Voltage Amplifier PD200 - Test Bench

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Contents

1 Introduction

The goal of this test bench is to characterize the Voltage amplifier PD200 from PiezoDrive.

The documentation of the PD200 is accessible here.

Figure 1.1: Picture of the PD200 Voltage Amplifier

2 Voltage Amplifier Requirements

Table 2.1: Requirements for the Voltage Amplifier

	Specification
Continuous Current	$>$ 50 [mA]
Output Voltage Noise (1-200Hz)	$<$ 2 [mV rms]
Voltage Input Range	+/- 10 [V]
Voltage Output Range	-20 [V] to 150 [V]
Small signal bandwidth (-3dB)	$>$ 5 [kHz]

3 PD200 Expected characteristics

Table 3.1: Characteristics of the PD200

Characteristics	**Manual**	**Specification**
Input Voltage Range	+/- 10 [V]	+/- 10 [V]
Output Voltage Range	-50/150 [V]	-20/150 [V]
Gain	20 [V/V]	
Maximum RMS current	0.9 [A]	$>$ 50 [mA]
Maximum Pulse current	10 [A]	
Slew Rate	150 [V/us]	
Noise (10uF load)	0.7 [mV RMS]	$<$ 2 [mV rms]
Small Signal Bandwidth (10uF load)	7.4 [kHz]	$>$ 5 [kHz]
Large Signal Bandwidth (150V, 10uF)	300 [Hz]	

For a load capacitance of $10\,\mu F$, the expected $-3\,dB$ bandwidth is $6.4\,kHz$ (Figure 3.1) and the low frequency noise is $650\,\mu V$ rms (Figure 3.2).

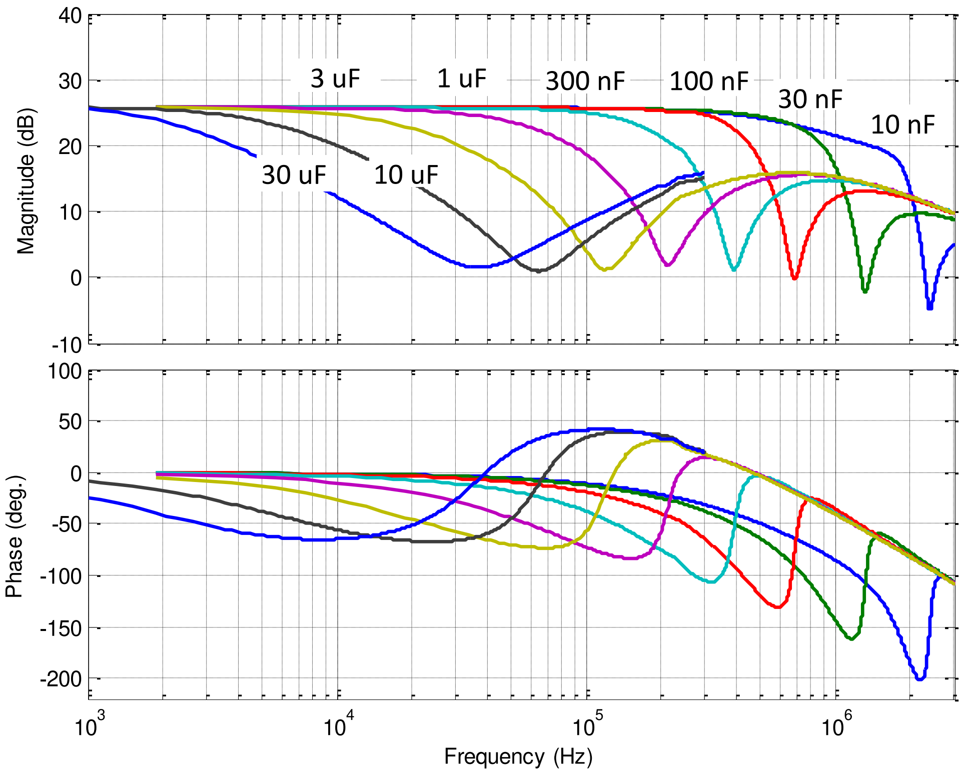

Figure 3.1: Expected small signal bandwidth

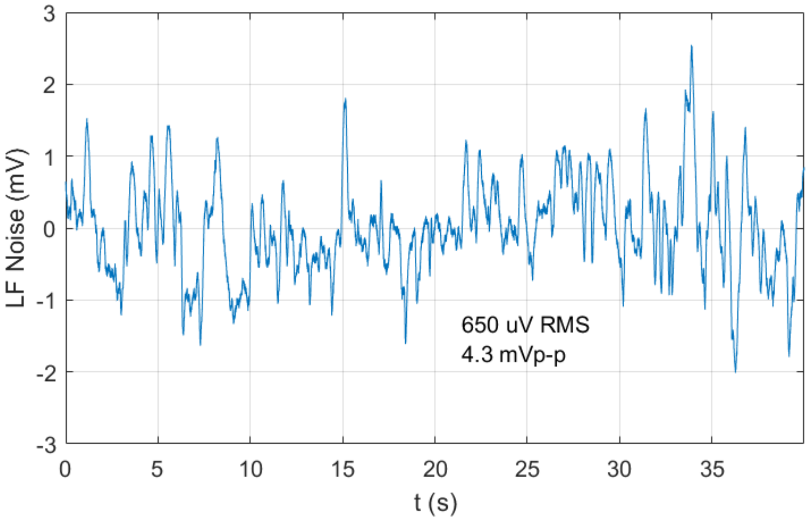

Figure 3.2: Expected Low frequency noise from 0.03Hz to 20Hz

4 Voltage Amplifier Model

The Amplifier is characterized by its dynamics $G_a(s)$ from voltage inputs V_{in} to voltage output V_{out}. Ideally, the gain from V_{in} to V_{out} is constant over a wide frequency band with very small phase drop.

It is also characterized by its output noise n. This noise is described by its Power Spectral Density.

The objective is therefore to determine the transfer function $G_a(s)$ from the input voltage to the output voltage as well as the Power Spectral Density $S_n(\omega)$ of the amplifier output noise.

As both G_a and S_n depends on the load capacitance, they should be measured when loading the amplifier with a 10 µF capacitor.

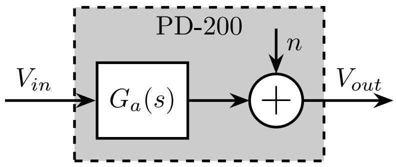

Figure 4.1: Model of the voltage amplifier

5 Noise measurement

5.1 Setup

Note

Here are the documentation of the equipment used for this test bench:

- Voltage Amplifier PD200
- Load Capacitor EPCOS 10uF Multilayer Ceramic Capacitor
- Low Noise Voltage Amplifier EG&G 5113
- Speedgoat ADC IO313

The output noise of the voltage amplifier PD200 is foreseen to be around 1mV rms in a bandwidth from DC to 1MHz. If we suppose a white noise, this correspond to an amplitude spectral density:

$$\phi_n \approx \frac{1\, mV}{\sqrt{1\, MHz}} = 1 \frac{\mu V}{\sqrt{Hz}} \tag{5.1}$$

The RMS noise begin very small compare to the ADC resolution, we must amplify the noise before digitizing the signal. The added noise of the instrumentation amplifier should be much smaller than the noise of the PD200. We use the amplifier EG&G 5113 that has a noise of $\approx 4nV/\sqrt{Hz}$ referred to its input which is much smaller than the noise induced by the PD200.

The gain of the low-noise amplifier can be increased until the full range of the ADC is used. This gain should be around 1000.

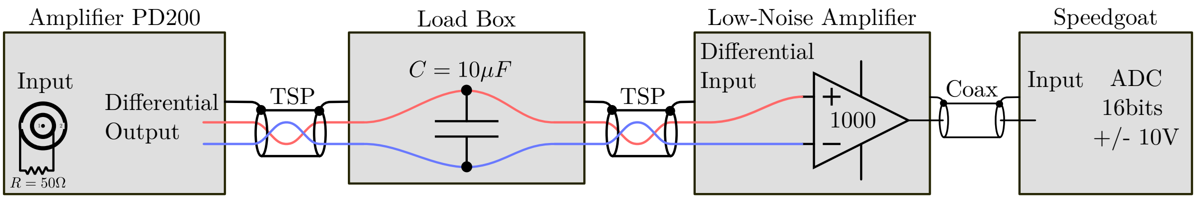

Figure 5.1: Schematic of the test bench to measure the Power Spectral Density of the Voltage amplifier noise n

A low pass filter at 10kHz can be included in the EG&G amplifier in order to limit aliasing. An high pass filter at low frequency can be added if there is a problem of large offset.

5.2 Results

6 Transfer Function measurement

6.1 Setup

In order to measure the transfer function from the input voltage V_{in} to the output voltage V_{out}, the test bench shown in Figure 6.1 is used.

Note

Here are the documentation of the equipment used for this test bench:

- Voltage Amplifier PD200
- Load Capacitor EPCOS 10uF Multilayer Ceramic Capacitor
- Speedgoat DAC/ADC IO313

For this measurement, the sampling frequency of the Speedgoat ADC should be as high as possible.

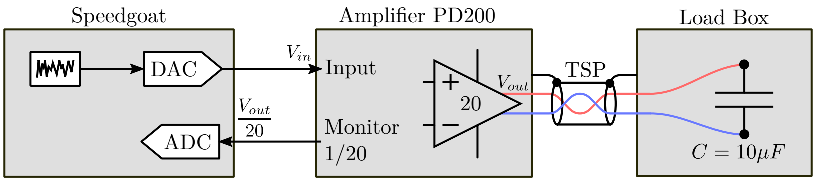

Figure 6.1: Schematic of the test bench to estimate the dynamics from voltage input V_{in} to voltage output V_{out}

6.2 Results

7 Conclusion

Table 7.1: Measured characteristics, Manual characterstics and specified ones

Characteristics	**Measurement**	**Manual**	**Specification**
Input Voltage Range	-	+/- 10 [V]	+/- 10 [V]
Output Voltage Range	-	-50/150 [V]	-20/150 [V]
Gain		20 [V/V]	-
Maximum RMS current		0.9 [A]	$>$ 50 [mA]
Maximum Pulse current		10 [A]	-
Slew Rate		150 [V/us]	-
Noise (10uF load)		0.7 [mV RMS]	$<$ 2 [mV rms]
Small Signal Bandwidth (10uF load)		7.4 [kHz]	$>$ 5 [kHz]
Large Signal Bandwidth (150V, 10uF)		300 [Hz]	-