ISIM Lab Report 10: Ultrasonic Rangefinder

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1 Description

In this lab, I built a circuit that gauges distance using an Ultrasonic sensor. The measurement circuit uses input from a transducer driving circuit, and a signal conditioning circuit that filters and amplifies the data to increase resolution.

To analyze the data, I created a calibration curve by finding the best fit line of the data as Time Delay vs. Distance. To test the accuracy of this model, I used a graphing calculator program to compute the coefficient of determination, a common statistical gauge of the accuracy of the variance in a given data set.

1.1 Circuit Schematic

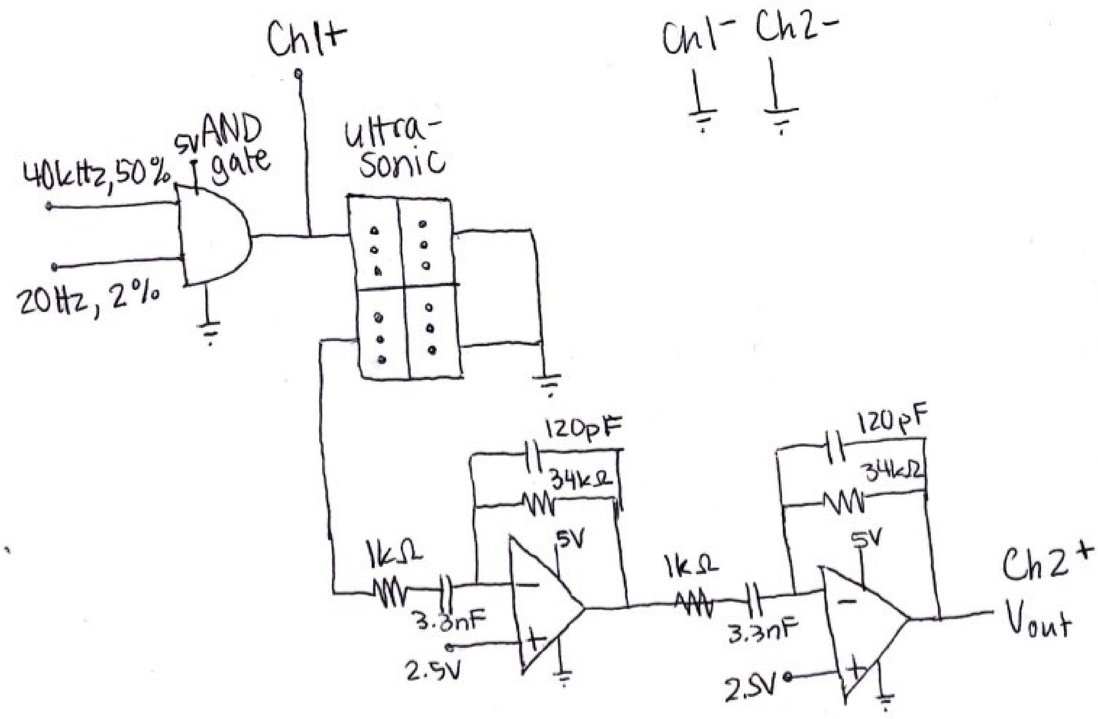

Figure 1: Ultrasonic Circuit Schematic

The input to the Ultrasonic sensor is the transducer driving circuit, consisting of a signal that is the output of the AND gate, with the inputs being a 40 kHz, 50% duty signal and a 20 Hz, 2% duty signal.

The output of the Ultrasonic sensor is then processed by two bandpass filters, centered on the 40 kHz output frequency. Below are the calculations that characterize the signal conditioning circuit.

High Pass cutoff frequency:

$$f_{high} = \frac{1}{120pF * 34k\Omega} = 39kHz \tag{1}$$

Low Pass cutoff frequency:

$$f_{low} = \frac{1}{3.3nF * 1k\Omega} = 48kHz \tag{2}$$

Total Gain:

$$G = (\frac{34k\Omega}{1k\Omega})^2 = 1156 \tag{3}$$

2 Circuit Picture

Here is the picture of my completed circuit.

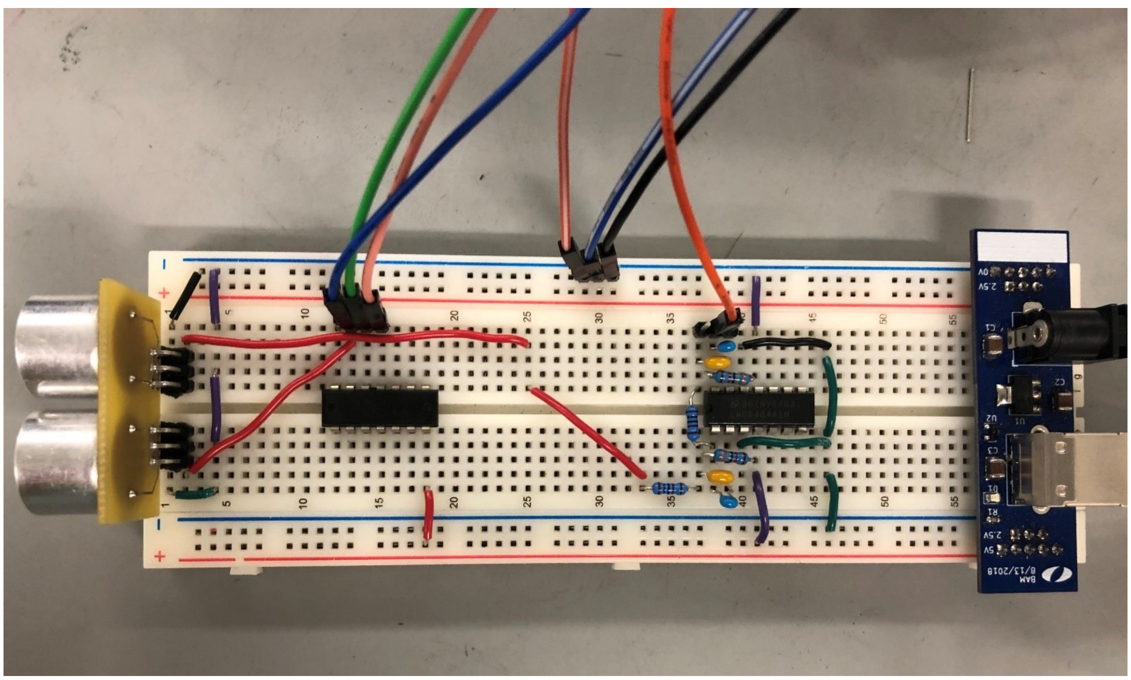

Figure 2: Ultrasonic Circuit Picture

3 Bode Plot

This is the resulting bode plot from the signal conditioning circuit. The peak of the plot is about 42 dB at 40 kHz.

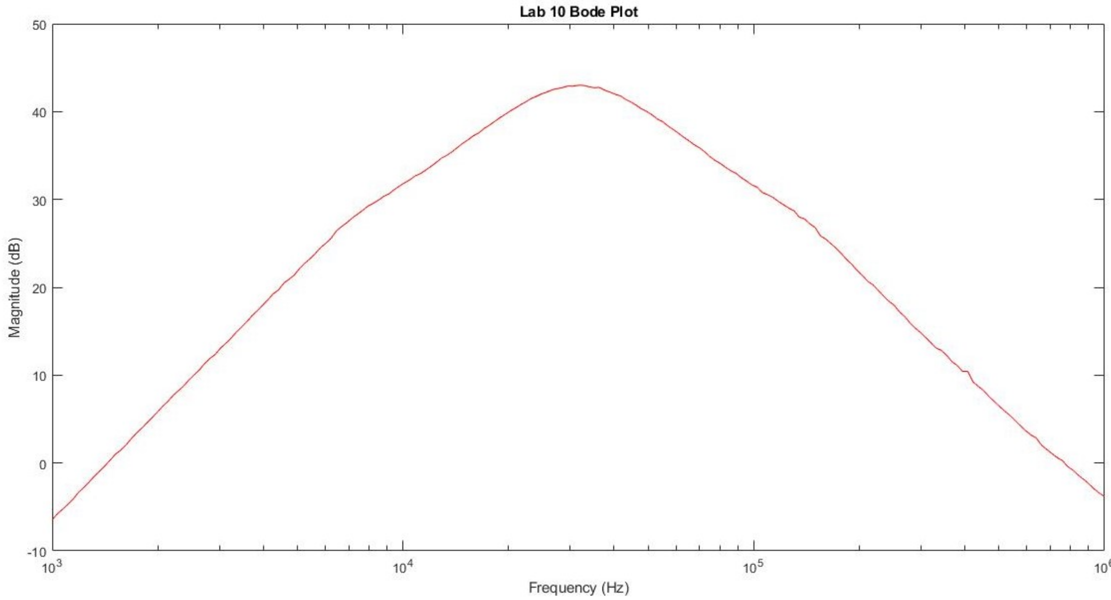

Figure 3: Signal Conditioning Circuit Bode Plot

4 Representative Data

Here is a graph of a representative data sample of my Ultrasonic sensor circuit working, with the time delay labelled. At a distance of 10 feet, the signal took 18 ms to bounce back.

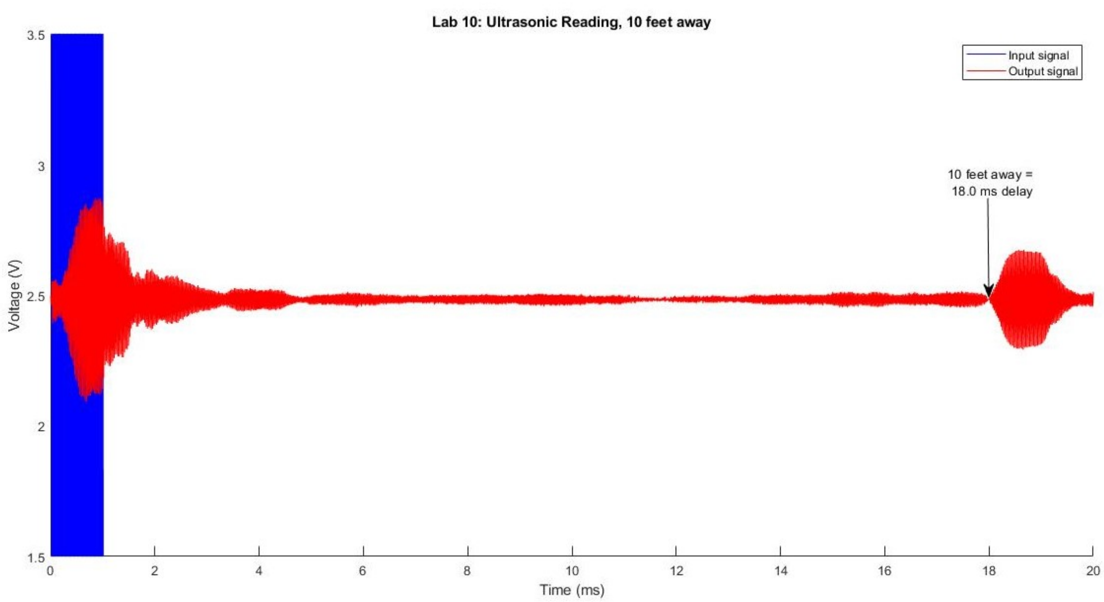

Figure 4: Input and Output Signal Graph

5 Distance Graph

The graph below shows the data collected of the response time delay versus distance. The data is strongly linear and is shown with the equation of best fit.

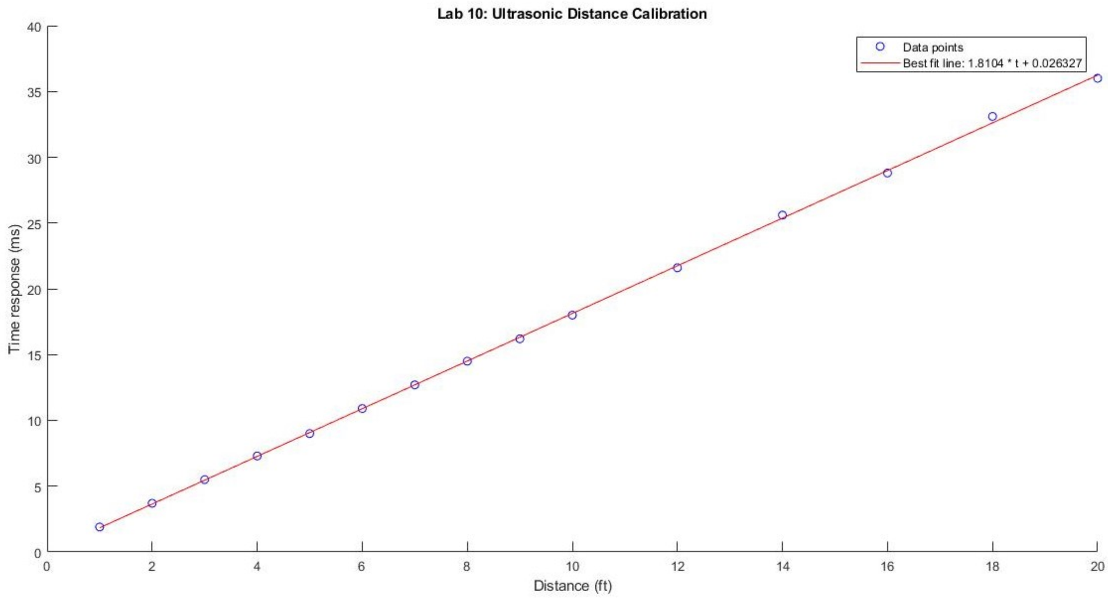

Figure 5: Time by Distance Graph

I plugged this equation and my data points into an online graphing calculator and received the same result, with a coefficient of determination, or "R^2", of 0.9997. This indicates a very strong correlation between the time delay and distance measurement.

My range finder is working quite well and reports relatively correct values within a 20 foot range. However, the signal was starting to fade and become harder to see even at a 15 foot distance, so I would trust it more the closer the target is.

The results would probably be more noisy if I hadn't taken care to clear all obstacles and objects in the vicinity and the view of the rangefinder before taking the data.