UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

DEPARTMENT OF ELECTRICAL / ELECTRONIC TECHNOLOGY EDUCATION

DESIGN AND IMPLEMENTATION OF THE ELECTRONIC MOSQUITO REPELLENT CIRCUIT USING 555 ASTABLE MULTI-VIBRATOR CIRCUIT

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BY

MORRISON OSMUND BAINN KWANSAH

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A THESIS SUBMITTED TO THE UNIVERSITY OF EDUCATION, WINNEBA – KUMASI, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF TECHNOLOGY EDUCATION IN ELECTRICAL / ELECTRONICS TECHNOLOGY

AUGUST, 2015

DECLARATION

Student's Declaration

I, Morrison Osmund Bainn Kwansah hereby declare that this submission is my own work except for the various duly cited works. To the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the university.

Signature:……. Date:…….

Supervisor's Declaration

I hereby declare that the preparation of this thesis was supervised in accordance with the guidelines on supervision of a thesis laid down by the University of Education, Winneba.

Signature: ……. Date:…….

Mr. Sekyere Francios

ACKNOWLEDGEMENT

My sincere gratitude goes to the Almighty God for His strength, guidance and wisdom throughout the process of coming out with this research work.

I would also like to express my sincere gratitude to my supervisor, Prof. Ofosu Willie and Mr. Sekyere Francios whose useful tutoring and pieces of advice led to the successful completion of this thesis.

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I would also say a very big thank you to all those who in one way or the other contributed immensely to the successful completion of this work.

DEDICATION

I dedicate this work to my wife, Mrs. Theresa Morrison, who took care of me throughout my educational life. Special appreciation goes to my brother, Mr. Alfred B. Morrison, who ensured that I got admission to this institution and also, gave me the necessary encouragement during my stay here on campus.

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ABSTRACT

Control of mosquitoes is something of utmost importance in the present day with rising number of mosquito borne illnesses. The effect of mosquito bites cannot be overlooked considering how many deaths it has caused over the years. Specialty products like mosquito repellent used to combat mosquitoes are required but most of the repellants available use chemical means to repel or kill the mosquitoes which in a long run also becomes detrimental to ourselves and the environment. This project presents the design and testing of an electronic mosquito repellent. The project aims at developing a device that is capable of emitting ultrasonic energy of varied frequencies. These frequencies do affect the auditory senses of pests such as mosquitoes, rodents, avian and nocturnal insects by making them uncomfortable in their abode. However, these frequencies do not affect the hearing ability of humans. This electronic mosquito repellent is based on the 555 timer IC. This is a simple and useful mosquito repellent. The mosquito repellent circuit generates an ultrasonic sound with a high output frequency that spreads within a wide radius. The circuit is quite simple and require few external components. The oscillation frequency is given by the value of resistors and capacitors and can be modified by changing the value of the capacitors or replacing the fixed resistors with a variable resistor (potentiometer). The actual oscillation frequency of this electronic mosquito repellent is above 20 kHz so what is needed is a good high frequency piezo speaker. The electronic mosquito repellent circuit can be supplied from a 12 V DC power supply. The method is to generate a high ultrasonic sound output capable of repelling mosquitoes within a wide range with minimum electronic components. In order to achieve this, the 555 timer is connected. The 555 timer has the ability to convert an analog signal input (voltage) to digital signal output (frequency). The result is that the 555 timer can produce or generate frequencies between 20 and 60kHz. This frequency can repel

female mosquitoes and does not pose any threat health since frequencies above 20kHz cannot be heard by humans. The results of the various tests carried out (test conducted in the opening that conducted in the classroom, those conducted during the day and finally those conducted in the night) showed that the device had effect on mosquito landing rate and actually caused repulsion.

However, the project is yet to reach full completion since it can be improved upon. The circuit can be improved upon in the following ways: i. Sensor and LED light can be connected in the circuit to detect the presence of mosquitoes. The implication of this is that if the LED light does not function (light), it will indicate an area free mosquitoes.

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CHAPTER ONE

GENERAL INTRODUCTION

1.0 Introduction

This chapter is being devoted primarily to justify the research topic. Accordingly, this chapter contains background to the study, statement of problem, purpose of the study, objectives of the study, significance of the study, limitation of the study and summary and organization of the entire project work.

1.1 Background to the Study

An electronic insect repellent is a safer alternative compared to toxic insect repellents. The electronic insect repellent devices have either electromagnetic or ultra sound waves to repel insects like mosquitoes and cockroaches. The effectiveness of these devices has not been clearly established but the numerous studies for experiments have shown that, these electrical devices are indeed effective in repelling or eliminating pests. Some examples of electronic insect repellents are plug in electronic repellents, ultrasonic transmitters and the electromagnetic lamps.

These electronic pest control devices are very affordable and despite the fact that they have been around for more than two decades, they have just recently been acknowledged worldwide because of their environmentally friendly claims. Apart from this, they have also been proven to be less noticeable and easy to use. The absence of stinking spray repellents is truly a blessing by itself. Several methods have been used and are still being used for the control of pest though some of them have been proved to be ineffective in one way or the other. The commonest method of pest control is the use of pesticides (chemicals).

Pesticides are substances or a mixture of substances used for destroying, preventing, repelling or mitigating pests. Pesticides are commonly used in and around homes because they are easy to apply, fast-acting, and effective against a wide variety of pests. There are instances where the use of pesticides in rodents control may be effective, but there is no registration which specifically refers to the use of pesticide against pests control which does not constitute a potential hazard to man and his environment.

The chemical method of pest control has been found to be very effective but quite expensive to maintain. Also, these chemicals are highly poisonous and harsh to both humans and pests alike; their ability to pollute the air. Air pollution is thought to be one of the most important risk factors for respiratory diseases, particularly for bronchial asthma and chronic obstructive pulmonary disease (COPD). However, a direct causal relationship is not easy to prove because air pollutants do not occur as individual entities but in combination.

In addition, the concentration and duration of exposure to air pollutants required for inducing an adverse pulmonary effect have not yet been determined. Moreover, it adversely affects the environment that it brings about the genetic mutation of the internal make up of these pests (especially mosquitoes) in that they produce offspring that are immune to these chemicals that were used to repel them. From the aforesaid, the society has become increasingly aware of the risks involved with the use of these chemicals, and this has created the need in the society for alternative methods of pest control.

1.2 Statement of the Problem

For some time now, research has shown that most people have been unsuccessful in trying to control mosquitoes in their homes. They have tried using different kinds of insecticides, creams, coil and other methods but all to no avail. Moreover, some of these chemicals tend to cause headaches and irritations. The treated mosquito net was the best alternative, however the chemical used in treating it causes irritations on their skin and also it is not conducive to sleep in one when the room is not properly ventilated. This creates a situation in which people begin thinking of other non-chemical alternative to repel mosquitoes; that is an electronic way of repelling mosquitoes.

Although insecticides may not cause much harm to humans, the development of resistance against this chemical by some insects is driving the manufacturers of those insecticides into using very harsh alternatives and this may be very detrimental to humans as well. Beside this, some repellants are costly hence poor people or people living below the poverty line cannot afford to consistently purchase them to help protect them against mosquitoes and other insects. Secondly, most of the EMRs produced or manufactured have multiple purposes. That is to say that they are used to repel more than one type of organism. Example being to repel mosquitoes and cockroaches at the same time. With these problems in view, it becomes clear that there has existed a growing need for the design and construction of a mosquito repellent which is within the reach of the people living below the poverty level in terms of cost and which does not pose a threat to humans and finally one which will have the sole aim of repelling only mosquitoes. It is in this regard that this research work attains its importance, agency and beauty.

1.3 Aims and Objectives

Studies have shown that, female mosquitoes bite when they are breeding. They use blood to nourish and develop eggs; to find blood meal is vital if the female mosquitoes are to lay eggs. However, during breeding the female mosquito tries to avoid the male mosquitoes. Consequently the ultra sound produced by male mosquitoes helps the female detects an incoming male mosquito. Hence the aim of this project is to design an electronic mosquito repellant which produces a similar ultra sound as the male mosquito by timer configured as an astable multi-vibrator that will generate ultra sound to repel female mosquitoes.

1.3.1 Specific Objectives

The specific objectives of the research are to:

i. identify electronic devices for mosquito control that generate multiple frequencies of oscillation. This device may be used both indoors and outdoors, and operated within a range of up to 2.5m.
ii. assess whether Electronics Mosquito Repellants prevent mosquito bites.
iii. identify mosquito repellent devices that may be produced at a less cost and make it affordable if not free for poor homes who are usually the victims of mosquito bites.

1.4 Research Questions

The following are the research questions used for the research:

i. What electronic devices for mosquito control are available that generates multiple frequencies of oscillation?
ii. To what extent do Electronics Mosquito Repellants prevent mosquito bites?

iii. What mosquito repellent devices may be produced at a less cost to make it affordable if not free for poor homes who are usually the victims of mosquito bites?

1.5 Scope of the Study

The general description of the project is to develop a device that produces an ultrasound; sound of frequency above the human audible range to repel the female mosquito. The electronic mosquito repellent schematic circuit diagram based on the 555 Timer IC is a simple and useful mosquito repellent circuit. In principle, male mosquitoes do not bite. It is the female mosquitoes that bite when they are breeding. The male mosquito produces the ultrasound to attract the female counterpart for mating. However, during the breeding period, female mosquitoes try to stay away from their male counterparts, therefore the ultrasound produced by male mosquitoes alerts female mosquitoes of an incoming male mosquito so they escape. This mosquito repellent circuit generates an ultrasonic sound with a high output frequency similar to that of the male mosquito to repel the female mosquitoes within a wide radius. The circuit is quite simple and require few external components.

1.6. Limitations of the Study

In the course of the design and test of this project, the following problems were encountered:

Some of the materials were not readily available on the market. For example a Piezo diaphragm that would respond to 15 kHz was very difficult to find. This delayed the presentation of the project work. Most components failed and had to be replaced with new ones.

1.7 Justification of the Study

From the problem definition, the electronic mosquito repellent (EMRs) will be better in that: It will not cause or contribute to environmental pollution. It will also reduce the rate of malaria infections as well as additionally eliminating or causing a reduction in allergic reactions from mosquito bites. When the aforesaid are achieved, the time, energy and money used in treating malaria may be diverted to other areas to enhance or foster economic development.

1.8 Summary of the Project Work

This project work is organized in five chapters. The first chapter, which is the general introduction looks at the background to the study, statement of problem, purpose of the study, objectives of the study, research questions, significance of the study, scope of the study, limitations of the study and summary of the entire project work. Chapter two is devoted to the review of related literature while chapter three is the methodology of the study. The fourth chapter is the presentation and analysis of the data collected whiles the last chapter contains a summary of findings, conclusion and recommendations of the study.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter includes an exhaustive but incisive review of relevant literature in the project area. The exercise is geared towards justifying the defined objectives of the project and establishing the theoretical framework for the project work. It will also identify gaps in the literature in which the study attempts to fulfill.

2.1 General Theoretical Framework

Electronic mosquito repellents (EMRs) are marketed in response to a huge demand from the public for convenient, safe, and effective anti-mosquito products. Female Anopheles mosquitoes transmit malaria by sucking blood from humans, and these small handheld, battery-powered EMRs are intended to repel them by emitting a high frequency buzz almost inaudible to the human ear. They can be used both indoors and outdoors, and are claimed to repel mosquitoes within a range of up to 2.5 metres, Kutz and Helson (1974 and 1977).

No adverse effects have been reported in the literature. Mobile phone companies also market a ring tone that is claimed to repel mosquitoes within a one-meter radius, BBC (2003). Some of the EMRs seem to be based on known aspects of mosquito behavior, while others have no scientific data to substantiate their claims. Manufacturers have put forward at least two reasons to explain the alleged repellent action of sound against mosquitoes. One reason is that the flight sound of males repels females once they have been inseminated, Foster (1985); thus whatever mimics the males' flight sound may repel females.

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. Wigglesworth, Chapman, McIver, Michelson (1965, 1982, 1985, 1985). Another reason is that mosquitoes avoid the ultrasonic cries of bats. Foster (1985). Although both explanations may be conceivable, there is no published scientific information to support either idea. Different brands of EMRs have been examined for their efficacy under laboratory conditions, none of which showed any effects for the devices tested; Singleton, Curtis, Iglisch, Foster, Jensen, Andrade, Cabrini, (1977, 1982, 1983, 1985, 2000, 2001, 2006). There are review articles concluding that the EMRs are ineffective in repelling mosquitoes; Coro (1998 and 2000). According to Curtis and BBC in 1994 and 2005 respectively, scientific skepticism over the last 30 years and a successful prosecution of EMR sellers under the UK Trade Description Act seems to have done little to deter manufacturers marketing EMRs and the people who buy them. This is a concern because it is likely to lead to consumers not using other protective methods that are proven to work. Jensen, in 2000, said this could result in an increased risk of infection with mosquito-borne diseases, especially malaria.

Despite the scientific view and research findings, Electronic Mosquito Repellants (EMRs) are still widely promoted and used by the public. Notwithstanding, the fact that all Electronic Mosquito Repellants (EMRs) operate on the same principle of generating ultrasound similar to those produced by male mosquitoes to repel female mosquitoes, investigations carried out on the internet show that almost all the EMRs produced have multiple purposes and are far above the means of people living below the poverty level.

2.1.1 Theoretical Framework as outlined by Prof. Girish Kumar

The purpose of the project is to design an ultrasonic pest repellent. Such a device can be very useful to counter the various problems caused by ants, insects, pests, rodents, etc. The device is compact, cheap, and it does not cause any pollution unlike the other chemical repellents. We have used a microcontroller to generate sweep in sound frequencies, and an assembly consisting of audio power amplifier, speaker and LCD for this purpose. The technical details of this project follow later. The circuit has been experimentally tested on ants, bugs, and small insects, and it has been successful in repelling them through the generation of ultrasonic frequency sound. It is possible that pests like insects, ants, rats, mice etc. are repelled by ultrasonic frequency in the range of 30 kHz to 50 kHz. Human beings can't hear these high-frequency sounds. Our product repels pests by emitting pulse ultrasonic waves. Using ultrasonic waves creates a noisy and hostile environment which repels pests, whilst remaining absolutely safe for humans and household animals. Unfortunately, all pests do not react at the same ultrasonic frequency. While some pests get repelled at 35 kHz, some others get repelled at 38 to 40 kHz or even higher frequencies. Thus to increase the effectiveness, frequency of ultrasonic oscillator has to be continuously varied between certain limits. Frequency of emission of ultrasonic sound is continuously varied by our product in different patterns to repel different insects.

Electronic pest control is the name given to the use of any of the several types of electrically powered devices designed to repel or eliminate pests, usually rodents or insects. There are basically two types of electronic pest control devices widely available, these are Ultrasonic and Electromagnetic. Ultrasonic devices operate by emitting short wavelength, high frequency sound waves too high in pitch to be heard by the human ear (all frequencies greater than 20,000 Hz). This is due to limitations in human hearing. Humans cannot hear ultrasound because the eardrum

does not vibrate fast enough, but some animals such as dogs, bats and rodents can hear well into the ultrasonic range.

Some insects, such as grasshoppers and locusts can detect frequencies from 50,000 Hz to 100,000 Hz, and moths and lacewings can detect ultrasound as high as 240,000 Hz produced by insect-hunting bats. Insects detect sound by special hairs or sensilla located on the antennae (mosquitoes) orgenitalia (cockroaches), or by more complicated tympanal organs (grasshoppers, locusts, moths and butterflies)."Ultrasound and Arthropod Pest Control"[1] an extensive Kansas State University study confirmed that ultrasonic sound devices do have both a repellent effect as well as are duction in mating and reproduction of various insects. However, the results were mixed and ultrasonic sound had little or no effect on some pests. Various ultrasonic devices where highly effective on crickets while the same devices had little or no repellent effect on cockroaches. Additionally the results were mixed with some devices being effective while others having no effect depending on the test subject. The study also concluded there was no effect on ants or spiders in any of the tests. They concluded, based on the mixed results, that more research is needed to improve these devices.

A 2002 study by Genesis Laboratories Incoporated does lend some credence to the ability of electronic repellent devices to repel certain pests in controlled environments. “Preliminary study of white-footed mice behavior in the test apparatus demonstrated a significant preference for the non-activated chamber among both sexes Cockroaches initially respond to electronic pest control devices by moving about a bit more than usual, but don't appear overly eager to escape from the sound waves. This includes devices that emit uniform frequency as well as changing

frequencies of ultrasound. Rodents adjust to the ultrasound (or any new sound) and eventually ignore it. However, researchers were able to use the increased cockroach activity to good effect by increasing the rate they caught the roaches in sticky traps. Tests of commercial ultrasonic devices have indicated that rodents may be repelled from the immediate area of the ultrasound device for a few minutes to a few days. Other tests have shown that the degree of repellence depends on the frequency, intensity, and the preexisting condition of the rodent infestation. The intensity of such sounds must be so great that damage to humans or domestic animals would also be likely. Commercial ultrasonic pest control devices do not produce sounds of such intensity.

2.2 Design approach

We are using an LM 380 audio power amplifier circuit to design the system capable of producing sound in the frequency range of up to 80 kHz. A speaker of appropriate frequency range is used to transmit these sound waves. We are using a separate power module to power the system. We are using the at mega–16 microcontroller to produce the different patterns of frequencies which we require in our experimentations, and an LCD – keyboard assembly to track and control this ongoing process. We have programmed the Atmega-16 micro controller so that it generates the different patterns of frequency sweeps in its different modes. A keyboard is also provided in the system, so that any of these different modes can be selected by the user. The above download shows that the project is multi purposed. The work cannot be as efficient as my work which focuses solely on the mosquito; “Jack of all trades, master of none”.

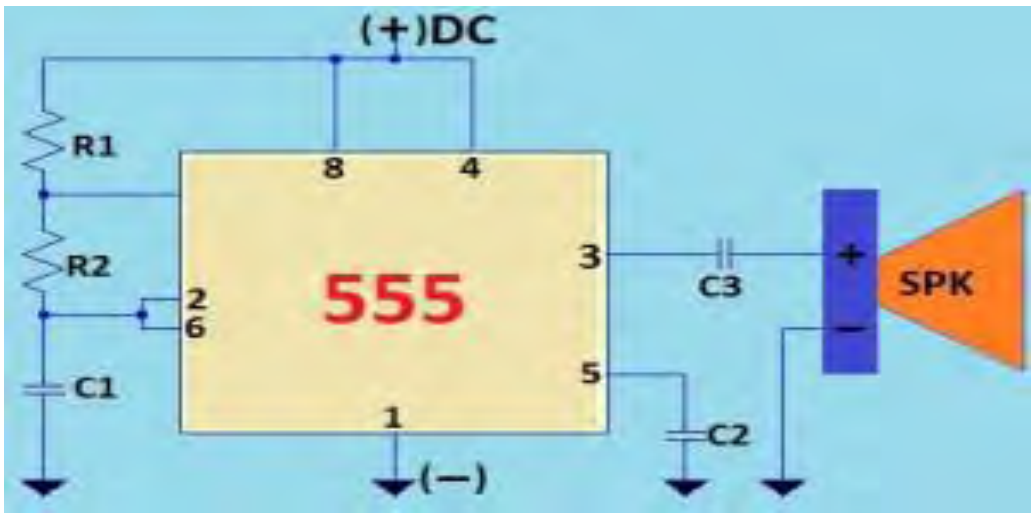


Fig. 2.1: Electronic Mosquito Repellent Circuit

2.3 Description of a Circuit

A multivibrator is an electronic circuit which is used to generate a pulsed output signal. Usually, multivibrators are classified into different types based on the stability of the output. Here the common form of a stable multivibrator is 555 Timer IC, which is used in this electronic mosquito repellent circuit, and it consists of 8 pins. A stable multivibrator can be used as an oscillator and it doesn't require external triggering. The 555 timer pin description is described below.

- Pin 1 is connected to the negative terminal of the battery.
- Pin 2 is a triggered active low pin, which is directly connected to the pin6 for as table operation.
- Pin 3 is an output pin.
- Pin 4 is a reset pin, which is an active low pin directly connected to the positive terminal of the battery.
- Pin 5 is the control pin connected to the ground through a microfarad capacitor.

- Pin 6 is the threshold pin that is shorted to pin2 and connected to pin7 using a resistor for a stable operation.
- Pin 7 is the discharge pin that provides a discharge path for the capacitor.

2.4 Circuit Operation

When the switch is closed, the 555 timer IC circuit gets the power supply, and then the capacitor voltage and triggered pin2 become zero. Here, the capacitor charges through the resistors R1 and R2. When the voltage at the pin6 is less than the capacitor's voltage, it causes a change in the output. The capacitor starts discharging through the resistor R2 through the discharge pin 7 and continues until the output voltage is back to the original. Thus, the piezo buzzer generates the output signal with a frequency of 38 KHz with regular repetitions. When the potentiometer value varies, the output frequency can also be varied. This high frequency sound is thus allowed to be heard by the incoming insects or mosquitos, and thus leads them to fly away or leave from the circuit and surrounding areas due to annoying sound.

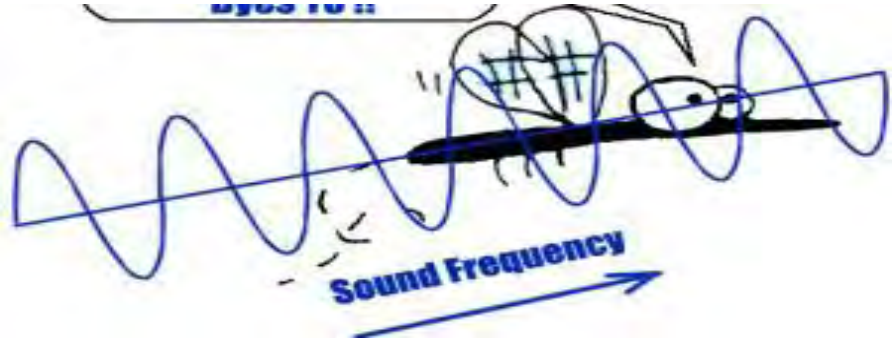


Fig. 2.2: Sound Frequency

By some changes to the values of the capacitors and resistors, this circuit can also be used as another insect repellent and can also be used as a buzzer alarm circuit. Thus, an electronic

mosquito repellent circuit keeps us safe from mosquitos and other insects e.g. cockroaches and ants by using very high frequency sound.

2.5 Electronic Mosquito Repeller

Here is the circuit diagram of an ultrasonic mosquito repeller. The circuit is based on the theory that insects like mosquito can be repelled by using sound frequencies in the ultrasonic (above 20KHz) range. The circuit is nothing but a PLL IC CMOS 4047 wired as an oscillator working at 22KHz. A complementary symmetry amplifier consisting of four transistors is used to amplify the sound. The piezo buzzer converts the output of amplifier to ultrasonic sound that can be heard by the insects.

2.6 Review of Circuit Components Used

The following are the circuit element that have been used to design the electronic mosquito repellents that have been made so far.

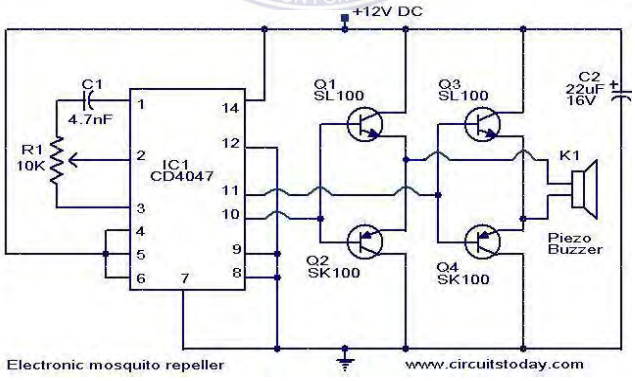


Fig. 2.3: Circuit Components

2.6.1 Diode (15392)

This is a rectifier diode molded in a plastic casing. The diode is rated to operate at a maximum ambient temperature of about 25°C and is capable of rectifying a single face, half wave, 60 Hz AC. The diode is ideal for voltage AC rectification due to its low forward voltage drop and ability to allow a high current to pass through it.

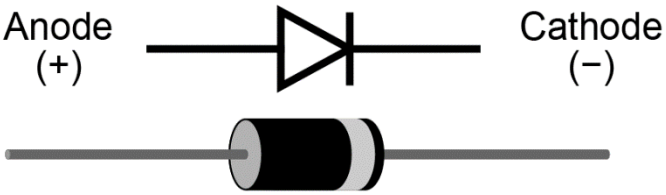


Fig. 2.4: Circuit symbol and image of 1n5392 rectifier diode

2.6.2 Zener diode (1n4742A 12V 1 W)

The circuit built operates on 12 V and to ensure that this voltage is constant, this Zener diode was connected across the circuit to provide voltage regulation. The Zener diode has a forward voltage drop of 1.2 V and a total power dissipation of 1 W which makes it ideal for this low power application.

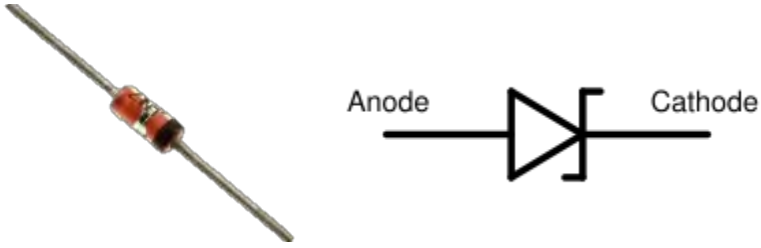


Fig. 2.5: Zener diode circuit and its circuit symbol

2.6.3 Resistor Capacitor (RC) Timer

This timer is a combination of a resistor and a capacitor. The two forms an RC circuit. The value of the resistor and capacitor determines how long it takes to charge and discharge the capacitor, thus creating a timer to control the 555 timer used in generating the ultrasound frequency.

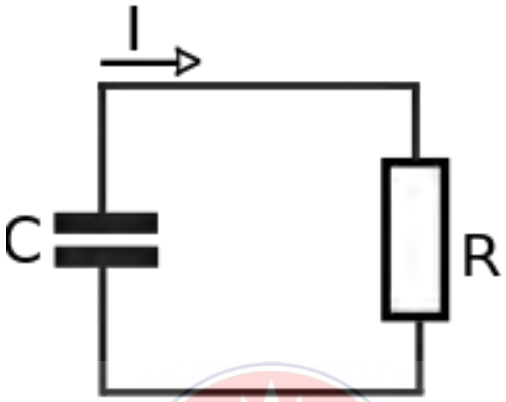


Fig. 2.5: RC Circuit for Charging and Discharging a Capacitor

2.6.4 Potentiometer (1 MΩ)

This circuit element was used to adjust the frequency produced. Tuning it either lowered or increased the frequency of the ultrasound produced. The higher the resistance, the lower the ultrasound frequency and vice versa.

Fig. 2.7: potentiometer for adjusting the ultrasound frequency

2.6.5 NE555 Timer

The NE 555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output circuit can source or sink up to 200 mA or drive TTL circuits. Its operation in this device was to generate the frequency that drives the buzzer in ultrasound range.

Fig. 2.8: 555 timer for generating ultrasound frequency

2.6.6 Buzzer

This was used as the audio signaling device. It is made of a piezoelectric element. The ultrasound frequency generated by the 555 timer was used to drive the buzzer. At that frequency, the sound generated by the buzzer is not audible to humans.

Fig. 2.9: Piezoelectric Buzzer

CHAPTER 3

METHODOLOGY IN CIRCUIT DESIGN AND CONSTRUCTION

3.0 Introduction

This section will provide information on methods used to design and construct the circuit, working principles behind the designed circuit and the application and functionality of the entire project.

3.1 The Research Design

The research design adopted here is the exploratory research, and as the name states, it intends to explore the research questions and does not intend to offer final and conclusive solutions to existing problems. This type of research is not intended to provide conclusive evidence, but helps us to have a better understanding of the problem. When conducting exploratory research, the researcher ought to be willing to change his/her direction as a result of revelation of new data and new insights.

Exploratory research is flexibility and adaptable to change. Similarly, it is effective in laying the groundwork that will lead to future studies. This type of study can potentially save time and other resources by determining the types of research that are worth pursuing. Exploratory research however, generates qualitative information and interpretation of such type that may be subjected to bias. Again these types of studies usually make use of a modest number of samples that may not adequately represent the target population.

3.2 The Circuit Design

The aim behind this research is to design and construct an electronic mosquito repellent capable of repelling mosquitoes and thereby reducing malaria. The concept is based on a known adaptation of the mosquito; after insemination the male mosquito produces a sound which disturbs the female mosquito thereby making the female mosquito to run away. This sound is called ultrasonic sound. With electronic components, this sound can be produced. The rationale behind this electronic mosquito repellent circuit is that, it will generate a high ultrasonic sound output capable of repelling mosquitoes within a wide range with minimum electronic components.

In order to achieve this, the 555 Timer is connected in the circuit. The oscillation is given by the value of the resistors and a capacitor component which can be modified by changing the values of the components or replacing the fixed resistor with a variable resistor. The actual oscillation frequency of this electronic mosquito repellent circuit is between (20 and 60) kHz. This therefore calls for a very good high frequency piezo busser to convert the output signal into ultrasonic sound capable of repelling mosquitoes.

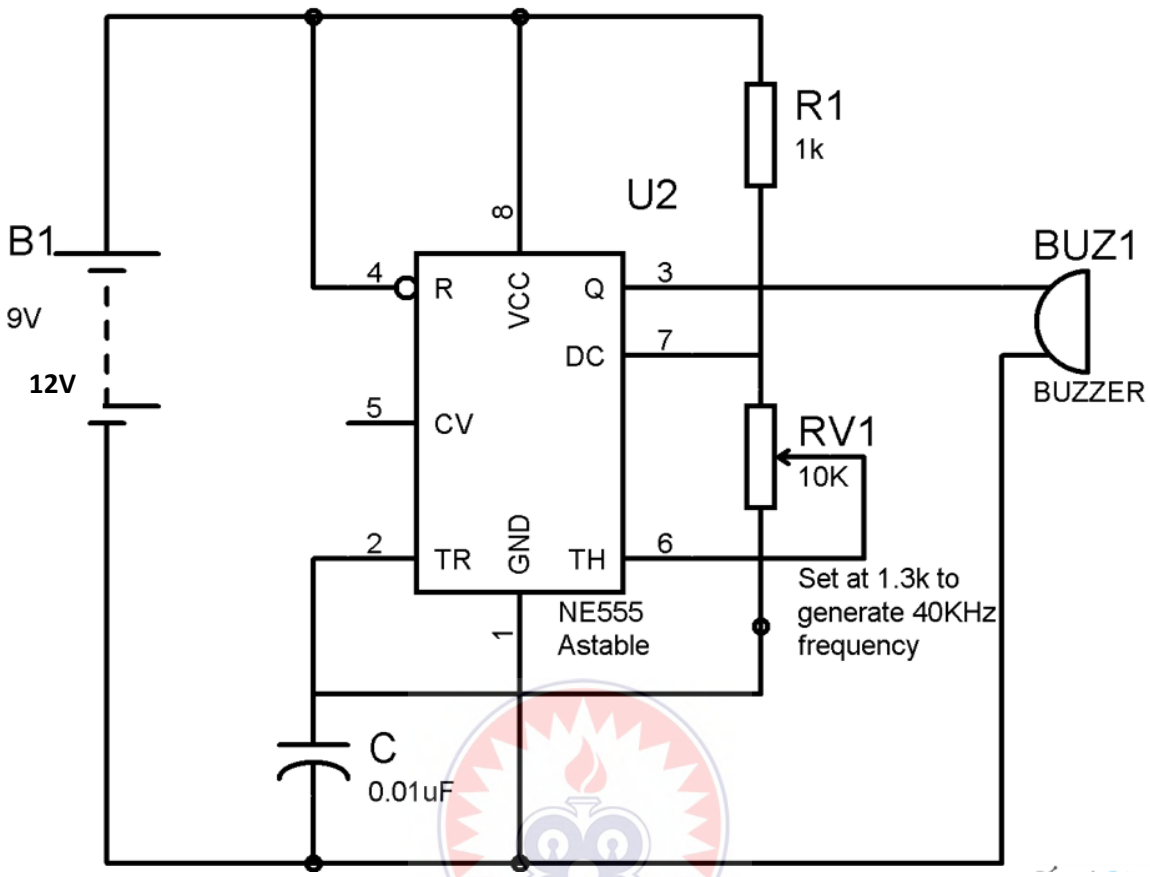


Fig 3.1 Electronic **Mosquito Repellent Circuit Diagram**

3.3 The 555 Timer Design

The main theory of the electronic mosquito repellent circuit is how it generates variable frequencies and how to control the frequencies generated. In order to perform the function of this circuit fully, a 555 Timer has to be used. The reason 555 Timer is used in this circuit is because it can convert an analog signal input (voltage) to digital signal output (frequency), which functions as an ADC (Analog to Digital Converter). 555 timer based circuit is a kind of voltmeter, also an analog to digital converter, which converts the analog input voltage to digital output pulses. The output pulse width is proportional to the difference between the analog input voltage and the

voltage across the capacitor. It can measure from +5V to +18V. The accuracy is high in the range of 6V to18V. The readings are about the same with the 10 bit ADC readings. The accuracy depends on only the + 5V supply voltage and the microcontroller's clock frequency. Depending on the manufacturer, a 555 could have around 20 transistors, 15 resistors and a couple of diodes.

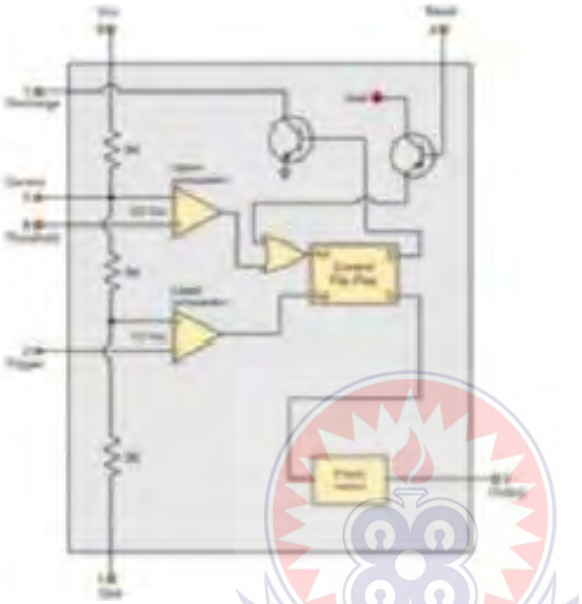


Fig 3.2: 555 Timer Diagram

An Astable Multivibrator is often called also an oscillator. A 555 Timer can be used to generate clock pulses in a wide range of frequencies with enough output power to drive several ICs.

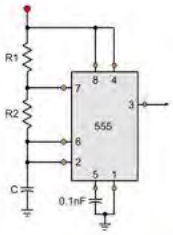
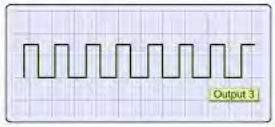


Fig 3.3: Output



The oscillation frequency is calculated with the following formula:

F = 0.67 (R1 + 2 x R2) x C

The same circuit can be used to control DC loads such as LEDs, lamps and DC motors. The idea is to use this circuit as a PWM signal generator. To do this, you need to replace R2 in Figure 1 with a potentiometer. By altering the potentiometer's value, this results in changing the duty cycle output. The duty cycle is calculated as follows:

D = TOTAL / THIGH

As for the design method, Multism 13.0 software is used to stimulate, modify and construct the schematic circuit. The purpose of using Multism 13.0 is that it is easier to construct and easier to understand. Besides, it can fully examine the relationship between the resistance and the frequency generated by the 555 Timer. Test run the hardware by connecting the circuit in a breadboard before soldering them into a circuit board in order to complete the prototype. This test must be performed several times until the desired result is achieved.

3.4 Hardware Components Analysis

The main components beside 555 Timer are resistors, preset resistors, variable resistors and speaker. Resistors are the most common electronic components used in any electronic circuits, electronic devices and electronic projects. Resistors limit the function of voltage across or through it. It also serves as the simplest voltage divider.

3.4.1 Preset Resistors

Preset resistors are used in circuits when it is necessary to alter the resistance. Dark/light and temperature sensors usually have these components as the preset resistor allows the circuit to be made more or less sensitive (they can be turned up or down - reducing or increasing resistance).

3.4.2 Variable Resistors

The variable resistor is a resistor with a resistance value that can be adjusted either mechanically by means of a revolving or sliding. It is also often referred to as VR. It has a resistance value which varies as choosing a fixed resistor. The types of VR are the type of potentiometer or preset.

3.4.3 Speaker

Speaker uses a coil of wire, which acts as an electromagnet, set inside of a magnetic gap of a permanent magnet. The speaker converts the electronic frequency to sound frequency. The frequency of the sound will be kept as high as possible. So that the annoying sound will be heard by insects only but not human because humans don't normally hear sound of frequency higher than 20 kHz.

3.4.4 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 the capacitor, electric charges of equal magnitude, but opposite polarity, build up on each plate. Capacitors are used in electrical circuits as energy-storage devices. They can also be used to differentiate between high-frequency and low-frequency signals and this makes them useful in electronic filters.

3.5 Choice of Design

The 555 Timer has been used to generate the needed frequency required to repel female mosquitoes. This is because the 555 timer can convert analog signal inputs to digital outputs

(frequency). It therefore functions as an ADC (Analog to Digital Converter). The 555 timer circuit is a kind of voltmeter. Since it is an analog to digital converter, it converts the analog input voltage to digital output pulses. The output pulse width is proportional to the difference between the analog input voltage and the voltage across the capacitor. It can also measure from 5v to 18v. This measurement shows a high degree of accuracy which lies in the range of 6v to 18v. The degree of accuracy depends on only the 5v supply voltage and the microcontroller clock frequency.

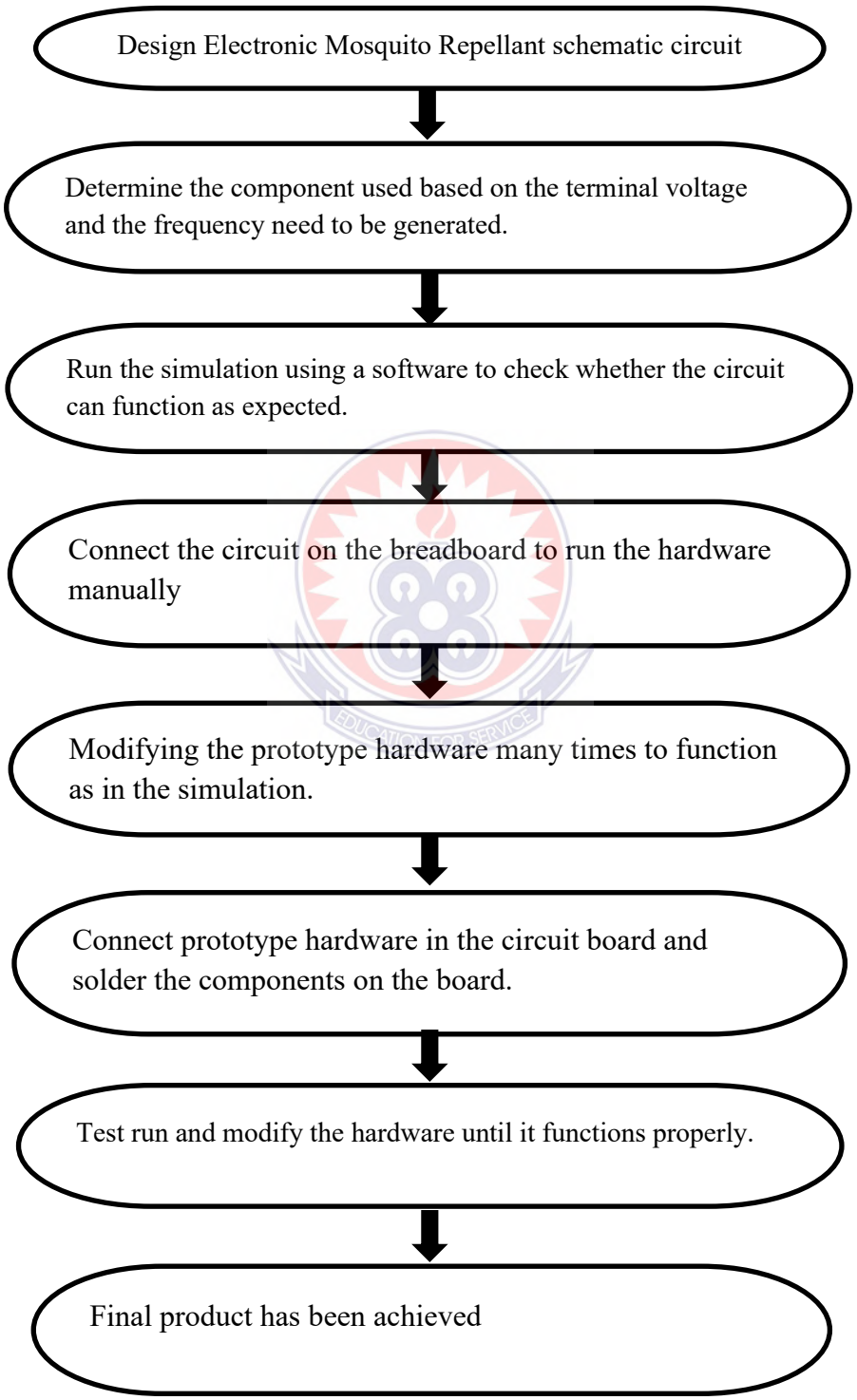
Again, from the manufacturer's specification, a 555 timer could have as many as 20 transistors, 15 resistors and a couple of diodes. It therefore produces very good results when used. In general, animals and other living things have limited hearing ranges in other words, their hearing abilities are different. Similarly, human beings cannot hear frequencies above 20kHz that can be heard by other organisms. Based on this theory, mosquitoes and cockroaches will be disturbed by high frequency sounds which will not affect humans. The following table shows various species hearing range:

Table 3.1: Frequency Reception Range by Different Organisms

Organisms	Frequency range
Human	64-23,000
Dog	67-45,000
Cat	45-64,000
Cow	23-35,000
Rat	200-76,000
Mouse	1,000-91,000
Bat	2,000-110,000
Owl	200-12,000
Chicken	125-2,000

3.6 The Process Flow Chart

The following flowchart is the process of production of Electronic Mosquito Repellent project from the beginning until the final production.



CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

Testing is a vital process in the development and realization of this design. The various components and their circuitry have to be tested to ensure that all the components on board are certified okay and in good working condition. The components that do not give the required output specification are isolated and troubleshooted to determine the nature and cause of the component failure through careful analysis, by examining the working principles of the component(s).

4.1 Cost Analysis

The estimated cost of the design and construction of the device is GH₵13.20 only. This is relatively low as compared to those manufactured abroad which cost as much as GH₵ 30 Ghana cedis.

Table 4.1: Cost of Materials Used

Items	Unit price (₵)	Quantity
Diodes	0.10	4
Zener diode	0.10	**1**
Resistors	0.20	5
Capacitors	0.70	5
Piezo Buzzer	1.50	1
Switch	0.50	1
Screw/knots	0.30	5
Package	2.50	1
Veroboard	1	2
LED	1	0.20

4.2 Expected Test Results

From the simulation carried out using Multism 13.0 software, it showed that the circuit was functioning well which follows the Astable Mode Theorem of Analog Integrated Circuit Timer (IC Timer) 555. The concept of the circuit was to generate continuous stream of rectangular pulses having a specified frequency. At the output speaker, there was a high pitch sound heard (a buzz) which triggered the mosquitoes' auditory senses thus scaring them away. Resistor R1 was connected between VCC and the discharge pin (pin 7) and another resistor (RV1) is connected between the discharge pin (pin 7), and the trigger (pin 2) and threshold (pin 6) pin shared a common node. Hence the capacitor was charged through R1 and (RV1), and discharged only through RV2, since pin 7 had low impedance to ground during output low intervals of the cycle, therefore discharging the capacitor. In the astable mode, the frequency of the pulse stream depended on the values of R1, R2 and C as shown in Fig.1.6.

$$F = \frac{1}{0.67(R1 + 2 \times R2) \times C}$$

$$F = \frac{1}{0.67(220 + 2 \times 5000) \times 0.005} = 29.2\ kHz$$

The frequency generated from the simulation was approximately the same with the frequency calculated by using the stable frequency theory. From the theory, this sound at this frequency was disturbing for insects specially mosquitoes, and drove them away. To repel other animal such as dogs and cats, the variable resistance needed to be adjusted as a result, the circuit would generate the needed frequency.

4.3 Testing and Results Analyses

Various mosquito repellents like coils, liquid vaporizers, and creams, all have possible adverse effects on one's health. This **electronic mosquito repellant is** equally efficient and relatively safer compared to other chemical and biological means. The concept of this electronic mosquito repellant is simple.

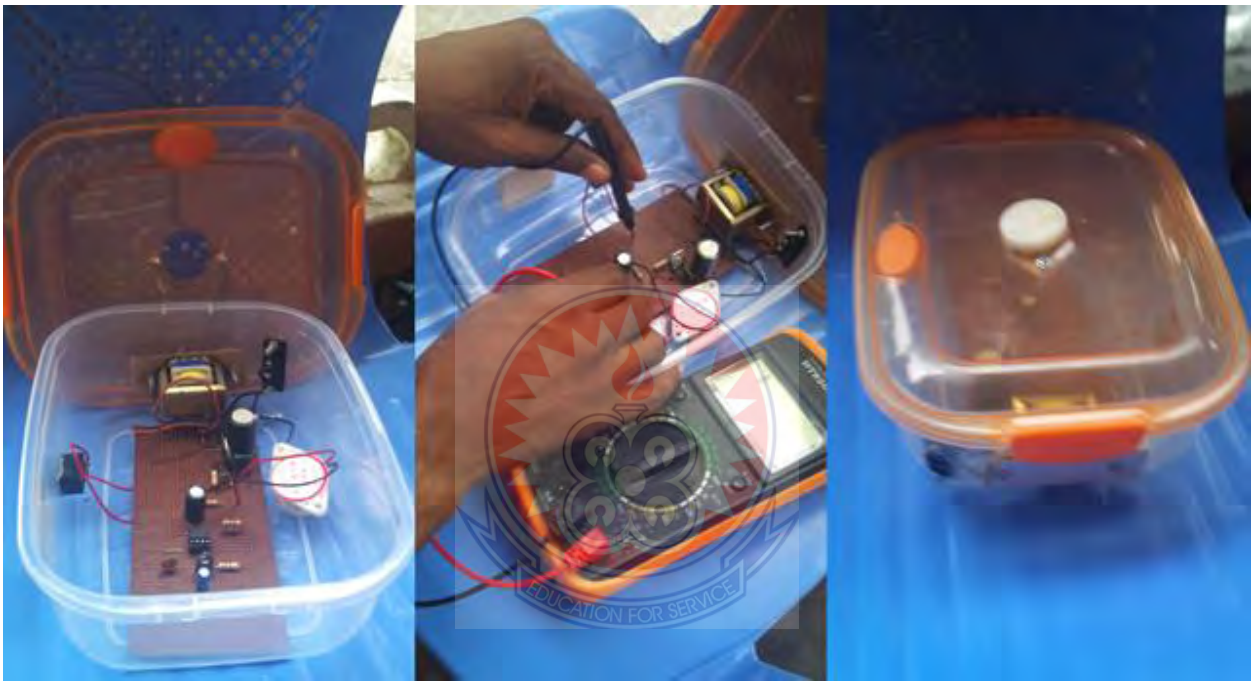


Fig. 4.1 Testing and Calibration

The device uses ultrasound; sound in the above 20 kHz frequency. Although this sound cannot be heard by humans, there are various animals and insects (including mosquitos) that could hear the ultrasound. Generally, ultrasound in a range of 20 kHz to 40kHz is transmitted by male mosquitoes and received by female mosquitoes, however after breeding female mosquitoes tend to avoid male mosquitoes and so they tend to avoid ultrasound in that range. Since only female breeding mosquitoes bite humans, this concept proofed effective in repelling the female mosquitoes.

4.4 Test Conducted in the Opening

The first test was conducted outside in a known mosquito breeding ground. A human subject; myself; sat in the opening without the device turned on. With a paper and a pen, the number of mosquitoes' landings felt were recorded for a period of 15 minutes as shown in Table 4.2. 27 mosquito landings were recorded. However, no study was possible to find out whether it was the same or different mosquitoes but most of the recording were upon landing on different parts of the body. The mosquitoes were quickly interrupted after the landing. Thus, preventing them from biting. The device was then turned on and observed for the next 15 minutes.

Initially, for the first 5 minutes, 8 mosquitoes' landings were recorded after which an average of about one per minute was recorded for the next 5 minutes and just 2 afterwards until the 15 minutes was up. The landing rates with and without the electronic mosquito repellant were different and thus the electronic mosquito repellant was successful in repelling mosquitoes in the opening.

Location	Duration	Number of mosquito landings when EMR was turned OFF		Number of mosquito landings when EMR was turned ON	
		Human bait 1	Human bait 2	Human bait 1	Human bait 2
Outside	8:00pm – 8:05pm	10	-	-	-
	8:05pm – 8:10pm	11	-	-	-
	8:10pm – 8:15pm	6	-	-	-
	8:15pm – 8:20pm	-	-	8	-
	8:20pm – 8:25pm	-	-	5	-
	8:25pm – 8:30pm	-	-	2	-
Classroom	9:00pm – 9:05pm	11	13	-	-
	9:05pm – 9:10pm	9	7	-	-
	9:10pm – 9:15pm	13	8	-	-
	9:15pm – 9:20pm	-	-	3	2
	9:20pm – 9:25pm	-	-	2	1
	9:25pm – 9:30pm	-	-	1	0

4.5 Test Conducted in a Classroom

The second test was conducted in a closed class room with two human bait, each recording the number of mosquito landings. One human bait was placed at the center of the room, and the other was placed at one corner of the room. For the first 15 minutes, mosquito landings were recorded as shown in Table 4.2. From the Table, it can be seen that the human bait in the middle of the class recorded the maximum number of mosquito landings. The device was turned on after the first 15 minutes. The electronic mosquito repellant was placed in between the two human baits. The first human bait at the center, recorded much mosquito landings according to the Table. He then reported that most of the landings were recorded from the side of the body away from the electronic mosquito repellant. The second human bait at the corner, recorded a few number of mosquito landings for the first 4 minutes after which the landing rate dropped drastically, to 0.

The results of these tests provided clear evidence from field-based studies that this device had effect on mosquito landing rates. The studies reported here examined the effectiveness of the electronic mosquito repellant on different locations (since the location and environmental conditions may affect the transmission of the Ultrasound). The frequencies of the sound emitted by the device was also adjusted (since mosquitoes may respond to a particular sound wavelength), and times of day (since day-biting and night-biting mosquitoes may behave differently to the sound emitted by the electronic mosquito repellant), and mosquito density (since this may affect electronic mosquito efficacy), but the differences were very subtle and unappreciable.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

From the simulation carried out using Multism, it showed that the circuit was functioning well. This follows the Astable Mode Theorem of Analog Integrated Circuit Timer (IC Timer) 555. The concept of the circuit was to generate continuous stream of rectangular pulses having a specified frequency. There was a high pitch sound heard (a buzz) at the output speaker which triggered the mosquitoes auditory senses thus frightened them away.

5.1 Conclusions

Preliminary results obtained from the preliminary performance evaluation revealed that the device has the potential to repel mosquitoes. This circuit or project can be used in domestic area to keep mosquitoes away. Based on the theory, a 555 Timer is needed to generate the desired frequency. 555 Timer acts as an Analog to Digital Converter as it can convert analog voltage signal to digital frequency signal. In Astable Multivibrator mode, it acts as an oscillator to generate clock pulse in a wide range of frequencies with enough output power to drive the IC.

Also, in order to control the frequency generated and also make the circuit functioned to generate variable frequencies, a preset resistor and variable resistor have to be included. As both resistors vary the resistance value gained the needed frequency to generate. For the success of this project, proper method to design and construct the circuit was taken into consideration. Multism 13.0 software simulation tool was used to simulate the circuit inside a computer.

After that, the circuit was connected to a breadboard to test run the project before transferring the circuit to a circuit board. Based on the simulation, the circuit successfully ran as was expected based on the theory. The concept of the circuit was to generate continuous stream of rectangular pulses having a specified frequency. When 555 Timer was in the astable mode, the frequency of the pulse stream depended on the values of R1, RV1 and C as can be calculated using a formula. Thus, when the values of R1, R2 and C1 were 220Ω, 5000 Ω and 0.005µF, the speaker emitted a frequency of 29.208 kHz this range of frequency was known to be irritating for insects like mosquitoes but totally cannot be heard by human.

5.2 Recommendations for Further Improvement

However, the project has still not reached full completion as it can be improved upon. There are many ways to improve the circuit. These include:

- To put sensor and led lights in the circuit to detect mosquitoes so that we would be able to know when there are mosquitoes around us. It can also be proved that the circuit is functional because if the LED light does not work that means the area will be safe from mosquitoes.
- In addition, we can use chargeable batteries. Thus, this circuit can operate during blacks out because usually mosquitoes are attracted to dark places.
- Next, we can improve by enlarging the field to repel mosquitoes so we can use a circuit covering a large area. In addition, this circuit can apply to another system and it will not be limited to mosquitoes only if the frequency is modified. Modifying the frequency will produce a sound that can be easily detect any other animal not only mosquitoes.

- Microcontrollers and ultrasonic sensors can be used to transmit the sound in a special band of frequency.

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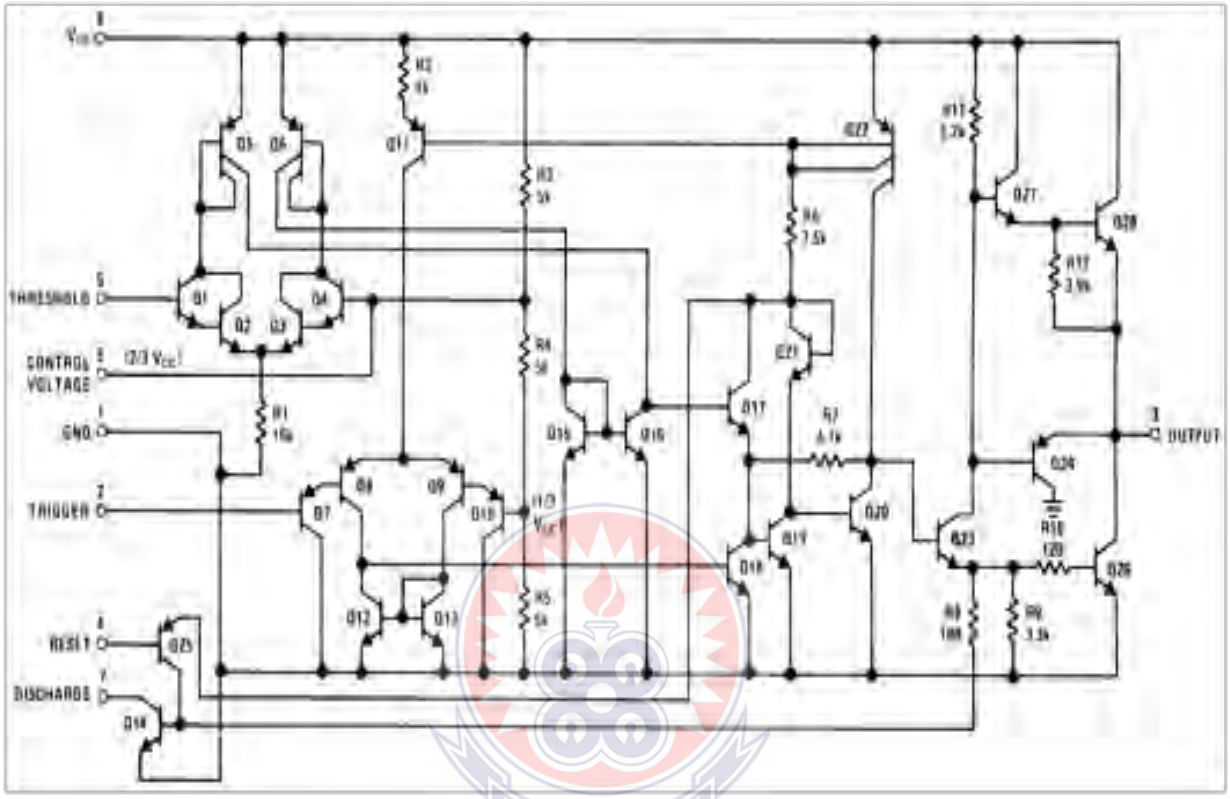
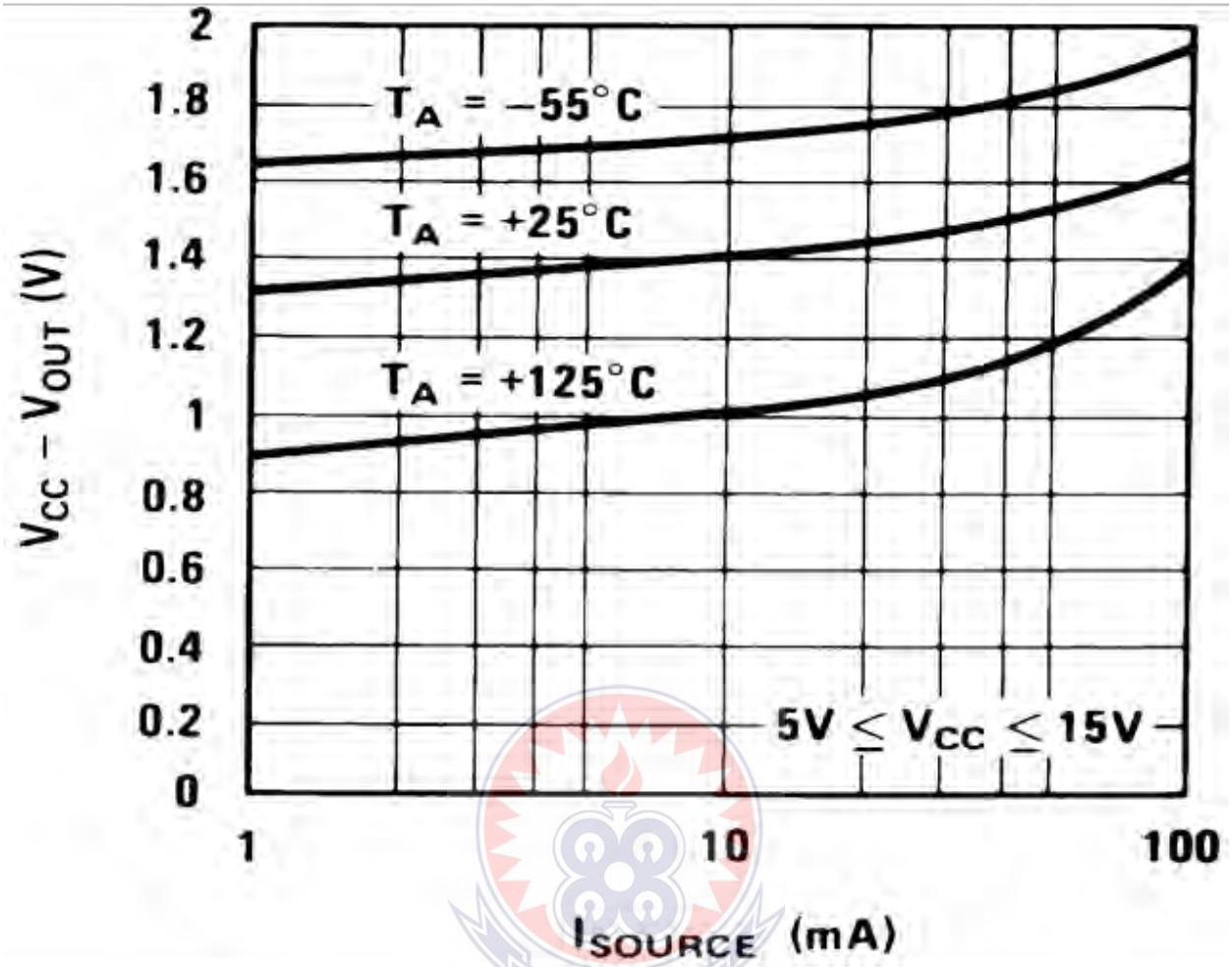
APPENDIX

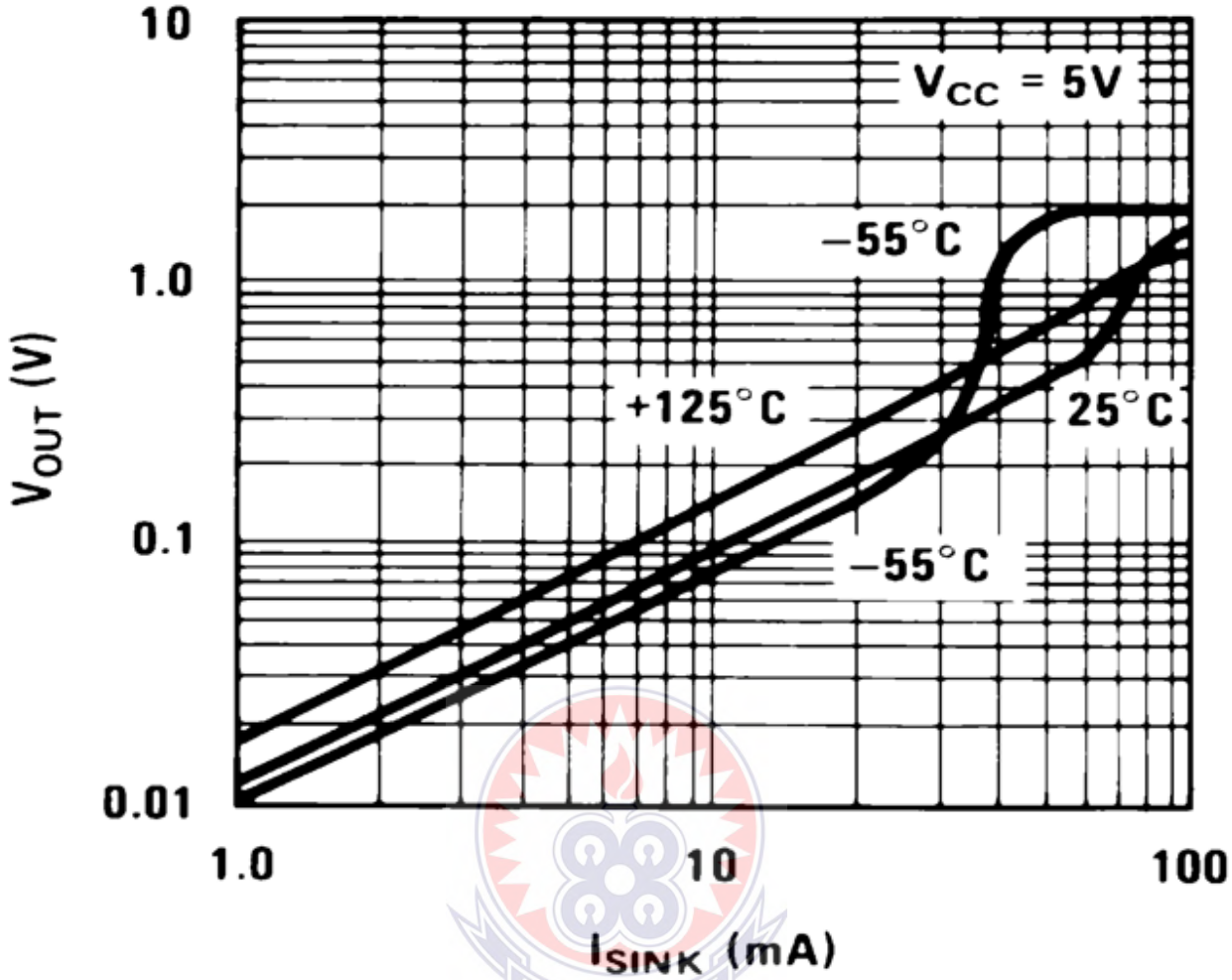
Functional Diagrams of Components Used



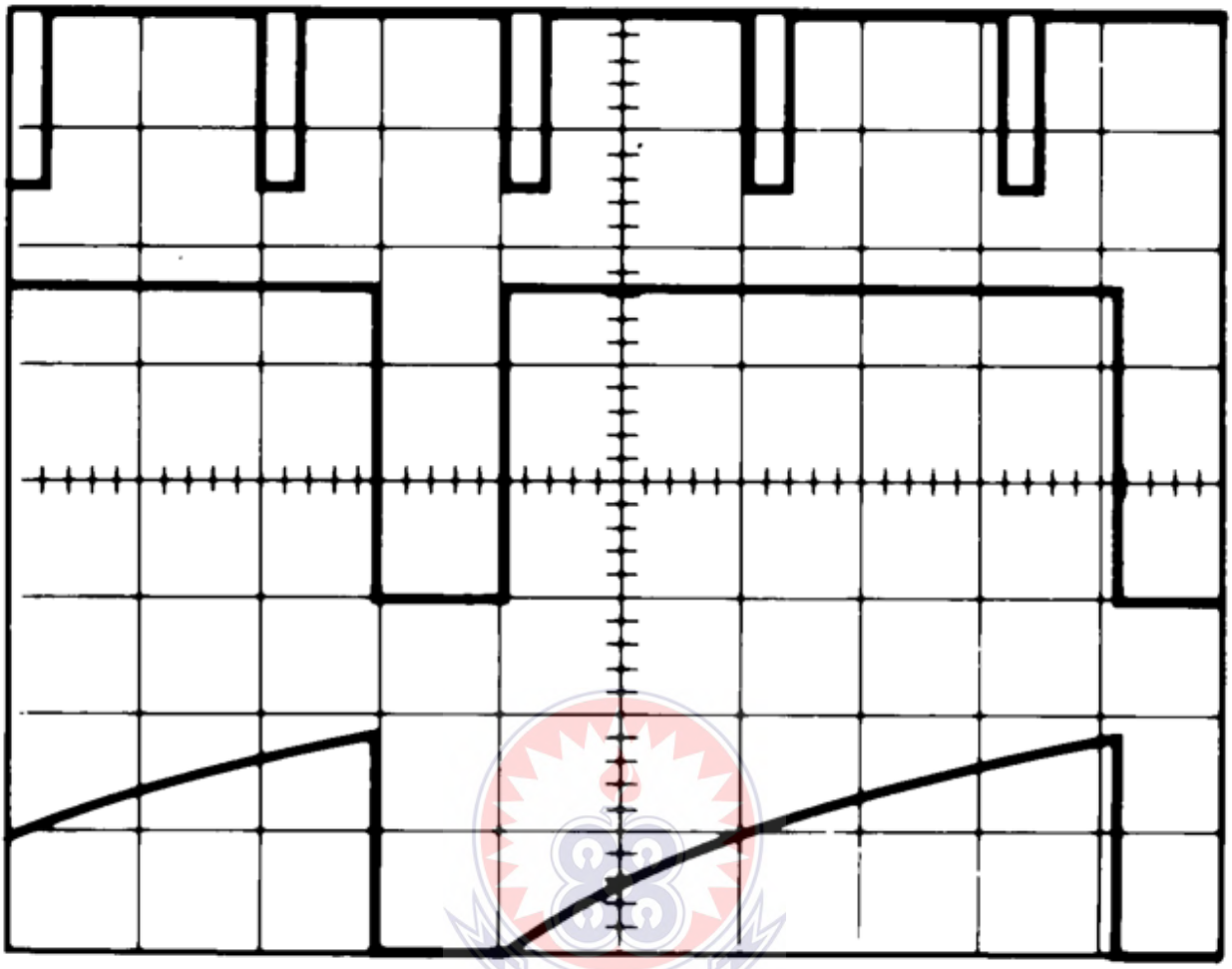
Internal circuitry of 555 timer



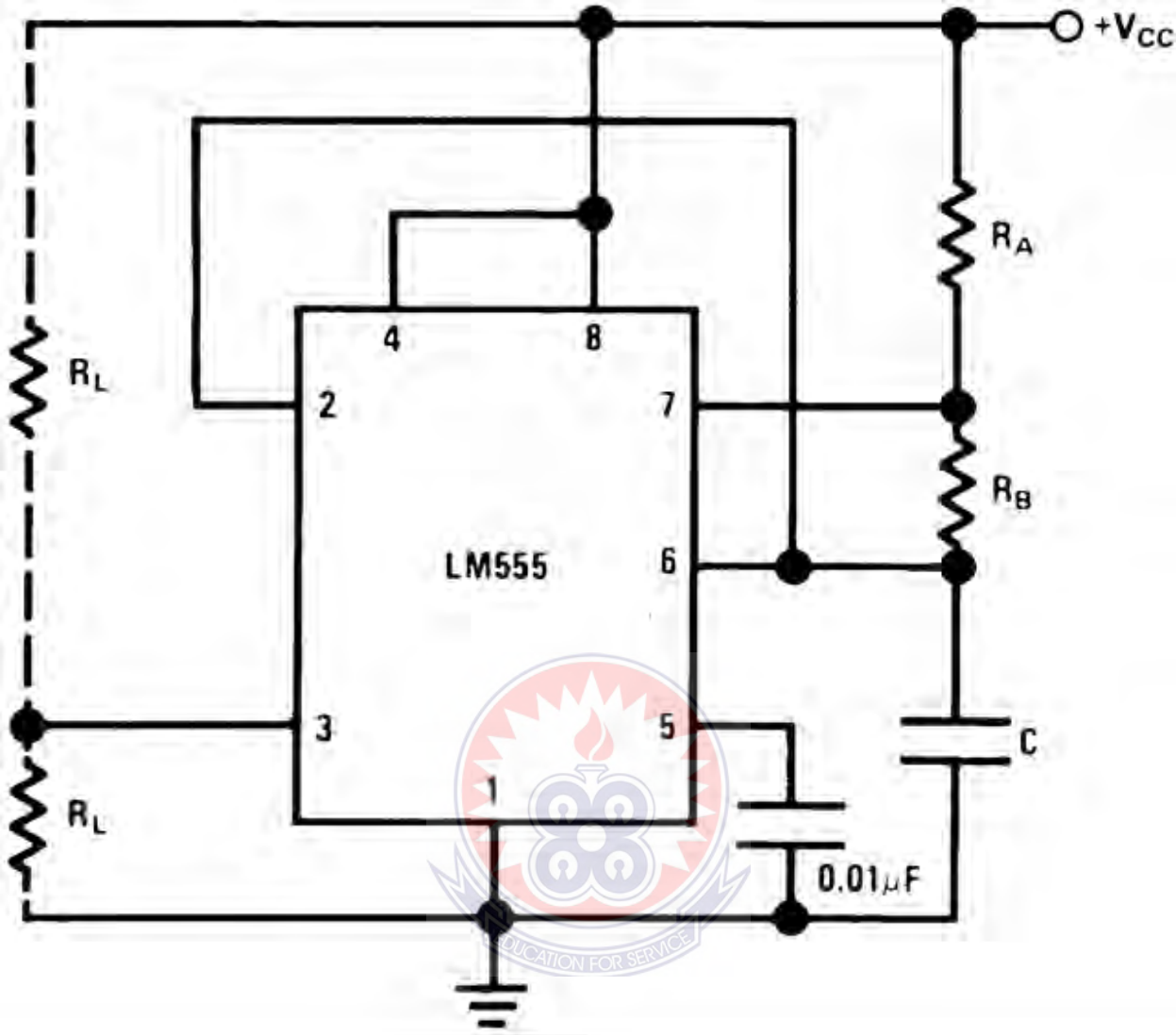
V-I Characteristics of 555



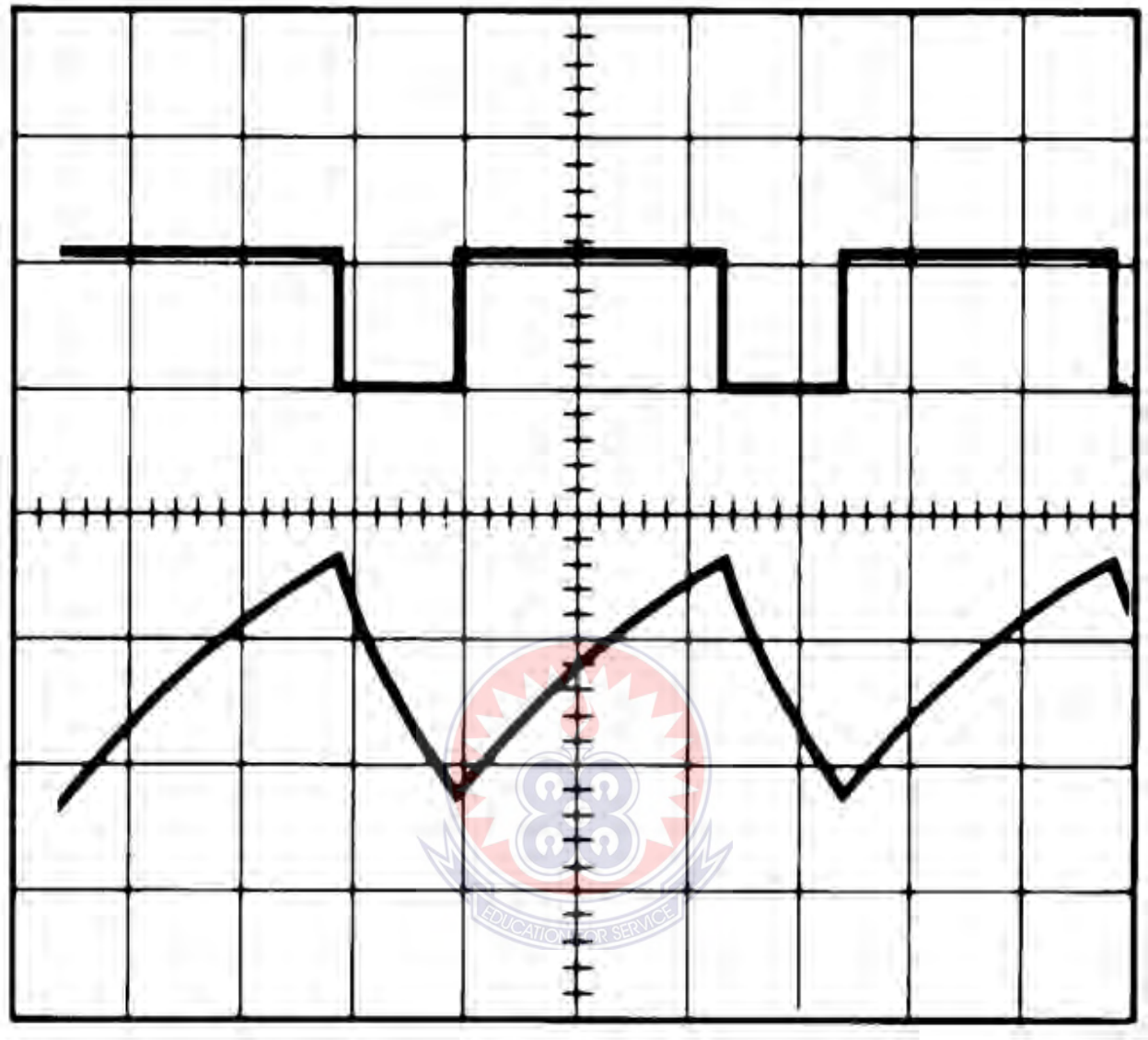
Current sinking characteristics of 555 timer



Various Oscilloscope Output of the 555 timer



Configuration of 555 timer as an Astable switch



Oscilloscope output for an As table 555 timer