DESIGN AND DEVELOPMENT OF A MOSQUITO REPELLING ROBOT USING ULTRASONIC SOUND

BY

OJIMIWE SIMEON OSUYA

(MEE/12/0865)

SUBMITTED TO

DEPARTMENT OF MECHATRONICS ENGINEERING,

FACULTY OF ENGINEERING,

FEDERAL UNIVERSITY OYE EKITI. EKITI STATE.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF

BACHELOR OF ENGINEERING (B.Eng) DEGREE IN MECHATRONICS ENGINEERING

NOVEMBER, 2017

Intentionally left blank

DECLARATION

I hereby declare that this project has been carried out by me OJIMIWE SIMEON OSUYA (MEE/12/0865), and submitted to the Department of Mechatronics Engineering, Federal University Oye-Ekiti, Ekiti State in partial fulfilment for the award of Bachelor of Engineering (B.Eng) degree in Mechatronics Engineering.

OJIMIWE SIMEON OSUYA
____

Name of Student

____

Signature and Date

APPROVAL

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

BY

SUPERVISOR

NAME: ______________________

SIGNATURE: ________________

DATE: ______________________

HEAD OF DEPARTMENT

NAME: ______________________

SIGNATURE: ________________

DATE: ______________________

EXTERNAL EXAMINER

NAME: ______________________

SIGNATURE: ________________

DATE: ______________________

DEDICATION

This project is dedicated to Almighty God (the author and finisher of all things), my Parents, siblings, friends, Prof. Christian Bolu, Dr. A. V. Balogun, Dr. A. A. Adekunle, lecturers, staff and my ever gallant course mates for their guidance and support through the years.

ACKNOWLEDGEMENT

I feel blessed and accomplished to have climbed this far on the academic ladder with blessings in form of humans around me.

I want to gracefully appreciate the efforts of my parents Mr. and Mrs. Ojimiwe (JP), my siblings and their families, Mr. and Mrs Anyaele, Mr. and Mrs. Babatunde Ojimiwe, Mr. Ojimiwe Solomon, Mr. kehinde Ojimiwe and Mr. and Mrs. Sadibo, Mr. Nghada Shadrach and Agadi Linus for their unwavering support in terms of finances, prayers and motivation before, during and after this project.

I also will appreciate my supervisor, Engr. (Dr.) A. A. Adekunle for his support and motivation, my sincere gratitude also goes go my lecturers Prof. Samuel Adejuyigbe, Engr. (Dr.) Vincent Aizebeoje Balogun, Engr. Aribisala, Engr. Martins, Engr. Otenaike, Engr. Adebimpe, Mr. Payne and the non-teaching staff of the department for their precious advice and support through the times.

I am indeed indebted to my friends, hostel mates, and course mates, Adedeji Faith, Akano Mary, Onyekwelu Chioma, Udeme Sarah, Isife Olisaemeka, Olatunji Jubril, Eniola Olugbemi, Oyetunji Samuel, Babayomi Samuel, Oladele Michael, Olaiya Oluwakorede, Bello Hussein, Abereola Oluwaseun, Omosebi Isaac, Orisabinone Toluwalase, Kolade Olawale, Agu Collins, Ugwuja Chibuzor, Bello Okikioluwa, Fatokun Oluwatobi, Ilesanmi Samuel and Samakinde Michael.

I convey my thanks to Mount of Peace and Chapel of Transformation, Engr. Abioye James, Mr. Baiyeri, Mr. Osamoka, Dr. (Mrs.) Ndububa and every member of the family for their support and prayers.

Finally, my appreciation goes to the former Dean of Engineering in the person of Prof. Christian Bolu and the present dean of Engineering Prof. Albert Alabadan for their mentorship and great lessons often time. We extend our foremost appreciation to all the teaching and non-teaching staffs in the department of Mechatronics Engineering for their humanitarian service and relentless participation in making us a well baked engineering graduates.

I pray God bless you all for your impact in my life. Amen.

ABSTRACT

The mosquito repelling robot using ultrasonic sound is developed to eradicate the seemingly unstoppable menace caused by the most deadly animals "mosquitoes". This robot is designed to be eco-friendly with no harmful effect to man, it operates on battery which can be recharged by either electricity or solar power and works autonomously due to the fact that it is controlled by a microprocessor and receives input signals from solar panel, ultrasonic sensor and the PIR sensor to detect if there is obstruction in its working range. The frequency with which it operates is higher than that which can be heard by man (40 kHz), the result obtained from the project makes it recommended because it works efficiently in terms of repelling mosquitoes, eco-friendly, easy to operate and fully automated. The components used for this project include; ATMEGA328P-PU microcontroller, ultrasonic sensor, piezoelectric sensor (PIR), light-emitting diodes, pushbutton, buzzers, liquid crystal display (LCD), solar panel, resistors, capacitors, crystal oscillator and potentiometers. After the development of the robot, it was tested in a standard room of dimensions 3m x 3m and throughout the hours of which the robot was tested, the mosquitoes were restless and could not cope with the sound which caused them to move away hurriedly.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

Mosquitoes are small, midge-like flies whose tube-like mouthparts (called a proboscis) pierce the hosts' skin to consume blood. The word "mosquito" (formed by *mosca* and diminutive *–ito*) is Spanish for "little fly", this its tiny nature has made it quite difficult to control by humans unlike other bigger flies. Thousands of species feed on the blood of various kinds of hosts, mainly vertebrates, including humans especially. Some mosquitoes also attack invertebrates, mainly other arthropods. Though the loss of blood is seldom of any importance to the victim, the saliva of the mosquito often causes an irritating rash that is a serious nuisance. Much more serious though, are the roles of many species of mosquitoes as vectors of diseases. In passing from host to host, some transmit extremely harmful infections such as malaria, yellow fever, West Nile virus, dengue fever, Zika virus and other, rendering it the deadliest animal family in the world. All mosquitoes must have water to complete their life cycle, mosquitoes do not develop in grass or shrubbery, although adults frequently rest in these areas during daylight hours, only the female mosquito bites to obtain a blood meal. The male mosquito feeds only on plant juices, Female mosquitoes are attracted by heat and carbon dioxide to hosts such as humans.

In pursuit of solutions to the seemingly uncontrollable invasion of these 'tiny flies' in Nigeria which has caused so many deaths and cases of diseases. Nigeria has the largest burden of malaria and lymphatic filariasis in Africa, yet very little is known about the distribution of Anopheles mosquitoes that act as vectors for both diseases, how the species interact, overlap or differ across the country (WHO, 2011),. Many ways have been invented to curb their activities such as to avoiding stagnant water in residential areas, use of chemical insecticides, use of chemical treated nets, mosquito coils, repellent creams etc. these solutions have overtime been put to question because of its side effects on humans which tend to more hazardous to human life than even the mosquito bites itself.

In recent times, a better approach of mosquito prevention has been sought after by health organizations around the world, the latest form of prevention is the use of electronic devices through the production of ultrasonic sound to scare off the mosquitoes. The mosquito repellent device has been invented to being within a few decades ago and has since then been sought improvement upon. It can be used indoors or outdoors as desired and be taken around even for long distance travels because of its small, compact nature.

1.1 Statement of the problem

With so many scientists and professionals working tirelessly on the eradication of mosquitoes, engineers also are looking for possible ways to assist in this process and propound a less dangerous, ecofriendly and less costly means.

The specific problems sought to be addressed by this study are:

1. Repelling of mosquitoes.
2. Reducing risk to human life during the prevention.
3. Eradicating malaria.

1.2 Aim and Objectives of the study

Aim – The aim of this project is to design and develop a mosquito repelling robot.

Objectives

1. To design and fabricate a mosquito repelling robot.
2. To develop a robot that repels mosquitoes without causing harm to humans and is environment friendly.

1.3 Significance of study

The motive of this project basically is to design a robot that will repel mosquitoes within a given perimeter indoors or outdoors. This is as a result of the significant havoc wreaked by the ever present mosquitoes in checkmating them in an eco-friendly manner rather than the conventional use of chemical sprays which can cause discomfort and also be a source of another unanticipated sickness to human or the use of chemical treated nets which is also dangerous and is believed to cause excessive heat when used. The use of this device brings comfort and has proven to be effective and at a lower cost.

1.4 Limitations

The researcher aims to design a robot capable of repelling mosquitoes within and outside the house. The system includes both electrical and computer parts. The limitations encountered in the project include:

1. If the robot is designed to operate at a frequency of about 70-100 kHz, it might be heard by babies and might discomfort to them. It requires a lot of frequency setting.
2. Some mosquitoes might get acclimatized to the repelling frequency of the robot over time.

3. Ultrasound signals travel at an angle of 45 degrees from the source. In case of any obstacles in the path, the signals get deflected or diverted.
4. It shows effect for lesser mosquito population but not as much as at least for a small room.
5. Some humans with good high-frequency hearing "hear" the emissions as an annoying high-pitched or clicking constant "background" sound.

1.5 Scope of Project

This is a mosquito killing/repelling robot based on the theory that female mosquitoes run away from their male counterparts and this project mimics the sound produced by the male mosquito. Also, at increased frequency (higher than the frequency of the mosquito), the sound causes discomfort to the mosquito and causes it to move away from the sound range within a few seconds.

CHAPTER TWO

2.0 LITERATURE REVIEW

The quest to make humans less attractive to mosquito has fueled decades of scientific research on mosquito behavior and control. In the United States, mosquito bites are mostly a nuisance. Worldwide, however, mosquitoes transmit disease to more than 700,000,000 people annually and will be responsible for the deaths of 1 of every 17 people currently alive (Taubes, 1977). Malaria results from infection with a protozoan carried by mosquitoes and, according to reports from the World Health Organization, causes as many as 3 000 000 deaths annually (Shell, 1997). Mosquitoes transmit the arboviruses responsible for yellow fever, dengue hemorrhagic fever, epidemic polyarthritis, and several forms of encephalitis (some of which are found in the United States). Bancroftian filariasis is caused by a nematode transmitted by mosquito bite.

Historically, the strategies for reducing the incidence of mosquito-borne disease have been two-pronged, centering on habitat control (through chemical and biological means) and the use of personal protection in the form of insect repellents. This paper reviews the scientific data on chemical (synthetic) and natural (plant-derived) insect repellents currently available, debunks some of the popular myths about alternative repellents, reviews effective techniques for reducing mosquito populations in the local environment, and provides the clinician with the practical information needed to advise patents on how to safely and effectively reduce their activities.

2.1 Mosquito

The name mosquito is Spanish for "little gnat". It is a derivative of *mosca*, the Spanish word for *fly*. It applies to any member of the insect family *Culicidae*, a group that comprises some 3,000 species and subspecies over virtually the entire earth. They also belong to the Diptera, the great order of flies. In this order there are many species of insects in which both the males and the females feed on blood; however, among mosquitoes, only the females consume blood. These illustrations show the stylet bundles of mosquitoes piercing, while their sheaths (labium) bend and the stylets come out of the grooves. A stylet is "a long thin pointed instrument." The finely toothed maxillae of the fascicle begin sawing into the tissue of the skin with fine back-and-forth movements. A fascicle is "a bundle of muscle or tendon fibers." The fascicle is guided into the skin between the labella. As it goes into the skin the labium folds back like a hairpin and the mosquito shifts its legs closer to its body. When about half of the length of the fascicle has been inserted into the skin, the mosquito begins to draw blood. After the mosquito's abdomen is filled, she straightens her front legs to quickly withdraw the fascicle. The fascicle springs upward and forward out of the wound and is fitted back into the deep groove in the labium.

Male mosquitoes drink only sugary fluids such as flower nectar. Both in the wild and in the laboratory, mosquitoes will visit certain flowers and will feed on fruit placed in their cage. Since they vigorously probe the flowers of some plants and can distinguish between different types of sugars, mosquitoes play a role in the pollination of certain plants. The females will also drink sugary fluids, but when hungry females are given a choice between sugar water and blood, they will always choose blood. If males are offered the same choice, they will always drink the sugar water. Since male mosquitoes do not suck blood, they also do not transmit diseases. Like the males of many other insect families, they are important for just one reason, and then they become superfluous. The female usually needs to mate just once in her life. She stores sperm in her body and fertilizes her eggs at the moment when she lays them. Shortly before or after mating, she takes a meal of blood to provide the eggs with protein. When the eggs are mature and ready to be fertilized, the female searches for a suitable place to lay them; usually, they lay their eggs in water that is full of decaying matter that includes bacteria and minute organisms. Some mosquito species lay their eggs in places that are likely to contain water in the future; such as, rusty coffee cans, old discarded tires, etc. In such situations, the eggs lapse into a state called diapause and they will not hatch until this dormant period passes, and the water level, temperature, and oxygen content are just right. The eggs of some species can survive for years in diapause, even in sub-freezing temperatures. After hatching from the eggs, they swim about and begin to feed by sweeping the water with two large fan-shaped bundles of chitinous bristles (or brush-like structures) at either side of their heads. The fans, or brushes, create currents in the water that direct food toward the larvae's mouthparts and help stuff the food into their deeply concealed mouths. The larvae are omnivorous; feeding on bacteria, pollen, microscopic plants, and a wide variety of other minute things. About 150 species of mosquitoes live in the United States, more than 3,000 worldwide. They don't really sting, in the sense of a hypodermic needle piercing the skin. They saw their way through instead, using four cutting stylets kept in a protective sheath along with a duct that carries anticoagulant into the wound and a tube that carries blood out. Mosquitoes fly into the wind, picking up scents which lead them to their victims. Just about everything attracts them, including the carbon dioxide we exhale. Mosquitoes will even suck the blood of birds, frogs, turtles, snakes and just about every warm-blooded animal. In fact, some mosquitoes prefer their sources of blood to be human. There are many species of mosquitoes that prefer the blood of birds or other animals. In fact, some species have been observed to feed on numerous mammalian groups, on a variety of reptilian species, and even on other kinds of insects. Anthropophilic mosquitoes are attracted to certain ranges of temperature and humidity, and to carbon dioxide from the exhalation of humans. They seem to prefer dark-colored objects to light. Certain chemical smells may also come into play; for example, components of blood and sweat such as hemoglobin and amino acids. The best explanation of what brings the mosquito to its victim is that she simply flies upwind until she comes upon a potential victim exuding a "host beam" of warm, moist air laden with carbon dioxide.

The mosquito proboscis (long tubular mouth parts used for feeding) consists of six different shafts. Four are cutting and piercing tools; a fifth transports blood from the host; the sixth transports saliva, thought to act as an anticoagulant for the blood going in the other direction. The saliva also transmits the organisms of malaria, yellow fever, dengue, and most of the other diseases for which mosquitoes are notorious. When a mosquito punctures ("bites") into the flesh, one usually feels an allergic reaction to the saliva, which causes the swelling and the itch. The fact that this reaction is allergic helps explain why some people suffer more than others when their skins are invaded. Some mosquito species are nocturnal, diurnal, or crepuscular (active at dawn and twilight). They also differ in their preferences for altitudes. The mosquito is said to be an enterprising creature that never waits for an opening, but she always makes one and has a great depth of feeling.

2.1.0 Blood-Feeding Techniques of Mosquitoes

To better understand the complexity of what is involved in the act of blood feeding, we need to know something about the anatomy of the mosquito's proboscis and alimentary canal. The proboscis projects directly in front of the insect. It consists of a large, scaly outer lower lip called the labium, which terminates at the tip in two hairy lobes called the labella. The labium forms a deep trough in which is concealed a smaller bundle of long tapering pale yellow feeding stylets that are collectively called the fascicle. The largest stylet is the sharply pointed labrum, which forms an inverted gutter up which the blood is drawn. At the side of the labrum are two long, thin mandibles. Under them are two much larger needle-like maxillae with fine saw toothed tips. Under them in turn is a flattened stylet, the hypopharynx, down the center of which runs a single salivary canal. The fascicle acts as both a piercing mechanism and a food canal. When the mosquito is poised for the moment of piercing, it has all six legs on the surface of the victim's skin, its hairy labella touching the skin and its maxillary palps raised. It is believed that after the mosquito spreads its labella the finely toothed maxillae of the fascicle literally saw their way into the tissue of the skin with extremely rapid back-and-forth movements. Next, the large labium is folded back like a hairpin. The skin is actually punctured without any obvious thrusting of the mosquito's body. About half the length of the fascicle is inserted into the skin. As it is inserted, the mosquito gradually shifts its legs closer to its body. It takes an average female mosquito about fifty seconds to insert her fascicle into the human skin, and unless she is interrupted (perhaps by being swatted by the victim!) she usually sucks blood for about two and a half minutes.

When she has drunk her fill, she withdraws the fascicle rather quickly (in about five seconds). The procedure is to straighten her front legs, leaning slightly backward, and moving the labium from side to side. Once the fascicle has been removed from the skin, it springs upward and forward and then returns to the deep groove of the labium. The feeding behavior and habits of mosquitoes varies widely from one species to the next. When asked about the habits of mosquitoes, Dr. George B. Craig Jr., director of the University of Notre Dame's Vector Biology Laboratory, responded with a question: "Which mosquito?" The *Aedes vexans,* the most common plague of Americans, both country and city, is different from *Aedes excrucians* of northern wooded areas, as well as from *Aedes tormentor* of the southern woods; *Culex pipiens,* the common house mosquito of the tropics; *Coquillettidia perturbans,* an inland swamp mosquito; *Toxorhynchitis rutilus* mosquitoes, which eat the larvae of *Aedes aegypti,* the yellow fever mosquito, the *Anopheles,* and so on down through 3,000 different species. To complicate matters even more, the species of mosquitoes that predominate vary widely from area to area, so that the type that hovers around a city bedroom or other parts of the home is likely to be quite different from the one that follows people around on the golf course or in the park. There are mosquitoes that rest during the day and emerge in the dim light of dawn and evening. Some feed at night, other during bright daylight; still others, like the vector of La Crosse encephalitis, are most active in late afternoon. Mosquitoes lay eggs in thousands of carefully selected places: tree holes, discarded tires, decorative fountains, flowerpot trays, elephant footprints, pitcher plants, empty cans, forest ponds, salt marshes, low spots in the yard; anywhere that water is likely to accumulate in the near future. It is said that some species of *Aedes* lay their eggs on dry ground that will be subject to future flooding, and the eggs may survive for as long as two years without water. The whole process from egg to blood-thirsty adult is accomplished in about ten days, and four to five days after her last blood meal, the female is ready to feed and lay again (about 100 at a time).

2.2 Mosquito Repellents

Anything that is used to apply to clothing, skin or other surfaces that repel the mosquito from attracting and biting on that surface is known as mosquito repellent (Walker, et al, 2011). Some mosquitoes repellent that are based on the ultrasound having high frequency sounds are also available in market (Sukumar, et al., 1991). Older methods of mosquito repellents include the rubbing of mana, vinegar and plant oils on the body (Singh, et al., 2012). Ancient people also used to burn the bay, black cumin, oregano and galbanum to restrict the mosquitoes. Burning of plant or plant materials produce the smoke that is oldest method to control mosquito (Uniyal, et al., 2015). One method for the controlling of the mosquito is fogging that is temporary method for controlling pests but is mostly essential in the situation of health dangers from severe bug inhabitants and for an outside movement where these pests are undesirable (Ramar, et al. 2014). Mostly thermal fogging is used whereas each gallon contains the 5.0% piperonyl Butoxide and

0.5% pyrethrins (Patel, et al., 2012). Another technology is transdermal technology where mosquito repellents are injected into the blood stream to protect itself from the mosquito bite (Kongkaew, et al., 2011). This type of repellent contains the thiamine or Vitamin B1 and it is known as most effective repellent known to date. Female mosquito remains repulsive to the fragrance of Thiamine that is major mechanism for the control of mosquito (Uniyal, et al., 2015).

2.2.1 Chemical Repellents

Different types of mosquito repellents such as synthetic compounds, aromatic oils and herbs are used against mosquitoes. Chemical mosquito repellents has an extraordinary protection profile but they are noxious against the nervous system and skin as eye irritation, swelling, low blood problem, rashes and worse problem (Patel, et al., 2012)

2.2.2 Synthetic Repellents

Most effective synthetic repellent is DEET that is poison and has ability to make the carbon monoxide and natural odor as human body produces (Impoinvil, et al., 2007). Longer lasting and most effective repellent is IR3535 (3-[NButyl-N-acetyl]-aminopropionic acid as compare to the DEET for defense against mosquitoes. Effective relief can also get from the plant-based repellents. The time of action of essential oils is short lived and it evaporates easily (Kayedi, et al., 2014).

There examples are as follow:

i. DEET (N,N-diethyl-m-toluamide)
ii. Icaridin known as Bayrepel, KPR 3023 and picaridin
iii. Bog Myrtle
iv. Permethrin (Patel, et al., 2012)

Among all the repellents the N, N-diethyl-3-methyl toluamide (DEET) is best synthetic mosquito repellent that can be available easily but it has harmful effects. It is considered that the use of DEET has maximum biting inhibition rate that is 88.7- 92.5% (Syed and Leal, 2008). But the study showed that the use of DEET has many side effects such as muscle twisting, seizures, slurred speech, nausea, rashes; affect motor capacity, sensory disturbance, loss of learning abilities and memory damage (Yang and Ferreira, 2008) and (Onyett, 2014). DEET does not deliver long lasting defense from the bite of all species of mosquito such as *Anopheles* that cause malaria. The use of the DEET is not suggested for the children, lactating and pregnant women (Katritzky, et al., 2010). Hydroxyethyl Isobutyl piperidine Carboxylate is commonly known as Icaridin. It is colourless and odourless and used against the insects (Katritzky, et al., 2008). It has same working principle as DEET because it can also block the olfactory receptors of the insects or it shades the insect's sense of smell and it is difficult for them to find the human. It is considered as best as compare to the DEET because it requires in less amount for action (Pal, et al., 2011). It is non-toxic for the skin and eyes; and slightly toxic for the oral route. It can be safe to use but cannot use on the broken skin. Icaridin is moderate chemical which do not accumulate and fade away easily. To make it less toxic it's better to use it with other compounds (Ramar, et al., 2014) and (Zhu, et al., 2012). Permethrin is only useable on camping gear, bed nets, shoes and clothing and cannot use on the skin (Gaddaguti, et al., 2016). It is very effective and has the ability to kill the ticks and mosquitoes. Cloths on which Permethrin is applied remain safe for humans but these products should not put on the skin. It should use in the form of spray on the cloth (Khoobdel, et al., 2005). Its effectiveness remains for six hours. Permethrin is obtained from the pyrethrum that is naturally occurring pesticide (Katritzky, et al., 2008). It gives more protection when mixed with the DEET. When Permethrin is applied on the uniform that is light weight it gives 97.7% protection from mosquitoes. When Permethrin is applied it causes somewhat skin irritation whereas it has no serious effect. It is non-toxic for humans and birds while highly toxic for insects (Ditzen, et al., 2008), (Ghosh, et al., 2012) and (Chandra, et al., 2008).

2.2.3 Natural Repellents

Natural repellents are basically obtained from the plants and known as essential oils. Substances that are present in the different odoriferous plants and have volatile nature are known as essential oils (Hewitt and Rowland, 1999) and (Al-Akel and Suliman, 2011). It is obtained from the various parts of plants and have volatile aroma with the form of concentrated hydrophobic liquid (Sukumar, et al., 1991). Essential oil can be extracted by various methods such as steam distillation, solvent extraction and hydro distillation. Soil and climatic conditions are important factors that affect the different plant species and composition of essential oils (Adeniran and Fabiyi, 2012). Synthesis and accumulation of the essential oils related with the secretory structure of the plants such as resin ducts, glandular ducts and trichomes (Kongkaew, et al., 2011). Storage of the essential oils occurs in the leaves, woods, flowers, rhizomes, fruits and roots. These plant based essential oils are used for the repellency of the mosquitoes and haematophagous insects (Uniyal, et al., 2015). Many research efforts revealed that essential oil compounds and their derivatives are alternative controlling measure for mosquitoes (Koech and Mwangi, 2014). Essential oils due to their volatile nature demand for frequent reapplication to maintain its potency. They evaporate completely and thereby their effectiveness is short lived and so complete protection cannot be achieved (Mendki, et al., 2015). Many plant origin essential oils are recognized to have insect repulsive possessions viz. citronella oil, lemon grass oil, rosemary, dill, eucalyptus, lavender, soybean, chrysanthemum, clove, castor, tulsi, camphor, limeone, geranium, Neem, galbanum, pepper mint, cedar essential oil and basil (Kumar, et al., 2011) and (Kayedi, et al,, 2014). Cedar oil is used against moths and mosquitoes, Cinnamon and Neem oil kills the larvae of the mosquito, clove, eucalyptus, rosemary, lemon grass, peppermint and citronella oil repel mosquito (Kongkaew, et al., 2011). Essential oil as natural product has maximum volatile chemical compounds and used as individual defense against blood sucking mosquito (Fayemiwo, et al., 2014). Lutes and rosewood are taken in the ratio of 1: 1 (V/V) with 10% concentration and it shows 86% repellency against the mosquito. Essential oil exhibited operative consequence are valuable for developing biodegradable, effective and eco-friendly insect repellent (Uniyal, et al., 2015). Eight essential oils collected from the citrus plants such as *Citrus aurantium*, *Citrus hystrix*, *Citrus medica*, *Citrus aurantifolia*, *Citrus reticulate* Blanco, *Citrus sinensis* and *Citrofortunella microcarpa* were collected and used against the *Culex quinquefasciatus* (Say) and *Aedes aegypti*(Linn.) and compared them with chemical repellent (IR3535 12.5 w/w) (Onyett, 2014). Thus, repellent action showed the direction of safety time and piercing rate against two mosquito species in eight essential oils as *C. aurantifolia* > *C. microcarpa* > *C. maxima* > *C. reticulate* > *C. sinensis* > *C. hystrix* > *C. aurantium* > *C. medica*var. *sarcodactylis*. Meanwhile, the period of protection time against two mosquito species of all herbal essential oil was higher than IR3535 (3.0±0 minutes for *Ae. Aegypti* and *Cx. quinquefasciatus*) (Soonwera, 2015). Essential oil of *Zingiber officinale* and *Cinnamomum zeylanicum* causes ovicidal and oviposition deterrent activites in the *Cx. Quinquefasciatus*, *Aedes aegypti* and *An. Stephensi* (Katritzky, et al, 2010). Against the *Ae. aegypti* the leaf extract of the *Cassia fistula* is used that cause the ovicidal, repellent and larvicidal activities. Extracted oil from the *Coriandrum sativum* (Apiaceae) showa repellency against the invasive species of mosquitoes (Tawatsin, et al., 2006) and (Ansari, et al., 2005). *Curcuma aromatic* (Zingiberaceae), *Azadirachita indica* (Meliaceae) and *Zanthoxylum alatum* (Rutaceae) also show repellency against the mosquitoes especially against the *Cx. quinquefasciatus* that is filarial vector (Pal, et al., 2011) and (Ghosh, et al., 2012). Safe and promising insect repellent is catnip oil that is obtained from the catnip. Two seterioisomers of nepetalactone is present in this oil (Ghosh, et al., 2012). It has repellency against the thirteen families of the insects due to presence of the two stereoisomers. E,Z-nepetalactone form of the oil has the ability of repellency against the cockroach while Z, Enepetalactone form has shot less repellency against American cockroaches and house flies whereas against the mosquito it has six hours of repellency (Rajkumar and Jebanesan, 2010). Experiments suggested that against the species of mosquitoes such as *Ae. albopictus, Cx. quinquefasciatus and Ae. aegypti* catnip oil has different time of repellency such as Six hours, sixty minutes and two hundred forty minutes respectively. Against the *Cx. quinquefasciatus, Cx. annulirostris* and *Ae. Vigilax* catnip oil shows more protection (Pattanayak and Dhal, 2000) and (Polsomboon, et al., 2008).

2.2.4 Non-Chemical Repellents

Non chemical methods comprise the physical and mechanical methods.

2.2.4.1 Physical Method

It is essential to change the water in the bird baths, pools, and fountains and rain barrels once a week. During the dawn and dusk it is necessary to use the full sleeved clothing. Screening of doors and windows is also very important to protect itself from the mosquito attack (Yang and Ferreira, 2008).

a. Mosquito Net

These nets are considered as more protective than coils and other repellents because their use does not cause any health problem (Peterson, 2001). Sleeping under netting also protect from the attack of mosquitoes. There are two types of nets such as medicated nets and non-medicated nets (Impoinvil, et al., 2007).

i. Medicated Net

Mosquito nets can be made medicated by K-O tablets that contain the 25% deltamethrin. In one liter of water one tablet is mixed, net is soaked in it for ten minutes and then dried it in chilled area (Peterson., 2011). This net remains effective for six months and mosquito will remain away. World Health Organization approves the medicated nets and these nets are more effective than the liquidators or coils (Atieli, et al., 2010).

ii. Non-medicated Net

Different sizes and shapes of mosquito netting is available that can be made of various materials such as polyester, polyamide and cotton. Style of net is important to protect itself from the mosquito bite (Gaddaguti, et al., 2016). It is important to buy a net that contain the mesh size large enough to pass the air and small enough to protect from the mosquito bite. Mosquito nets are an operative way to naturally prevent from mosquitoes (Zhu, et al., 2012).

b. Mosquito traps

Mosquito traps are used to capture and lure the female mosquitoes. These traps copy the various mosquito attractants such as body heat and exhaled carbon dioxide. Most of the traps are powered by the propane or electricity so their use is safe (Raja, et al., 2015). Traps contain impeller fan when mosquito is attracted toward the trap it will attach on the sticky surface on the trap and will electrocuted (Sumithra, et al., 2014).

1. **Mechanical Methods**

a. **Electronic mosquito zipper**

For trapping the mosquito this device works by using the ultraviolet light and then killing of mosquito occurs when mosquito interact with the lethal charge of electric charge (Onyett, 2014).

b. **Mosquito magnet**

Its principle based on copying of mammals properties such as giving off heat, moisture and carbon dioxide. When mosquito comes close to the device it drew in and suddenly dies. This magnet also combined with the octenol and can be used for the sand flies, black flies, midges and mosquitoes (Onyett, 2014).

2.2.5 Biological Control of Mosquitoes

1. **Entomopathogenic Fungi**

For the control of malarial vector entomopathogenic fungus has very important role. Fungus species that are used for this purpose are belongs to the genera *Beauveria*, *Coelomomyces*, *Metarhizium*, *Culicinomyces*, *Entomophthora* and *Lagenidium* (Sritabutra and Soonwera, 2013). For protection from the mosquitoes fungal spores are used in the curtains, cotton pieces, indoor house services and outdoor traps (Tawatsin, et al., 2006). Fungus can be used with DDT to use effectively against the insecticide susceptible and insecticide resistance mosquitoes. *Anopheles gambiae* is more susceptible to the fungus infection as compare to other insecticides but rate of fungal infection is slow as compare to the insecticide action (Scholte, et al., 2004).

Fungi have negative effects on the malarial transmission because it changes the fitness conditions and behavior of the vector. It also affects the survival rate of parasites with in the mosquitoes and feeding habits of the mosquitoes (Chandra, et al., 2008). It has been shown that use of *Metarhizium* against the mosquitoes induces the production of the anti-malarial peptides, obstructed the communication of the malarial parasite from the vector (Iturbe-Ormaetxe, et al., 2011). Pathogenic fungi have their effect on the *Anopheles* at its later stage of life cycle that is considered very important. If the mosquito develops the resistance against the fungi it will be temporary because weak selection for this resistance would occur (Pattanayak and Dhal, 2000).

2. Bacterial Agents

For the malarial vector control *Bacillus sphaericus (Bs)* and *Bacillus thuringiensis (Bt)* can be used because these are environmentally safe, highly effective, exert selective effects and non-toxic in nature (Kayedi, e tal., 2014). Strains of *Bacillus* are easily handled, locally manufactured, practically applied and cheap and having the ability of fast spreading. As compare to the *Aedes, Culex quinquesfasciatus* and *A. arabiensis* the effect of *Bs* and *Bt* is more on the *A. gambiae* (Singh and Mohanty, 2012) and (Chandra, et al., 2008). *Bs* and *Bt* cause the production of the endotoxin proteins that damages the stomach of larvae and its death occurs (Ogoma,et al., 2012). There two type of endotoxin proteins such as Cry and Cyt1A that work by interlinking with each other. Cyt1A delays the resistance to the Cry proteins and causes its long lasting uses (Kamareddine, 2012). Genus *Asaia* contain the acetic acid bacteria that colonize in the female eggs and male reproductive systems of the *A. albopictus*, *A. stephensi*, *A. gambiae* and *A. aegypti* that transmit in the offspring of their population. It results in the lessening the life span, reduce immunity and render the development of the parasites within the mosquitoes (Maia and Moore, 2011). For combating the malaria microbial agents are considered very important; they can abandon the growth of the *Plasmodium* in the mosquito or directly mark the *Anopheles* vector (Koech and Mwangi, 2014).

2.2.6 Electronic Mosquito Repellent

(United States Patent No. 3931865, 1976) The invention relates to mosquito repellent apparatus and more particularly to electronic mosquito repellent apparatus which generates a signal found to attract male mosquitos and thereby repel the 'blood' seeking, pregnant female mosquitos. Not only is the mosquito bite uncomfortable and always liable to infection, but very often mosquitos serve as carriers of diseases. Therefore, human beings have long sought for means of keeping mosquitos from biting them. The most common presently used method of discouraging mosquitos from biting is the use of chemical repellants, either in salve, spray or liquid form. The difficulty with these types of repellants are multifold. Many people are allergic to the chemical repellents or are discomforted by the odors present in the repellant. Also, it is extremely difficult to adequately spray the exposed skin. Besides that, it is often necessary to spray clothes through which mosquitos can bite. Another chemical method of repelling mosquitos is through the use of anti-insect bars which' present an odor that is supposed to repel mosquitos. The difficulty with this type of repellant is that it must be used in an enclosure, because it does not perform adequately out-of-doors where the majority of the mosquitos are located.

It is also known in the art to use electronic devices to attract insects for entrapment purposes; however, such entrapment fails as an aid to an individual fisherman or group of fishermen located by a stream in the woods. The entrapment apparatus is sometimes used by a Municipality or other government agency for-mosquito abatement purposes, rather than for repellant purposes. Further electronic devices are known in the arts that are used for repelling rodents', for example. This is accomplished by recording the noises emitted by a frightened or agitated rodent and replaying the recording. The replay equipment, even if it is on a cassette, is relatively unwieldy. Accordingly, an object of the present invention is to provide a unique electronic means for repelling insects. A more particular object of the invention is to provide the small electronic sonic mosquito repellant. Yet, another object of the invention is to provide an ultrasonic generator which can be used to repel mosquitos within its effective range indoors or outdoors with equal facility. Yet another object of the invention is to provide an electronic means for repelling mosquitos that bite; the electronic means is extremely small, portable and capable of being attached to the outside of one's clothing, to effectively prevent mosquitos from biting the transporter of the repelling means. In accordance with a preferred embodiment of the present invention, the foregoing objects are accomplished by providing a small transistorized oscillator using an RC network to obtain the frequency required to drive a speaker and transmit a male mosquito attracting signal. The oscillator is powered by a standard small voltage battery. Fine frequency control is obtained through the use of a controllable, variable resistor in the RC network. The transistorized oscillator and the speaker are encased in a plastic case such as is normally provided for small transistor radios. The case is equipped to be attached to the belt or other outside appurtenance of the transporter's clothing.

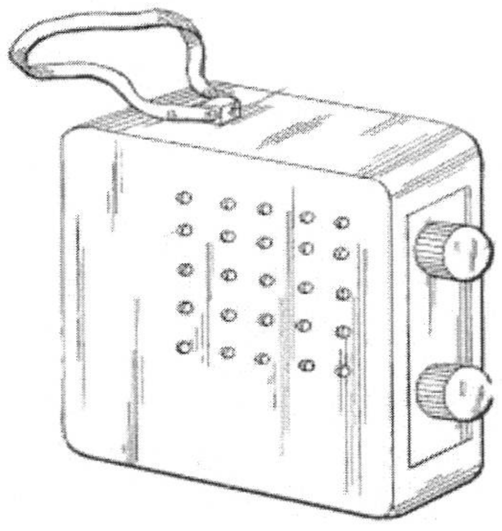

Figure 2.1: Electronic Mosquito Repellent

(United States Patent No. 6293044, 2001) Obtained the U.S. patent on the invention of a switchable mosquito expelling/killing device. The invention relates to a switchable mosquito expelling/killing device which can be switched between a mosquito expeller for expelling mosquitoes and an electric mosquito incense device for killing the mosquitoes. The switchable mosquito expelling/killing device is applicable to various outdoor situations such as camping, mountaineering, etc.

It is known that mosquitoes are harmful insects which bite people and are media of various kinds of infectious diseases such as Japanese encephalitis, dengue fever, malaria, etc. Therefore, it is important to kill the mosquitoes. In general, the mosquitoes are killed by means of mosquito incense or pesticide. Such measures will result in stimulating odor which is hard to bear. In addition, the above measures are usable indoors. In the case that they are used outdoors, the incense tends to dissipate with wind and the mosquito-killing can be hardly achieved. In order to improve the stimulating odor produced by the mosquito incense or pesticide, electric mosquito incense device and mosquito expeller have been developed. With respect to the electric mosquito incense device, a heater is used to heat an electric mosquito incense mat so as to release a gas for killing or expelling the mosquitoes. Those mosquitoes which will attack people or animals are female mosquitoes during egg laying period. The female mosquitoes during this period will avoid male mosquitoes. The mosquito expeller employs this principle to generate a sound wave simulating the sound produced by the male mosquitoes and thus expel the female mosquitoes. The above two measures have their intended functions, and therefore one measure is not convertible to the other because of the external environment or factors. For example, in case the electric mosquito incense mat is exhausted and no spare is available, the electric mosquito incense device will become useless.

(United States Patent No. 6570494, 2003) In his invention *MOSQUITO GUARD* proved that the invention meets the needs identified above by providing a Waterproof cabinet, speakers, power source, processor, and solar panel which together operate to emit high frequency sound waves that can repel mosquitoes and other flying pests. The cabinet can contain one, two or four speakers, solar cells in a panel on the top of the cabinet, a rechargeable nickel-cadmium battery, electrical wiring and circuitry, and a circuit board or an Integrated Circuit (IC) chip to generate waveforms of frequency above the range of human hearing. The output strength would be in the range of 100 dB to 135 dB. The device, When activated, emits ultrasonic sounds to replicate the wing-beat frequency of the Dragonfly, the mosquito's most significant predator and sonic sounds to replicate the wing-speed sound of the male mosquito (to repel females who have already mated). Additionally, the device may emit sonic frequencies from 11 to 12 kilohertz and from 36 to 38 kilohertz.

Comparing the scope of the reviewed works which are electronic, it is seen that the mosquito repelling devices make use of mosquito incense which dissipates the odour in order to kill the mosquitoes and others make use of ultrasonic sound to replicate the wing-beat sound of a dragonfly to scare off the mosquitoes. But for this particular project, the buzzer is used to replicate the sound of a male mosquito, the LCD to display the working conditions of the device, the PIR sensor to detect obstacles within the working range of the device and the ultrasonic sensor to measure distance of obstacle.

CHAPTER THREE

3.0 METHODOLOGY

This chapter deals with the components, approach, techniques and methods implemented in order to achieve the aim and the objectives of the study.

3.1 Target of Study

Mosquito is the target of study. It must be able to repel mosquitoes. The project consists of three sections namely; the input, processing and the output sections.

i. Input section: This section comprises the piezoelectric sensor (PIR sensor), the ultrasonic sensor, pushbutton and the power supply.
ii. Processing section: This comprises the microcontroller (ATMEGA328P-PU).
iii. Output section: This comprises the light-emitting diodes (LEDs), the buzzers and the liquid crystal display (LCD).

These various sections work together to provide an effective mosquito repelling robot. The various components are connected to the microcontroller which serves as the brain for the robot.

The PIR and the ultrasonic sensors are programmed to work together in a way that the PIR sensor detects if there is an obstruction in the working range of the robot and the ultrasonic sensor measures the distance of the obstruction to the robot causing the buzzer to buzz loudly twice and the LCD displays the presence of an obstruction as well as the distance measured by the ultrasonic sensor. There are two LEDs, one (YELLOW) to indicate when the robot is charging and the other (RED) to indicate that the robot is ON. The robot is designed to run on two modes; the automatic or the manual modes.

i. Automatic mode: The robot works autonomously when switched to this mode. If the robot is being charged by the solar panel (i.e. during the day), it goes on standby which means it is not active then, immediately it stops receiving input from the solar panel, it automatically comes on till (i.e. morning) when it starts receiving input from the solar panel again.

ii. Manual mode: The robot is manually controlled when switched to this mode causing it to work at any time either if it is being charged or not.

Note: The pushbutton is used to switch between these two modes.

The robot is powered using in-built batteries that can be charged using either the solar panel or connecting it directly to electricity using the USB cable. The robot also has a reset button to restore it to the initial point but the use of this is not often required.

3.2 System Overview

The researcher takes several steps to meet the objectives of the project design. This levels are the following; system requirements hardware selection and designing, hardware and software assembly. These steps are illustrated in the figure below.

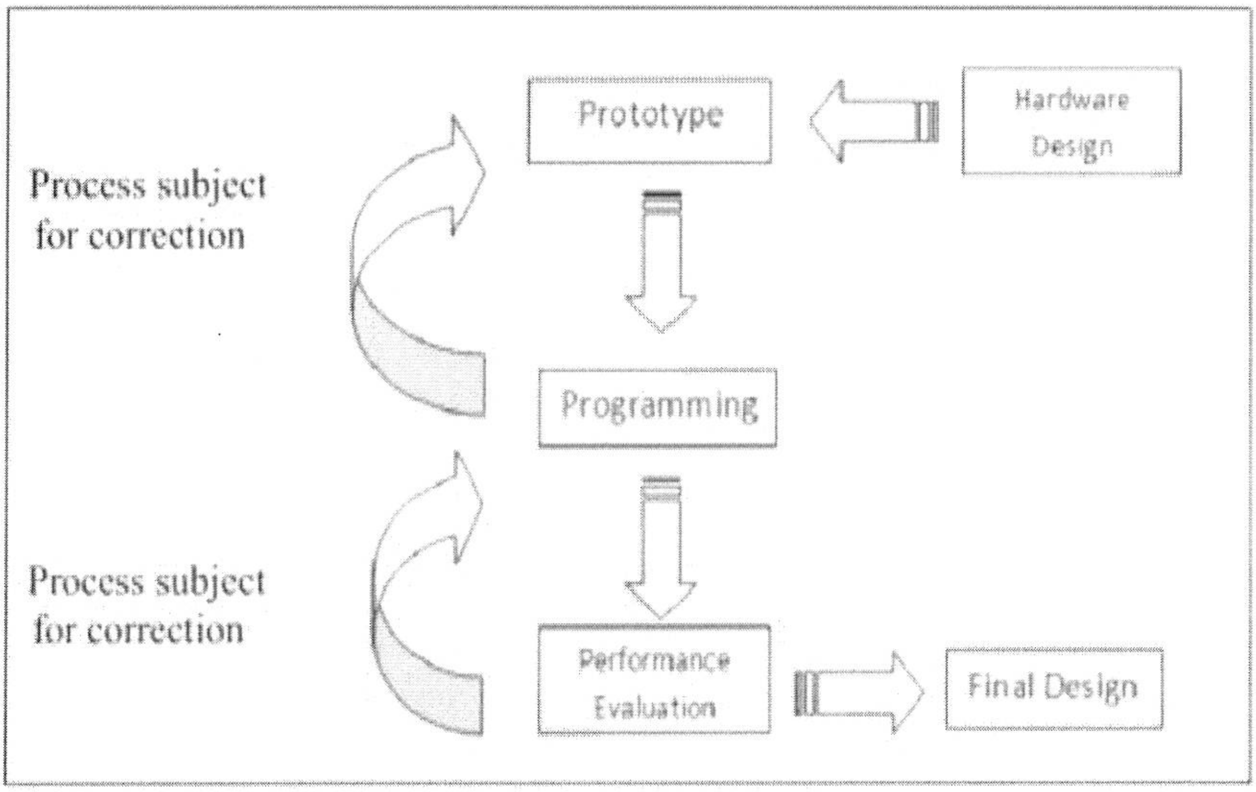

Figure 3.1: Project Evaluation Chart

3.3 System Block Diagram

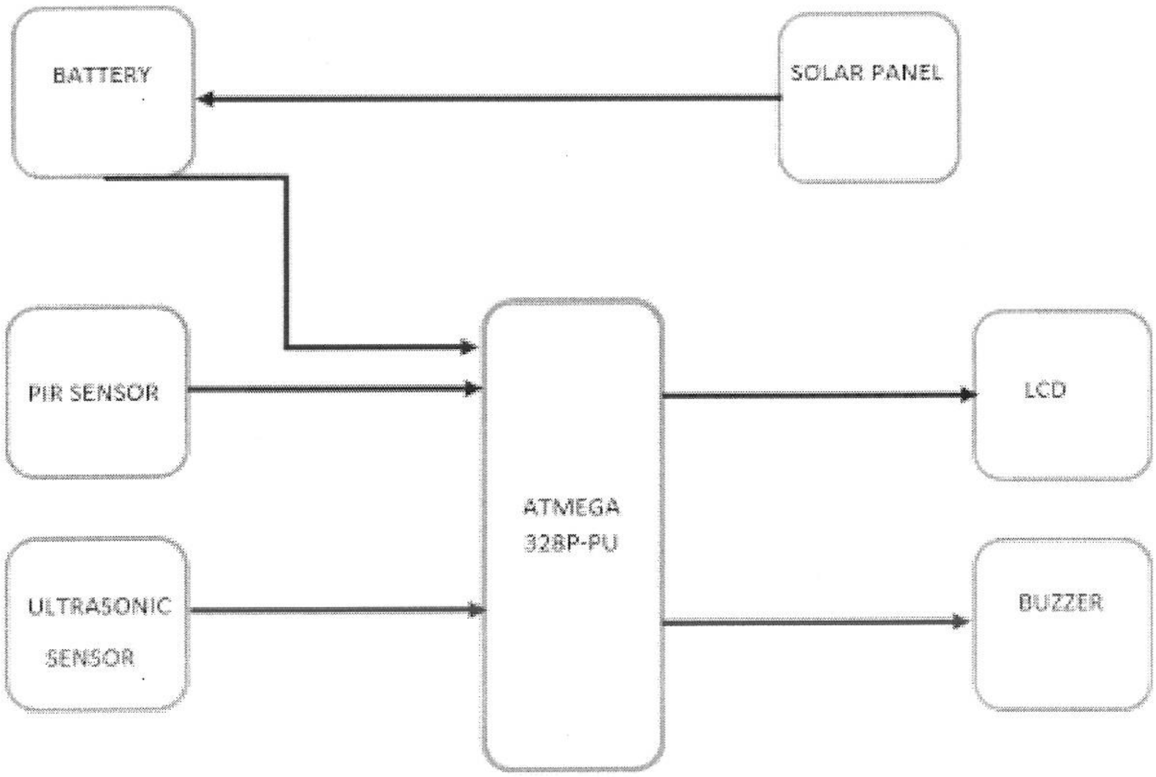

Figure 3.2: System Block Diagram

3.4 Liquid Crystal Display (LCD)

LCD stands for liquid crystal display. Since their interface serial/parallel pins are defined so it's easy to interface them with many microcontrollers. A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. In order for the LCD to display the obstruction, it is interfaced with the microcontroller.

They are used to show status of the product or provide interface for inputting or selecting some process. A 16x2 Liquid Crystal Display is used in the circuit design to notify when there is a human obstruction.

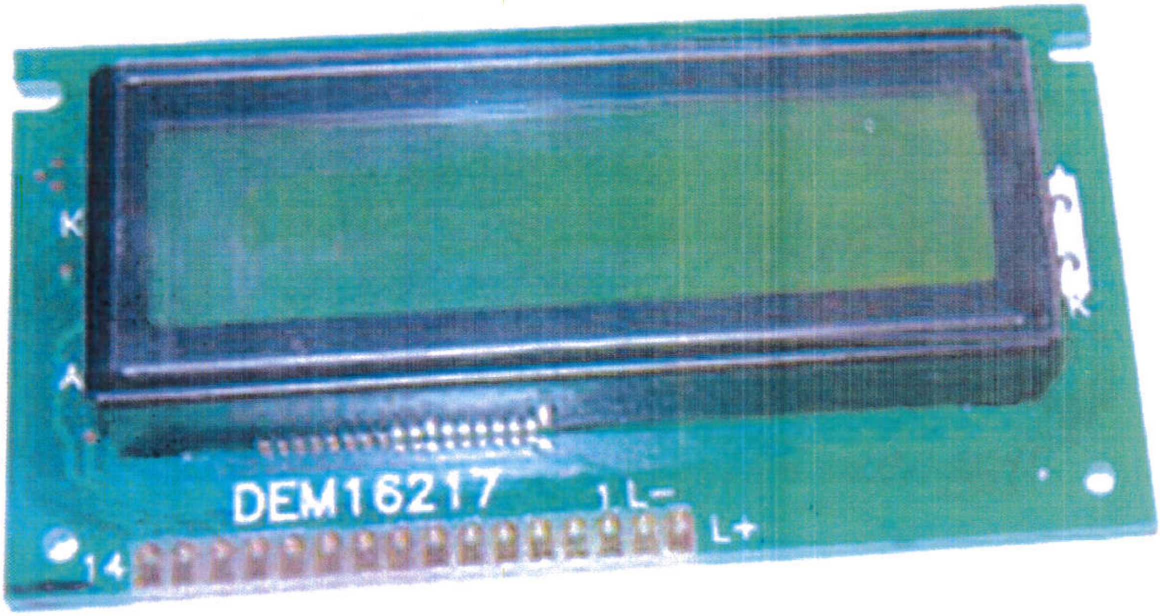

Figure 3.3: Liquid Crystal Display

3.5 Microcontroller

A microcontroller is a small computer on a single integrated circuit containing a processor, memory, and programmable input/output peripherals. Program memory is also included on chip and a small amount of RAM. Microcontrollers are designed for embedded applications (Bhupesh Aneja et al., 2011). The controller used for this project is ATMEGA-328P-PU microcontroller. It is the data processing element of the system and it is responsible for the receiving the output signal of the sensor or set point and provides an output to a control element.

3.5.1 ATMEGA 328P-PU description

ATmega328P-PU is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. It provides the following features: 32Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 1Kbytes EEPROM, 2Kbytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 1 serial programmable USARTs , 1 byte-oriented 2-wire Serial Interface (I2C), a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages) , a programmable Watchdog Timer with internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. In Extended Standby mode, both the main oscillator and the asynchronous timer continue to run. (Atmel)

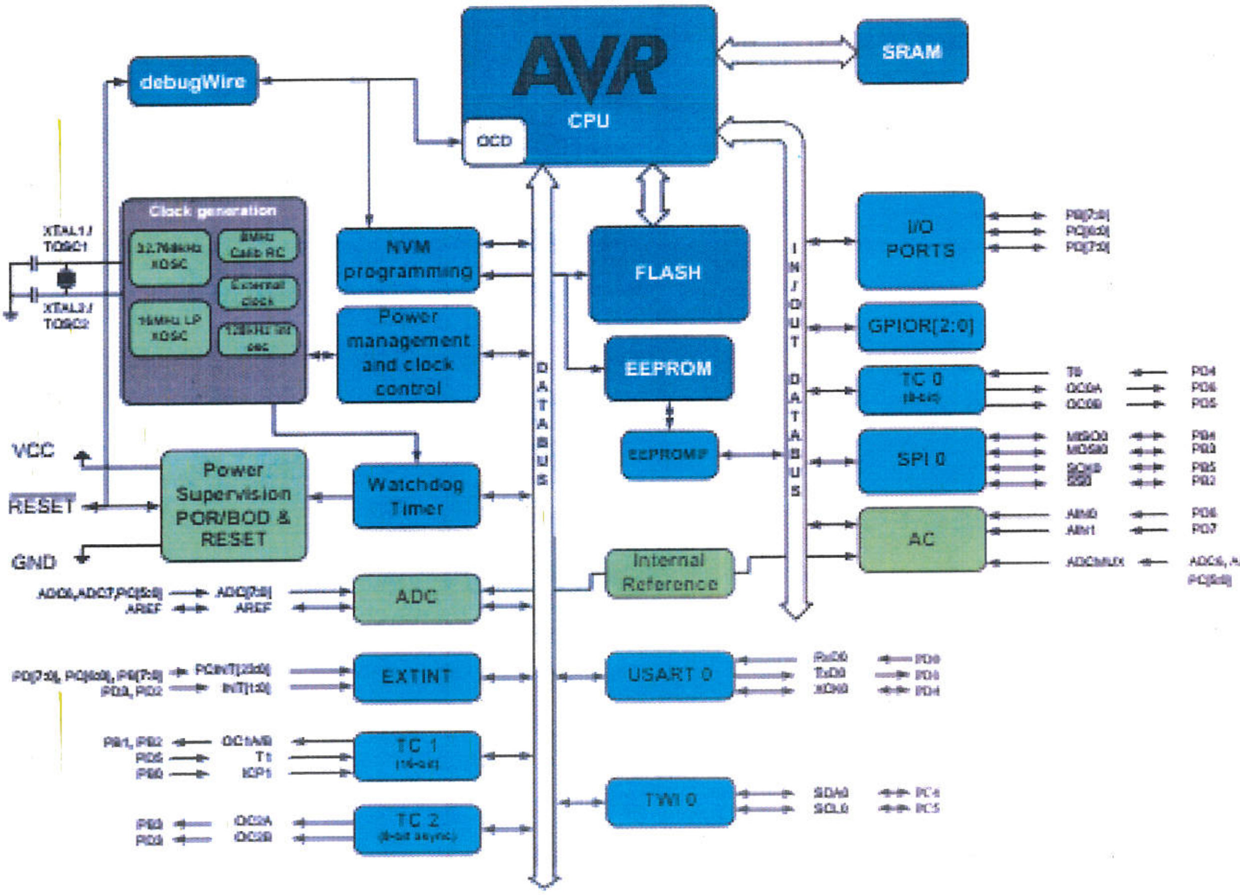

Figure 3.4: ATMEGA328P-PU Architecture

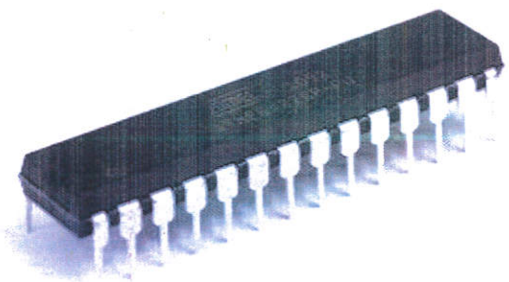

Figure 3.5: ATMEGA328P-PU

3.6 PIR Sensor

The PIR sensor detects a human moving around within approximately 10m and an angle of 110^o from the sensor they are fundamentally made of a pyro electric sensor which can detect levels of infrared radiation. If the robot detects a human close up then it will buzz and display on the LCD of such obstruction. This specific PIR sensor will output a pulse of 5V if it detects humans and will output 0V when idle. This chip has three pins: Vcc (5V), ground, and 'alarm' data pin.

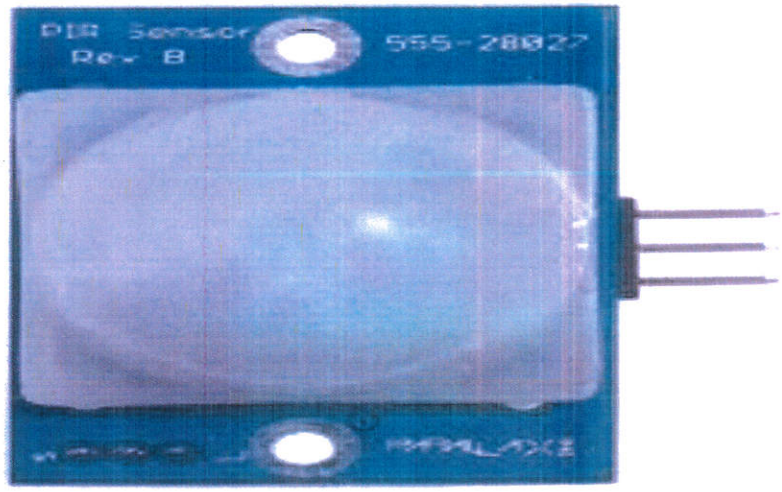

Figure 3.6: PIR Sensor

3.7 Ultrasonic Sensor

This is a device that is used traditionally to measure distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. But for this project, the ultrasonic sensor sound frequency will be targeted at mosquitoes at a frequency higher than that of mosquitoes to repel them.

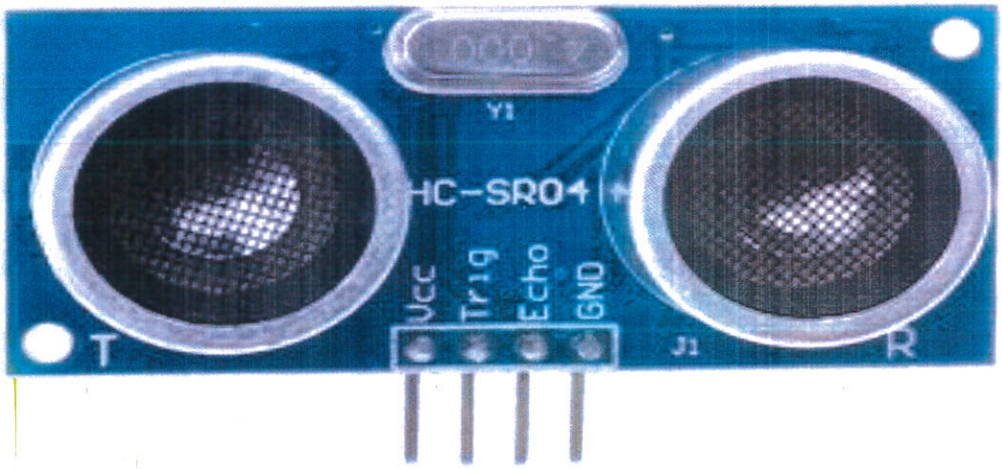

Figure 3.7: Ultrasonic Sensor

3.8 Solar Panel

This is rugged and durable in its finished form and requires a complex and very technical process in its production. In traditional solar modules (polycrystalline and monocrystalline), silicon wafers are impregnated with impurities to create a semiconductor that converts sunlight into electric current. Electrical contacts are then created to join one solar cell to another. As silicon reflects, an anti-reflective coating is placed on top of the silicon wafers, usually titanium dioxide or silicon oxide. The solar cells are laid between a superstrate layer on the top and a back sheet layer on the bottom. The superstrate is usually glass, and the backsheet is plastic. This is then placed inside an aluminum frame to create a finished solar panel in thin film solar panels, it's a different process. It begins with a thin layer of flexible substrate such as coated glass, stainless steel or plastic and metal contact, and the solar cell is then built up in a series of layers. An oxide layer is then applied at the end to form the electrical contact of the cell. The cell is then laminated with a weather resistant superstrate material. When light hits a solar cell, electrons are knocked loose from a solar cell's semiconductor material atoms. Positive and negative electrical conductors associated with each solar cell form a circuit that capture this energy in the form of an electrical current. (Energy matters, 2017)

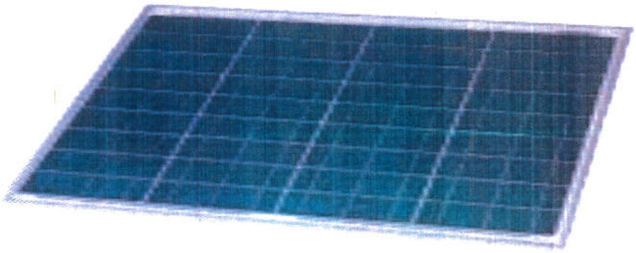

Figure 3.8: Solar panel

3.9 Buzzer

This is a mechanical electromechanical, magnetic, electromagnetic, electro-acoustic or piezoelectric audio signaling device. It can be driven by an oscillating electronic circuit or other audio signal source. It can be categorized by type, sound level, frequency, rated voltage, dimension and packaging type. Its output is measured in decibels (dB). For this project, the buzzer indicates when there is a human obstruction within the working range of the ultrasonic sensor. (Future Electronics, 2017)

Figure 3.9: Buzzer

3.10 Battery

This part is responsible for the storage, supply of the required voltage and distribution of the voltages. Three rechargeable Lithium cells of 3volts each are connected in parallel to obtain the required 9V. It is charged by the solar panel.

Figure 3.10: Battery

3.11 Crystal oscillator

This is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a precise frequency. The frequency is commonly used to keep track of time, to provide a stable clock signal for digital integrated circuits and to stabilize frequencies for radio transmitters and receivers.

Figure 3.11: Crystal oscillator

3.12 Potentiometer

A three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat. They are commonly used to control electrical devices such as volume and audio equipment.

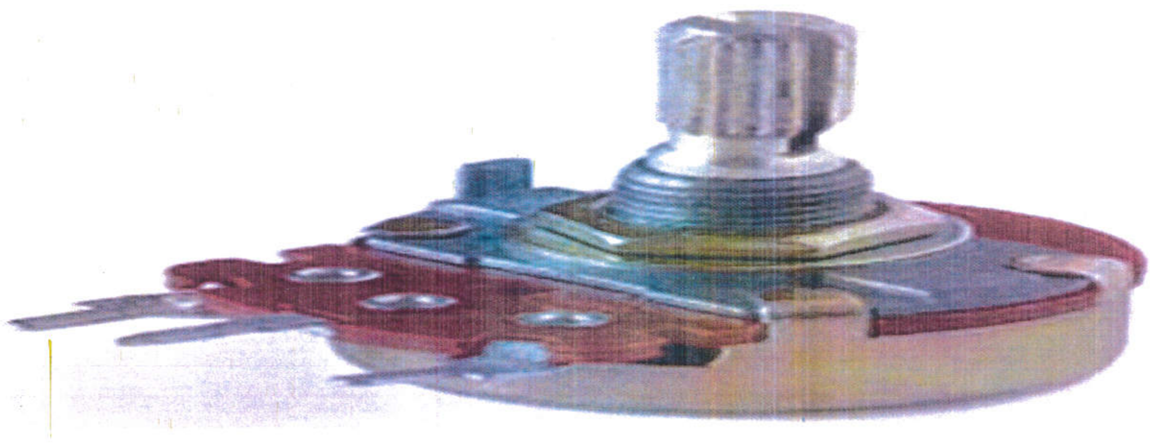

Figure 3.12: Potentiometer

3.13 Software

- Proteus
- Arduino software
- Sketch-up

DESIGN CALCULATION

PIR sensor

Calculating the pulse time and timeout length

Tx timeout – this is how long the LED is lit after it detects motion.

Ti timeout – this is how long the LED is guaranteed to be off when there is no movement.

The little trim potentiometer on the sensor which is a 1 megaohm adjustable resistor added to a 10k series resistor and a capacitor 0.01µF.

Therefore, $Tx = 24567\ x\ (10k + Rtime)\ x\ 0.01\mu F$

If the potentiometer is turned all down counterclockwise to 0ohms,

Then, $Tx = 24567\ x\ (10k)\ x\ 0.01\mu F = 2.5 seconds$

If the potentiometer is turned all the way up clockwise to 1 megaohm,

Then, $Tx = 24567\ x\ (1010k)\ x\ 0.01\mu F = 250 seconds$

Note: if the $Rtime$ is in the middle, the value is about 120seconds and can always be adjusted as desired.

The operating range of a PIR sensor is about 10 meters and that of the ultrasonic sensor is about 2cm – 400cm.

These values make the sensors suitable for use in a standard room which is 3m x 3m in size.

The Capacitor Breakdown Voltage

The capacitor breakdown voltage can be determined by applying Kirchhoff's voltage law at the output of the rectifier to the terminal of the filter capacitor.

$$V_{peak} - 2(\text{Diode drop } (V_D)) = \text{Voltage at filter capacitor}$$

For silicon made diode $V_D = 0.7V$

$$\therefore V_C = 16.97 - 2\ (0.7) = 15.57V$$

Taking a safety factor of two, the capacitor voltage, V_C becomes 31.14V, and since this is not a common capacitor voltage, a 25V capacitor was chosen

The capacitance of the capacitor used is gotten using the relationship

$$V_{max} = \frac{I_L}{2fC}$$

I_L = load current = 895.7mA (as calculated)

f = frequency = 2 × supply frequency = 2 ×50Hz = 100Hz

C = capacitance

Maximum peak = 11.33V

Obtaining capacitance, we have that:

$$V_{max} = \frac{I_L}{2fC} = \frac{895.7 \text{ x } 10-3}{2 \ x \ 50 \ x \ C}$$

$$11.33 = \frac{895.7 \text{ x } 10-3}{2 \ x \ 50 \ x \ C}$$

$$C = \frac{895.7 \text{ x } 10-3}{1133} = 0.000790556F \ = \ 791\mu F$$

3.14 Circuit Design Using Proteus

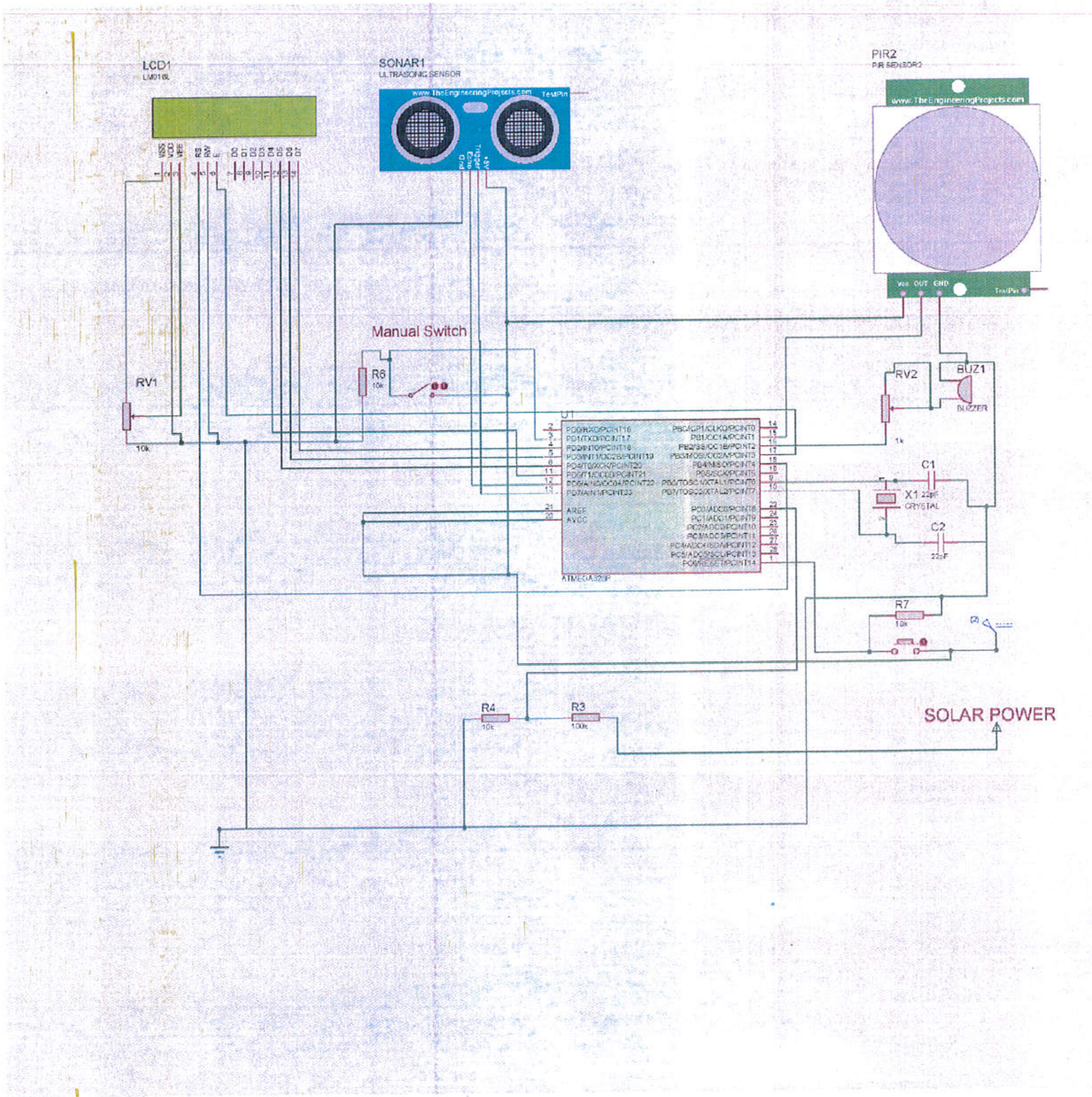

Figure 3.13: Circuit Diagram

3.15 The Sketch-Up 3D Design/Model

Figure 3.14: Top-view of design implementation

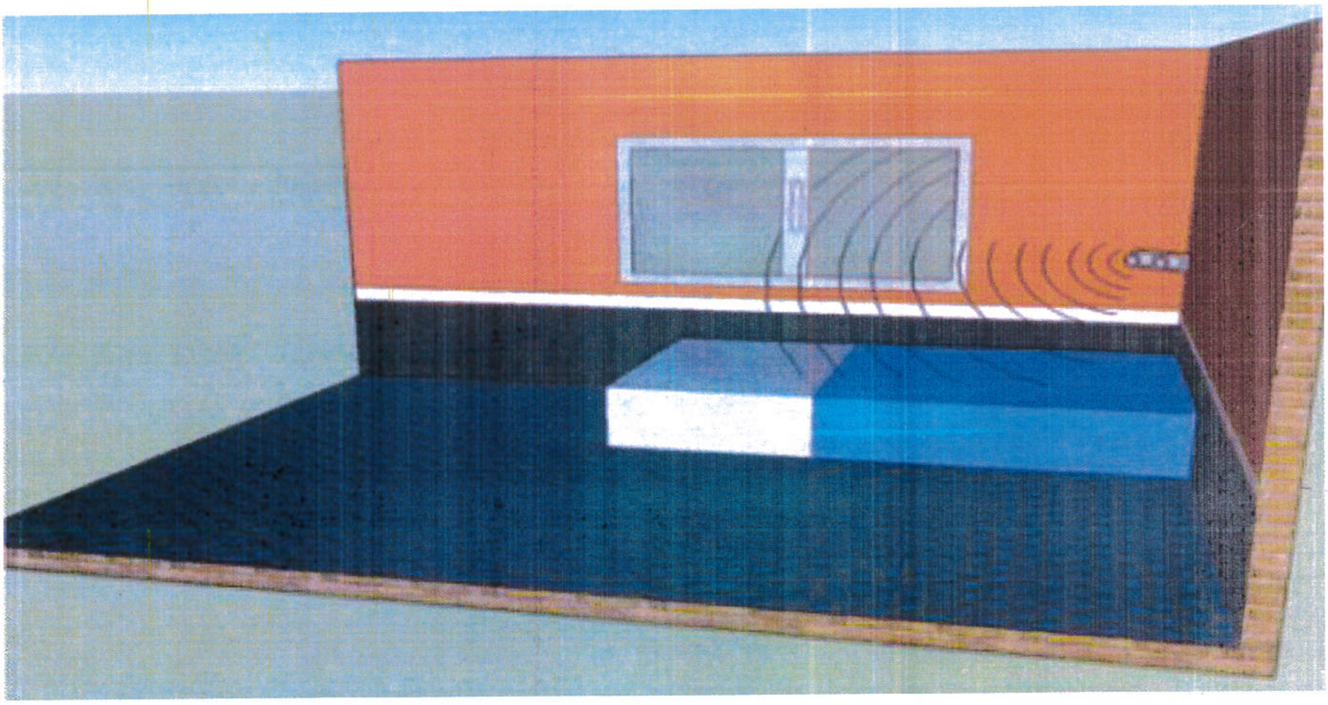

Figure 3.15: Inside-view of design implementation

Figure 3.16: Window-view of design implementation

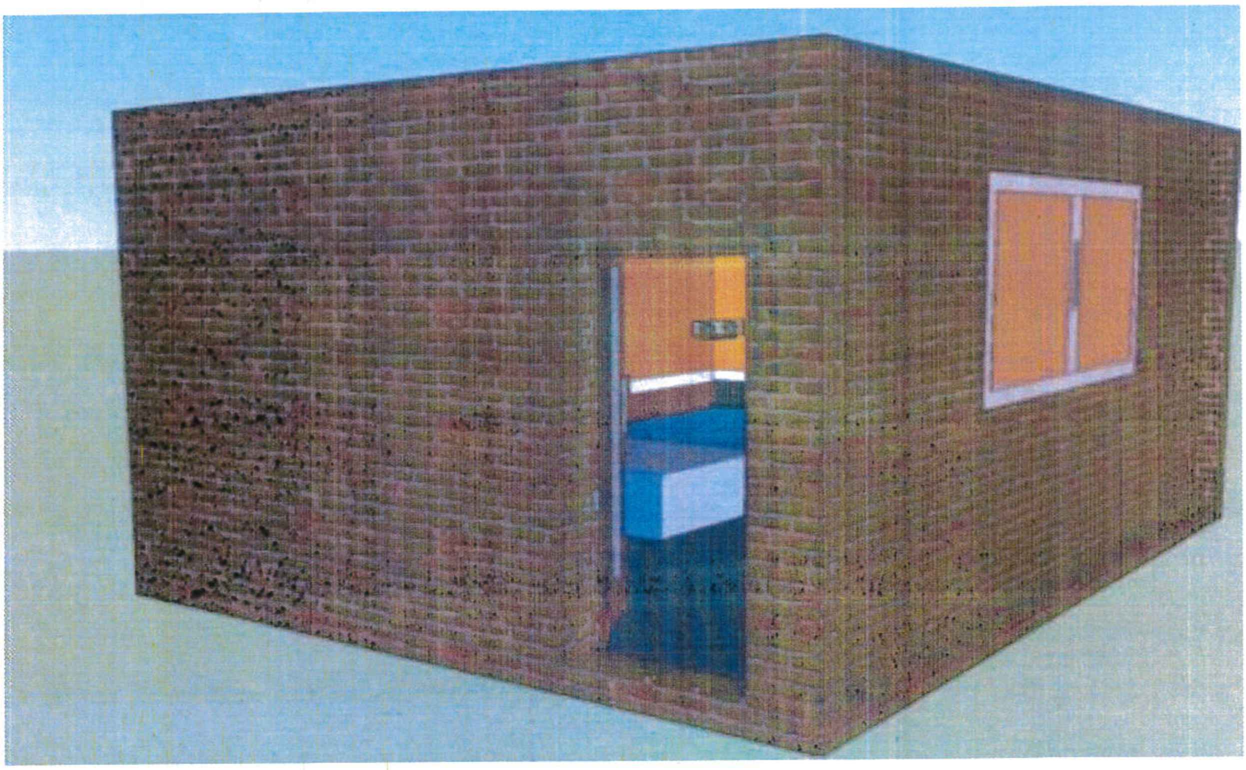

Figure 3.17: Door-view of design implementation

3.16 Flowcharts

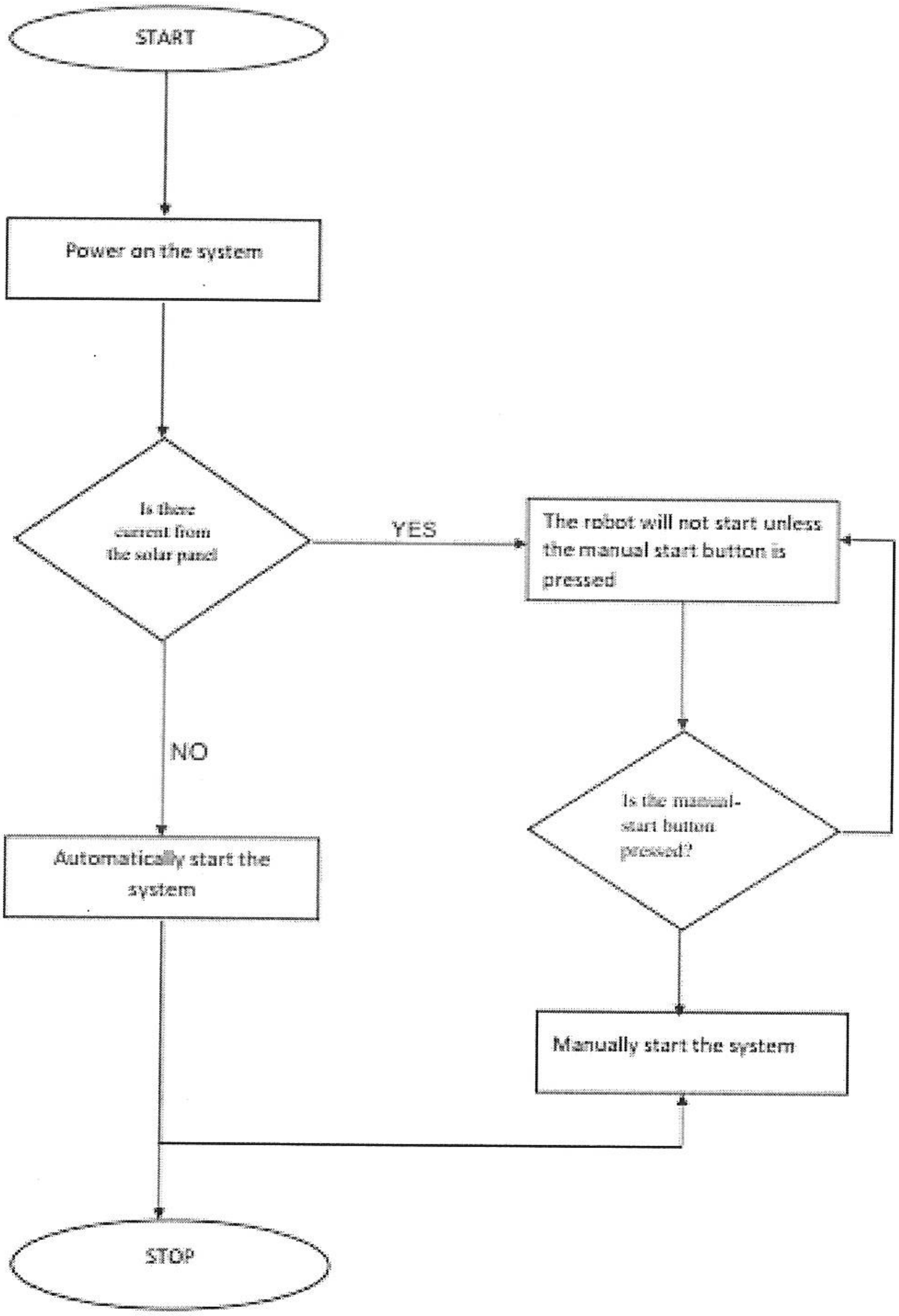

Figure 3.18: Flow chart

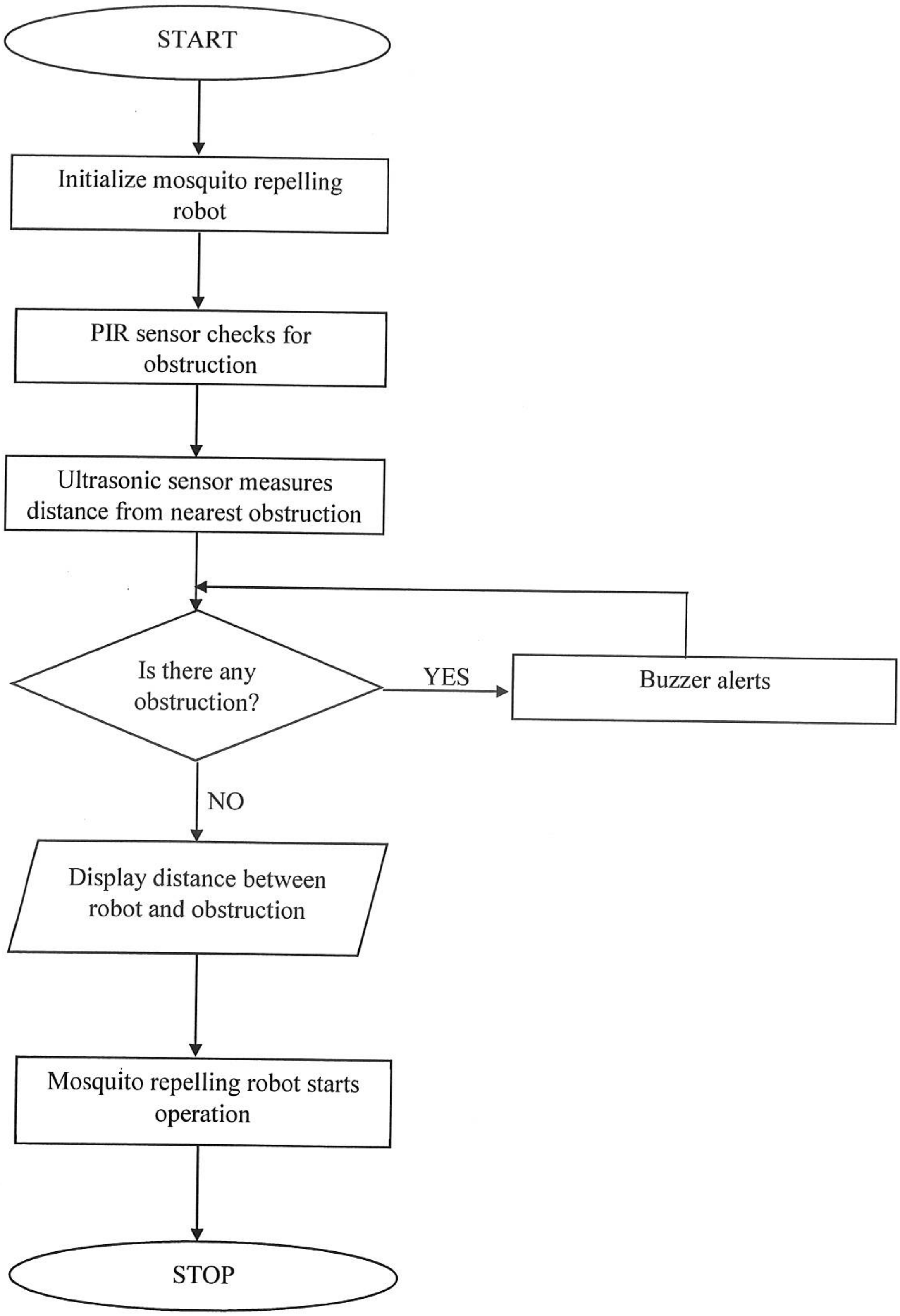

Figure 3.19: Flow chart

CHAPTER FOUR

4.0 RESULT AND DISCUSSIONS

The objectives of this project are to research, design and test its effectiveness. This chapter covers the results of the design, development and testing of the overall system.

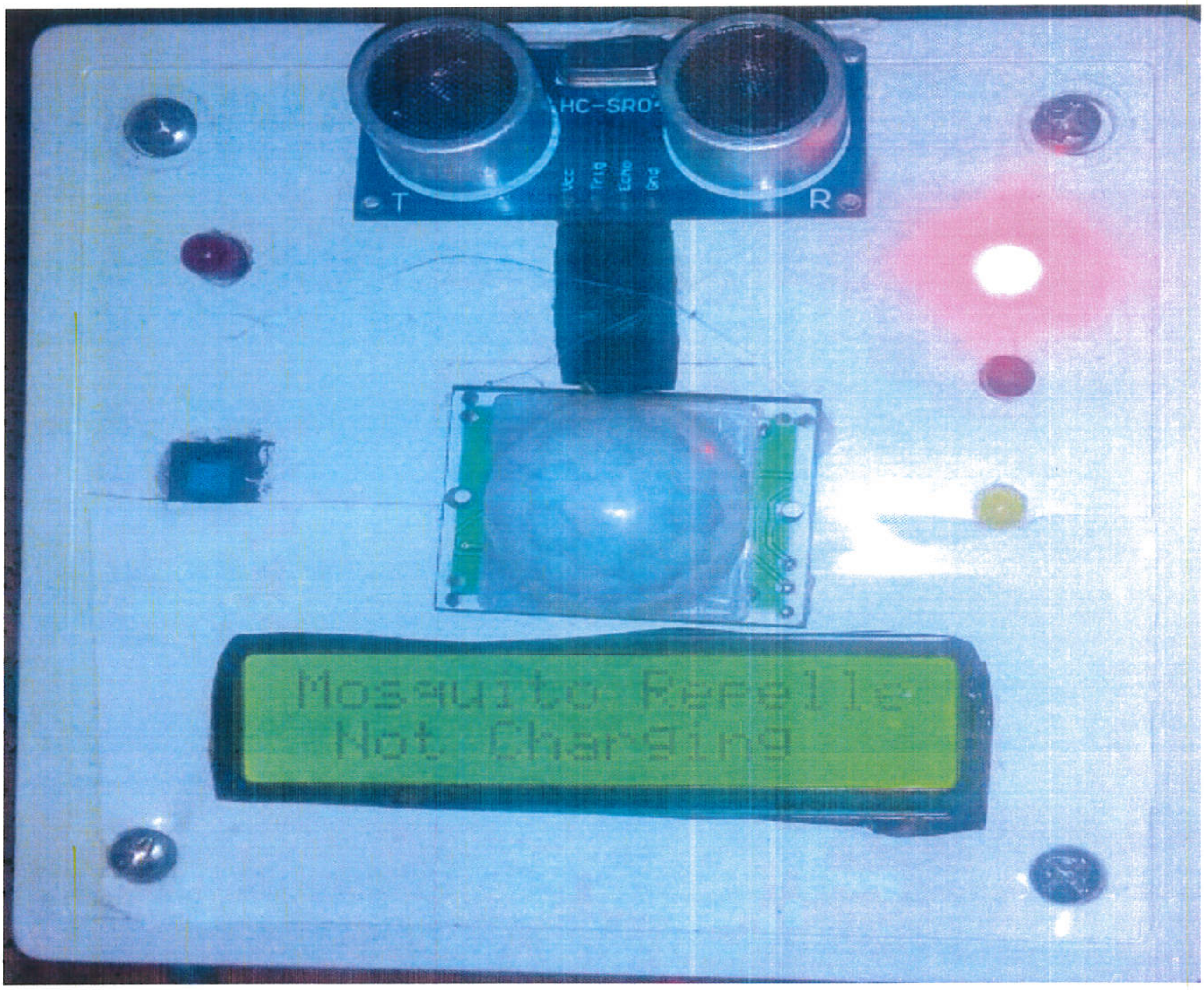

Figure 4.1: Final Implementation

4.1 Observation and Results

Once the robot is put on using the main switch, it has a delay of few seconds for the PIR sensor to calibrate. The buzzer then starts buzzing in quick successions. An human obstacle was brought close to the system, the PIR detected the obstacle and signaled the ultrasonic sensor to display the obstacle distance as well as the buzzer to beep two times to indicate obstacle.

4.2 Testing

Each of the components were first tested using the multimeter in order to check for their state of performance and accurate values. In the connection, each component on the vero-board was then tested. This was done in order to carry out the continuity which is meant for proper connection of the circuit and to detect any wrong connection. The sensory unit was tested to ascertain the degree of sensitivity as expected. After proper testing was conducted, the packaging of the design into a model and casing was considered, the connecting wires were properly connected and well insulated.

4.3 Results

The device was tested in a room in the FUOYE male hostel with the windows open and a lamp put on to attract the mosquitoes into the room, the device was switched on, the human obstacles were moved away from the working range of the device, throughout the time when the device was tested for a period of three hours, the mosquitoes that came close were disturbed on hearing the sound and could not hang-on in the room. This clearly demonstrates the effectiveness of the device

4.4 Problems Encountered

i. Availability of the components required.

ii. Programming the microcontroller.

iii. Design of the circuit.

iv. Getting the appropriate voltage to power the components conveniently.

v. Conflict between PIR and ultrasonic sensors.

CHAPTER FIVE

5. 0 RECOMMENDATION AND CONCLUSION

5.1 CONCLUSION

The system requirements for the mosquito repelling robot are met. The possibility of repelling mosquitoes autonomously without the need to manually turn it on makes me recommend this robot as a laudable project that will enhance the healthcare sector of Nigeria and cut expenses on malaria treatment.

Compared to other means of repelling mosquitoes i.e. biological, chemical etc. this robot eliminates a lot of inconveniences caused by the other methods although its initial cost is high but it pays for its initial cost with its durability. The design of the device relies on the sensors (PIR sensor and Ultrasonic sensor) and the buzzer for the sound production. An ease in modification and troubleshooting has helped me in acquiring good results. Finally, I was able to achieve these results:

i. Determination of the materials and electronic components needed for the design.

ii. Usage of both electricity and solar power in recharging the battery as a power source of the system.

iii. Development of a mosquito repelling robot that is environment friendly.

iv. Ensuring that the frequency of the sound produced does not disturb humans.

5.2 RECOMMENDATIONS

1. The initial goal of the project is to detect mosquitoes using a microphone input, further research on the device can get a means of detecting the mosquitoes without interference.

2. The working range of the project can be increased by using a component of higher and farther sound frequency.

REFERENCES

Adeniran, O. I., & Fabiyi, E. (2012). A cream formulation of an effective mosquito repellent: a topical product from lemongrass oil (Cymbopogoncitratus) Stapf. *J Nat Prod Plant Resour.*, 322-327.

Adeniran, O. I.; Fabiyi, E. (2012). a topical product from lemongrass oil (Cymbopogoncitratus) Stapf. J Nat Prod. *A cream formulation of an effective mosquito repellant*, 322-327.

Al-Akel, A. S., & Suliman, E. M. (2011). Biological control agent for mosquito larvae: Review on the killifish, Aphanius dispar dispar (Rüppel, 1829). *African Journal of Biotechnology.*, 8683-8688.

Ansari, M. A., Mittal, P. K., Razdan, R. K., & Sreehari, U. (2005). Larvicidal and mosquito repellent activities of Pine (Pinus longifolia, Family: Pinaceae) oil. *Journal of vector borne diseases.*, 95.

Atieli, F. K., Munga, S. O., Ofulla, A. V., & Vulule, J. M. (2010). The effect of repeated washing of long-lasting insecticide-treated nets (LLINs) on the feeding success and survival rates of Anopheles gambiae. *Malaria journal.*, 1-9.

Atmel. (n.d.). *ATmega328/P*, pp. 9-13.

Bhupesh Aneja et al. (2011). Review Of Temperature Measurement And Control. *International Journal of Electrical and Electronics Engineers*, 29-37.

Chandra, G., Bhattacharjee, I., Chatterjee, S. N., & Ghosh, A. (2008). Mosquito control by larvivorous fish. *Indian Journal of Medical Research.*, 13-27.

Ditzen, M., Pellegrino, M., & Vosshall, L. B. (2008). Insect odorant receptors are molecular targets of the insect repellent DEET. *Science*, 1838-1842.

Energy matters. (2017, July 30). Retrieved from Energy matters: http://energymatters.com.au/education/

Fayemiwo, K. A., Adeleke, M. A., Okoro, O. P., Awojide, S. H., & Awoniyi, I. O. (2014). Larvicidal efficacies and chemical composition of essential oils of Pinussyl vestris and Syzygium aromaticum against mosquitoes. . *Asian Pacific journal of tropical biomedicine.*, 30-34.

Feng, H.-M. (2001). *United States Patent No. 6293044.*

Future Electronics. (2017, July 30). Retrieved from Future Electronics: http://www.futureelectronics.com/en/passives/buzzers.aspx

Gaddaguti, V., Rao, T. V., & Rao, A. P. (2016). Potential mosquito repellent compounds of Ocimum species against 3N7H and 3Q8I of Anopheles gambiae. *Biotech*, 1-8.

Ghosh, A., Chowdhury, N., & Chandra, G. (2012). Plant extracts as potential mosquito larvicides. *Indian J Med Res.*, 581-598.

Hewitt, S., & Rowland, M. (1999). Control of zoophilic malaria vectors by applying pyrethroid insecticides to cattle. *Tropical medicine & international health.*, 481-486.

Impoinvil, D. E., Ahmad, S., Troyo, A., Keating, J., Githeko, A. K., & Mbogo, C. M. (2007). Comparison of mosquito control programs in seven urban sites in Africa, the Middle East,and the Americas. *Health Policy*, 196-212.

Iturbe-Ormaetxe, I., Walker, T., & LO'Neill, S. (2011). Wolbachia and the biological control of mosquito-borne disease. *EMBO reports.*, 508-518.

Kamareddine, L. (2012). The biological control of the malaria vector. *Toxins*, 748-767.

Katritzky, A. R., Slavov, S., Dobchev, D. A., Hall, C. D., & Tsikolia, M. (2010). Novel carboxamides as potential mosquito repellents. *Journal of medical entomology.*, 924-938.

Katritzky, A. R., Wang, Z., Slavov, S., Tsikolia, M., Dobchev, D., & Akhmedov, N. G. (2008). Synthesis and bioassay of improved mosquito repellents predicted from chemical structure. *Proceedings of the National Academy of Sciences.*, 7359-7364.

Kayedi, M. H., Haghdoost, A. A., Salehnia, A., & Khamisabadi, K. (2014). Evaluation of repellency effect of essential oils of Saturejak huzestanica (Carvacrol), Myrtus communis (Myrtle), Lavendula officinalis and Salvia sclarea using standard WHO repellency tests. *Journal of arthropod-borne diseases.*, 60-68.

kenneth Charles Leftridge, S. (2003). *United States Patent No. 6570494.*

Khoobdel, M., Shayeghi, M., Ladonni, H., Rassi, Y., Vatandoost, H., & Alipour, H. K. (2005). The efficacy of permethrin-treated military uniforms as a personal protection against Culexpipiens (Diptera: Culicidae) and its environmental consequences. *International Journal of Environmental Science & Technology.*, 161-167.

Koech, P. K., & Mwangi, R. W. (2014). Synergistic repellent activity of plant essential oils against Aedes aegypti on rabbit Skin. *International Journal of Mosquito Research.*, 55-59.

Kongkaew, C., Sakunrag, I., Chaiyakunapruk, N., & Tawatsin, A. (2011). Effectiveness of citronella preparations in preventing mosquito bites: systematic review of controlled laboratory experimental studies. *Tropical Medicine & International Health.* , 802-810.

Kumar, S., Wahab, N., & Warikoo, R. (2011). Bioefficacy of Menthapiperita essential oil against dengue fever mosquito Aedes aegypti L. *Asian Pacific journal of tropical biomedicine.*, 85-88.

Levitt, R. (1976). *United States Patent No. 3931865.*

Maia, M. F., & Moore, S. J. (2011). Plant-based insect repellents: a review of their efficacy, development and testing. *Malaria Journal.*, 1-14.

Mendki, M. J., Singh, A. P., Tikar, S. N., Parashar, B. D., Veer, V., & Shukla, S. V. (2015). Repellent activity of N, N-diethylphenylacetamide (DEPA) with essential oils against Aedes aegypti, vector of dengue and chikungunya. *International Journal of Mosquito Research.*, 17-20.

Ogoma, S. B., Moore, S. J., & Maia, M. F. (2012). A systematic review of mosquito coils and passive emanators: defining recommendations for spatial repellency testing methodologies. Parasites & vectors. 1-10.

Onyett, H. (2014). Preventing mosquito and tick bites: A Canadian update. *Paediatrics & child health.*, 329-333.

Pal, M., Kumar, A., & Tewari, K. S. (2011). Chemical composition and mosquito repellent activity of the essential oil of Plectranthusincanus link. *Factauniversitatis-series: Physics, Chemistry and Technology.*, 57-64.

Patel, E. K., Gupta, A., & Oswal, R. J. (2012). A review on: mosquito repellent methods. *IJPCBS*, 310-317.

Pattanayak, B., & Dhal, N. K. (2000). plants having mosquito repellent activity: an ethnobotanical survey. *International Journal of Research and Development in Pharmacy and Life Sciences.*, 1760-1765.

Peterson, C. J. (2001). Insect repellents of natural origin. *catnip and osage orange.*

Peterson, C. J., & R., C. J. (2011). Catnip Essential Oil and Its Nepetalactone Isomers as Repellents for Mosquitoes. *Recent Developments in Invertebrate Repellents.*, 59-65.

Polsomboon, S., Grieco, J. P., Achee, N. L., Chauhan, K. R., Tanasinchayakul, S., & Pothikasikorn, J. (2008). Behavioral responses of catnip (Nepetacataria) by two species of mosquitoes, Aedes aegypti and Anopheles harrisoni, in Thailand. *Journal of the American Mosquito Control Association.*, 513-519.

Raja, A. S., Kawlekar, S., Saxena, S., Arputharaj, A., & Patil, P. G. (2015). Mosquito protective textiles-A review. *international Journal of Mosquito Research.* , 49-53.

Rajkumar, S., & Jebanesan, A. (2010). Prevention of Dengue fever through plant based mosquito repellent Clausena dentata (Willd.) M. Roem (Family: Rutaceae) essential oil against Aedes aegypti L. (Diptera: Culicidae) mosquito. *Eur Rev Med Pharmacol Sci.*, 231-234.

Ramar, M., Ignacimuthu, S., & Gabriel, P. (2014). Mosquito knock Down and Adultcidal Activities of Essential Oils by Vaporizer, Impregnated Filter Paper and Aerosol Methods. *International Journal of Mosquito Research.*, 231-234.

Scholte, E. J., Knols, B. G., Samson, R. A., & Takken, W. (2004). Entomopathogenic fungi for mosquito control: a review. *Journal of Insect Science.*, 184-191.

Shell, E. R. (1997, Aug.). Resurgence of a deadly disease. *The Atlantic Monthly.*, pp. 45-60.

Singh, B. S., & Mohanty, M. K. (2012). Toxicity of a plant based mosquito repellent/killer. *Interdisciplinary toxicology*, 184-191.

Soonwera, M. (2015). Efficacy of essential oils from Citrus plants against mosquito vectors Aedes aegypti (Linn.) and Culex quinquefasciatus (Say). *J Agri Tech*, 669-681.

Sritabutra, D., & Soonwera, M. (2013). Repellent activity of herbal essential oils against Aedes aegypti (Linn.) and Culex quinquefasciatus (Say.). *Asian Pacific Journal of Tropical Disease.* , 271-273.

Sukumar, K., Perich, M. J., & Boobar, L. R. (1991). Botanical derivatives in mosquito control. *Journal of the American Mosquito Control Association*, 210-237.

Sumithra, V., Janakiraman, A., & Altaff, K. (2014). Bio-control of mosquito larvae through the black molly, poecilias phenops. *International Journal of Pure and Applied Zoology*, 270-274.

Syed, Z., & Leal, W. S. (2008). Mosquitoes smell and avoid the insect repellent DEET. *Proceedings of the National Academy*, 13598-13603.

Taubes, G. (1977, Aug. 24). A mosquito bites back. *The New York Times Magazine.*, pp. 40-6.

Tawatsin, A., Asavadachanukorn, P., Thavara, U., Wongsinkongman, P., Bansidhi, J., & Boonruad, T. (2006). Repellency of essential oils extracted from plants in Thailand against four mosquito vectors (Diptera:Culicidae) and oviposition deterrent effects against Aedesaegypti (Diptera: Culicidae). . *Southeast asian j trop med public health.*, 915-937.

Uniyal, A., Tikar, S. N., Singh, R., Vinay, S., Shukla, O. P., & Sukumaran. (2015). Synergistic effect of effective oils against Aedesaegypti female mosquito, vector of dengue and chikungunya. *International Journal of Mosquito Research*, 29-35.

Yang, H. M., & Ferreira, C. P. (2008). Assessing the effects of vector control on dengue transmission. *Applied Mathematics and Computation.* , 401-413.

Zhu, J. J., Berkebile, D. R., Dunlap, C. A., Zhang, A., Boxler, D., & Tangtrakulwanich, K. (2012). Nepetalactones from essential oil of Nepetacataria represent a stable fly feeding and oviposition repellent. *Medical and veterinary entomology.*, 131-138.

APPENDIX A

User's Manual;

The preparation for using the device has the following steps to be followed to ensure the correct operation and to come up with the right output with respect to its main objective.

1. Hang the robot on a wall close to the bedside or where the person is.
2. Press the power switch after which the red LED comes on to indicate the ON state of the device.
3. The device boots for a few seconds before operation.
4. When charging the device:
   a. If you wish to charge it using the 5V DC cable, plug it to the power source.
   b. If you wish to charge it using the solar panel, connect the wires appropriately and place the panel outside.
5. If the device is to run on automatic mode, leave it connected to the solar panel. After the solar panel stops receiving light, the device comes on by itself.
6. If the device is to run on manual mode, detach it from the solar panel and press the pushbutton to switch mode.
7. While the device charging with the solar panel, it goes on standby mode i.e. it is not active.
8. Keep device away from moisture.

APPENDIX B

The Code

```
//Library
#include <LiquidCrystal.h>
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);
/// REGISTER SELECT PIN,ENABLE PIN,D4 PIN,D5 PIN, D6 PIN, D7 PIN

  // pins declaratiom

 int manual = A2;

 int lcdl = A1;
 int mosquitok = 10;
int obstled = 13;
 int standby = 8;
int obst =9;
    const int trig = 7;
    const int echo = 6;
int analogInput = A0;
float vout = 0.0;
float vin = 0.0;
float R1 = 100000.0;
float R2 = 10000.0;
int value = 0;

long duration;
    int distance;

    //pins definition and mode
void setup() {
 Serial.begin(9600);

//mode declarations
    pinMode(manual, INPUT);
     pinMode(mosquitok, OUTPUT);
       pinMode(standby, OUTPUT);
     pinMode(obstled, OUTPUT);
       //pinMode(lcdl, OUTPUT);
       pinMode(obst, INPUT);
        pinMode(trig, OUTPUT); // Sets the trig as an Output
    pinMode(echo, INPUT); // Sets the echo as an Input

  // set up the LCD's number of columns and rows:
  lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.print("Hi!                    ");
delay(100);
 lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.print("Mosquito Repelling robot              ");
```

```
 lcd.setCursor(0,1);

 // Print a message to the LCD.
  lcd.print("     System                          ");
delay(100);


 lcd.begin(16, 2);

 // Print a message to the LCD.
  lcd.print("........BY.........                  ");

 lcd.setCursor(0,1);

 // Print a message to the LCD.
  lcd.print("Ojimiwe Simeon                          ");

delay(200);

 digitalWrite(echo,LOW);

 digitalWrite(standby,LOW);


 digitalWrite(lcdl,HIGH);

 lcd.begin(16, 2);

 // Print a message to the LCD.
  lcd.print("Mosquito Repeller                ");

}

void loop() {
 digitalWrite(lcdl,HIGH);

 digitalWrite(standby,LOW);


value = analogRead(analogInput);

   vout =  value * (5.0 / 1024.0);
 // see text
   vin = vout / (R2/(R1+R2));
int manualbt = digitalRead(manual);

int obstruction = digitalRead(obst);



// MANUAL MODE
 if(manualbt ==HIGH){
  lcd.setCursor(0,1);
```

```
lcd.print("Manual Mode                    ");

 delay(100);

   if (vin<1) {
   lcd.setCursor(0,1);
lcd.print("Not Charging          ");

delay(200);


  digitalWrite(obstled,LOW);

 digitalWrite(standby,LOW);


       vin=0.0;//statement to quash undesired reading !
if( obstruction  == 1){
  lcd.setCursor(0,1);

lcd.print("Obstruction Alert!                ");

 delay(100);

digitalWrite(obstled, HIGH);

delay(50);

 digitalWrite(obstled, LOW);

delay(50);

digitalWrite(obstled, HIGH);

delay(50);

 digitalWrite(obstled, LOW);

delay(50);
 digitalWrite(obstled, HIGH);

 delay(50);
  digitalWrite(obstled, LOW);

 delay(200);


}

 //MOSQUITOE REPELLER1
 // Clears the trig
    digitalWrite(trig, LOW);
```

```
delayMicroseconds(100);

// Sets the trig on HIGH state for 10 micro seconds
  digitalWrite(trig, HIGH);

delayMicroseconds(100);
  digitalWrite(trig, LOW);

  // Reads the echo, returns the sound wave travel time in microseconds
  duration = pulseIn(echo, HIGH);

 // Calculating the distance
  distance= duration*0.034/2;

 // Prints the distance on the Serial Monitor
  lcd.setCursor(0,1);

lcd.print("Distance: ");

 lcd.println(distance);

digitalWrite(mosquitok, HIGH);

delay(4000);


digitalWrite(obstled,LOW);

digitalWrite(standby,LOW);



// Clears the trig
  digitalWrite(trig, LOW);

 delayMicroseconds(100);

// Sets the trig on HIGH state for 10 micro seconds
  digitalWrite(trig, HIGH);

delayMicroseconds(100);
  digitalWrite(trig, LOW);

 // Reads the echo, returns the sound wave travel time in microseconds
  duration = pulseIn(echo, HIGH);

  // Calculating the distance
  distance= duration*0.034/2;

 // Prints the distance on the Serial Monitor
  Serial.print("Distance: ");

 Serial.println(distance);
  lcd.setCursor(0,1);
```

```
    lcd.print("Distance: ");

  lcd.println(distance);

  digitalWrite(mosquitok, HIGH);

  delay(4000);
 // Clears the trig
    digitalWrite(trig, LOW);

   delayMicroseconds(100);

  // Sets the trig on HIGH state for 10 micro seconds
    digitalWrite(trig, HIGH);

   delayMicroseconds(100);
    digitalWrite(trig, LOW);

  // Reads the echo, returns the sound wave travel time in microseconds
    duration = pulseIn(echo, HIGH);

    // Calculating the distance
    distance= duration*0.034/2;

   // Prints the distance on the Serial Monitor
    Serial.print("Distance: ");

    Serial.println(distance);

   lcd.setCursor(0,1);

  lcd.print("Distance: ");

  lcd.println(distance);

  digitalWrite(mosquitok, HIGH);

   delay(4000);


  digitalWrite(obstled,LOW);

 digitalWrite(standby,LOW);



} else{
  digitalWrite(obstled,LOW);

  digitalWrite(standby,LOW);
```

```
  lcd.setCursor(0,1);

 lcd.print("Charging                ");

 delay(100);
lcd.setCursor(0, 1);

lcd.print("DC INPUT=");

lcd.print(vin);
delay(200);



if( obstruction  == 1){
  lcd.setCursor(0,1);

 lcd.print("Obstruction Alert!             ");
 Serial.print("Obstruction Alert!             ");
 delay(100);
 digitalWrite(obstled, HIGH);
 delay(200);
  digitalWrite(obstled, LOW);
 delay(200);

 digitalWrite(obstled, HIGH);
 delay(200);
  digitalWrite(obstled, LOW);
 delay(200);

 digitalWrite(obstled, HIGH);
 delay(200);
  digitalWrite(obstled, LOW);
 delay(200);

}

  digitalWrite(obstled,LOW);
  digitalWrite(standby,LOW);


 delay(100);
 //MOSQUITOE REPELLER1
 // Clears the trig
    digitalWrite(trig, LOW);
    delayMicroseconds(100);
    // Sets the trig on HIGH state for 10 micro seconds
    digitalWrite(trig, HIGH);
    delayMicroseconds(100);
    digitalWrite(trig, LOW);
    // Reads the echo, returns the sound wave travel time in microseconds
    duration = pulseIn(echo, HIGH);
    // Calculating the distance
```

```
    distance= duration*0.034/2;
    // Prints the distance on the Serial Monitor
    Serial.print("Distance: ");
    Serial.println(distance);
   delay(4000);
 // Clears the trig
    digitalWrite(trig, LOW);
    delayMicroseconds(100);
    // Sets the trig on HIGH state for 10 micro seconds
    digitalWrite(trig, HIGH);
    delayMicroseconds(100);
    digitalWrite(trig, LOW);
    // Reads the echo, returns the sound wave travel time in microseconds
    duration = pulseIn(echo, HIGH);
    // Calculating the distance
    distance= duration*0.034/2;
    // Prints the distance on the Serial Monitor
    Serial.print("Distance: ");
    Serial.println(distance);
   delay(4000);
 // Clears the trig
    digitalWrite(trig, LOW);
    delayMicroseconds(100);
    // Sets the trig on HIGH state for 10 micro seconds
    digitalWrite(trig, HIGH);
    delayMicroseconds(100);
    digitalWrite(trig, LOW);
    // Reads the echo, returns the sound wave travel time in microseconds
    duration = pulseIn(echo, HIGH);
    // Calculating the distance
    distance= duration*0.034/2;
    // Prints the distance on the Serial Monitor
    Serial.print("Distance: ");
    Serial.println(distance);
   delay(4000);

  digitalWrite(obstled,LOW);
  digitalWrite(standby,LOW);

    //MOSQUITOE KILLER2
     digitalWrite(mosquitok, HIGH);   // turn the mosquitok on (HIGH is
the voltage level)
  delay(100);                        // wait for a second
  digitalWrite(mosquitok, LOW);    // turn the mosquitok off by making the
voltage LOW
  delay(50);
  digitalWrite(mosquitok, HIGH);   // turn the mosquitok on (HIGH is the
voltage level)
  delay(100);                        // wait for a second
  digitalWrite(mosquitok, LOW);    // turn the mosquitok off by making the
voltage LOW
  delay(50);
   digitalWrite(mosquitok, HIGH);   // turn the mosquitok on (HIGH is the
voltage level)
```

```
  delay(200);                          // wait for a second
  digitalWrite(mosquitok, LOW);      // turn the mosquitok off by making the
voltage LOW
  delay(50);
   digitalWrite(mosquitok, HIGH);    // turn the mosquitok on (HIGH is the
voltage level)
  delay(100);                          // wait for a second
  digitalWrite(mosquitok, LOW);      // turn the mosquitok off by making the
voltage LOW
  delay(50);
  digitalWrite(mosquitok, HIGH);     // turn the mosquitok on (HIGH is the
voltage level)
  delay(100);                          // wait for a second
  digitalWrite(mosquitok, LOW);      // turn the mosquitok off by making the
voltage LOW
  delay(50);

}}


//NORMAL MODE
 if (vin<0.09) {
    lcd.setCursor(0,1);
 lcd.print("Not Charging         ");
 delay(200);

  digitalWrite(obstled,LOW);
  digitalWrite(standby,LOW);

       vin=0.0;//statement to quash undesired reading !
if( obstruction  == 1){
  lcd.setCursor(0,1);
 lcd.print("Obstruction Alert!            ");
 Serial.print("Obstruction Alert!            ");
 delay(100);
 digitalWrite(obstled, HIGH);
 delay(200);
  digitalWrite(obstled, LOW);
 delay(200);

 digitalWrite(obstled, HIGH);
 delay(200);
  digitalWrite(obstled, LOW);
 delay(200);

 digitalWrite(obstled, HIGH);
 delay(200);
  digitalWrite(obstled, LOW);
 delay(200);

 }

  //MOSQUITOE KILLER1
  // Clears the trig
```

```
  digitalWrite(trig, LOW);
  delayMicroseconds(100);
  // Sets the trig on HIGH state for 10 micro seconds
  digitalWrite(trig, HIGH);
  delayMicroseconds(100);
  digitalWrite(trig, LOW);
  // Reads the echo, returns the sound wave travel time in microseconds
  duration = pulseIn(echo, HIGH);
  // Calculating the distance
  distance= duration*0.034/2;
  // Prints the distance on the Serial Monitor
 lcd.print("Distance: ");
  lcd.println(distance);
 delay(4000);

digitalWrite(obstled,LOW);
digitalWrite(standby,LOW);

// Clears the trig
  digitalWrite(trig, LOW);
  delayMicroseconds(100);
  // Sets the trig on HIGH state for 10 micro seconds
  digitalWrite(trig, HIGH);
  delayMicroseconds(100);
  digitalWrite(trig, LOW);
  // Reads the echo, returns the sound wave travel time in microseconds
  duration = pulseIn(echo, HIGH);
  // Calculating the distance
  distance= duration*0.034/2;
  // Prints the distance on the Serial Monitor
  Serial.print("Distance: ");
  Serial.println(distance);
 delay(4000);
// Clears the trig
  digitalWrite(trig, LOW);
  delayMicroseconds(100);
  // Sets the trig on HIGH state for 10 micro seconds
  digitalWrite(trig, HIGH);
  delayMicroseconds(100);
  digitalWrite(trig, LOW);
  // Reads the echo, returns the sound wave travel time in microseconds
  duration = pulseIn(echo, HIGH);
  // Calculating the distance
  distance= duration*0.034/2;
  // Prints the distance on the Serial Monitor
  Serial.print("Distance: ");
  Serial.println(distance);
 delay(4000);


digitalWrite(obstled,LOW);
digitalWrite(standby,LOW);

  //MOSQUITOE KILLER2
```

```
    digitalWrite(mosquitok, HIGH);    // turn the mosquitok on (HIGH is
the voltage level)
  delay(100);                         // wait for a second
  digitalWrite(mosquitok, LOW);     // turn the mosquitok off by making the
voltage LOW
  delay(50);
  digitalWrite(mosquitok, HIGH);    // turn the mosquitok on (HIGH is the
voltage level)
  delay(100);                         // wait for a second
  digitalWrite(mosquitok, LOW);     // turn the mosquitok off by making the
voltage LOW
  delay(50);
   digitalWrite(mosquitok, HIGH);    // turn the mosquitok on (HIGH is the
voltage level)
  delay(200);                         // wait for a second
  digitalWrite(mosquitok, LOW);     // turn the mosquitok off by making the
voltage LOW
  delay(50);
   digitalWrite(mosquitok, HIGH);    // turn the mosquitok on (HIGH is the
voltage level)
  delay(100);                         // wait for a second
  digitalWrite(mosquitok, LOW);     // turn the mosquitok off by making the
voltage LOW
  delay(50);
  digitalWrite(mosquitok, HIGH);    // turn the mosquitok on (HIGH is the
voltage level)
  delay(100);                         // wait for a second
  digitalWrite(mosquitok, LOW);     // turn the mosquitok off by making the
voltage LOW
  delay(50);


} else{
  digitalWrite(obstled,LOW);
   digitalWrite(lcdl,LOW);

  digitalWrite(standby,HIGH);
  delay(100);
 digitalWrite(standby,LOW);
 delay(100);
   digitalWrite(standby,HIGH);
  delay(100);
 digitalWrite(standby,LOW);
 delay(100);
   digitalWrite(standby,HIGH);
  delay(100);
 digitalWrite(standby,LOW);
 delay(100);
 lcd.setCursor(0,1);
 lcd.print("STAND BY              ");
 delay(100);
   lcd.setCursor(0,1);
 lcd.print("Charging              ");
 delay(100);
```

```
lcd.setCursor(0, 1);
lcd.print("DC INPUT=");
lcd.print(vin);
delay(200);
}


      }
```

APPENDIX C

Bill of Materials

S/N	COMPONENT NAME	SPECIFICATION	QUANTITY	UNIT PRICE (₦)	PRICE (₦)
1.	Capacitors	22p 22n	1 1	20.00 20.00	20.00 20.00
2.	Resistors	100k 10k 220k	1 3 3	10.00 10.00 10.00	10.00 30.00 30.00
03.	Microprocessor (ATMEGA328P-PU)		1	1,500.00	1,500.00
4.	Diodes	G R Y	1 1 1	10.00 10.00 10.00	10.00 10.00 10.00
5.	Buzzer		1	100.00	100.00
6.	LCD		1	2,000.00	2,000.00
7.	PIR sensor		1	700.00	700.00
8.	Ultrasonic sensor		1	1,500.00	1,500.00
9.	Crystal oscillator		1	700.00	700.00
10.	Potentiometer		2	50.00	100.00
11.	Veroboard		1	200.00	200.00
12.	Switch		2	300.00	600.00
13.	Plastic casing		1	1,000.00	1,000.00
14.	Solar panel		1	5,000.00	5,000.00
15.	Battery		2	500.00	1,000.00
16.	LED		3	50.00	150.00
17.	Miscellaneous				20,310.00
	TOTAL				35,000.00