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Introduction to Sensors, Instrumentation, and Measurement

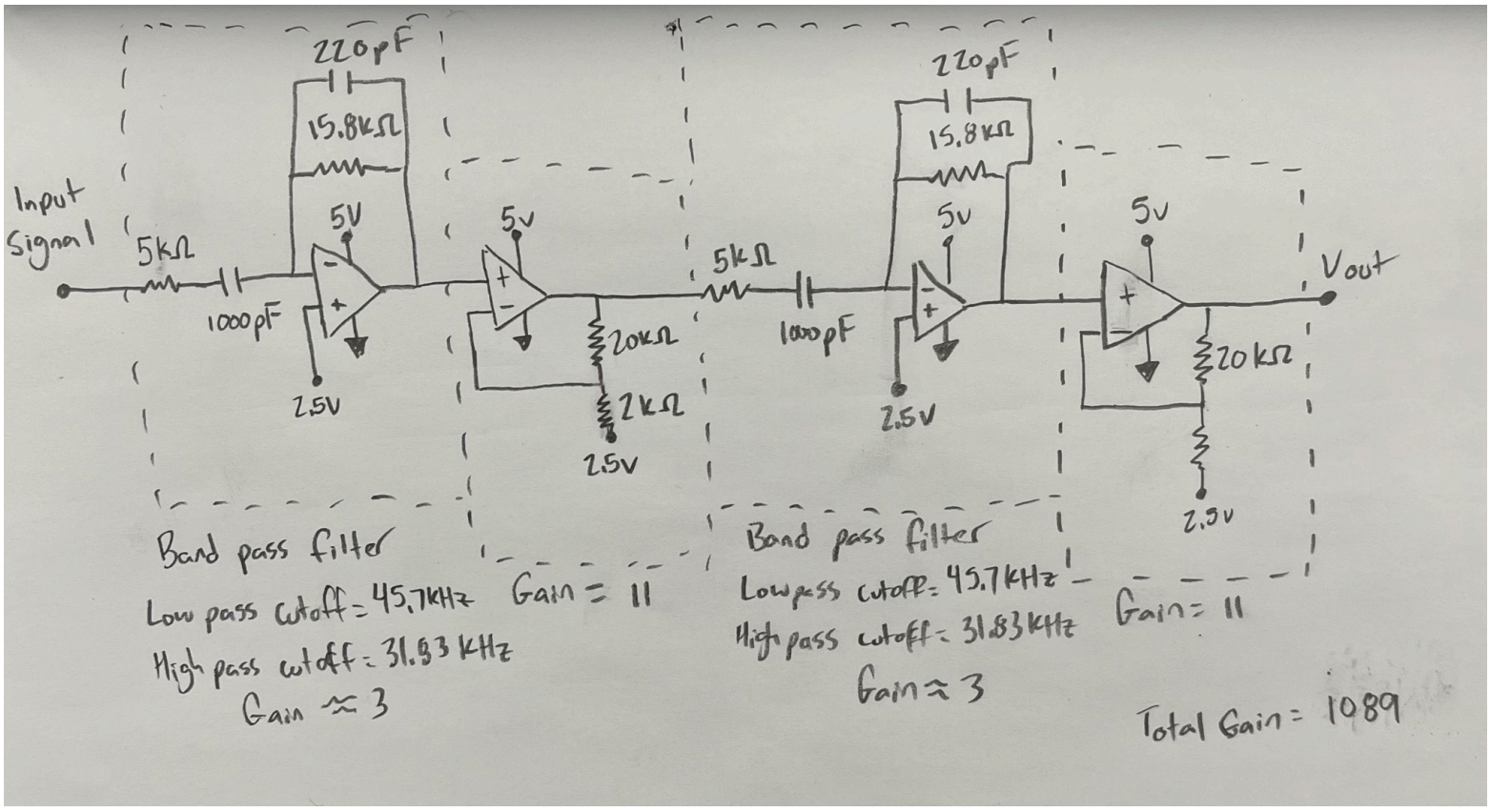
03/19/2024

Lab Nine: Ultrasonic Range Finder

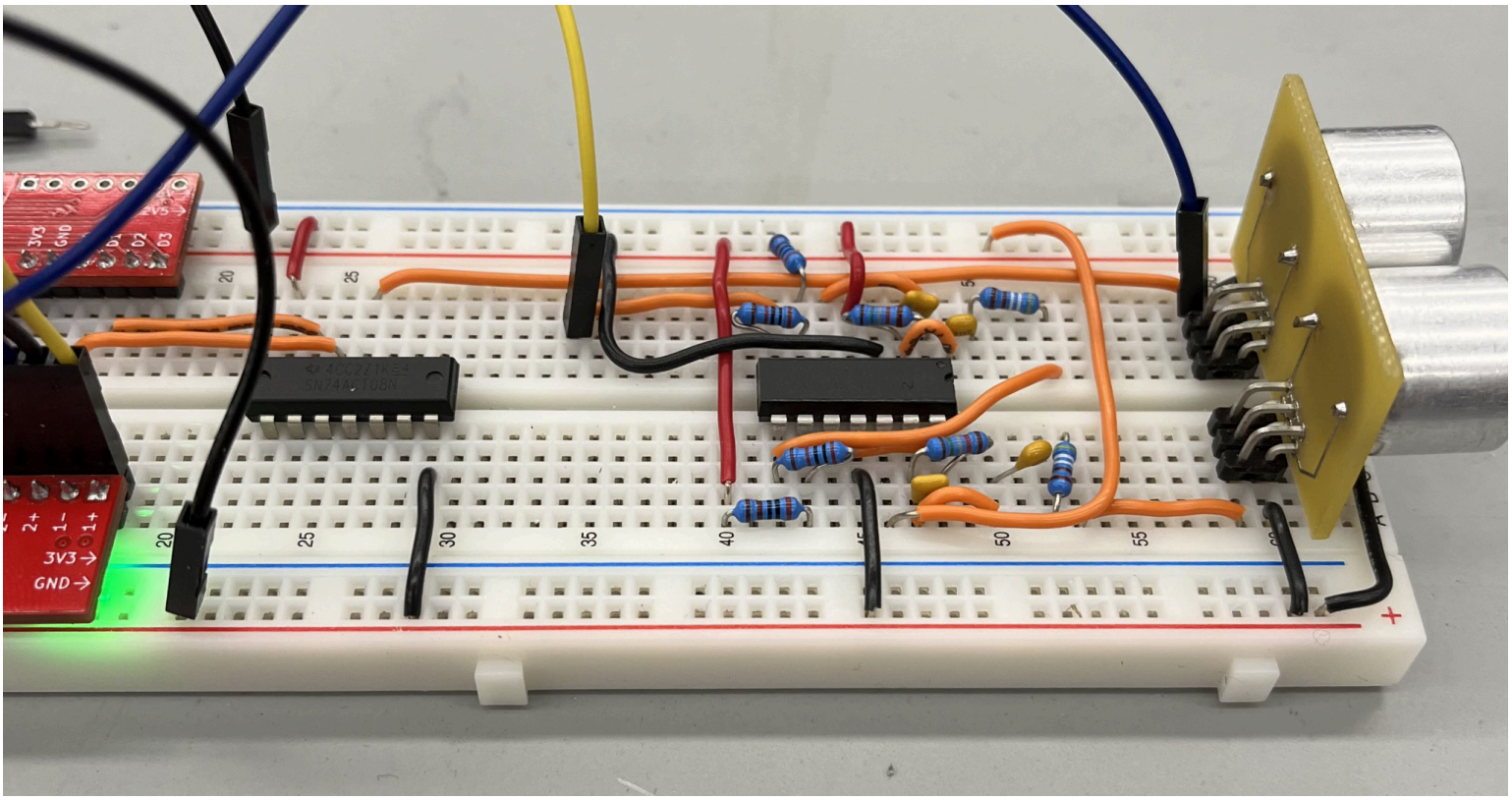
Purpose:
Design, build and test an ultrasonic range finder.

Results:

1.) 1/2 point: A sketched and labeled schematic of your receiver circuit.

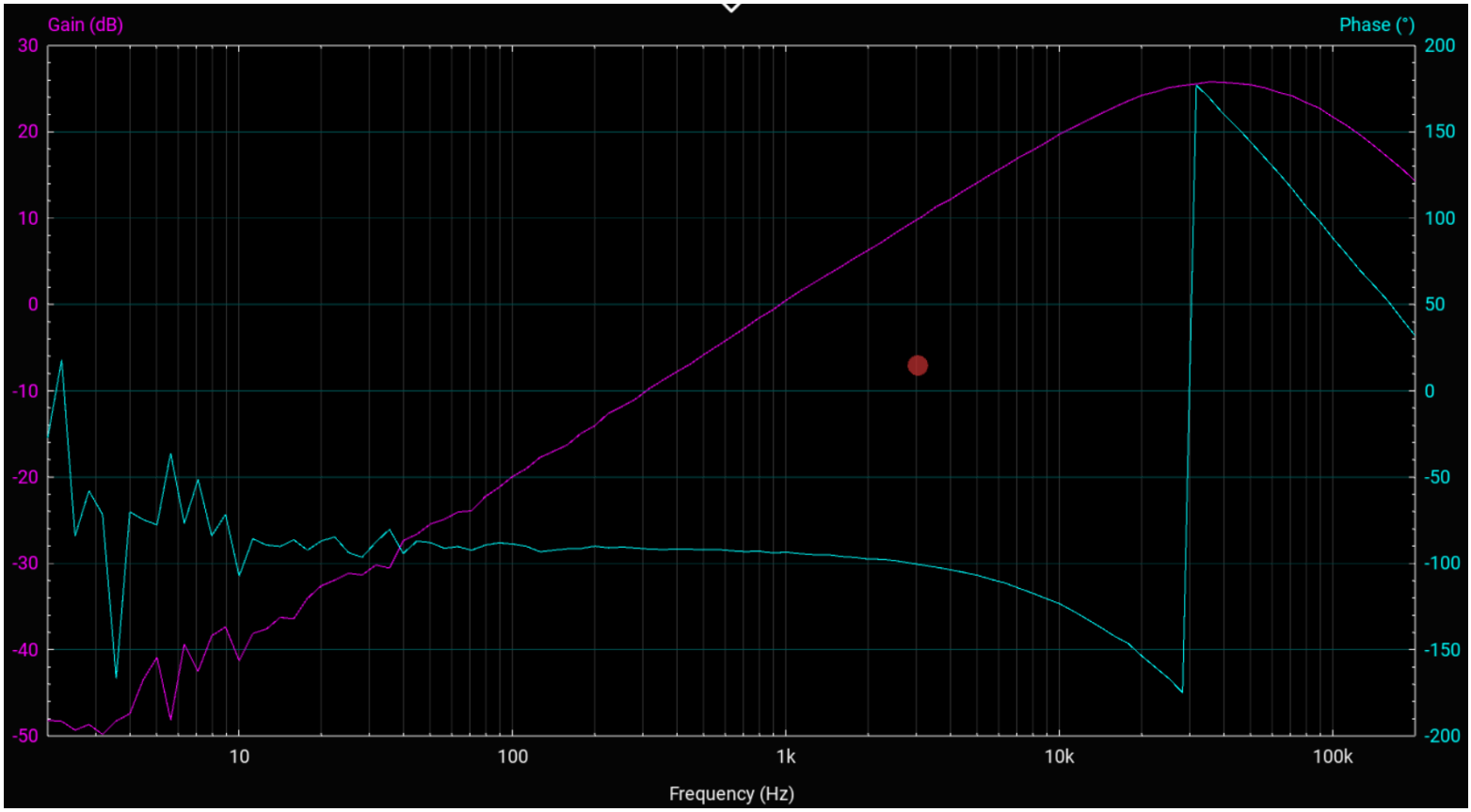


2.) 1/2 point: A photo of your circuit.



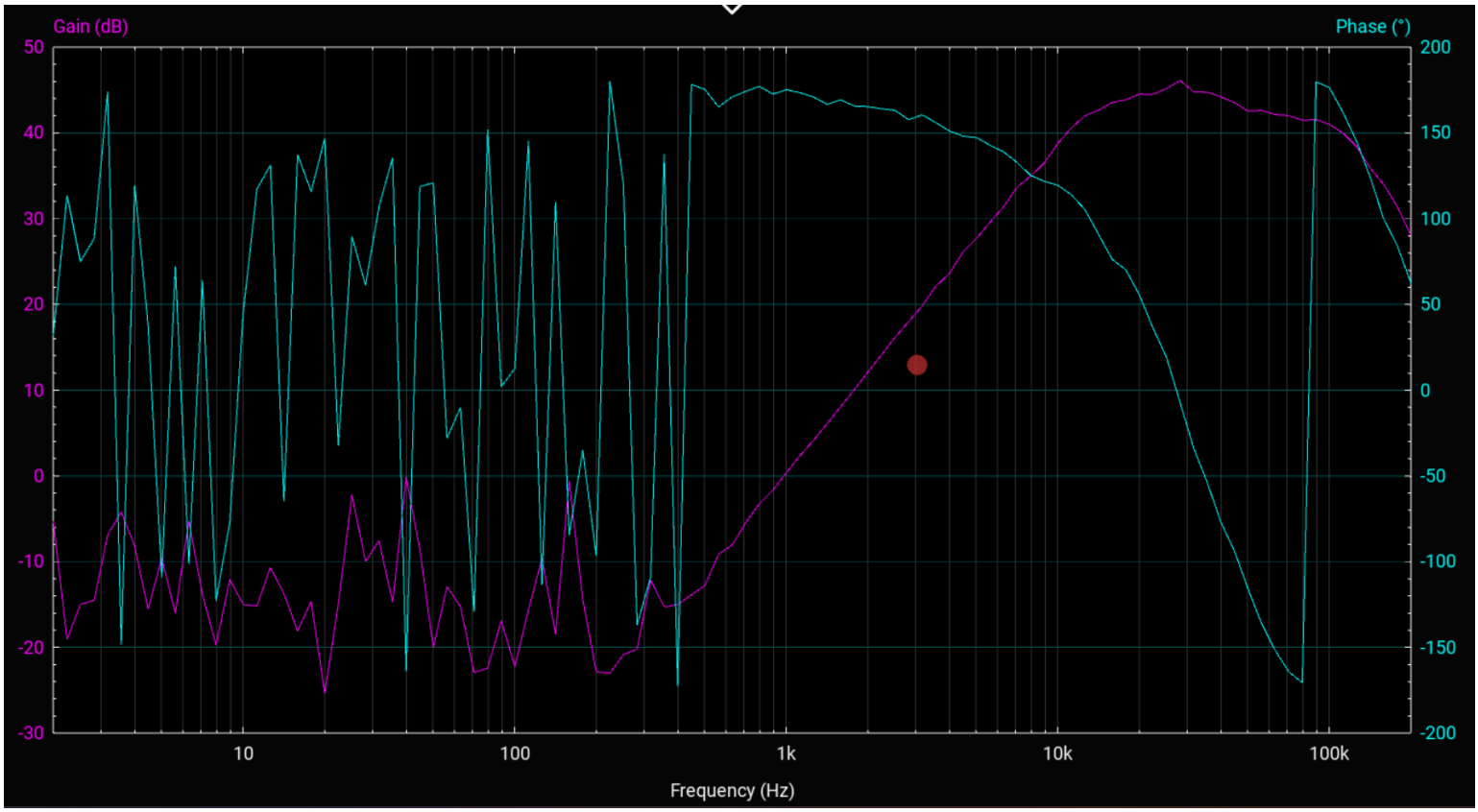
3.) 1/2 point: A measured Bode plot for your complete receiver circuit.

Bode Plot for Half of Receiver Circuit



Bode Plot for half of my receiver circuit. This has a band-pass filter with a low-pass cutoff of 45.7kHz, a high-pass cutoff of 31.83kHz, and a gain of three. It also has an operational amplifier with a gain of 11. This centers the amplification of the input signal around 40kHz.

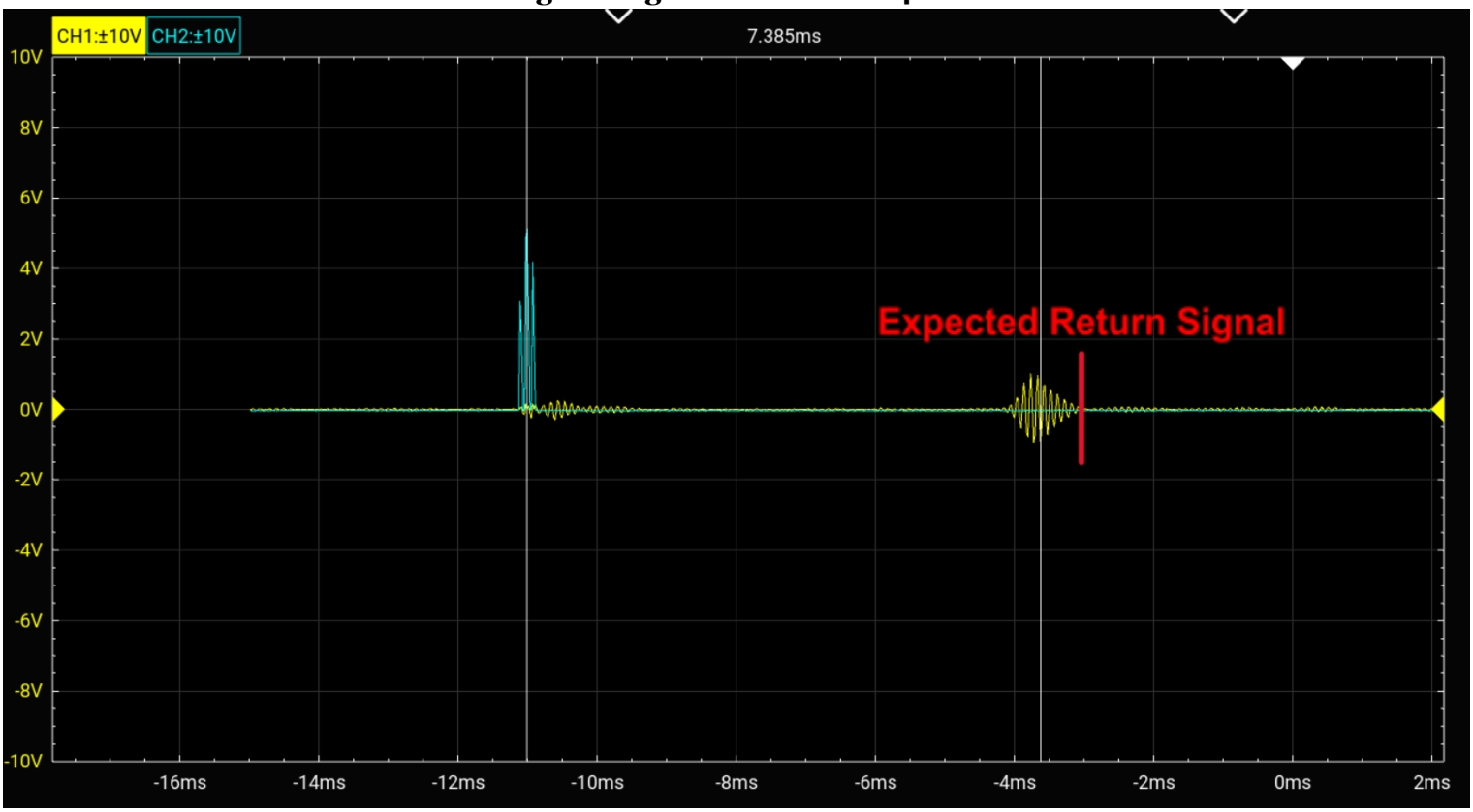
Bode Plot for Full Receiver Circuit



Bode Plot for full receiver circuit. This circuit contains two identical halves. The input signal first passes through a band-pass filter with a low-pass cutoff of 45.7kHz, a high-pass cutoff of 31.83kHz, and a gain of three, as well as an operational amplifier with a gain of 11. Then, the signal passes through a second band-pass filter and operational amplifier with the same values. Although tested individually, both circuits produce a bode plot with amplification focused on 40kHz like the one featured above, when combined, the amplification is centered on 30kHz. However, the dropoff is much steeper in comparison to half of the circuit, and a signal of 40kHz is still amplified by nearly 50 dB.

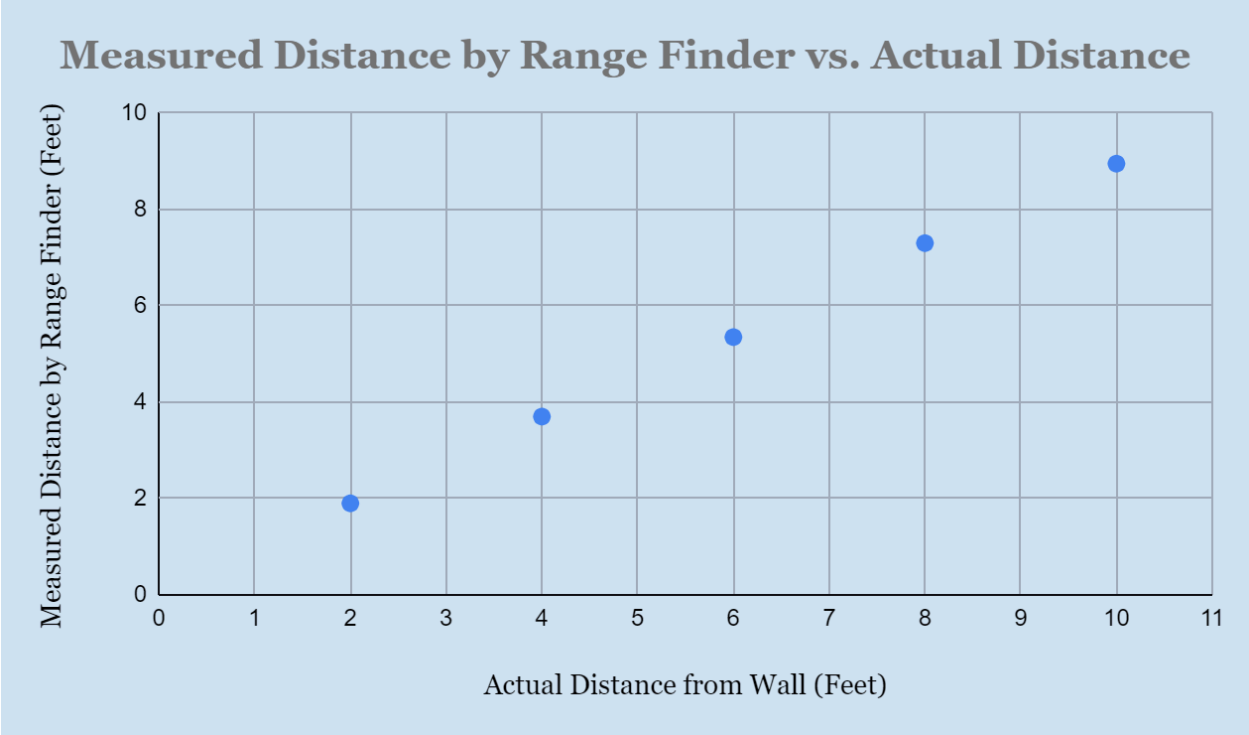
4.) 1/2 point: Representative data from a single blip with the transmitted and received signal on a single plot. Denote on the graph the time where the echo would be expected to be returned from the known distance to the wall.

Single Range Finder Test at 4 Feet



This is a single test of the rangefinder from a distance of 4 feet from the wall. However, the rangefinder detects the return signal after 7.385 ms, or roughly 7.39 feet of travel. Since this accounts for travel to and from the wall, the rangefinder predicts the wall is 3.7 feet away. Compared to the actual measurement of 4 feet, the range finder has a percent error of 7.5%.

5.) 2 points: A labeled plot of “measured distance from your ultrasonic range finder“ vs. “the known distance” with units. Plot all your data as points on a scatter plot.



a.) Comment on how well your range finder works (Is it linear? does it give the correct result?).

The plot produced is linear within 10 feet of the wall, but the measured distance is consistently shorter than the actual distance. Additionally, although the graph is linear, the farther the distance, the larger the error in measurement. My range finder works with about an average of 7.5% error.

b.) Comment on to what accuracy you would trust your range finder (this is an estimate, we have not discussed statistically how to make these judgments in a more formal way!).

I would trust my rangefinder to measure something with 90% accuracy as long as the distance was under 10 feet, as I had trouble consistently getting measurements more than 10 feet in distance.