DESIGN AND CONSTRUCTION OF PHOTO-DETECTION AND TOUCH SENSITIVE SECURITY SYSTEM

BY

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DEDICATION

This project work is dedicated to the Most High God who has brought me thus far.

I also dedicate this work to my uncle, Chief Michael Ochigbo for his financial and moral support throughout my stay in the university.

DECLARATION

I, Ochigbo Peter 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, Minna.

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ABSTRACT

This project work deals with the design and construction of an integrated alarm system which provides security for a room, office etc. This device achieves its objective by incorporating a touch sensor and a photo-sensor into the alarm system. The photo sensor detects an intruder via interruption of a beam of light directed on it, while the touch sensor triggers an alarm whenever there is physical touch on the touch sensitive mechanism. These two sensors function as a single electronics security system. This integrated system employs an OR gate which accepts inputs from the sensors for a single output into the alarm circuit.

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CHAPTER ONE

INTRODUCTION

1.1 GENERAL INTRODUCTION:

One of the major problems in our society is insecurity. Homes, offices and industries are still under threat of burglars, vandals, and thieves. A lot of time and resources have been devoted to designing projects that will make life easier and more comfortable for man. As a result, there are various forms of security systems with their merits and demerits.

Even with the introduction of alarm systems, there is also a problem of false alarm which has to be minimized. The biggest cause appears to be user error. Other causes can be improper system design, poor quality equipment, improper installation, and poor maintenance. [1]

In these times of increasing crime rates, it has become imperative to safeguard our buildings and properties with adequate safety devices with increased level of sophistication. The cost of these safety devices depend on the equipment and technology being used, the layout of the building and wiring required. For this reason, a photo-detection and touch sensitive security system is uniquely designed in this project to produce dual purpose solutions to insecurity problems.

The design and construction of photo-detection and touch sensitive security system as the name implies serves dual purposes: the ability to detect an intrusion/intruder with or without physical touch. Detection without physical touch is made possible using a photo-detector or light dependent resistor (LDR) which is sensitive to ambient light. The operation is based on the principle of interruption of light rays on the light dependent resistor which triggers an alarm circuit. The second form of detection is the ability to sense an intrusion/intruder via a touch on the mechanism. This was made possible due to the capacitive or inductive effect of the human body in contact with a touch-response circuit arrangement and thereby producing an alarm.

The circuit design presented in this project work consists of six units. These are:

1. The power supply unit which employs the use of mains supplies to ensure constant power supply to the circuit.
2. The light sensor unit which is capable of detecting an intrusion when a beam of light is interrupted on the sensor.
3. Touch sensor unit which is capable of detecting an intrusion via a physical touch on the mechanism.
4. Signal conditioning unit which combines two signals from the photo-sensor and touch sensor using an OR gate.
5. Timer unit which determines the duration an alarm signal stays before going out when triggered.
6. Alarm and driver unit which produces an alarm sound when the circuit is activated.

All these six units were integrated into the circuit design to form a cost effective and reliable electronic alarm system with reduced rate of false alarm.

The entire circuit construction was manually done using tools and equipment available within the immediate environment and tested with available measuring instruments.

1.2 AIMS AND OBJECTIVES

They are:

1. To develop an alarm system that will check the increasing activities of burglars and vandals thereby reducing crime rate in the society.

2. To develop a reliable means of raising an alert in the event of unauthorized intrusion to residential and commercial buildings.

3. To develop a security alarm system that has dual functions.

4. To develop an alarm system that is cheap, effective, and easily acquired by the common man.

1.3 SCOPE OF THE PROJECT

Photo-detection and touch sensitive security system is designed to detect an intruder or intrusion when a beam of light is interrupted on a photo-sensor and to detect intrusion/intruder when there is a touch on a touch sensor. It is however, best used as an indoor alarm system. Due to false alarm vulnerability and weather influence, it is not perfectly suited for outdoor use.

1.4 METHODOLOGY

For this project, various types of sensors could be used such as photo-diode or photo-transistor. However, special consideration was given to light dependent resistor (LDR) due to the following advantages:

1. Good spectral sensitivity
2. Flexible power supply requirement. [16]

The circuit design was implemented in two main stages briefly described below:

The first stage was realized with the use of voltage divider theorem. Since the light dependent resistor (LDR) is a resistance variable device which decreases or increases its value depending on light intensity on it, this resistance is converted to a voltage parameter using voltage divider theorem. That is, a fixed resistor is combined in series with the light dependent resistor through which a voltage is unevenly distributed.

The second stage employs the capacitive and inductive effect of the human body to trigger on the circuit. The sensor comprises of two wires connected between pin 2 of a 555 Timer and ground of power supply. This low signal produced at pin 2 of the 555 Timer is then passed to the timer circuit which generates an output signal through its pin3

An OR gate was then used to combine signals from the two sensors so as to produce a single output signal for the alarm circuit.

Also, the power unit of the circuit is designed to provide +5v dc for effective operation of the system and the timing circuit determines the time at which the alarm goes ON and OFF.

1.5 PROJECT OUTLINE

This project is divided into five main chapters, which are enumerated as follows:

CHAPTER ONE; consist of introduction, aims and objectives, scope and methodology.

CHAPTER TWO; consist of literature review and historical background.

CHAPTER THREE; deals with design and analysis, calculations and decision on component selection choice, for building circuit.

CHAPTER FOUR; deals with construction and testing of the circuit, discussion of result, problems encountered and troubleshooting guide.

CHAPTER FIVE; consist of general conclusion, recommendation and references.

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND

An alarm system is a device that warns people of a particular danger [3]. They are designed to alert the user to a specific danger. The development of alarm systems started with the creation of man. Man required a way of giving alert information which was in form of signals and exclamation or shouting. This was however, replaced by clapping of hands and beating of gongs by town carriers to alert the community in order to disseminate information in the early African society. All these methods of raising alert or warning were crude and unreliable.

With the advancement in science and technology, these crude methods of alarm gave way for electronic alarm systems in the 18th century. These electronic alarm systems operated without any human effort. Once they sense a particular signal depending on their design, they gave an indication in form of a loud sound or noise [4].

In 1852, the first electric alarm system was invented by Edwin Holmes in Boston [5]. The basic operation featured a tripwire that electrically powered a solenoid that struck a gong when it was set off. This alarm was first installed in February 21, 1858 in Boston, Massachusetts [6].

When they were first available in the early 1900's, house alarms were expensive to install and difficult to monitor. As a result, they were not something bought by the average man but instead reserved for those with lots of cash and lots of project. As technology has improved however, cheaper house alarms have found their place in the market and are now a featured of many homes. As the home alarm system became more common, the number of false alarms increased to such a degree that many 'local' alarms began to go unnoticed and unreported. Intruders also learnt how to disarm the system so could quickly and easily stop the alarm. When first invented, house alarms were triggered by the release of a pressure button fitted into a window frame. This basic alarm was fundamentally flawed as all the intruder needed to do to silence the alarm was to close the door or window. Nowadays, there are various alarm systems on the market ranging from inexpensive DIY alarms to highly sophisticated system requiring professional installation. Unsurprisingly, house alarms have changed a lot over the last century and no doubt will continue to improve as technological knowledge expands [7].

Today, we have the new generation of security alarm systems which can be classified into two main fields: home burglar alarms and industrial perimeter intrusion detection.

Generally, there are two types of alarm for security purposes which are: indoor and outdoor alarms [8].

2.2 INDOOR ALARMS

These types of alarm system use sensors which are designed for indoor use. Outdoor use would not be advised due to false alarm vulnerability and weather influence.

(a) Passive Infrared Detectors (PIR)

This is one of the detectors found in most household and small business environment because it offers affordable and reliable functionality. The term passive means the detector is able to function without the need to generate and radiate its own energy (unlike ultrasonic and microwave volumetric intrusion detectors that are active in operation). Passive infrared detectors are able to distinguish if an infrared emitting object is present by first learning the ambient temperature of the monitored space and then detecting a change in the temperature caused by the pressure of the object. Using the principle of differentiation, which is a check of pressure or non-pressure; PIRS verify if an intruder or object is actually there. Creating individual zones of detection where each zones comprises one or more layers can achieve differentiation. Between the zones there are areas of no sensitivity (dead zones) that are used by the sensor for comparism [8].

(b) Ultrasonic Detectors

Using frequencies between 25KHZ and 75KHZ, these active detectors transmit ultrasonic sound waves that are inaudible to humans. The Doppler shift principle is the underlying method of operation, in which a change in frequency is detected due to object motion. This is cause when a moving object changes the frequency of sound waves around it. Two conditions must occur to successfully detect a Doppler shift event.

1. There must be motion of object either towards or away from the receiver.
2. The motion of the object must cause a change in the ultrasonic frequency to the receiver relative to the transmitting frequency.

The ultrasonic detector operates by the transmitter emitting an ultrasonic signal into the area to be protected. The sound waves are reflected by solid objects (such as the surrounding floor, walls and ceiling) and then detected by the receiver. Because ultrasonic waves are transmitted through are, then hard-surfaced objects tend to reflect most of the ultrasonic energy, while soft surfaces tend to absorb most energy. When the surfaces are stationary, the frequency of the waves detected by the receiver will be equal to the transmitted frequency. However, a change in frequency will occur as a result of the Doppler principle, when a person or object is moving toward or away from the detector. Such an event initiates an alarm signal. This technology is considered obsolete by many alarm professionals, and is not actively installed [8].

(c) Glass Break Detectors

The glass break detector may be used for internal perimeter building protection. When glass breaks it generates sound in wide band frequencies. These can range from infrasonic, which is below 20 hertz (HZ) and cannot be heard by the human ear, through the audio band from 20HZ to 20KHZ which human can hear right up to ultrasonic, which is above 20KHZ and again cannot be heard. Glass break acoustic detectors are mounted in close proximity to the glass panes and listen for sound frequencies associated with glass breaking. Seismic glass break detectors are different in that they are installed on the glass pane. When glass breaks it produces specific shock frequencies which travel through the glass and often through the window frame and surrounding walls and ceiling. Typically, the most intense frequencies generated are below 3 and 5 KHZ, depending on the type of glass and the pressure of a plastic interlayer. Seismic glass break detectors "feel" these shock frequencies and in turn generate an alarm condition [8].

(d) Smoke, Heat, And Carbon Monoxide Detectors

Most systems may be equipped with smoke, heat, and/ or carbon monoxide detectors. These are also known as 24 hour zone (which are on at all times). Smoke detectors and heat detectors protect from the risk of fire and carbon monoxide detectors protect from the risk of carbon monoxide [8].

2.3 OUTDOOR ALARMS

These types of alarm systems use sensors found most of the time mounted on fences or installed on the perimeter of the protected area. Some of these are given below.

(a) Vibration or Inertial Sensors

These devices are mounted on barriers and are used primarily to detect an attack on the mechanical configuration that forms part of the electrical circuit. When movement vibration occurs, the unstable portion of the circuit moves and breaks the current flow, which provides an alarm. The technology of the devices varies and can be sensitive to different levels of vibration. The medium transmitting the vibration must be correctly selected for the specific sensor as they are best suited to different types of structures and configurations.

A rather new and unproven type of sensor uses piezo-electric components rather than mechanical circuits, which can be tuned to be extremely sensitive to vibration.

Advantages: very reliable sensors, low false alarm rate and middle place in the price range.

Disadvantage: The disadvantage here is its higher price and must be mounted on the fence.

(b) Passive Magnetic Field Detection

This buried security system is based on the magnetic Anomaly Detection principle of operation. The system uses an electromagnetic field generator powering with two wires running in parallel. Both wires run along the perimeter and are usually installed about 5 inches apart on top of a wall or about foot buried in the ground. The wires are connected to a signal processor which analyzes any change in the magnetic field.

This kind of buried security system sensor cable could be on the top of almost any kind of wall to provide regular wall detection ability or be buried in the ground.

Advantages: very low false alarm rate can be put on top of any wall, very high chance of detecting real burglars.

Disadvantages: cannot be installed near high voltage lines, radar, or airports [8].

(c) Microwave Barriers

The operation of a microwave barrier is very simple. This type of device produces an electromagnetic beam using high frequency waves that pass from the transmitter to the receiver, creating an invisible but sensitive wall of protection. When the receiver detects a difference of condition within the beam (and hence a possible intrusion), the system begins a detailed analysis of the situation. If the system considers the signal a real intrusion, it produces an alarm signal that can be treated in analog or digital form.

Advantages: low cost, easy to install, invisible perimeter barrier, unknown perimeter limits to the intruder.

Disadvantages: extremely sensitive to weather as rain, snow and fog for example would cause the sensor to stop working, bushes or anything that blocks the beam would cause false alarm or lack of detection [8].

(d) Fiber Optic Cable

A fiber-optic cable can be used to detect intruders by measuring the difference in the amount of light sent through the fiber core. If the cable is disturbed, light will 'leak' out and the receiver unit will detect a difference in the amount of light received. The cable can be attached directly to a chain wire fence or bonded into a barbed steel tape that is used to protect the loops of walls and fences. This type of barbed tape provides a good physical deterrent as well as giving an immediate alarm if the tape is cut or severely distorted.

Advantages: very simple configuration, easy to install, can detect for distances of several kilometers on a single processor.

Disadvantage: high rate of false alarm or no alarms at all for systems using light that leaks out of the optical fiber [8]

2.4 MODERN ELECTRONIC ALARM SYSTEMS

A modern security system with its array of electronic components is designed to sense, decide, and act. The security system senses events such as motion in a room, decides if the event passes a threat, and then acts on the decision [9].

Some of the modern alarm systems commonly used these days are; duress alarms, burglar alarms, anti-theft alarms, speed limit alarms

(a) Duress Alarm Systems

Modern duress alarms are generally electronic devices that vary widely in capabilities. They are used when under threat to send alarm signals to a specific location. There are three general overlapping categories of duress alarms that can send one or more levels of distress signals to a particular location [10]. They are:

1. A panic button alarm- a push button mounted in a fixed location.
2. An identification alarm- a portable device that identifies the owner of the device.
3. An identification/location alarm- a portable device that identifies location and tracks the person who activated the duress alarm.

The panic button is by far the most common type of duress alarm. It is found in schools, banks, offices e.t.c. The simplest application is a strategically located button that when initiated, would engage a dedicated phone line. A pre recorded message specifying the location and urgency is sent to several locations such as police department or other security agencies.

The second type of duress alarm incorporates a pager-like device that has a panic button built in and is either worn by the user or installed within a foot switched located under a desk. When the panic button is pushed, a wireless alarm signal is sent to the closest installed wireless unit (a type of repeater) which sends the signal to an alarm console. This system does not give specific locations other than the general pre programmed zone of repeater. This type of alarm also incorporates a two way radio built into the pager that would allow communication between the console operator and the person under duress.

The third type of duress alarm is a smarter version of the second type. It can identify, locate and track the person who activates the duress alarm of his or her pager. The electronics and software of such a system produces a positioning symbol on a console or map like display. Some advance duress alarm systems use hybrid design that tracks the user with global positioning satellite (GPS) technology and radio frequency or infrared system [10].

(b) Burglar Alarm Systems

Most burglar alarm systems involve a circuit loop system that rings a bell or activates a siren when set off. A central control box monitors several motion detectors and perimeter guards and sound an alarm when any of them are triggered. Some burglar alarms work on the concept of magnetic contacts and others on the concept of sensitivity. Sometimes, sensors are placed in the hallways or large rooms, which activate an alarm when the beam of light is interrupted by a person walking across it. Motion detection is also carried out by ultrasonic means. Point detector burglar alarm brings to notice any intrusion at a specific point such as doors or windows. Area detection for intruders is done within a protected area with the help of ultrasonic transducers and passive infrared detectors. These sensors can be used individually or in combination depending on the kind of burglar alarm sophistication required [11].

(c) Speed Limit Alarm Systems

These are wireless portable devices or units adaptable with most internal combustion engines. The circuit is designed to alert the vehicle driver when he has reached the maximum speed limit. It eliminates the needs to look at the speedometer thereby reducing the risk of accident while driving. This system works on the basis of the relationship that exists between the revolution per minutes (RPM) and speed of vehicle. It monitors the RPM and starts giving a deep when the maximum speed is attained [12]

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 DESIGN UNITS

The system design was implemented in six units as shown in fig 3.1. These units are:

a. The power supply unit
b. The light sensor unit
c. The touch sensor unit
d. The signal conditioning unit
e. The timer unit
f. The alarm and driver units

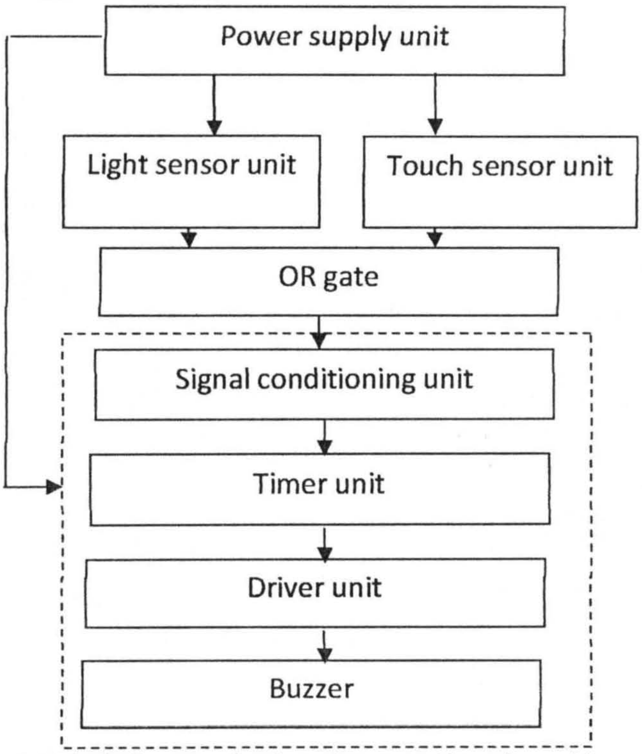

Fig 3.1 Block diagram of a photo detector and touch sensitive security system

The various units are explained below:

3.2 POWER SUPPLY UNIT

This unit supplies regulated power to the entire circuit. It is made up of a power transformer, rectifier, filter and voltage regulator, requiring 5v d.c supply. Power to the system must be supplied from a reliable source and a standby alternate power source is also desirable because security checks must be conducted regularly.

The schematic diagram of the power supply unit is shown below.

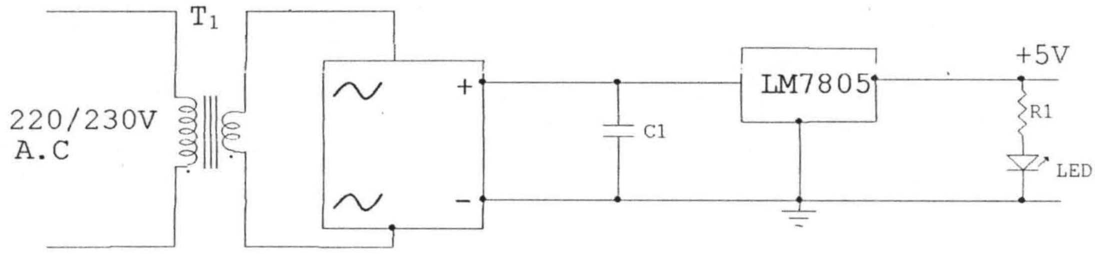

Fig 3.2 Schematic diagram of the power supply unit

3.2.1 Power transformer

Power transformer is a static electrical machine used in stepping-down or stepping-up the electrical voltage and current. The one used in this project is a 220/12v/500mA step-down transformer with the 220v as the primary winding voltage and 12v as the secondary winding voltage. The schematic diagram of a power transformer is shown below.

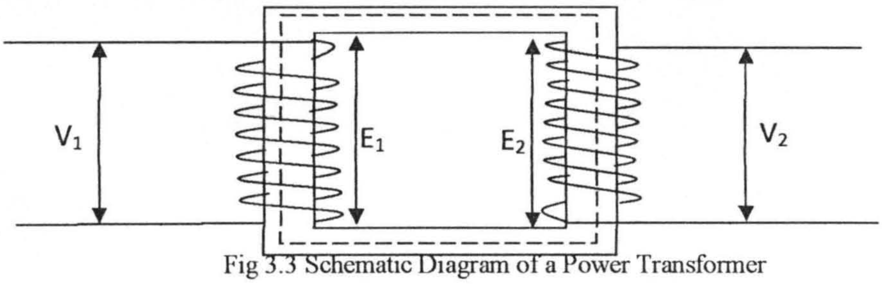

Fig 3.3 Schematic Diagram of a Power Transformer

The operation of the power transformer is described below:

When an alternating voltage is applied to a transformer; an alternating current, limited in value by the inductance of the winding flows. The magnetizing current produces an alternating magneto motive force (mmf) which operates an alternating magnetic flux (φ) in weber. The flux is constrained within the magnetic circuit and induces a voltage in the linked secondary window (V_2) which produces an alternating current if it is connected to an electric load. This secondary load (I_2) in turn produces its own mmf (E) and creates a further alternating flux which links backs with the primary winding (V_1) [2].

A load current then flows in the primary winding (V_1) of sufficient magnitude to balance the mmf produced by the secondary load current (I_2) so the primary winding turn (N_1) carries load current and the magnetic core carries only the flux produced by the magnetizing current. The relative voltage across each winding and the current flowing in them are related by the ratio of turns in the two windings as follows:

Voltage relation

$\frac{V_1}{V_2} = \frac{N_1}{N_2} = K$ [2].

Where K = winding turn ratio or transformer ratio

V_1 = primary voltage (r.m.s value)

V_2 = secondary voltage (r.m.s value)

N_1 = primary winding turn

N_2 = secondary winding turn

$$\frac{I_1}{I_2} = \frac{N_1}{N_2} = k$$

Where, I_1 = induced primary current

I_2 = induced secondary current

3.2.2 The bridge rectifier

The waveform of the transformer secondary voltage (V_2) is an alternating sinusoidal voltage which corresponds to 12V and assumes a sinusoidal voltage given by $V = V_{max}Sinwt$. This alternating current (a.c) has a property of changing its polarities which can either be positive or negative half cycles. The process of converting this sinusoidal a.c voltage to a direct component (d.c) of 12v is called rectification and employs the use of rectifiers (mostly diodes) to change a.c voltage into d.c by eliminating the negative half cycle of the a.c voltage.

A full wave rectification method is employed here because a half-wave rectification will not make use of the other half of the supply waveform but a full wave transposes both halves of the sine-wave input into a single output. In the bridge rectification circuit shown below, when diodes $D_2$and D_4 are forward biased they conduct for the first half cycle and when the polarity changes (reverse biased), diodes D_1 and D_3 will conduct in the second half cycle. The result is a full wave rectified output with two diodes conducting in series on each half cycle [2].

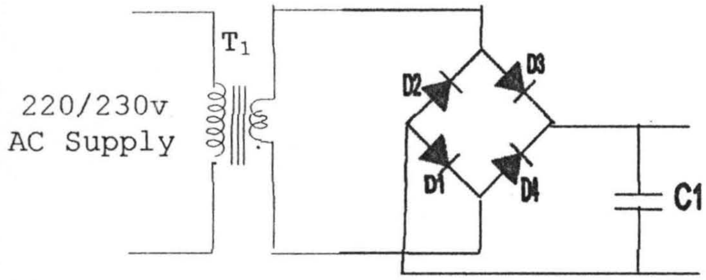

Fig 3.4 full wave rectification

3.2.3 Filter

The pulsating d.c voltage output from the rectifier stage is converted into constant d.c voltage with the aid of a filter capacitor (C_1). This capacitor is a large value electrolytic capacitor. It charges up (i.e delivers energy) during the non-conducting half cycle thereby opposing any change in voltage. The filter stage therefore filters out voltage pulsations (or ripple).

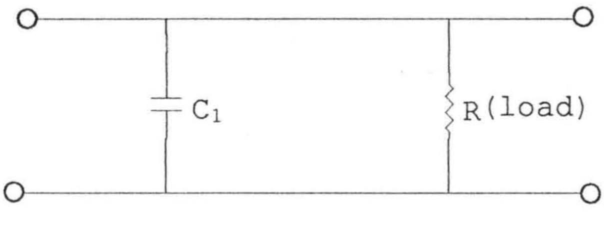

Fig 3.5 circuit diagram of the filter circuit

Mathematical analysis for capacitor selection

Supply voltage by transformer, $V = 12V$

Peak voltage, $V_{peak,} = \sqrt{2} \times V$

$= \sqrt{2} \times 12$

$= 16.97V$

Assuming that the unregulated voltage has a ripple factor of 15% of peak voltage,

$\therefore d_v = \frac{15}{100} \times 16.97$ (d_v = peak-to-peak ripple voltage)

$= 2.546V$

But $d_v = \frac{1}{4cf}$ volt [13]

$$C = \frac{1}{4 \times 50 \times 2.546}$$

$= 1963.86\mu f$

$2200\mu f$ Was selected.

Mathematical analysis for limiting resistor (R_1)

The limiting resistor (R_1) for the light emitted diode (LED) was calculated as shown below:

From ohm's law, V = IR [2]

Where, v = applied voltage

I = flow of current

R = resistance

$$\therefore R_1 = \frac{V_{cc}-V_{LED}}{I_{LED}}$$

Where, $V_{cc} = supply\ voltage$

$V_{LED} = supply\ voltag\ eacross\ LED$

$I_{LED} = Maximum\ allowable\ current\ across\ LED$

$V_{cc} = 5v$

$I_{LED} = 20mA$

Choosing $I_{LED} = 4mA$

$$R_1 = \frac{5-1.7}{4\times10^{-3}}$$

= 825kΩ

The preferred resistor value closest to 825Ω is 1 kΩ

Current drawn by LED $= \frac{5V}{1000\Omega}$

$= 5mA$

3.2.4 Voltage regulation

The output of the filter stage varies slightly when the load current or input voltage varies and it is a 12v d.c supply which is higher than the circuit arrangement. For this reason, an LM7805 regulator was used to stabilize the voltage and also reduce it from 12v to 5v steady d.c supply. Another option for regulation is the zenar diode, LM317. Also, a limiting resistor was used to light up an LED so that it can serve as an indicator for input power source.

3.3 LIGHT SENSOR UNIT

This unit is made up of a light dependent resistor (LDR), two variable resistors, and a comparator as shown below. The circuit detects a sudden shadow falling on the light sensor and sounds the buzzer when this happens. The circuit will not respond to gradual changes in brightness to avoid false alarm. Normal lighting can be used, but the circuit will work best if a beam of light is arranged to fall on the light sensor. Breaking this beam will generate a signal to the signal conditioning unit which then triggers the alarm.

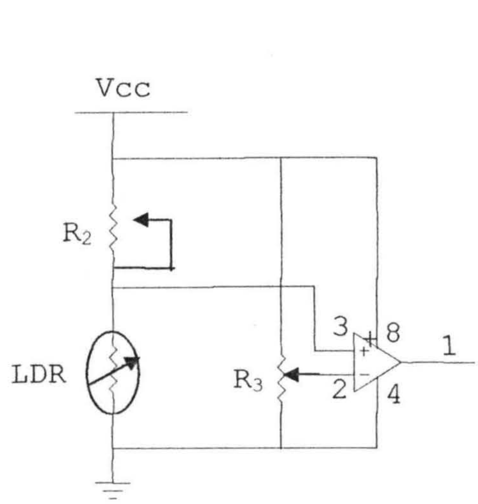

Fig 3.6 circuit diagram of light sensor unit

3.3.1 Light dependent resistor

Light dependent resistors (LDRS) are made from cadmium sulphide containing no or very free electrons when not illuminated. The resistance is then quite high. When it absorbs light, electrons are liberated and the conductivity of the material increases. Cadmium sulphide (cds) is, therefore a photoconductor. The approximate relationship is;

$R = AE^{-\alpha}$

Where E = Illumination in lux

R = Resistance in ohms

A and α *are constants*

The device consists of a pair of metal film contacts separated by a snake-like track of cadmium film, designed to provide the maximum possible contact area with the two metal films [14]

The basic structure and symbol of LDR are given below

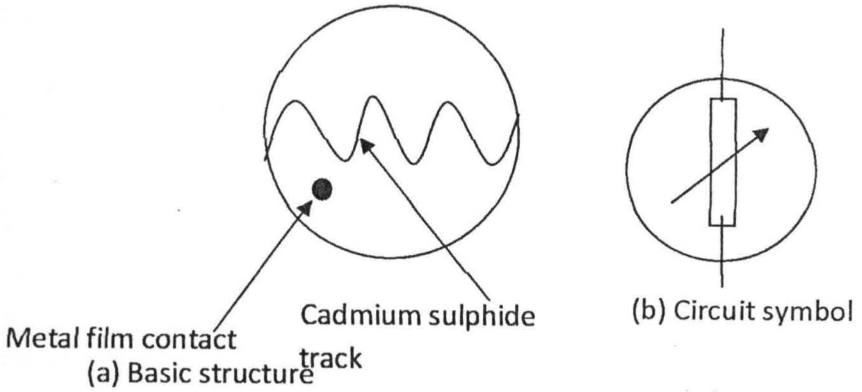

Fig 3.7 Basic structure and circuit symbol of LDR

In this design, the light dependent resistor detects a sudden shadow falling on it and gives corresponding output when this happens. It is combined in series with a variable resistor so as to achieve voltage divider between them. This enables supply voltage (Vcc) to be split up into two voltages corresponding to their resistances.

From fig 3.6 above, the variable resistor R_2, is set at 1kΩ and in series with the LDR term so as to achieve a voltage divider as shown below

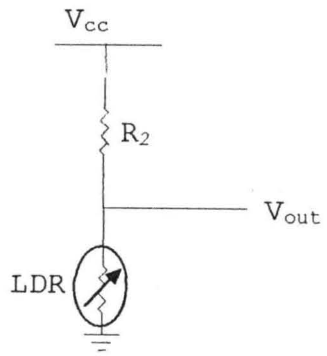

Fig. 3.8 circuit diagram of a voltage divider

Let $R_2 = R_a$

$$\therefore V_a = voltage\ across\ R_a$$

Let LDR = R_b

$$\therefore V_b = voltage\ across\ R_b$$

Resistance of LDR at light = 300Ω

Resistance of LDR at darkness = 2.8kΩ

From voltage divider theorem,

$$V_{out} = IR_b = \frac{R_b}{R_a+R_b} \qquad [2]$$

At light:

$$V_b = \frac{R_b}{R_a+R_b} \times V_{cc}$$

$$= \frac{300}{(300+1000)} \times 5$$

$$= \frac{200}{1300} \times 5 = 1.15v$$

$$V_a = V_{cc} - V_b = 5 - 1.15 = 3.85v$$

In total darkness;

$$V_b = \frac{2800}{2800+1000} \times 5$$

$$= 3.68v$$

$$V_a = V_{cc} - V_b = 5 - 3.68 = 1.32V$$

From the analysis shown above, the voltage across LDR at night (i.e when it senses darkness) is higher than when the LDR is at light.

3.3.2 Comparator section:

This section of the light sensor unit compares two voltages together. It has an output, inverting and non-inverting input as shown in fig 3.6 above.

The principle of operation is that the voltage at the non-inverting input unit most be greater than the voltage at the inverting input for an output. Therefore, since we want the system to output a low except when shadow comes on it, the output of the potential divider (in fig 3.6) is connected to the non-inverting input and the variable resistor R_3, is used to determine the voltage at the inverting input.

The variable resistor, R_3 is set at 50% if its value dividing the supply voltage (Vcc) into two equal halves. Therefore, provided there is light on the sensor, the voltage at the inverting input becomes greater than that of the non-inverting making the comparator to output a low. When darkness comes on it, the voltage at the non-inverting input becomes higher than that of the non-inverting input making the comparator to output a high.

A standard op-amp operating in open-loop configuration (without negative feedback) can be used as a comparator. When the non-inverting input (V+) is at higher voltage than the inverting input (V-) the high gain of the op-amp causes it to output a positive voltage. When the non-inverting input (V+) drops below the inverting input (V-), the op-amp outputs a negative voltage it can.

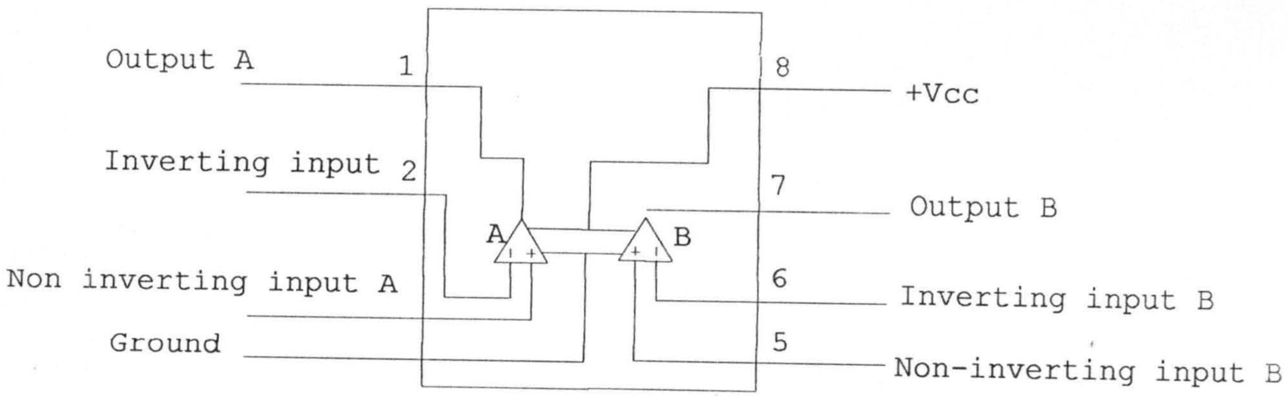

Fig 3.9 Integrated LM358 OP-amp DIP Package pin connections

3.4 TOUGH ACTIVATED SENSOR UNIT

This unit serves as a sensor or signal detector when there is a physical touch on it. It was designed with a 555 timer IC connected in a monostable mode as shown below.

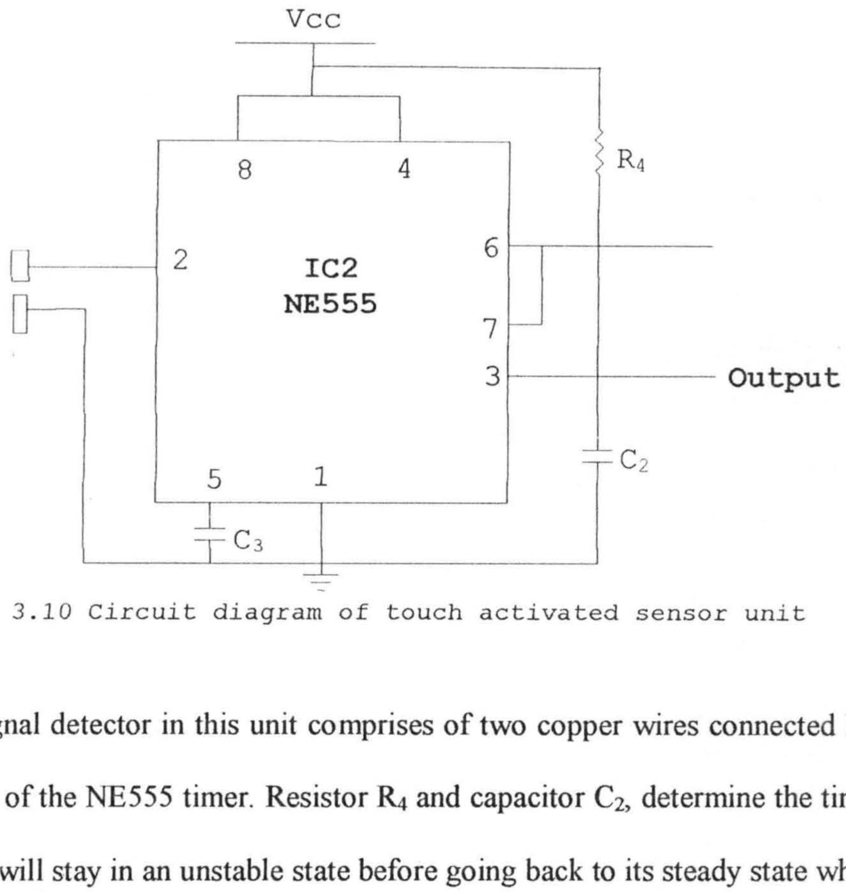

Fig 3.10 Circuit diagram of touch activated sensor unit

The signal detector in this unit comprises of two copper wires connected between pin 2 and ground of the NE555 timer. Resistor R_4 and capacitor C_2, determine the time range when the output will stay in an unstable state before going back to its steady state when triggered. 1 μf capacitor is connected between pin 5 and ground to avoid false trigger when the system is made active from an unstable state.

When the touch activated sensor is triggered, the output stays for a particular period of time before going back to zero (0) volt. This time is determined by the formula.

$T = 1.1RC$ (in second)

Where T = time range

R = resistor

C = capacitor

Therefore, choosing T=4 seconds, C = $100\mu f$, the value of resistor used is calculated as follows;

$T = 1.1R_4C_2$

$4 = 1.1 \times R_4 \times 100 \times 10^{-6}$

$$R_4 = \frac{4}{1.1 \times 100 \times 10^{-6}}$$

=36.3kΩ

In this design, 33kΩ was chosen as an approximate value of the required output.

3.4.1 Operation of A 555 timer IC

The 555 timer is an IC which consists of two comparators (simply op-amps), an R-S flip-flop, two transistors and a resistive network. It can be used as an oscillator as well as a timer. It has two basic modes of operation which are monostable mode which has only one stable state and astable mode which has no stable state.

The diagram below shows the internal circuitry of a 555 timer IC

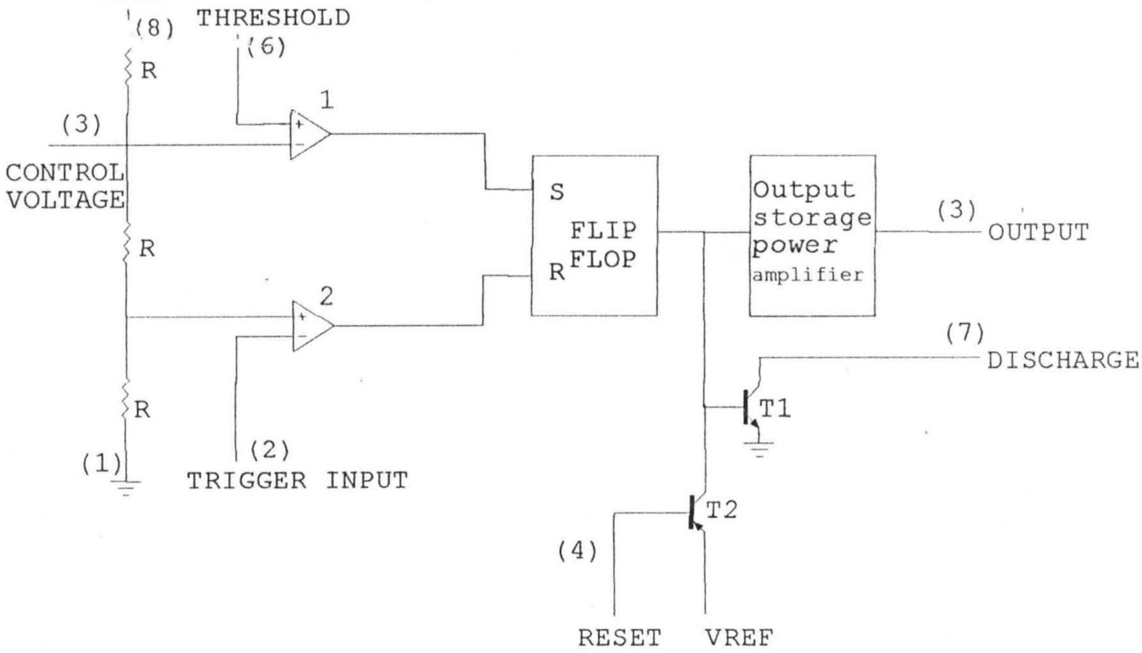

Fig 3.11 555 Timer IC showering its internal circuitry

From the figure above, the resistive network consists of three equal resistors and acts as a voltage divider. Comparator 1 compares threshold voltage with a reference voltage, V+ $^2/_3\,V_{cc}$ volts. Comparator 2 compares the trigger voltage with a reference voltage, $V + \frac{1}{3}V_{cc}$ volts. Output of both the comparator is applied to the flip-flop. Flip-flop assumes its state according to the output of the two comparators.

One of the two transistors is a discharge transistor of which collector is connected to pin 7. This transistor saturates or cuts-off according to the output state of the flip-flop, the saturated transistor provides a discharge path to a capacitor connected externally. Base of another transistor is connected to a reset terminal. A pulse applied to this terminal resets the whole timer irrespective of any input [14].

3.4.2 Pin definition

a. Pin 1 (ground): This is the most negative supply potential of the 555 timer IC which is normally connected to the circuit ground when operated from positive voltage.
b. Pin 2 (trigger): This pin is the input to the comparator 2 and is used to set the latch which in turn causes the output to go high.
c. Pin 3 (output): This pin is set to high condition when ever pin 2 is momentarily taken from a high to a low level. The output voltage available at this pin is approximately equal to the supply voltage applied to pin 8 mines 1.7v.
d. Pin 4 (reset): This is used to reset latch and return the output to a low state.
e. Pin 5 (control voltage): This pin allows direct access to the $^2/_3 V_{cc}$ voltage divide point, the reference level for the comparator 1.
f. Pin 6 (threshold): This is one of the input to comparator 1 and is used to reset the latch which causes the output to go low.
g. Pin 7(Discharge): This pin act as the discharge for the 555 timer IC.A timing capacitor is usually connected between this pin and the ground and is discharged whenever the internal transistor of the 555 timer turn on.
h. Pin 8 (V_{cc}): This is the positive supply voltage of the 555 timer IC. The operating range of the IC voltage supply is +5v (minimum) to +18v (maximum) [14].

3.5 SIGNAL CONDITIONING UNIT

This unit consists of two diodes, an LM741 operation amplifier and a variable resistor as shown below

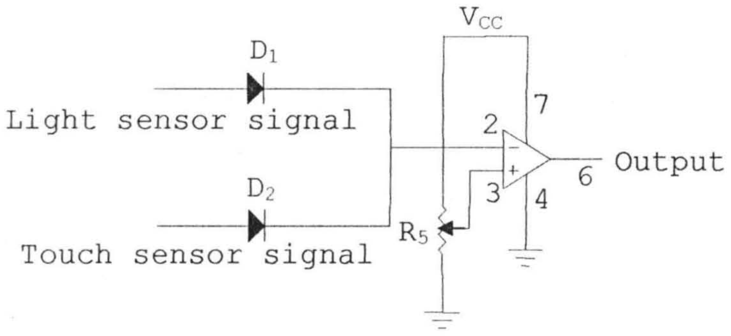

Fig 3.12 Circuit diagram of signal conditioning unit

The two diodes (D_1 and D_2) act as an OR gate and the LM741 operational amplifier as a comparator. The Output signal from this unit is fed into pin 3 of a 555 timer connected in a monostable mode. To trigger the timer would require a signal that is originally high then goes low, so the signal conditioning is necessary.

The output signal from both sensors is initially at logic low but when they sense signals, they go high. This would not be able to trigger the timer as required, so these signals from the sensors are ORED using diodes to the inverting arm of the comparator while the non-inverting arm is given the reference voltage.

The variable resistor, R_s is set at 50% of its value so that 2.5v is seen at the non-inverting input. The output from the light sensor gives 3.6v as the high voltage and the touch sensor gives 3.33v as the high voltage so these two signals are ORED to give a low output thereby triggering the 555 timer IC of the alarm and driver unit.

3.5.1 741 operational amplifier

This section of the signal conditioning unit compares two voltages together. Due to the large gain of the operational amplifier, it either outputs a HIGH or a LOW depending on the configurations.

The LM741 op-amp is a plastic encapsulated device with dual in line (DIL) rows of pins. Such device are said to be directly pin compactable. The pin connections are shown below

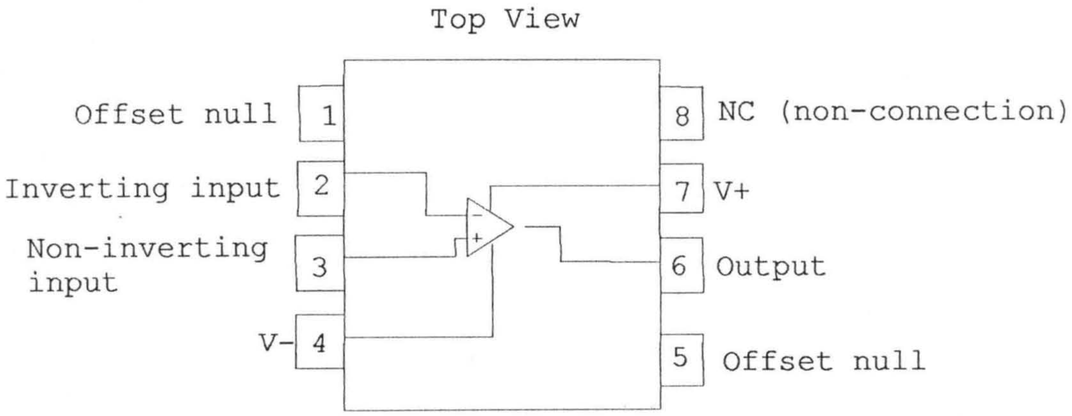

Fig 3.13 integrated 741 op-amp pin connections

The operational amplifier has two types of connections: inverting and non-inverting. When a voltage is applied to inverting input pin 2, the output voltage has a sign which is opposite to that of the input. In case, the input voltage is applied to pin 3, which is designated as non-inverting, the output voltage has the same sign as the input.

The operational amplifier is shown by a triangular symbol with inverting and non-inverting inputs being connected at pin 2 and 3 respectively. The op-amp output appears at pin 6. Several other pins are labeled in the diagram. Pin 7 and 4 are connected to positive and negative to the integrated circuit. Two other pins (1 and 5) are provided on 741 and are labeled offset null [15].

3.6 TIMER UNIT

This unit consists of a 555 timer connected in a monostable mode as shown below.

The function of the timer unit is to produce a trigger current which comes out through its pin 3 whenever pin 2 is activated through the signal conditioning unit and to determine the time the alarm will sound before going off.

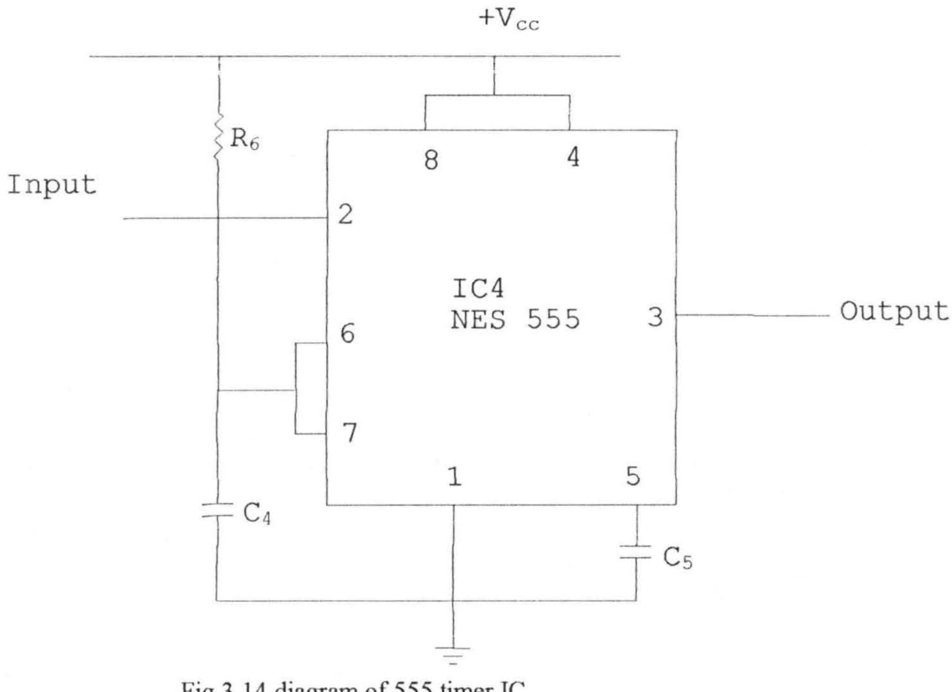

Fig 3.14 diagram.of 555 timer IC connection in monostable mode

The resistor, R_6 and capacitor C_4 determines the time range when the output will stay in an unstable state before going back to its stable state when triggered. An Output signal from the signal conditioning unit is fed into pin 2 of this timer IC.

The time the output stays before going back to off state is determine by the formula;

$T = 1.1R \times C$ (in seconds)

Where T = time in seconds

R = resistance in ohm's

C = capacitance in farads

Choosing T = 4 seconds and L = $100\mu f$, the value of R_6 is calculated as follows:

$T = 1.1R_6 \times C_4$

$4 = 1.1\ R_6 \times 100 \times 10^{-6}$

$$\therefore R_4 = \frac{4}{1.1 \times 100 \times 10^{-6}} = 36.3\Omega$$

In the design, 33kΩ was chosen as the nearest value to the calculated value.

3.7 ALARM AND DRIVER UNIT

This unit consists of buzzer, a transistor and resistor as shown below

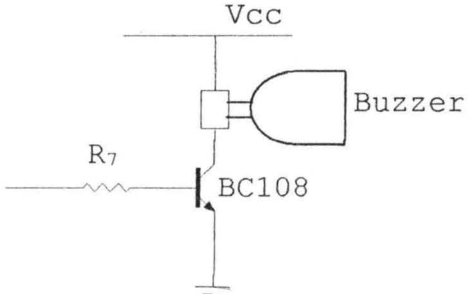

Fig 3.15 Diagram of alarm and driver unit

Buzzer driver: This is a transistor used to supply enough current so as to drive the buzzer.

The buzzer is a transducer which coverts electrical energy to sound. The transistor used is an NPN (BC108). It is a general purpose transistor and is cheap. A limiting resistor is used at the base of the transistor to prevent it from being damaged by excess current.

Mathematical analysis for resistor, R7

$$V_{CC} = I_c R_c + V_{CE}$$

But V_{CE} = at saturation

$$\therefore V_{CC} = I_C R_C$$

$$I_c = \frac{V_{CC}}{R_C}$$

Where, R_c= Resistance of buzzer = 100Ω

I_c = Collector current

$$\therefore I_c = \frac{5}{100} = 0.05A$$

Taking hfe = 15

$$\text{hfe}= \frac{I_c}{I_b} = \frac{0.05}{I_b}$$

Where I_b = base current

$$I_b = \frac{0.05}{15} = 0.0033$$

$$V_B = voltage\ from\ timer = {}^{2}/_{3}V_{cc}$$

$$= 3.33v$$

$$V_B = I_B R_B$$

$$R_B = \frac{V_B}{I_B} = \frac{3.33}{0.003} = 1009.09\Omega$$

$$\therefore R_B = R_7 = 1K\Omega$$

3.8 CIRCUIT OPERATION

The complete circuitry of the photo-detector and touch sensitive system is shown in fig 3.16. This security system comprises of two sensor units (light and touch sensor) ORED to produce a single output signal. The 555 timer in the touch sensor unit gets activated whenever pin 2 senses a smaller potential that is less that ${}^{1}/_{3}$ of supply voltage. Pin 2 acts as a capacitance sensor and detects changes in electrostatic fields. When activated, it triggers the buzzer for time duration determine by R_6 and C_4 in the timer unit. $R_4 and C_2$ also determines how long the signal from the sensor stays before going off.

In actual operation, the touch sensor wire is usually connected to a metallic door's hand, protectors (for windows and doors) or even metallic gate. Whenever the human body comes in contact with such materials, the trigger unit gets activated and the alarm sounds.

The sensor in the photo-detector unit detects a sudden shadow falling on it and sounds the buzzer when this happens. The circuit works best if a beam of light is arranged to fall on the light sensor. Breaking this beam will then cause the buzzer to sound for time duration determined by R_6 and L_4 in the 555 timer IC.

Table 3.1 Key to circuit Diagrams

Symbol	Component	Ratings
T_1	Transformer	220/230v, 300mA
S_1	Switch	1A
LDR	Light dependent resistor	300-2.8kΩ
C_1	Capacitor	$2200\mu f$
C2, C4	”	$100\ \mu f$
C3, C5	”	$1\ \mu f$
R1, R7	Resistor	1 kΩ
R4, R6	”	33 kΩ
R5	Variable resistor	500 kΩ
R2, R3	”	5 kΩ
D1, D2	Diodes	IN4001
LED	Light emitting diode	NTE3000

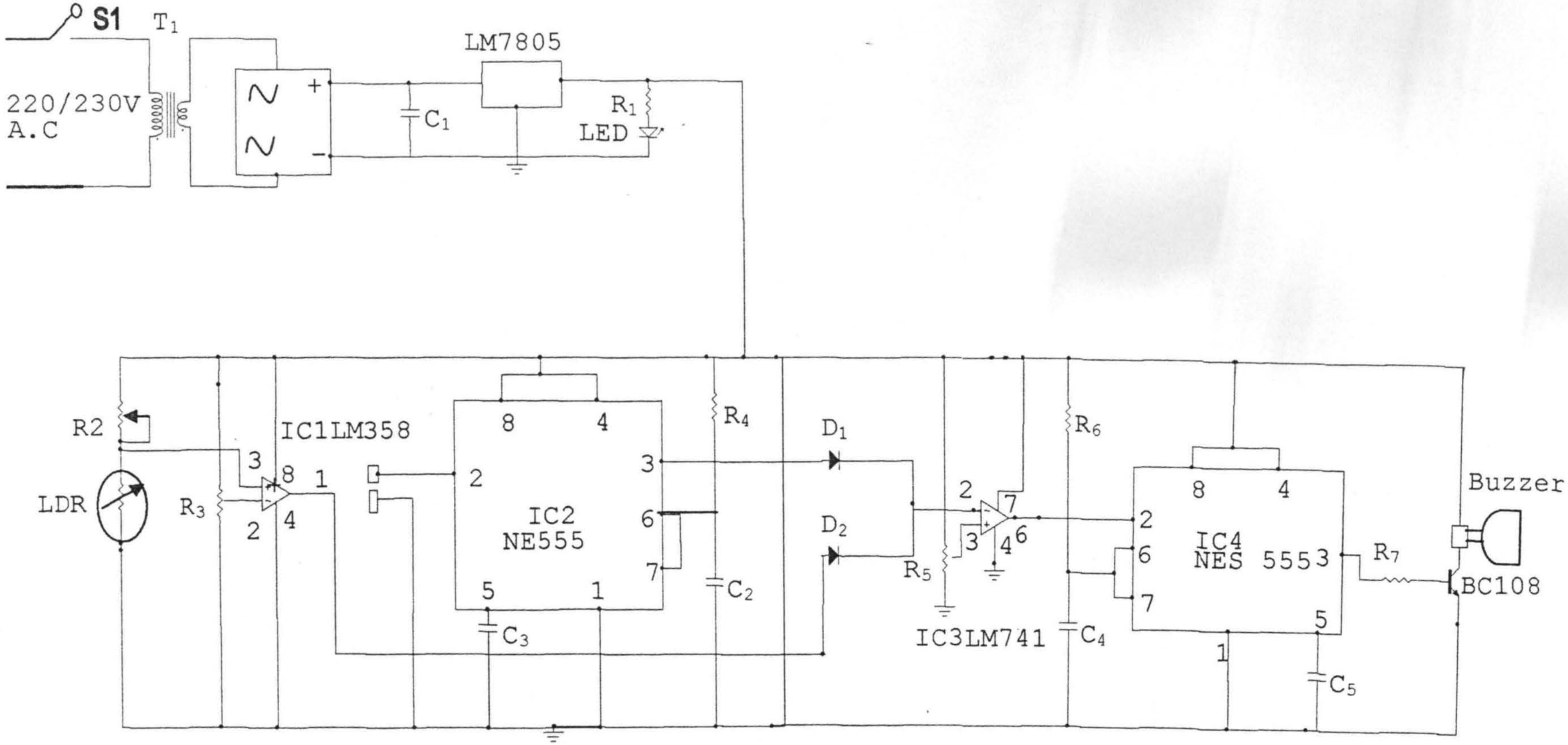

Fig 3.16: complete circuit diagram of photo-detector and touch sensitive security system

CHAPTER FOUR

CONSTRUCTION AND TESTING

4.1 CASE CONSTRUCTION

The materials used for the project casing are sheet metal and transparent plastic. The desired dimensions were properly marked out on the material with pencil and cut to the desired shape using chisels, hammer and hacksaw. The holes for screws and various outlets were drilled using manual drilling machines and smoothened with a file.

4.2 TESTING AND RESULTS

The following steps were taken to test the work:

1) All the components were tested with a digital multimeter to ensure they were in good working condition.
2) The actual connections of the components as shown in the design was first tested out on a bread board and powered by 12v d.c battery. Faulty connections were troubleshooted and the circuit eventually worked.
3) Components were transferred to a verobord and soldered with a hot soldering iron of 60 watts.
4) After soldering, the entire circuit path on the veroboard was tested for continuity using digital multimeter. At the end of the test no breakage was detected in the circuit path.
5) The Veroboard and the transformer were then mounted with screws unto the metal box. The project was tested and proved to be working fine.

4.3 DISCUSSION OF RESULTS

The aim of testing each component before soldering was to avoid the trouble of de-soldering faulty components. The continuity test carried out along the circuit path recorded no breakage along the path which implies that the circuit was in perfect working condition. Also, the timing of the alarm sound produced corresponds with that obtained from the design calculations.

4.4 PROBLEMS ENCOUNTERED

1) A problem encountered during the implementation stage was that the circuit was unable to detect intrusion through the light sensor. This problem was solved by increasing the sensitivity of the light sensor (i.e. by varying R_2)
2) Some components needed for the project work were not available within the town. Equivalent components were used in place of such components with the aid of data books.

CHAPTER FIVE

CONLUSION AND RECOMMENDATION

5.1 CONCLUSION

The major aim of this project work is to develop a cheap, affordable, reliable and efficient security system which was successfully realized at the end of the project work. The cheapness of the product was attained by the choice of components used as only readily available and replaceable components were used in implementing the circuit. The incorporation of two sensors in the circuit increased the reliability of the entire alarm system as they produced a single output though function independently

Finally, the system was tested and found to be working to specification and safe for use in residential and commercial buildings.

5.2 RECOMMENDATION

To increase the efficiency of the system, further improvement can be made on the alarm system by interfacing its output to a micro computer system or incorporating a digital display through embedded system.

Also, a warning device announcing failures in the alarm system can also be designed and incorporated into the system.

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APPENDIX

Electrical Characteristics of BC 108

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
		$I_E = 0$; $V_{CB} = 20$ V $I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	– –	– –	15 15	nA nA
I_{EBO}	emitter cut-off current	$I_C = 0$; $V_{EB} = 5$ V	–	–	50	nA
h_{FE}	DC current gain BC107A; BC108A BC107B; BC108B; BC109B BC108C; BC109C	$I_C = 10$ μA; $V_{CE} = 5$ V	 – 40 100	 90 150 270	 – – –	
h_{FE}	DC current gain BC107A; BC108A BC107B; BC108B; BC109B BC108C; BC109C	$I_C = 2$ mA; $V_{CE} = 5$ V	 110 200 420	 180 290 520	 220 450 800	
V_{CEsat}	collector-emitter saturation voltage	$I_C = 10$ mA; $I_B = 0.5$ mA $I_C = 100$ mA; $I_B = 5$ mA	– –	90 200	250 600	mV mV
V_{BEsat}	base-emitter saturation voltage	$I_C = 10$ mA; $I_B = 0.5$ mA; note 1 $I_C = 100$ mA; $I_B = 5$ mA; note 1	– –	700 900	– –	mV mV
V_{BE}	base-emitter voltage	$I_C = 2$ mA; $V_{CE} = 5$ V; note 2 $I_C = 10$ mA; $V_{CE} = 5$ V; note 2	550 –	620 –	700 770	mV mV
C_c	collector capacitance	$I_E = i_e = 0$; $V_{CB} = 10$ V; f = 1 MHz	–	2.5	6	pF
C_e	emitter capacitance	$I_C = i_c = 0$; $V_{EB} = 0.5$ V; f = 1 MHz	–	9	–	pF
f_T	transition frequency	$I_C = 10$ mA; $V_{CB} = 5$ V; f = 100 MHz	100	–	–	MHz
F	noise figure BC109B; BC109C	$I_C = 200$ μA; $V_{CE} = 5$ V; $R_S = 2$ kΩ; f = 30 Hz to 15.7 kHz	–	–	4	dB
F	noise figure BC107A; BC108A BC107B; BC108B; BC108C BC109B; BC109C	$I_C = 200$ μA; $V_{CE} = 5$ V; $R_S = 2$ kΩ; f = 1 kHz; B = 200 Hz	– –	– –	10 4	dB dB