DESIGN AND CONSTRUCTION OF AN ELECTRONIC MOSQUITO REPELLANT

BY

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DECLARATION

I Kwesiga Isaac a student of Kabale University Pursuing Bachelor of Science with Education declares that this work was done by me and it has never been presented for any award in any University or Institution.

Signature .....~.'! .....

Date: 11/04/2022

APPROVAL

I approve that this work was done by Kwesiga Isaac Registration Number 2018/KEP/0383/F and this project has never been presented in any institution or for any award.

Supervisor

Mr Opio Phillip

Signature ___ -~ _____ _

Date _: 11/04/2022

DEDICATION

This particular piece of work is dedicated to my Family, friends and relatives who rendered support to me throughout my academic life at Kabale University from the beginning up to now. May God unconditionally bless you all for the support you rendered to me.

ACKNOWLEDGEMENT

In the first place I would like to thank the Almighty God for the peace of mind and health He has given to me that actually helped me to do this Final Year project from the beginning to the end. May His name be glorified.

In a special way, I would like to appreciate my Supervisor Mr. Opio Phillip for all the advice and guidance he rendered to me throughout my project. I really learnt a lot while working with you.

I would not forget to thank my parents who stood by my side and supported me financially and spiritually from the very beginning of my academic journey.

Thanks to all the Lecturers and Laboratory Technicians at the Department of Physics Kabale University and my friends who supported me in my project. Thanks to my friends for the support, I cannot pay you but all I can just say is may God grant you wisdom and guide you throughout your study. It would not have been easy for me to complete this project without your presence.

ABSTRACT

This work is titled design and construction of an electronic mosquito repellant device Mosquito repellants like coils, mats, liquid vaporizers and creams are often used at various places. However, they are prone to be fatal and can cause harm to human beings. For instance, mosquito repellant creams and creams can cause adverse effects on the skin like allergic reactions. Coils, mats can produce toxic fumes when heated and cause breathing trouble whereas liquid vaporizers can also produce fumes when heated.

For efficient result without any side effects, the most optimum solution is constructing a simple electronic device with minimal components which can produce output so as to repel the mosquitoes.

The aim of this work is to design an a simple electronic device which can produce ultrasound in the frequency range of 20kHz to 38kHz, which can scare away mosquitoes.

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LIST OF ACRONYMS

IC:	Integrated Circuit
CRO	Cathode Ray Oscilloscope
TTL:	Transistor-Transistor Logic

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

A report by the World Health Organization (WHO) 2005 shows that, Malaria affects more than 250 million people and causes more than a million deaths each year in the whole world. A report by the Daily Monitor dated Tuesday April 16, 2013 shows that, Malaria is Uganda's leading cause of death and according to the Ministry of Health accounts for up to four in every ten people who visit health facilities. One important strategy against this and other mosquitoborne diseases is mosquito control which aims at reducing human mosquito contact.

In an attempt to fight against Malaria, various means are routinely being used against mosquitoes and their larvae. Measures like indoor residual spraying using chemical (insecticide) called DDT (Dichlorodiphenyltrichloroethane) was put forward by the Government of Uganda in the bit to fight against mosquitoes. However, some people especially in Northern Uganda could not allow the village Health Team to spray their houses due to the perception that the chemical is very deadly and indeed it is if not handled properly. According to the report by the Daily Monitor dated Wednesday June 5, 2019, residents of Lira District rejected residual indoor spraying to fight Malaria due to fear that the chemical being used would make men weak by reducing their man power. And also, other ill-mannered people used the chemical for poisoning other people and animals.

Other control measures being used are insecticide-treated or untreated mosquito nets. However, chemicals and fumes emitted by the treated mosquito nets intended to be harmful to the mosquitoes can also prove toxic to our health in a long run. This measure is also not working very well at some places in Lango Sub-region, like Amolatar District and other districts, where people are using the mosquito nets for fishing, protecting seedlings in the nursery bed against insects, trapping white ants, making a makeshift bathroom, bathing sponge and others use mosquito net for tying goats. There is therefore a great misuse of government funds since the citizens are using what the government is distributing to fight Malaria for other purposes. Other mosquito repellent solutions like coils, creams and liquid vaporizers all have possible adverse effects to health.

Oils and creams can lead to skin disease and possibly skin cancer while coils being burnt to repel away mosquitoes can produce toxic fumes that lead to breathing problems, asthmatic individuals are greatly affected by these fumes. In a long run, these fumes also cause cancer.

There is undoubtedly a need for a safe, convenient and effective measure that is the use of an Electronic Mosquito Repellant which is a small hand-held battery powered device that repels mosquitoes by emitting a high frequency buzz almost inaudible to the human ear through the speaker. The concept that will be used in the circuit is basically ultrasound which is the sound with frequency higher than 20 kHz. The frequency range audible to humans is 20Hz to 20 kHz whereas mosquitoes are able to hear ultrasonic sound. Sound of any frequency above 20 kHz is termed as ultrasound and is usually transmitted by male mosquitoes and received by female mosquitoes. Generally, male mosquitoes transmit ultrasound in the range of 20 kHz to 40 kHz. However, female mosquitoes tend to avoid male mosquitoes once they have been inseminated and so they tend to avoid ultrasound in the range of 20 kHz to 40 kHz. Since only female anopheles mosquitoes spread Malaria, designing a circuit which produces the ultrasound in the range specified above would repel away female mosquitoes and reduce Malaria transmission.

1.2 Problem Statement

Frequent use of chemicals mn the institutions and at home to repel mosquitoes causes environmental pollution which may result into complications like Respiratory diseases. Also some ill-mannered people in the society use the chemical for poisoning others.

There is wastage of government funds which were not going to be wasted if other measures like Electronic Mosquito Repellants were adopted. This is because Mosquito nets are being used for other purposes.

Existing mosquito control measures like mosquito nets have limited applications that cannot be used in offices, sitting rooms, in cars and yet mosquitoes attack humans irrespective of the place.

1.3 Objectives

1.1.1 Overall objective

i) To design and construct an Electronic Mosquito Repellant.

1.2.2 Specific Objectives

i) To design an Electronic Mosquito Repellant circuit using 555 timer

ii) To test the workability of the Electronic Mosquito Repellant

1.4 Justification

Electronic Mosquito Repellant will be better in such a way that there will be;

i) No environmental pollution

ii) Reduction in Malaria infection

iii) Reduction in the misuse of government funds

And above all it can be used anywhere like in sitting rooms, offices, cars since it is just a small device that is easily portable and cannot affect the beauty of the place like a mosquito net.

1.5 Scope of the study

This study was carried out at Kabale University Physics laboratory, Nyakambu division Kabale municipality, Kabale district in western Uganda.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter describes the historical development of an Electronic Mosquito Repellant and some written journals on the use of Electronic Mosquito Repellant to reduce Human-Mosquito contact.

2.1 Historical Development.

Sound has been used for millennia to scare off pests with its humble origin starting with loud claps and yells in ancient Agricultural fields. The use of electronic sounds as a treatment option for pests largely took root during the 1950s and 60s, although attempts were made such as the work of Frings (1948) discussing the potential use of ultrasonic sound to control rodents and insects, and Kahn and Offenhauser (1949) who tested the effectiveness of sound to combat mosquitoes also realised that sound was able to repel away mosquitoes.

Mobile phone companies also marketed a ringtone in 2003 that is claimed to repel mosquitoes within a one metre radius (BBC, 2003). Some of the Mosquito Repellants seem to be based on the known aspect of mosquito behaviours. One of the reasons put forward to explain the alleged action of sound against mosquitoes is that the flight sound of the males repels the female once they have been inseminated Forster (1985). **But** the females that are not inseminated are not repelled by the flight sound of the male mosquitoes. Hence the repellent will have no effect on them. So whatever sound that resembles the flight sound of the male mosquito repels the females once inseminated.

Another reason is that mosquitoes avoid the ultrasonic cries of the bat, Forster (1985). This is so because mosquitoes are eaten by the bats and for these reasons anything that sounds like the flight sound of the bat would scare away the mosquitoes due to fear of being eaten up by the bats. Although both explanations may be conceivable, more research is still being carried out to give greater support to these arguments.

This small hand-held Electronic Mosquito Repellent is intended to repel mosquito by emitting an ultrasonic sound almost inaudible to the human ear which can be used both indoors and outdoors.

It is expected to repel mosquitoes within a range of2.5 metres (Kutz 1974, Helson 1977). Due to a huge demand by the public for a convenient, safe and effective anti-mosquito product, Electronic Mosquito repellent would offer a better solution.

However, research has shown that male mosquitoes are actually the ones attracted by the female flight sound and females normally have a very weak sensitivity for sound compared with the males (Wiggles worth 1965; Chapman 1982; Mciver 1985; Michelsen 1985).

Different brands of Electronic Mosquito repellents have been examined for their efficacy under laboratory conditions, none of which showed any effects for the devices tested (Singleton; Curtis 1982; Iglisch 1983; Foster 1985; Jensen 2000; Andrade 2001; Cabrini 2006).

Despite the scientific view and research findings, Electronic Mosquito repellents are still widely promoted and used by the public. (Jensen 2000). The decision was made to systematically review all reliable research about the effects of high-pitched sounds mn preventing mosquito bites and hence to assess whether there is any evidence that Electronic Mosquito repellents have any potential in preventing malaria in the field setting.

CHAPTER THREE: THEORY OF THE PROJECT

3.0 Introduction

An Electronic Mosquito Repellant consists of simple components of small sizes that can be fitted into a small circuit. This makes it highly portable hence a small hand-held electronic device. Each component has its principle of operation and a combination of these components produces an ultrasonic sound that can be used as a mosquito repellant.

3.1 Hardware Components

3.10 1 kilo ohm resistor, Rl

This resistor connects the power source to pin 7 of the 555 Timer IC, which basically protects the circuit from the direct power supply by imposing resistance to the current flowing in the circuit through the Timer and to the entire circuit.

3.11 0.0lμF ceramic capacitor, Cl

It ensures stability of oscillation of the Timer as it stores charge temporarily during the operation of the circuit.

3.12 555 Timer, IC

The 555 Timer IC is an integrated circuit that works on a stable multivibrator principle.

Its use in the circuit is to provide time delays as an oscillator circuit drives the buzzer.

3.13 0.0lμF ceramic capacitor, C2

This capacitor is connected through pin 5 that is the control pin of the 555 Timer IC to the ground. It ensures safety of the timer where excess current is discharged through this capacitor to the ground.

3.14 2.0 kilo ohm resistor (potentiometer), R2

It is a potentiometer that offers resistance ranging from zero to 2.0 kilo-ohms. Being variable, it allows production of signal of various frequencies. It is connected to pin 6 of the 555 Timer IC and is used to vary the frequency of the oscillator.

3.15 Piezo buzzer

Piezo buzzer is the output device in this circuit. It is connected to pin 3 that is the output pin of the Timer. This buzzer produces the sound which is the most important element in this circuit and is driven by the oscillation produced by the Timer. The

frequency of the sound produced by the buzzer depends on the frequency of the oscillator which is the 555 Timer in this case.

3.16 A 5V battery, Vl

It acts as the source of power for the working of the circuit. Pin 4 and pin 8 of the 555 Timer IC are connected directly to the 5V battery.

iv))

3.17 An APST switch

For ON and OFF switching of the circuit.

3.2 Circuit Diagram

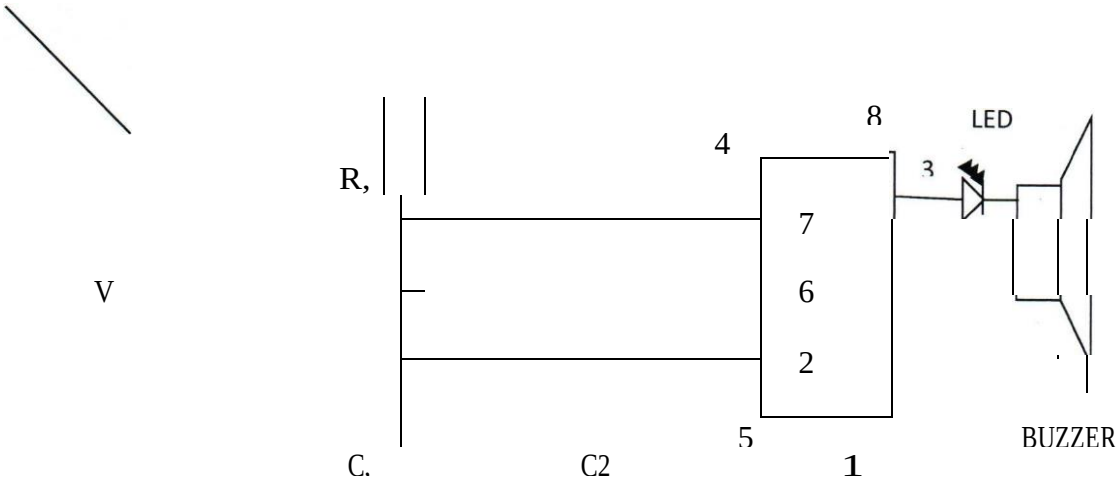


Fig 3. I Circuit Diagram of Electronic Mosquito Repellant

3.3 Theory of Major Components

3.3.1 555 Timer, IC

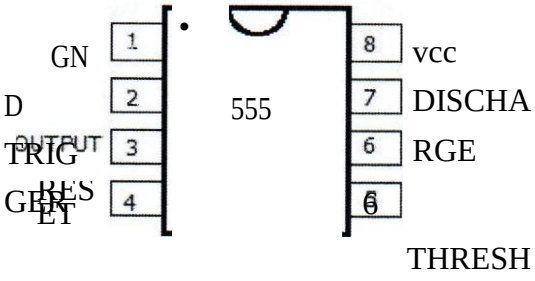
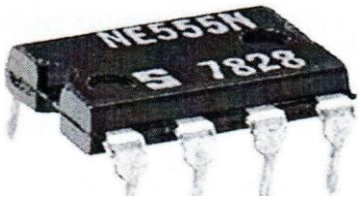


Fig 3.2 555 Timer IC



The 555 Timer IC is an integrated circuit chip used in a variety of timer, pulse generation and oscillator applications. The 555 Timer IC can be used to provide time delays as an oscillator,

as a flip-flop element and it is a stable multivibrator which accounts for its wide range of application.

This IC is commonly used simply because it is multipurpose and cost effective. NE 555 Timer IC is basically a monolithic timing circuit that produces an accurate and highly stable time delays or oscillations and it operates at a power supply ranging from 5V to 16V.

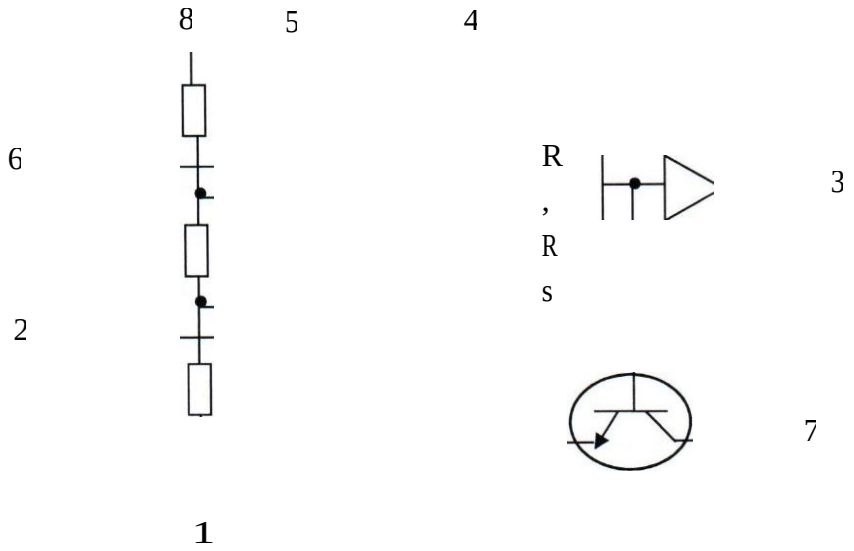


Fig 3.3 Internal Block Diagram of 555 Timer IC

The most common form of a stable multivibrator is **555 Timer IC. It** is basically an 8 pin IC with the following pin description.

i) **Pin 8-** VCC, this pin is connected directly to the positive terminal of the battery.

ii) **Pin** 1-Ground pin, which is directly connected to the negative terminal of the battery

iii) **Pin** 2-Trigger pin. **It** is an active low pass pin. The timer is triggered when signal at this pin is less than one third of the supply voltage. For a stable operation, this pin is connected directly to pin 6.

iv) **Pin 6- It** is the threshold pin. The Timer output is back to its stable state when voltage at this pin is greater than or equal to two third of the supply voltage. For a stable operation, this pin is shortened to pin two and connected to pin 7 using a resistor.

v) **Pin 4-** It is the reset pin. It is an active low pin which is usually connected to positive terminal of the battery.

vi) **Pin 5-** it is the control pin and is seldom used. For safety purpose, this pin is connected to ground through a 0.0lµF ceramic capacitor.

vii) **Pin 3-** output pin. The output from this pin is connected to the load.

viii) **Pin 7-** it is the discharge pin and provide the discharge path for the capacitor.

3.3.2 Piezo Electric Speaker

A Piezo electric speaker (sometimes called pizo) or buzzer is a loud speaker that uses the Piezo electric effect for generating sound. The initial mechanical motion is created by applying a voltage to a Piezo electric material and this motion is typically converted in to audible sound using diaphragm and resonators. Compared to other speaker designs, Piezo electric speakers are relatively easy to drive. For instance, they can be connected directly to TTL outputs although other complex drivers can give greater sound intensity. Typically, they operate well in the range of 1 to 5 KHz and up to 100 KHz in ultrasound applications.

3.3.3 Potentiometer (variable resistor)

A variable resistor is a resistor with a resistance value that can be adjusted either mechanically by revolving or sliding. It has a resistance value which varies as choosing a fixed resistor. It is also called a variable resistor.

Fig 3.4 Circuit Representation of a potentiometer

3.4 Fixed Resistor

A resistor is an Electronic device that limits the amount of current passing through a given point in a circuit by increasing the resistance in the transmission line of the current.

The resistors are usually colour coded with different colour codes representing different values of resistance of the resistors and these values are normally fixed. These resistors can be connected either in series or in parallel with other components in the circuit depending on whether you need a resultant resistance which is high or low.

Series connection leads to a resultant resistance which is higher than the highest value of a single resistor whereas parallel connection leads to a resultant resistance which is less than the value of the smallest resistor in the string of resistors.

Fig 3.5 A Resistor and its Circuit Diagram.

3.3.5 **Capacitors**

A capacitor is an electrical device that can store energy in the electric field between a pair of closely spaced conductors called plates. When voltage is applied to a capacitor, electric charges of equal magnitude but opposite polarity builds up on each plate which is separated by a dielectric. The two plates are connected one with positive and the other one with negative voltage and is characterized by the parameter capacitance which is measured as the difference of charge **between** the plates and total called voltage drop between the plates.

The conductors can be thin films of a metal aluminium foil whereas the non-conducting dielectric acts to increase the capacitor's charge capacity. A dielectric can be glass, ceramic, plastic film, paper, air or mica. Capacitors are used in electrical circuits as energy storage devices.

3.3.5.1 Electrolytic Capacitor

An electrolytic capacitor is a capacitor that uses an ionic conducting liquid as one of its plates to achieve a large capacitance per unit volume than other types of capacitors. Due to large

capacitance, electrolytic capacitors are practically suitable for passing or bypassing low frequency signals and storing large amounts of energy. They are mainly used in power supplies and interconnection stages of amplifiers at audio frequencies. An electrolytic capacitor will generally have higher leakage current than a comparable capacitor (dry) and may have significant limitations in its operating temperature range, parasitic resistance and inductance.

3.3.5.2 **Ceramic Capacitor**

Ceramic capacitor does not use Liquids for storage of charge hence they are sometimes called dry capacitors. The advantage that a ceramic capacitor bas over an electrolytic capacitor is that it has unlimited operating temperature.

Fig 3.6 Ceramic Capacitor and its circuit diagram

3.5 **CIRCUIT DEVELOPMENT**

3.5.0 **Introduction**

This section shows clearly the development of the Electronic Mosquito Repellant Circuit from the initial to the final step.

3.5.1 **The Circuit on the Bread Board**

Following critically the circuit diagram, the components of the circuit where connected and it's working tested as below.

vi)

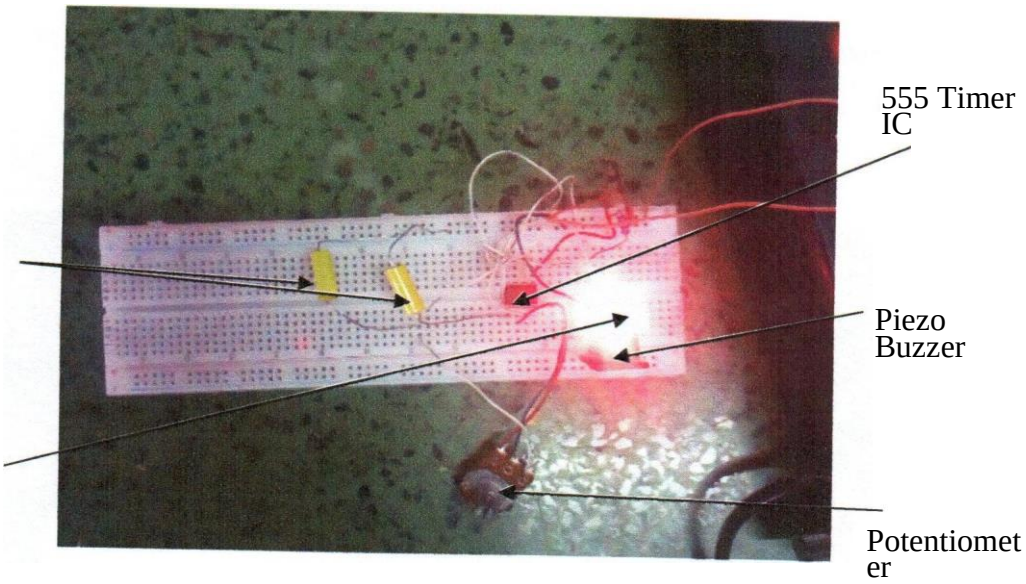


Fig 3.7 Electronic Mosquito Repellant on the Bread Board

vii)

3.5.2 Circuit on the Vero Board

After testing the working of the circuit on the Bread board, the entire components where transferred to the Vero board and soldered as shown below.

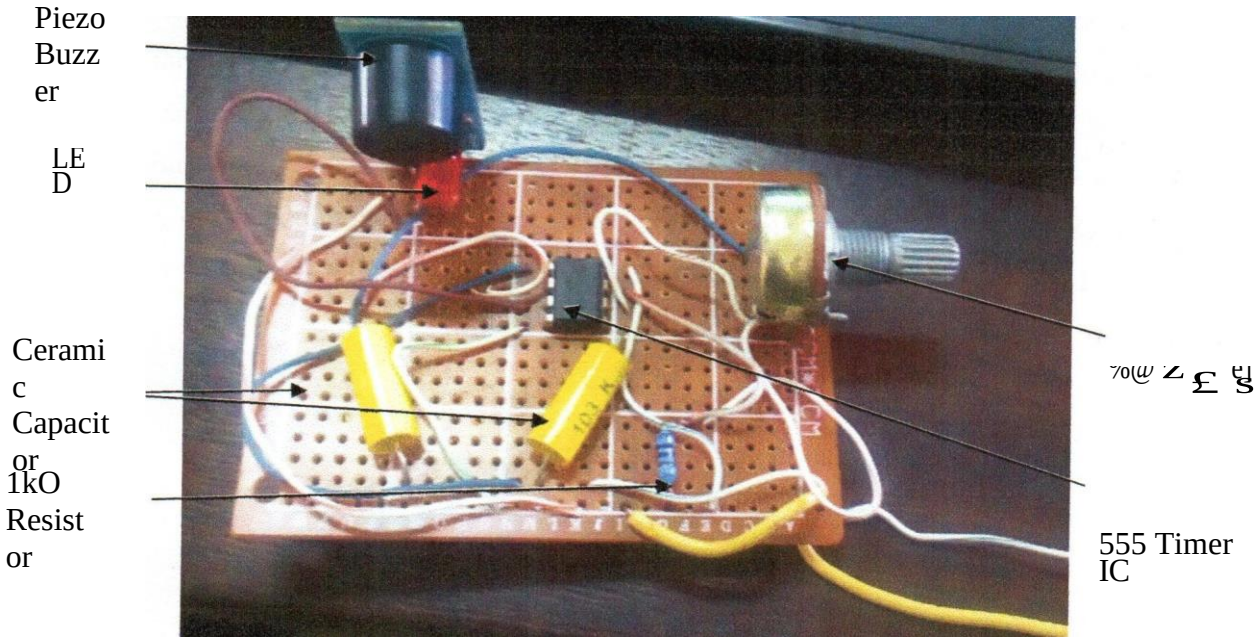


Fig 3.8 Electronic Mosquito Repellant on the Vero Board

3.6 **Circuit Design**

The basic idea behind developing the circuit is to use a buzzer to produce ultrasound. The buzzer is driven by an oscillator circuit. In this project 555 Timer IC used is based on a stable multi vibrator circuit as the oscillator circuit. Generally, frequency of the output signal produced through the buzzer by a 555 Timer a stable multivibrator is given by

$$F = \frac{1.44}{(R_t + 2R)C} \quad \text{.....3.1}$$

Where; R_t is the resistance of the resistor between pin 7 and 4 R; is the resistance of resistor between pin 7 and pin 6

C is the capacitance of the capacitor between pin 6 and ground.

3. 7 **Circuit Operation**

Once the switch is closed, the 555 Timer IC gets powered. As per the inner circuit which consist of Resistors, Operational Amplifiers, a Transistor and a flip-flop, initially the capacitor voltage will be zero and hence voltage at threshold and trigger pins will be zero. As the capacitor charges through the resistors R; and R>, at a certain point, voltage at the threshold pin is less than the capacitor voltage. This causes a change in the timer output. The capacitor now starts discharging until it reaches its original value. The output signal is an oscillating signal with its frequency of oscillation depending on the values of the capacitor and the resistor R> in the circuit. On varying the value of potentiometer, the output frequency can also be varied.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 Introduction

This chapter explains and shows the results obtained from the project. It indicates the objectives of the project that has been achieved and the overall performance of the circuit and the project as a whole.

4.1 Results

After completing the construction of the circuit, it was tested and found out that it is functioning well as it follows the astable multivibrator principle of the analogue integrated circuit timer (555 timers IC). The concept of the circuit is to generate continuous stream of rectangular pulse having a specified frequency range. At the output of the Electronic Mosquito Repellant circuit, a buzzer produces a high frequency sound which can be detected if it is within the audible range. If it is beyond the audible range, that is, above 20 KHz the sound cannot be heard by Humans and this sound is what triggers the auditory sense of the mosquitoes. The frequency of the sound produced can be varied by changing the value of the variable resistor R> in the circuit. The user can vary this resistor depending on the desired frequency of operation and the relationship is given by equation 3.1 above.

In the circuit, the resistor R is a fixed resistor of resistance lkilo ohm, R2 is a variable resistor of resistance 2 kilo ohm and C is a ceramic capacitor of capacitance 0.01 microfarad.

Therefore, setting R2 at 2 kilo ohm the buzzer is expected to produce a sound of frequency calculated as

$$F = \frac{1.44}{(1000+(2x2000))x0.01x106}$$

$$F = 28.8 \text{ kHz} \quad \text{.....4.1}$$

When the working of the circuit was tested and the frequency measured for the sound signal produced by the buzzer, the frequency also varied with the value of the resistor R2 as expected according to a stable frequency theory. The results were obtained by taking readings from the CRO as below.

viii)

4.1.1 CRO Readings

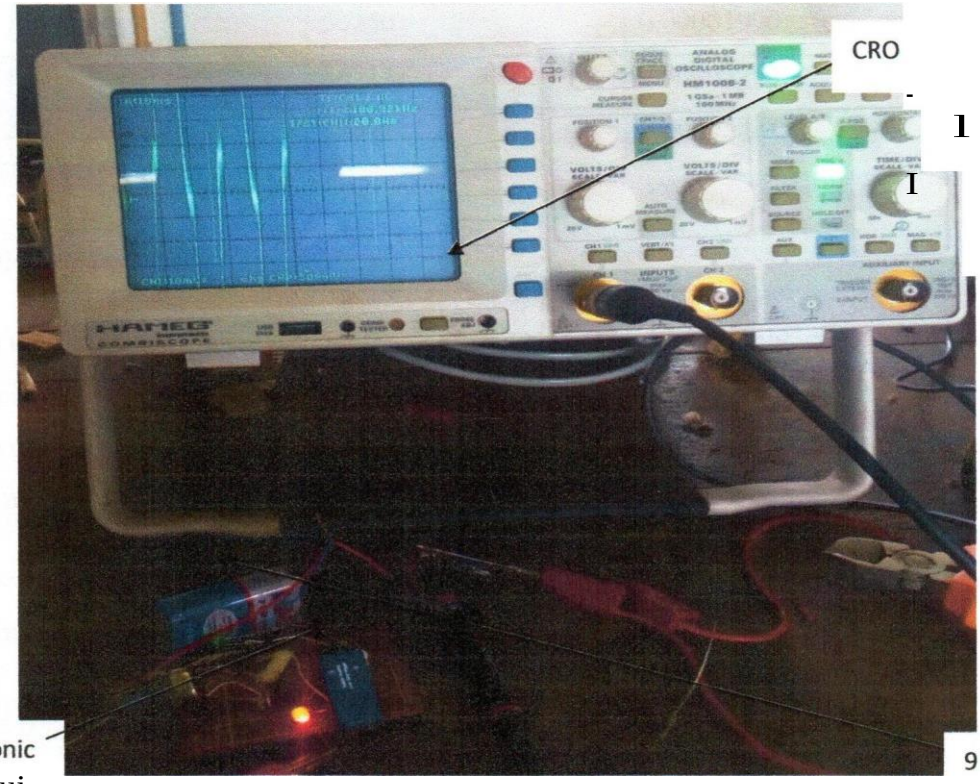


Fig 4.1 CRO Readings

The frequency was read and recorded as shown in the table below

4.1.2 Table of results for variation of Frequency with Distance, D

[Source: Experimental values from the laboratory.]

D(cm)	Frequency, *F* (Hz)	$\frac{1}{F}$ -(s)
0	101220	0.00000988

50	65660	0.00001523
100	50250	0.00001990
150	36311	0.00002754
200	29671	0.00003371

4.2 Discussion of Results

From the results above, the desired range of frequency is achieved only when the value of D is 150cm and above. If the value of D is less than l 50cmS the frequency of the sound produced is beyond the required range of operation which is the range of frequency of flight sound of male mosquitoes (20 kHz to 40 kHz).

However, sufficiently high frequency sound that is above 40 KHz is known to induce stress on the antennae of Mosquito hence scaring them away.

4.2.1 Variation of Frequency with distance, D

A GRAPH OF 1/F AGAINST D

ix)

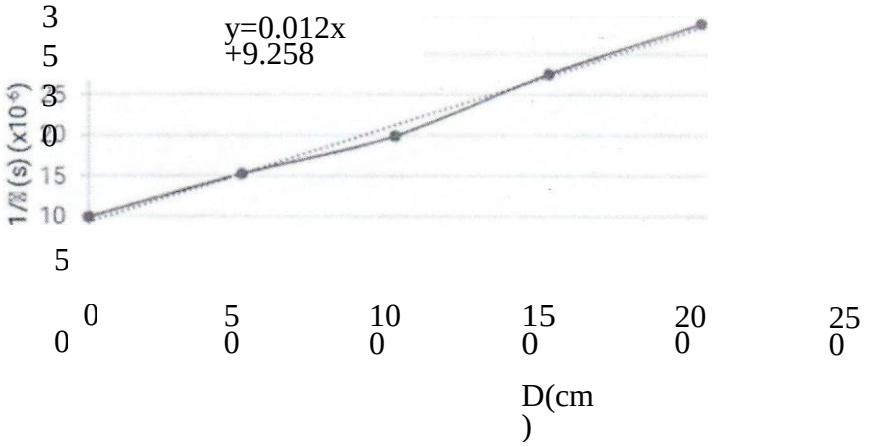


Fig 4.2 A graph of 1/F against Distance

D **4.2.2 Comparison with A stable Frequency Theory**

From astable frequency theory, frequency of the signal produced by the oscillator circuit is given by equation 3.1. This would give the table ofresults as shown below

D(cm)	Frequency, *F* (Hz)	$\frac{1}{F}$ -(s)
0	144000	0. 00000694444
50	72000	0.00001388889
100	48000	0.00002083333
150	36000	0.00002777778
200	28800	0.000034 72222

[Theoretical Calculated values]

4.2.3 A theoretical graph of Distance against frequency

A GRAPH OF 1/F AGAINST D

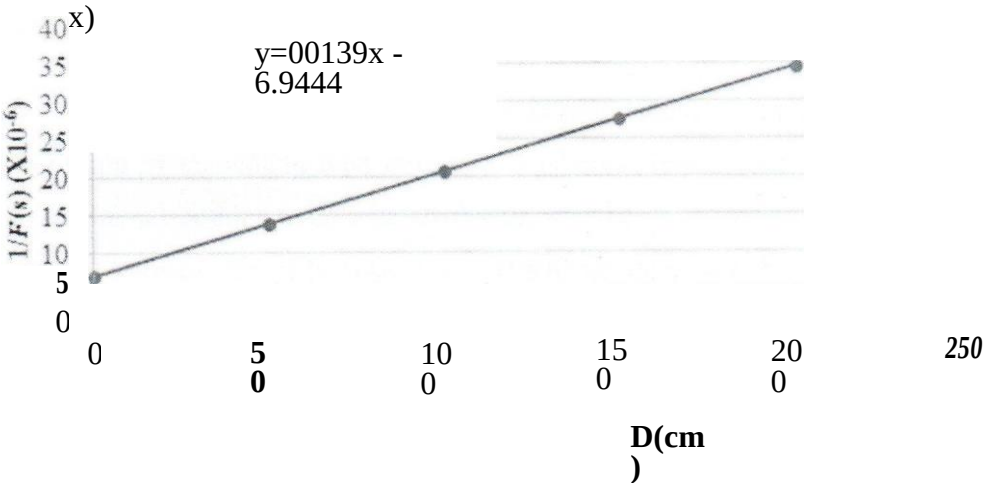


Fig 4.3: +A theoretical graph of 1/F against R2

The expected slope of the graph is 0.0139. The obtained slope is 0.012 which is very close to the slope of the graph above. This implies that the circuit is actually working following a stable multivibrator principle which says that the frequency of an a stable multi vibrator varies with the distance.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATION

5.0 Introduction

This is the last chapter that gives the conclusive remark on the entire project and it also spells out the recommendations for improvement of the project basing on the difficulties met during the whole project.

5.1 Conclusion

Development of a mosquito repellant that is safe, effective and superior to chemicals in the protection of humans against mosquito is of great importance. Since Electronic Mosquito Repellant has nothing to do with chemicals, it is therefore safe and convenient with no health threat to humans. This is because it produces ultrasound, inaudible to humans and no effect but affect mosquitoes.

Basing on the theory, the 555 Timer IC works on an a stable multivibrator principle where in the circuit it acts as an oscillator used to generate clock pulses in a wide range of frequencies with enough output power. This output then drives the high frequency buzzer hence producing the sound. The frequency can be varied by using a potentiometer.

The results obtained show that the circuit is able to generate an ultrasound ranging from the frequency of 29,670Hz to 101,220Hz according to the value of the resistor R; that is the potentiometer. According to the studies, mosquitoes are repelled by sound whose frequency ranges from 20 kHz to 40 kHz. This is because the sound produced by the flight of the male mosquito lies within this range which was the basis for the design of the circuit.

Audible sound can also be generated and can repel mosquitoes but basing on a different principle. That is high frequency but audible sounds are known to induce stress on the antenna of the mosquitoes hence irritating and scaring them away. Since the sound is irritating, it is less likely that the mosquitoes will get used to the sound.

If audible sound is being used, it is preferable that it is placed outside to avoid inconveniencing people who are inside.

5.2 Recommendations

Therefore, the following need to be improved

i) Placing a sensor that can detect the presence of mosquito and switches on the circuit automatically.

ii) Use of direct current and battery charger circuit so that the circuit can operate even during black out because usually mosquitoes are attracted to dark places.

iii) Using microcontrollers and ultrasonic sensors to transmit the sound in a special band of frequency.

iv) According to the results above, varying the resistance of the potentiometer brings about variation in the frequency of the sound produced. This implies that the device requires a lot of frequency setting in order to realize the desired frequency. I would propose the use of a fixed resistor so that the desired frequency can be realized without need for frequency setting.

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