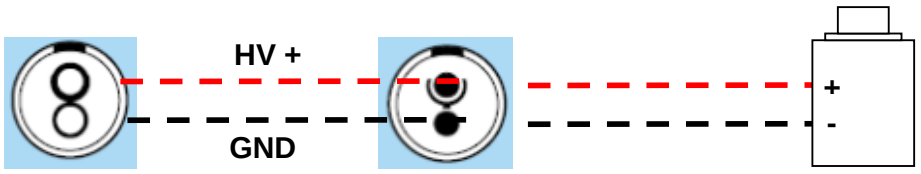
Plug	LEMO 0B 2-Way Straight Cable Plug
Crimp Terminal Version	*LEMO FGG.0B.302.CYCZ
Solder Tag Version	LEMO FGG.0B.302.CLAZ
Max Conductor Size	AWG22
Cable Collet	FGG.0B.742.DN
Cable Diameter	3.1mm – 4mm
Strain Relief Boot	GMA.0B.035.DN (3.5–3.9mm Cable)

*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.

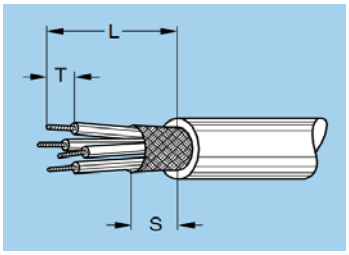
Cable	Belden 8451
Conductor Size	AWG22 (0.64mm diameter)
Resistance	53 mOhms/m
Capacitance	115 pF/m core–core, 220 pF/m core-shield
Outside Diameter	3.5mm

The actuator wiring diagram is shown below.



4.1.1 LEMO Plug Cable Preparation

(Taken from LEMO 0B Series Cable Assembly Instructions)

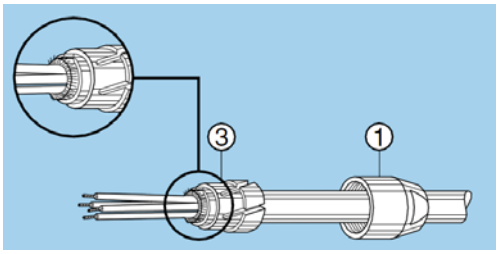


Solder			Crimp		
L	S	T	L	S	T
13.0	7	3.0	17.0	7	4.0

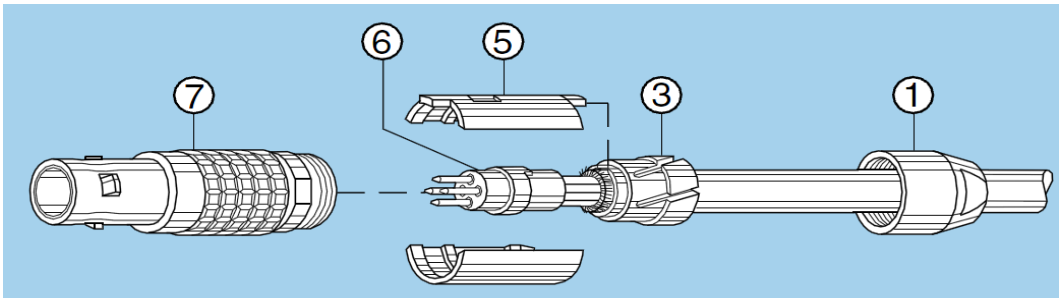
4.1.2 LEMO Plug Assembly

(Taken from LEMO B 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,



4.2 Overload Protection

4.2.1 Shutdown Indicator

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.

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

4.2.2 External Shutdown

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.

4.3 Enclosure

The PDUS200 Driver 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 above.

The PDUS200 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.