Mixed Electronics Lab 9
Ultrasonic Range Finder

Caitlin Armstrong, Riley Myers

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1 Introduction

In this project students will design their own ultrasonic range finder (URF) system and will display distances measurements. Students will test their system and determine its accuracy and precision. They will present these results in a formal report.

2 Speakers

Ultrasonic speakers are characterized to work at 40kHz, but can be operated at various frequencies. Students will need to determine the limits on their sensor performance and confirm that the ultrasonic speakers behave as expected.

1. Using both speakers, design a test apparatus where one speaker is used to emit a 40 kHz signal the other is used as a microphone to receive the signal.
2. Create a table that describes the performance of your speaker and receiver system at varying frequencies, input voltages, and distances.
3. Using the speaker and receiver system, what is the maximum distance you can separate the two elements before transmission is lost?

3 Chirp Signals and Distance Measurements

Because waves move through air at a uniform speed, it is possible to determine the distance to objects by measuring the delay between a chirp and its echo. This is a measurement technique known as time-of-flight sensing. In order to build an URF, students will need to develop a program using their micro controller (or FPGA) to generate a brief 40kHz chirp. They will need to use a second speaker to receive the echo, and develop a system that amplifies and digitizes this signal. The digital controller will then measure and return the duration of the echo, converted into a distance measurement based on the speed of sound in air.

1. How can you control the frequency of your chirp?
2. How long will the chirp play, and how long will the total period of your signal be?
3. How do these settings affect the limit of your measurement? Consider exploring several different chirp durations and periods.
4. How can you maximize the range of reliable values?

4 Characterizing Performance

For this project it is important to determine the accuracy and precision of your sensor in order to confirm the success of the design. System accuracy is measured in reference to true values, while precision relates to the range of results produced from a single arrangement.

1. Determine what measurements will confirm the accuracy of your device, design a test and record your results.
2. Determine what measurements will confirm the precision of you device, design a test and record your results.

4.1 Design Challenge: Build your own distance sensor

After testing their speakers, and having generated an input signal students will show that they are sending a 40 kHz chirp from one speaker.

Once students have shown that they've generated a reasonable chirp signal, they will demonstrate that the design of their filter and amplification signal produces a digital high when an echo is measured. They will be able to read this output from their microcontroller or FPGA.

With all the hardware assembled, students will write a program that measures the delay between chirps and echos and converts that measurement to a known distance. The measured distance will be displayed on one or more seven-segment or LCD displays. Remember to characterize the the accuracy and the range of the system and discuss various tuning parameters.

As an extra challenge, consider what would be needed to compute the doppler velocity of the measured object. Sketch out what modifications to the current sensor (or code) you would need to implement.