

**DESIGN AND CONSTRUCTION OF AN
INTRUDER DETECTION AND SECURITY
SYSTEM**

BY

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DEDICATION.

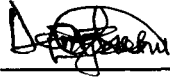
I dedicate this project work to my Lord Jesus Christ. The inspiration, impetus and sustenance enjoyed throughout this work and my degree program as a whole is attributable to Him alone.

DECLARATION

I Egbunu Mopa David declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology

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(Signature and Date)

(Signature and Date)

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Looking back after these years of laborious academic toil here culminated in this project work, a few persons have proven very contributory to my success.

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I must also appreciate my home: the members of the Fellowship of Christian Students (FCS) "His dwelling place", you've made me what I am; you are my greatest treasure.

To all my friends and loved ones, I cherish you all. Thanks for accepting me and improving me, I can't forget you all: Wale Adebayo, Patience Kolo, Folu, Kayode (Gbile), Richard, Oyeladun, Wemimo, Joyce, Deola, Chawa, Jigo, Shola (Omo'ba), Emayojo, Funmi- Fire, Maye, Joy, Ibhide, Asherites, Atima, Jude... God bless you all. I will not forget my guardians; Mr & Mrs Adesina, Mr & Mrs Orhevba, Dr M. Onimole (Chaplain), Dr E. Udensi, Dr Oyero, thank you all. For all others that I may not have appreciated, God appreciates your contribution to my life- we will meet at the top.

ABSTRACT

The intruder detection and security system here designed and constructed is essentially a three (3) trigger zone and a five (5) circuit module electronic system with the primary objective of securing life and property by detecting the operation of an intruder and achieving apprehension before the intruder is aware of being monitored. This security system can find use in any enclosed area or building. The first zone is sound or vibration triggered, this is triggered when the intruder tries to break in through an entrance. The second is triggered by depressing switches embedded in an electric mat; this happens immediately the intruder steps into the building. The third is triggered when the intruder in an attempt to proceed further into other sections of the house interrupts an infrared beam. According to design, the triggering of the first, second and third zones is indicated by three (3) light emitting diodes (LED), radiating yellow, green and red pilot lights respectively. In addition, the triggering of these zones generates a tone that is amplified and transmitted by an audio- radio frequency transmitter system that transmits the tone at a modulated frequency. Hence, the alarm can be received remotely by security officers with receivers tuned to that frequency and within the range of transmission. After testing, the triggering of the individual zones was indicated by a lighting of each of the LED's sequentially as expected. Also, after powering the transmitter, with a pure DC source, a power of about 3.45W was found to be generated in the transmitter by calculation and a signal of 96MHz was received clearly over a range of about 150meters.

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CHAPTER ONE

1.1 GENERAL INTRODUCTION

By way of introduction the title of this project is the design and construction of an intruder detection and security system.

As developing countries like ours climb up the ladder of civilization and as developed countries try to hit the apex of the same, there is one common denominator that ranks high in demand and that is security. Its expedience cuts across almost every ramification of human life and activity; the neglect of which puts all developments or structure at the risk of being undermined. A few areas where the need for security cannot be overemphasized include:

1. **Communication:** This is a major sector that continuously needs an upgrade of security measures to curtail the intrusion into restricted areas. For example the internet:

Here, all internet users are compelled to be engrossed in the unending war against hackers, virus developers, online Spy, electronic money robbers and the likes. Some of the security agents in place include antivirus, firewalls, Spywares, encryption software, etcetera. However, the challenge only remains suppressed and not solved.

2. **Transportation:** Virtually all aircrafts, land vehicles, trains, water boats, and ship manufacturers are by the day beefing up security systems to counter the teaming horde of intruders all around. Metal detectors, touch sensors, temperature sensors and others are some of the parameters that have been used to provide security for automobile systems.

3. **Housing:** To the common majority, this looks like the most obvious- being the one that touches a larger generality especially around this part of the world. All houses, buildings and enclosed areas need security. This is necessitated by the unfortunate hike in the cases of burgling, robbery and other forms of assaults that breach the boundaries of privacy and fundamental human rights.

As a students of electrical and Computer engineering and as a concerned citizen of the

World, the aforementioned need for security and the numerous unmentioned, provided the initial nudge to join the fight against insecurity- hence my project topic.

AIM AND OBJECTIVE

The primary objective of this project is to secure life and property by detecting the operation of an intruder in any enclosed area or building and achieving easy apprehension.

Other objectives are:

- To reduce to barest minimum the occurrence of false alarms by operating multiple trigger zones.
- To realize the system design using simple- basic electronic component

This particular security system has a unique feature: the burglar or intruder would not have any suspicion of being monitored while in operation and so, apprehension of the culprit would be sudden and rather unprecedented. This is made possible by not locating the output indicators (light emitting diodes 'LED' and alarm) at the burgling site or point of entry.

1.3 METHODOLOGY

This project is a simple security system that operates three (3) trigger zones and five (5) circuit modules altogether. In the design, the first module is the power supply unit which is basically an AC rectification module that receives about 220V ac from mains and delivers 9V ac rectified which powers the system. The second module consists of a vibration or sound triggered circuit which is triggered when the intruder tries to break in through an entrance. This is achieved using an electrets microphone which picks the sound pressure as a physical signal and converts it to an electrical signal. The third module consists of an electric mat/step switch circuit which is triggered by depression when an intruder steps on it. When this happens, a low pulse is sent which triggers the 555 timer IC. The fourth module of the system is an infrared transmitter and receiver based circuit which is triggered by passage when an intruder interrupts the infrared beam between the transmitter and receiver. The fifth and final module is a simple audio- radio frequency transmitter that sends a tone signal at a particular frequency band within the FM bandwidth. The tone is generated by an oscillation set up by an astable configured 555 timer IC and is transmitted by an LC tank circuit. The whole system is powered by a 9V source.

1.4 SCOPE OF THE WORK

This intruder detection and security system can only be used in an enclosed area or building. The system operates three (3) sensor zones designed with an intelligent counter approach to the mode of operation of an intruder. The operation and outputs of the trigger zones are 555 timer controlled. In other words, the various stages operate on either the astable or latch multivibration operation modes of the 555 timer IC.

The system also incorporates into it an audio- radio frequency tone transmitter circuit. However, this system does not include the radio frequency receiver. Hence, extensive theoretical and mathematical discussions are not very well covered in this work.

The block diagram of the system is shown below;

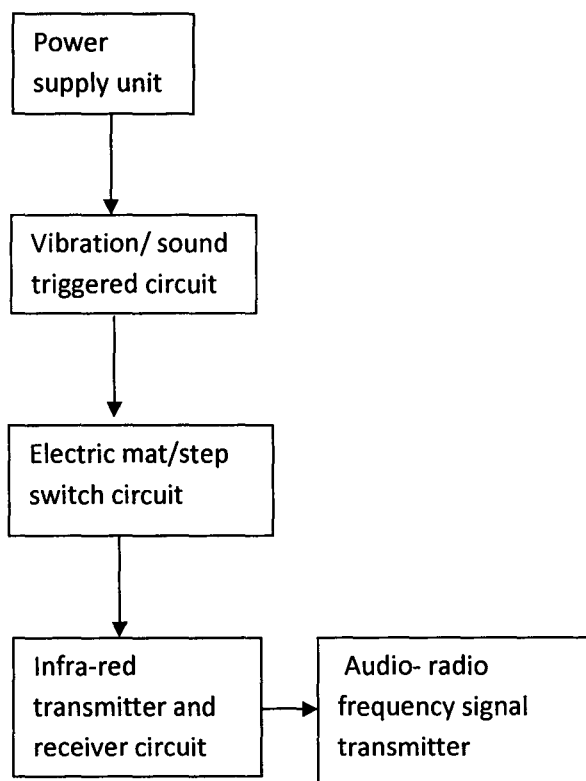


FIG 1.1 Block diagram of an intruder detection and security system

CHAPTER TWO (2)

LITERATURE REVIEW

2.1 INTRODUCTION

An intruder security or detection system is a network of electronic components intelligently connected to sense the presence of an intruder and raise a form of alarm to that effect; either directly or wirelessly.

2.2 A BRIEF HISTORY OF ELECTRONIC BASED SECURITY SYSTEMS

The evolution of security systems cannot be exactly traced, but as long as man has existed, security has always topped the list of his dare needs. Now, coming to electronic based security systems, we can say a few specific things here. As a matter of fact, the use of basic electronic components to construct intruder detection or security systems is almost as old as the evolution of electronics technology, dating as far back as the 19th century.

Before the evolution of electronic burglar alarm, people used different techniques to forestall attacks from enemies. In the years before 1000BC many cities had watch towers at which watchman were located to keep watch or vigil over the city. In the event of approaching danger, the watchman signals the city or raises some form of alarm to get the people alert. Besides, each household had a system for ensuring security against intruders.

Another ancient but fairly recent non electronic method of intruder detection was the use of animals- particularly dogs, to track down on intruders. Usually, it is a traditional belief that dogs perceive smell and/or sight the presence of intruders and by barking, they raise an alarm to signal their presence. Also, the domestic use of vigilante or watch guards who signal with a whistle, the presence of an intruder was also common place. All these ancient and medieval

techniques had their limitations- particularly they required so much of human attention and monitoring.

The invention or manufacture of electronic alarms dates back to February 21, 1858. This from history is accredited to Edwin Holmes. He developed what can be considered the first electric home burglar alarm system. Usually, when a door or window is opened, a spring is released that closes an electric circuit and then a bell would ring. He installed this first alarm system in Boston.

Since then, different burglar alarms or intruder detectors have been designed and constructed using diverse sensors and electronic configuration.

2.3 TYPES OF INTRUDER OR ALARM SYSTEMS

Detector alarm systems are very common in our world of today. Some of the very common ones include:

1. Motion detectors
2. Professional burglar alarm
3. Anti – theft car alarm
4. Photoelectric cell burglar alarm.
5. Intruder detector alarm system.

2.3.1 MOTION DETECTOR BURGLAR ALARM

This is a type of electronic security device that senses movement usually in enclosed or indoor areas and then triggers an alarm. Passive infrared motion detector burglar alarms are

sensitive to infrared wavelength of energy that is not visible to the natural eye. It senses the heat that a human emits and has sensors that enables it to view an area as several distinct zones within the range of the detector. These zones spread out vertically and horizontally from the detector lens as a series of finger like area, fanning out from the lens across the protected area and down to the floor. The electronic circuit enables the detector to recognize the usual amount of heat usually present in the area; hence, when an intruder enters, the heat from the intruder's body adds to the amount of heat initially present.

2.3.2 ULTRASONIC MOTION DETECTOR BURGLAR ALARM

This is an older burglar alarm technology in which sound of very high frequency is used to detect motion. Here a transmitter sends out sound of a frequency that is too high for the human ear to hear. A receiver picks up the sound waves reflected from the area under protection. The motion of someone or something in the space between the receiver and transmitter will cause change in the frequency of the sound. A circuit in the system detects any unusual shift in the frequency known as doppler effect and the device triggers the alarm. Usually, a small shift such as that produced by a device triggers the alarm. However, small shifts such as that produced by an insect is ignored but such as that produced by a moving person is detected. (Ref: Steven R. Keller).

2.3.3 INTRUSION DETECTION ALARM SYSTEM

This intrusion detection system alerts you as unexpected guests approach your property. The system consists of two basic components; an infrared sensor and a radio wave transmitter. First the infrared sensor detects the presence of a vehicle or person through heat and motion and then

transmits a radio signal of about 300MHZ to the receiver in the house which sounds the alarm. It has an exceptional range of up to 1500ft. The sensor has an adjustable field with a 30ft detection zone and is powered by a 9 volts battery. The receiver / alarm unit is plugged into a standard electrical socket outlet inside the house. Upon receipt of the transmitted signal from the sensor unit, the receiver sounds its alarm and activates an LED light for 5 seconds and then resets itself.

2.3.4 PROFESSIONAL BURGLAR ALARM

This is a burglar alarm system that is triggered when a protective circuit is broken. The technology requires that a window foil is used, and the window foil 'breaks' a circuit immediately the window glass is broken. This professional burglar alarm can be used to protect doors, windows or glass. All protective doors and window circuits are normally closed series connected so that an opening of any protective device will trigger the alarm. Immediately the alarm is triggered, it can only be turned off by opening the master switch. The recommended supply is an AC powered 6V DC source or a lantern battery.

2.3.5 PHOTOELECTRIC CELL BURGLAR ALARM

The photoelectric cell which is popularly known as the electric eye is usually employed in operating burglar alarms. A phototube which may be invisible to the eye forms an essential part of the electric circuit. Light is produced by a bulb at one end of the circuit and it falls on the phototube located some distance away. Interrupting the beam of light breaks the circuit and this

in turn causes a relay to close which then energises the burglar alarm. This circuit is used for intruder detection.

2.3.6 MODULAR BURGLAR ALARM

This particular burglar circuit features automatic exit and entry delays and a timed bell cut-off. It has provision for both normally closed and normally open contacts, and a 24-hour personal attack / tamper zone. It is connected permanently to a 12volts supply and its operation is enabled by opening a switch. To set this system, the green LEDs should be lighting before you open the switch. You then have up to a minute to leave the building. As you do so, the buzzer will sound. It should stop sounding when you shut the door behind you. This indicates that the exit / entry loop has been successfully restored within the time allowed. When you re-enter the building, you have up to about 1 minute to turn the switch up. If any of the switches in the normally closed loop is open by any intruder, the resistor (R) will trigger the SCR and the bell will ring.

2.3.7 FIVE (5) ZONE ALARM SYSTEM

This is a complete alarm system with 5 independent zones suitable for a small office or home environment. It uses just 3 CMOS ICs and features a timed entry / exit zone, 4 immediate zones and a panic button. There are indicators for each zone, and a system armed indicator; each zone uses a normally closed contact. This can be micro switches or standard alarm circuits (usually reed switches). Suitable switches can be brought from alarm shops and concealed in door frames or window ledges. Zone 1 is a timed zone which must be used as the entry and exit point of the

building. Zones 2 – 5 are immediate zones which will trigger the alarm with no delay. Some RF immunity is provided for long wiring runs by the input capacitors, C1 – C5, C7 and R14 also form a transient suppressor. The key switch acts as the set / unset and reset switch. For good security this should be the metal type with a key.

2.4 PECULIARITIES OF MY INTRUDER DETECTION/SECURITY SYSTEM

The various types of electronics based burglar alarm or intruder detectors as discussed briefly above, have different principles of operation when considered in detail. However, a common principle that applies to all of them is that there is always a primary circuit(s) that serves as sensor or detector of any other form of indicator. All other differences are rather extra-curricular to this fundamental principle.

Having established this fact, I would quickly admit that the principles of operation of my project still subscribes to this common underlying principle of all burglar / intruder security systems. However, being an original work, here are some peculiarities and of course preferences my project work presents.

2.4.1 A SYNERGY OF MULTI TECHNOLOGIES OR PRINCIPLES

Due to the fact that most of the available burglar alarm circuits make use of a single technology or single detection circuits, they are quite unreliable and often prone to false alarms. Many times, only one parameter is not enough to ascertain that a burgling operation is in process as most of those circuits pre-suppose. However, my project provides three (3) stages of intruder detection

using three parameters namely sound/vibration, match/ step pressure and motion detectors. This places it at advantage to many others.

2.4.2 CONCURRENT USE OF VISUAL/AUDIO INDICATORS

Earlier works on burglar alarms as discussed earlier only adopt either of the sound alarm or LED indicator; only a few make use of both at the same time. My design of an intruder security puts into use three different LED lightings for each of the trigger zones and further complements it with a sound alarm, just in case the LED light indicators don't suffice.

2.4.3 TRANSMISSION OF SIGNALS TO A 'REMOTE' LOCATION

Another rare feature in my project design is the intelligent separation of the secondary or output circuit from the trigger circuit. By this I mean the LEDs that indicate security breach are not located at the site of the breach, but are wired to a remote security post. Also, instead of the alarm or sound buzzer residing within the intruder's hearing range, the signal is transmitted at a fixed frequency that can only be received by security officers with receivers set to that frequency. Hence, the burglar is completely oblivious of the entire security arrangement.

2.4.4 UNIQUE CIRCUIT DESIGN

Apart from the aforementioned peculiarities discussed, the entire circuit design adopted in this project is uniquely different from others. Here, we have the predominant use of very simple

electronic components like the 555 timer, diodes, transistors, resistors and capacitors among others. A design requiring this kind of output would have required the use of digital logic circuits, micro-controllers among others. However, this project adopts a simple design and use of simple and readily available electronic components. Below is a concise theory on the application of some of the components used.

2.5 DISCUSSION OF SOME COMPONENTS USED

2.5.1. THE TRANSISTOR

The transistor was developed at Bell Telephone Laboratories by the American physicists Walter Houser Brattain, John Bardeen, and William Bradford Shockley. The invention of the transistor in 1948 was a turning point in the history of electronics. Transistors are composed of a semiconducting material- that is, a substance that can act as either a conductor or an insulator. Transistors quickly replaced vacuum tubes for amplifying electronic signals in devices

In the transistor, a combination of two junctions may be used to achieve amplification. One type, called the n-p-n junction transistor, consists of a very thin layer of p-type material between two sections of n-type material. The n-type material is the emitter element of the transistor, constituting the electron source. To permit the forward flow of current across the n-p junction, the emitter has a small negative voltage with respect to the p-type layer, or base component that controls the electron flow. The n-type material in the output circuit serves as the collector element, which has a large positive voltage with respect to the base to prevent reverse current flow. Electrons moving from the emitter enter the base and are attracted to the positively charged collector, and flow through the output circuit. The input impedance or resistance to current flow,

between the emitter and the base is low, whereas the output impedance between collector and base is high. Therefore, small changes in the voltage of the base cause large changes in the voltage drop across the collector resistance, making this type of transistor an effective amplifier.

Similar in operation to the n-p-n type is the p-n-p junction transistor, which also has two junctions and is equivalent to a triode vacuum tube. Other types with three junctions, such as the n-p-n-p junction transistor, provide greater amplification than the two-junction transistor.

Fig.2.1 shows the transistor as a switch.

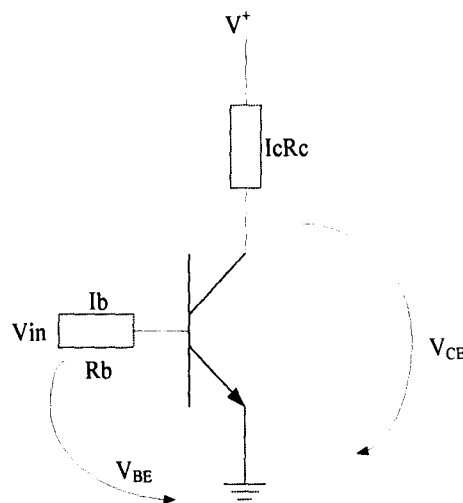


Fig. 2.1 transistor as a switch

2.5.2. THE 555 TIMER IC

The 555 monolithic integrated circuit timer was first introduced by Signetics Corporation in 1972 in bipolar technology. It quickly became an industry standard for timing and oscillation functions. Many manufacturers produce a version of a 555 IC, some in CMOS technology. The

555 timer is a general purpose IC that can be used for precision timing, pulse generation, sequential timing, time delay generation, pulse width modulation, pulse position modulation, and linear ramp generation. The 555 timer can operate in both astable and monostable modes with timing pulses ranging from microseconds to hours. It also has an adjustable duty cycle and can generally source or sink output currents up to 200mA. Its functional diagram is shown in fig. 2.2

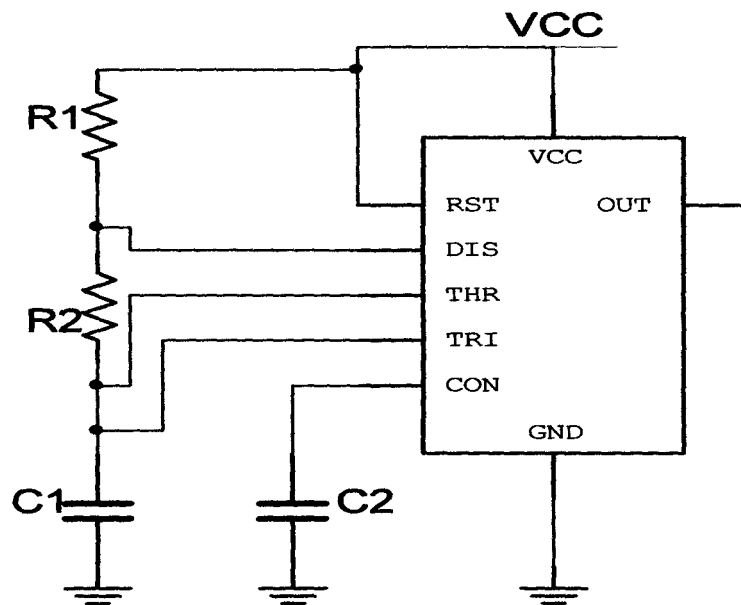


Fig.2.2 functional diagram of a 555 timer IC

2.5.3. THE LIGHT EMITTING DIODE (LED).

The Light-Emitting Diode (LED) is a device that emits visible light or infrared radiation when an electric current passes through it. LEDs are made of semiconductors, or electrical conductors, mixed with phosphor substances that absorb electromagnetic radiation and reemit it as visible light. When electrical current passes through the diode the semiconductor emits infrared

emission is useful for indicator lamps and alphanumeric displays in various electronic devices and appliances. Devices such as remote controls and cameras that focus automatically use infrared LEDs, which emit infrared radiation instead of visible light. Light-emitting diodes use the properties of *electroluminescence*, in which certain substances emit electromagnetic radiation when excited by the flow of an electric current, and *fluorescence*, in which some substances absorb wavelengths of electromagnetic radiation other than visible light and reemit the radiation as visible light. When charged particles such as electrons pass through certain semiconductors, they boost to higher orbits one or more electrons in some of the atoms in the semiconductor. When these electrons fall back to lower orbits, the atom emits infrared radiation. When this radiation strikes a phosphor atom, electrons in the phosphor atom jump to higher orbits. The phosphor atom emits visible light when the electrons fall back to a lower orbit.

2.5.4. THE RESISTOR.

The resistor is a component of an electric circuit that resists the flow of direct or alternating electric current. Resistors can limit or divide the current, reduce the voltage and hence protect an electric circuit. Resistors are designed to have a specific value of resistance. Most resistors used in electric circuits are cylindrical items a few millimeters long with wires at both ends to connect them to the circuit. Resistors are often colour coded by three or four color bands that indicate the specific value of resistance. Some resistors obey Ohm's law, which states that the current density is directly proportional to the electrical field when the temperature is constant. The resistance of a material that follows Ohm's law is constant, or independent of voltage or current, and the relationship between current and voltage is linear. Resistors can help divide voltages, and when

combined with other elements can help convert voltages for a specific electrical design. Resistors can also be used to provide intense light or heat.

2.5.5. THE CAPACITOR.

The capacitor or electrical condenser is a device used for storing an electrical charge. In its simplest form a capacitor consists of two metal plates separated by a non conducting layer called the dielectric. When one plate is charged with electricity from a direct-current or electrostatic source, the other plate will have induced in it a charge of the opposite sign; that is, positive if the original charge is negative and negative if the charge is positive.

Capacitors are limited in the amount of electric charge they can absorb; they can conduct direct current for only an instant but function well as conductors in alternating-current circuits. This property makes them useful when direct current must be prevented from entering some part of an electric circuit. Fixed-capacity and variable-capacity capacitors are used in conjunction with coils as resonant circuits in radios and other electronic equipment. Large capacitors are also employed in power lines to resonate the load on the line and make it possible for the line to transmit more power.

Capacitors are produced in a wide variety of forms. Air, mica, ceramics, paper, oil, and vacuums are used as dielectrics, depending on the purpose for which the device was intended.

CHAPTER THREE (3)

DESIGN ANALYSIS.

3.1 THE POWER SUPPLY UNIT

For the circuit we would require a 7809-voltage regulator as shown in the figure below, which gives a required output of 9V. The voltage regulator regulates input voltages above its required output voltage. If the input voltage is below its required output voltage, it would be passed out without been regulated.

The power unit involves the transformer-bridge rectifier circuit. A 12V transformer is used to provide power to the 7809 regulator, which produces regulated 9V.

The common bridge rectifier, comprising four rectifying diodes, is used for converting the 12V ac power supply into a corresponding roughly 12V dc voltage. The ripple involved at the output of the bridge rectifier is filtered through a 1000 μ F, capacitor. The voltage rating of the capacitor is made much higher than the expected output voltage of the rectifier, to protect the device from the effect of high voltage supply.

A power switch was used to open and close the complete circuit when required. The 7809-voltage regulator is connected in parallel across the rectified voltage output. The devices are aimed for stability of the complete circuit. The 9V power supply from the 7809 is connected to the main circuit.

3.1.1 Analysis of Power Supply

If the unregulated input of the 7809 is greater than the required output by a factor of 4, that is $9+4=13$, the voltage regulator IC, starts getting hot and will be damaged. Hence we will assume an input into the 7809 regulator to be approximately 12V.

Since each diode drops 0.6V and we have 4 rectifying diodes forming the full wave bridge, the voltage drop will then be $0.6 \times 4 = 2.4V$

For a peak voltage of $12+2.4=14.4V$ peak.

$$\text{For the r.m.s voltage} = \frac{14.4}{\sqrt{2}} = \frac{14.4}{1.4} = 10.2857V$$

Hence a transformer of a preferred value of 12V was employed. I.e. 220V/12V transformer

3.2 CIRCUIT ANALYSIS.

The circuit was built using widely the integrated circuit (IC) known as the 555 timer. The 555 timer is a time dependent IC which can be configured to operate in different forms such as astable, monostable, multivibrator, and also as a latching device.

3.2.1 Astable Operation of 555 Timer

Astable multivibrator also known as the free running vibrator is achievable with the time dependent IC- 555 timer. The configuration is shown below:

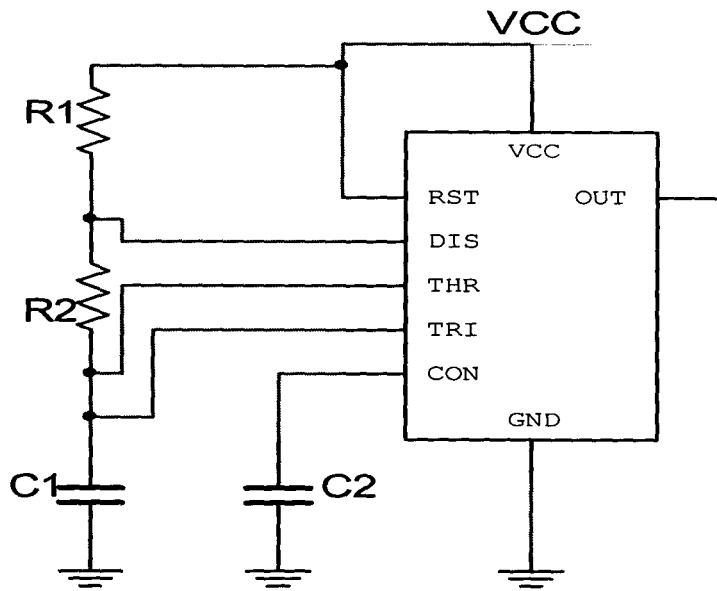


FIGURE 3.5a THE CONFIGURATION OF A 555 TIMER

When the circuit is powered, the capacitor C_1 begins to charge through R_1 and R_2 until the voltage at the Threshold pin (pin6) reaches $\frac{2}{3}V_{CC}$. When this occurs, the internal comparator of the IC toggles the flip flop embedded inside the IC and changes the state of the output pin (pin3) from logic 1 to Logic0. Also, the state of the internal NPN transistor's base changes from logic 0 to logic1. As a result of this, the internal NPN transistor is being forward biased and discharges the capacitor gradually through resistor R_2 because the collector pin of the transistor is connected to the discharge pin (pin7) and emitter to the ground.

After each cycle when the voltage across the capacitor falls to $\frac{1}{3}V_{CC}$, the circuit sustains the oscillation.

The time of charge and discharge of the circuit is calculated below:

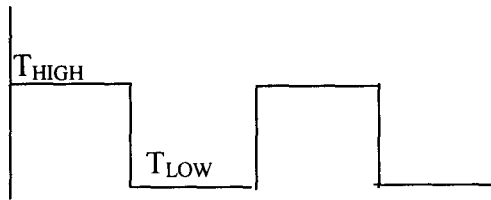


FIGURE 3.5b OUTPUT PULSE OF AN ASTABLE 555 TIMER

T_{high} is the time taken for the capacitor to attain its threshold voltage. It is calculated thus;

$$T_{high} = 0.693(R1+R2) C1 \dots (3.1)$$

T_{low} is the time taken for the capacitor to discharge to $1/3V_{cc}$

$$T_{low} = 0.693(R2) C1 \dots (3.2)$$

Therefore, the period of oscillation is given as:

$$T = T_{high} + T_{low} \dots (3.3)$$

$$T = 0.693(R1+R2) C1 + 0.693(R2) C1$$

$$T = (0.693R1 + 0.693R2) C1 + 0.693R2C1$$

$$T = 0.693R1C1 + 0.693R2C1 + 0.693R2C1$$

$$T = 0.693R1C1 + 1.386R2C1$$

$$T = 0.693C1 (R1+2R2)$$

The frequency of oscillation is given as

$$F = 1/T$$

$$F = 1/0.693(R1+2R2) C1$$

$$F = 1.44 / (R_2 + 2R_1) C_1 \dots (3.4)$$

3.2.2 Monostable Multivibrator Operation Of 555 Timer.

Monostable multivibrator also known as one shot timer is realized using the 555 timer IC. The configuration is as shown below:

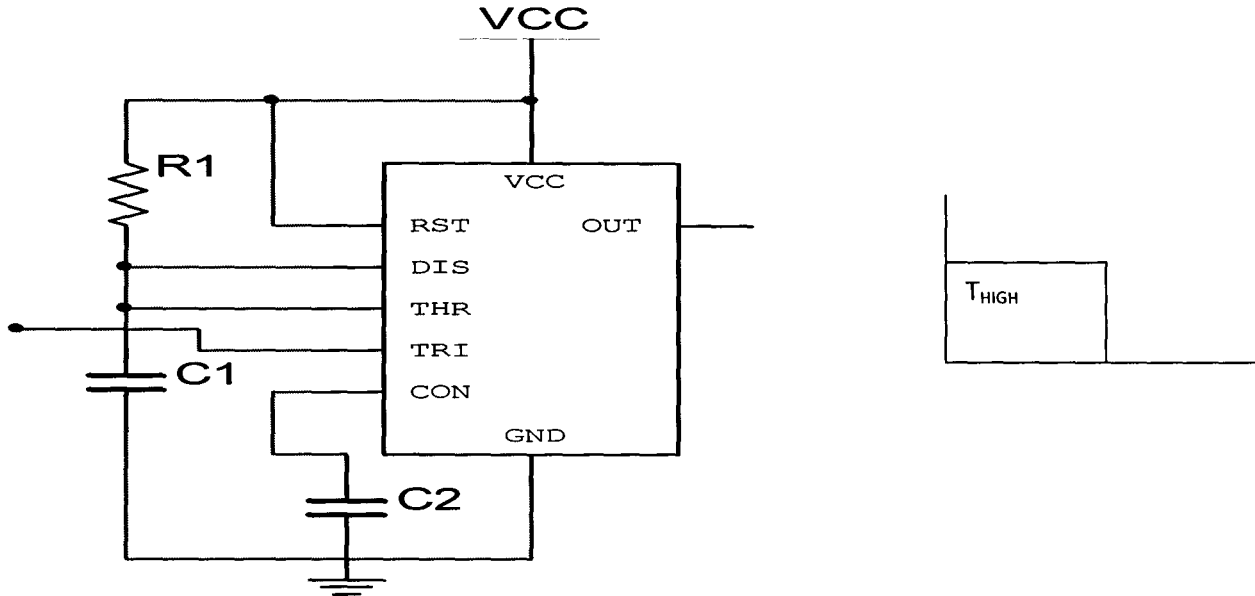


FIGURE 3.6 MONOSTABLE OPERATION OF A 555 TIMER.

When this circuit is triggered, the output goes high for a predetermined time interval calculated as follows:

$$T_{high} = 1.1R_1C_1 \dots (3.5)$$

3.2.3 Latch Operation Of 555 Timer.

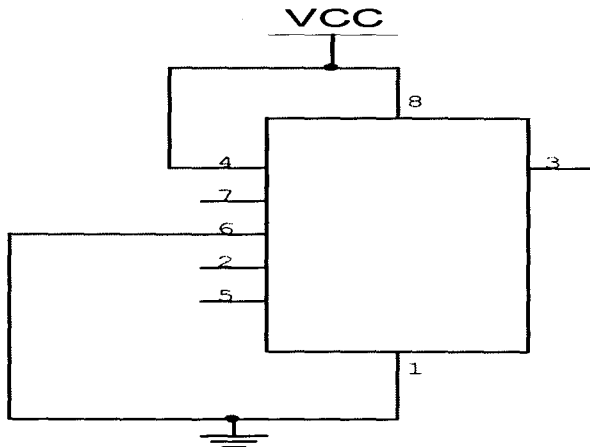


FIGURE 3.7 LATCH OPERATION OF A 555 TIMER

When this circuit is triggered its output goes high and remains high because there is no capacitor or any source to set pin6 (threshold pin) to $2/3V_{cc}$ which causes a toggling of the output. As a result of this, the output remains high until the timer is being reset through pin 4 (reset pin).

3.3 THE GENERAL CIRCUIT OPERATION.

The circuit comprises of four sections that make for efficient and effective intruder detection. These are the sound detector section, the match/step section, the infrared-detector section and the audio- radio frequency (RF) transmitter section.

3.3.1 The Audio Detector Section.

Considering an audio alert system, when an intruder tries to break in through the entrance, the electret microphone picks the signal (sound) and triggers the latch configured 555 timer IC1 and this keeps the pin4 (reset pin) of IC2 (astable multivibrator) high/set. This oscillator causes a steady blink of the yellow LED- indicating that an intruder has started breaking an entrance.

This is achieved with the use of a transducer called electric/condenser microphone. This device picks the sound pressure as an analogue or physical signal and converts it to an electrical signal.

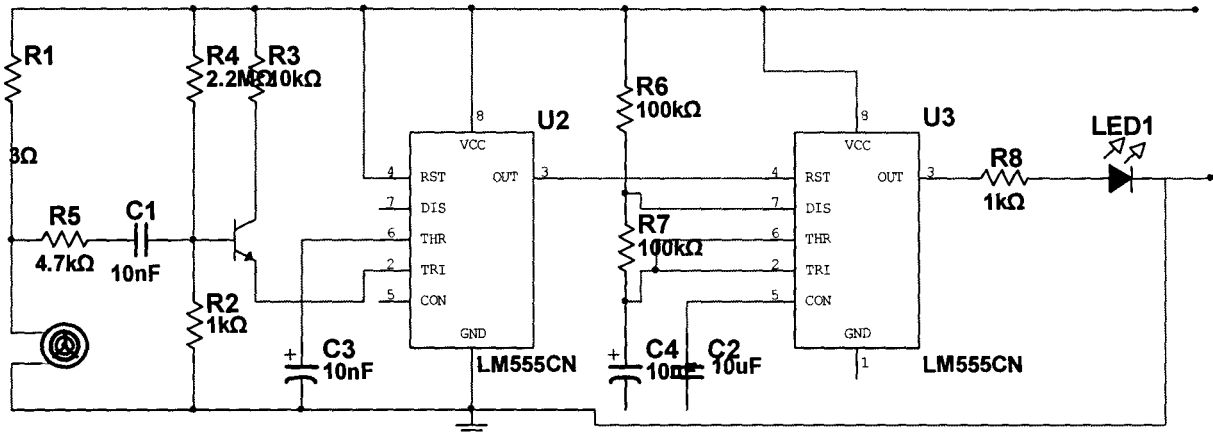


FIGURE 3.8 CIRCUIT DIAGRAM OF AUDIO DETECTOR MODULE

For effective operation of the electric microphone, the microphone is forward biased through resistor R3. The forward current for the microphone is about 3mA (as provided by the manufacturer).

Now to calculate for R3 we apply Ohm's law $V = IR$

Where $V = 9V$, $I = 3mA$,

and $R = V/I = 9/3 = 3k\Omega \pm 10\%$. Choosing a nearest value of $3.3k\Omega$

This signal current from the microphone is then reduced by the 4.7k resistor in order to achieve an audio level which is coupled by the coupling capacitor C2. This coupling capacitor gives room for the ac signal to pass and rejects the dc signal

We then have the class AB amplifier designed using resistors R5, R6 and R7 as follows:

Given that the transistor TR1 has a current gain (β) of 100

$$\text{Therefore, } I_c/I_b = \beta \dots (3.6)$$

$$\text{Applying KVL we have } V_{cc} - I_1 R_5 - I_b R_c = 0 \dots (3.7)$$

$$I_b = V_{cc} \cdot R_6 / (R_5 + R_6) \dots (3.8)$$

$$I_1 = I_2 + I_3 \dots (3.10)$$

For a small collector current I_c of 0.37mA (small trigger current)

$$I_b = I_c / \beta = 0.37 / 100 = 0.0037 \text{mA}$$

From equation (3.11)

$$I_b = V_{cc} / (10R_6 + R_6) = V_{cc} / 11R_6$$

$$\text{Therefore, } 0.0037 \text{mA} = 9 / 11R_6.$$

$$11R_6 = 9 / 0.0037$$

$$R_6 = 9 / (11 \times 0.0037) = 221.1 \text{k} \approx 220 \text{k}\Omega$$

$$\therefore \text{ since } R_5 = 10R_6 = 10 \times 220 \text{k}\Omega = 2.2 \text{M}\Omega$$

Applying KVL to obtain R_7 .

$$V_{cc} - V_{ce} - I_c R_L = 0 \dots (3.12)$$

$$\text{Since } V_{ce} = V_{cc} / 2 = 4.5$$

$$9v - 4.5 - 0.37R_L = 0$$

$$4.5 = 0.37 R_C$$

$$4.5/0.37 = R_C$$

$$12.16 = R_C$$

$$= 10k$$

For the astable multivibrator

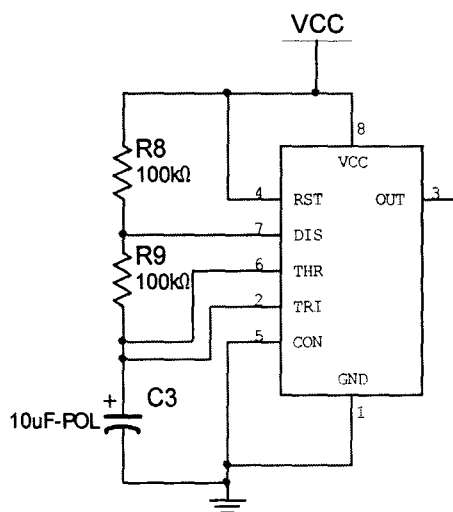


FIGURE 3.9 ASTABLE MULTIVIBRATOR FOR THE AUDIO DETECTOR SECTION.

Choosing a low frequency of 0.5 hz.

For capacitance value of $C_3 = 10\mu f$.

∴from equation (3.4)

$$F = \frac{1.44}{(R_1 + R_2)C_1}$$

$$0.5 = 1.44/(R_1+2R_2)10 \times 10^{-6}$$

$$R_1 + 2R_2 = 1.44/(0.5 \times 10 \times 10^{-6}) = 288,000 \Omega.$$

$$\text{Choosing } R_1 = 100,000 \Omega = 100 \text{ k}\Omega$$

$$2R_2 = 288000 - 100,000$$

$$= 188,000$$

$$R_2 = 18800/2 = 94000 = 94 \text{ k}\Omega$$

$$\text{Choosing } R_2 = 100 \text{ k}$$

$$\therefore F = \frac{1.44}{(R_1+2R_2)C_1} = 0.48 \text{ Hz}$$

3.3.2 The Step/Match Switch.

In any electrical/electronic circuit, there is a need for switching to allow current flow or triggering. Switching applications depend on the current flow through the circuit. A high current flow requires a high capacity/ rated switch which could be in form of electrostatic, electromagnetic and mechanical switch.

In this design, the push-to-make (Tap switch) is a small mechanical switch that is very sensitive when depressed. Essentially, the design is achieved by connecting the switches in parallel to

each other. This way, when any of the switches is depressed by an intruder, trigger will be sent to the oscillator hence, it is indicated on the pilot light (amber).

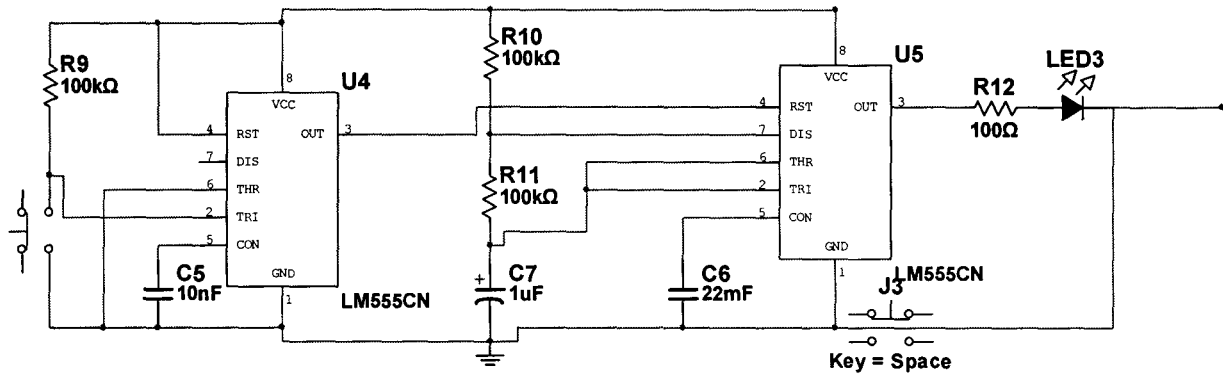


FIGURE 3.10a CIRCUIT DIAGRAM OF STEP/MAT SWITCH MODULE

3.3.3 Infrared Transmitter Section.

In this section, the system has an infrared (IR) transmitter oscillator, beaming at a high frequency of 38kHz. The transmitter is designed to operate in 38kHz which is the band frequency for most IR receivers. The oscillator circuit is designed as follows:

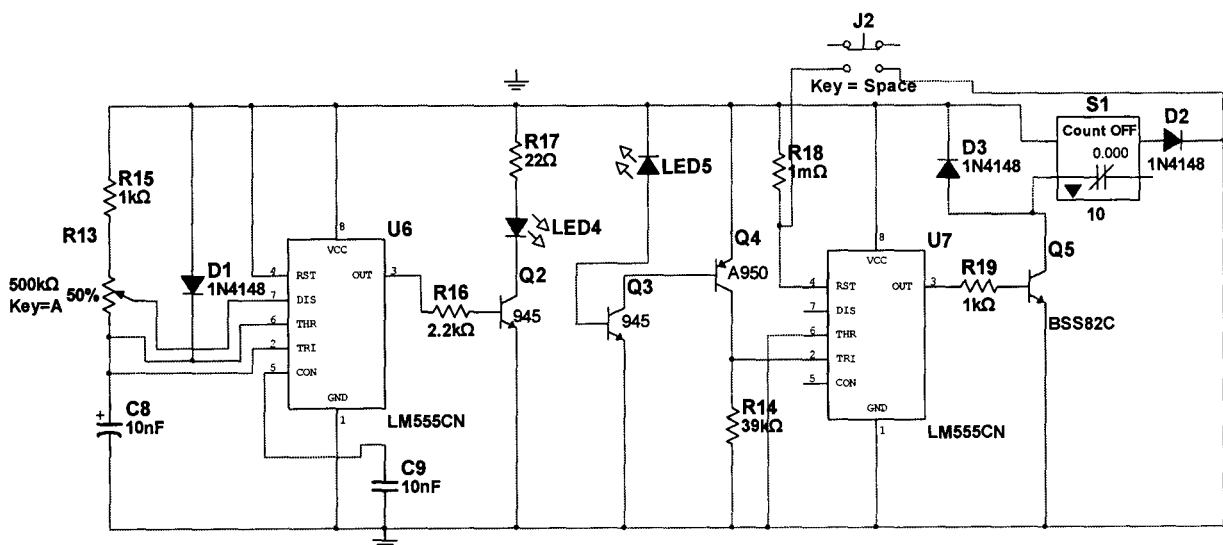


FIGURE 3.10b INFRARED TRANSMITTER AND RECEIVER CIRCUIT

For $F = 38\text{kHz}$. $C_4 = 0.01\mu\text{f}$, $T_{\text{HIGH}} = 0.693 (R_{10}) C_4 \dots (3.13)$

Choosing $R_{10} = 1k\Omega$ we can obtain V_{R1} set value.

$$T_{high} = 0.693 (1 \times 10^3) \times 0.01 \times 10^{-6} = 6.93 \times 10^{-6} \text{sec.}$$

$$F = \frac{1}{T_{high} + T_{low}} \dots (3.15)$$

$$38 \times 10^3 = 1 / (6.93 \times 10^{-6} + T_{low})$$

$$0.26334 + 38 \times 10^3 T_{low} = 1 - 0.26334$$

$$T_{low} = 0.73666 / 38 \times 10^3 = 2.05 \times 10^{-5} \text{sec.}$$

$$\therefore T_{low} = 0.693 (V_{R1}) C_4$$

$$2.05 \times 10^{-5} = 0.693 V_{R1} \times 0.01 \times 10^{-6}$$

$$V_{R1} = 2.05 \times 10^{-5} / (0.693 \times 0.01 \times 10^{-6}) = 2.958 k\Omega$$

$$= 3k\Omega$$

3.3.3 The Infrared Receiver Section

The IR receiver sensor used is the IR diode which is connected in reverse biased mode. When the IR diode in the receiver module receives infrared beam, it allows current to cross its junction and thus provide positive current for the base of the NPN transistor TR2. This transistor turns on and provides a negative current for the PNP transistor TR3. TR3 then conducts and sets pin 2 of the 555 timer above $1/3V_{cc}$. Moreover when this happens, there will not be any triggering hence, its output remains at low state.

Hence when an intruder interrupts the IR beam, the base of transistors TR2 and TR3 goes off and the two transistors go into conduction state. Then pin2 receives a negative trigger through the 39k resistor.

This allows conduction when the diode receives an infrared beam. This beam is amplified by a transistor. T_{R2} and T_{R3} . The 39k resistor helps to trigger the IC₆ when beam is cut off.

3.3.4 The Radio Frequency Tone Transmitter

In every radio frequency transmitter, the important circuits that help to achieve workability are; the audio circuit, the oscillator circuit, the amplifier circuit and the tank circuit. This is so if the signal involves the determination of its bandwidth, signal strength (amplification), its frequency and wavelength.

The alarm/tone transmitter is achieved using the frequency modulation (FM) transmitter. The modulation involves changing the low frequency of the information carrier (audio or tone signal) by allowing it to pass through a high frequency oscillator so that it can be transmitted or carried by an antenna.

In this project, the design implementation was achieved using a 555 timer IC operating in an astable mode with 50% duty cycle as shown below.

For a low frequency of 500Hz, choosing $C = 0.1\mu\text{f}$

The unknown value R is calculated as

$F = 1/T$ where $T = t_{\text{high}} + t_{\text{low}} = 50\%$ duty cycle.

$$T = RC + RC = 2RC$$

$$F = 1/T$$

$$500 = 1/2RC$$

$$RC = 1/(2 \times 500),$$

$$R = 1/2C. 500 = 1/1000C = 1/(1000 \times 0.1 \times 10^{-6})$$

$$R = 1/0.0001 = 10000\Omega = 10k$$

Since the oscillator maintains a stable frequency irrespective of change in voltage. The modulation is achieved by the generator, but for a stable oscillation feedback is required and this is achieved by choosing a high resistor that will provide a small signal current to the input of the amplifier. This is achieved using a 100k resistor.

Therefore a current of 0.6mA to the signal amplifier, we have:

$$V_{cc} - V_{ce} - I_c R_c = 0$$

$$\text{Where } V_{cc} = 6v, \quad V_{ce} = \frac{1}{2}(V_{cc}) = 3v$$

$$6 - 3 - 0.6R_c = 0, \quad 0.6R_c = 3$$

$$R_c = 3/0.6 = 5k \text{ (choosing the nearest value } = 4.7k \pm 10\%)$$

Signal Amplifier: This is achieved using a high frequency transistor of 250MHz and current gain of 200mA. The choice of transistor is 2N2222.

$$\text{Choosing a base voltage of } 2v, \quad V_b = \frac{V_{cc}}{R_1 + R_2} \cdot R_2$$

Choosing $R_1 \gg 3R_2$ (we can choose $R_1 = 10k$).

$$2 = \frac{6}{10 + R2} \cdot R2$$

$$20 + 2R2 = 6R2$$

$$R2 = 20/4 = 5k \text{ (choosing } R2 = 4.7k \pm 10\%)$$

Tank Circuit: $f = \frac{1}{2\pi \sqrt{LC}}$ (choosing a frequency band of 96 MHz and inductor value of 0.2μH)

$$4\pi^2 f^2 LC = 1, \quad C = 1/(4\pi^2 f^2 L)$$

$$C = 1/(4 \times 3.142^2 \times (9.6 \times 10^6)^2 \times 0.2 \times 10^{-6})$$

$C = 13.739\text{pF}$ (Note: with the help of Variable C, frequency range could be changed incase of relocation)

To calculate the amplification current I_c we calculate the reactances of the inductor and capacitor

$$X_L = 2\pi f l = 2\pi \times 96 \times 10^6 \times 0.2 \times 10^{-6} = 120.637\Omega$$

$$X_c = 1/(2\pi \times 96 \times 10^6 \times 13.739 \times 10^{-12}) = 120.668\Omega$$

Therefore $X_L = X_c$

Since R and C are in parallel, the total impedance is given as

$$Z = X_L \cdot X_c / (X_L + X_c)$$

$$= \frac{120.637 \times 120.668}{120.637 + 120.668}$$

$$Z = 60.326\Omega.$$

Therefore, $I_c = I_e$

$$V_{cc} - V_{ce} - I_c Z - I_e R_3 = 0 \text{ and } I_c = I_e = I$$

$$6 - 3 = 60.326I - 220I = 0, \quad 3 - 280.32I = 0$$

$$I = 3/280.32 = 10.7\text{mA.}$$

Therefore the power of the transmitter is $P = I^2 Z$. after substituting for I and Z , we have the power as = 3.45W.

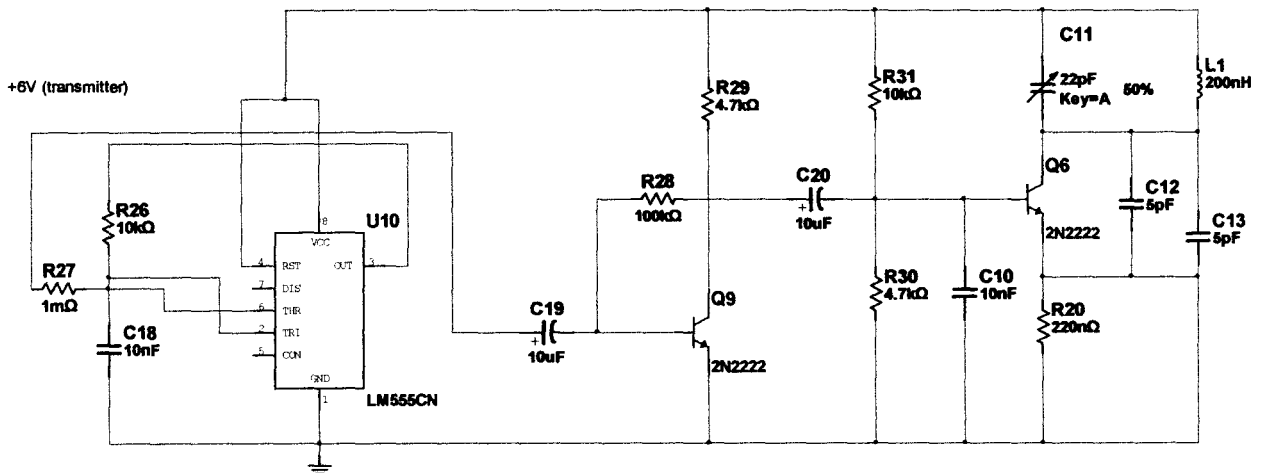
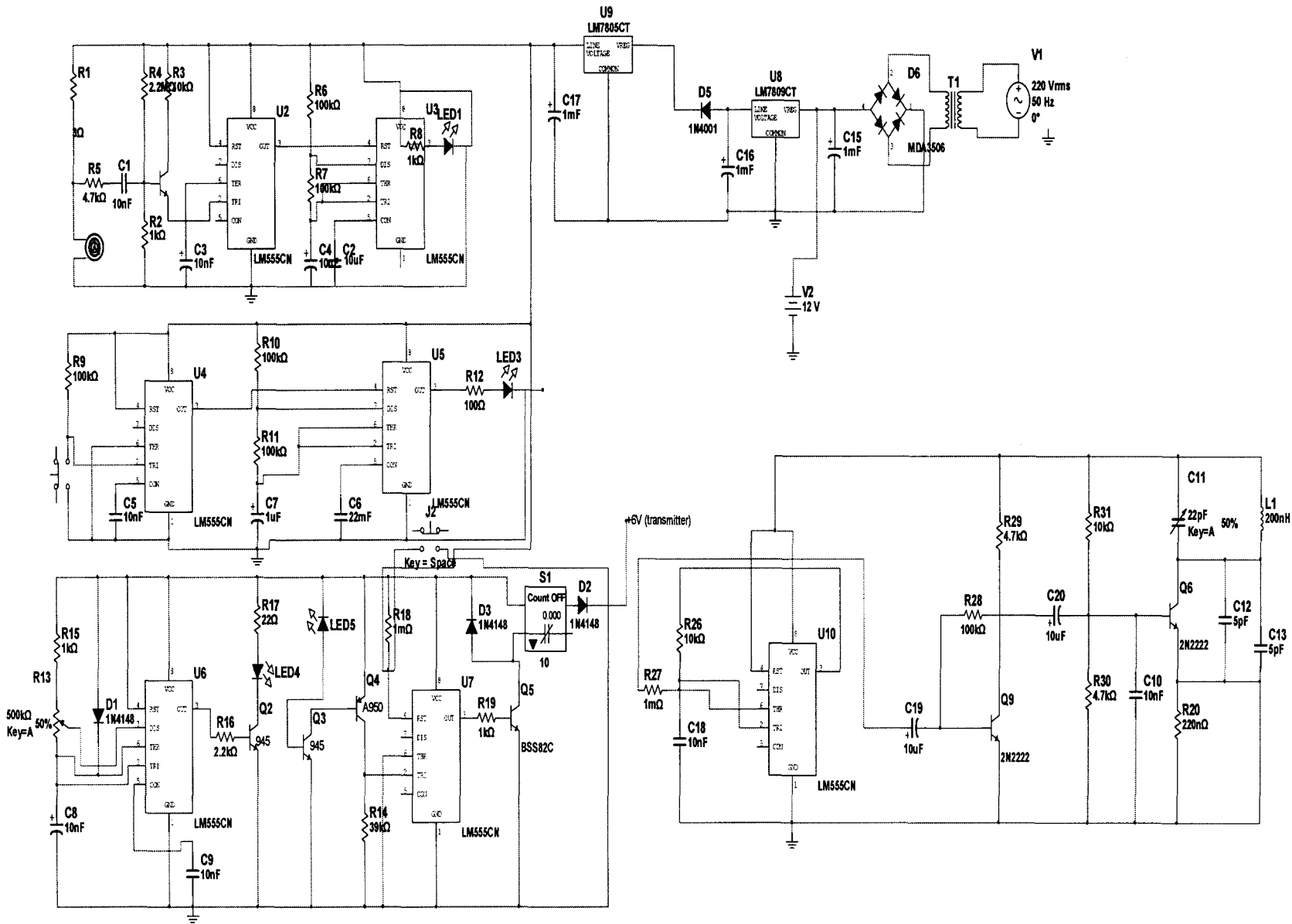


FIGURE 3.11 AUDIO- RADIO FREQUENCY TRANSMITTER CIRCUIT

FIGURE 3.13 COMPLETE CIRCUIT



CHAPTER FOUR (4)

CONSTRUCTION, TESTING AND RESULT

4.1 CIRCUIT CONSTRUCTION

The construction of the intruder detection system was carried out by a process of component to component connection in accordance with the design of the system circuitry. First of all, it was ensured that the various components required for the construction were economically purchased and professionally tested- using a digital multi meter to ensure that they were in good working condition. Also, the accuracy of the values and polarity of the respective components were ascertained using the digital multi-meter as well as other signs and codes. Moreover, a duplicate of most of the components were also purchased alongside to make for easy replacement in the event of damage of any component.

4.1.1 Breadboard Implementation.

As a preliminary step, the system circuitry was first implemented module by module on a breadboard. This was necessary for prior testing for workability before carrying out a final implementation on a Vero-board.

4.1.2 Vero-board Implementation.

Subsequent upon a successful implementation on the breadboard, the components were then transferred and intelligently mounted on the Vero-board with strict adherence to the system

design and circuit diagram. Each component after the other was carefully connected and affixed to the Vero-board by means of appropriate lead-soldering. This was carried out module by module for easy analysis of the system circuitry. Some of the tools used to make for neat and effective connection include: Soldering leads, Electric soldering iron, Sucker, Cutting scissors, Sand paper, Pliers, Digital multi-meter, Brush, Celotape, Cutting knife, et cetera.

Below is a photograph picture of the entire system circuitry:

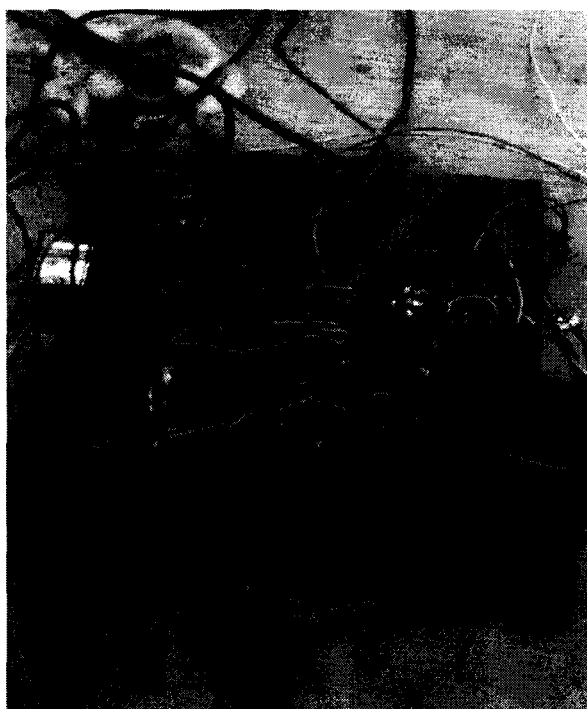


FIGURE 4.1a

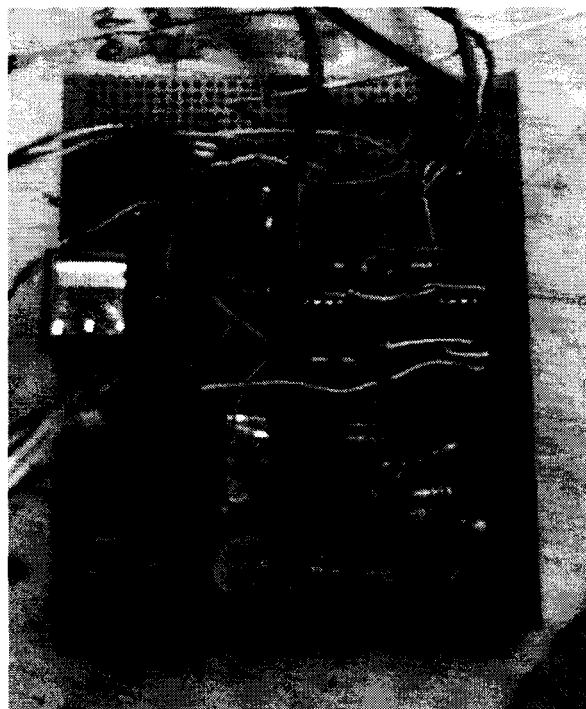


FIGURE 4.1b

4.1.3 Casing and Modeling

Bearing in mind that this project work is supposed to be incorporated into any building and particularly an enclosed area, it became expedient to make a model of a simple building to serve as prototype.

A bit of architectural prowess was applied in the design and construction for the house model. The model was done on a scale 1:50. Predominantly used for the model were cardboard papers, plastics strong adhesives, cutting scissors and razor blades.

The system circuitry was then incorporated into the building prototype and fastened with adhesives.

4.2 TESTING.

Carrying out a module by module implementation of the circuit on the breadboard provided the initial confirmatory tests to ascertain that the project was realizable. The final implementation on the Vero-board was tested module by module by connecting the circuit to ac mains. Forthwith, the sound/vibration detection section being the first module was tested by generating a sound of adequately high intensity near the electronic microphone to test if the circuit would be triggered and the LED come on.

Thereafter, the match/step switch section was tested by applying sufficient pressure on each of the six (6) switches to confirm if each of them could trigger on the circuit for the second module and its corresponding LED.

Next was the infrared beam interruption triggered section. The area between the transmitter and receiver was crossed through to test if the interruption of the invisible beam would trigger on the third LED as well as generate an oscillation for the audio RF transmitter.

Finally, a simple everyday FM receiver (radio) was used to test if the signal could be received and especially at the predetermined design frequency. The receiver was also used to test for the

bandwidth of the frequency by determining the distance from the transmitter at which the signal fades away completely.

Also, the set/reset switch was also operated to test if it efficiently controlled the entire system.

4.3 RESULTS

The result of the module by module test is given below:

For the sound/vibration detection section, after generating a sound of adequately high intensity the circuit was triggered and the corresponding LED came on as expected.

For the match/step switch section, it was noticed that each of the six (6) switches and a varying combination of them all triggered the circuit and the corresponding LED came on as expected.

The result of the infrared beam interruption triggered circuit was not any different as well, immediately the area between the transmitter and receiver was crossed through, the third LED came on.

For the audio- RF transmitter section, the receiver used at the point of test received the signal at a modulated frequency of about 96MHz and over a range of about 150meters the signal was clearly received.

Finally, operating the set/reset switch proved very efficient as the whole circuit was both set and reset by the switch.

CHAPTER FIVE (5)

CONCLUSION, PRECAUTION AND RECOMMENDATION

5.1 CONCLUSION

After going through the rather painstaking rigours of the design and construction of a 555 timer based intruder detection system, I was able to achieve my primary objective of securing life and property by detecting the operation of an intruder and achieving apprehension before the intruder is aware of being monitored.

My auxiliary objectives were also realized, which include;

- Elimination of the discrepancies and false alarms often encountered in the use of single-zone burglar alarm systems by using three (3) detection or trigger zones.
- Avoiding the use of alarm speakers or buzzers at the site of intrusion by employing the audio- radio frequency transmission system- thus making the burglar completely oblivious of being monitored.
- The predominant use of cheap, simple and readily available electronic components like the transistor, resistor, capacitor, diode, and the 555 timer IC rather than other expensive, scarce or sophisticated electronic components.

Conclusively, I would say that the design was successfully realized at construction. Also, the uses and applications of the basic electronic components as taught throughout the bachelors in engineering programme were better appreciated in the course of design and construction.

5.2 PRECAUTIONS

1. Integrated circuit sockets were used to ensure protection of the 555 timer IC in the event of any failure or error in circuit connections.
2. Over-congestion of components during connection was avoided to make for easy soldering and prevent bridging of components at the points of soldering.
3. The copper plating of the Vero-board was scratched out or cut open at points where necessary to avoid short circuiting or bridging of the system.
4. A digital multi-meter was used to verify the polarities and values of the various components used to ensure that the construction was consistent with the design.
5. Special care was taken when connecting the predominantly used IC (555 timer) to avoid any errors in the connection of the pins.

5.3 PROBLEMS ENCOUNTERED.

1. The major problem encountered was the problem of bridging of the circuit due to poor soldering.
2. Another problem encountered was false triggering especially at the sound detection due to the sensitivity of the electrets microphone and the resistors used to bias it.
3. Also, sensitivity of the inductor coil of the tank circuit to ambient conditions also caused variation of the tone frequency being transmitted.

5.4 RECOMENDATIONS.

I would like to propose the following recommendations to aid further work and improvement on this project.

1. The project here submitted can serve only one entry point. I would like to recommend that the system be designed to secure all possible entry points into a building and a micro-controller employed to manage it. With this, a program can be written for intelligent management of the security system by dividing the various entry points into main zones and so, the particular point of entry of the intruder can be detected.
2. This project has only three detection zones; this can be improved upon by incorporating more sensory zones. It is believed that the more the detection zones, the more effective the whole security system would be.

[12] Ayodele S.S. (1998) "Design and Construction of an Anti – buglar alarm system; project report. Unpublished Electrical Engineering Department, ABU, Zaria pp 7 -8,11.

[13] Wes Hayward: Introduction to Radio frequency design

[14] V.K. Mehta and S. Mehta, Principles of Electronics.S. Chand and company Ltd, Ram Nagar, New Delhi (2004), pp 149, 152 – 153, 164 – 166.