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2559-2971

Active Filter Design and Construction

Introduction

This module utilizes the Filter Pro software to design an active bandpass filter, with a specific center frequency, that has 0 dB gain in the passband, a passband bandwidth of 100Hz, a stopband bandwidth of 1000Hz, and stopband attenuation of -30 dB per decade. This design is built and simulated in LTSpice and realized with hardware. A general method of building this type of filter involves using one op-amp circuit as the input to a second op-amp circuit with the same components, as to collocate two poles at the same frequency to meet the requirements. The output to this circuit is used to drive a speaker, to verify that the attenuation specifications are met. Moreover, for any periodic waveform with a harmonic that is in the passband, that harmonic will appear.

Design

The block diagram for the circuit is provided in Figure 1. The LTSpice circuit is given in Figure 2. The physical circuit is shown in Figures 3 and 4. In the design, the input waveform is fed to a bandpass op-amp circuit with a pole at 1971Hz. The output to this circuit is fed to another circuit with the same pole, so that the gain at the center frequency remains the same, but the amplitude reduction of signals at different frequencies will be larger. The tuning of the frequency selection is done primarily by varying smaller resistor values. The 162K and 158K resistors are used to reduce the input signal, so that it can be again amplified by the circuit, to attain the gain of 0dB at the center frequency. The bill of materials is shown in Table 1, with the total cost coming to $27.12.

Conclusion

The circuit meets the specifications, as shown in Figures 5-12. At the center frequency, the gain is 0, as shown in Figure 5. When the frequency decreases slightly, such as in Figure 6, the output amplitude drops steeply, as shown in Figure 6. As the frequency continues to decrease, the output drops to nearly zero, shown in Figure 7. As the frequency increases from the center frequency, the amplitude decreases, albeit not as quickly as it does with frequency decrease, as shown in Figures 8 and 9. For square and ramp waves at the center frequency, only the first harmonic appears, as shown in Figures 10 and 11. Moreover, for lower-frequency waves with harmonics within the passband, the harmonic in the passband is output, as is shown in Figure 12, which has the third harmonic in the passband.

Appendix

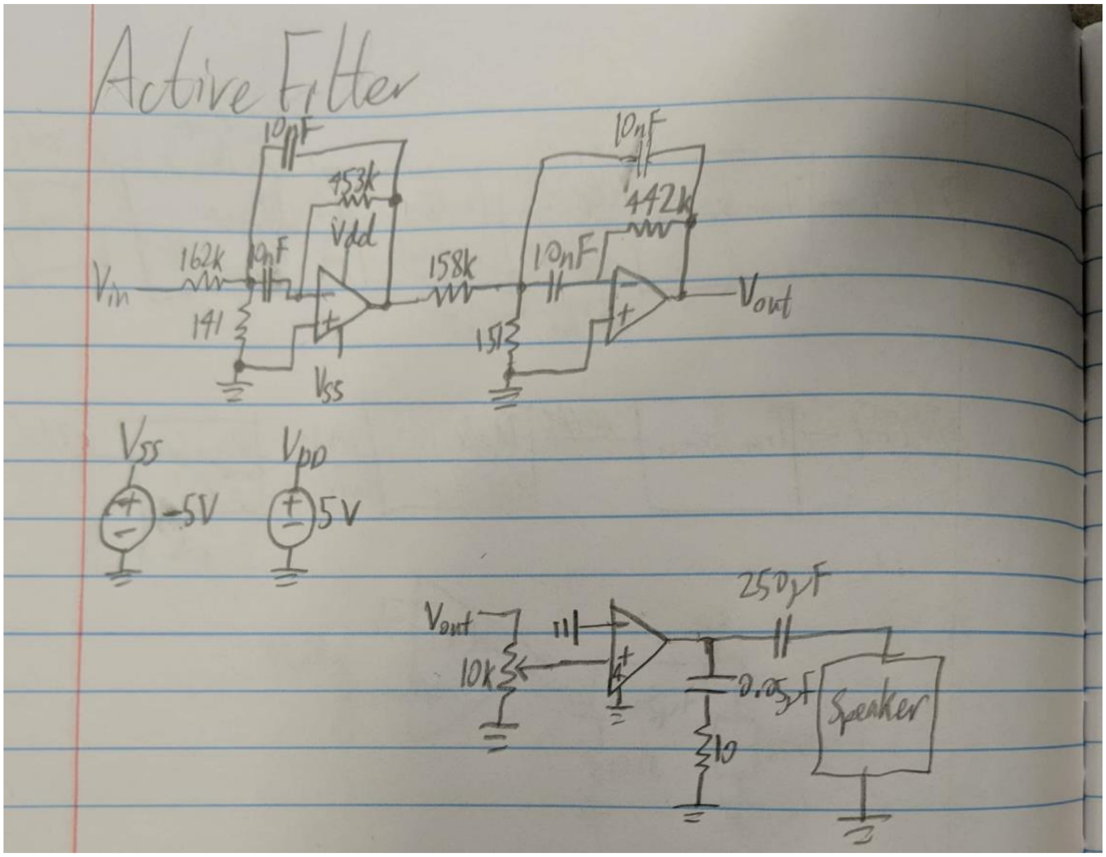

Figure 1: Block Diagram of Active Filter Circuit

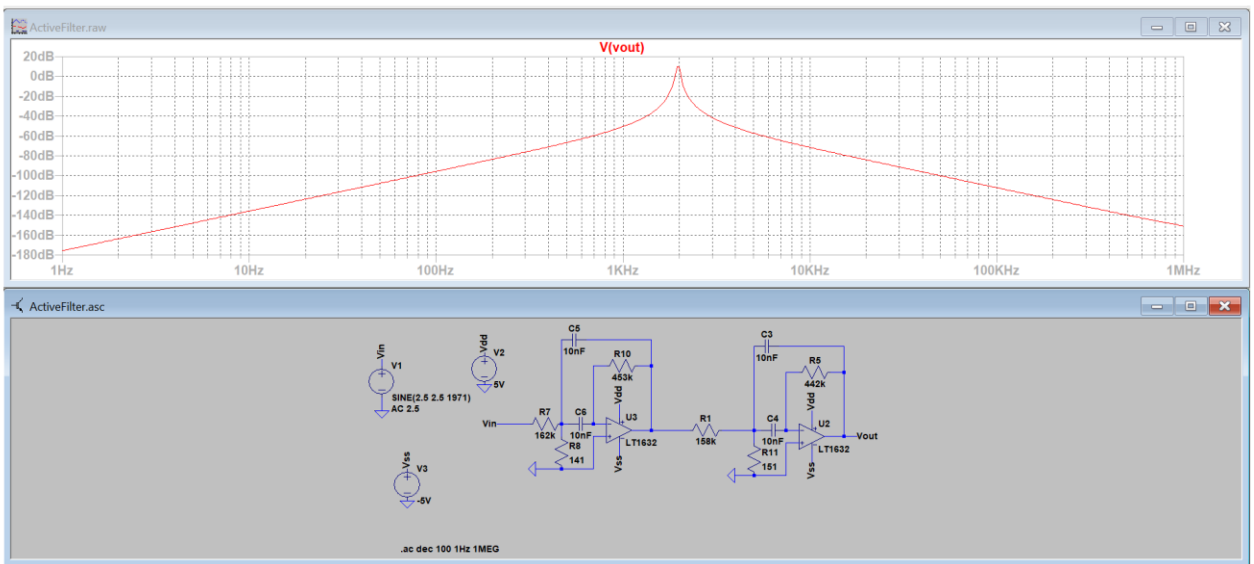

Figure 2: LTSpice Schematic of Active Filter, with Simulation

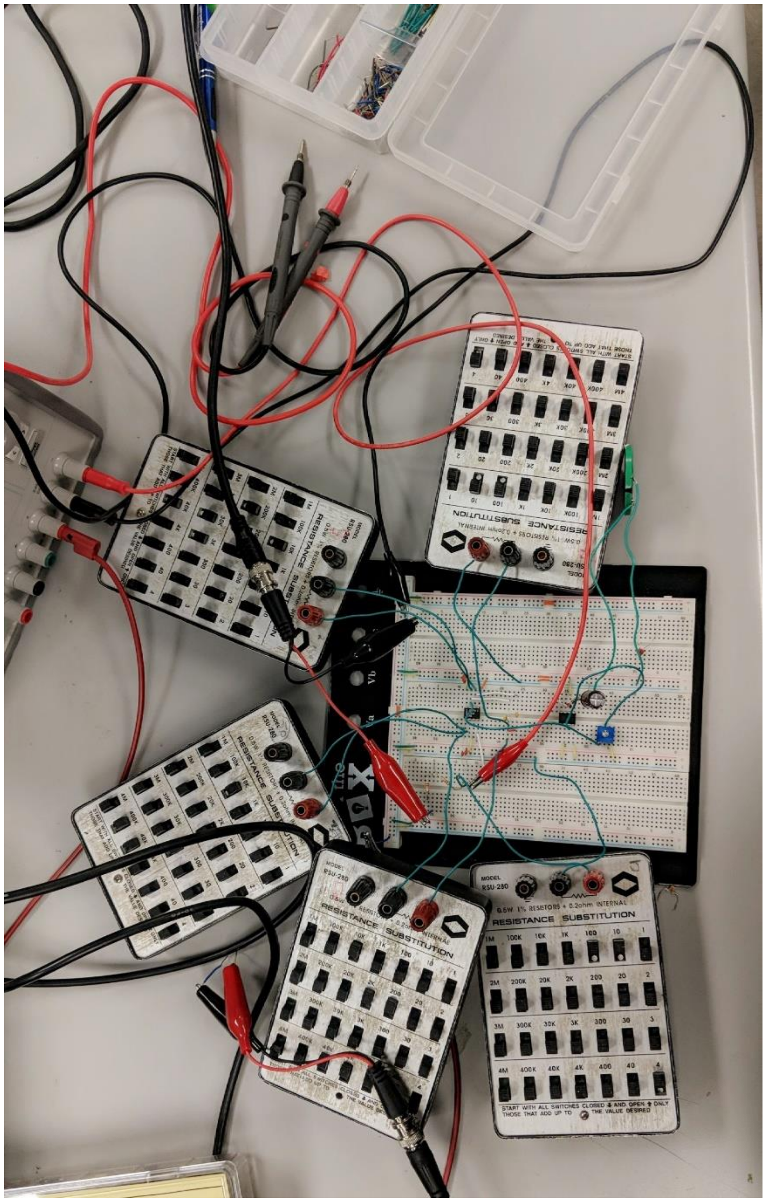

Figure 3: Complete Circuit

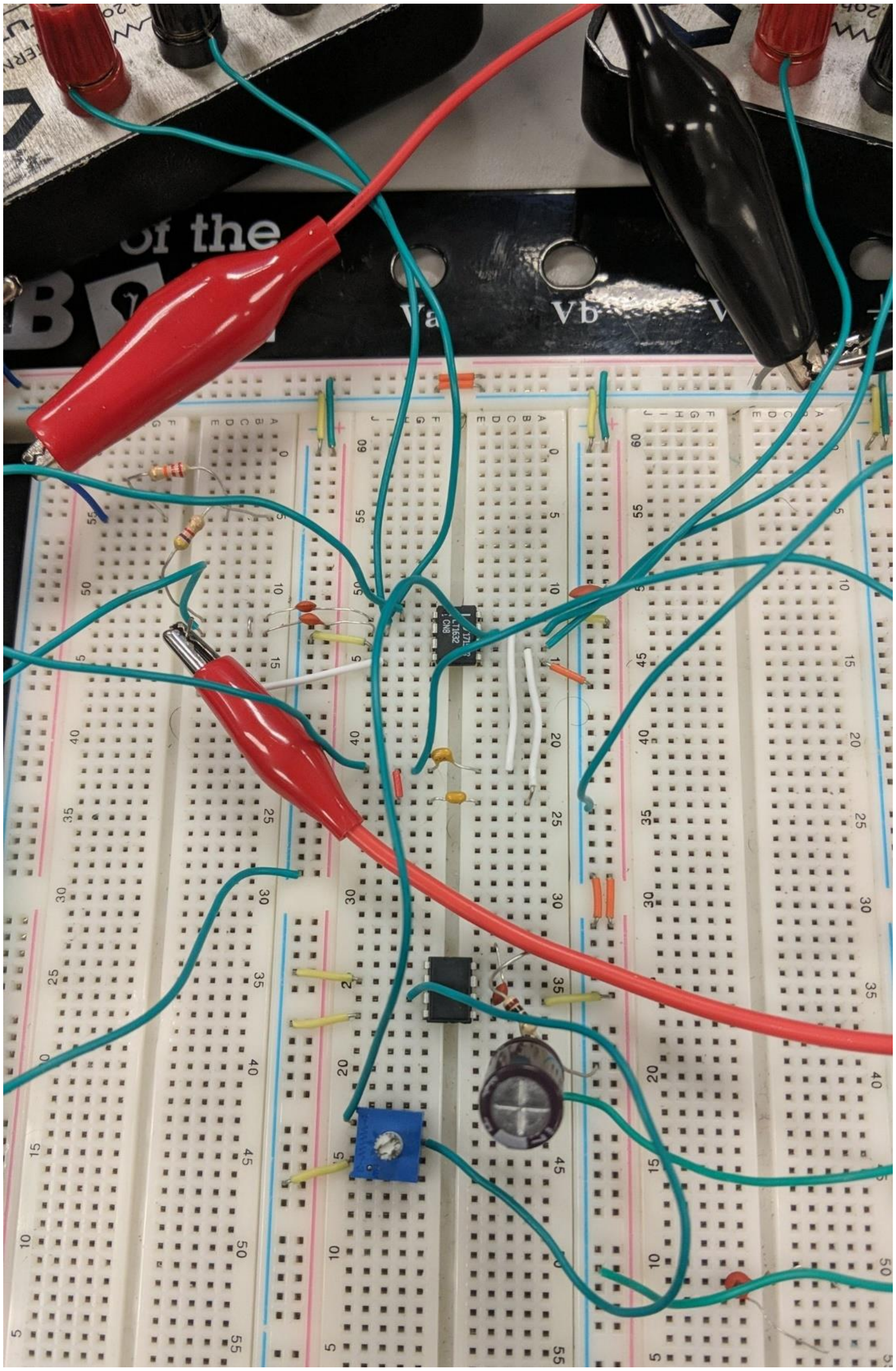

Figure 4: Close-Up of Complete Circuit

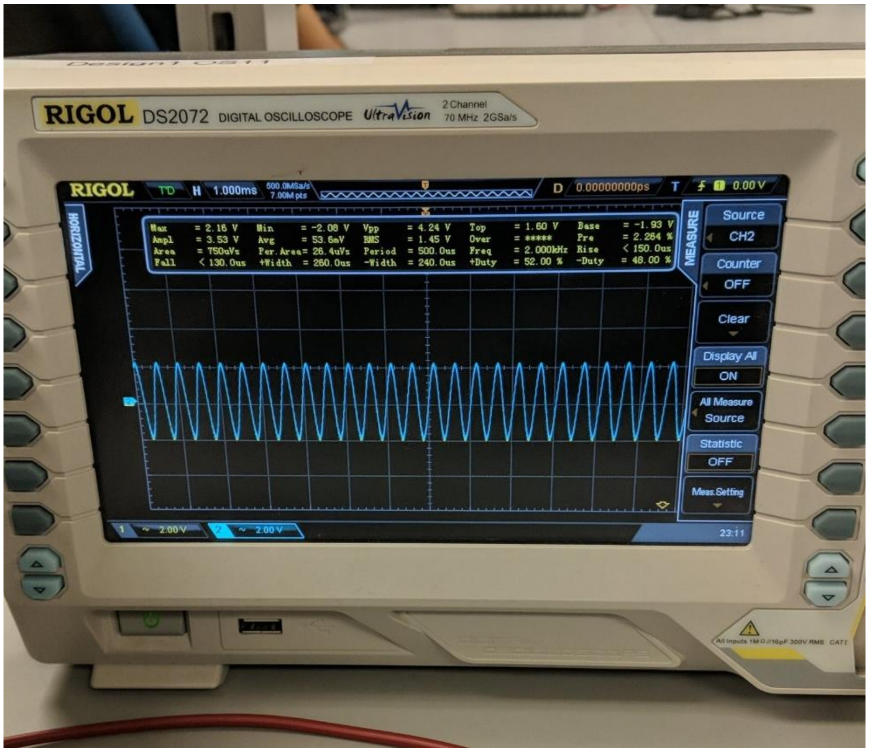

Figure 5: Output with 1.971 kHz Sine Input

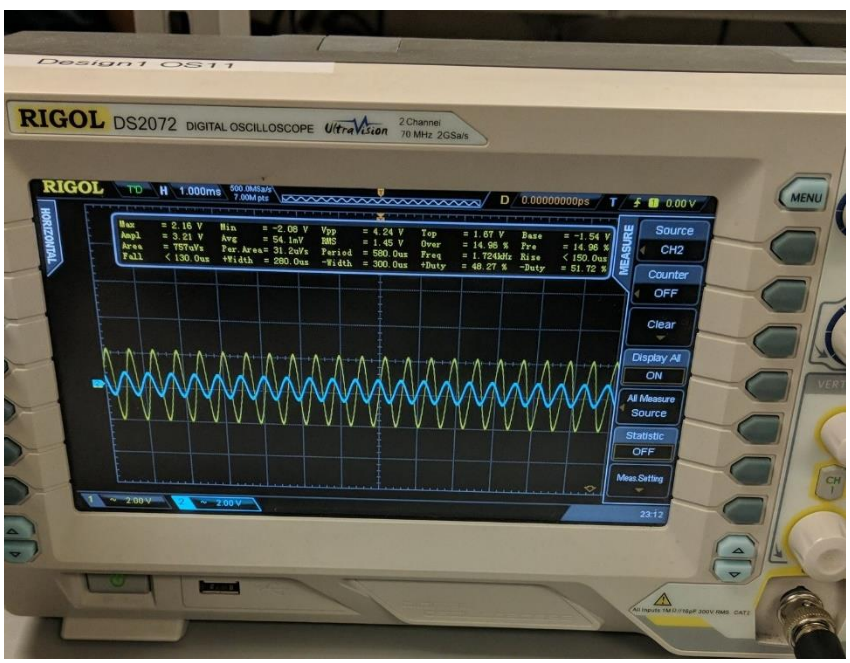

Figure 6: Output with 1.7 kHz Sine Input

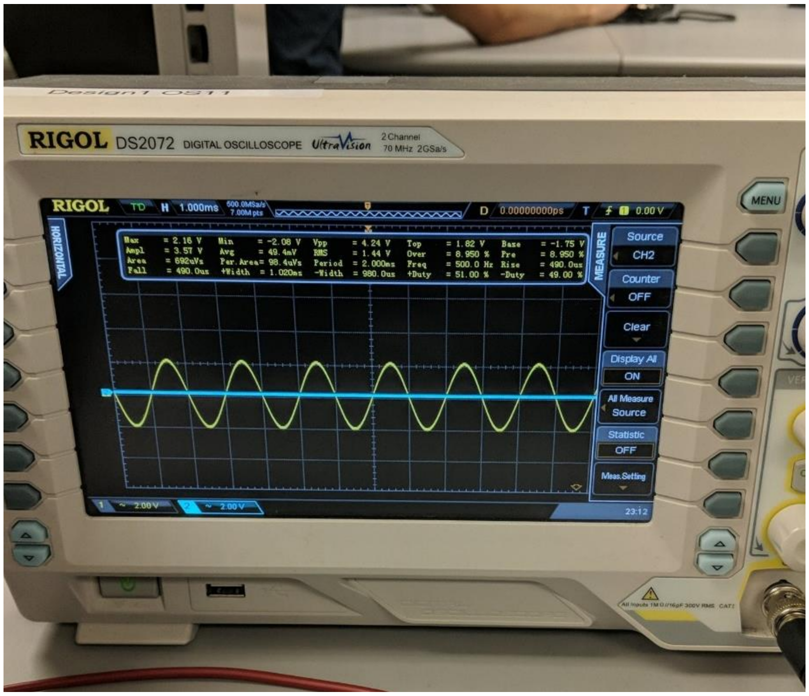

Figure 7: Output with 500Hz Sine Input

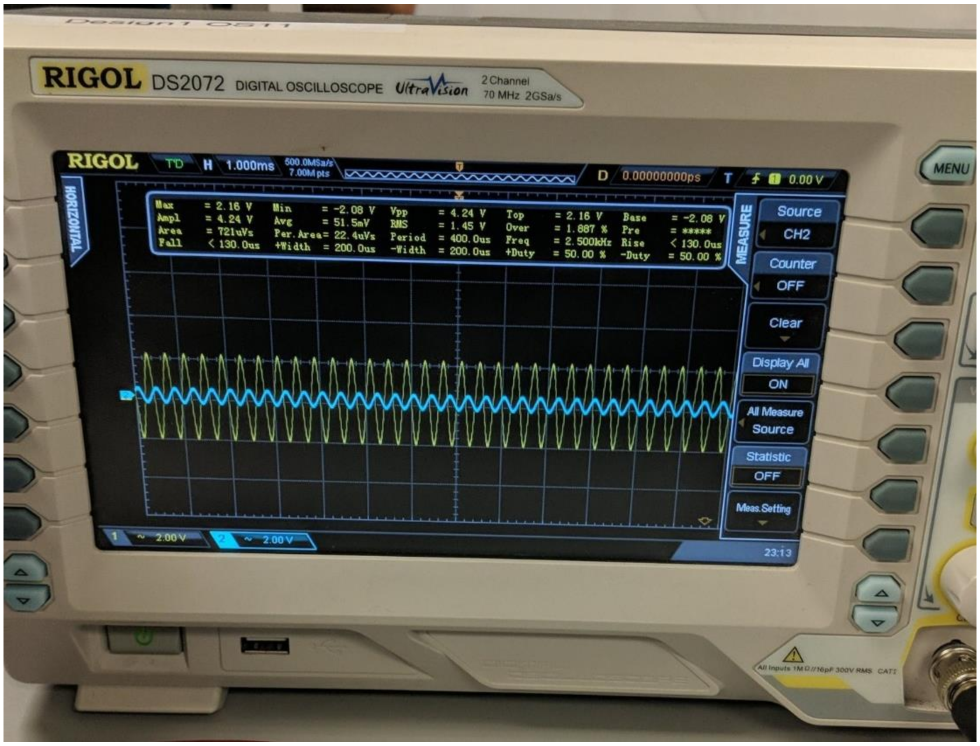

Figure 8: Output for 2.5kHz Sine Input

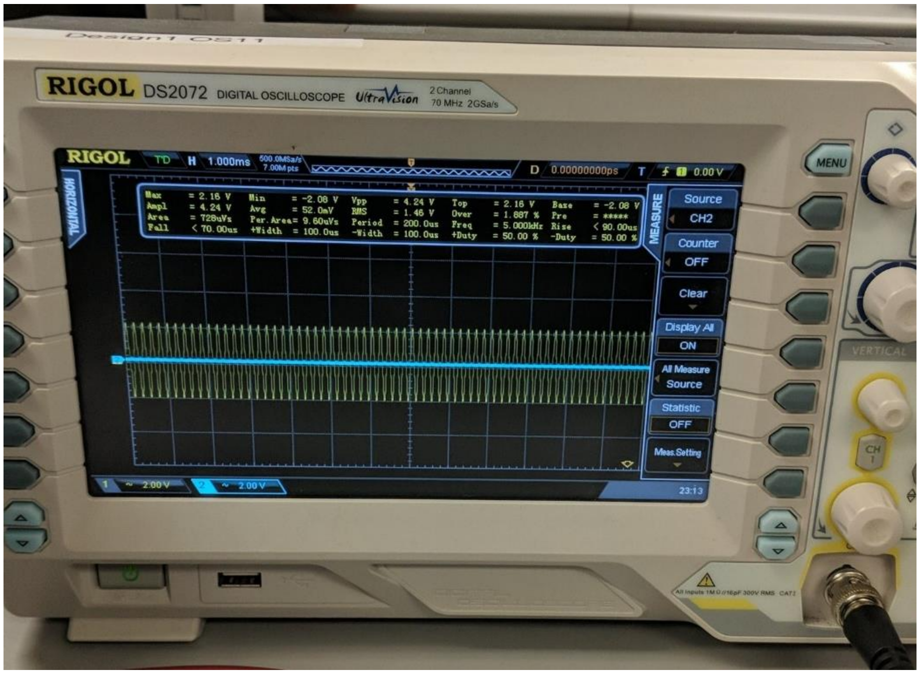

Figure 9: Output for 5kHz Sine Input

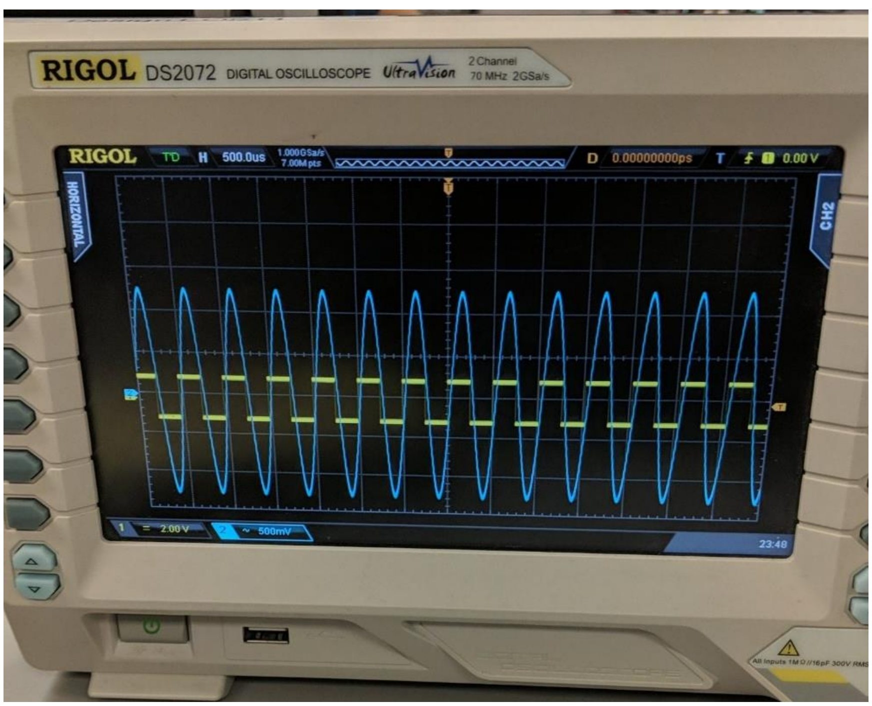

Figure 10: Output for 1.971kHz Square Wave

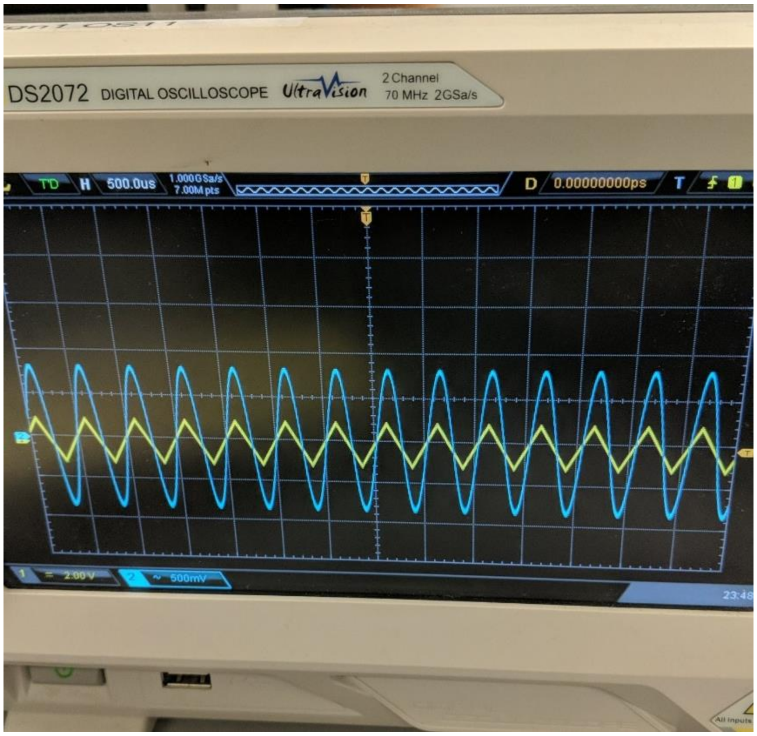

Figure 11: Output for 1.971kHz Ramp Input

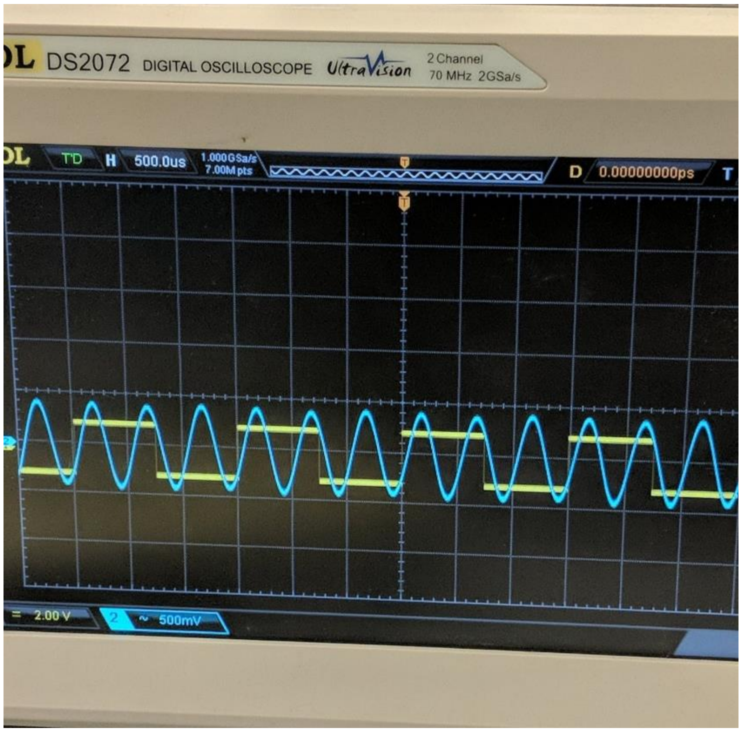

Figure 12: Output for 671Hz Square Input

Part Number	Part Name	Cost per Part	Volume Discount (Price per unit for 100 units)	Source
1	Breadboard with Wires	$3.59	N/A	Amazon
2	162K Resistor	$0.22	N/A	Mouser Electronics
3	158K Resistor	$0.49	$0.39	Vetco Electronics
4	453K Resistor	$0.22	$0.02	Mouser Electronics
5	442K Resistor	$0.10	$0.02	Mouser Electronics
6	10nF Capacitor (x4)	$0.10	$0.04	Mouser Electronics
7	141 Ohm Resistor	$1.41	$0.88	Mouser Electronics
8	151 Ohm Resistor	$0.02	$0.02	Allied Electronics
9	LT1632 (x2)	$6.80	$3.33	Mouser Electronics
10	LM386	$0.80	$0.43	Mouser Electronics
11	10K Potentiometer	$0.90	$0.56	Mouser Electronics
12	10 Ohm Resistor	$0.01	$0.01	Allied Electronics
13	8 Ohm Speaker	$1.95	N/A	Mouser Electronics
14	0.05uF Capacitor	$0.15	N/A	Allied Electronics
15	250uF Capacitor	$3.26	$2.32	Allied Electronics
Total		$27.12		

Table 1: Bill of Materials