

Household Premises Surveillance System Using Ultrasonic Sensor

Ilori Oluwaseyi Ayodeji¹

¹(Physical Sciences, Redeemer's University, Nigeria)
Corresponding Author: Ilori Oluwaseyi Ayodeji

Abstract: Motion detectors play a vital role in our daily lives, a very common example is an automatic door which opens when an individual approaches it and closes after the individual has passed through. They are also used in the control of lighting systems; the light is switched on when the sensor detects motion and switched off when no motion is detected. In this article an ultrasonic sensor was interfaced with a PIC microcontroller and a buzzer which makes a beeping sound when an intruder is detected. An ultrasonic sensor was chosen because the range of detection can be distinctively set with aid of the microcontroller and any object outside a specific range will not be detected. An ultrasonic sensor (HC-SR04) was used and it has a maximum range of about 4 m.

Keywords: Ultrasonic, Motion detector, microcontroller

Date of Submission: 04-01-2019

Date of acceptance: 21-01-2019

I. Introduction

Various types of motion sensors can be found around us and they are applied differently depending on the nature of the environment and what purpose it is to serve. Motion sensors are basically classified into two major groups which are passive and active sensors. Passive sensors generally listen for changes in environment to detect motion; an example of such sensor is the passive infrared sensor. Active sensors send out energy to be reflected off a target. The ultrasonic sensor is an example of an active sensor; it generates ultrasonic waves which have a frequency that is greater than 20 kHz. This is clearly above the human audible range. Ultrasound has various applications some of which include treatment and medical imaging, [1] underwater navigation [2], vehicle detection at parking gate, anti-collision system in vehicles, bottle counting in industries etc. An ultrasonic sensor typically comprises at least one ultrasonic transducer which transforms electrical energy into sound and, in reverse, sound into electrical energy, a housing enclosing the ultrasonic transducer or transducers, an electrical connection and, optionally, an electronic circuit for signal processing also enclosed in the housing [3]. In this paper a system was designed using ultrasonic sensor to detect motion within a range of 2 m and trigger an alarm when an object is detected. This simply means that any motion that occurs beyond 2 m will not be detected.

II. Literature Review

Ultrasonic sensors have three major applications which are object detection or ranging, mapping and navigation. The ultrasonic sensor works on a principle similar to radar or sonar (sound navigation and ranging), it generates high frequency sound wave (ultrasonic waves) which evaluates attributes of a target by interpreting the echo signal [4]. Ultrasonic waves are of very high frequency and low wave length, this gives it high directivity and this is why ultrasonic sensors can be used for the above applications. Other advantages of ultrasonic sensors are;

- i. Its response is not solely dependent on the surface colour of the target.
- ii. Ultrasonic sensors are very sensitive this makes their response time very fast.
- iii. One major advantage is that the ultrasonic sensor can be used to determine the accurate distance from the target

And we will be exploiting these advantages in this project.

Much work has been done with ultrasonic sensors one of which it was used in a security system [4]. In this design an ultrasonic sensor was placed on a rotating motor and interfaced with a microcontroller, GSM module and digital camera. As the ultrasonic sensor rotates when it detects an objects the motor stops and the microcontroller calculates the range of the detected object. If the object is within the minimum range the microcontroller initiates a sound alarm and also the GSM modem to send an SMS to the concerned person and camera will capture the image of object to the storage device. One of the downside of this system is that there is a high chance of missing an intruder due to the rotating motor and also the range of detection is just only between 20cm-30cm which means the intruder has to be very close before he can be detected.

An array of ultrasonic sensors was also used as an indoor presence detector to control a lighting system in order to save energy. The proposed ultrasonic array sensor comprises of a broad-beam transmitter and co-located

array of receiver elements. Short bursts of sinusoidal pulses are periodically transmitted. This signal is reflected from the environment and the echoes are received at the receiver array [5]. In order to differentiate between moving objects and static objects the echoes corresponding to consecutive transmission bursts are subtracted. If the object is moving there will be a change in the frequency of the reflected bursts but if there is no change it means the object is static (no Doppler shift).

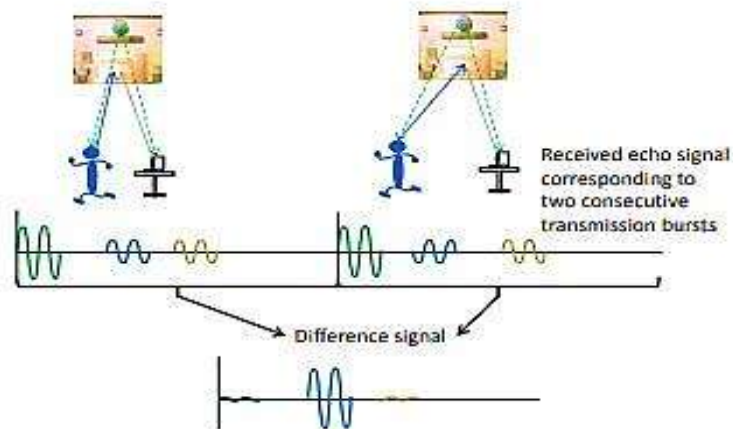


Figure 2: Illustration showing difference signal obtained by taking difference of received echo signals corresponding to consecutive transmission bursts with a static object and moving user in the sensing region [5].

In robotics ultrasonic sensors play a major role in object detection and avoidance. A smart security surveillance rover [7] was designed by interfacing an ultrasonic sensor with an Arduino board and a program deployed for the motion of the rover within the Arduino. When an obstacle is detected, the signal is sent to Arduino and the rover is turned to the suitable direction. A Raspberry Pi incorporated with the following - Wi-Fi repeater, web camera and a GPS module. As the rover is in autonomous motion it takes images and stores it on the Raspberry Pi. These images are sent to a remote PC monitored by the security people in the host area. When the rover is controlled manually through the remote host, the intrusion is detected by capturing each frame and image processing is performed. In case of any difference found, the remote device will receive an alert message.

III. Methodology

The device basically comprises of an ultrasonic sensor (HC-SR04) for sending and receiving ultrasonic waves, a microcontroller (PIC18F4620) which coordinates all the activities of the circuit and a buzzer. A 5v dc supply powers the entire circuit. The ultrasonic sensor is continually triggered by the microcontroller, when triggered it sends out short burst of ultrasonic waves until it falls on an object and it is reflected back. Once an echo is received by the ultrasonic sensor, the microcontroller calculates the time it took the ultrasonic wave to travel to and fro. If the object is within 2m of range the buzzer is switched on until the system is reset.



Figure 1: Block diagram of system

3.1 Ultrasonic Sensor (HC-SR04)

The ultrasonic sensor plays a vital role and it is interfaced with the microcontroller so that the microcontroller will be able to determine when to carry out a specified action based on the signals it receives from the ultrasonic sensor. The ultrasonic sensor has four terminals namely VCC, TRIG, ECH and GND. Table 3.1 shows the pin description of the ultrasonic sensor.

The microcontroller sends a high output signal to the trigger pin of the ultrasonic sensor. This causes the ultrasonic sensor to generate a short burst of ultrasonic waves, on reaching an object these waves are reflected back to the sensor and a high output signal is sent to the microcontroller through the echo pin. Using the following equations the range of the object from the ultrasonic sensor can be calculated by the microcontroller. The Ultrasonic wave propagation velocity in the air is approximately 340 m/s at 15°C of air or atmospheric

temperature, the same as sonic velocity. To be precise, the ultrasound velocity is governed by the medium and its temperature hence the velocity in the air can be calculated using the equation 1 [6]. But in this project we ignored the temperature and take the velocity (V) to be approximately 340 M/s

$$V = 340 + 0.6(t - 15) \text{ M/s} \tag{1}$$

t= temperature, °C

The distance between the object and the ultrasonic sensor can be calculated using equation 2.

$$\text{distance} = \text{speed} \times \text{time} \tag{2}$$

$$2d = v \times t$$

$$d = \frac{v \times t}{2}$$

v = Speed of sound in air

t = high level time (time it takes pulse to travel to and fro)

d = distance

The ultrasonic sensor (HC-SR04) has a maximum distance of 4m and objects beyond this range may not be detected.

Table 1: HC-SR04 Pin Configuration and Function

PIN	PIN NAME	FUNCTION
VCC	Power supply	Positive supply input (+5v)
GND	Ground	Ground reference
TRIG	Trigger	Receives input signal from microcontroller to activate sensor
ECH	Echo	Sends output signal to microcontroller

3.2 Microcontroller

The microcontroller is considered as the brain of the whole work because it coordinates the operations of the other peripherals; therefore all other parts depend directly or indirectly on it. A Microchip microcontroller (PIC18F4620) was used to achieve this. The microcontroller is divided into hardware and software.

The microcontroller hardware or structure which consists of a number of input and output ports, memory, CPU etc. is strictly determined by the manufacturer and cannot be changed. The software was programmed to give instructions to the microcontroller in order to perform some functions as required by the work. The pin out of the microcontroller is shown in figure 2.

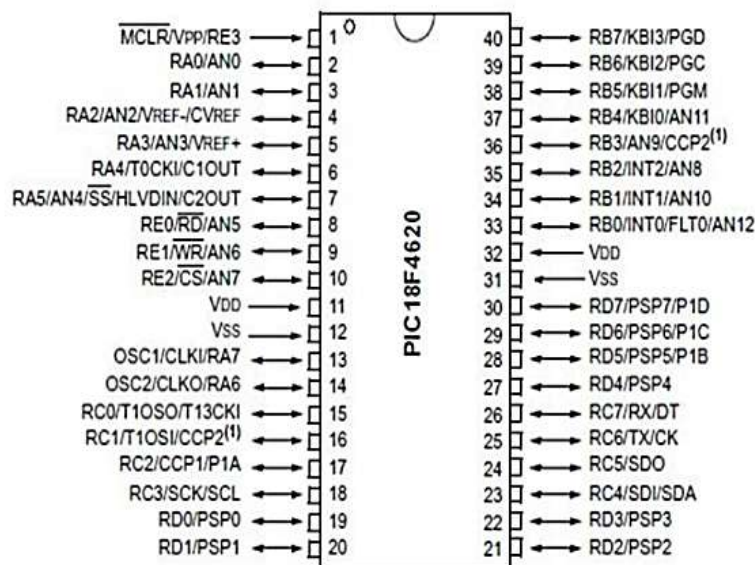


Figure 2: PIC18F4620 Pin Configuration

3.2.1 Microcontroller software

A program was loaded on the microcontroller to be able to perform the desired function in the circuit. The flowchart in figure 3 simplifies the program on the microcontroller.

When the microcontroller is powered it starts working almost immediately, after a very short booting process the microcontroller triggers the ultrasonic sensor by raising the logic state of PORT RA3 high and bringing it back low suddenly. The timer is initiated and the microcontroller waits for an echo which will be a high logic state input received by PORT RD1. This echo is the reflection from an incident body; if no echo is received the process starts all over again. But once an echo is received the timer stops and period between the trigger and the echo is saved. With this the microcontroller calculates the distance from the object using equation 2 and once the object is within the specified range the buzzer is activated until the system is reset.

The program for the microcontroller was written using *mikroC PRO for PIC*. After compiling the hex file was burned to the microcontroller using PIC KIT 2 programmer by Cana Kit.

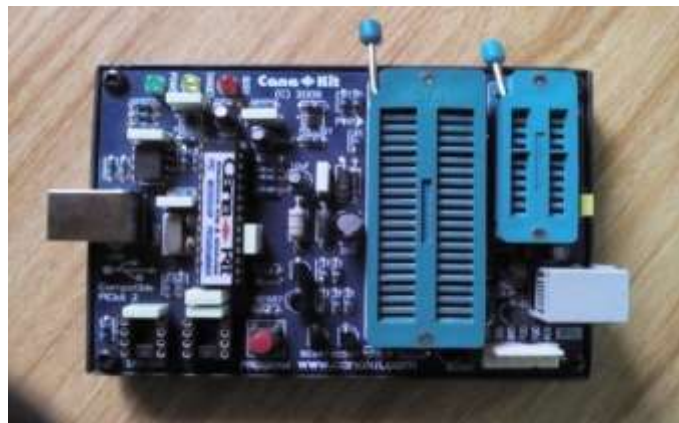


Figure 4: PIC KIT 2 by Cana kit

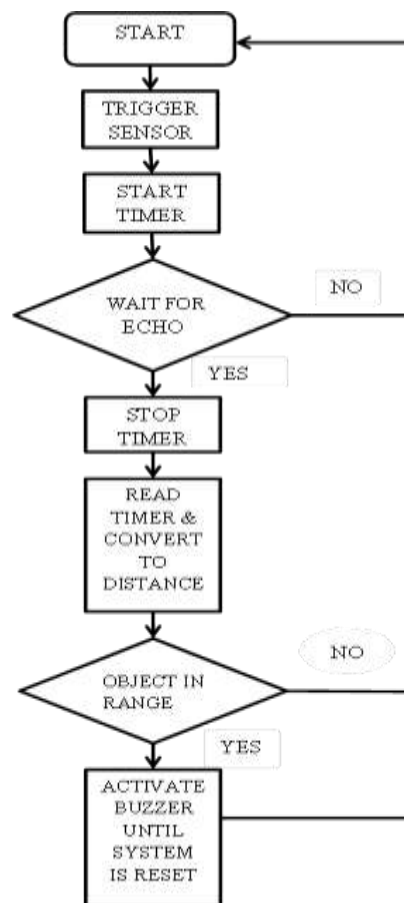


Figure 4: Flowchart of program

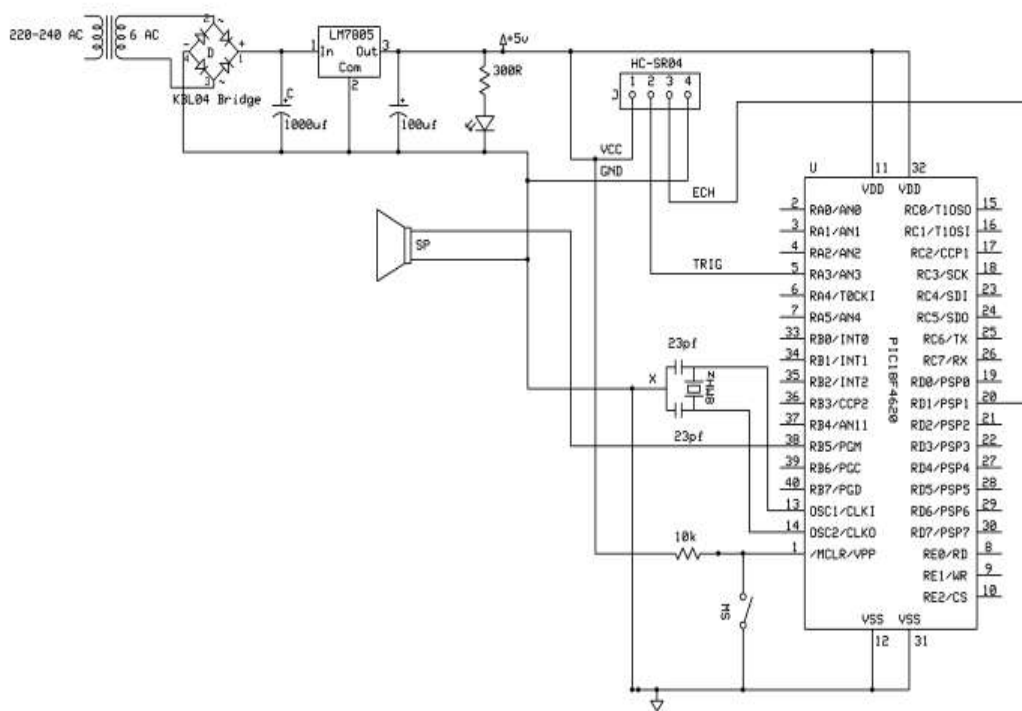


Figure 6: Circuit diagram

IV. Results

After all components were mounted and soldered on the Vero-board. When the system was powered an object was placed at a distance greater than 2m. The buzzer was not triggered but when the object was moved closer to a range between 0m to 2m, the buzzer was triggered until the system was reset.

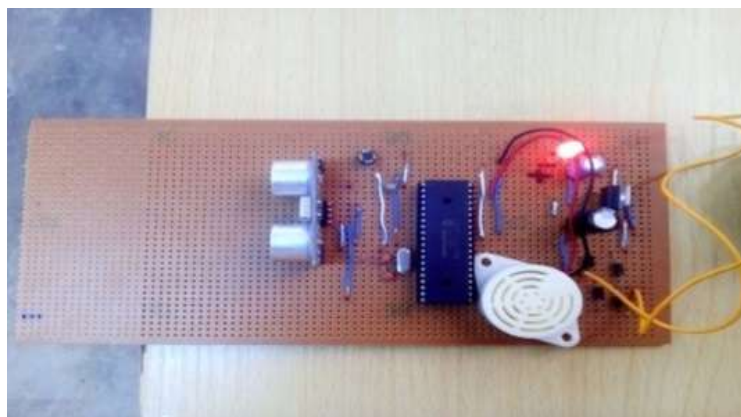


Figure 7: Ultrasonic motion sensor switched on

V. Conclusion

This system can be applied as a simple house hold security system. It can be used around windows because of it short range for alerting the user whenever an intruder tries to break through. The device can still be improved by;

- i. Increasing the number of ultrasonic sensors used so that it can cover a larger area.
- ii. A rechargeable battery can be integrated to keep the device in case of power outage.

References

- [1]. Aladin Carovac, Fahrudin Smajlovic and Dzelaludin Junuzovic, Application of Ultrasound in Medicine, *Journal of Academy of medical sciences of Bosnia Herzegovina*, 19, 2011, 168-171.
- [2]. Stefan B. Williams, Paul Newman, Julio Rosenblatt, Gamini Dissanayake and Hugh Durrant-Whyte, Autonomous Underwater Navigation and Control, *Robotica*, 19(5), 2001, 481-496.

- [3]. S. Jeneeth Subashini, Implementation, working and results of circuit detection of intruders movement using ultrasonic sensors, *International Journal of Computer Science and Information Technolog Research*, 2(3), 2014, 520-526.
- [4]. Abhay Pratap Singh, A Review on Ultrasonic Radar Sensor for Security system, *Journal of Emerging Technologies and Innovative Research*, 3(4),2016, 137-139.
- [5]. David Caicedo and Ashish Pandharipande, Ultrasonic array for indoor presence detection, *20th European Signal Processing Conference*, 175-179, 2012.
- [6]. A. K. Shrivastava, Distance Measurement of an Object or Obstacle by Ultrasound Sensors using P89C51RD2, *International Journal of Computer Theory and Engineering*, 2, 2010, 64-68.
- [7]. N.Suganthi1, R.Arun, D.Saranya and N.Vignesh, Smart security surveillance rover, *International Journal of Pure and Applied Mathematics*, 116(12), 2017, 67-74.

IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) is UGC approved Journal with Sl. No. 5016, Journal no. 49082.

Ilori Oluwaseyi Ayodeji. " Household Premises Surveillance System Using Ultrasonic Sensor." IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) 14.1 (2019): 11-16