PiezoDrive

PDUS210
210 Watt Ultrasonic Driver

Contents

Safety Warnings

High Voltage

This product produces potentially lethal voltages up to 282 Vrms.

Observe Low-Voltage (as per ANSI C84.1-1989) safety precautions, e.g.

- Use an observer trained in low-voltage rescue
- Do not operate with exposed conductors
- Use appropriate signage, etc.

Revision History

Date	Manual	Changes
06/05/2021	R9	Added unipolar output options
06/02/2020	R8	Added recommended impedance range
31/10/2020	R7	Added support for external transformers Minimum frequency changed to 6 kHz Added frequency range specifications Added 175V version
15/01/2020	R6	Added notes to "Standard Output Voltage Ranges"

Quick Start Recommendations

Most users will need to read the following sections in detail to gain an understanding of transducer characteristics and the various operating modes. That is, read the following sections in order.

If you already have expert knowledge of ultrasonic transducers and their different operating modes, go straight to the [Desktop Software](#).

Delivery Contents (Standard)

- PDUS210 Amplifier (in chosen configuration)
- Handheld controller
- Handheld controller cable (DSUB9 3ft)
- 280W Desktop power supply
- IEC Power cable suited to the destination shipping address
- USB Cable (Type A)
- 3 Way plug-in screw terminals for output (Amphenol TJ0331530000G)
- 4 Way plug-in screw terminal for RS-485 connector (Amphenol TJ0431530000G)

Overview

The PDUS210 is a complete solution for driving precision and high-power ultrasonic actuators. Functions include high-speed resonance tracking of both series or parallel resonance modes, vibration amplitude control, and analysis functions such as impedance and frequency response measurement. The PDUS210 is well suited to both OEM product integration and laboratory use for research and development. Applications include ultrasonic drilling and cutting, medical devices, dental devices, ultrasonic testing, liquid cavitation, and vaporization.

The PDUS210 is controlled via USB and the included software package. An RS485 interface also provides a straight-forward method to control and monitor the amplifier for automatic test and OEM applications.

The PDUS210 generates a pure sine-wave output which avoids the excitation of secondary resonance modes by the drive harmonics. This makes it ideal for operating at the electrical parallel resonance, or 'anti-resonance'. This operating point is close to the mechanical resonance frequency but is less sensitive to changes in load dissipation, which is useful in precision machining applications where constant vibration amplitude is desired.

The PDUS210 is available with standard output voltage ranges from 17 Vrms to 282 Vrms, and current ranges from 0.7 Arms to 11 Arms. These ranges are optimized for load impedances ranging from 1.5 Ohms to 400 Ohms at resonance. For research and development applications, a reconfigurable version is available (PDUS210-FLEX), this version uses external output matching transformers to allow operation at any of the available output voltage ranges.

Electrical Specifications

Specification	Value	Notes
Output Voltage	0 – 800 Vp-p	See standard voltage ranges
Output Current Max	0 – 32 Ap-p	See standard voltage ranges
Load Impedance	1Ω – 5 kΩ	See standard voltage ranges
Output Waveform	Sine wave	
DC Output Voltage	Zero	DC offset possible
Output Isolation	Isolated output	Grounded is also possible
Max Output Power	210 W	With optimal load impedance
Internal Power Dissipation	130 W	Maximum
Frequency Range	See table below	6kHz to 500kHz with modifications
Power Supply	48 V, 280 Watt	
Controller	Phase tracking and power control	2ms frequency update rate Resonance or anti-resonance
Interface	USB, RS485	
Digital IO	4 DIO	For manual control

Standard Output Voltage Ranges

The following table lists the specifications of each model variant, including: the maximum output voltage, the maximum output current, optimal load impedance and the recommended frequency range.

Order Code	Voltage pk-pk	Voltage RMS	Amps pk-pk	Amps RMS	Optimal Load Ohms	Load Range Ohms*	Frequency kHz
PDUS210-800	800	282	2	0.71	400	260 – 840	20 – 200
PDUS210-600	600	212	2.6	0.92	225	146 – 472	20 – 200
PDUS210-400	400	141	4	1.4	100	65 – 210	20 – 200
PDUS210-200	200	70	8	2.8	25	16 – 52	20 – 200
PDUS210-175	175	62	9.1	3.2	19.1	12 – 40	10 - 100
PDUS210-100	100	35	16	5.7	6.25	4 – 13	20 – 200
PDUS210-50	50	17	32	11.3	1.56	1 - 3	20 – 200

Note: The output voltage resolution and tolerance is 8 bits, or 256 levels. Therefore, the smallest possible change in voltage is full-scale range / 256. The minimum output voltage is also limited by resolution. When the amplifier is enabled and the output voltage is set to zero volts, the actual output voltage may be up to 2% of the full-scale range.

* The load impedance range is the range of impedances which guarantee more than 100W of power supplied to the load. Higher or lower impedances can be driven but with reduced power.

The relationship between maximum achievable power and the load impedance is plotted in the following figure. In this plot, the impedance is normalized by the optimal impedance; that is,

$$Z_{norm} = \frac{Z_{Load}}{Z_{opt}}$$

For example, the optimal impedance of the PDUS210-400 is 100 Ohms, so with a 50 Ohm load, the normalized impedance is 0.5, From the plot, it can observed that greater than 100 W can be achieved with a normalized impedance from 0.65 to 2.1, which for the PDUS210-400, is 65 Ohms to 210 Ohms.
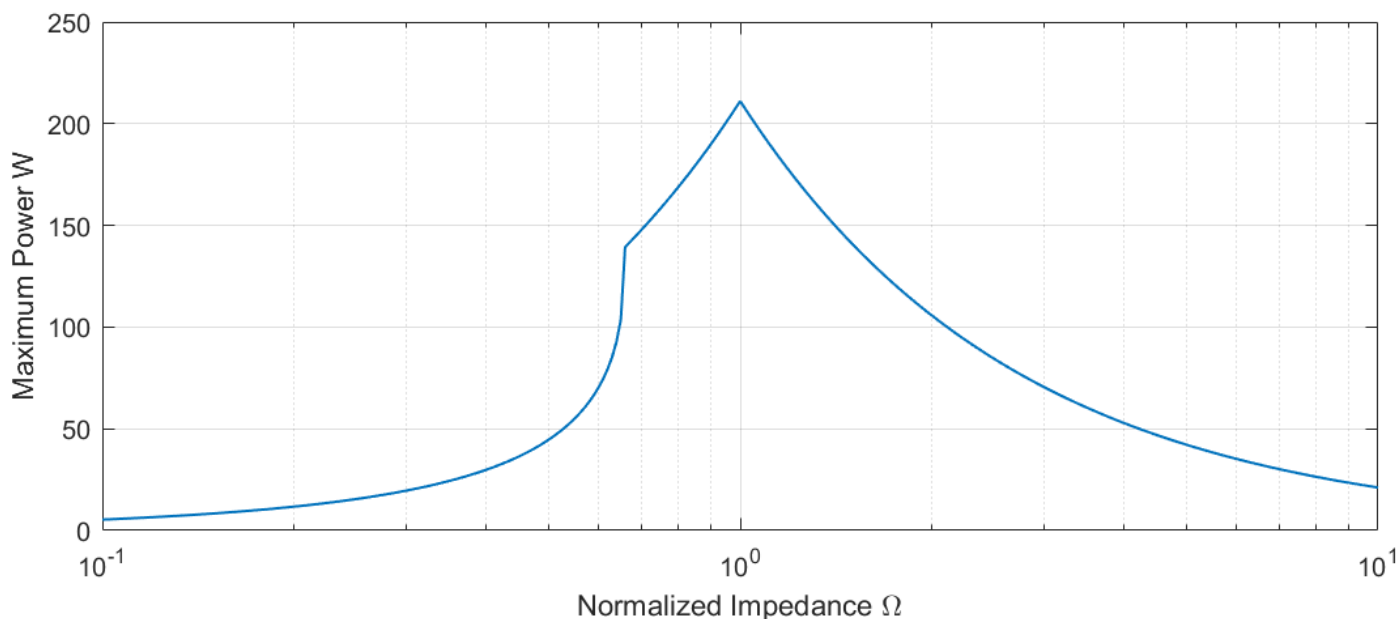

Figure 1. Maximum output power versus normalized impedance

The impedance ranges for other common power levels are listed in the following table. For example, all amplifiers will supply more than 150W with a normalized load impedance between 0.71 and 1.4. For the PDUS210-400, this is equivalent to 71 Ohms and 140 Ohms.

Minimum Power	Z_{Load} Lower Bound	Z_{Load} Upper Bound
150W	$0.71 \times Z_{opt}$	$1.4 \times Z_{opt}$
100W	$0.65 \times Z_{opt}$	$2.1 \times Z_{opt}$
50W	$0.53 \times Z_{opt}$	$4.2 \times Z_{opt}$

Table 1. Minimum achievable power versus load impedance.

Unipolar Output Voltage

The output voltage of a standard PDUS210 or TX210 device is bipolar. For example, the maximum output voltage of the PDUS210-200 or TX210-200 is +/-100V. The PDUS210 and TX210 can also be configured with a positive or negative unipolar output range using the order code suffix –UnipolarPositive or –UnipolarNegative. For example, the order code PDUS210-200-UnipolarPositive or TX210-200-UnipolarPositive would result in a maximum output voltage range of 0V to +200V, as shown in Figure 2.

The unipolar option adds a DC offset voltage which is equal to half the signal amplitude; therefore, the resulting voltage is always between zero volts and the chosen amplitude, as shown in Figure 2. Compared to a fixed DC offset voltage, this approach minimizes the average DC voltage, which improves transducer lifetime.

Since the output of the standard PDUS210 and TX210 is electrically isolated, the polarity of the offset voltage can be inverted by reversing the connection of the transducer to the amplifier or transformer. In other words, except for very specific applications where the phase of the output voltage is important, the –UnipolarPositive option can be used to create both positive and negative offset voltages by reversing the polarity of the transducer connection.
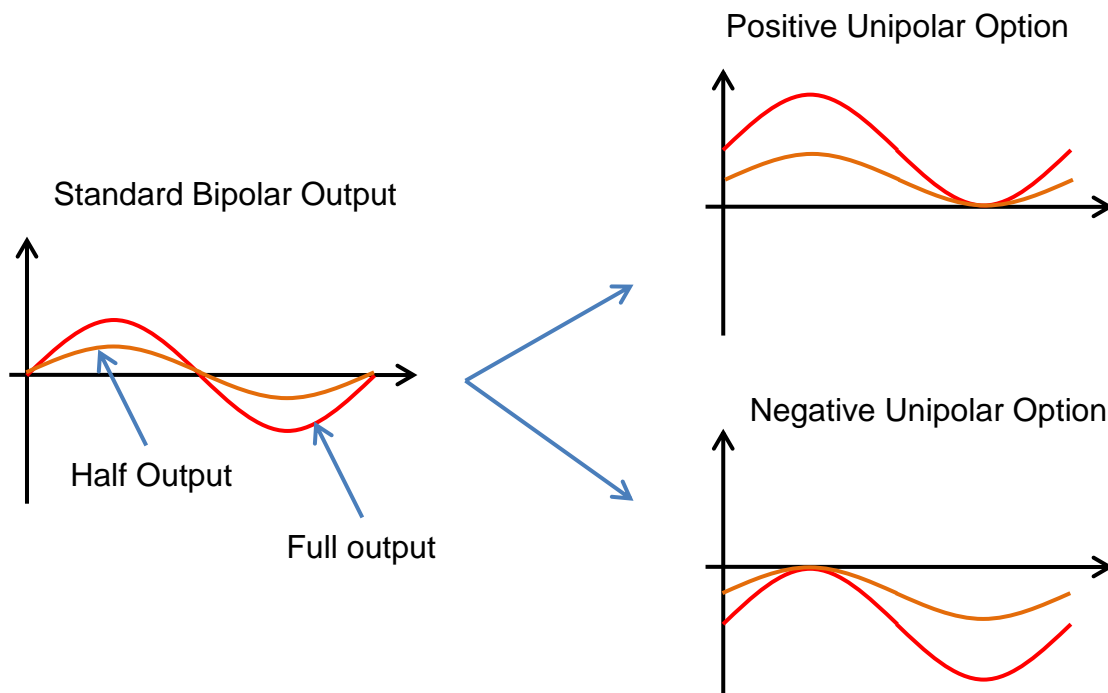
Figure 2 Comparison of standard bipolar output voltage and unipolar output options.

Mechanical Specifications

Specification	Value	Notes
Enclosure Dimensions	227 x 168 x 54 mm	L x W x H
Mass	1.4 kg	
Temperature Range	0C - 50C	
Humidity	Non-condensing	

PDUS210-FLEX Specifications

The PDUS210-FLEX is identical to the standard PDUS210 except that it requires an external transformer connected between the amplifier and transducer using the supplied cable. This allows the user to switch between different output voltage ranges by changing the external transformer. Please refer to PDUS210-FLEX Operation for instructions.

The PDUS210-FLEX must be purchased with at least one external transformer. The default output configuration is electrically isolated with a bipolar voltage. Refer to Unipolar Output Voltage for other options. The available part numbers and specifications are:

Order Code	Turns Ratio	Voltage pk-pk	Voltage RMS	Amps pk-pk	Amps RMS	Optimal Load Ohms	Load Range Ohms*	Frequency kHz
TX210-800	18.18	800	282	2	0.71	400	260 – 840	20 – 200
TX210-600	13.64	600	212	2.6	0.92	225	146 – 472	20 – 200
TX210-400	9.09	400	141	4	1.4	100	65 – 210	20 – 200
TX210-200	4.55	200	70	8	2.8	25	16 – 52	20 – 200
TX210-175	3.98	175	62	9.1	3.2	19.1	12 – 40	10 - 100
TX210-100	2.27	100	35	16	5.7	6.25	4 – 13	20 – 200
TX210-50	1.14	50	17	32	11.3	1.56	1 - 3	20 – 200

Table 2. External transformer specifications (only for the PDUS210-Flex)

A kit containing six transformers ranging from 17Vrms to 282Vrms is also available (TX210-Kit1). This includes the following output voltage ranges: 17, 35, 70, 141, 212, and 282 Vrms.

Figure 3. Output transformer (e.g. TX210-800)

Specification	Value	Notes
Input Connector	Plug-in screw terminal	Connecting cable supplied
Output Connectors	Identical to PDUS210	See Front Panel
Transformer Dimensions	104 x 57 x 51 mm	L x W x H
Mass	0.2 kg	

Table 3. External transformer mechanical specifications

Introduction to Ultrasonic Transducers

An introduction to the behaviour and operation of ultrasonic transducers can be viewed at the following link. Please familiarize yourself with these concepts before operating the PDUS210.

- https://www.piezodrive.com/ultrasonic-drivers/intro-ultrasonic/

The most important concept to understand is the relationship between the electrical and mechanical impedance response of a transducer. Figure 4 plots the mechanical and electrical frequency response of an ultrasonic transducer.

The impedance minima at f_s is known as the series resonance, which is approximately equal to the mechanical resonance frequency. At this frequency, the impedance phase response has a high positive slope and a value of approximately zero degrees. In this mode, the current is approximately proportional to the vibration amplitude, so current control is used to maintain constant vibration amplitude. If the mechanical load does not vary significantly, constant voltage amplitude is also appropriate.

The impedance maxima at f_p is known as the parallel resonance, which also has an electrical phase of approximately zero degrees but a high negative slope. In this mode, the voltage is approximately proportional to the vibration amplitude, so constant voltage results in approximately constant vibration amplitude regardless of mechanical load variations.
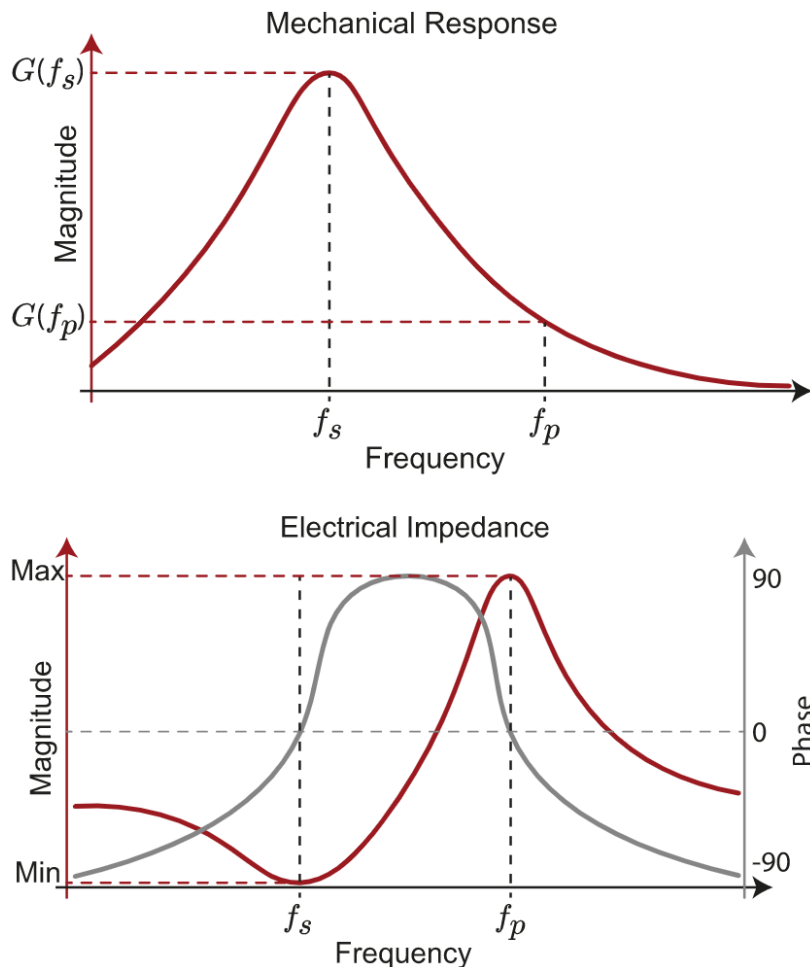

Figure 4. Electrical and mechanical frequency response of an ultrasonic transducer

PDUS210 Operation

Overview

The operating principle of the PDUS210 is summarized in Figure 5. The transducer is connected on the right hand side to the output transformer. The transformer converts the internal +/-24V drive voltage to the desired output voltage range, for example +/-200V. By default, the output connection to the transducer is electrically isolated from ground but the negative output can also be internally grounded using the jumper shown.

During operation, the voltage and current in the transducer is used to estimate the phase θ. The measured phase is then used to control the frequency of the signal generator by comparing it to the phase set point θ_{ref}. The frequency controller stabilizes the feedback loop and controls the settling time of the closed loop system. The feedback gain is normally determined experimentally by slowly increasing the gain until the desired performance is reached or the response begins to become unstable.

The signal generator has a variable amplitude and the frequency is normally controlled by the phase control loop. It is connected to the power amplifier, which drives the output transformer and transducer.
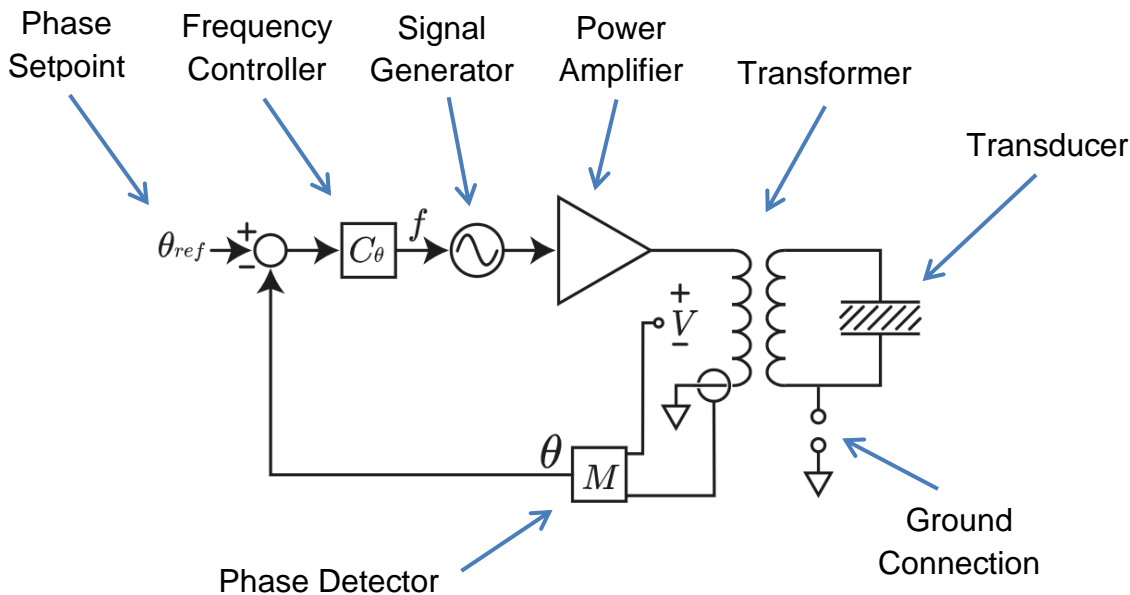

Figure 5. Internal PDUS210 operation (in constant voltage, resonance tracking mode).

Resonance Tracking

The resonance tracking system of the PDUS210 is illustrated Figure 4. The phase detector (M) measures the impedance phase angle between the primary voltage and current. The phase controller $C_\theta(s)$ varies the drive frequency to maintain a constant phase set point θ_{ref}, which is usually equal to zero.

To operate at a <u>series resonance</u> (impedance minima), the <u>phase controller gain must be positive</u> to create a stable operating point.

To operate at a <u>parallel resonance</u> (impedance maxima), the <u>phase controller gain must be negative</u> to create a stable operating point.

Applications with high losses, i.e. low quality factor, may have a non-zero impedance phase angle at resonance, e.g. 45 degrees. In such cases, an impedance response should be performed first, to identify the desired operating phase that corresponds to the desired mechanical resonance.

Control of Vibration Amplitude

Power ultrasonic applications can be categorized as either constant mechanical load, or variable mechanical load. The requirements for both of these cases are described in the following.

Constant Mechanical Load

Constant load applications are the simplest case and include, for example, ultrasonic cleaners, ultrasonic mixers, and any other application where the mechanical load does not vary significantly. These applications can be operated with constant voltage at either the series or parallel resonance.

Variable Mechanical Load

Applications with variable mechanical load include ultrasonic drills and cutters where the mechanical load conditions are variable during operation. These applications generally require some form of amplitude control in order to: 1) maintain vibration amplitude when the mechanical load dissipation increases; and 2) to avoid vibration amplitude increasing when the mechanical load dissipation is removed.

To achieve approximately constant vibration amplitude, a transducer can be driven with constant voltage at the parallel resonance frequency, or constant current at the series resonance frequency.

Constant voltage is the natural operating mode of the PDUS210 but constant current can also be achieved by enabling the current tracking mode. The operation of current tracking mode is illustrated in Figure 6. Current tracking mode has the same frequency control loop as Figure 5 but it also has an additional feedback loop that varies the voltage to maintain a constant load current. The current set point is I_{ref} and the controller is C_I.

Current tracking mode is most useful for achieving constant vibration amplitude in transducers operated at the series resonance mode (impedance minima).
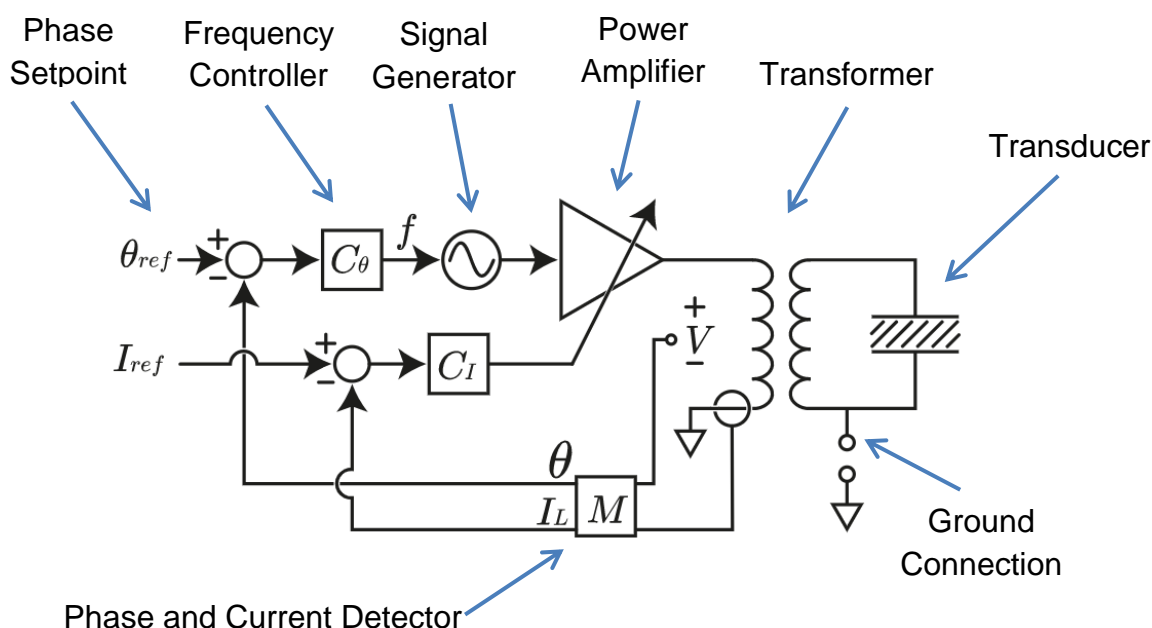

Figure 6. Phase and current control loop in the PDUS210 driver.

Power Control

When operating with constant voltage or current, a limit can be set on the maximum power dissipation in the load. This power is the sum of dissipation in the mechanical load and the transducer itself.

In some applications, such as welding, it may be preferable to control the dissipated power rather than the vibration amplitude. The PDUS210 has a power control function that varies the voltage to maintain a constant power dissipation in the load. As shown in the Figure 7, the power control loop includes the power measurement P which is compared to the power set-point P_{ref}. The gain of the controller P_{ref} is tuned experimentally to provide a fast transient response and stability.
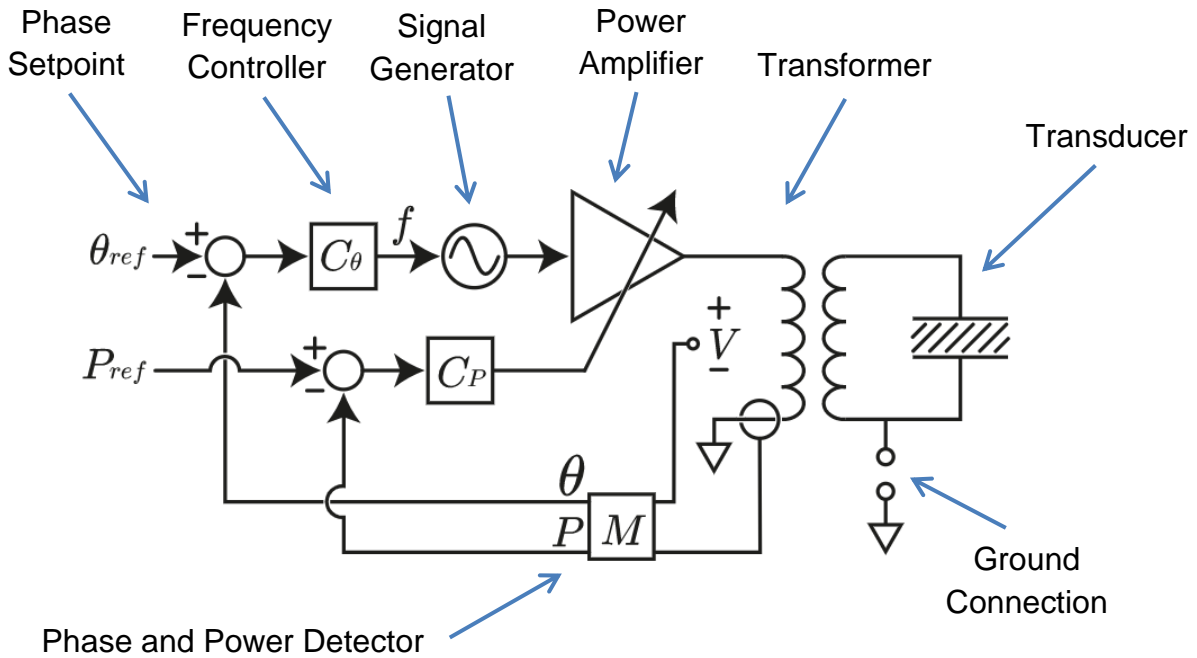

Figure 7. Phase and power control loop in the PDUS210 driver.

Choosing the Voltage Range

The PDUS210 is available in voltage ranges from 17 Vrms to 282 Vrms, which suit load load impedances ranging from 1.5 Ω to greater than 400 Ω. The optimal choice is determined by the transducer impedance at resonance, and the choice of series or parallel resonance. If the load impedance is unknown, or a range of load impedances are expected, the PDUS210-Flex configuration is recommended with the transformer kit (TX210-Kit1), please refer to PDUS210-FLEX Specifications.

The first step is to measure the impedance of the transducer at the series and parallel resonance. This can be performed with an impedance analyser or simply a signal generator and oscilloscope. If possible, these tests should be performed at moderate power with both minimum and maximum load conditions, i.e. using a PDUS210 driver. Fill out the values in the table below:

	Unloaded	Fully Loaded
Series Resonance	$R_{1,min}$:	$R_{1,max}$:
Parallel Resonance	$R_{2,max}$:	$R_{2,min}$:

Table 4. Operating impedance at resonance

Series Resonance

For operation at the series resonance, the most suitable amplifier has an optimal impedance which is close to, or slightly greater than the fully loaded impedance. Since transducer impedance tends to increase with applied power, an amplifier with a higher optimal impedance is recommended. If the amplifier has a higher optimal impedance than the load, the current limit will be reached before the voltage limit, and the maximum achievable output power is:

$$P = I_{rms}^2 R_{1,max}$$

where I_{rms} is the maximum driver current.

Parallel Resonance

For operation at the parallel resonance, the most suitable amplifier has an optimal impedance which is close to, or slightly less than the fully loaded impedance. Since transducer impedance tends to reduce with applied power, an amplifier with a lower optimal impedance is recommended. If the amplifier has a lower optimal impedance than the load, the voltage limit will be reached before the current limit, and the maximum achievable output power is:
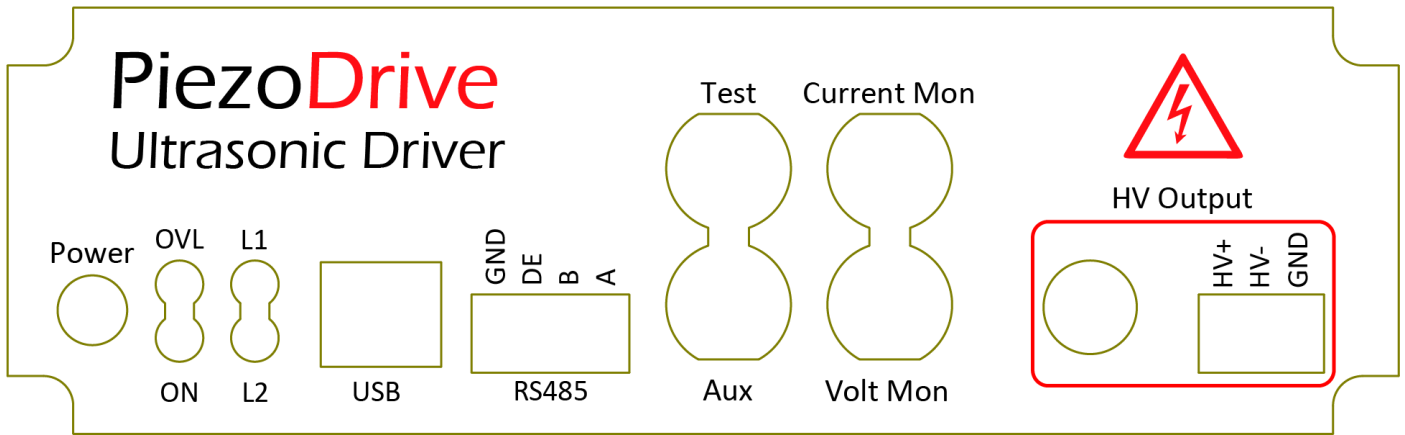
$$P = \frac{V_{rms}^2}{R_{2,min}}$$

where V_{rms} is the maximum driver voltage.

Custom Voltage Range

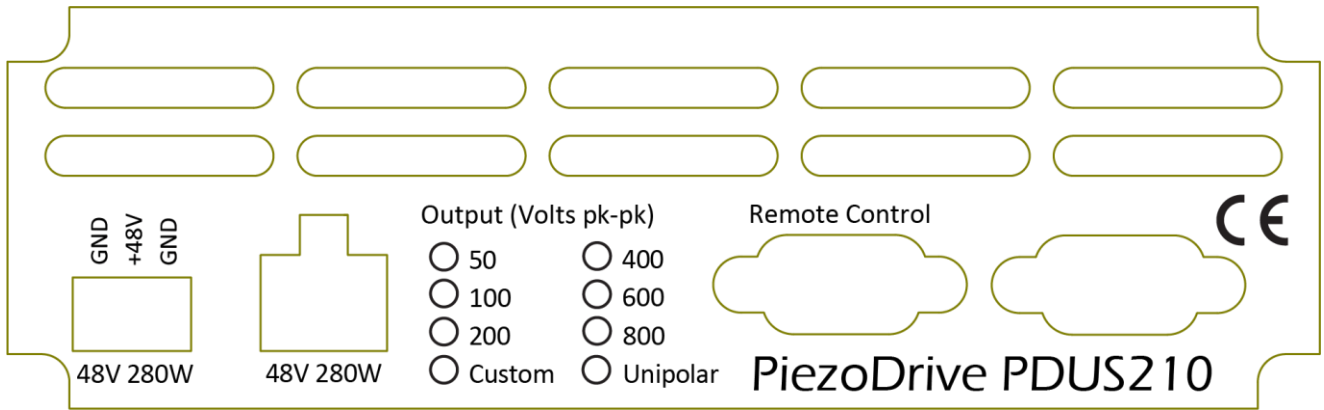Custom voltage ranges and optimal impedances are available to provide maximum power for a specific transducer.

Front Panel

Label	Function
ON	Power indicator
OVL	Indicates an overload or shutdown state, see overload protection
USB	USB 2.0 Type-B device connector
L1	Uncommitted LED indicator
L2	USB Activity indicator
RS485	Isolated RS485 interface, suits Amphenol TJ0431530000G connector GND is the isolated ground.
Test	+/-4V Input produces full-range output voltage. Test use only.
Aux	Connected to ADC converter, not presently used
Current Mon	Output current monitor, AC coupled. The gain is $0.00264 \times V_{pp}$ V/A
Volt Mon	Output voltage monitor, AC coupled. The gain is $5.06/V_{pp}$ V/V
LEMO HV Output	Suits LEMO 0B.302 Connector (e.g. FGG.0B.302.CLAD42)
Screw HV Output	Suits Amphenol TJ0331530000G connector

The sensitivity of the current and voltage monitors are determined by the peak-to-peak output voltage range. For example, the peak-to-peak output voltage range of the PDUS210-400 is 400 V, so the current gain is 1.056 V/A, and the voltage gain is 0.01265 V/V.

Rear Panel

Label	Function
48V 280W	Suits Amphenol TJ0331530000G Connector
48V 280W	Suits 6-Pin power connector for Meanwell GST280A48-C6P
Remote Control	Refer to Handheld Controller

Overload Protection

There are three types of overload protection:

Hardware Overload

This overload is triggered when the current to the power amplifier exceeds 5.7 Amps average. When triggered, the power amplifier is shutdown, causing the 'Overload' front panel LED to illuminate. To restart the amplifier, an enable command is required.

At power-on, the power amplifier is shutdown by default and requires an enable command to start.

Load Power Dissipation Overload

This overload is triggered when the real power dissipated by the load exceeds the threshold defined in the user interface. An enable command is required to clear this overload.

Amplifier Power Dissipation Overload

This overload is triggered when the real power dissipated by the amplifier exceeds 130 Watts. An enable command is required to clear this overload. Triggering this overload usually means that the load impedance is poorly matched to the output voltage and current range of the amplifier.

Thermal Overload

This overload is triggered when the heatsink temperature exceeds 70C. An enable command is required to clear this overload. Check the fan and heatsink for blockages.
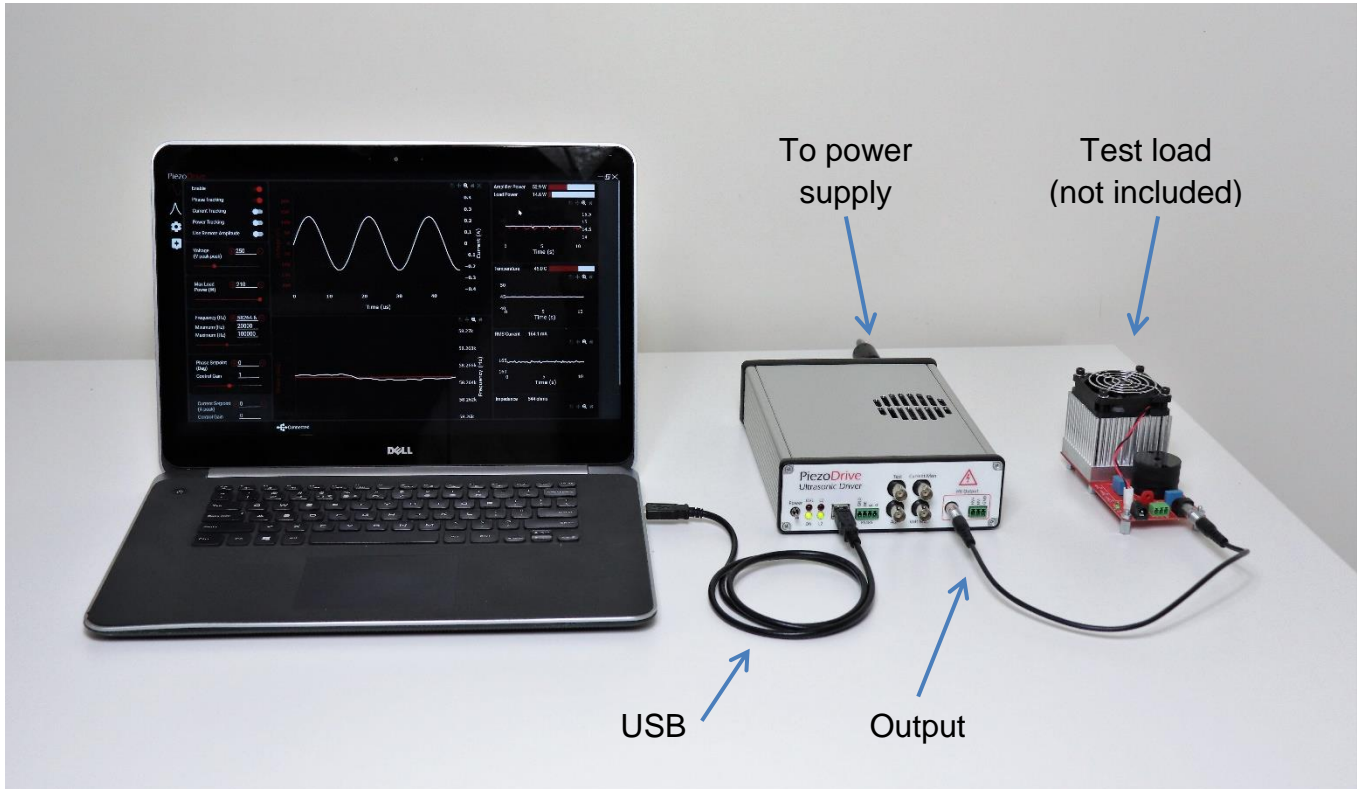
Desktop Software

Installation

Download the latest software from www.piezodrive.com and run the executable, which will extract the desktop software to the selected folder. Go into the folder and launch the executable (piezodrive.exe).
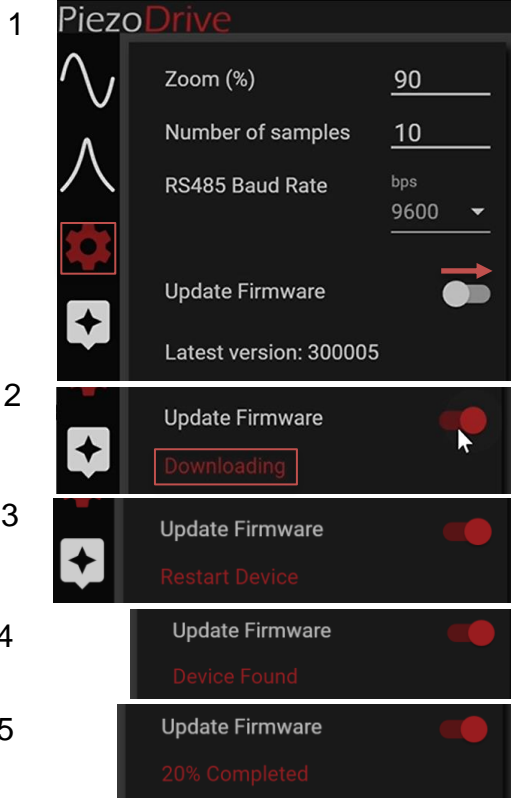
First Connection

The PDUS210 uses the HID device class to communicate over USB. For the first connection, the amplifier should be powered on before connecting it to the PC. After this first connection, widows will assign the appropriate driver.

Firmware Update

After the first connection, the amplifier's firmware needs to be updated to ensure compatibility between the amplifier and desktop software. The firmware also needs to be updated after downloading a new version of the desktop software. The desktop software will automatically download the latest compatible version of the firmware; thus, it is import to check for new desktop software periodically at: https://www.piezodrive.com/ultrasonic-drivers/pdus210-ultrasonic-driver/

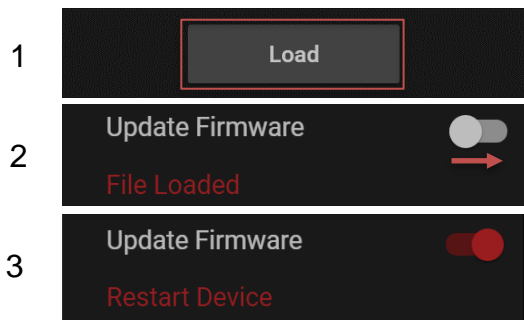The procedure for firmware update is:

1.

   To update the firmware, click on the settings tab, then click the 'Update Firmware' switch. When the update firmware switch is on, the desktop software will begin downloading the latest firmware.

   Once the firmware has been downloaded, the software will prompt you to restart your amplifier (turn the power switch off and on). If your amplifier was already turned off, simply turn it on.

2.

   Once the amplifier is reset, the desktop software will start the transfer. Do not interrupt this transfer. If the transfer fails or the device is not found, start the firmware update process again.
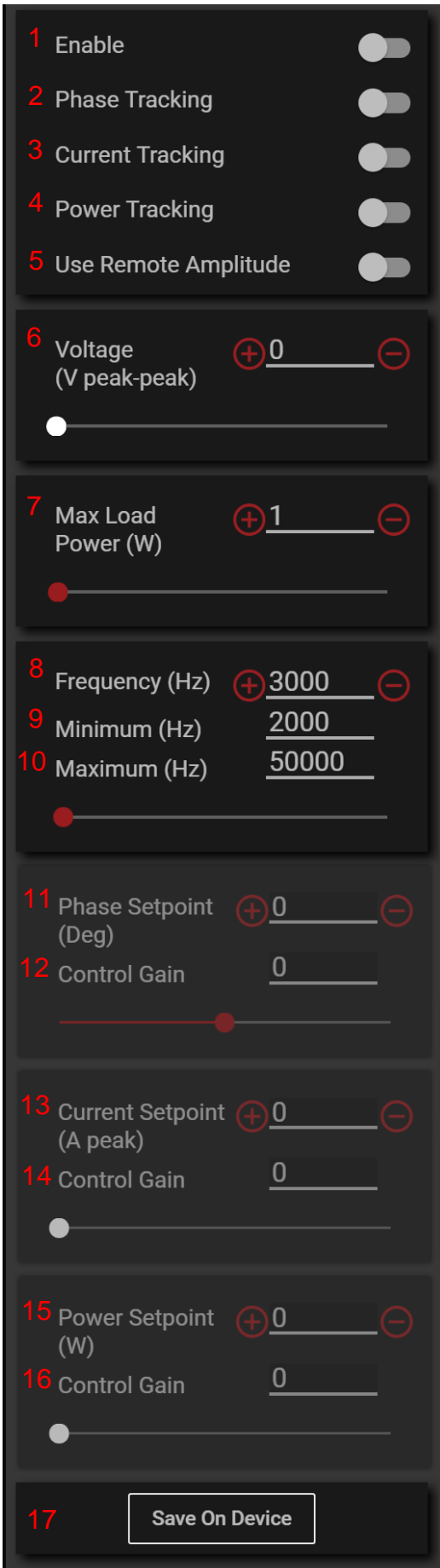
3.

4.

5.

Offline Firmware Update

1.

   If an internet connection is not available or you do not have access to Google servers. You can manually download the latest firmware from www.piezodrive.com. To ensure compatibility, also download the latest version of the desktop software.

2.

   To perform a manual firmware update, press the 'Load' button at the bottom of the settings tab. Use the file browser to select the downloaded firmware. The software will now show the 'File Loaded' status. Click the update firmware switch and restart the PDUS210 when prompted. This update process has an identical result to the online procedure.
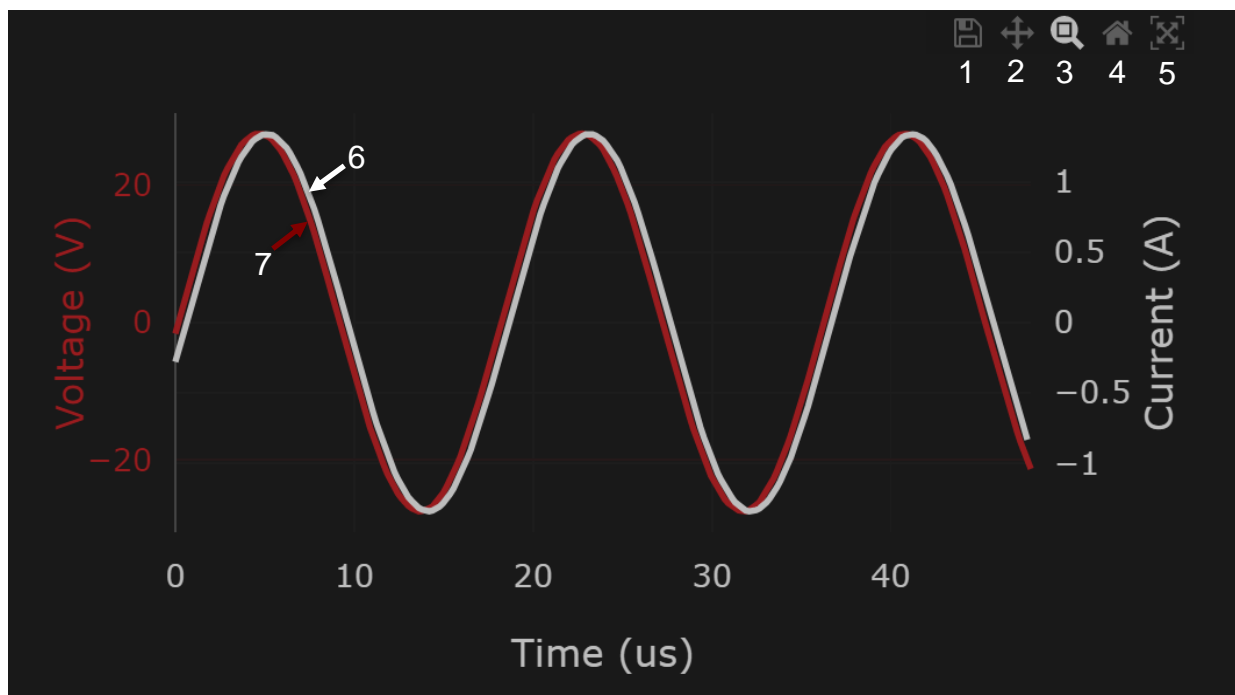
3.

Overview of Main Controls

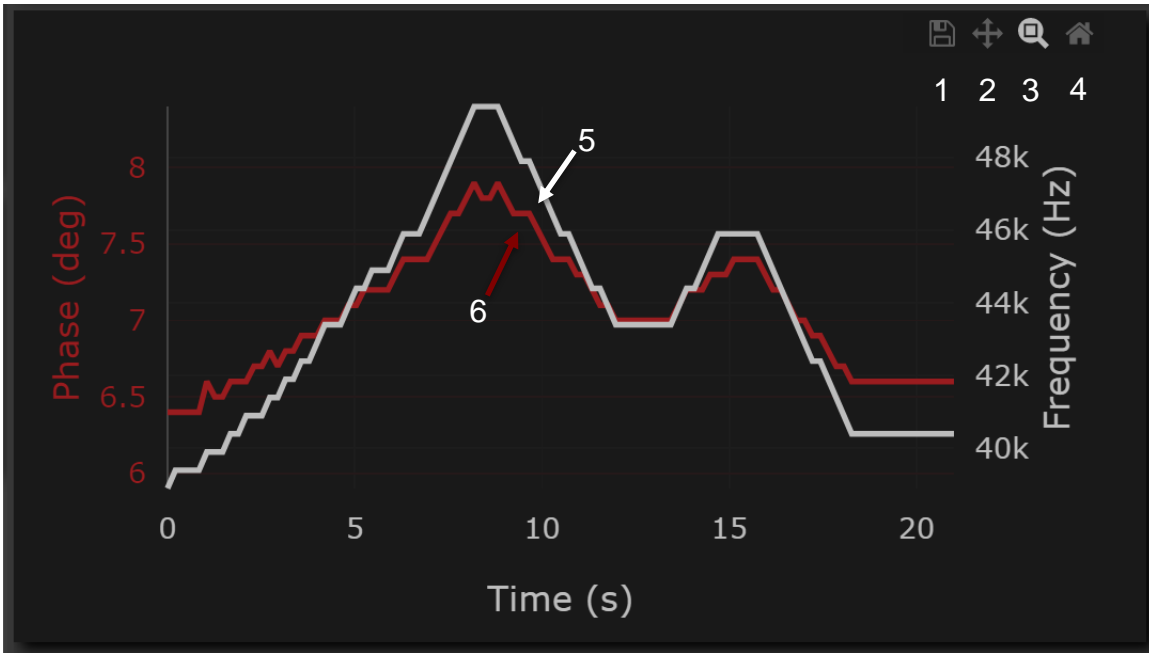|	Name	Description
1	Enable Switch	• Enables and disables the amplifier output. • Enabling the amplifier clears all present overloads.
2	Phase Tracking Switch	• Enables and disables phase tracking. • When enabled, the output frequency will be adjusted until the measured phase equals the phase set point. • When enabled, the output frequency cannot be manually changed. • When the maximum frequency is encountered, the frequency will be reset to the minimum, and vice-versa.
3	Current Tracking Switch	• Enables and disables current tracking. • The output voltage will be adjusted until the measured current equals the current setpoint. • When enabled, the output voltage cannot be manually changed. • Recommended when tracking a series resonance. • Will disable power tracking • The voltage will not be adjusted until the phase tracking is locked, i.e. there is less than 10 degrees difference between the measured phase and the phase set point.
4	Power Tracking Switch	• Enables and disables power tracking. • The output voltage will be adjusted until the measured load power equals the power set point. • When enabled, the output voltage cannot be manually changed. • Will disable current tracking • The voltage will not be adjusted until the phase tracking is locked, i.e. there is less than 10 degrees difference between the measured phase and the phase set point.

Controls panel:

1 Enable
2 Phase Tracking
3 Current Tracking
4 Power Tracking
5 Use Remote Amplitude

6 Voltage (V peak-peak) ⊕ 0 ⊖

7 Max Load Power (W) ⊕ 1 ⊖

8 Frequency (Hz) ⊕ 3000 ⊖
9 Minimum (Hz) 2000
10 Maximum (Hz) 50000

11 Phase Setpoint (Deg) ⊕ 0 ⊖
12 Control Gain 0

13 Current Setpoint (A peak) ⊕ 0 ⊖
14 Control Gain 0

15 Power Setpoint (W) ⊕ 0 ⊖
16 Control Gain 0

17 Save On Device

	Name	Description
5	Use Remote Amplitude Switch	• Enables and disables remote amplitude control. • This will only work if the amplifier is enabled by the remote. • When enabled, the remote dial will change the output voltage from zero to the maximum amplitude. • If current tracking is enabled, the dial will change the current set point from zero to the maximum output current. • If power tracking is enabled, the dial will change the power set point from zero to the maximum load power.
6	Output Voltage (V peak-peak)	• Shows and sets the output voltage, in Volts peak to peak. • Cannot be changed if power or current tracking is enabled
7	Max Load Power (W)	• Sets the maximum power that can be supplied to the load, in Watts. If this maximum value is exceeded, an overload will be triggered and the amplifier output will be disabled.
8	Output Frequency (Hz)	• Shows and sets the output frequency, in Hertz. • Cannot be changed if phase tracking is enabled. • Limited to values between the minimum and maximum frequencies.
9	Minimum Output Frequency (Hz)	• Shows and sets the minimum output frequency, in Hertz. • Limited to values between 5450 Hz and the maximum frequency. • The operating frequency range should not exceed the output transformer specifications.
10	Maximum Output Frequency (Hz)	• Shows and sets the maximum output frequency, in Hertz. • Limited to values between the minimum frequency and 520 kHz. • The operating frequency range should not exceed the output transformer specifications.
11	Phase Setpoint (Deg)	• Shows and sets the phase set point, in degrees.
12	Phase Control Gain	• Shows and sets the control gain for phase tracking. • Negative values are used to track a parallel resonance. • Positive values are used to track a series resonance. • Increasing the absolute value will increase the controller speed but may lead to instability.
13	Current Setpoint (A pk)	• Shows and sets the current set point, in Amps peak.
14	Current Control Gain	• Shows/sets the controller gain for the current tracking controller. • Accepts only positive values. • Increasing the value will increase the controller speed but may lead to instability.
15	Power Setpoint (W)	• Shows and sets the power set point, in Watts.
16	Power Control Gain	• Shows and sets the control gain for power tracking. • Accepts only positive values. • Increasing the value will increase the controller speed but may lead to instability.
17	Save On Device	• Saves all current settings to the amplifier non-volatile memory.

Signal Graph

	Name	Description
1	Save Waveform	• Saves the displayed waveform to a csv file.
2	Pan	• Pans the plot.
3	Selection Zoom	• Drag over selection to zoom.
4	Resets Zoom	• Zooms out to the maximum values for the voltage and current.
5	Auto-scale	• Zooms to fit the voltage and current waveforms
6	Current waveform	• Current waveform, measured at 5.2 (M samples/s), 250 samples are displayed.
7	Voltage waveform	• Voltage waveform, measured at 5.2 (M samples/s), 250 samples are displayed.

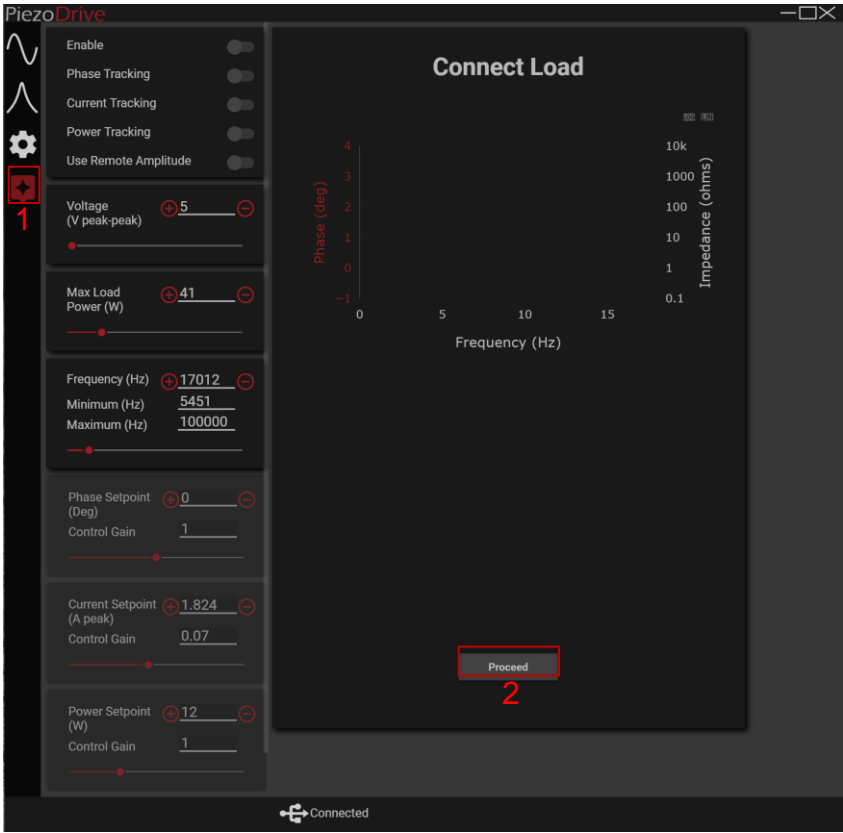**Frequency and Phase Graph**

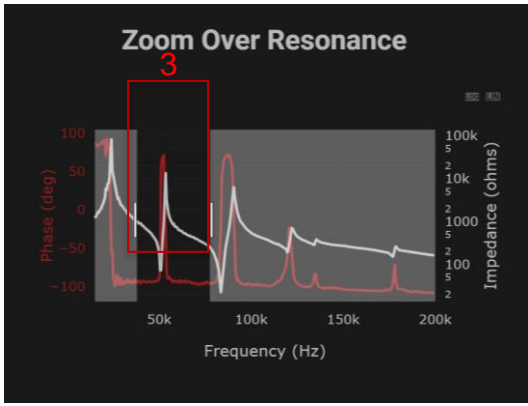|	Name	Description
1	Save to file	• Saves the traces for the frequency and phase to a csv file. Also saves the load power, amplifier power, temperature impedance, and RMS current.
2	Pan	• Pans the signals.
3	Zoom selection	• Drag over selection to zoom.
4	Reset zoom	• Zooms out or in to fit the bounds of the frequency and the phase signals.
5	Frequency signal	• Frequency signal sampled at approximately 5 samples/s. The number of samples stored can be changed in the settings tabs.
6	Phase signal	• Phase signal sampled at approximately 5 samples/s. The number of samples stored can be changed in the settings tabs.

Small Graphs

Graphs for the amplifier power, load power, temperature, impedance, and RMS current will appear when the software is maximized. These small graphs have the same controls as the frequency and phase graph. The save button for all of these graphs will save the frequency, phase, amplifier power, load power, temperature, impedance, RMS current, output voltage, phase setpoint, current setpoint, and power setpoint as a csv file. The number of samples saved is the same as the number of samples for the graphs, which can be changed in the settings tabs. This save function is recommended for any logging that may be required.
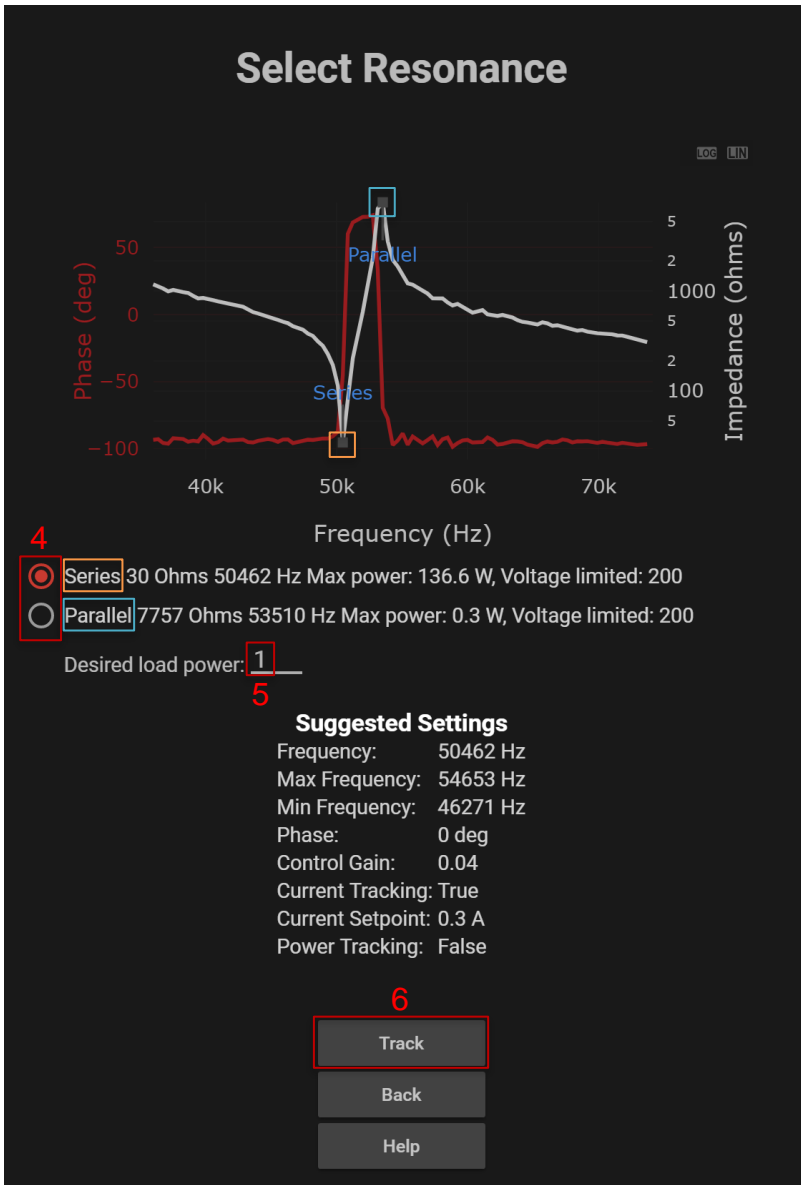
Assistant Quick Start Guide

To aid new users find settings for an ultrasonic load, the software provides an assistant tool. The assistant tool has three key stages; the first will perform a wideband impedance sweep; the second will perform a narrowband impedance sweep; and the last will perform analysis and apply the determined settings. The procedure is:

1. Select the Assistant tab

2. Ensure the load is connected then press 'Proceed'. The assistant will perform an impedance sweep from 15 kHz to 200 kHz.

3. Zoom over the desired resonance; you may need to consult the transducer manufacturer if you do not know the operating frequency range. The assistant will start the second sweep over the selected region.

Select Resonance

LOG LIN

Phase (deg): 50, 0, −50, −100

Parallel

Series

Frequency (Hz): 40k, 50k, 60k, 70k

Impedance (ohms): 5, 2, 1000, 5, 2, 100, 5

4

⦿ Series 30 Ohms 50462 Hz Max power: 136.6 W, Voltage limited: 200
◯ Parallel 7757 Ohms 53510 Hz Max power: 0.3 W, Voltage limited: 200

Desired load power: 1
5

Suggested Settings

Frequency:	50462 Hz
Max Frequency:	54653 Hz
Min Frequency:	46271 Hz
Phase:	0 deg
Control Gain:	0.04
Current Tracking:	True
Current Setpoint:	0.3 A
Power Tracking:	False

6

Track

Back

Help

4. Select either the series or parallel resonance. The assistant will give an estimate for the maximum power that can be achieved for each resonance. In this example, it can be seen that the maximum output power is 137 W for the series resonance and is limited by the maximum output voltage. For the parallel resonance case, the maximum output power is limited to 0.3 W. The reduction in output power is the result of poor impedance matching between the load and the transformer. A far better model for operating at the parallel resonance would be PDUS210-800.

5. Enter the desired load power; this will adjust either the current setpoint of the output voltage depending on the type of resonance selected. A series resonance will turn on current tracking, and parallel resonance will set the output voltage.

6. Press track to apply the suggested settings and enable the amplifier. It is recommended that you save these settings to the amplifier.
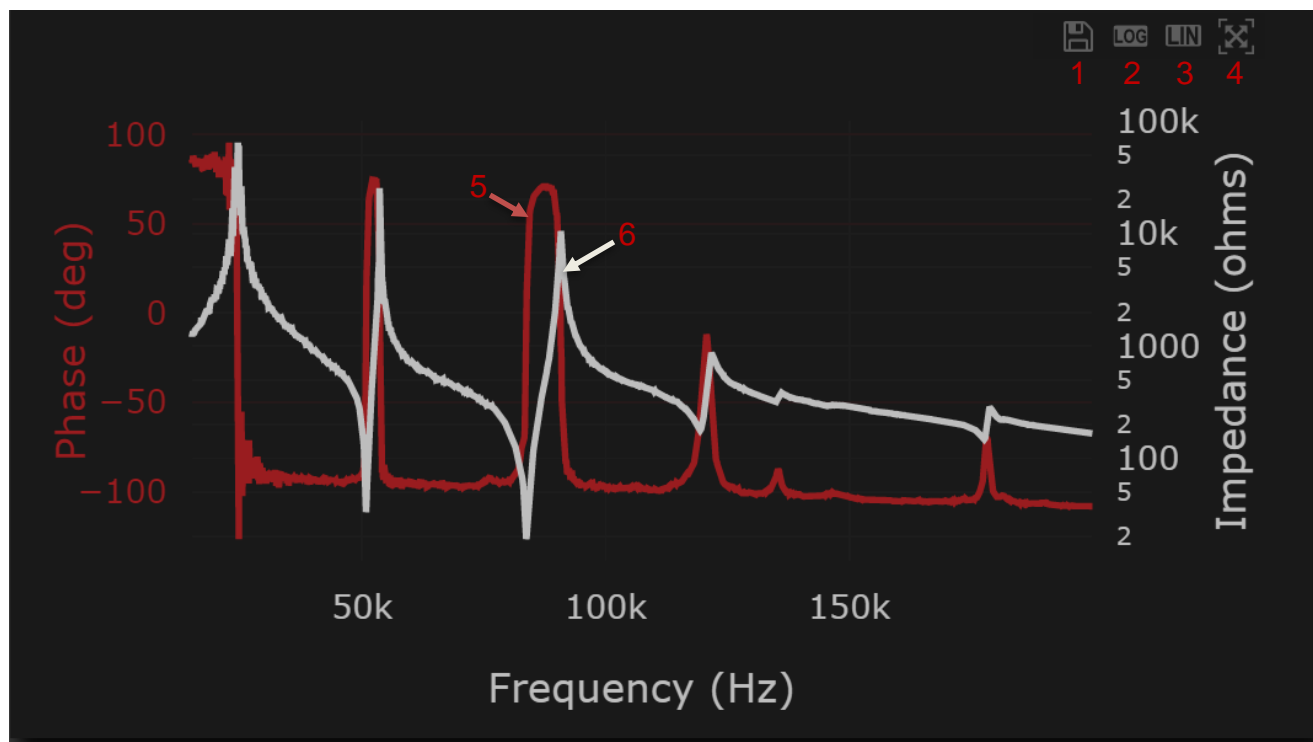
Frequency Sweep Function

Impedance frequency responses are useful for diagnostics and identifying suitable operating ranges. The frequency response can be exported in csv format. To perform a manual sweep, select the sweep tab.

	Description
1	Output voltage when performing the sweep. Higher voltages may decrease noise but may lead to overloads.
2	The maximum load power. If the measured load power exceeds this value, an overload is triggered. This overload will stop the sweep and disable the amplifier output.
3	Starting frequency for the sweep.
4	End frequency for the sweep.
5	The frequency step or the resolution of the sweep.
6	The minimum delay between frequency steps. A longer delay provides greater settling time between frequencies, which may be required for systems with low damping or quality factor above 100.
7	Start sweep.
8	Pause sweep.
9	Stop sweep.

Frequency Sweep Graph

	Description
1	Save the sweep data as a csv file
2	Sets the impedance scale to log
3	Sets the impedance scale to linear
4	Auto-scale
5	Phase data
6	Impedance data

PDUS210-FLEX Operation

The PDUS210-FLEX is identical to the standard PDUS210 except that it requires an external transformer connected between the amplifier and transducer using the supplied cable. This allows the user to switch between different output voltage ranges by changing the external transformer.

The PDUS210-FLEX must be purchased with at least one external transformer. The available part numbers and specifications are listed in [PDUS210-FLEX Specifications](#)

A kit containing six transformers ranging from 50 Vpk-pk to 800 Vpk-pk is also available (TX210-Kit1). This includes the following output voltage ranges: 50, 100, 200, 400, 600, and 800 Vpk-pk.

Figure 8. PDUS210-FLEX Output transformer (e.g. TX210-800)

To operate the PDUS210-FLEX, the instructions are identical to the standard PDUS210 except for the following steps that must be completed first, or when changing the transformer:

1. Disconnect the amplifier from power and connect the desired transformer, e.g. TX210-800
2. Connect the PDUS210-FLEX output to the transformer input, using the supplied cable
3. Read the turns-ratio (N) from the transformer, or specifications table, and enter this into the textbox in the desktop software labelled 'Turns Ratio'.
4. Read the frequency range from Table 2. Then check that the Maximum and Minimum frequency settings in the desktop software are within this range.
5. In the desktop software, press the 'Save on Device' button. This step is optional but will retain settings after cycling the power.

Handheld Controller

The handheld controller allows the PDUS210 to operate in a stand-alone mode. It is recommended that suitable settings are found using the assistant and then saved to the amplifier. The handheld controller can then be used to enable the amplifier and change the output amplitude.

The amplitude knob on the controller adjusts either the output voltage, current, or power set point, depending on the selected operating mode.

When the ON button is pressed momentarily, the PDUS210 is armed, which means the output is enabled but the output amplitude is set to zero. If the ON button is pressed and held, and tracking functions are enabled and the output is set to the value indicated by the amplitude knob.

The shutdown button will disable the PDUS210 output. The shutdown button only works if the PDUS210 is enabled by the handheld controller.

To operate the hand controller, the control functions are:

	Description
1,2	• **Slow alternating flash:** armed, output is enabled but voltage is set to zero. • **Fast alternating flash:** output is enabled but tracking has not locked. • **Solid green:** output is enabled and tracking has locked. • **Solid red:** output is disabled.
3	• Adjusts the output amplitude from zero to the maximum. • Adjusts the voltage, current, or power depending on the selected operating mode.
4	• A short press enables the remote and arms the amplifier. • Holding the switch on enables the output and any selected tracking functions.
5	• Disables amplifier and remote. • Only works if the amplifier is enabled with the remote.

Custom Remote Controllers

PiezoDrive encourages the development of application specific remote controllers; for example, a footswitch. The following schematic of the hand controller can be used as a template. The only required components are the On and Shutdown switches. The dial functionality provided by the variable resistor can be bypassed using the remote amplitude switch in the desktop software. Alternatively, contact PiezoDrive for customization service.
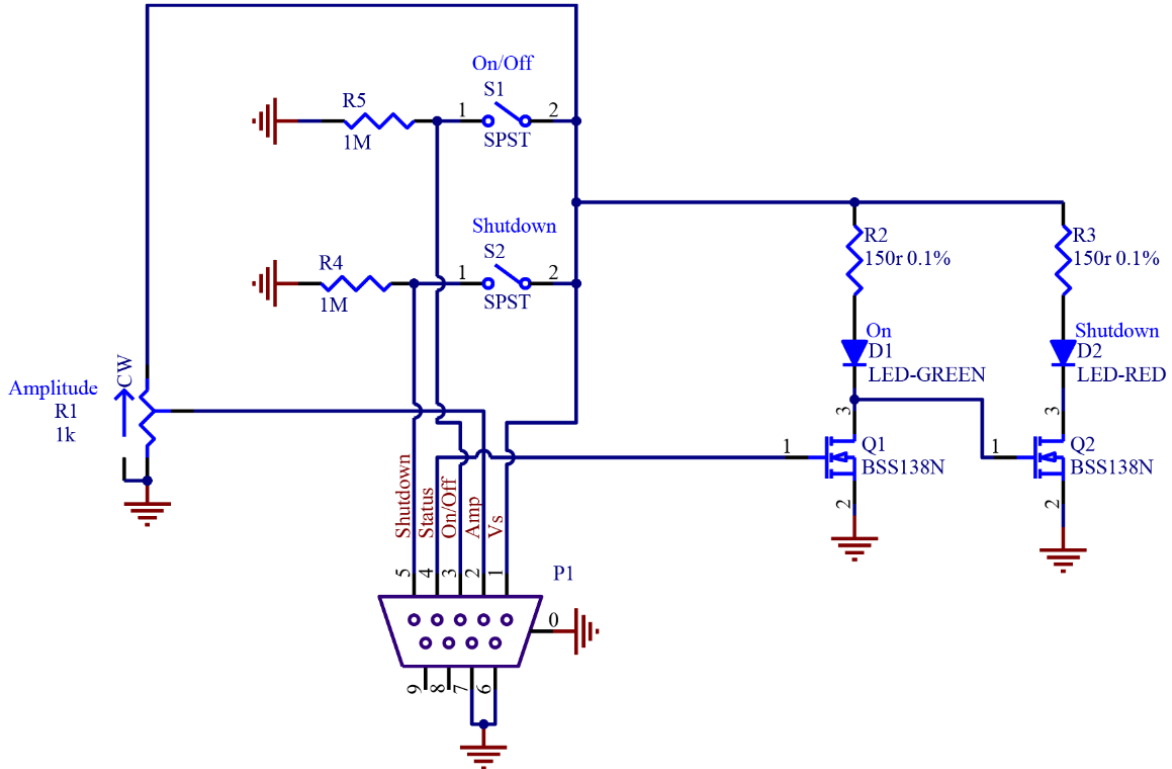

Figure 9. Hand controller schematic diagram

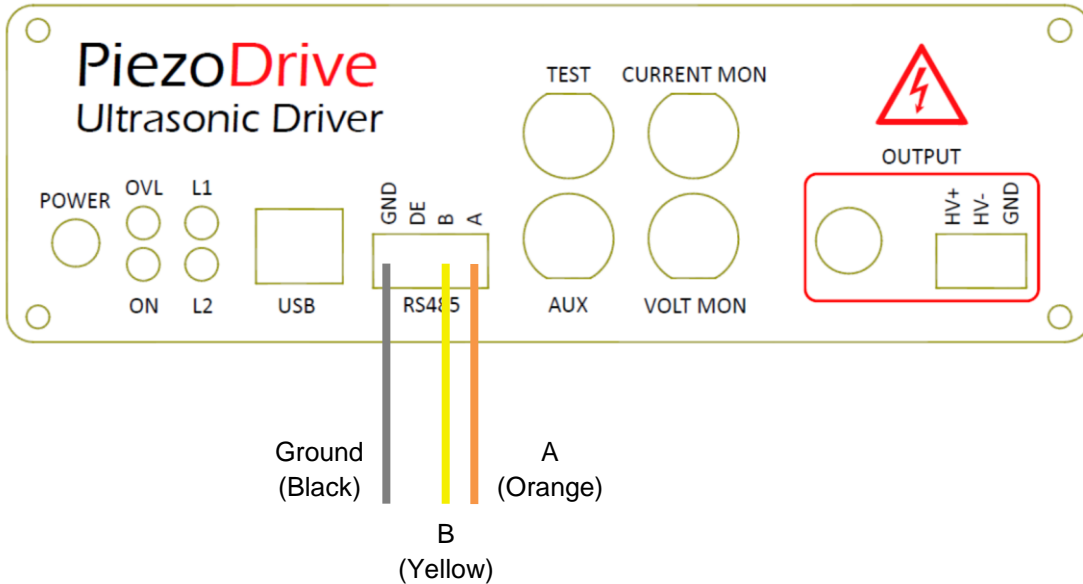| Pin	Name	Limits	Description
0	Ground		Ground
1	Vs	3.3 V	Supply voltage for the controller
2	Amp	0 - 3.3 V	Amplitude control from a 1k potentiometer
3	On/Off	0 V low, 3.3 -10 V high	On switch, active when high
4	Status	0 V low, 3.3 V high	High = enabled Low = disabled Slow toggle = armed Fast toggle = tracking in progress
5	Shutdown	0 V low, 3.3 -10 V high	Shutdown switch, active when high
6	Ground	0 V	Ground
7	Ground	0 V	Ground
8	NC		
9	NC		

Table 5. Hand controller connector pinout.

RS485 Interface

RS485 is a two-wire communication standard, commonly used for machine-to-machine, and computer-to-machine communications (Introduction to RS485).

The PDUS210 responds to the commands described in https://github.com/PiezoDrive/RS485-API

For testing purposes or to control the amplifier from a PC, an RS485 USB cable is required, for example, FTDI USB-RS485-WE-1800-BT. The connection diagram below is recommended. A text-based application such as Putty can be used to send or receive commands.

Baud Rates	9600, 115200, 460800, 921600
Data Bits	8
Stop Bits	1
Parity	None

Table 6. RS485 Parameters

Figure 10. USB-RS485-WE-1800-BT Cable

Warranty and Service

The PDUS210 is guaranteed against manufacturing defects for 12 months from the date of purchase.

Contact your distributor or info@piezodrive.com for service. Please include the amplifier serial number.