SENSORS AND ACTUATORS

ULTRASOUNDS

Laboratory Guide

IDENTIFICATION

Weekday	Date	Hour	Group	Students
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INTRODUCTION

An acoustic wave is an alternating compression and expansion of a medium that can be solid, liquid or gaseous. These waves are said to be sound if the frequency is between 20 Hz and 20 kHz. Below 20 Hz they are called infrasound and above 20 kHz are called ultrasound.

Detection of infrasound is used in structural analysis of buildings, forecast earthquakes and other large sources. When infrasound has a significant magnitude it can be felt by humans even causing psychological effects (panic, fear, etc.).

Audible waves can be created by vibrating strings (stringed musical instruments), vibrating columns of air (wind instruments) and vibratory plates (some vibrating tools, vocal cords, and loudspeaker).

Ultrasounds are typically used to measure distance or proximity. A wave is emitted at a certain point and the time it takes for it to return to that point after being reflected in a given object is measured to determine the distance traveled by the wave.

The ultrasonic transducers in general can act as transmitters or receivers. These translators can be constructed using piezoelectric materials.

The emitters convert a voltage into a deformation which in turn displaces the air (or other medium) causing a wave. The receiver does the opposite. The pressure change causes the medium to deform the piezoelectric material which in turn produces a voltage.

There are several methods used to estimate the distance using ultrasound. This work uses the time of flight of a sinusoidal burst determined using the correlation peak of the signal sent and received.

A target structure consisting of a wooden square with a width of 20 cm is available, as well as a printed circuit board containing the ultrasound transmitter and receiver. You are free to move them on a horizontal track. It is possible to manually adjust the distance between the ultrasonic transducer and the target.

Recommended reading: Book Sensors and Actuators by Francisco Alegria, sections 6.4, 6.5 and 6.6.

EXECUTION

1) Connecting the Ultrasound Module to the Microcontroller

Connect the module that contains the ultrasound emitter and receiver (HC-SR04 from Cytron Technologies) to the Arduino microcontroller. Present a drawing of the connections with the pin names/numbers used. Describe the function of each of the 4 pins of the ultrasonic module.

2) Programming the Microcontroller

Create a program for the microcontroller using the Arduino IDE that is able to obtain from the ultrasound module the information about the distance to a target and display it in the PC console as a distance in centimeters. Present only the main parts of that program. What is the signal read from the ultrasound module? How is it converted into a distance-to-target? Send the application code, compressed in a ZIP or RAR file to the teacher by email.

3) Characterizing the Performance of the Ultrasound Module

Using a ruler and the application created, determine the relationship between real and measured distance-to-target (use 5 to 10 different values of distance). Plot a chart with that relationship. Determine an upper bound for the linearity.

4) Upsetting the Normal Operation of the Distance Measurement System

Make hypothesis about what could affect the operation of the distance measurement system. Experimentally evaluate as many of those hypothesis as possible. Write down some conclusions.

MATERIAL

- Ultrasonic module HC-SR04 (Cytron Technologies)
- Aluminum track
- Wooden target
- Arduino Uno
- Personal Computer