Lab 10

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1 Introduction

In this lab, we build a ultrasonic range finder. We built two parts of a circuit. The first part was a transmitter which send out bursts of ultrasound. The second part of the lab was a receiver. The details of these circuits are presented below.

2 What's Happening

The first part of the circuit consists of two digital inputs and an and gate. We are able to produces short bursts of $40kHz$ ultrasound spaced apart. This is possible by "and"ing a $40kHz$ wave on a 50% duty cycle and a $20kHz$ on a 2% duty cycle. A single blip is shown below in Figure 1.

The second part of the circuit was the receiver that we designed in class. It consisted of two band pass filters followed by an amplifier. The band filters had a high pass filter section of $4k\omega$ resistor and a $1000pF$ capacitor. The low pass filter of $34k\omega$ (This value was picked as a of $40k\omega$ resistor was not available resistor and a $100pF$ capacitor. With roughly the same RC value the and pass filter attenuates all values outside of 40kHz. Additionally, the gain due to these filters was to be $10x$ due to the ratio of the resistors. The second band pass filter was made identical to the first one. The schematic for these can be seen below in Figure 2.

The gain for the final amplifier was initially determined to be $10x$. However, after creating a bode plot of our two band pass filters, we found that the net amplification was only $25x$. We found that because our band pass filter was focused in on one point, the voltage at $40kHz$ only had a gain of $5x$. To compensate for this the gain of the final amplifier was made to be $40x$. With this the amplification of the entire circuit was made to be $1000x$. This decision did however lead to some issues which are seen below in Figure 4.

3 Figures

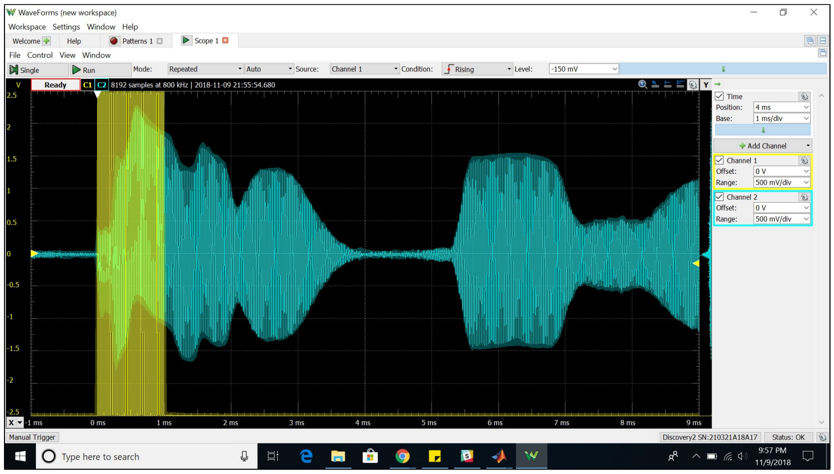

Figure 1: Blip
The Figure shows the blip as seen in Waveforms.

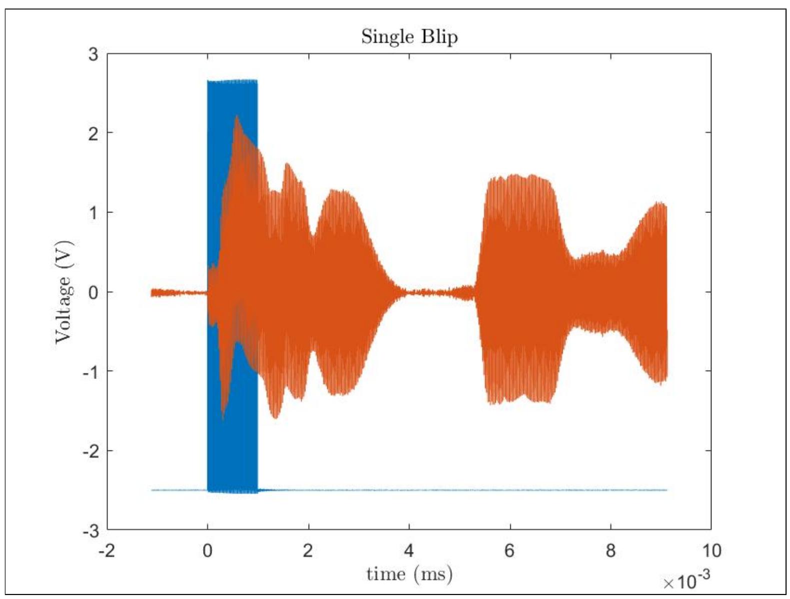

Figure 2: Clean Blip
The Figure shows the blip as cleaned up in Matlab. The Blue bar shows the output of the transmitter while the orange shows the receiver. There is noise around the origin as the receiver is picking up signal that it is sending out in the moment. The second blip seen at about 6 seconds shows the data of an object $3feet$ away. The sound roughly travels at $1ft/ms$. So it should take roughly double the time for the sound to travel to the object and then back to the receiver.

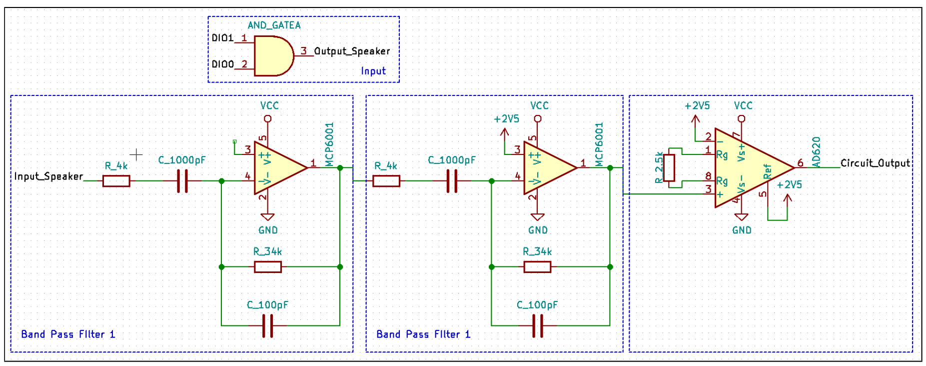

Figure 3: Circuit Schematic
This figure shows the final circuit schematic for the Ultrasonic Range Finder. The circuit consists of two parts. The first is the input which is shown above; it consists of two digital inputs and and And gate. The second part of the gate is a receiver that consists of two band pass filters and and amplifier

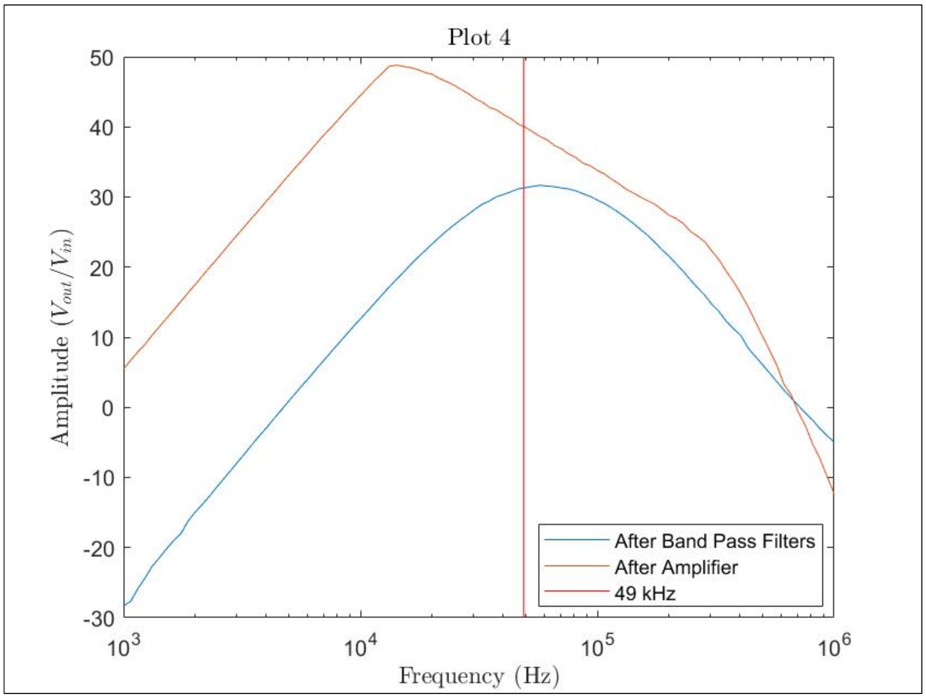

Figure 4: Ultrasound Range Finder Bode Plot
This figure shows the bode plot for the circuit. I chose to show two bode plots. One before the final amplifier shown in blue and one after the final amplifier shown in orange. The red line shows the $40kHz$ line. The before amplifier shows the circuit on track to the desired output. The after amplifier as a severe dent beginning at approximately $10,000Hz$. This behavior can be explained by the slew rate and the gain-bandwidth trade off. As we approach the limits of what the op amps can do. In a future design this flaw can be mitigated by having the gain occur in even smaller pieces as not to push the limits of the op- amps

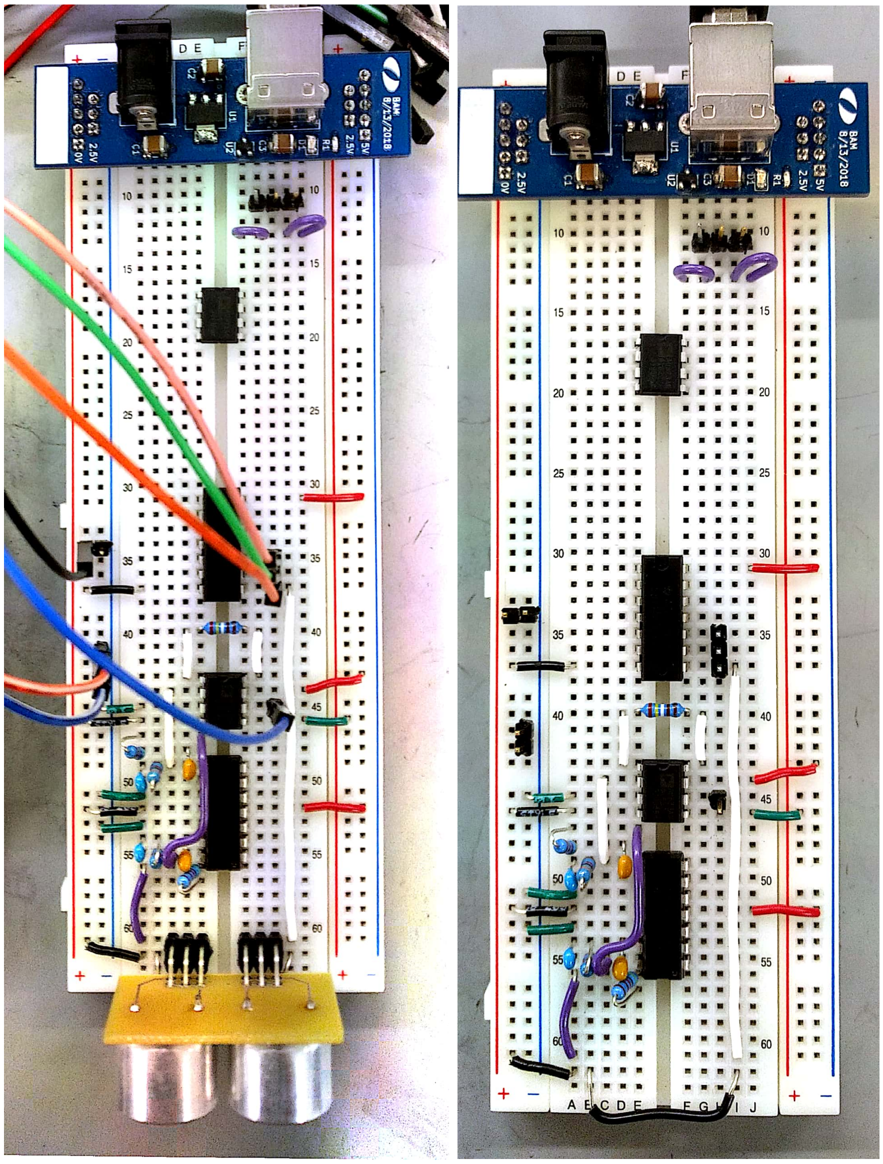

Figure 5: Clean Circuit with and without Analog Discovery Wires and Transducer Board

Distance	Time
1	2
1.5	3
2	4
2.5	4.5
3	5.5
3.5	6.5
4	7
4.5	7.25
5	9
5.5	10
6	11.5
6.5	13

Figure 6: Distance Data
This figure shows the recorded data of Distance vs. time readout on the ultrasonic range finder

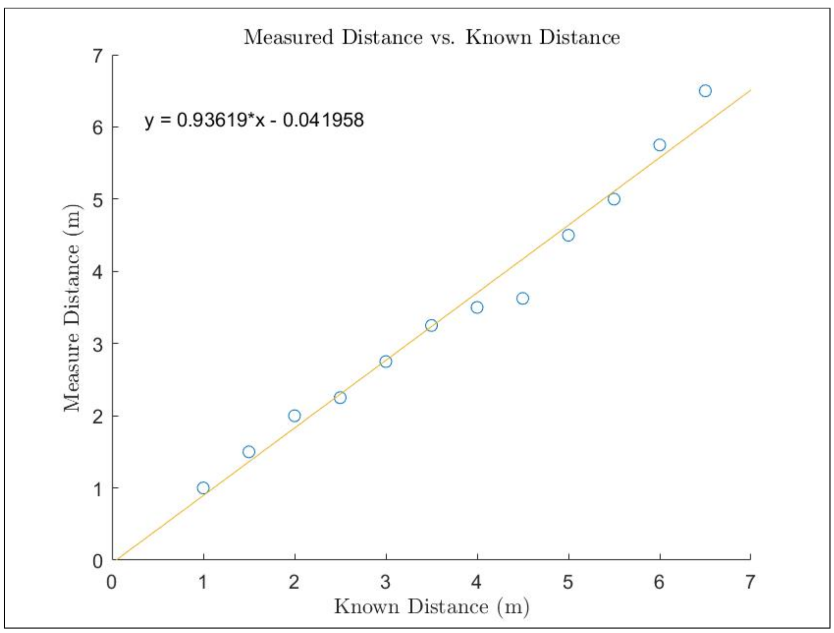

Figure 7: Measured Distance vs. Known Distance
The above figure shows a scatter plot comparing measured vs. known distances. The times were divided in half to compare and see if the data was directly proportional. With the exception of the data point at $4.5m$, the data does follow the trend pretty well. The data is indeed roughly linear and gives values that are on average just a little under double the distance. I would trusts this a way to estimate distance but not as a measurement tool. I would say that this range finder has roughly 80% accuracy. While not exactly directly proportional, the percent error is 6.381%. I would trust this when I need an estimate