Signoff Request - April 29th, 2022 - Navigation (IR and Ultrasonic Sensors)

Sunday, April 24, 2022 2:15 PM

IR and Ultrasonic Sensors:

This signoff request is for the infrared (IR) and ultrasonic sensors which will be used in the design for the Autonomous Crawl Space Inspection Robot. The IR sensors reside in the "Navigation Subsystem" on our block diagram and will be responsible for obtaining distance measurements of the robot from the floors of the crawlspace environment so that the robot will not be damaged by sudden drops or become stuck in various height dips of the crawlspace. The ultrasonic sensors also reside in the navigation subsystem and will be responsible for obtaining distance measurements from walls and other obstacles within the crawlspace environment. The Ultrasonic sensors will be working in conjunction with the Lidar sensor and will serve as a failsafe/error check for close objects to the robot. In the case that the lidar sensor stops spinning or does not detect objects that are out of sight in terms of height, the Ultrasonic sensors will detect and help mitigate any collision or mapping mistakes that would otherwise occur.

An infrared (IR) sensor is a module which uses infrared (IR) light to determine the distance from objects in a surrounding environment by emitting an infrared beam of light and receiving the light and calculating the angle between the transmitted beam and received beam. The capstone team will be utilizing an IR sensor to obtain the distance of the autonomous robot from the floor of the crawlspace environment. While there are many infrared sensors available for purchase, the team believes that the chosen sensor is sufficient due to the supplied schematic, power draw, data output, and cost. The IR sensor will be positioned on the robot in a way that sufficient measurements can be taken with enough time reserved for the robot to detect the drop offs and process the needed to stop.

An Ultrasonic sensor is a module which utilizes sound waves to determine distance from objects by emitting a sound wave and recording the time that it takes for the soundwave to be received. While the Lidar sensor is being used to analyze and draw a map of the crawlspace environment for movement, the Ultrasonic sensors will be used as an error check as well as a measurement of distance from objects that are below the line of sight of the Lidar sensor.

IR Sensors:

The chosen IR sensor has three connections, one for the supplied voltage (VCC), one for the ground (GND), and one for the data output by the sensor (DATA). Since there will be two IR sensors used on the robot, one for the front and one for the back, in total there will be two VCC connections, two GND connections, and two DATA connections coming from the IR sensors to the Raspberry Pi. The chosen IR sensors can output digital data with the digital data being observed as low (0 Volts) or as high (5 Volts). The logic low represents when an object is not present and the logic high represents when an object is present. The specific range of the IR sensor can vary from 2 cm to 30 cm and is adjustable using the built in potentiometer (variable resistance of 10 kOhms on the device. Since the Raspberry Pi GPIO pins are only rated for 3.3 Volts, a voltage divider will be used in order to drive the voltage down to an acceptable voltage value that will not cause damage to the pins [1]. A bandpass filter is included in the design of the IR sensor [1]. The IR sensors have a measuring angle of 35 degrees which can be used to detect the upcoming drop-offs in the crawlspace. The schematic for the detailed information of the IR sensor is shown in figure 1 and the physical appearance of the IR sensor as well as the pins that will be used are shown in figure 2. In total, two IR sensors will be needed and are priced at $0.99 per unit, resulting in a total price of $1.98, however, the chosen device and other devices like it are only available in packs of multiple sensors. Thus, the total price for the IR sensors would be $10.00 for a pack of 10 which could be used in the case that the sensors break of additional sensors are added on each side of the robot.

Figure 1 [1]:

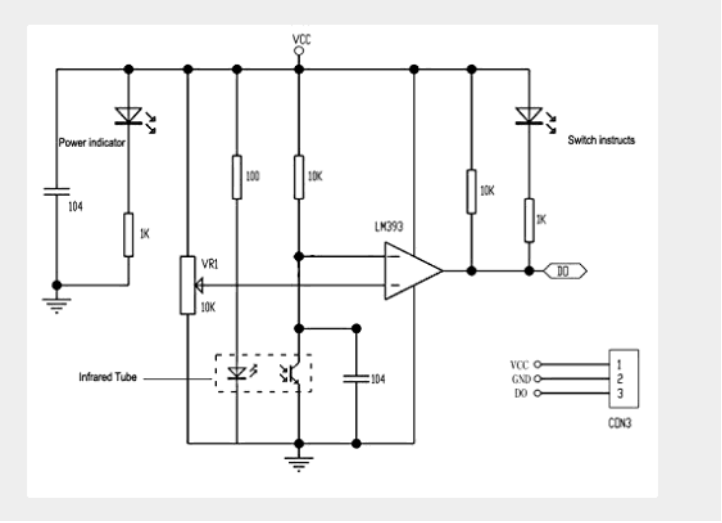
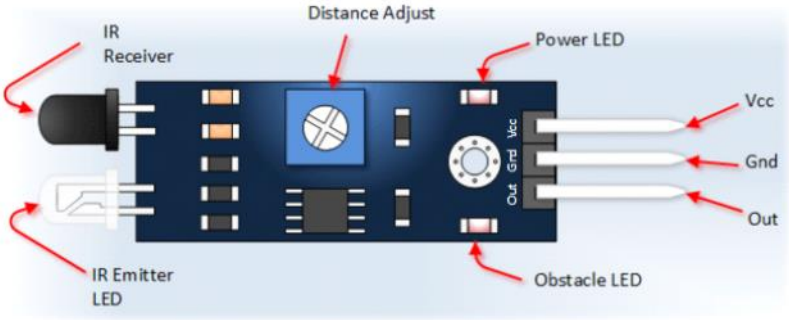


Figure 2 [1]:

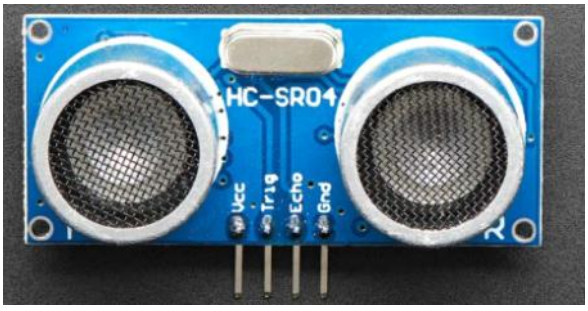


Ultrasonic Sensors:

The chosen Ultrasonic sensor has four connections, one for the supplied voltage (VCC), one for the ground (GND), one for the emitted sound signal (TRIG), and one for the received sound signal (ECHO). Since there will be four IR sensors used on the robot, one for each side, in total there will be four VCC connections, four GND connections, four TRIG connections, and four ECHO connections coming from the Ultrasonic sensors to the Raspberry Pi. The chosen Ultrasoinc sensors output digital data with the digital data being observed as low (0 Volts) or as high (5 Volts). The way that distance measurements are calculated is by measuring pulse time between the generated signal and the received signal. Since the speed of sound is constant in the vacuum of air, the distance can be traveled can be determined by the flowing formula: (speed)*(time)/(2). In this formula, the distance from the sensor to the object and back to the sensor is calculated by (speed)*(time), with the division of two being needed so that only the distance from the sensor to the object is calculated.

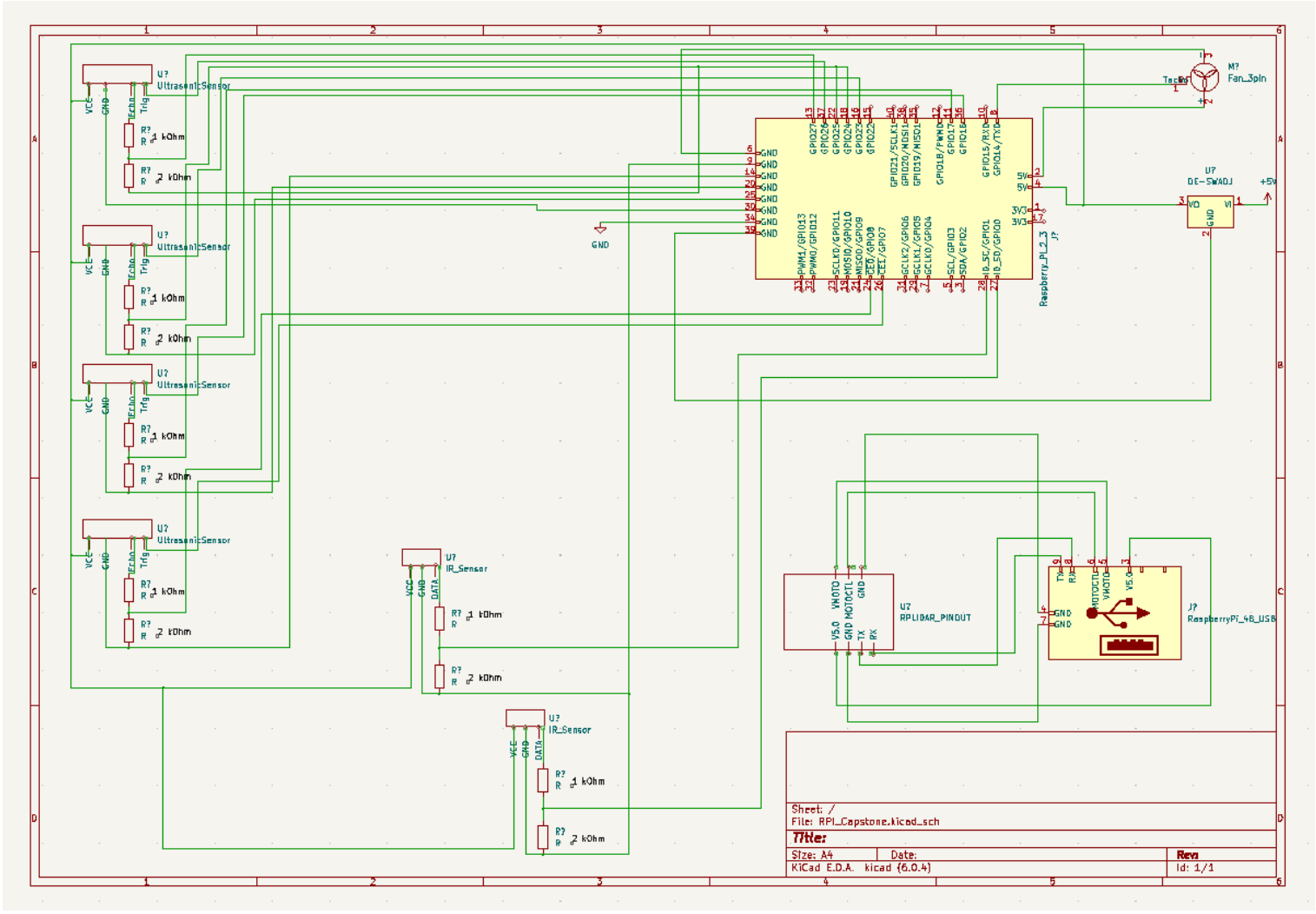
The specific range of the IR sensor can vary from 10 cm to 250 cm. Since the Raspberry Pi GPIO pins are only rated for 3.3 Volts, a voltage divider will be used in order to drive the voltage down to an acceptable voltage value that will not cause damage to the pins [1]. Additionally a band pass filter is included in the design of the sensor. The schematic for the detailed information of the IR sensor is shown in figure 3. The IR and Ultrasonic sensors connected to the Raspberry Pi with the needed voltage dividers are shown In figure 4. In total, four Ultrasonic sensors will be needed and are priced at $3.95 per unit, resulting in a total price of $15.80.

Figure 3 [2]:



IR and Ultrasonic Sensors With Raspberry Pi Schematic:

Figure 4:

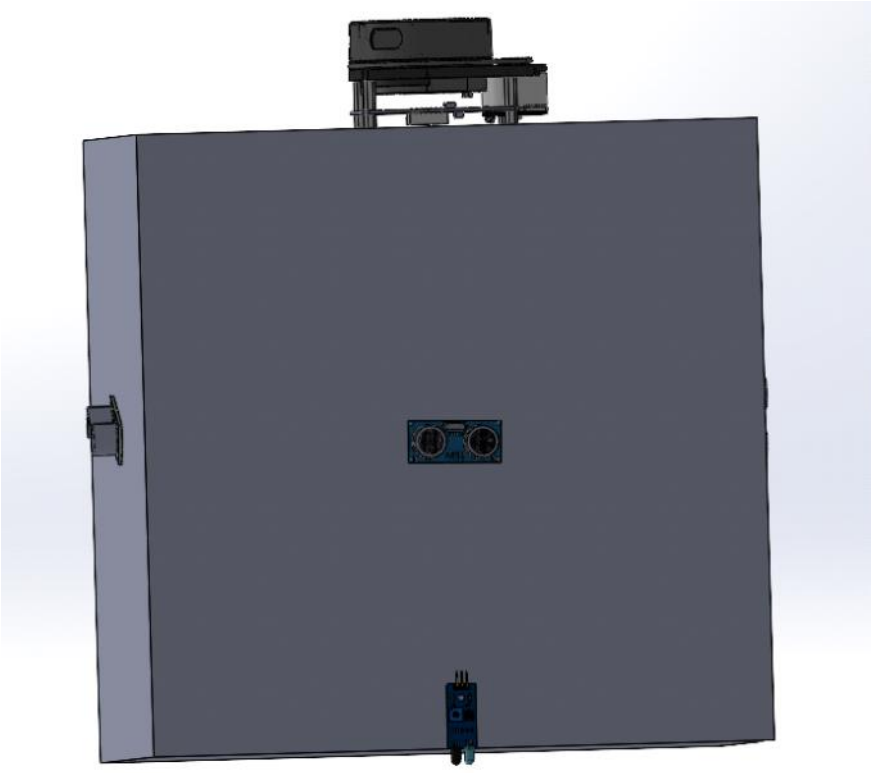


3D Model (Position On Robot)

As stated by the manufacturer, the dimensions of the IR sensor are as follows: a height of 1.22 cm, a width of 1.5 cm, and a length of 3.1 cm (0.47 inches x 0.59 inches x 1.22 inches) [1]. In this initial design of the robot's structure, the IR sensors will be mounted on the front and back of the robot, pointing towards the ground. As seen in figure 5, the IR sensors will sit towards the bottom of the robot on the front and back sides to detect the distance from the ground and upcoming drop offs. The overall structure of the robot has not yet been designed, so as with the Lidar sensor an estimated size of the robot is being used.

As stated by the manufacturer, the dimensions of the Ultrasonic sensor are as follows: a height of 1.55 cm, a width of 2.0 cm, and a length of 4.55 cm (0.61 inches x 0.78 inches x 1.79 inches) [1]. In this initial design of the robot's structure, the Ultrasonic Sensors will be mounted on the front. Back. Left. And Right sides of the robot, pointing perpendicular to the faces on which they are mounted. As seen in figure 5, the Ultrasonic sensors will sit near the middle of the sides to detect the distance from the upcoming objects and the robot. The overall structure of the robot has not yet been designed, so as with the Lidar sensor an estimated size of the robot is being used.

Figure 5:



Sources:

[1] IR Sensor Manufacturer Specifications and Datasheet:
https://osoyoo.com/2018/12/21/ir-obstacle-avoidance-module/

[2] Ultrasonic Sensor Manufacturer Specifications and Datasheet:
https://media.digikey.com/pdf/Data%20Sheets/Adafruit%20PDFs/3942_Web.pdf