DESIGN AND CONSTRUCTION OF FIRE AND SMOKE ALARM – SYSTEM

BY

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DECLARATION

I hereby declare that, this presented in partial fulfillment of the requirement for the Award of Bachelor Degree in Electrical and Computer Engineering (B. Engr.) is the hand work of Janet Olajumoke Alege

Information are obtained from both published and unpublished work of other Engineers.

CERTIFICATION

I certify that this project was calculated by Miss. Alege O. JANE (93/4093) f the Department of Electrical Computer Engineering under my supervision for he partial fulfillment of the Award of Bachelor Degree in Electrical and Computer Engineering (B. Engr.)

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Signature ______________________ 6/4
External Examiner Date

DEDICATION

This project is dedicated to God Almighty and to my parents Mr. John Oke Alege and Late Mrs. Alice Silas Alege.

Also, to the memory of my late in-laws Mrs. Arinola Kola-Alege and Mr. Ade-Daniel, may their gentle souls rest in perfect peace. (Amen.)

ACKNOWLEDGEMENT

To almighty most gracious God, do I give thanks and praises for the measurable assistance gotten to make this project a success.

Honour is said to be given to those whom honour is due to. I would like to start by acknowledging my father, Mr. John Oke Alege for his parental & support on my education, financial and prayer wisely, thank you and God bless.

I cannot but to appreciate the human vessels whom God had used in various dimensions to make my career pursuit and this project a dream come true. To the following:

i. Mr. And late Mrs. Kola Alege (Thank you for your financial and material support.)

ii. Mrs. Ronke Ade Daniel (thank you big sister for everything being done for God bless.)

iii. Mr Dauda Abari and Mr. Moses J. Dare (friends, you shall always be in my memory, thank you for all your assistance and advices, God bless.)

iv. To my lecturers Miss. Elizabeth Onwuka; Mr. Ajala and Mr. Raji (thank for being a friend in need.)

v. Lastly, to all my siblings and well wishers, I say thank you for your supports, prayers and contributions throughout the period for design and construction of this project.

Finally, I say thank you Jesus. My secret, my success.

ABSTRACT

The design and construction of fire and smoke alarm system is described in this project. The project is intended to produce an Audio alarm tone in 8Ω 4W Audio speaker, as well as visual flashing light alarm using lighting emitting diodes (RED) red and (green) for fire and smoke presence respectively.

This project report is intended to produce two outputs, which depends on the temperature of the sensor device (thermistor) and the high resistance of the photocell sensor due to the blocking of light by smoke. The thermistor here is fully immersed in hot water with its two leg pins connected to wire and connected to the probes digital multimeter, the resistance of the thermistor increase as its temperature increases, thereby causing it to approach the set trip value of the variable resistor.

When the thermistor resistance becomes more than the set-value of the variable resistor or when the photocell resistance becomes higher than the set value of the variable resistor, the comparator output switches to a high output state and both the low frequency and audio oscillator start to run.

The output of both oscillators are fed through transistor amplifier into the relay to energies and give an audio alerting output signal from the speaker.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

CHAPTER ONE

GENERAL INTRODUCTION

1.0 INTRODUCTION

Ever since the discovery of fire, man has realised the importance of being able to control it as an uncontrollable fire, can lead to wide spread devastation. Through out history, there had being cases of cities, which were being devastated by fire. Examples are some in AD64, London in 1666 and Chicago in 1871.Over the centuries, several methods of providing fire-safety had been adopted such as slaves fire watchout -men adopted in Rome and other means of combating fire. But as centuries go by, technological ways of monitoring and control fire were developed say from 1900....up to date. Among these inventories are: Automatic-sprinkler systems, Flame and smoke detectors, single-station alarms, extinguishers etc. but, despite the use of these modern methods of combating fire, so is the rate at which fire outbreak occurs increases tre-mendously as years go by, so is increases in lives lost and property destroyed.

The same effects smoke caused, in fact recent studies show that 85% of lives lost result from smoke more than are caused by burns, falls, heart-attacks and all other causes of death related to fire.

Firemen are hampered in their reuse attempts by smoke fire as its make it difficult to locate and effectively combat fire. Explosions occur as the result of gases not promptly vented, these toxic gases are produced as the result of burning materials properties that's the reason why fireman break out windows and chop hole in the roof to vent the smoke. There are many factors to be considered when exploiting the potential for fire -safely in a structure. Therefore, the ability to integrate fire-safely and security capabilities into a total system allows the design to provide maximum protection for individual and properties in a building.

.1 METHODOLOGY

The approach is to first consider each element the circuit on a description bases in order to provide a clear understanding and intuitive finds for the design behaviours.

After obtained the physical insight into the operation of the circuit, mathematics is then applied in deriving the circuit parameters. The concluding steps include the construction, testing and trouble-shooting, packaging of the fire and smoke alarm system, conclusion and recommendation.

Each chapters is well defined, illustrations using block diagrams, circuit - diagrams and graph are provided where necessary.

The project write up is divided into four chapters. Chapter one introduce the project, contains aim and objective, types of detectors with literature review. Chapter Two gives general analysis of the project design and calculations. Chapter Three, shows the design construction works, testing and trouble-shooting and discussion of result. The last chapter (chapter four) contains conclusion, recommendation and references.

1.2 AIM AND OBJECTIVE

The aims and objective of this project is to design a better improved fire and smoke detection system which is of high sensitivity and reliability with fidelity i.e. (no false alarm).

The objective is obtained by using the latest electronic components and Ics, which also make the system circuit simple.

1.3 ECONOMIC IMPORTANT

The economic important of this design is to save cost. It cost below ₦2,500.00 to design and construct both fire and smoke detecting system (reference to page 45 for bill of material and quantity) whereas, from researches carried out at the fire station, on imported fire and smoke detector, cost within ₦3,000:00 - ₦3,500:00 depending on the brand. Whereas both combined together in this project design, cost below a price for a single detecting system.

1.4 LITERATURE REVIEW

A protective signaling system is designed to accomplish some objective. One, to alert the occupants of building of fire outbreak and permit prompt evacuation of the premises.

Two, to notify the fire fighting agency and signed the location of the outbreak. Thirdly, as a comprehensive alarm system, is to monitor automatic extinguished facilities and signal failure. Lastly, an Alarm system is to monitor building functions, industrial process and signal any dangerous place, such as a boiler or furnace failure, breakdown of electrical or air-conditioning system.

Alarming system can be classified as manual or automatic, depending on their scopes of their function.

Local Alarm system often house separate auxiliary systems to notify the public fire fighting force. Also, is the fire alarm box which is seen in many residential commercial, industries and public buildings to notify local fire station of fire outbreak by means of signal carried over wire lines.

Over the years, many different kinds of fire and smoke detecting systems have been designed to combat fire out-break. But, despite all these technological fire and smoke detecting system, the rate at which fire outbreak occurs increases tremendously as years go-by. "One is now left to ask if these detecting systems are not reliable?"

The answer is "No". The truth is that, these detecting systems have differed efficiency and sensitivity responses. These low sensitivity and fidelity of the detecting systems can be attributed to the components used in the designs of the system circuits.

With the modern electronic components and advance Ics, this project is design using integrated circuits Ics, photo-conductive cell, FC27M2070. Thermstor, which is an advance - improved thermistor, Relay, etc for the design and construction of this project work.

1.5 DETECTORS

These are devices in fire -alarming system that inform the control unit about the presence of fire or smoke in a building. An automatic fire alarm initiating devices can be actuated by heat, smoke and flame radiation. This forms the basis for classifying the operational -principle of these alarming system.

1.5.1 HEAT DETECTION SYSTEM

This detection is the oldest types of automatic system, thermostat s used for the construction of this system. It operation by setting the thermistor to a certain fixed temperature which triggers off if that temperature is reached or exceeded. This detector has the lowest false -alarm rate out of all fire detectors, but it's the slowest in detecting of fire. Heat detector has are best suitable for fire -detecting in a small confirmed place. Where rapid fire with high heat output ar expected. Heat detectors are the cheapest detectors out of all fire -detection systems.

1.5.2 SMOKE DETECTION SYSTEM

These detectors are more costly than heat detector but provided considerable faster detection time but subsequently, higher false alarm rates. Smoke detector are used in place where material stored are likely to create much -smoke before generating enough heat to activate the detector. Smoke detector are very effective for life-safety application but also more difficult to be installed in areas where air current might affect the direction of smoke flow. So therefore, to install smoke detectors engineering survey work have to be done to determine the effect of air -velocity, ventilation, air -conditioning facilities, Existing dust or vapours that could affect their operation.

The detection should be installed in areas where high value is placed to life and properties protection, the detector operates within seconds of fire generation to alert the occupants

1.5.3 FLAME DETECTION SYSTEM

These detection operated by principle of " line of sight ". They must sight of fire before an alarm is raised. Flame detectors respond to change of light intensity which is caused by the flickering of flames. It has a unit that measures variations in wire tension as a result of heat expansion. Also, it contains a balance (wheat-stone bridge) circuit in which products of combustion bring about fast impedance changes that upset the balance of the circuit to trigger an alarm.

Flame detectors have the highest false-alarm rates but fastest detection time. Detection time of flame detectors is generally measured in milliseconds from fire ignition.

Flame detectors are generally used in high natural situations such as: fuel loading platforms and de-loading filling stations. And other places with hazardous atmosphere in which explosion or rapid fire may occur.

CHAPTER TWO

SYSTEM DESIGN AND CALCULATIONS

2.0 **INTRODUCTION**:- The details analysis of the Design and theoretical principles of the circuits, the components used are extensively discussed in this chapter.

The design system comprises of power supply unit, control unit Alarm unit, Amplifier and Relay

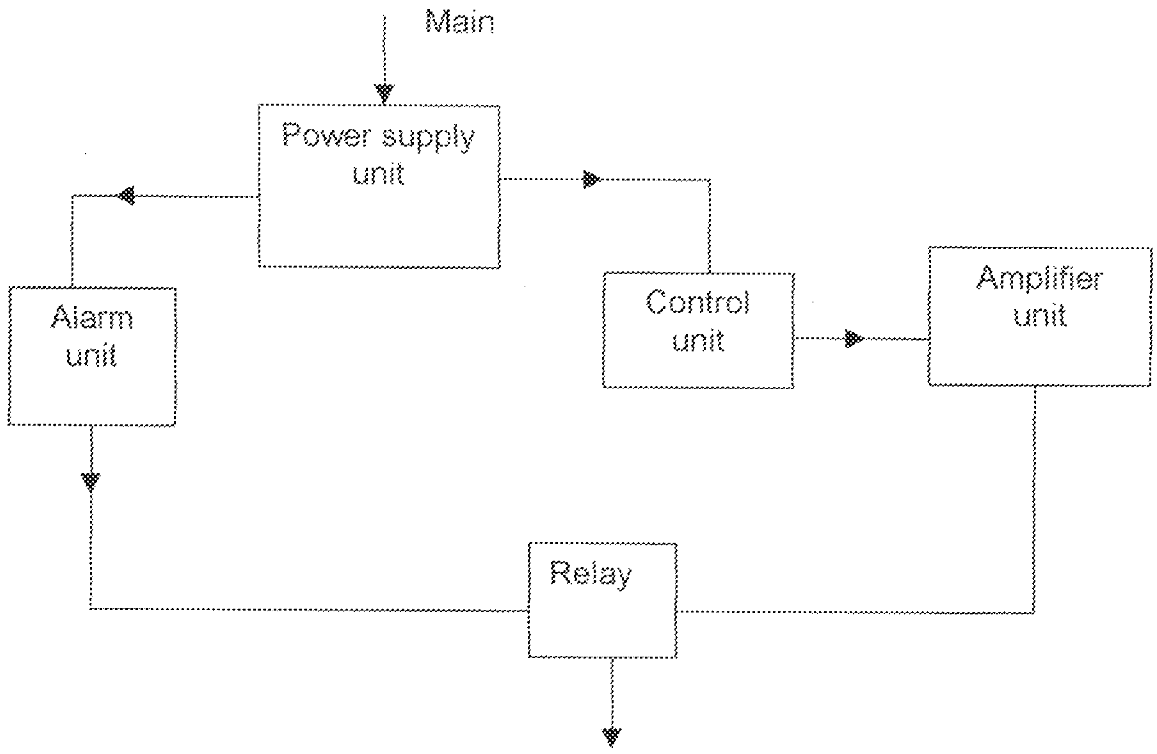


Fig 2.0 Block diagram of (Speaker) o/p

2.1 **POWER SUUPPLY UNIT:** The system is designed to receive its initial power supply from an A.C main supply. Th power supply unit converts the a.c voltage to d.c voltage of the designed value. This unit supply the required d.c voltage and current with low level of a.c ripples, which filtered by the capacitor and correct regulation to give the exact voltage required, irrespective of the changes in the main input voltage.

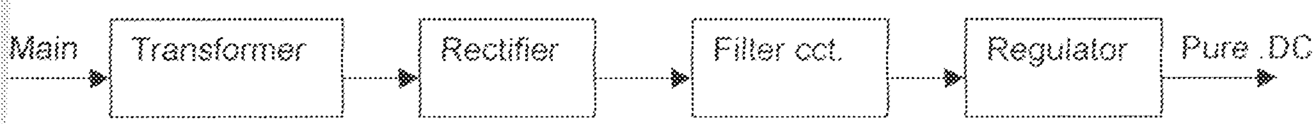


Fig 2.1 Block diagram of a main D.C system

2.2.1.3 **FULL-WAVE BRIDGE RECTIFIER**

In this project Design, full-wave bridge rectifier is used because we achieve both face of the input voltage without a transformer with the use of four diode, which make it to be more cheaper and lighter in weight.

Four diode are used in place of transformer to achieve both face of the input voltage in full-wave bridge rectifier. When Vs is positive, diode D_1 and D_2 are one on and diodes D_2 and D_4 are off. On the other hand, when Vs in negative, diodes D_3 and D_4 conducts while D_1 and D_2 are off.

However, when Vs is positive, the upper terming of the load is connected of the upper terminal of the source, and the load voltage V_L follows the input voltage Vs. while for negative Vs supply, the upper terminal of the load is connected to the lower terming of the source, so that the load voltage V_L follows –Vs

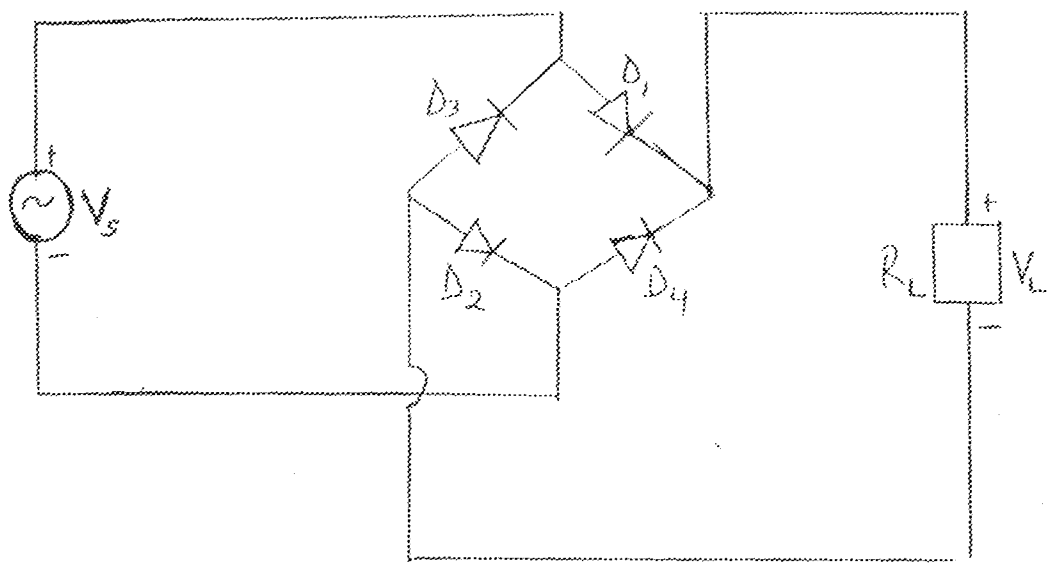
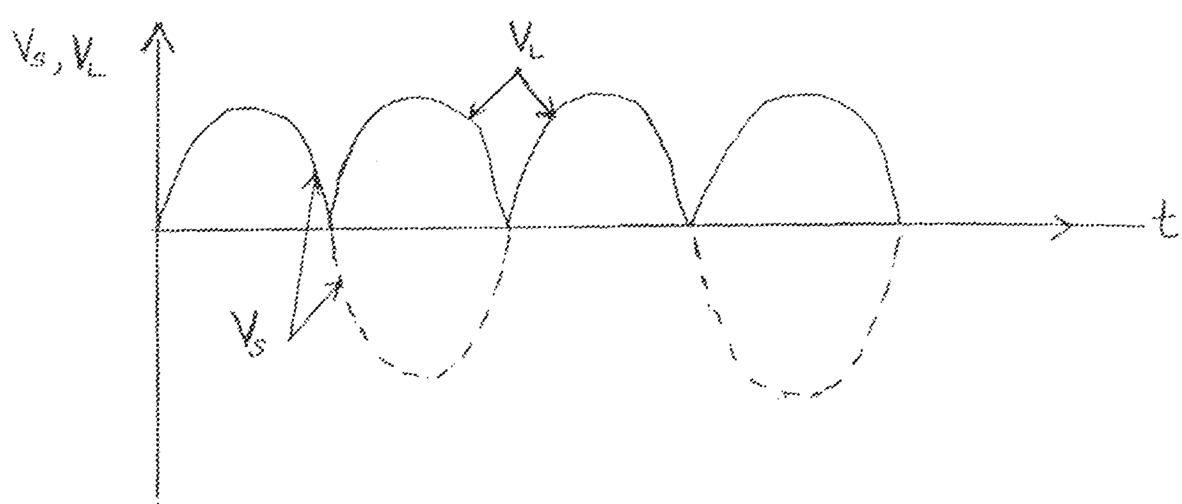


Fig 2.5 (a) Full-wave bridge rectifier circuit



b) Full Wave Bridge Rectifier Inputs & Output Wave form

2.3.0 RIPPLE FILTERING

The a.c component of the output voltage can be characterized in terms of the peak-to-peak ripple V. small values of the conduction interval t. The ripple can be reduced by increasing the Rc time constant, thereby decreasing the rate of decay of the load voltage and decreasing the duration of the conduction interval.

Capacitor value must be large in order to present a small a reactance as possible to the pulsating rectified d.c output and to store sufficient charge, so as to maintain current flow in the load during the period that rectifier is not conducting. Capacitor of range 1000μF is used in the construction to the project.

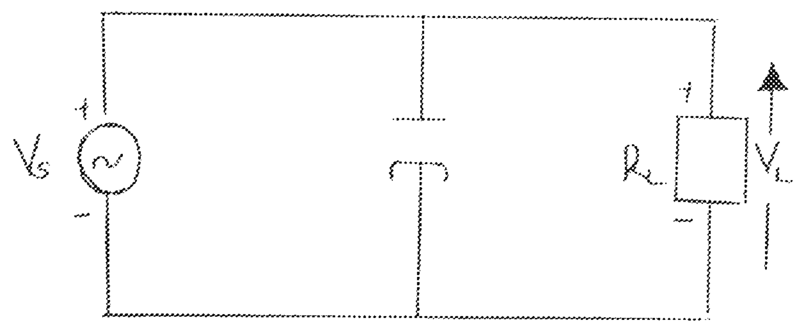
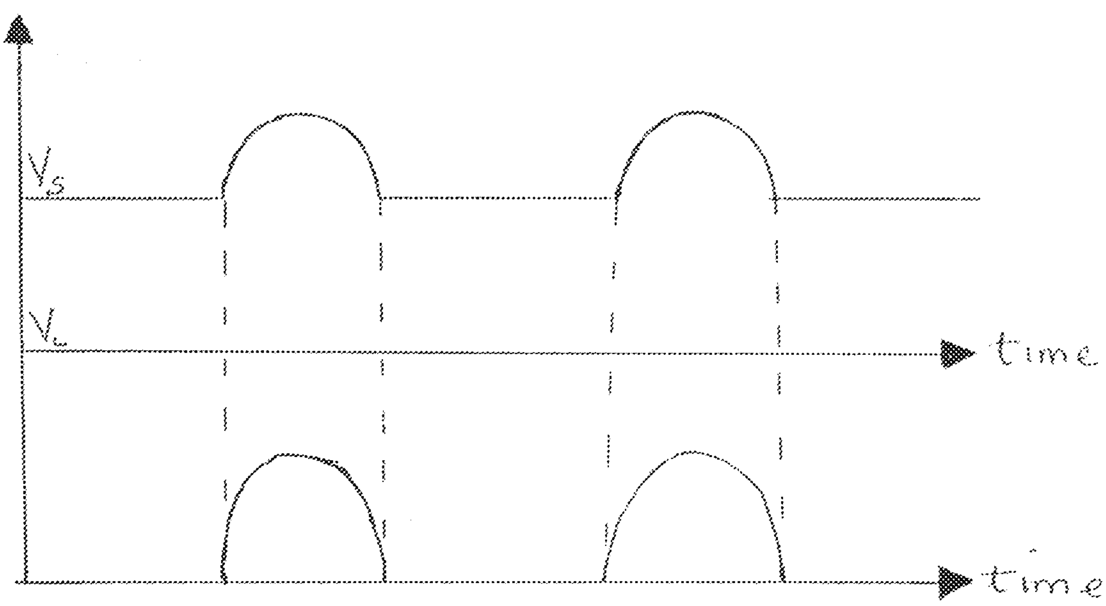


Fig. 2.6a Ripple filtering circuit



b. Output wave form of the filter

2.4.0 VOLTAGE REGULATOR

The selected voltage regulator is 7805 regulator. The 7805 regulator provide + 5V for the voltage comparator LM339 and 555 Timer IC

An unregulated d.c power supply may be adequate for some applications but, there is often a need for the supply voltage to be constant (good regulation) as well as having a low amplitude, that is the reason for using voltage regulator, so that, a constant voltage supply is produced regardless the load variation or the input voltage to the power supply. A block diagram of a voltage regulator is shown in Fig 2.7

Stability factor (s) for a voltage regulator is a measure of the effectiveness of the regulator. The stability factor is given as

$$S = \frac{Vout}{Vin}$$

For a constant output current I_l for a good regulator for ranging from 0.005 to 0.002, s should be in practice. And the output resistance of the regulator should be zero ohm.

Typically, Ro= Vout for constant input voltage. Where, Ro should be less then 1ohm, sometimes, considerably less

There are different types of voltage regulators (line and switching). They can be connected either in series or in parallel. The regulation can be dome by a zener diode or by an integrated circuit.

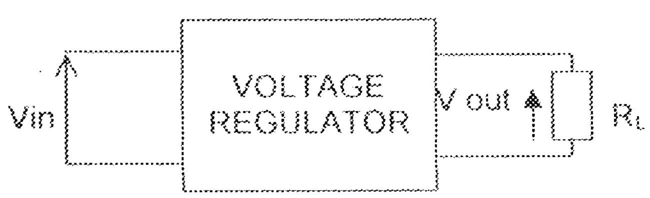
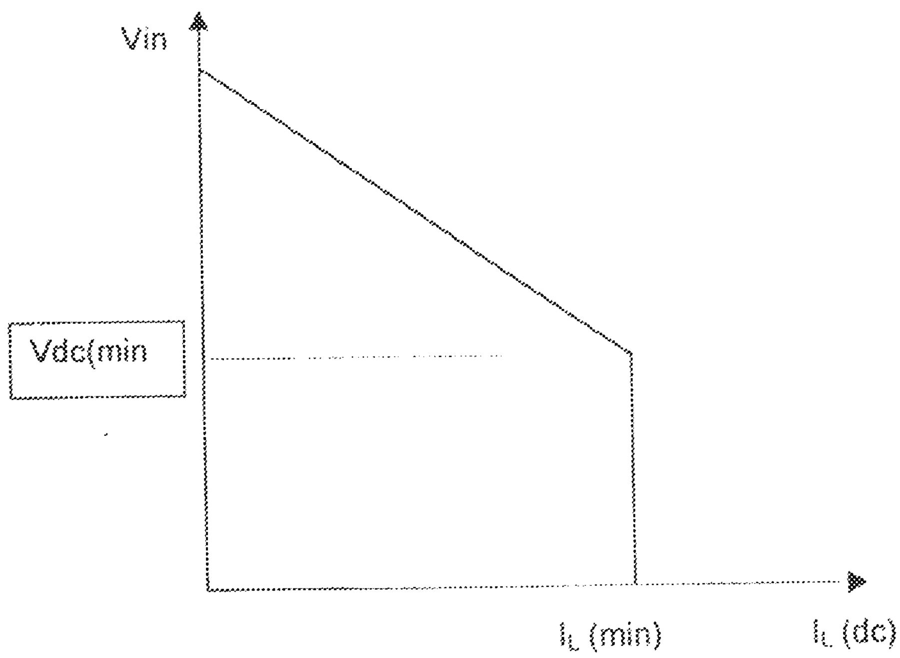
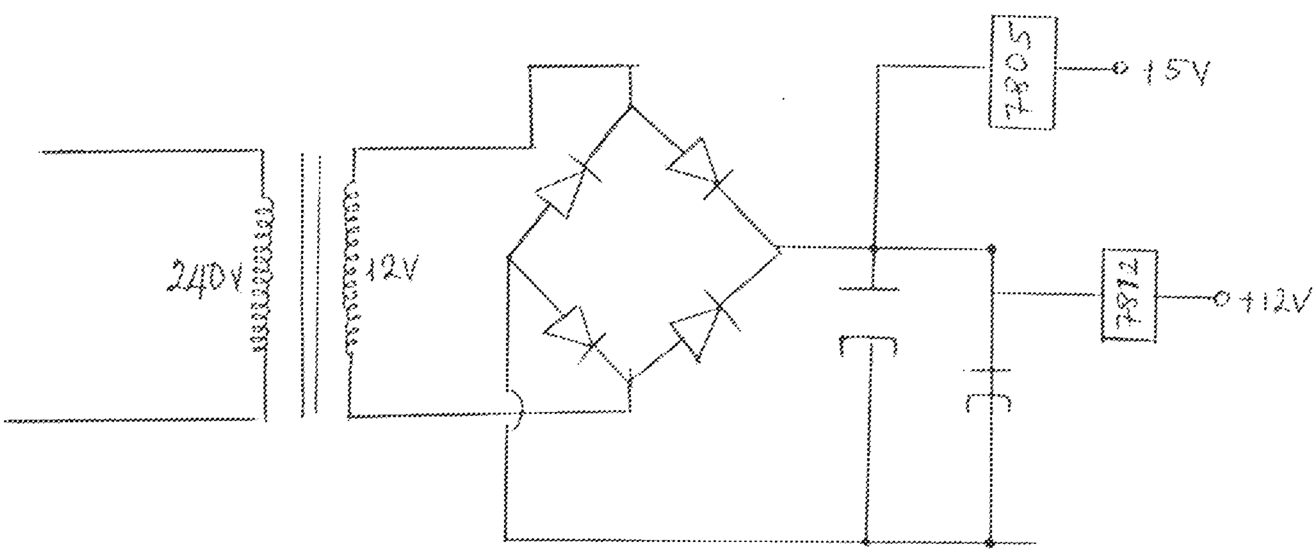


Fig 2.7a. Block-diagram of a voltage regulator

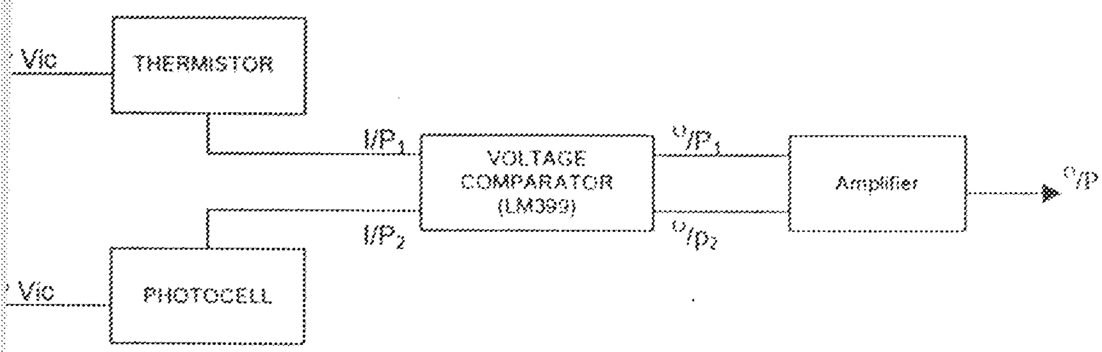




Power supply circuit

2.5 CONTROL UNIT

The detection circuit comprises a differential voltage comparator LM339aIC, two tranduscers, which are thermistor and a photo resistive cell and an Amplifier



Block diagram of the fire and smoke detector circuit

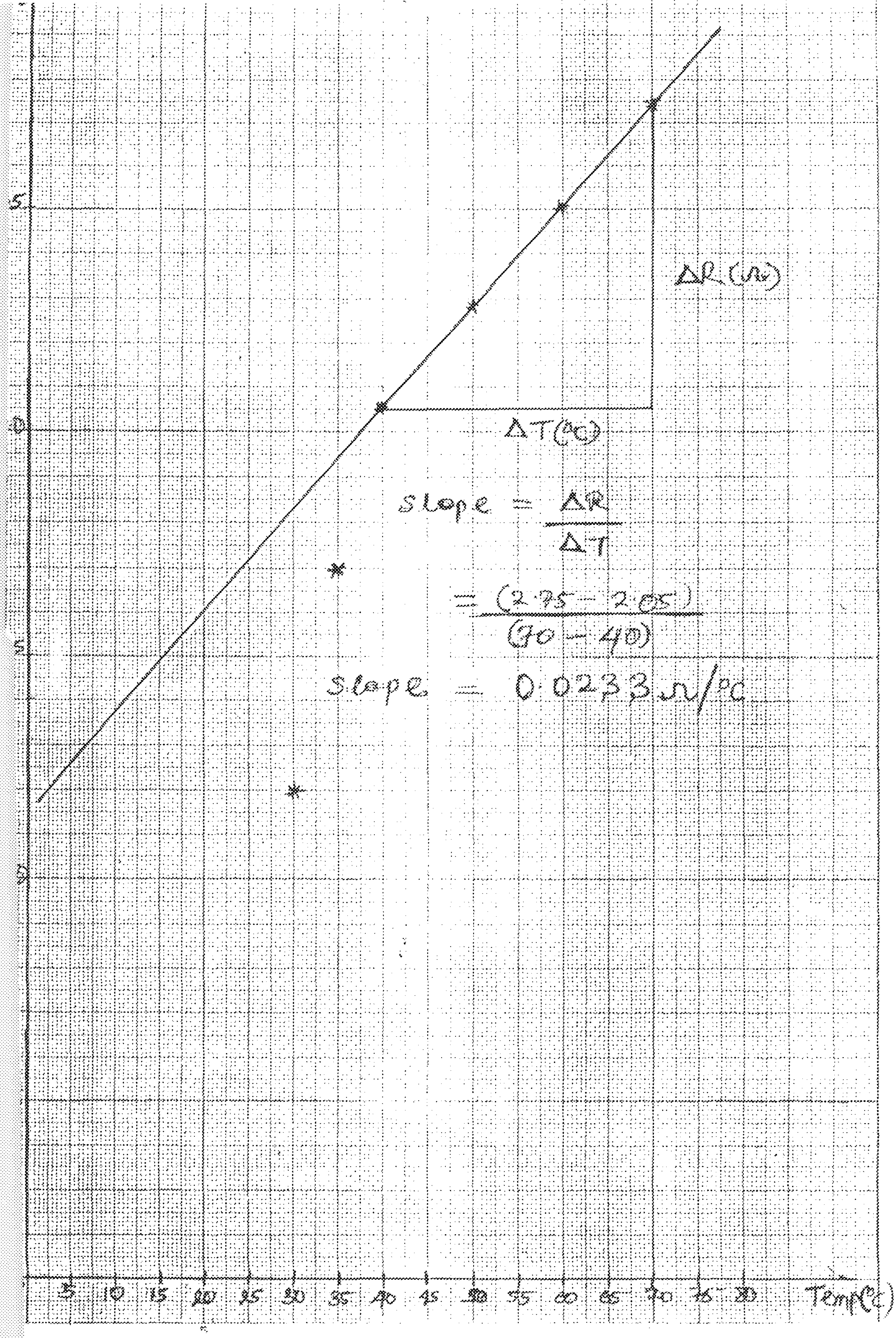
2.5.1 THE THEMISTOR

Thermistor is a transducer which converts Heat-energy to Electrical signals. A thermistor is a semi-conductor whose resistance varies as the temperature changes. The thermistor used in this project is FC27M 270 As already mentioned, the thermistor is used as a control device which actuated be changes in temperature. A laboratory measurement of resistance variation versus temperature was effected to enable proper design of the quiescent operating point of the bridge-circuit. The data collected is given in table 2.5.1.1 and the ensuring graph in fig 2.5.1.2. the general temperature Versus resistance relation is of the form.

$$R = R_o \exp(1/T - 1/T_o)$$

Where,

Ro and R_o are resistance of T_o and T respectively


ΔR(Ω)
ΔT(°C)
slope = ΔR / ΔT
= (2.75 − 2.05) / (70 − 40)
slope = 0.0233 Ω/°C
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
Temp(°C)

$-\beta/T^2 \Omega/(\Omega^\circ c)$

Table2.5.1.1

Temperature (°C)	**Resistance (kΩ)**
30°	1.20
35°	1.70
40 °	2.05
50 °	2.30
60 °	2.50
70 °	2.75

Increment in Resistance(Ω) Versus Increase in temperature. (°C) Table

2.5.2 THE PHOTOCELL

Photo-conductive cell is a semi conductor light sensor, which experiences changes in its electrical characteristics when light energy releases charge carriers in the material, this causing a change in its conductivity.

The photo-conductive cell is a semiconductor whose electrical resistance depends on the intensity of illumination reaching the semi-conductor material. This semi-conductor can also be called photo-resistive-cell or light dependent resistor. To use photo cell as a transducer, a constant voltage is applied to it. Its output signal, which is a current varies with the intensity of illumination A typical cell varies in resistance from about 400Ω when the cell is under strong illumination to 1MΩ when it's in complete darkness.

The photo cell bridge circuit is the same design as that of the thermistor. Below is the technical specification of phot-conductive cell.

Table 2.5.2.3

TECHNICAL SPENIFICATION

Peak spectral response.............................530nm

Cell resistance at 10 Lux..............................9KΩ

Cell resistance at 1000 Lux.............................400Ω

Dark resistance (Min) 1MΩ

Max .voltage d.c or a.c peak................................320V

Max dissipation at 25 ° c 250mW

Typical resistance rise time 18ms

Typical resistance fall time ....120ms.

2.5.3 VOLTAGE COMPARATOR UNIT

The voltage comparator is a circuit which compares input signal Vin with a reference voltage Vref. When the input signal exceeds the reference signal the output of the conparator, Vout changes from its value.

A voltage comparator exhibits a non-linear operational anpinfier characteristics while as a differential amplifier behaves linearly. A comparator is therefore a two inputs, one output voltage comparing devices that is capable of high input resistance and low output. While this may be taken as the definition of an operational amplifiers, it should be noted that voltage comparison is just one of the areas of application of op-amps. A comparator performs the following functions

- Detects two in put-voltages
- Provides an output that has two discrete states.
- The differential voltage comparator is operated via dual power supply with a common ground, thus enabling the output to swing either to positive or negative with respect to the ground. Typically it gives a voltage gain A of about 10^5 between inputs

One input terminal is denoted negative, it gives an inverted output (i.e) the inverting terminal and the other is devoted positive, which gives a non-inverting output (i.e) the non-inverting terminal the output at the terminal is ideally zero. When identical signals are simultaneously applied to both inputs, since the two signals are concealed out by the differential out come of amplifier. The output of the circuit is proportioned to the differential signal between the input and it's given by.

$$V_o = A_o V_{in} - V_{ref}$$

Where,

A_o = the open-loop of the op –amp.

V_{in} = the input signal at the non-inverting terminal

V_{ref} = the reference voltage at the inverting terminal

V_o = the output voltage.

2.5.3.1 THE LM339 (QUAD OPERATIONAL AMPLIEIER) AS A VOLTAGE COMPARATOR.

The LM339 is used in this project as a differential voltage comparator circuit, on the basis that, one of the inputs is greater or less than the other. So the output voltage of the two input voltage levels is the decided by the saturation position of the op-amp.

When the input voltage (positive input voltage) is greater than the negative input voltage i.e reference by few hundred micro-volts, the output is driven into saturation positively and when the positive input voltage is lesser then the negative input voltage by fewer hundred micro-volts, the output is driven to negative saturation.

The magnitude of the differential input voltage dictates the magnitude of the output voltage. So therefore, an absolute value of the input voltage is of importance. The circuit thus functions as a precision voltage-comparator. Fig2.9 shows the transfer characteristic of a differential voltage comparator circuit

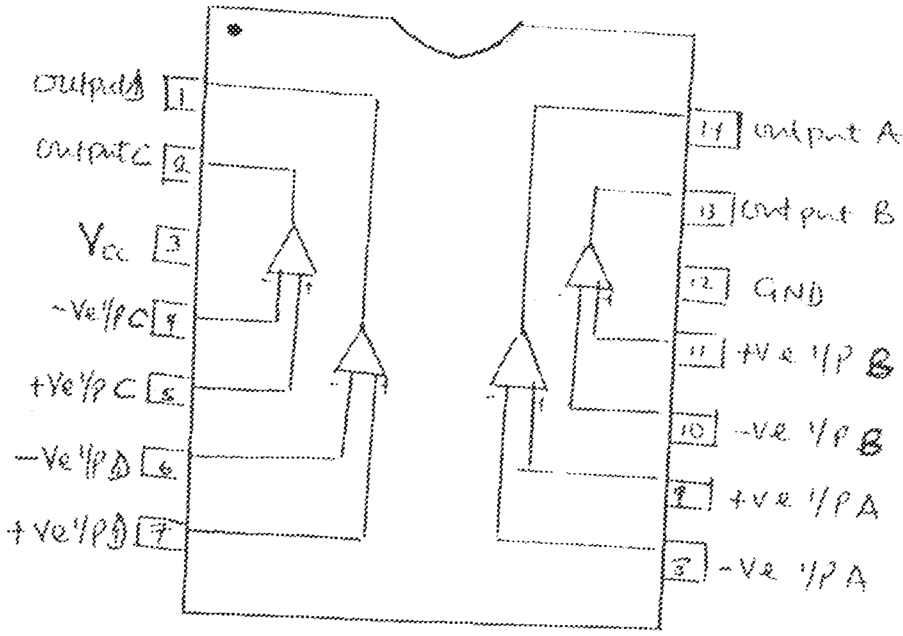


Fig 2.9 Pin-out of the LM339 operational amplifier

2.5.4 AMPLIFIER

Amplifiers are active devices such as Bipolar function transistor (BJT) or field effect transistor (FET) that are biased in such a way that they amplifies signals at their inputs.

Amplifiers can be classified on the functional as voltage or power amplifier.

They can also be classified on the basic of the frequency range covered in their normal operation as Audio frequency (AF) and Radio frequency (RF) amplifier. Amplifiers can also be classified on the basic of Base gate or Base bias of FET or BJT as class A, class B, class AB or class c amplifier.

2.5.4.1 CLASS A AMPLIFIER.

This class of Amplifiers have their Base bias value. So chosen that, the amplifier (output) current flow through out the entire cycle or 360 °. They are used where quality or fidelity is of prime consideration. since, they have the lowest distortion of about 20% and 20 to 40% efficiency.

2.5.4.2 CLASS B AMPLIFIER

This class of Amplifiers are biased in such a way that, the collector output current flows during one half cycle of the input with the zero signal input the collector a current is almost zero and flow only during the positive half cycles of the input voltage. The efficiency is high and the signal distortion is also high.

2.5.4.3 CLASS AB AMPLIFIER

This class of Amplifiers have its characterisation lies between those of class A and class B. Here, the current flows for more than 180°

2.5.4.4 CLASS C AMPLIFIER

In this class, the Base is biased in such a way that, the current flows in a way that collector current flows in pulses of less then one half cycle i.e collector current flows over angle as small as 50 ° to 120° of the cycles.

It offers the highest efficiency (about 80%). It's mainly used in R.F power Amplifier and it allows the greatest A.C power output but with more distortion.

2.5.5 TRANSISTOR

The transistor was developed in 1948, the name was derived from its original title 'transfer-resistor'. Transistor is a three terminal device in which current flowing between two of its terminals can be controlled by signal on the third terminal. This facility means that a transistor has properties that enable it to be used as an electronic switch and an amplifier. There are many types of transistors available, but they can be effectively be grouped into two.

- The bipolar function transistor (BJT)
- The unipolar or field effect transistor (FET)

THE BIPOLAR FUNCTION TRANSISTOR: This transistor is a current operated device. It is a three-layer semiconductor device that has three electrodes; the Base, the Collector and the Emitter.

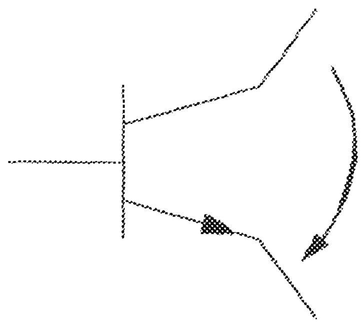
There are two types of transistor

N-P-N and P-N-P

The name of the electrodes come from the role they play in the device operation.

- The Base controls the flow of electrons from emitter to collector.
- The collector collects the electrons.
- The Emitter emits electrons.

However, to understand the simple operation of the device, it's only necessary to consider one of the charge carriers. Electrons for n-p-n device holes for a p-n-p device. For and n-p-n transistor the electrons flow from the emitter region into the base region and continues on to be collected in the collector region-because, conventional current flows in opposite direction. The arrow on the circuit symbols indicates, the flow of conventional current through the device.



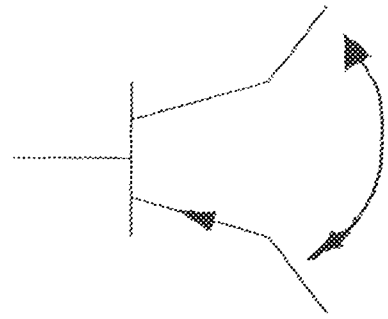
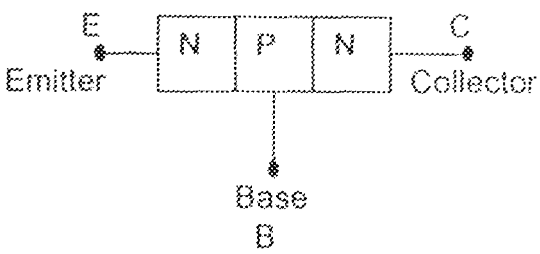


Fig. 2.10a. N-P-N Conventional current P-N-P Convection current



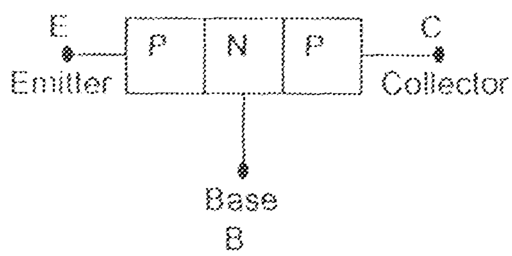
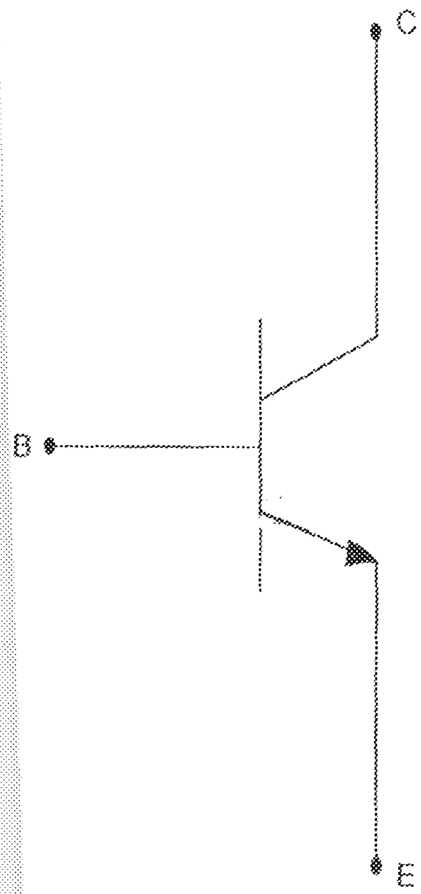


Fig. 2.10b. The structure of a Transistor.



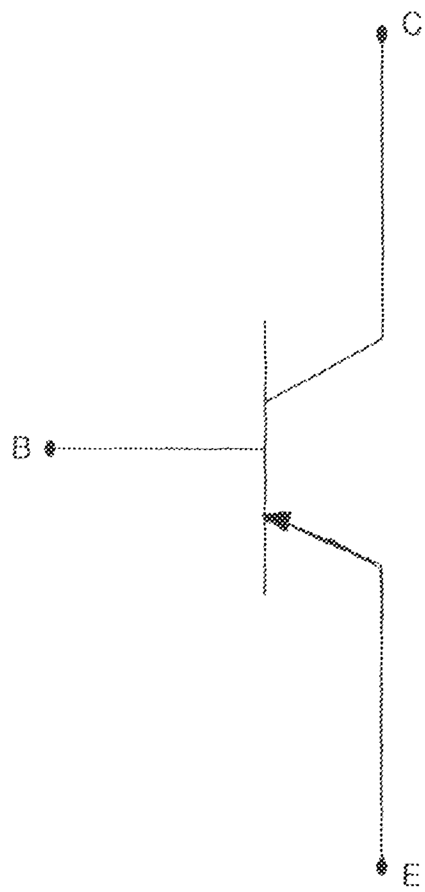


Fig. 2.11a N-P-N Symbol b. P-N-P Symbol

2.5.6 **RELAY**

A relay is an electromagnetic device or solid state device. It's in form of a switch which changes in the input are used to control other devices connected to its output.

A relay basically consists of:

i. The core

ii. The Armature and,

iii. The return springs.

In an electromagnetic Relay, when the core is energized by the control current from an external circuit, a magnetic field is formed around the core which is proportional to the in flowing current

This causes the armature (which is a soft Iron) to be attracted, thus a opening or closing contacts are attached to it at some point. The system losses its magnetism as soon as current seized flowing through the coil.

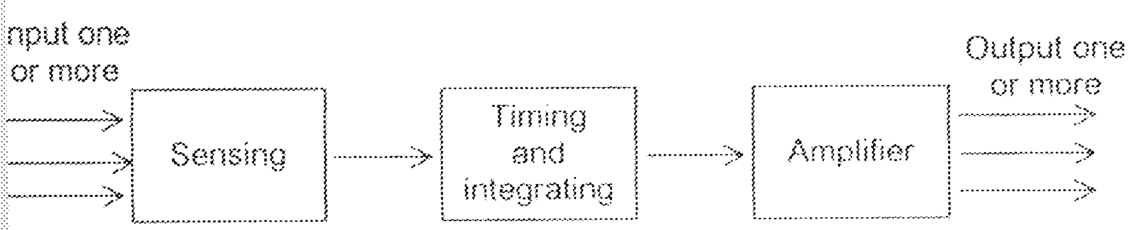


Fig 2.12 Block diagram of a relay showing its basic units.

Relay normally have a timing integrating block, which in most cases are springs. This determines the speed of operation. A relay may be a normally opened or normally closed relay. A normally open relay closes when energized while a normally closed relay opens when energised. A d.c or a.c control current can be used to energised the circuit. With and A.C supply, the electromagnetic Iron core is laminated to reduce eddy current. This is done because of two reasons. First, Eddy currents have an undesirable heating effect and secondly, they slow down the operating speed of the device.

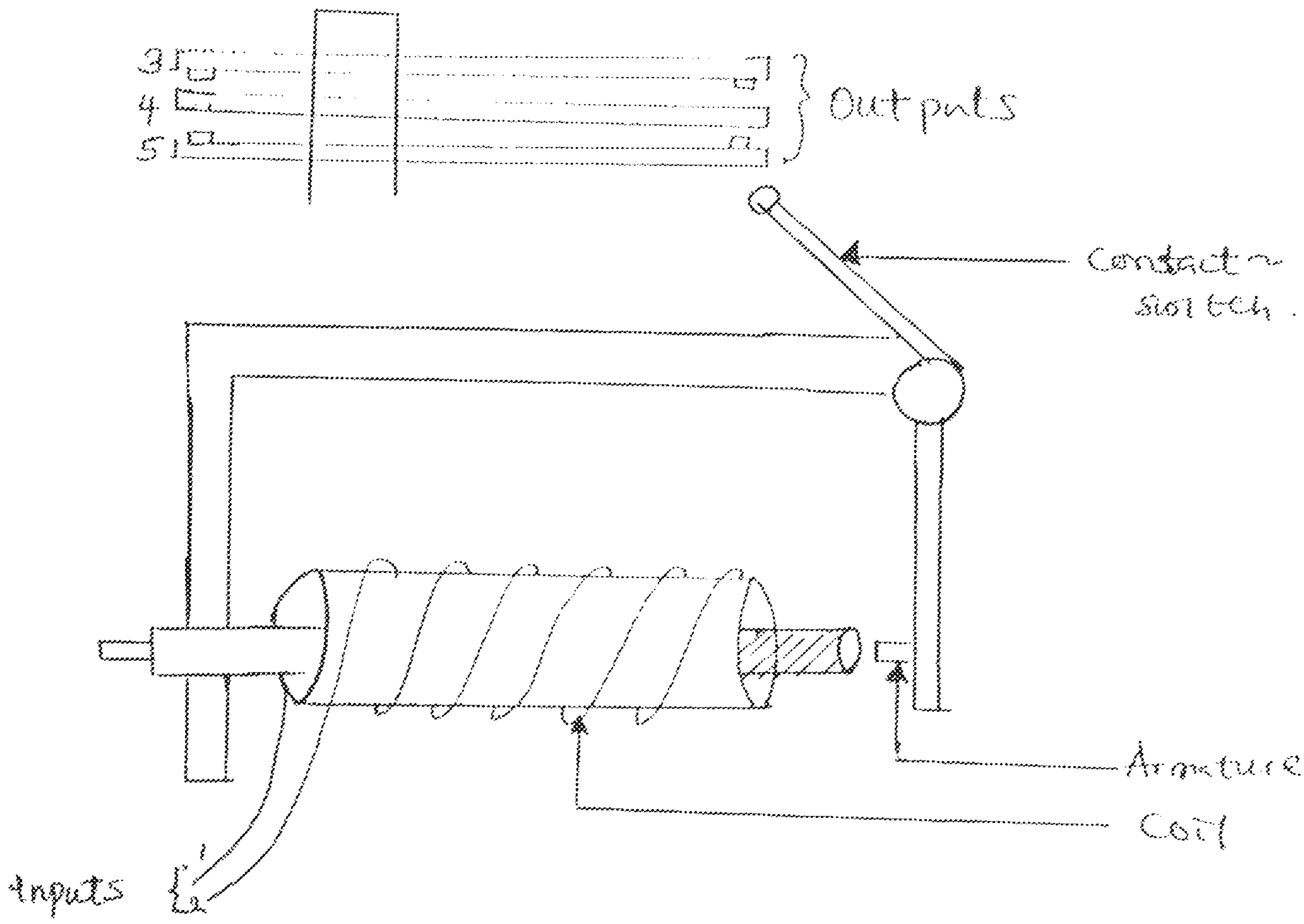


Fig 2.13 Relay diagram.

2.5.7 THE ALARM CIRCUIT

The alarm circuit is designed to give an andio alerting signal whenever the traduces (thermistor and photocell) detect presence of fire of smoke, apart from the LED indicators. The circuit composed a 555 timer Ic, which is designed as Astable multiuiberator. Ones of the three Non –sinusoidal oscillator (an inverter.)

2.5.7.1 **OSCILLATORS**

Oscillators are inverters which convert d.c current to a.c Oscillator are divided into two types according to their output waveform

a. Sinusoidal oscillator: this produces pure sine wave output

b. Non-sinusoidal (relaxation) oscillator type:it produces pulse of rectangular waveform output. They are also known as multilviberatios.

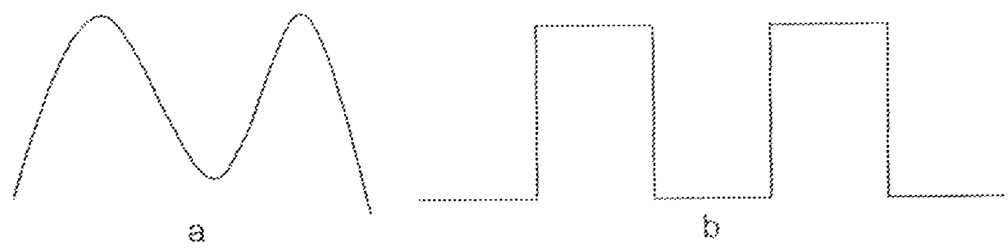


Fig 2.14 Output wave form for both type of oscillator

a. Sinusoidal oscillator waveform.

b. Non-sinusoidal oscillator waveform.

Types of non-sinusoidal oscillator

i. The monostable

ii. The Bi-stable

iii. The Astable –multi-viberator

Monostable multiviberator

The monostable multiviberator or (one shot) circuit produces a rectangular output pulse in response to a trigger signal applied to its input. It is designed in such a way that output pulse is only produce each tine trigger pulse is applied

Bistable multiviberator.

A bis table multiubrator or flip flop is a circuit having two stable states. This circuit will remain in one stable state until a trigger pulse is applied to switch the current to the other state. I.e it remains in either state permanently.

Astable multivibrator

This is the type employed in this project because of its advantage as a free running multiuibrator. It is a simple relaxation oscillator that produces square wave signal from two identical amplifiers circuit collected in a closed loop. It has two unstable states and will continuously change from one to the other to generate a square wave

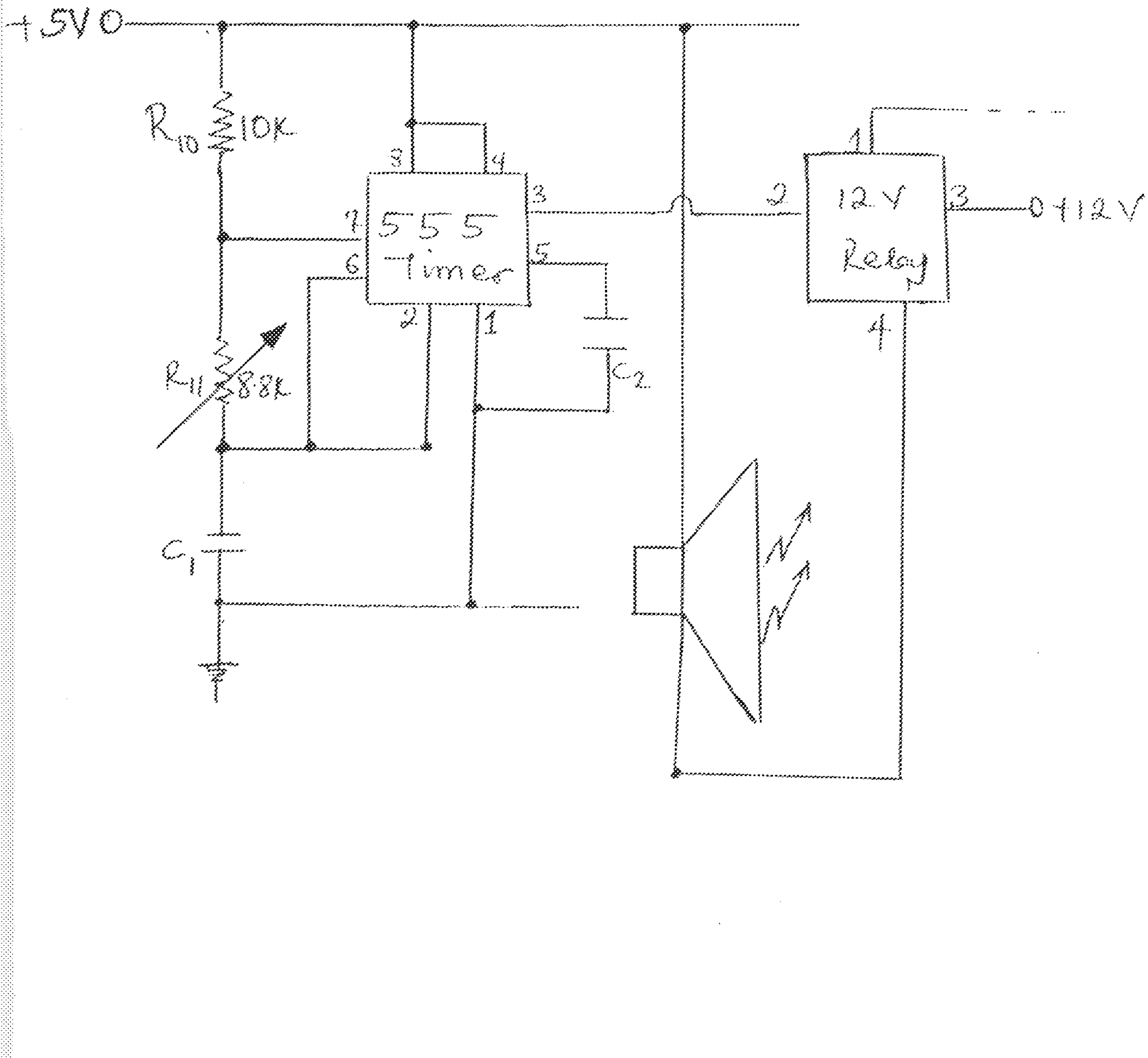


Fig 2. 15 Alarm circuit in astable multiviberator mode.

2.5.7.2 **555TIMER**

The 555 timer IC is non-sinusoidal Oscillator used to generate wave form, 555 timer IC comprises two voltage comparators, a flip flop; transistors and three Resistors.

The comparators in the 555 timer IC are usually operational amplifiers that compare input voltage to the internal reference voltage, which are generated by an internal voltage divider chain of three 500Ω resistors. The reference voltage provided are one third of V_{cc} and two-third of V_{cc}. When the input-voltage to either of the compactors is higher than the reference voltage of the comparator, the amplifier goes into saturation and produces an output signal to trigger the flip-flop which controls the output state of the timer. The pin-out connections of 555 timer Ic are show in fig 2.16

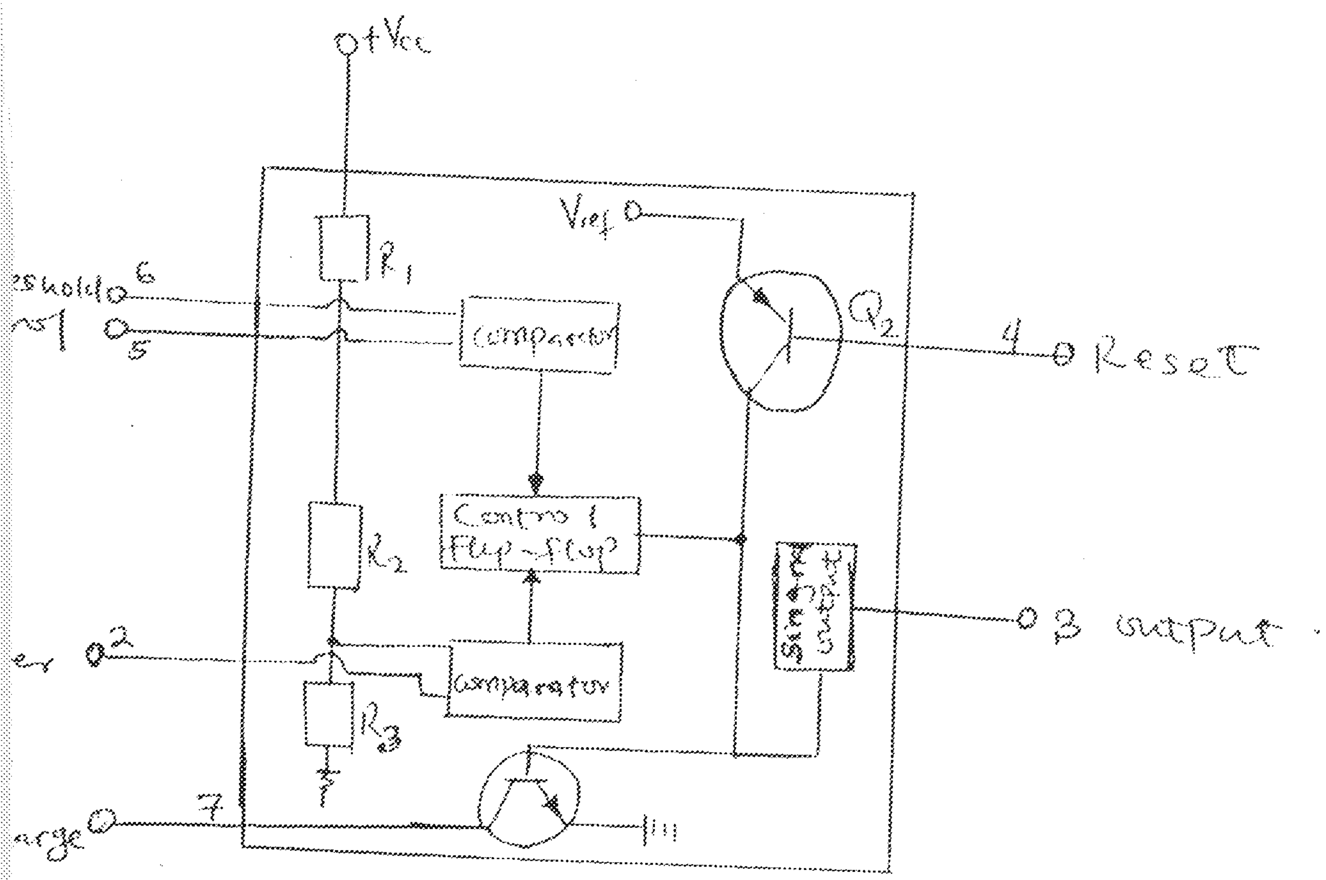


Fig 2.16 Block diagram of 555 timer Ic

Details regarding connections to be made to pins are as follows.

PIN1: This is the ground pin and should be connected to the negative side of the supply voltage.

PIN2: This is the trigger-input. A negative voltage pulse is applied to this pin when falling below one third V_{cc}, which causes the comparator output to change state, The output level then switches from low to high,

PIN3: This is the output-pin and, it's capable of sinking or sourcing a load requiring up to 200mA and can drive TTL circuits. The output voltage available is approximately $V_{cc} - 1.7V$

PIN4: This is the Reset-pin. It's used to reset the flip flop that controls the state of output-pin3. Reset is activated with a voltage level of between OV and O.4V and forces the output low-regardless of the state of the other flip-flop inputs.

PIN5: This is the control-Voltage input. A voltage applied to this pin allows device-timing Variations, which in dependently of the external timing network. Control voltage may be varied from between 45% V_{cc} Value in mono stable mode. In Astable –mode the variation is from 1.7V to the full value of the supply voltage.

PIN6: This is the threshold input. It resets the flip-flop and hence, drives the output low, if the applied voltage rises above third of the voltage applied to pin8.

PIN7: This is the discharge pin. It's connected to the collector of the NPN transistor, while the emitter is grounded. Thus when the transistor is turned ON, pin7 is effectively grounded.

PIN8: This is the power supply pin and its connected to the positive side of the supply. The voltage-applied many vary from 4.5V to 16V.

2.6 CALCULATION

THE TRANSFORMER

The voltage from the a.c mains is 220-240 V. Vs is the secondary voltage of the transformer given that,

$$V_o = \frac{2V_{sp}}{\Pi} \quad \text{......} 1$$

Where

V_o = output d.c voltage for rectification

V_{sp}= peak value of the secondary voltage.

V_o is escapade to be 12 Volt therefore,

V_{sp} = V2 x Vr.s.m ...(2)

From eqn. 1

$$12V = \frac{2Vsp}{\Pi}$$

$$V_{sp} = \frac{12\Pi}{\sqrt{2}} = \frac{18.8V}{\sqrt{2}}$$

from eqn. 2.

Vr.m. s= V_{sp} =18.8

Vr.m.s = 13 volts.

Therefore, a 240/ 12V transformer is preferred.

2.6.2 THE RECTIFIER

A bridge rectifier is preferred because its allows the use of the total secondary voltage of the transformer, Bridge rectifier D. type 600V, 6A Ic was chosen.

2.6.3 THE FILTERING CAPACITOR

The filtering capacitor used for this design is 2200μF 50V. The voltage was chosen considering the output of the rectifier

2.6.4 THE VOLTAGE REGULATOR

The selected regulators for this project design are 7805 and 7812 regulator provides +5V for the LM 339 IC and 555 timer IC. While the 7812 regulator produces +12V for the +12 Volt relay.

2.6.5 THE VOLTAGE- COMPARATOR LM339 IC

Thermistor-Bridge circuit

At 30°C R_{TH} = 1.20KΩ

At 35°C R_{TH} = 1.70KΩ (Reference temperature)

V_{cc} = + 5V

At 30°C

For R_1: R_{ao1} = 24.05kΩ (resistance between GND and output of R_1)

R_{as1} = 24.00kΩ (Resistance value between GND and V_{cc} of R_1)

Therefore Reference voltage (V_{in1}) at the negative Voltage input Pin 6. Applying voltage -divider equation is;

$$\frac{V_{in1}}{V_{cc}} = \frac{R_{Go1}}{R_{Go1} + R_{Gs1}}$$

$$V_{in1} = \frac{R_{Go1}}{R_{RGo1} + R_{Gs1}} \times V_{cc}$$

$$= \frac{24.05k}{(24.05 + 24)\,K} \times 5V$$

V^{-}_{in1} = 2.50V (reference voltage1)

Also, = $V_{in}{}^{+}{}_{1}$ at 30°C

$$\frac{V_{in}{}^{+}{}_{1}}{V_{cc}} = \frac{R_{TH}}{R_{TH} + R_2}$$

$$V^{+}_{in1} = \frac{1.20}{(1.20+1.5)\,K} \times 5V$$

$V^{+}_{in1} = 2.22V$

<u>At 35°C</u>

$$V_{in}{}^{+}{}_{1} = \frac{1.70k}{(1.70 + 1.5)k} \times 5V$$

$V^{+}_{in1} = 2.67V$

Voltage – gain A

$V_o = A(V_{in} - V_{ref})$

Where,

V_o = the output voltage

V_{in} = the input signal at the non-inverting terminal

V_{ref} = Reference voltage at the inverting-terminal.

A = the open- loop of the op-amp (Voltage-gain)

$$A = \frac{V_o}{(V_{in} - V_{ref})} \qquad V_o = 2.40V \text{ (constant)}$$

$$= \frac{2.40V}{(2.67 - 2.50)V}$$

$A = 14.12$

2.6.6 PHOTO-CELL BRIDGE-CIRCUIT

Under illumination R_{ORP} = 400Ω =0.4kΩ

At Darkness Road = 9kΩ

V_{cc} = 5V

R_4 = 3kΩ

R_5 =1k

Applying (KVL) equation to determine reference Voltage ($V_{in}{}^{-}{}_{2}$) of the smoke- circuit.

$V^{-}_{in2} = ?$

For R_3: R_{Go3} = 12.20kΩ (Resistance value between the GND and output of R_3)

R_{Gs3} = 12.00kΩ (Resistance- value between the ground and V_{cc} of R_3)

Therefore,

$$V_{in}'{}_2 = \frac{R_{Go3}}{R_{GO3} + R_{as3}} \times V_{cc}$$

$$= \frac{12.2 \times 5V}{(12.2 + 12)\ k}$$

$V_{in}'{}_2$ = 2.50V (reference-voltage for the smoke circuit)

Also, V^+_{in2} under illumination

$$V^+_{in2} = \frac{(R_{oRp} + R_5)}{(R_{oRp} + R5) + R4} \times V_{cc}$$

$$= \frac{(0.4 + 1)\ k}{(1.4 + 3)\ k} \times 5V$$

V^+_{in2} =1.60k

At darkness,

$$V^+_{in2} = \frac{(9+1)k}{(10 + 3)\ k} \times 5V$$

V^+_{in2} = 3.85V

Voltage gain

$$A = \frac{V_o}{(V_{in} - V_{ref})} \qquad V_o = 2.40V$$

$$= \frac{2.4}{(3.85 - 2.50)}$$

A = 1.78

2.6.7 LIGHT EMITTING DIODE

From Data book.

V_{LED} =1.7V

I_{LED} = 25mA

$$R_n = \frac{V_{cc} - V_{LED}}{I_{LED}} = \frac{5 - 1.7}{25 \times 10^{-3}}$$

R_8 = 132 a little bit higher value will also do to protect the LED. Therefore,

preferred value is 160Ω

2.6.8 AMPLIFIER (BJT) TRANSISTOR.

V_{in} = 1.5V

I_B =1.9mA.

hfe =156 = β

V_{BC} = 0.6 V

Therefore,

β =$\underline{I_c}$

$I I_c$ =I_B β =1.9 x10^{-3} x156

=296mA

Therefore, $R_8 = \frac{V_{in} - V_{BE}}{I_B}$

$$\frac{2.5 - 0.6}{1.9 \times 10^{-3}} = 1000\Omega$$

$R_9 = R_8$ =1kΩ

2.6.9 ASTABLE MUTIVIBRATIOR (555 TIMER)

V_{R11} =2.34V

C_l=100μF

R_{10} =10k

R_{ll} =?

Using voltage divider theorem.

$$V_{R11} = \frac{R_{11}}{R_{10} + R_{11}} . V_{cc}$$

$$V_{R11} (R_{10} + R_{11}) = R_{11} . V_{cc}$$

$$V_{R11}.R_{10} + V_{R11} . R_{11}.V_{cc}$$

$R_{11} (V cc - V r_{11}) = R_{11}.Vcc$

$R_{11} (V_{cc} - V_{R11}) = R_{10}.V_{R11}$

$R_{11} = \frac{R_{10}.V_{R11}}{(V_{cc} - V_{R11})}$

$R_{11} = \frac{2.34 \times 10}{5 - 2.34}$

$R_{11} = 8.8k$

Time constant T_H (during the High interval is)

i. $T_H = 0.693 (R_A + R_B) C \; R_A=R_{10}, R_B = R_H$

$T_H = 0.693 (10 \times 103 + 8.8 \times 10^3) 10 \times 10^{-6}$

$T_H = 0.130$ sec. (i.e T_{on})

Low –state time interval C

$T_L = 0.683 R_B C$

$= 0.693 \times 8.810^3 \times 10 \times 10^{-6}$

$T_L = 0.61$ sec

Period T

$T = T_H + T_L$

$= 0.13 + 0.061$

$T = 0.191$ sec

Frequency

$F = \frac{1}{T} = \frac{1}{0.191} = 5.24Hz$

$F = 5.24 H_z$

v. **Duty cycle is**

$D = \frac{T_H}{T} = \frac{ton}{T} \times 100\%$

$D = \frac{0.130}{0.191} \times 100\%$

D = 68.06% (i.e. For 68.06% of the cycle, the system is t_{on} and for 31.94% it's in t_{off}

THE RELAY

Relay resistance = 355Ω

$V_{cc} = 12V$

Therefore,

$I_R = \frac{V_{cc}}{R}$

$= \frac{12V}{355} = 0.0338A$

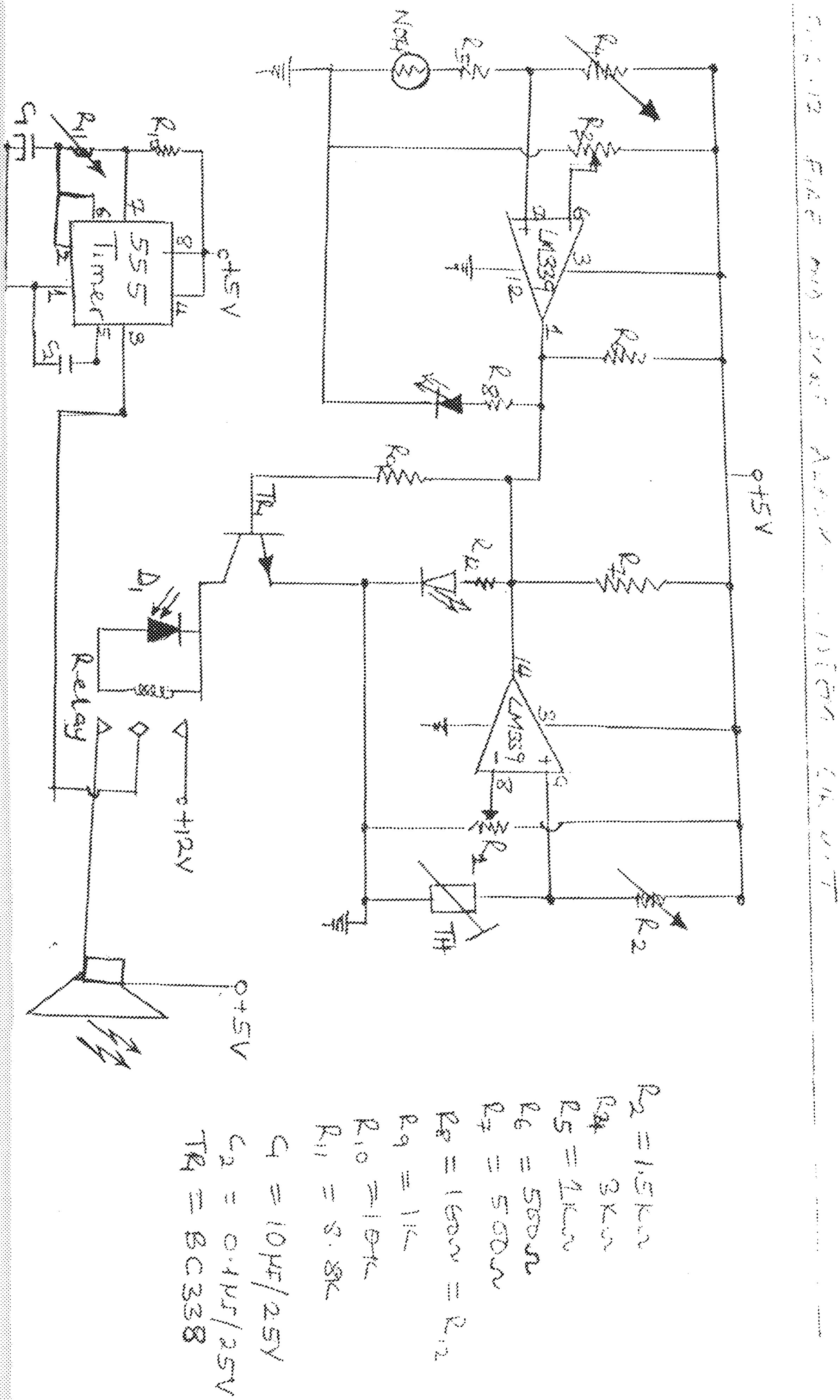
I_R = 33.8Ma

2.7 CICRUIT OPERATION

The circuit design of the fire and smoke alarm system is voltage comparator, using LM339IC + 5V is supplied to the V_{cc} i.e Pin 3 of the operating Amplifier IC

For the thermistor bridge circuit, Variable resistor R_1 was set at a fixed reference value , which to determines the reference voltage (V_{in}) at the negative input pin8, which is 2.50V. the thermistor control variable resistor R_2 is set to a resistance value, which is below R_1 therefore making the positive input voltage lesser than the negative reference voltage, this the output volt at pin4 (0.04V this condition is at the room temperature) when heat is applied to the sensor, its resistance increases with the increase in temperature. This caused R_2 to increase in resistance and more current flows into positive input voltage pin9. Hence, positive input voltage becomes greater then the negative reference voltage and the output voltage increases to 2.40V, triggering the alarm circuit to produce flashing visual and Audio alerting signals.

The photo cell circuit operates under similar principle. Pins –6,7 and 1 of LM339Ic are used for this smoke bridge circuit. R_3 which is the fixed pre-set value is connected to the negative voltage in put pin 6, to obtain a reference voltage, which is 2.50V. R_4 is connected through the sensor to positive voltage input pin 7, It's resistance is lesser then R_3, under illumination. When smoke enters into the circuit, its reduces the amount of illumination that reaches the sensor or surface this the resistance of the photocell increases rapidly with reduction in illumination intensity. When the pre-set value is reached, the voltage at the positive input exceeds that of the negative voltage input and the output voltage increases from 0.04V to 2.40V, which triggers the used and Audio alarm circuit.



2.17Complete Fire/Smoke alarm circuit diagram

CHAPTER THREE

3.0 CONSTRUCTION, TESTING AND RESULTS

The circuit connections of the fire and smoke alarm system were carefully constructed.

3.1.1 ARRANGEMENT

To enhance convenience and easy maintenance of the alarm-circuit connection, the components and Ic's were well played out on the vero-board.

Components like variable resistor and capacitors were mounted cross in their positions while those of fixed resistors were mounted flat. Ics are amounted on sockets, which were soldered to the vero-board already, so that heating-up of the Ics when want to solder them directly on the vero-board will not destroy the Ics. In arrangement and soldering of the components, great care was taken to avoid shorting the leads and proper soldering was done to avoid dry-joints.

3.1.2. SOLDERING

Some soldering precautions taken are outline below.

i. Little but enough solder was applied to any joint to ensure proper contact of the components.

ii. Care was taken to ensure proper soldering of each joint, so that the lead of individual joints would not contact (i.e. shorting).

iii. Heat sink was used to conduct heat away.

iv. Made sure that the soldering-iron temperature was not too high to prevent damage that could result from other-heating.

3.2 TESTING

The following tests were carried

1. Flame test.
2. Smoke test.

3.2.1 FLAME TEST

A preset resistance value had been chosen for the thermistor – transducer that gives a reference voltage for the flame-detector circuit to come on . The value at which it comes on is 1.70KΩ at 35°c

The probes of a digital multi-meter set to resistance is in contact with the two-legs at the thermistor while the metal-end of the thermometer was placed in contact with the body of thermistor. Candle flame was applied to the transducer as the temperature of the thermistor increase i.e. 30°c, the resistance of the thermistor also increase. But, when the preset resistance value is reached, the positive voltage impact of the voltage comparator becomes greater the negative voltage of the comparator and an output signed in given which triggers both the (Red) LED and the audio alarm circuit on.

This alerting signal continued until the resistance value of the thermistor dropped back to 1.20k at 30°c

3.2.2 SMOKE TEST

The photo-conductive cell set to a preset resistance value of a reference voltage in the voltage comparator circuit was subject to smoke test. by using "hand cover test" to serve as a "smoke – concentration" on the sensor at the cell. When the sensor was in complete darkness (i.e. dark condense smoke) the photocell resistance increases within 18ms from 400Ω to 9kΩ. This made the positive voltage of the op-amp. greater than the negative-voltage and, alerting signed outputs were given by both the (GREEN) indicator and audio alarm.

This alerting signals continued until the resistance of the photocell reduced back to 400Ω within 120ms.

3.3 RELIABILITY TEST

The reliability values for 24hours givens the failure rate of each component is computed below.

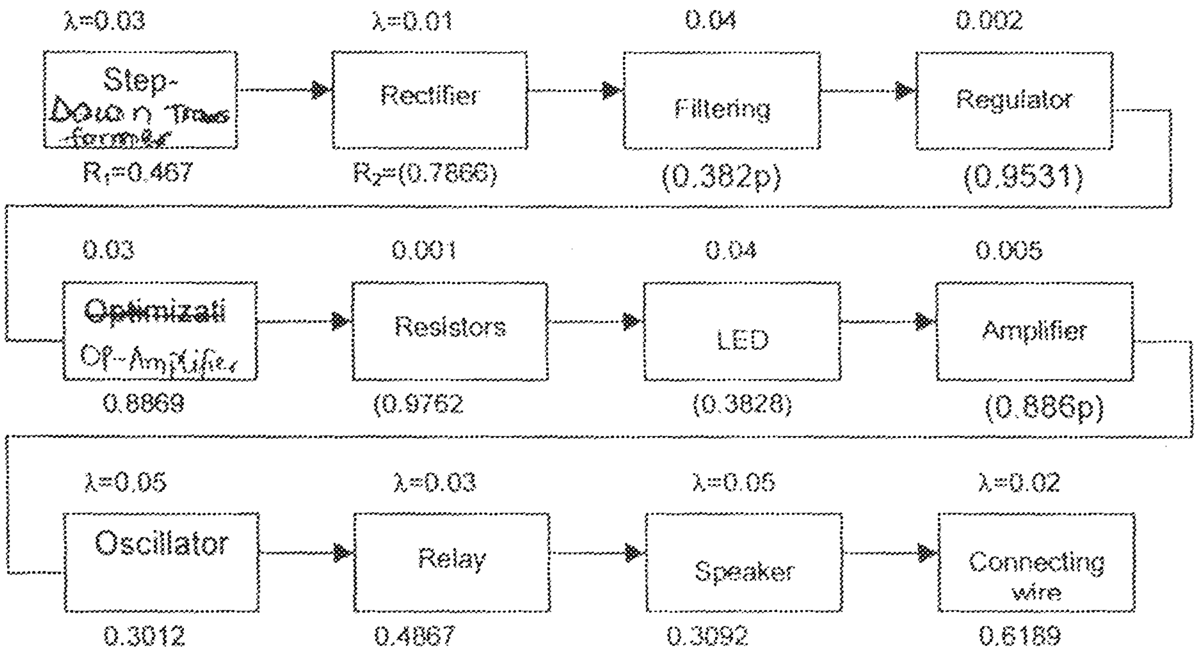


Fig. 2.18 The reliability block diagram

The total reliability of the system is give as $R(E) = R_1(t). R_2(t). R_3(t)$ ----- $R_{12}(t)$

Therefore,

For 24 hours of operation.

$R_1(24\ hrs) = e^{-\propto t} = e^{-(0.03)24} = 0.467$

$R_2(24\ hrs) = e^{-(0.01)24} = 0.7866$

$R_3(24\ hrs) = e^{-(0.04)24} = 0.3829$

$R_{12}(24\ hrs) = e^{-(0.02)24} = 0.6189$

Therefore

$R(E) = (0.4670)(0.7866)(0.3829)(0.9531)(0.8869)(0.9762)$

$(0.3828)(0.8869)(0.4867)(0.3012)(0.3012)(0.6189)$

$R(E) = 0.9989$

3.3 DISCUSSION OF RESULT

From table 2.5.1.1, it can be seen that the thermistor resistance once increases with increase in temperature. When heat is applied to the sensor, it's resistance changes from 1.20Ω to 1.70KΩ, which increases resistance value of R_2. Thus more current flows into p in 9 (the positive input voltage). This causes the output voltage to change from 0.04v to 2.40v to trigger the visual and audio alarming circuits, for about 3 minutes, until the positive input voltage falls below the negative reference voltage, (V'_{in})

Like-wisely for the smoke test, when smoke covered the surface of the sensor by blocking illumination away from it, the resistance of the photocell increases within 18ms unity the preset value is reached and R_4 is greater than R_3, increases from 400Ω to 9KΩ. This makes the +ve input voltage greater than –ve input and an output – signal is given, which triggers the visual and the audio alarm. This continues for about 5 seconds, till when the V'_{in2} is greater than V'_{n2}.

3.5 CASING.

In this project, a galvanized metal sheet was used for the casing. This is because it's readily available cheaper and convenient to construct.

The case is rectangular in shape It's constructed in such a way that, there is enough opening at the top, sides and front parts of the case, so that there is enough room for heat and smoke to enter into the chamber of the fire/smoke alarm system case

The dimension for the casing is as follows:

Length = 12.0cm

Breath = 8.0cm

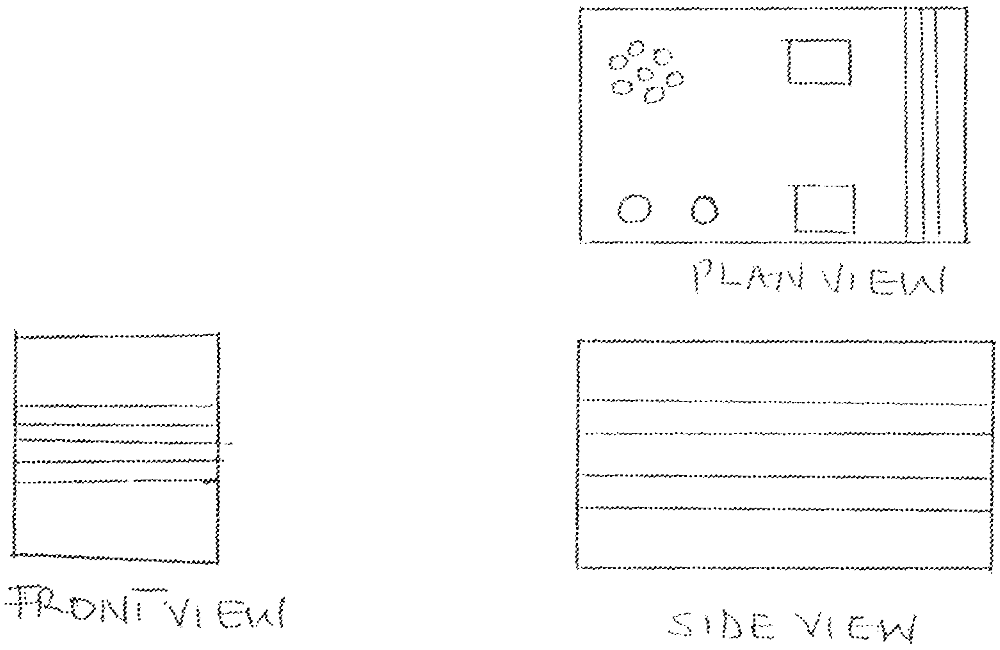
Height = 7.0cm

The total volume of the casing is:

Volume = length x breath x height

= 12 x 8 x 7

= $672cm^2$ = $0.000672m^3$



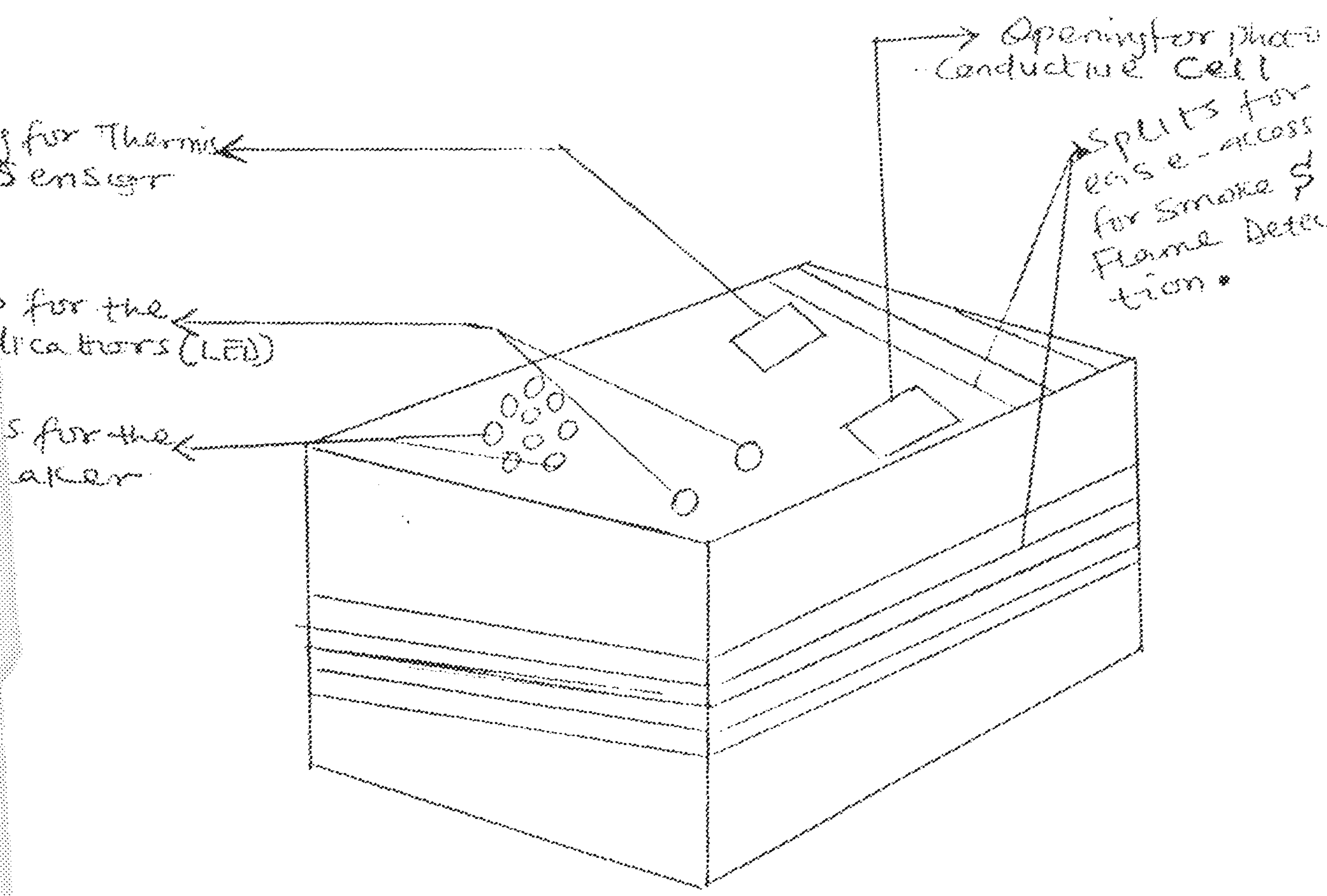


Fig 2.19 ISOMETRIC VIEW OF THE CASE

BILL OF MATERIAL (QUANTITY FOR THIS PROJECT DESIGN

S/NO	Name of components	Quantity	Voltage/circuit rating	Per unit Price(N)	Total Price (N)
1	Step down transformer	1	240V/2v	150.00	150.00
2	Diode	1	IN4001	20.00	20.00
3	Resistor fixed	8	-	10.00	80.00
4	Resistor variables	5	-	20.00	100.00
5	Relay	1	10A/12VDC	150.00	150.00
6	Regulator	2	+5V, 12V	40.00	80.00
7	Bridge rectifier	1	600V,6A	80.00	80.00
8	Capacitor	2	1μF, 50V	20.00	40.00
9	Capacitor	2	1000μF, 50V	40.00	80.00
10	Capacitor	2	10μF, 35V	20.00	20.00
11	Transistor	1	BC 338	40.00	40.00
12	Loud-speaker	1	4Ω, 4W	60.00	60.00
13	Thermistor	1	FC 27M270	200.00	200.00
14	Photocell	1	NORP 12	400.00	400.00
15	555 timer ic	1	4V – 18V	50.00	50.00
16	LM339 Ic	1	+5V	80.00	80.00
17	Switch	1	15A, 250V AC	40.00	40.00
18	Plug	1	10A, 25oV	20.00	20.00
19	Vero board	1	-	100.00	100.00
20	LED	2	25mA/1.7vDc	10.00	20.00
21	Connecting wires	-	-	40.00	80.00
22	Miscellaneous	-	-	500.00	500.00
					2,400.00

CHAPTER FOUR
CONCLUSION AND RECOMMEAATIONS

4.0 CONCLUSION

Having designed the fire and alarm system, it can be seen that the alarming system is better reliable and more efficient than previous existing detectors. This fact is proved by the good sensitivity and high reliability value from the test and calculation respectively, that the designed project have.

These good sensitivity and high reliability value is due to the Ic i.e. LM339 Op-Amp and the transducers FC27M27. Thermistor and photo-resistive-cell used. Also, the use of class A based (BJT) amplifier, which is of good efficiency, lowest distortion and high fidelity for 360° along relay and 555 timer IC a stable multivibretor for alarm circuit, makes this designed project a unique, very sensitive and much more reliable.

4.1 RECOMMENDATION

I'll like to advice the department to expose the students to more practiced works before embarking on find year projects. This will ease the problems encountered during project design and construction.

Also, the department should encourage students to present their own projects i.e. standard projects. This will task the students to discharge their ideas and knowledge acquired during the course of their degree programme in the university.

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