# DESIGN AND IMPLEMENTATION OF A MOBILE SURVEILLANCE ROBOT WITH NIGHT VISION CAMERA

BY

**FATOKUN, O. D.**
(MEE/12/0860)

A project report submitted to Mechatronics Engineering Department, Federal University Oye-Ekiti in partial fulfillment of the requirements for the award of the B. Eng. (Hons) in Mechatronics Engineering.



Department of Mechatronics Engineering
Faculty of Engineering

## APPROVAL

THIS PROJECT REPORT HAS BEEN APPROVED FOR ACCEPTANCE BY THE MECHATRONICS ENGINEERING DEPARTMENT, FEDERAL UNIVERSITY OYE-EKITI, EKITI STATE AND MEETS THE REGULATIONS GOVERNING THE AWARD OF BACHELOR OF ENGINEERING OF FUOYE.

BY

| SUPERVISOR | HEAD OF DEPARTMENT |
|---|---|
| NAME: Engr. O.O. Martins | NAME:__________ |
| SIGNATURE:__________ | SIGNATURE:__________ |
| DATE: 14/12/2017 | DATE:__________ |

EXTERNAL EXAMINER

NAME:__________

SIGNATURE:__________

DATE:__________

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## List of Abbreviations

RF – Radio Frequency

DTMF – Dual Tone Multi Frequency

US – United States

ISIS – Islamic State of Iraq and Syria

LED – Light Emitting Diode

LCD – Liquid Crystal Display

PIC – Peripheral Interface Controller

ID – Identity

WI-FI – Wireless Fidelity

RFID – Radio Frequency Identification

GUI – Graphic User Interface

PC – Personal Computer

LDR – Light Dependent Resistor

IC – Integrated Circuit

CCTV – Closed Circuit Television

TV - Television

DVR – Digital Video Recorder

CCD – Charge-coupled Device

CMOS – Complementary Metal-Oxide Semiconductor

PAL – Phase Alternating Line

NTSC – National Television System Committee

PIR – Pyroelectric ("Passive") Infrared

IR – Infrared

# ACKNOWLEDGEMENT

I appreciate the guidance, attention to detail and astute intelligence of Engr. O.O Martins, my supervisor who help me through the project and for his patience, continuous supervision and encouragement during the project. Am deeply grateful to the head of Mechatronics Engineering department, Federal University Oye Ekiti (FUOYE) in person of Dr. A.A Adekunle for his fatherly love and guidance. To the department Technologist who assisted me in the fabrication I say thank you. Special thanks to Ugwaju Chibuzor, department of Mechatronics Engineering for his willingness to share his ideas and helpful suggestions when the need arise. Special thanks to Mr and Mrs Fatokun for been there for me and to my siblings and lastly to all the staff of the department of Mechatronics Engineering Federal University Oye-Ekiti.

# ABSTRACT

Mobile surveillance robot is a robot which is used for the purpose of surveillance, monitoring, analysis of data and gathering of information with or without the approved knowledge of the holder of the information and the timely dissemination of information to those who need to know so that action can be taken. The designed mobile surveillance robot has a night vision camera with the ability to monitor its surrounding environment and collect data from it. The need to survey secured place to prevent intruders, to reduce labor force and cost attached to human surveillance of places, hazardous places, in repetitive jobs, and areas impossible for human being to fit in gave rise to the design and implement of a mobile surveillance robot. The project is aimed at designing and implementing a mobile surveillance robot, to develop a robot that can work autonomously and can be wirelessly controlled via a remote control and to send audio and video in real time of the surveyed surrounding. The mobile robot was fabricated using acrylic plastics and has four wheels that helps in motion. It uses Arduino UNO on it a ATmega 328P microcontroller programmed to be the brain of the system, an ultrasonic sensor to detect obstacle, a PIR for infrared ray sensing emitted by living creatures, a night vision camera, a RF 433MHz for remote control and a motor shield for driving the motors. The mobile robot can avoid obstacles within its environment which allows it to be able to work with human being. The night vision camera having a viewing angle of 180-degrees sends what its captures from the environment in audio and video format to the base station. It also allows the robot to be useful at night due to

# DECLARATION

I, Fatokun Oluwatobi David hereby declare that the project work entitled "Design and Implementation of a Mobile Surveillance Robot with Night Vision Camera" submitted to Mechatronics Engineering department, Federal University Oye-Ekiti (FUOYE), is a record of an original work done by me under the supervision of Engr. O.O Martins in Mechatronics Engineering department of Federal University Oye-Ekiti. This project work is submitted in partial fulfillment of the requirement for the award of the degree of bachelor of Engineering in Mechatronics Engineering. This project has not been submitted to any other institution for the award.

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FATOKUN OLUWATOBI DAVID

# DEDICATION

This project is firstly dedicated to God almighty for giving me the grace to be able to see the project through. Also I dedicate this project to my late dad for his quest to want to see me through my education but sadly he is not here to see it, to my mum who picked up the quest of my dad and lastly my elder brother who shouldered the responsibility of been there for me financially and lastly my family who supported me morally.

# CHAPTER ONE

## INTRODUCTION

Surveillance is the monitoring of behavior, activities, or other changing information for the purpose of influencing, managing, directing, or protecting people (Lyon, 2007). A robot is a virtual or mechanical artificial agent (Dhiray *et al.*, 2013), it is a field of Engineering that covers the mimicking of human behavior. Robotics includes the knowledge of Mechanical, Electronics, Electrical and Computer Science Engineering. It is the branch of technology that deals with the design, construction, operation, and application of robots well as computer systems for their control, sensory feedback, and information processing. Autonomous robots are intelligent machines capable of performing tasks in the world by themselves, without explicit human control (George, 2007). The robot is programmed to respond in a particular way to an outside stimulus.

Mobile surveillance robot is a robot which is used for the purpose of surveillance, monitoring, analysis of data and gathering of information with or without the approved knowledge of the holder of the information and the timely dissemination of information to those who need to know so that action can be taken.

It is useful in security places, places that are hazardous to human, collection of data, environmental studies, repetitive works and for monitoring since it sends real time audio and video coverage of the environment.

Earlier the robots were controlled through wired networks but now to make robot more a high performance robot that is faster, reliable, accurate and more intelligent robot which can be devised by advanced control algorithm, robot control devices and new drivers.

There are situations where ground information is priceless, like search and rescue operations. Also there are many places where people cannot go due to various reasons. For example, if a person wants to know what is on the ceiling of his house, he has to climb on to the ceiling. But that is not safe and there might be practical issues such as the person may not fit in the available space. The cost that comes with employing a lot of people in order to guard places can cause an increase in labor cost. Life is always at risk during surveillance, collection of data and from hazardous and dangerous environment.

All these problems focus on a common solution and that is a mobile surveillance robot which can provide information of its surrounding environment to a remote user. This project contains a robotic based solution to gather information to solve the problems mentioned above. This is a project to build a mobile robot that can work autonomously providing information about its surrounding environment to its user via a computer and also the user can control the movement of the robot via radio frequency (RF) module if the need arises.

## 1.1 Background

Increase in bombing of populated areas and suicide bomber by the Boko haram

40%. Today, roughly one out of ten houses and companies has surveillance protection be in in the form of a surveillance camera or a trained personnel. The camera used are always fixed in a particular direction creating blind spot for the camera which makes it less than 100% efficient for surveillance and even rotational camera can only cover a small angle of view when the surveyed surrounding is too large. Most of the cameras used lack adequate sensor like motion sensor and also three to four people are likely to be employed in the surveillance of a confined area and more in a large area, this would increase the labor cost and sometimes lead to fatigue due to repetitive task.

Nowadays autonomous robot and wireless technology is gaining more ground, most machines can work autonomously without the need for any human input or are controlled wireless because of the security, cost and range. We read about them in the newspapers almost every day; about drone strikes in war, about robots in nursing homes keeping the elderly company or about cars with the ability to park or even drive without human supervision (Allen *et al.*,2000).

The basic theory behind the proposed concept is a mobile surveillance robot that can work autonomously and that can also be controlled by a wireless controller if need be. Sending audio and video in real time to the base station.

## 1.2 Problem Statement

Around the world there has been an increase in insecurity due to different acts of terrorism happening around the world, the US 9/11 attack, Nigeria Boko haram

Some areas are impossible for human being to trend for inspection or monitoring which a robot can. Tunnels surveillance, underground mines are usually rugged and it is very difficult for human beings to reach there and collect the information, the detailed information of tunnel and mines can be easily monitored by a robot or in search and rescue situations where a person is expected to cover a large area which can be tedious in carrying out and lastly to replace humans for surveillance purposes since their sensory input/organs are limited.

## 1.3 Aim and Objectives

The aim of the project is to design and implement a Mobile surveillance robot with night vision camera while the objectives are:

i. To describe and explain the fabrication and design of a mobile surveillance robot with a night vision camera that capture audio and sound and send it through wireless communication to the station base for surveillances

ii. To develop a robot that can work autonomously and can also use wireless controller for remote control.

## 1.4 Significance of Study

The mobile surveillance robot has the significance of helping humans for surveillance purposes, ability to monitor places that human being cannot fit in, ability to work in hazardous environment, reducing the labor forces and cost in surveillance of secured places, giving real time information of places for study purposes, reduces the stress and

# CHAPTER TWO

## LITERATURE REVIEW

Conducting the literature review is done prior to undertaking the project. This will critically provide as much information as needed on the technology available and methodologies used by other research counterparts around the world on the topic. This chapter provides the summary of literature reviews on topics related to mobile surveillance robot or robot that has capability to survey the environment autonomously via wireless vision system using wireless technology as control, including robot with obstacle sensor, autonomous robot, mobile robot and unmanned robot.

Nyi & Kyaw, (2016) designed a spy robot controlled using Bluetooth and an android phone, interfaced with a created graphical user interface (GUI) with an Arduino Uno. The user controls the robot by using the android phone while the robot receive command from the android phone via a Bluetooth module connected to the Arduino. The draw back was that the camera had no night vision. The block diagram for the method used is shown below

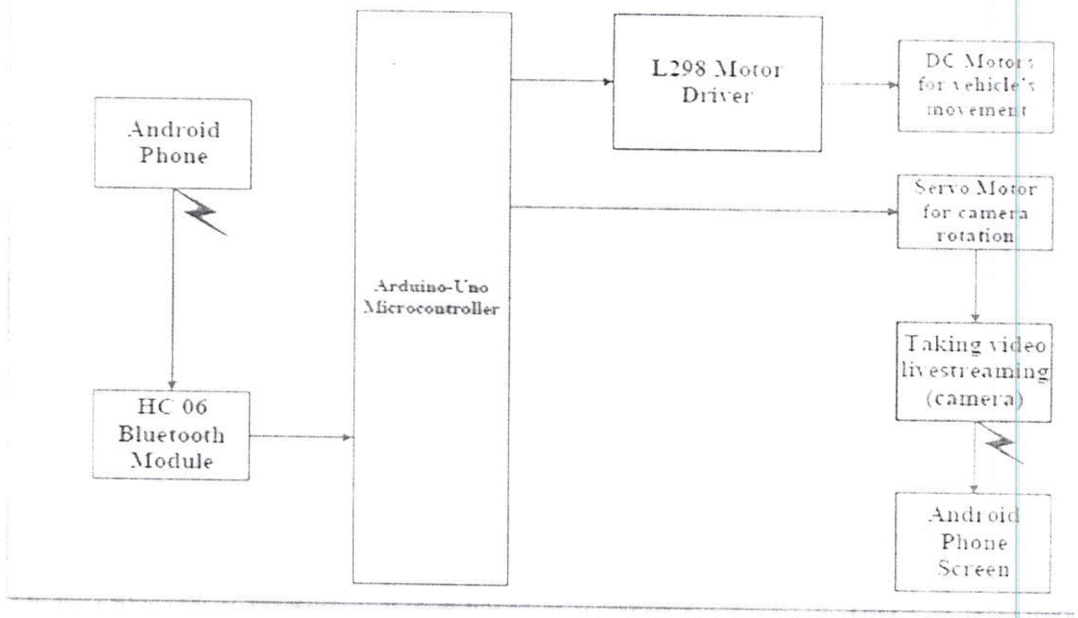



Figure 2.1: Wireless Based Android Controlled Spy Robot Block Diagram
Source: (Nyi & Kyaw, 2016)

Anil *et al.*,(2017) used a microcontroller(AT89C52) and an android based application to create an intelligence spy robot using Bluetooth as the communication link between the robot and the control based (Android). The camera used was a wireless night vision camera, the distinct applications of this concept in such robot can be a smart phone controlled robot where the movement of the robot is controlled by a robot on the basis of android platform. Smart phone transmits the AT commands and data to the 8051 controller and controls the motor by motor driver L923D. The robot motions left, right, Vivek *et al.*, (2015) proposed a system that uses the Zigbee technology to control the military spy robot, it also used gas sensor, metal detector and a color sensor with ATmega 16 microcontroller in addition to the wireless night vision camera in order to allow the robot to be able to detect harmful gases, detect bombs, and easily adapt to the environment by camouflaging respectively. The robot was created extensively for war purposes. The ZigBee extend range to 1.6 km. MOSFET is used to drive the LED strips which will help to acquire colour of surrounding. At the robot side, ZigBee receiver receives the signal from transmission module which is decoded by ATmega 16 microcontroller and processes these signals to input to the L293 Motor driver and robot moves according to the signal received. Colour sensor detects a surrounding colour, provides feedback to the microcontroller and then microcontroller again generates a signal to illuminate LED strips. Wireless camera will capture real time videos and images of surrounding and transmit it to the operator.

Wai,(2014) uses a RF module(434MHz) with the camera able to move from left to right by the press of a button from the transmitter side, it also uses light emitting diode(LDR) sensor to switch on surrounding LEDs around the camera in order for the camera to be able to see at night since it is not equipped with night vision ability. It uses PIC16F628A and PIC16F877 instead of an Arduino and has a Liquid crystal display(LCD) at the transmitting section to show the direction of the allocated button.

Dhayagonde & Shantanu, (2014) proposed a web based surveillance and human detector robot using PIR in which the robot is web controlled Raspberry Pi is used f pi to transmit over the web network. The system uses PIC16F877 as the microcontroller, the raspberry gives unlimited range as long internet is available in the area, the only drawback is that the camera used is a webcam without night vision.

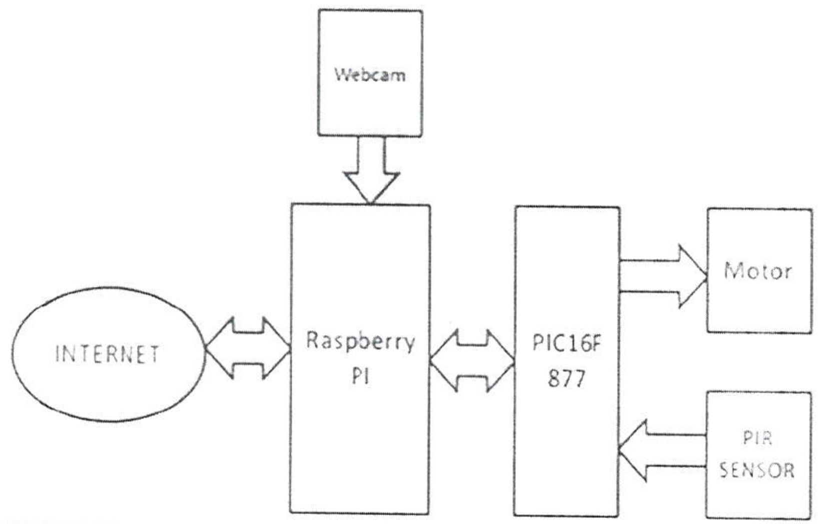



Figure 2.2: Web Based Controlled Robot Block Diagram
Source: (Wai, 2014)

Adarsh *et al.*, (2015) proposed a robot which is controlled over a wireless network by using a laptop's web browser and accessing a webpage. The live video feed of the IP-camera (installed on the robot) can be viewed on this website. Thus with such minimal requirements, the robot can be controlled irrespective of the position of the user. Another method to control this robot is by using an android application in which the

CORTEX M3 STM32F103CBT6 microcontroller. The advantage and the main difference of using this spark core from other methods (like simply interfacing a Wi-Fi module) is the spark cloud which is allotted to every core and is unique for each of them. This spark cloud is nothing but a virtual space or in other words, it acts as a control room for the spark core. This control room (spark cloud) can be accessed from the internet at any corner of the world if the unique spark core ID and its access token (password) of that particular core is known. The spark core coordinates with its own cloud through the Wi-Fi connection wherein it receives the commands given via its cloud.

Kumar *et al.*, (2015) designed a robot using an ARM controller, the robot can be controlled to various directions through Voice recognition circuit(VRC) HM2007 and also controlling the camera by taking the voice data from the microphone which is stored in HM2007 in the form of digital data in an array. Each input data stored has its unique codes. These codes are transmitted to ARM via RF transmitter, here the VRC converts the voice command into the code which can be understood by transmitter. The voice recognition circuit (SR-07) uses a simple keypad and digital display to communicate with and program the HM2007 chip. RF receiver on the other side performs the exact opposite process as the transmitter.

The ARM7 board is programmed using Flash Magic tool gotten after the program is simulated and tested in Keil software. The drawback of the project was difficulties in recognizing speech by the application because speech is different for every speaker

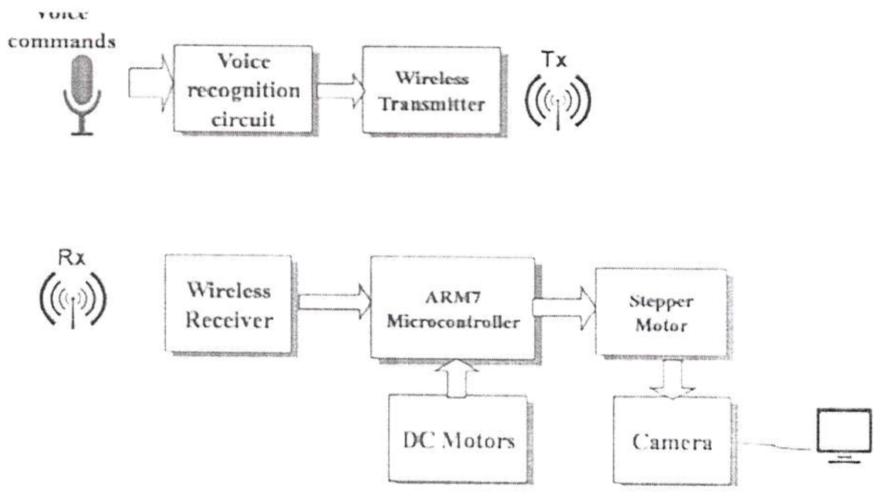



Figure 2.3: Block Diagram of Multi-Task Surveillance Robot Using ARM Controlled Robot
Source: (Kumar *et al.*, 2015)

Nagalla & Subbarao, (2015) designed a robot capable of reducing causalities incurred during war by designing a robot that works with the Zigbee technology, it uses the ATmega 8 microcontroller for control, RFID Tag is to identify the unauthorized soldiers; these tags are given to only our soldiers to identify our soldiers which is helpful to avoid mistakes while attacking with the laser gun and a metal detection to detect the metal. For coding purpose MATLAB software was used. The software is used to operate robot in different directions i.e. forward, backward, right, left, trigger. When we run the program then GUI file window is opened that is used for direction of robot via a personal computer (PC). The method used is shown in Figure 2.4

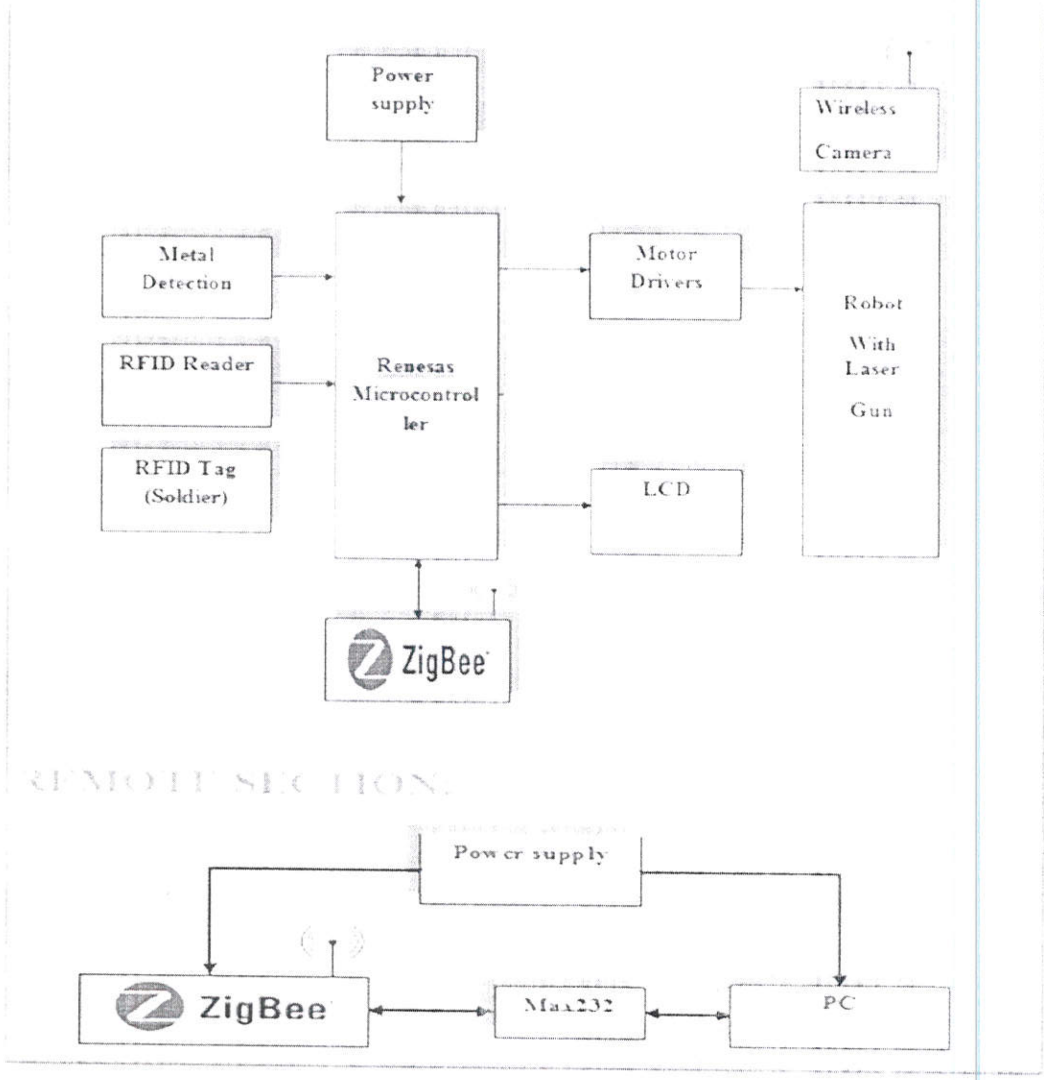



Figure 2.4: Project Block Diagram for Soldier Detecting Robot
Source: (Nagalla & Subbarao, 2015)

Bhargavi & Manjunath, (2011) designed a robot similar to Nagalla & Subbarao, (2015) RLP434A at 418MHz. Decoder and Encoder was used to convert a N-bits of address and 12 bits of data into an 8 address bits and 4 data bits, each are connected to the receiver and transmitting RF module respectively.

Vansh, (2015) proposed a model that has firefighting capability apart from it being remotely controlled through RF transmitter and receiver module at 434MHz. it can detect fire (or smoke) and can extinguish the fire itself. It can be used at oil mine fields which are usually inaccessible to humans and are prone to catch fire. The robots are used to detect and extinguish fire at such places. The firefighting robot has an addition of Thermistor (heat sensor), LM358 (Op-amp), fan, potentiometer and a variable resistor.

Dhiray *et al.*, (2013) used a Dual Tone Multi Frequency (DTMF) better known as touch-tone to control the movement of the mobile spy robot. the robot is controlled by a mobile phone that makes a call to another mobile phone attached to the robot. In duration of this call, if any key is pressed a tone corresponding to the key pressed is heard at the other end hence the DTMF tone. The robot receives these tones with help of phone stacked in the robot. The received tone is processed by the 8051 microcontroller with the help of DTMF decoder IC CM8870. This IC sends a signal to the motor driver IC L293D which drives the motor forward, reverse, left and right.

Ankita *et al.*, (2014) proposed a spy robot been controlled by a touch screen and using the Zigbee technology. The touch screen panel is composed of several layers, the most the electrical current which is registered as a touch event and sent to the controller for processing. Layers uniformly coated with a transparent resistive material and separated by an air gap. Electrodes placed along the edges of the layers provide a means for exciting and monitoring the touch screen.

Gaurav & Rahul, (2007) fabricated a surveillance robot using both RF module, Dual Tone and Multi Frequency(DTMF) and autonomous mode within the RF range because of the range limit for RF and the unlimited range for the DTMF, basically the DTMF is used to bring the robot back to the range of the RF control. The designed robot consists of power supply, robotic arm, radio frequency module (433 MHz), DTMF module, LDR sensor for night vision by turning the Flash light on, audio and videos camera, Metal and magnetic field detector for detecting metals and mines underground and the presence of any magnetic field in the region to provide security respectively and thermistor for fire detection, moisture detector unit sensor to sense the presence of water or moisture in any area, laser gun as a weapon, robotic arm, Infrared ray(IR) sensors for path finding and obstacle avoidance. The wireless camera is used to capture the live video present in the surveillance area and it will be transferred to the RF receiver at the operator end which is further interfaced to the computer system using interface card. AT89S52 is used as a controller to accept and send the corresponding data to the other section. The project block diagram is shown below

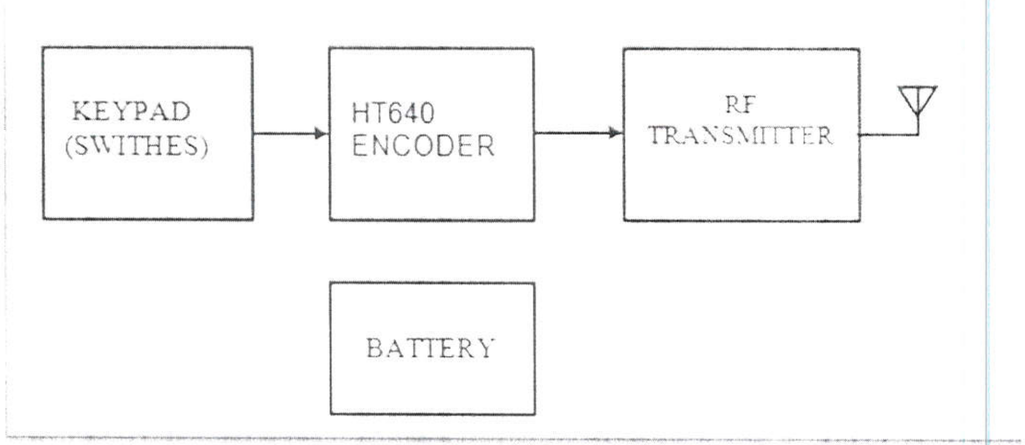



Figure 2.5: Touch Screen and Zigbee Controlled Robot Block Diagram Transmitter Side
Source: (Gaurav & Rahul, 2007)

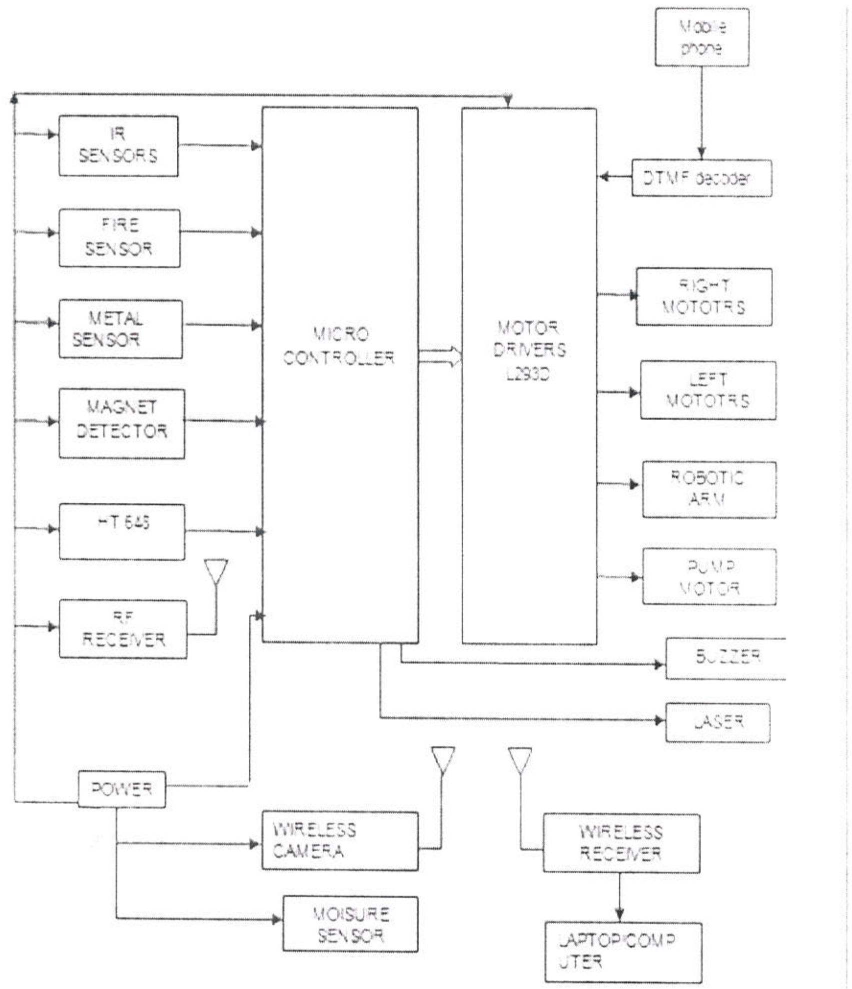



Figure 2.6: Touch Screen and Zigbee Controlled Robot Block Diagram Receiver side
Source: (Gaurav & Rahul, 2007)

Abhiskek *et al.*, (2014) fabricated an autonomous cleaning robot using microcontroller and also an obstacle sensor in form of IR sensor in order to avoid obstacle in its path.

cleaning process. The power unit consist of a 12V rechargeable battery and a voltage regulator. The LM7805 IC connected to the output of the battery, provides a constant output of 5V,regardless of the load in the circuit. Thus the power requirements of the system are strictly met without putting the system at risk during high loads.

# CHAPTER THREE

## METHODOLOGY

This section gives a comprehensive step by step in achieving the surveillance robot with night vision and the ideology behind the project. The surveillance can work autonomously or remotely by RF 433MHz depending on the purpose or case the robot is to be used for.

### 3.1 Materials Selection and Design Calculation.

The material used for the construction of the surveillance robot is an acrylic plastic of thickness 1mm. the material was selected because of it machinability, durability and presentation.

The part made with the material are the chassis of the robot, the top and base. the design calculation is used to obtain the measurement shown in Fig 3.1 and Fig 3.2 for the base and top respectively.

#### 3.1.1 Design Calculation for Ultrasonic Sensor

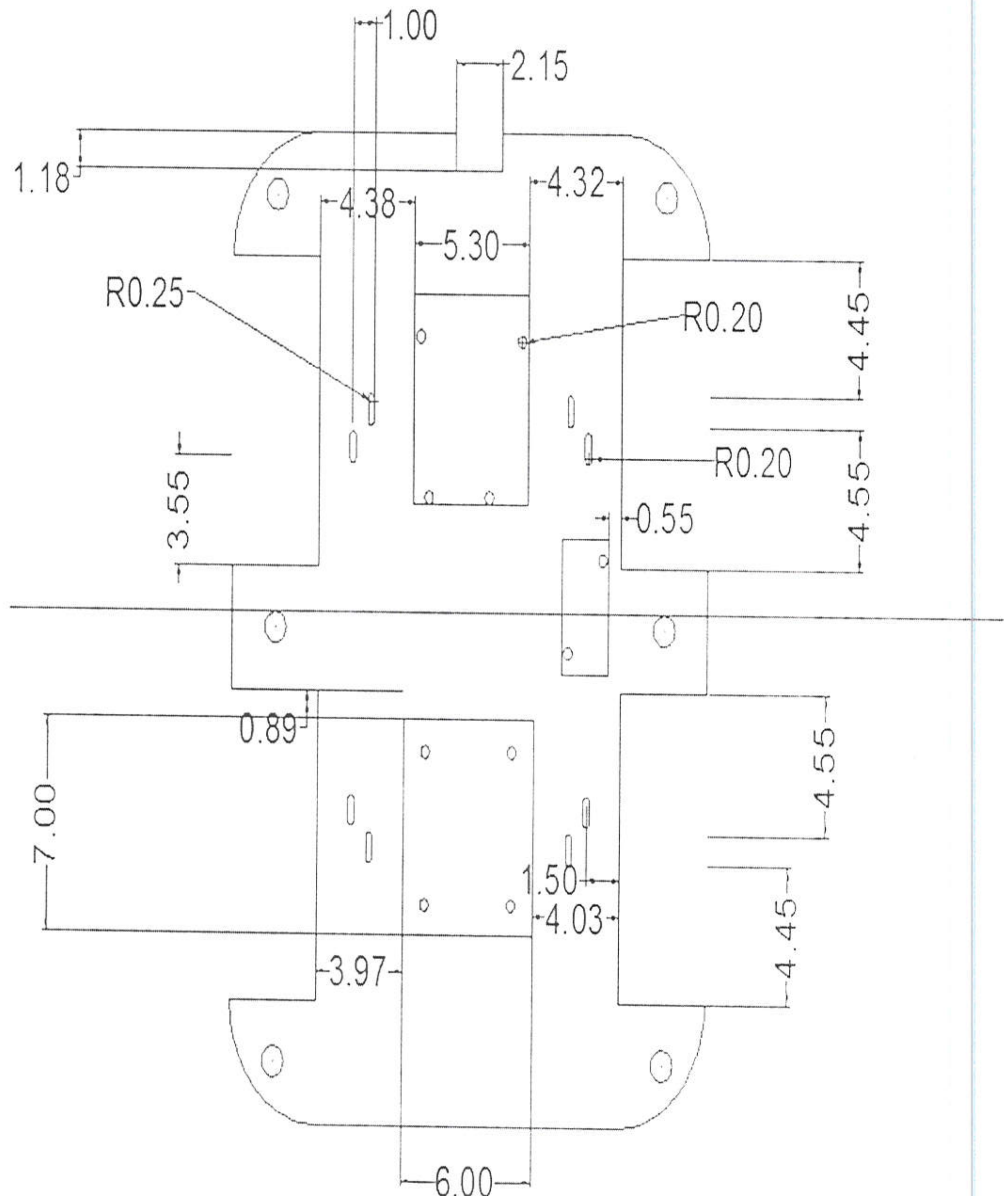
$FOSC = 20Mhz$

$Cycle = \frac{4}{20} = 0.2\mu S$

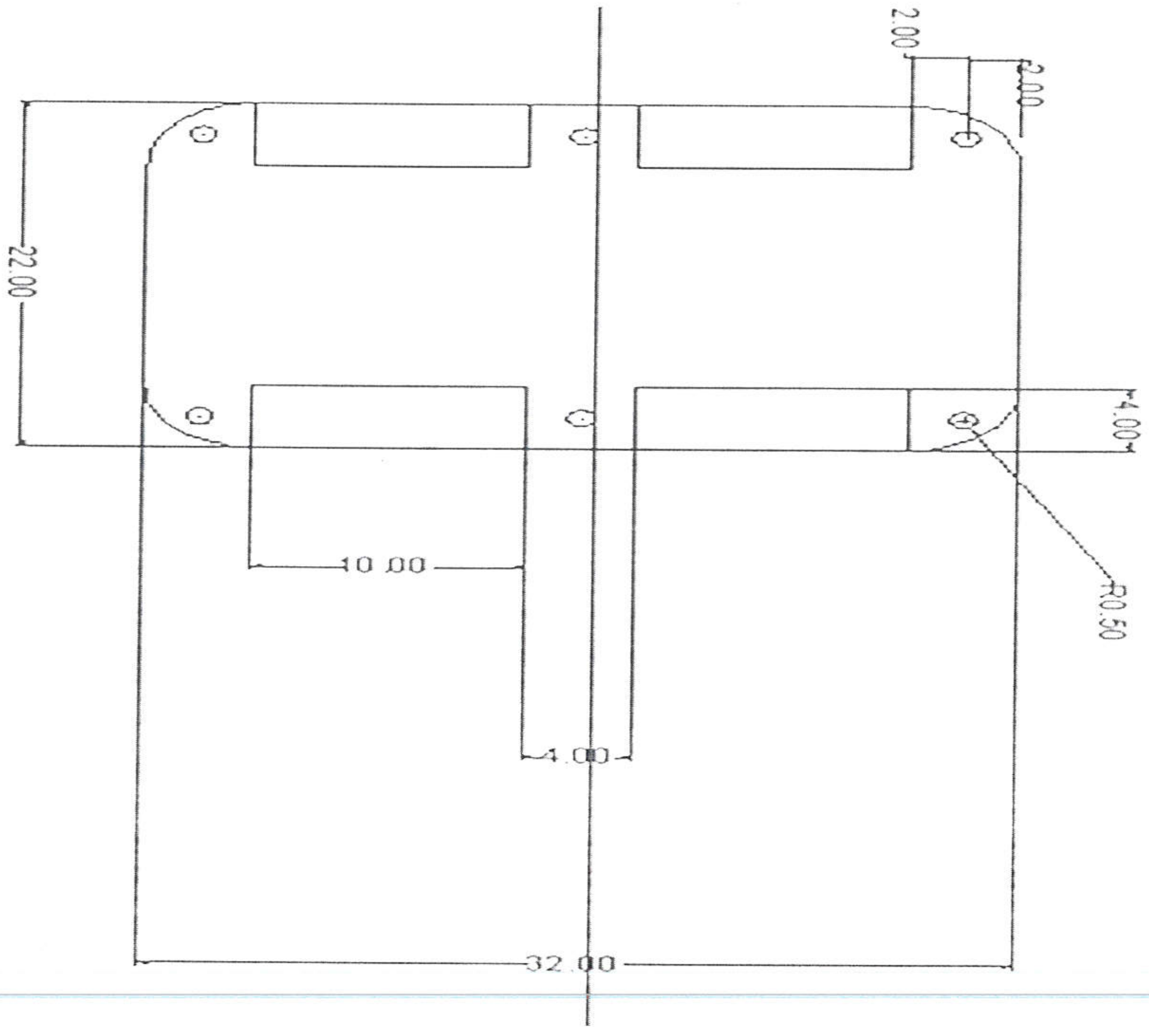
$timer\ count\ =\ 0.2 \times 8 = 1.6\mu S$ (prescaler = 8)

$at\ 20°C\ sound\ speed\ =\ 34000\ cm/sec$

$within\ 1.6\mu S\ distance\ =\ 1.6 \times 0.000001 \times 34000 = 0.0544\ cm\ per\ count$



1.00
2.15
1.18
4.38
4.32
5.30
R0.25
R0.20
4.45
R0.20
4.55
3.55
0.55
0.89
7.00
4.55
1.50
4.03
3.97
4.45
6.00



2.00
2.00
22.00
4.00
R0.50
10.00
4.00
32.00

To start the measure, the device needs a pulse of 10μS in the trigger input then send (itself) a burst of 8periods of 40Khz (so during 200μS) then echo output signal goes to 1 status and return to 0 status when echo is back. Timer1 measure this duration to avoid to hear the receiver when the emitter sends the burst value of 40khz.

Timer1 start again to begin count after 10 +200 = 210μS.

so minimum distance (theoretical) is

$$210 \times 0.0272\ (because\ of\ the\ only\ one\ way) = 5.712\ cm\,.$$

Using the Calculation above, the Ultrasonic sensor can be used to measure an obstacle within 30cm, because that the limit the ultrasonic sensor would be set at for this project since the lowest distance it can measure is 5.712cm.

### 3.1.2 Design Calculation for Resistor

Red LED has the following specification

Voltage = 2V

Current = 15mA

Green LED has the following Specification

Voltage = 2.1V

Current = 20mA

The formula to calculate the values of the Resistors to attach to the LEDs is given below

$For\ the\ green\ LED$

$Source\ voltage\ =\ 5V$

$$\frac{5-2.1}{25\times10^{-3}}=\frac{2.9}{0.025}=116\Omega$$

$For\ the\ Red\ LED$

$$\frac{5-2}{15\times10^{-3}}=\frac{3}{0.015}=200\Omega$$

The values gotten for the green and red LEDs respectively are the lowest value of resistor to use with the LEDs in order not to damage the LEDs. These values of resistor would result into the LED been in its brightest stage, so in order to reduce the brightness a 1KΩ was used.

### 3.1.3 Design Calculation for The Torque Required by The Camera

To calculate the torque required for moving the camera using the metal gear servo motor the formula below was used

$Torque = F\cdot r$

$Torque = (m\cdot g\cdot c\cdot f)r$

Where

$m =\ Mass$

$g\ =\ Acceleration\ due\ to\ gravity$

$c\ =\ Coefficient\ of\ friction\ between\ meshing\ gears\ (steel\ -\ steel)$

the metal gear servo motor that is to be used to provide the torque has the following specification

Working gear = 2kg/cm = 0.02kg/m

Reaction speed = 0.11seconds /60 degrees

Rotation angle= 180 degrees

Operating voltage= 4.8V

The camera to be rotated weighs 0.19 kg, using the above equation

$$Torque = (m \cdot g \cdot c \cdot f)r$$

$m = 0.19\,kg, \quad g = 9.8\,m/s, \quad c = 0.78, \quad f = 0.35, \quad r = 0.02$

$$Torque = 0.19 \times 9.8 \times 0.78 \times 0.35 \times 0.02 = 0.0102\,kg/m$$

Since the servo torque is greater than the required torque, then the metal servo motor should be able to move the camera.

## 3.2 System Components and Description

Table 3.1: System Components of The Mobile Surveillance Robot

| S/N | System component | Qty | Model/ Version | Description | Why Used |
|---|---|---|---|---|---|
| 1 | Arduino board | 2 | UNO R3 | An Arduino is an open source hardware platform with built in programming support. No additional hardware or software (e.g. Hex burner) is required to transfer your programs (i.e. hex file) to the Arduino. It uses microcontroller ATmega328 | The first Arduino is used to allow automation between the motor shield attached, servo motors, the PIR sensor, the ultrasonic sensor and the RF module |
| 2 | DC motors and Wheels | 4 | TT motors | The DC motors | It was used to make the robot mobile |
| 3 | Ultrasonic Sensor | 1 | HC-SR04 | The ultrasonic sensor uses sound to identify obstacle in its part | It gives the robot ability to move around its environment without colliding with any obstacle |
| 4 | Pyroelectric Infrared | 3 | HC-SR501 | It is a passive sensor meaning it does not | Used to enable the robot detect the |

| | | | | | |
|---|---|---|---|---|---|
| | and metal gear) | | | control signal. It can hold the shaft at that desired angle until that control signal is removed or changed. | sensor rotation to the left and right in order to ascertain obstacle in the environment while the camera is mounted on the metal gear to give the camera a 180-degree view. |
| 6 | Motor bracket T-head set | 4 | TT geared | This is an acrylic plastic machined for fastening | It helps to fasten the DC motors to the base of the robot. |
| 7 | Male to Male and Female to Male | 50 | Dupont line | They are jumper wires | Used for accurate connection between component |
| 8 | Arduino Battery clip | 3 | | They are jumper wires with a battery clip at one end and a male connector at the other end | Used for connecting the batteries to the Arduino and motor shield. |
| 9 | Wireless CCTV camera set | 1 | | it is a camera that transfers audio and video in real time. it has six IR LEDs that helps the camera for night vision | Used to wirelessly transfer audio and video in real time to the base station |
| 10 | Adafruit Motor shield | 1 | Adafruit | It is a motor driver with 2 servo motors plug in and 4 stepper motors plug in. it is an attachment/shield | Used to drive the 4 DC motors and servo motors |

| | | | | | |
|---|---|---|---|---|---|
| 12 | RF 433MHz transmitter and receiver | 1 | 433MHz | It is a RF module that uses 433MHz and has a maximum range of 200m | Used for remotely controlling the robot if the need be from the base station. |
| 13 | TV TUNER | 1 | USB 2.0 video capture card AVG rabber | It is a kind of a television tuner that allows television signal to be received by a computer or phones. | It is used to send the video and audio through USB of the computer or phones |

### 3.3 Component Overview

Radio frequency (RF) has a frequency rate of oscillation in the range of about 3 KHz to 300 GHz which corresponds to the frequency of radio waves, and the alternating currents which carry radio signals. RF usually refers to oscillations in electrical circuits or electromagnetic radiation. Electrical currents that oscillate at radio frequencies have special properties not shared by direct current signals. One of such property is the ease with which it can ionize air to create a conductive path through air. This property is exploited by "high frequency" units used in electric arc welding. Another property is the ability to appear to flow through paths that contain insulating material like the dielectric insulator of a capacitor. The degree of effect of these properties depends on the frequency of the signals.

Let us take a RF transmitter wiggling an electron in one location. This electron wiggling will cause a ripple effect, similar to dropping a pebble in a pond. The effect is an

The receiver can make the same information available at a remote location by establishing a communication with no wires. In most of the wireless systems a designer has two overriding constraints: it must operate over a certain distance (range) and transfer a certain amount of information within a time frame (data rate)

In order to receive radio signals an antenna must be used. When an RF current is supplied to an antenna, it gives rise to an electromagnetic field that propagates through space. This field is sometimes called an RF field: in less technical term "radio wave". This antenna will pick up thousands of radio signals at a time and need to use a radio tuner to tune it into a particular frequency. This is done by using a resonator. Resonator amplifies oscillations within a frequency band while reducing the oscillations at other frequency outside the band. Any RF field has a wavelength which is inversely proportional to the frequency. In the atmosphere, in the outer spaces, or anywhere in our ambience, if frequency F is in MHz and the wavelength in meters, then S=300/f. The frequency of RF signal is inversely proportional to the wavelength of the EM field to which it corresponds. At 9 KHz, the free-space wavelength is approx. 33 kilometers or 21 miles (mi). At the highest radio frequencies, the EM wavelengths measure around one millimeter (1mm). Most wireless technology usually composed of two sections; the transmitting section and the receiving section. The transmitting section broadcast or send the instructions or data over a range of distance while the receiving section receives such instructions or data and carries out the process. Radio frequency has the following advantages:

4. It is not sensitive to light
5. It is not much sensitive to the environmental changes and weather conditions
6. Low cost
7. Readily available
8. Good for demonstration and mini project because of it cost

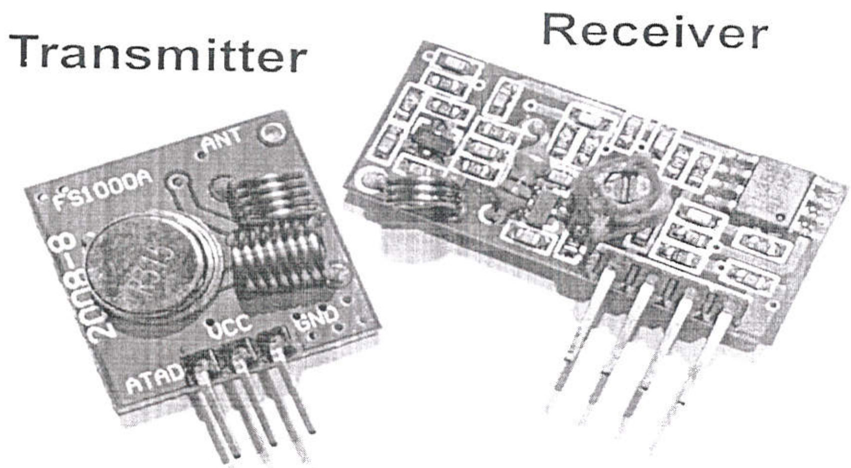



Figure 3.3: Radio Frequency Module (RF) Receiver and Transmitter
Source: (klaus, 2017)

ARDUINO: is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button

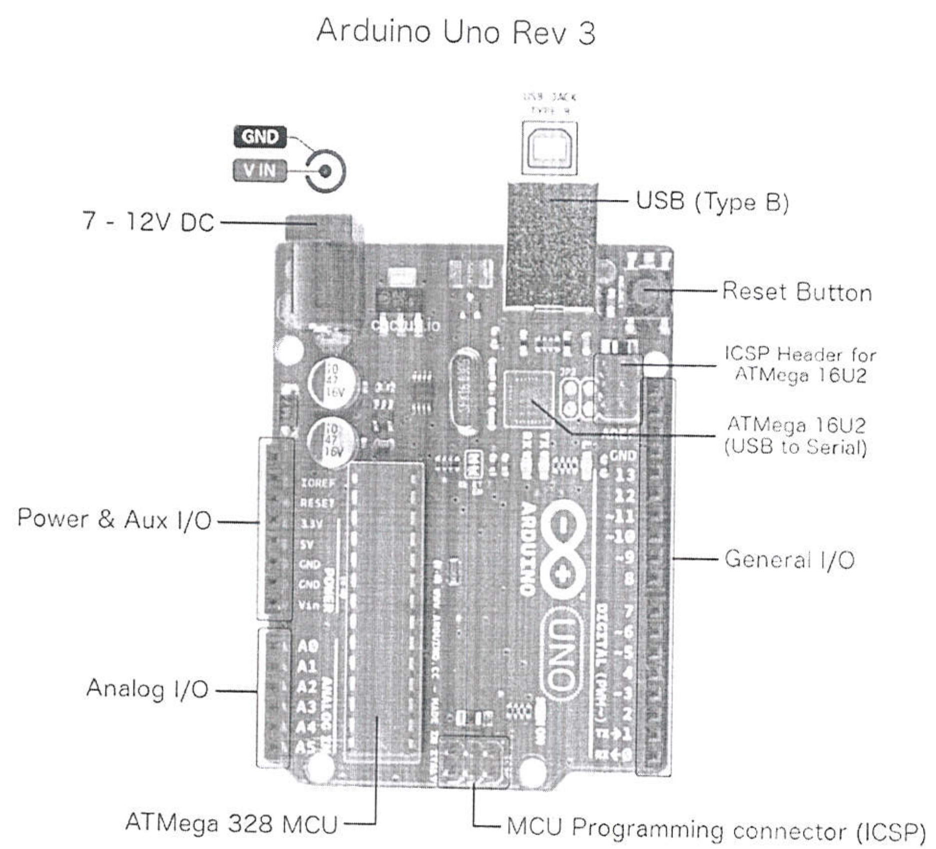



Figure 3.4: Components on Arduino Uno Rev 3
Source: (Admin, 2017)

CCD camera is placed on the robot. The camera captures the audio and video signals and sends those signals to the remote station and with the help of the camera receiver which is connected to the television or a computer through which we will be able to see the captured signals. This is a mini wireless monitoring video camera and wireless receiver set for home, small business surveillance, and security and has the ability to see in the night. The camera is install on the robot where the surveillance is needed and the wireless receiver is set to receive the audio and video from the camera and can be hook up to a TV or DVR to watch the action or record the footage for the security purpose. Features of the wireless camera with night vision are

1. Automatic motion detection features
2. Minimum of 100meters transmission distance without block.
3. Imaging Sensor 1/3-inch CMOS
4. CMOS total pixels:628*582(PAL)/510*492(NTSC)
5. Minimum illumination:1.5 lux
6. View angle:62 degree
7. Camera head weight: 15g

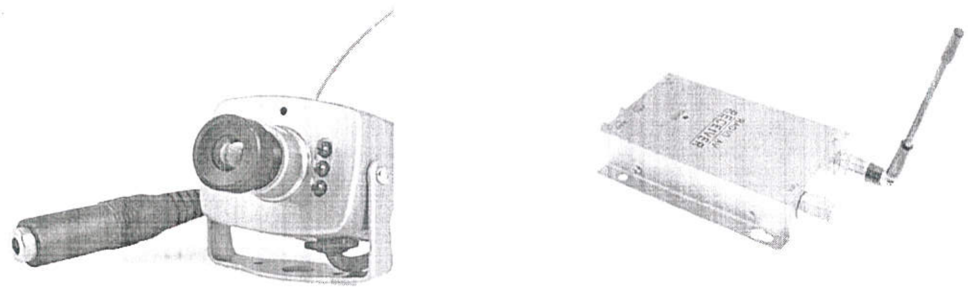


Figure 3.5: Wireless Night Vision Camera and Receiver
Source: (Keycube, 2017)

PYROELECTRIC ("PASSIVE") INFRARED (PIR) SENSOR

All objects with a temperature above absolute zero emit heat energy in the form of radiation. Usually this radiation isn't visible to the human eye because it radiates at infrared wavelengths, but it can be detected by electronic devices designed for such a purpose like the passive infrared sensor(PIR), the passive used refers to the fact that PIR devices do not generate or radiate any energy for detection purposes. They work entirely by detecting the energy given off by other objects. PIR sensors don't detect or measure "heat" instead they detect the infrared radiation emitted or reflected from an object. Infrared radiation enters through the front of the sensor, known as the 'sensor two slots can 'see' out past some distance (basically the sensitivity of the sensor). When the sensor is idle, both slots detect the same amount of IR, the ambient amount radiated from the room or walls or outdoors. When a warm body like a human or animal passes by, it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves. When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These pulse changes are what is detected.

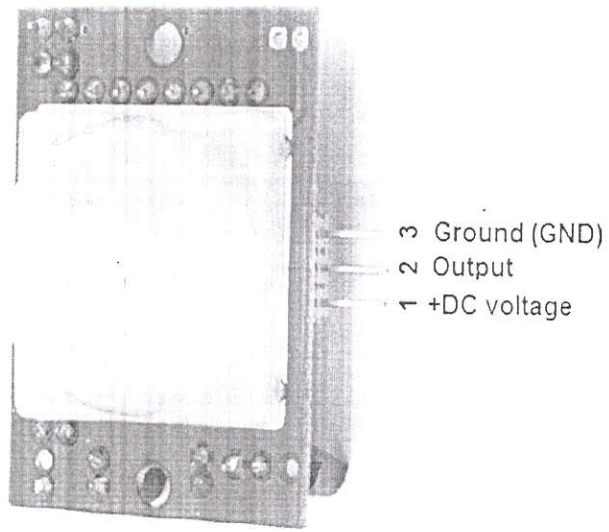



Figure 3.6: PIR Sensor External View
Source: TheoryCircuit.com

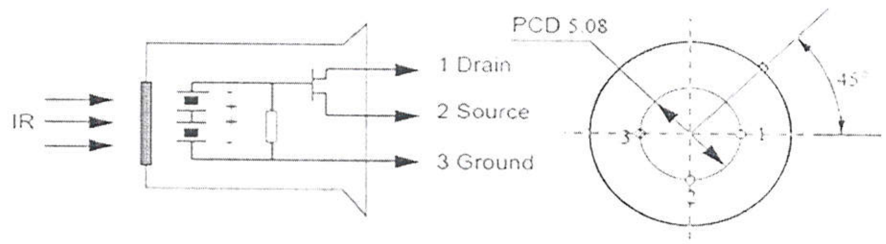



Figure 3.7: PIR Sensor Schematics
Source: RE200B Datasheet

## ULTRASONIC SENSOR

An ultrasonic sensor works by using the principle of sound. The term "ultrasonic" means above human hearing as the sensor uses a frequency we cannot hear. This is important to the function of the sensor because the specific frequency used is very rarely generated elsewhere – avoiding interference with other sources of sound. Ultrasonic sensors transmit a series of sound waves that hit the intended target and bounce back. The distance is calculated based on the time it takes the sound waves to travel to and from the target. The Ultrasonic Sensor sends out a high-frequency sound pulse and then times how long it takes for the echo of the sound to reflect back. The sensor has 2 openings on its front. One opening transmits ultrasonic waves, (like a tiny speaker), the other receives them, (like a tiny microphone). The speed of sound is approximately 341 meters (1100 feet) per second in air. The ultrasonic sensor uses this information along

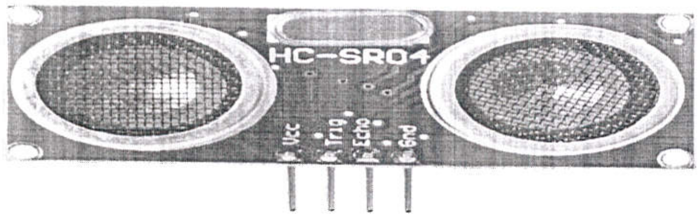
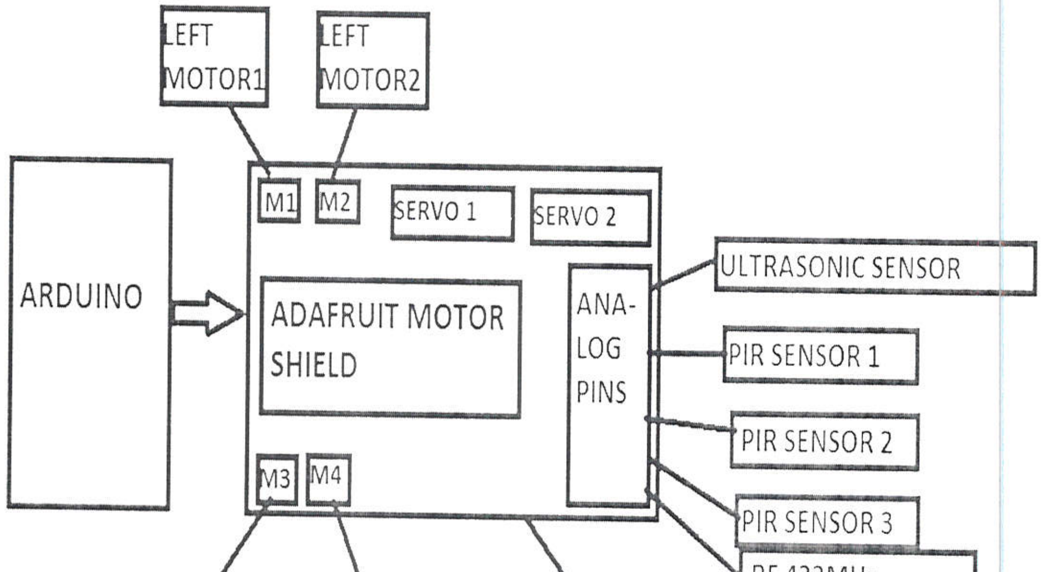



Figure 3.8: Ultrasonic Sensor
Source: (Daniel, 2017)

### 3.4 Circuit Diagram and Analysis



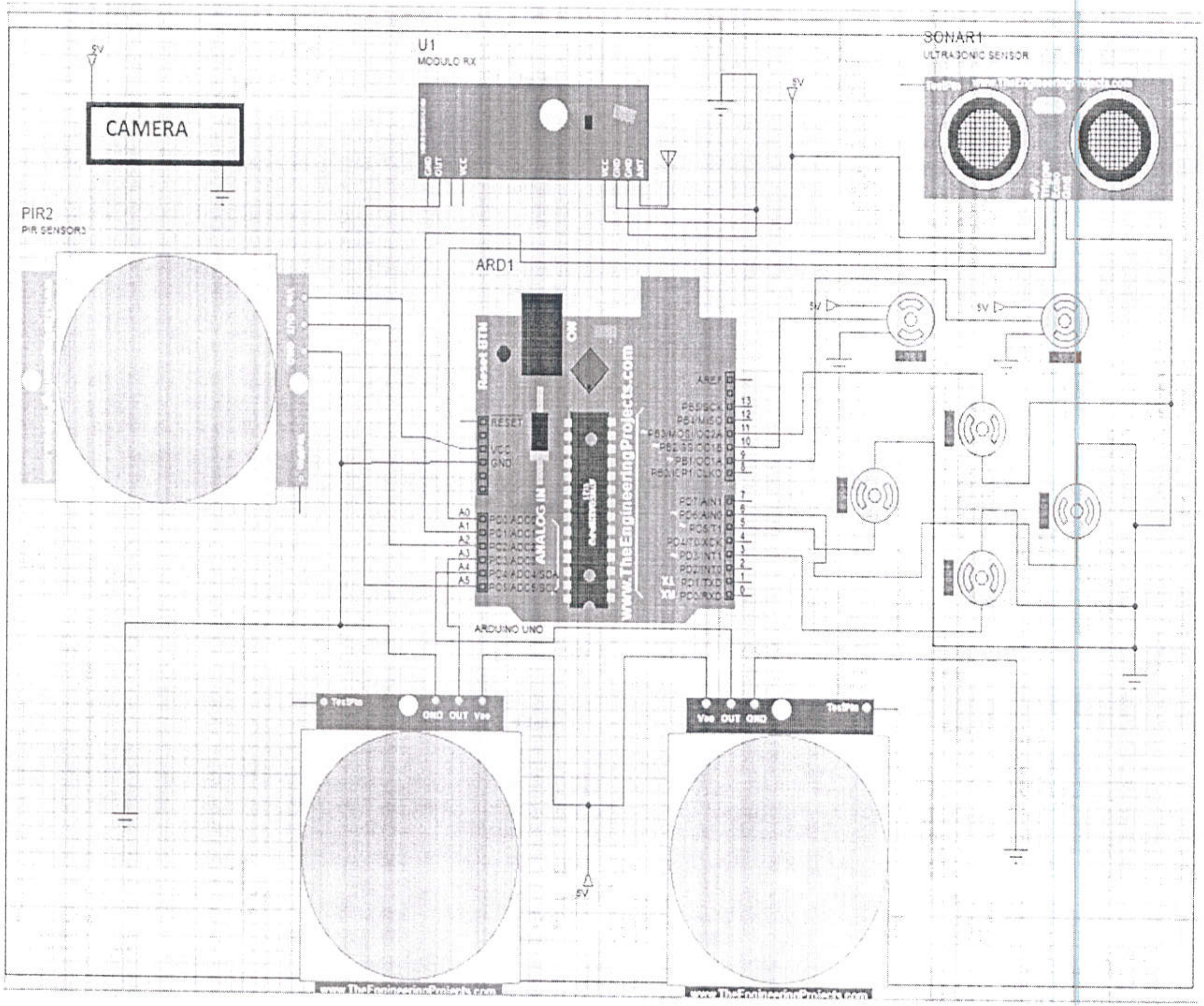



Figure 3.10: Circuit Diagram for The Surveillance Robot

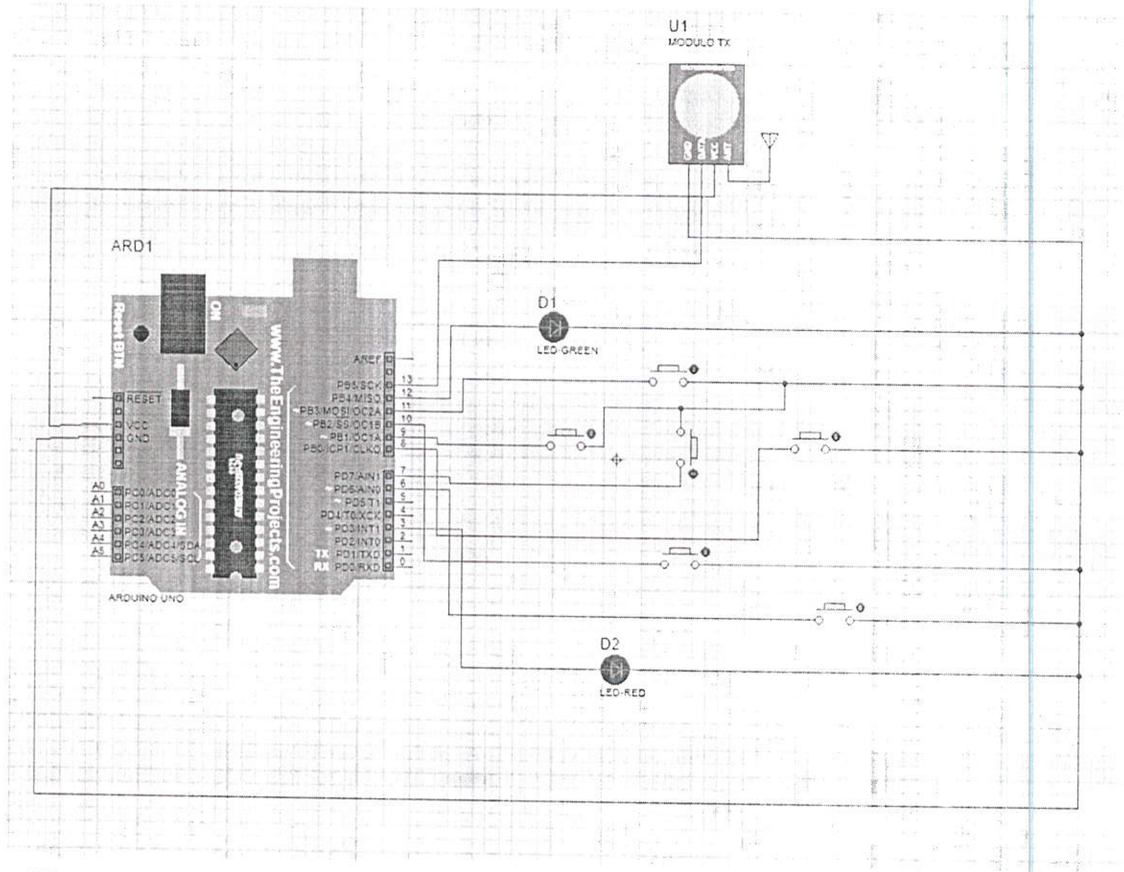


Figure 3.11: The Remote Control Circuit Diagram for The Surveillance Robot

NOTE: the circuit diagram in fig 3.10 has the adafruit motor driver omitted in the circuit, this is due to most circuit drawing software lacking the adafruit motor driver as a component but each component is connected to the Arduino pins just the same way the motor driver would connect to the Arduino if it was used/attached to it.

### 3.4.1 Circuit Explanation

The ultrasonic sensor has terminals: Echo, Trigger, VCC and ground. The trigger is connected to analog pin A0, the echo is connected to analog pin A1 while the VCC and ground are connected to a 5V supply and ground terminal on the motor shield respectively. The trigger send the sound wave and the echo receive the bounce back sound from the obstacle. The Ultrasonic sensor range has been set to 300cm. The plastic type of servo has the ultrasonic sensor on it, it gives the ultrasonic sensor the ability to have a wider range of obstacle detection by rotating it from 0 to 144 degrees.

When in remote mode the desired push button signifying which movement to make is pressed from the base station and the data is transmitted by the transmitter (connected on pin 13 on the Arduino in the remote) to the receiver on the robot (connected on analog pin 5) and the receiver would pass the collected data to the Arduino that translate the data into the desired movement. The LEDs in fig 3.11 turns ON when any button is pressed and remain ON until the receiver is ready to receive another command.

### 3.5 Coding

The coding of the Arduino is done using the Arduino IDE software by using C language and the sketch gotten is uploaded into the Arduino. The main mode of operation of the robot is autonomous mode but due to the need to want to remotely control the robot to a specified direction, a remote control was made as shown in fig 3.11 using a RF 433MHz transmitter and receiver. Two sketches were made for autonomous mode and

### 3.6 Night Vision Camera

A program is created by focusing the camera on a scene. The camera changes light from the scene into an electric signal, called the video signal, which varies depending on the strength, or brightness of light received from each part of the scene. The video signals from the cameras are processed in the base station including audio signals from microphones placed in or near the environment. The camera captures the video and audio signals and is then sent to the transmitter. The transmitter amplifies the video and audio signals, and uses the electronic signals to modulate or vary carrier waves. The carrier waves are combined and then sent to the transmitting antenna. In the antenna, the oscillations of the carrier waves generate electromagnetic waves of energy that radiate horizontally throughout the atmosphere. The waves excite weak electric currents in the receiving antennas within the range. These currents have the characteristics of the original picture and sound currents. The currents flow from the antenna attached to the television or computer into the receiver, where they are electronically separated into audio and video signals. These signals are amplified and sent to the picture tube and the speakers, where they produce the picture and sound portions of the program. Its output signals are in the form of audio and video, these signals are directly connected to a television, computer or a phone through a tuner card in the base station with the help of the camera receiver. So whatever the camera captures can be viewed from the base station.

# CHAPTER FOUR

## RESULT AND DISCUSSION

The mobile surveillance robot was built with an acrylic plastic with a four wheels drive ability, an Arduino UNO R3, a motor shield, an RF 433MHz module, PIR sensors, ultrasonic sensor, push button, a power bank of 2020mAh (output 5V, 1A) to power the motor shield and the Arduino, a 9V battery to power the wireless camera and the mobile robot moves at 0.125m/s. Due to the type of methodology used the following results were gotten

### 4.1 Mode of Operation of The Surveillance Robot

By default, the mobile surveillance robot mode of operation is autonomous mode whereby it doesn't take any command but uses the environmental input to control it movement but another mode was created due to necessity which is the remote control mode

#### 4.1.1 Autonomous Mode

When in autonomous mode, the PIR has been configured in repeatable trigger mode, time delay at 3 seconds and sensitivity at 5meters range. The PIR at the left gives an HIGH output, the microcontroller on the Arduino gives the motor driver the command to turn left and the metal gear servo rotate the camera in a 180-degree view in order to capture the living creature sensed on the camera. The same process happens for the PIR infrared signal, the surveillance robot moves around the environment and around obstacle without colliding with them by sending sounding wave via the trigger of the ultrasonic sensor and receives the bounced back signal through the echo, I was able to programmed the minimum distance the robot is supposed to maintain between obstacle and itself to be 30cm. so anytime the distance between the obstacle and the robot is less than 30cm it moves backward a few centimeters and stop then the plastic servo motor rotate the ultrasonic sensor to the left and the ultrasonic measure the distance between itself and any nearby obstacle and save the reading then to the servo again rotate it to the right to measure the distance of any nearby obstacle to the robot and save the reading, the reading is then processed by the microcontroller to determine which direction is less obstructed if the left is ,then the robot takes a left turn but if the right is less obstructed, the robot takes a right turn and if both left and right are equally obstructed the robot turnaround and face back where it was coming from. For every obstacle sensed by the ultrasonic sensor during the no output by the PIR sensors, the metal servo motor rotates the camera to show the obstacle detected and also to show the surrounding area, hence survey the environment.

### 4.1.2 Remote Control Mode

Due to the fact that people would want to control the robot to places that human cannot fit, hazardous to human being, to a specified place and for search and rescue purposes, a remote control mode was designed. In this mode the mobile surveillance would maintain between itself and any obstacle has been set to be 1cm so the robot can navigate through really tight corners.

The remote side consist of 6 push buttons signifying forward, backward, left, right, stop and turnaround and each push button has been coded to send a particular data via the transmitter on the Arduino in the remote control side when pressed and such particular data is received by the receiver on the mobile robot and interpreted by the Arduino to signify the desired wanted direction and such direction is passed to the attached motor driver. The ability of the robot to turn to the direction of a sensed infrared rays from living creatures such as human is disabled due to the fact that the robot must maintain the direction given to it via the remote and now the camera is fixed in a direction, so there would be blind spot which the camera cannot see.

Table 4.1 shows how the robot with a four wheels' drive achieve its forward, backward, left, right and turnaround operation.

Table 4.1: Operation Performed for The Robot Movement

| Operation | Forward | Backward | Left | Right | Turnaround |
|---|---|---|---|---|---|
| **Left motor 1** | Forward | Backward | Backward + extra speed | Forward | Forward + timer |
| **Left motor 2** | Forward | Backward | Backward + extra speed | Forward | Forward + timer |
| **Right motor 1** | Forward | Backward | Forward | Backward + extra speed | Backward + extra speed+ timer |

## 4.2 Video and Audio Transmission

The night vision camera of the robot has 6 IR LEDs that assist in image viewing during the night, it can transmit audio and video in real time to the base station. The camera receiver must be within 15meters from the mobile surveillance robot for proper receiving of the audio and video signal from the wireless night vision camera.

### 4.2.1 Video Transmission

The video from the camera receiver is passed through the TV tuner and an application called honestech TVR 2.5 is used to view the video on the computer, it also allows recording of the video and audio at the same time on the computer for reference purposes. The USB 2.0(tuner card interface) is selected in the video mode of the TVR 2.5, so that the video and audio receive by the camera receiver is shown on the screen because the TVR can also use the webcam or any video input device attached to the system.

### 4.2.2 Audio Transmission

The audio gotten from the honestech TVR 2.5 still possess noise from the surrounding and from the wave. In order to remove the noise for clarity, a computer application called Audacity is used, select the USB 2.0(tuner card interface) as the interface, isolate the quiet moment and click effect ribbon in the Audacity and select noise

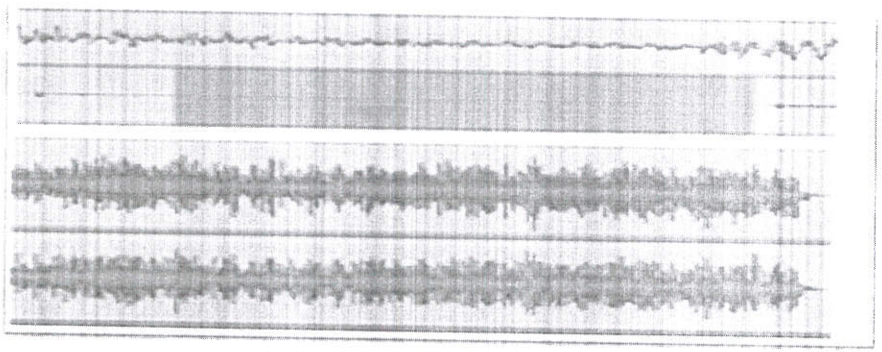


Figure 4.1: Isolating The Quiet Moment When Using the Audacity Software

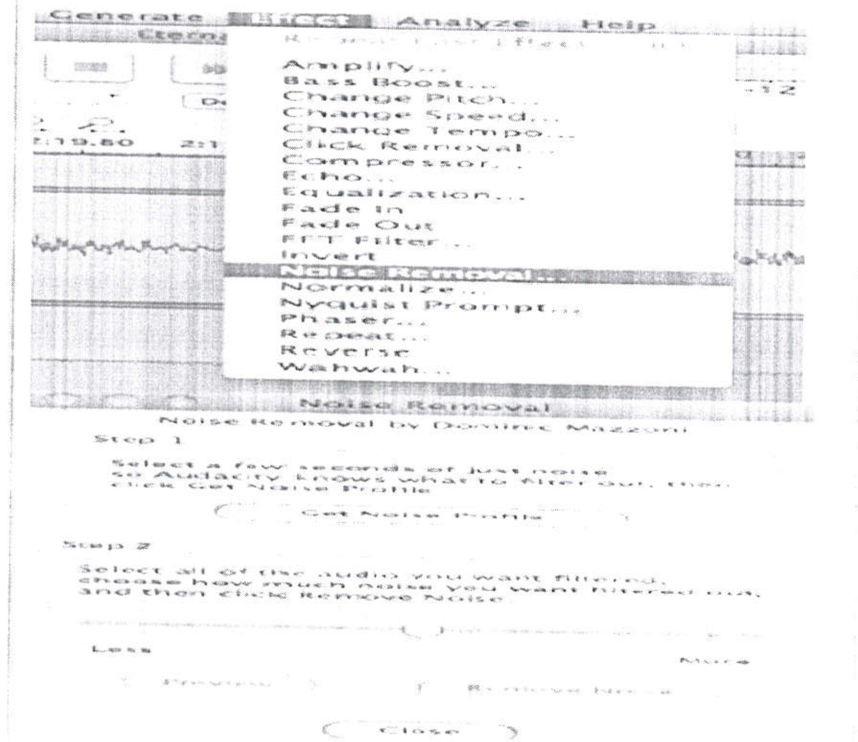
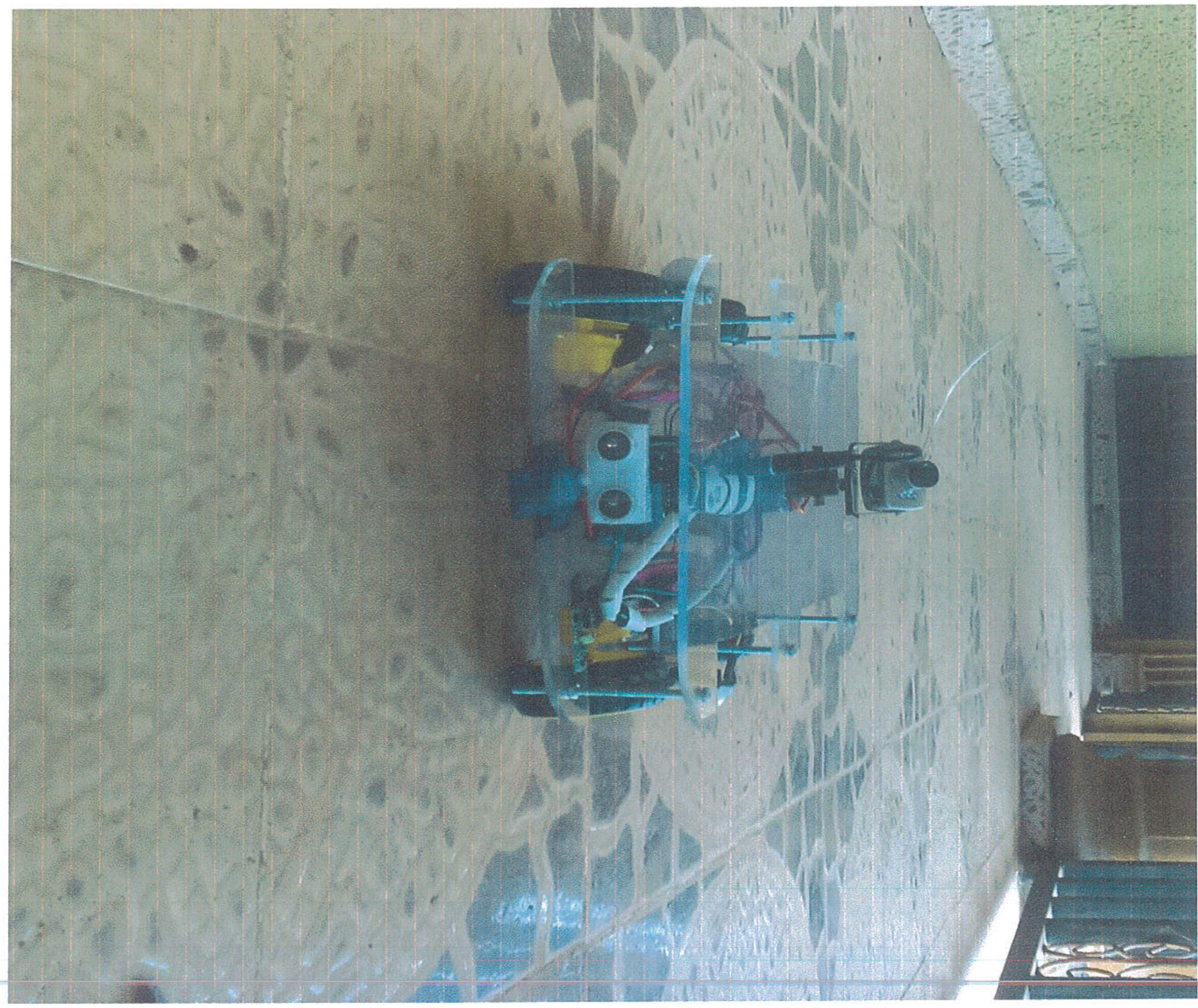
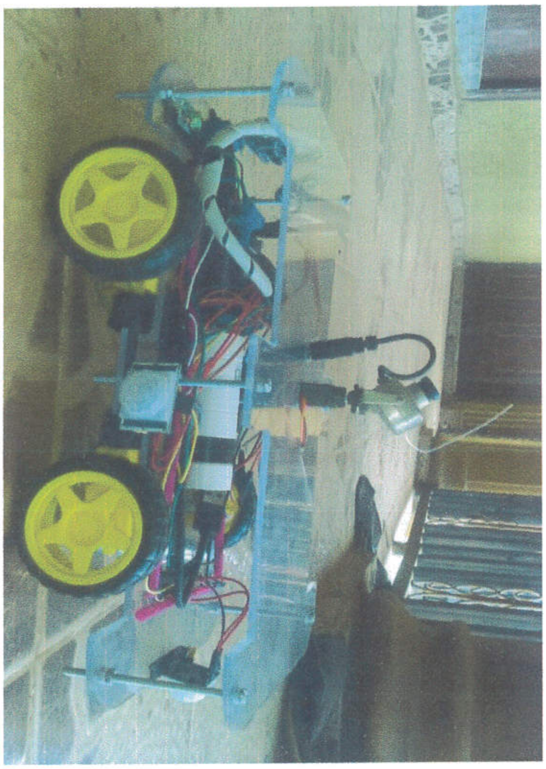



Figure 4.2: Fetching the Noise Profile in Audacity Software





# CHAPTER FIVE

## CONCLUSION AND RECOMMENDATION

The goal of this project was to fabricate and design a mobile surveillance robot with night vision camera with the idea to want to see the places we wish to see at will and also gives us audio and video at real time, to helps in the repetitive task and labor cost usually involved in surveillance, hazardous and dangerous places, places human being cannot fit, military operation and to ease search and rescue operation. The goals were fulfilled with quite good results and the idea is realized at our fingertips.

The surveillance robot was made to works autonomously using the environment impulse but if the robot is to be used for hazardous places, places that human cannot fit and to move to a particular place, a remote control was fabricated to assist with such operation.

We have been able to view things accurately that are currently happening in the surrounding area. Our design has not caused any sort of disturbances. The robot will move depending on the motor direction based upon the infrared ray sensed by the PIR form the environment or the input we give through command from the base station. With the aid of the night vision camera, the robot can also be used in the night without having any problem with the video.

### 5.1 Future Implementation

- Easily operated by Cellphones by implementing DTMF system.
- Android Apps can be easily developed for operate the robot.
- By implementing GPS system, the detection of robot can be easily determined.
- By implementing RFID system, these play a major role in security systems and save database.
- Facial recognition and detection can be implemented in the robot.
- A wider coverage of the wireless camera can be used.
- Ability to make some drastic action to intruders seen in the surveyed environment can be implemented.
- The disadvantage of using PIR sensor in detecting infrared rays from living creature is that it only detects but does not include the particular location the infrared ray was sensed in its 110-degree view angle.

## 5.2 Recommendation

1. The robot size can be reduced to allow it to be able to penetrate places.
2. The mobile robot can be used to monitor secure places.
3. The mobile robot can be converted into a spy robot and used in war front for collection of information on the war front.

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# Appendix 1: Bill of Materials

| S/N | Item | Quantity | Price Per Quantity in Naira | Subtotal |
|---|---|---|---|---|
| 1 | Arduino Board | 2 | 3000 | 6000 |
| 2 | DC Motors | 4 | 1500 | 6000 |
| 3 | Wheels | 4 | 300 | 1200 |
| 4 | Ultrasonic Sensor | 1 | 1500 | 1500 |
| 5 | PIR Sensor | 3 | 1000 | 3000 |
| 6 | Servo Motor(Metal Gear) | 1 | 3000 | 3000 |
| 7 | Servo Motor(Plastics Gear) | 1 | 2000 | 2000 |
| 8 | Motor Bracket T- Head Set | 4 | 200 | 800 |
| 9 | Jumper Wire Bundles | 1 | 1000 | 1000 |
| 10 | Arduino Battery Clip | 3 | 200 | 600 |
| 11 | Wireless CCTV Night Vision Camera Set | 1 | 15000 | 15000 |
| 12 | Adafruit Motor Shield | 1 | 3500 | 3500 |
| 13 | Push Buttons | 6 | 100 | 600 |
| 14 | RF 434Mhz Pair | 1 | 200 | 200 |
| 15 | Vero Board | 1 | 100 | 100 |
| 16 | Resistors(1KΩ) | 2 | 30 | 60 |
| 17 | Capacitor(0.1µF) | 4 | 50 | 200 |
| 18 | LEDs | 2 | 20 | 40 |
| 19 | Screws and Nuts | 20 | 50 | 1000 |
| 20 | Double Sided Tape | 1 | 500 | 500 |
| 21 | Battery(9V) | 3 | 200 | 600 |
| 22 | Power Bank(2020mAh) | 1 | 2500 | 2500 |
| | | | Grand Total | 49400 |

# Appendix 2: Autonomous Mode code

```
#include <Servo.h>        // the servo library
#include <AFMotor.h>      //add Adafruit Motor Shield library
#include <NewPing.h>      //add Ultrasonic sensor library
#define TRIG_PIN A0 // Pin A0 on the Motor Drive Shield soldered to the ultrasonic sensor
#define ECHO_PIN A1 // Pin A1 on the Motor Drive Shield soldered to the ultrasonic sensor
#define MAX_DISTANCE 300 // sets maximum useable sensor measuring distance to 300cm
#define MAX_SPEED 150 // sets speed of DC traction motors to 150/250 or about 70% of full
speed to get power drain down.
#define MAX_SPEED_OFF 40 // this sets offset to allow for differences between the two DC
traction motors
#define COLL_DIST 30 // sets distance at which robot stops and reverses to 30cm
#define TURN_DIST COLL_DIST+20 // sets distance at which robot veers away from object
#define roll 9// // define the pins for the servos that carries the ultrasonic
#define poll 10// define the pins for the servos that carries the camera
NewPing sonar(TRIG_PIN, ECHO_PIN, MAX_DISTANCE); // sets up sensor library to use
the correct pins to measure distance.
AF_DCMotor leftMotor1(1, MOTOR12_1KHZ); // create motor #1 using M1 output on Motor
Drive Shield, set to 1kHz PWM frequency
AF_DCMotor leftMotor2(2, MOTOR12_1KHZ); // create motor #2, using M2 output, set to
1kHz PWM frequency
AF_DCMotor rightMotor1(3, MOTOR34_1KHZ);// create motor #3, using M3 output, set to
1kHz PWM frequency
AF_DCMotor rightMotor2(4, MOTOR34_1KHZ);// create motor #4, using M4 output, set to
1kHz PWM frequency
int leftDistance, rightDistance; //distances on either side
int curDist = 0;
String motorSet = "";
int speedSet = 0;
const int PIR1=A2;//assign A2 for the left PIR
const int PIR2=A5;//assign A5 for the right PIR
const int PIR3=A4;//assign A4 for the back PIR
Servo servo1;//create an object to control servo1
Servo servo2;//create an object to control servo2
int i=0;
void setup() {
  // put your setup code here, to run once:
pinMode(PIR1,INPUT);
pinMode(PIR2,INPUT);
pinMode(PIR3,INPUT);//set all the PIRs as input
servo1.attach(poll);//servo1 is attached to pin 10
servo2.attach(roll);//servo2 is attached to pin 9
servo1.write(90);//set the servo at 90-degree
servo2.write(90);//set the servo at 90-degree
```

```
  delay(100);//wait for 100ms
  turnLeft();//turn left
  moveStop();//stop the motors
  delay(100);//wait for 100ms
  Camera_rotate();//rotate camera through 180-degree
  check_State();//check for any near by obstacle
  Camera_rotate();//rotate camera again through 180-degree
     if(curDist > COLL_DIST){//if the obstacle is not within 30cm
   check_State();
   moveForward();//move forward
   delay(500);//wait for 500ms
   check_State();//check for any near by obstacle
   Camera_rotate();//rotate camera through 180-degree when motors are moving forward
  }
 }
  else if(digitalRead(PIR2)==HIGH){//when the right PIR sense a person on the right side
    moveStop();
   delay(100);
   turnRight();//ruen right
   moveStop();
  delay(100);
  Camera_rotate();//rotate the camera through 180-degree
  check_State();//check for any near by obstacle
  Camera_rotate();//rotate camera again through 180-degree
   if(curDist > COLL_DIST){//if the obstacle is not within 30cm
  check_State();
  moveForward();//move forward
  delay(500);
  check_State();//check for any near by obstacle
  Camera_rotate();//rotate camera through 180-degree when motors are moving forward
  }
 }
else if(PIR3==HIGH){//when the back PIR sense a person from the back
  moveStop();
  delay(100);
  turnAround();//turn around
  delay(1000);//wait for a second
  moveStop();
  delay(100);
  Camera_rotate();
check_State();
Camera_rotate();
   if(curDist > COLL_DIST){//if the obstacle is not within 30cm`
  check_State();
  moveForward();
  delay(500);
```

```
    if(curDist < COLL_DIST) {//if obstacle is within 30cm
     moveStop();
     delay(100);
     moveBackward();//move backward
     delay(50);
     Camera_rotate();//rotate the camera through 180-degree
     changePath();}  // if forward is blocked change direction
   moveForward();  // move forward
   delay(500);
  }
 }
 void changePath() {//if front is obstructed
  moveStop();   // stop forward movement
  servo1.write(30);  // check distance to the right
    delay(500);
    rightDistance = readPing(); //set right distance
    delay(500);
    servo1.write(150);  // check distace to the left
    delay(700);
    leftDistance = readPing(); //set left distance
    delay(500);
    servo1.write(90); //return to center
    delay(100);
    compareDistance();//check which one is less obstructed
  }

void compareDistance()   // find the longest distance
{
  if(leftDistance>rightDistance) //if left is less obstructed
  {
   turnLeft();
  }
  else if (rightDistance>leftDistance) //if right is less obstructed
  {
   turnRight();
  }
  else //if they are equally obstructed
  {
   turnAround();
  }
}


//---------------------------------------------------------------------------------------------------------
int readPing() { // read the ultrasonic sensor distance
  delay(70);
```

```
   motorSet = "FORWARD";
   leftMotor1.run(FORWARD);     // turn it on going forward
   leftMotor2.run(FORWARD);     // turn it on going forward
   rightMotor1.run(FORWARD);    // turn it on going forward
   rightMotor2.run(FORWARD);    // turn it on going forward
  for (speedSet = 0; speedSet < MAX_SPEED; speedSet +=2) // slowly bring the speed up to
avoid loading down the batteries too quickly
  {
   leftMotor1.setSpeed(speedSet);
   leftMotor2.setSpeed(speedSet);
   rightMotor1.setSpeed(speedSet);
   rightMotor2.setSpeed(speedSet);
   delay(5);
  }
}
//---------------------------------------------------------------------------------------------
void turnRight() {
 motorSet = "RIGHT";
  leftMotor1.run(FORWARD);     // turn motor 1 forward
  leftMotor2.run(FORWARD);     // turn motor 2 forward
  rightMotor1.run(BACKWARD);   // turn motor 3 backward
  rightMotor2.run(BACKWARD);   // turn motor 4 backward
  rightMotor1.setSpeed(speedSet+MAX_SPEED_OFF);
  rightMotor2.setSpeed(speedSet+MAX_SPEED_OFF);
  delay(1500); // run motors this way for 1500
  motorSet = "FORWARD";
  leftMotor1.run(FORWARD);     // set both motors back to forward
  leftMotor2.run(FORWARD);
  rightMotor1.run(FORWARD);
  rightMotor2.run(FORWARD);
}
//---------------------------------------------------------------------------------------------
void turnLeft() {
 motorSet = "LEFT";
 leftMotor1.run(BACKWARD);     // turn motor 1 backward
 leftMotor2.run(BACKWARD);     // turn motor 2 backward
 leftMotor1.setSpeed(speedSet+MAX_SPEED_OFF);
 leftMotor2.setSpeed(speedSet+MAX_SPEED_OFF);
 rightMotor1.run(FORWARD);     // turn motor 3 forward
 rightMotor2.run(FORWARD);     // turn motor 4 forward
 delay(1500); // run motors this way for 1500
 motorSet = "FORWARD";
 leftMotor1.run(FORWARD);      // turn it on going forward
 leftMotor2.run(FORWARD);      // turn it on going forward
 rightMotor1.run(FORWARD);     // turn it on going forward
```

```
 rightMotor1.setSpeed(MAX_SPEED+MAX_SPEED_OFF);
 rightMotor2.setSpeed(MAX_SPEED+MAX_SPEED_OFF);
 delay(3000); // run motors this way for 3000
 motorSet = "FORWARD";
 leftMotor1.run(FORWARD);      // set both motors back to forward
 leftMotor2.run(FORWARD);
 rightMotor1.run(FORWARD);
 rightMotor2.run(FORWARD);
 moveStop();
}
void check_State(){
 curDist = readPing();
 if (curDist < COLL_DIST) {//if the obstacle is within 30cm
  moveStop();
  delay(100);
  moveBackward();
  delay(50);
  moveStop();
  delay(200);
 }
}
//-------------------------------------------------------------------------------------------
void Camera_rotate(){
 int i;
 for(i=0;i<=180;i=i+20){
  servo2.write(i);//rotate the camera by 20-degree
  delay(500);//wait for 500ms
 }
 servo2.write(90);//position the servo at 90-degree
 delay(1000);//wait for a second
}
//-------------------------------------------------------------------------------------------
void moveBackward() {
  speedSet = 0;
  motorSet = "BACKWARD";
  leftMotor1.run(BACKWARD);     // turn it on going backward
  leftMotor2.run(BACKWARD);     // turn it on going backward
  rightMotor1.run(BACKWARD);    // turn it on going backward
  rightMotor2.run(BACKWARD);    // turn it on going backward
  leftMotor1.setSpeed(speedSet+MAX_SPEED);
  leftMotor2.setSpeed(speedSet+MAX_SPEED);
  rightMotor1.setSpeed(speedSet+MAX_SPEED);
  rightMotor2.setSpeed(speedSet+MAX_SPEED);
  delay(1500);
  moveStop();
}
```

## Appendix 3: Remote Control Code for The Transmitter side

```
#include <VirtualWire.h>//include the RF library
int push=11;//forward button is connected to pin 11
int push1=10;//backward button is connected to pin 10
int push2=9;//left button is connected to pin 9
int push3=8;//right button is connected to pin 8
int push4=7;//turnaround button is connected to pin 7
int push5=6;//brake button is connected to pin 6
int led1=12;//green LED is connected to pin 12
int led2=3;//red LED is connected to pin 3
int dataout=13;//assign pin 13 as the signalpin for the transmitter
char *data;// create a storage memory to store the data transmitted by the transmitter
and name the storage memory as data
int remotePins[]= {6,7,8,9,10,11};//array to store pin nos
void setup() {
  // put your setup code here, to run once:
vw_set_ptt_inverted(true);
 vw_set_tx_pin(dataout);// set the transmitter data pin as pin 13
 vw_setup(2000);//transmit at 2000bps
  for(int i=0;i<7;i++)
    {
      pinMode(remotePins[i], INPUT);//set the push buttons as inputs
      digitalWrite(remotePins[i],HIGH);//make all the push buttons high
    }
    pinMode(led1,OUTPUT);
    pinMode(led2,OUTPUT);//set the green and red LEDs has outputs
}

void loop() {
  // put your main code here, to run repeatedly:
if(digitalRead(push)==LOW){// when the forward button is pressed
  digitalWrite(led1,HIGH);//turn on the green LED
  digitalWrite(led2,LOW);//turn off the red LED
  data="1";//send 1 to the receiver when the forward button is pressed
  vw_send((uint8_t *)data, strlen(data));
   vw_wait_tx();// wait for the transmitter to send the data
   delay(1500);//put there to know when to press the second button so that it can be
received by the receiver
```

```
    vw_wait_tx();//wait for the transmitter to send the data
    delay(1500);//put there to know when to press the second button so that it can be
received by the receiver
    digitalWrite(led1,LOW);//turn off the green LED
}
else if(digitalRead(push2)==LOW){//when the left button is pressed
  digitalWrite(led1,HIGH);//turn on the green LED
  digitalWrite(led2,LOW);//turn off the red LED
  data="3";//send 3 to the receiver when the left button is pressed
   vw_send((uint8_t *)data, strlen(data));
    vw_wait_tx();//wait for the transmitter to send the data
    delay(1500);//put there to know when to press the second button so that it can be
received by the receiver
    digitalWrite(led1,LOW);//turn off the green LED
}
else if(digitalRead(push3)==LOW){//when the right button is pressed
  digitalWrite(led1,HIGH);//turn on the green LED
  digitalWrite(led2,LOW);//turn off the red LED
  data="4";//send 4 to the receiver when the right button is pressed
   vw_send((uint8_t *)data, strlen(data));
    vw_wait_tx();//wait for the transmitter to send the data
    delay(1500);//put there to know when to press the second button so that it can be
received by the receiver
    digitalWrite(led1,LOW);//turn off the green LED
}
else if(digitalRead(push4)==LOW){//when the turnaround button is pressed
  digitalWrite(led1,HIGH);//turn on the green LED
  digitalWrite(led2,LOW);//turn off the red LED
  data="5";//send 5 to the receiver when the turnaround button is pressed
   vw_send((uint8_t *)data, strlen(data));
    vw_wait_tx();//wait for the transmitter to send the data
    delay(1500);//put there to know when to press the second button so that it can be
received by the receiver
    digitalWrite(led1,LOW);//turn off the green LED
}
if(digitalRead(push5)==LOW){//when the brake button is pressed
  digitalWrite(led2,HIGH);//turn on the green LED
  digitalWrite(led1,HIGH);//turn on the red LED
  data="6";//send 6 to the receiver when the brake button is pressed
```

## Appendix 4: Remote Control Code for The Receiver side

```
#include <AFMotor.h>     //add Adafruit Motor Shield library
#include <VirtualWire.h> //add Rf library
#define MAX_SPEED 150 // sets speed of DC traction motors to 150/250 or about 70%
of full speed - to get power drain down.
#define MAX_SPEED_OFFSET 40 // this sets offset to allow for differences between
the two DC traction motors
AF_DCMotor leftMotor1(1, MOTOR12_1KHZ); // create motor #1 using M1 output
on Motor Drive Shield, set to 1kHz PWM frequency
AF_DCMotor leftMotor2(2, MOTOR12_1KHZ); // create motor #2, using M2 output,
set to 1kHz PWM frequency
AF_DCMotor rightMotor1(3, MOTOR34_1KHZ);// create motor #3, using M3 output,
set to 1kHz PWM frequency
AF_DCMotor rightMotor2(4, MOTOR34_1KHZ);// create motor #4, using M4 output,
set to 1kHz PWM frequency
String motorSet = "";
int speedSet = 0;
const int datain = A3;// assign analog pin 3 as the receiver signal pin
void setup() {
  // put your setup code here, to run once:
Serial.begin(9600);
 vw_set_ptt_inverted(true);
 vw_set_rx_pin(datain);//set the receiver signal as analog pin 3
 vw_setup(2000);//receive at 2000bps
 vw_rx_start();//start receiving
pinMode(datain,INPUT);//set analog pin 3 as input
}

void loop() {
  // put your main code here, to run repeatedly:
uint8_t buf[VW_MAX_MESSAGE_LEN];
uint8_t buflen = VW_MAX_MESSAGE_LEN;
if (vw_get_message(buf, &buflen)){//if any message is received
if(buf[0]=='1'){//if one is received
  moveForward(); // move forward
 delay(1000);//wait for  second
 Serial.print(buf[0]);//print what is received on the screen
}
```

```
  delay(1000);//wait for a second
  Serial.print(buf[0]);//print what is received on the screen
  }
 if(buf[0]=='4'){//if four is received
   turnRight();  // turn right
  delay(1000);//wait for a second
  Serial.print(buf[0]);//print what is received on the screen
  }
  if(buf[0]=='5'){//if five is received
   turnAround();  // turn around
  delay(1000);//wait for a second
  Serial.print(buf[0]);//print what is received on the screen
  }
  if(buf[0]=='6'){//if six is received
   moveStop;   // stop the motor
}
 }
}
//------------------------------------------------------------------------------------------
void      moveStop()      {leftMotor1.run(RELEASE);      leftMotor2.run(RELEASE);
rightMotor1.run(RELEASE); rightMotor2.run(RELEASE);}  // stop the motors.
//------------------------------------------------------------------------------------------
void moveForward() {
   speedSet = 0;
   motorSet = "FORWARD";
   leftMotor1.run(FORWARD);      // turn it on going forward
   leftMotor2.run(FORWARD);      // turn it on going forward
   rightMotor1.run(FORWARD);     // turn it on going forward
   rightMotor2.run(FORWARD);     // turn it on going forward
    rightMotor1.setSpeed(speedSet+MAX_SPEED);
    rightMotor2.setSpeed(speedSet+MAX_SPEED);
    leftMotor1.setSpeed(speedSet+MAX_SPEED);
    leftMotor2.setSpeed(speedSet+MAX_SPEED);
  delay(1500);
  moveStop();
 }
//--------------------------------------------------------------------------------------------
----
void moveBackward() {
```

```
  leftMotor2.setSpeed(speedSet+MAX_SPEED);
  rightMotor1.setSpeed(speedSet+MAX_SPEED);
  rightMotor2.setSpeed(speedSet+MAX_SPEED);
  delay(1500);
  moveStop();
 }
 //---------------------------------------------------------------------------------------------
void turnRight() {
 speedSet = 0;
 motorSet = "RIGHT";
 leftMotor1.run(FORWARD);     // turn motor 1 forward
 leftMotor2.run(FORWARD);     // turn motor 2 forward
 rightMotor1.run(BACKWARD);   // turn motor 3 backward
 rightMotor2.run(BACKWARD);   // turn motor 4 backward
 rightMotor1.setSpeed(MAX_SPEED+MAX_SPEED_OFFSET);
 rightMotor2.setSpeed(MAX_SPEED+MAX_SPEED_OFFSET);
 delay(1500); // run motors this way for 1500
 motorSet = "FORWARD";
 leftMotor1.run(FORWARD);     // set both motors back to forward
 leftMotor2.run(FORWARD);
 rightMotor1.run(FORWARD);
 rightMotor2.run(FORWARD);
 moveStop();
}
//---------------------------------------------------------------------------------------------
void turnLeft() {
 speedSet = 0;
 motorSet = "LEFT";
 leftMotor1.run(BACKWARD);     // turn motor 1 backward
 leftMotor2.run(BACKWARD);     // turn motor 2 backward
 leftMotor1.setSpeed(MAX_SPEED+MAX_SPEED_OFFSET);
 leftMotor2.setSpeed(MAX_SPEED+MAX_SPEED_OFFSET);
 rightMotor1.run(FORWARD);     // turn motor 3 forward
 rightMotor2.run(FORWARD);     // turn motor 4 forward
 delay(1500); // run motors this way for 1500
 motorSet = "FORWARD";
 leftMotor1.run(FORWARD);      // turn it on going forward
 leftMotor2.run(FORWARD);      // turn it on going forward
 rightMotor1.run(FORWARD);     // turn it on going forward
```

```
  leftMotor1.run(FORWARD);      // turn motor 1 forward
  leftMotor2.run(FORWARD);      // turn motor 2 forward
  rightMotor1.run(BACKWARD);    // turn motor 3 backward
  rightMotor2.run(BACKWARD);    // turn motor 4 backward
  rightMotor1.setSpeed(MAX_SPEED+MAX_SPEED_OFFSET);
  rightMotor2.setSpeed(MAX_SPEED+MAX_SPEED_OFFSET);
  delay(3000); // run motors this way for 3000
  motorSet = "FORWARD";
  leftMotor1.run(FORWARD);      // set both motors back to forward
  leftMotor2.run(FORWARD);
  rightMotor1.run(FORWARD);
  rightMotor2.run(FORWARD);
  moveStop();
}
//---------------------------------------------------------------------
```