THE DESIGN OF AN AUTOMATIC FIRE, SMOKE/FLAME ALERT SYSTEM WITH SPRINKLER UNIT INCORPORATED

BY

EYO VERONICA AKIBA
2000/9828EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY,

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

OCTOBER, 2006.

THE DESIGN OF AN AUTOMATIC FIRE, SMOKE/FLAME ALERT SYSTEM WITH SPRINKLER UNIT INCORPORATED

BY

EYO VERONICA AKIBA
2000/9828EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY,
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A BACHELOR OF ENGINEERING DEGREE (B.ENG) IN ELECTRICAL/COMPUTER ENGINEERING

OCTOBER, 2006.

Dedication

This project is dedicated to God for the strength, wisdom, knowledge and understanding he has given me to complete my program.

My parents for all they have done for me and for enabling me to come this far in my endeavors.

My brother,sisters and friends whose prayers, support and encouragement has been of tremendous help to me.

Declaration

I, Eyo Veronica Akiba (2000/9828EE), 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

VERONICA EYO AKIBA
(Name of student)

Eyo 10-10-2006
(Signature and date)

DR ... TSADO
(Name of supervisor)

(Signature and date)

ENGR M. D. ABDULLAHI
(Name of H.O.D)

(Signature and date)

(Name of External Examiner)

(Signature and date)

Acknowledgement

I would like to thank God almighty for his grace, favour and faithfulness. My sincere gratitude goes to my supervisor Dr. Tsado for his intelligent and valuable suggestions and constructive criticism provided throughout the period of this work. I am highly grateful to all members of staff of the department for the numerous ways in which they have been of help to me during the course of my studies.

I will remain forever grateful to my parents, brother and sisters for their unreserved support during the course of this project. I am most grateful to you all. Thank you all and may God bless you.

which contributed greatly to my success.

I am greatly indebted to my friends, Mairo, Baby Hanan, Wale, Goldima, Deji, Alex, Florence, Gellal, Bode, Seun and all my colleagues in the department who have been a source of inspiration to me

Abstract

The design and construction of the automatic fire, smoke/flame alert system is presented in this project. The device provides a means of detecting the outbreak of fire through the use of two sensors. A particular sensor (LM35) monitors the temperature of the location while the other detects smoke in the air through a simple configuration of two infrared devices.

The audio alarm, light alarm and sprinkler are triggered on whenever there is a trace of fire. The sprinkler unit provides a means of quenching the fire, thus controlling the fire to a harmless level. The device is reset through a switch to put the output off.

This project was carried out by first conceptualizing the idea, then constructing the device block by block; ensuring that each block has operated as conceived before proceeding to the next block.

This project ensures the safety of lives and property because it alerts people about the possibility of fire outbreak. The economic importance of this project is to save cost. Most of the references used in this project is obtained from internet books and journals.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FOUR: CONSTRUCTION, TESTING AND RESULT

CHAPTER ONE

1.1 Introduction

The consequences of fire outbreak to lives and properties can never be over emphasized. Over the years the accidents caused by the outbreak of fire is one of the most destructive nature of accidents.

Smoke also is deadly since it prevents escape, reducing visibility and dulling of the senses. Recent studies have shown that 65% of all fire deaths results from smoke, more than those that are caused by burns, falls, explosions and other causes related to fire.[26]

For these reasons and as part of the industrial and safety regulation, it is necessary to design and install some fire alert systems in buildings which will detect heat, flame and smoke and provide an early warning in the event of a fire outbreak; thereby allowing people to reach safety before it grows into an uncontrollable proportion.

Most fires are easy to control at an early stage except petroleum. This is done by removing one or more of the 3 elements of combustion (fuel, heat and oxygen) or by interrupting the combustion chain reaction. [27], over the fire area resulting in the fire being controlled to a substantially harmless level. This could be achieved by using a sprinkler system which is an integrated system of underground pipes designed in accordance with the fire protection engineering standards and connected to one or more automatic water supplies. When the unit is activated, the sprinkler units discharge water

1.2 Aims and Objectives of the Project

1. To provide a means of detecting the outbreak of fire in a location

2. To ensure the safety of lives and property by alerting the occupants of a building about the presence or the possibility of a fire outbreak.

3. To put off the fire during the event of a fire outbreak. By the incorporation of a sprinkler unit into the system

4. To save cost. It is found that a single zone fire alarm panel costs N7,000 whereas this whole design cost lower (N5000) than the price of a single detecting system.

1.3 Scope of The Project

The scope of this project is to design a fire alarm system with some complex features such as temperature sensor, smoke/flame detector, loud speaker, sprinkler unit and the light alarm. This system could be much more complex if control panels, fire detectors, pull boxes and telephones are included in the design.

1.4 Methodology Adopted In the Project

This project was carried out by first conceptualizing the idea, then constructing the device block by block; ensuring that each block has operated as conceived before proceeding to the next block. Most of the references of this project are from the internet due to its nature, though many books and articles were also consulted. Some individuals who are specialists in electronics were also contacted for advice and correction. The concluding steps includes the construction, troubleshooting and packaging of the fire alarm system. Each chapter is well defined with illustrations using block diagrams and circuit diagrams provided where necessary.

The project is divided into five chapters. Chapter one introduces the project. Chapter two contains the literature review. Chapter three gives the design and system operation for the project. Chapter four gives construction, testing and the results obtained. Chapter five gives the conclusions, precautions and recommendations.

1.5 Constraints of The Project

The constraints of this project is that it is limited to the design and construction of a smoke/flame and fire alarm system which can detect heat, smoke and give an alarm signal. It can't be interfaced and monitored by a computer system because no consideration was made for any digitally controlled input/output system.

1.6 Project Layout

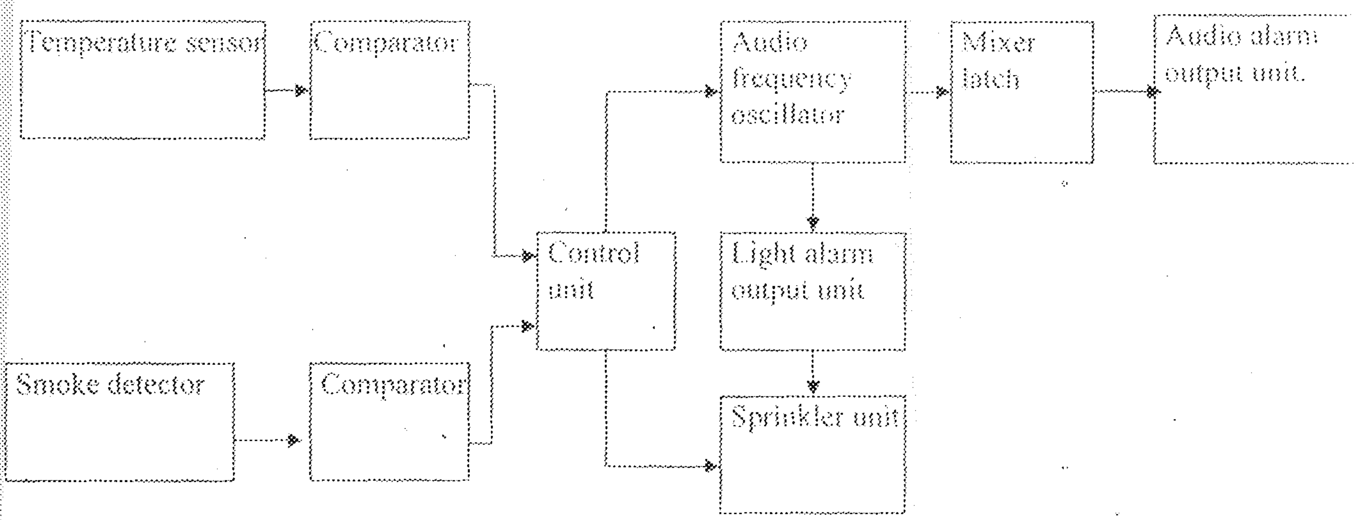


Fig. 1.6 Block Diagram Of The Fire, Smoke/Flame Alert Unit With Sprinkler

CHAPTER TWO

LITERATURE REVIEW

2.1 History and Development of Fire Alarm System

The design of a heat and smoke detector is dated back to 1902, when George Andrew Darby, an electrical engineer of 211 Bloomsburg Street, Birmingham, England invented the electrical Heat-Indicator and Fire Alarm.[12]

The device indicated any change in the temperature of an apartment where it was fixed. The device merely worked by closing an electrical circuit to trigger on the alarm unit if the temperature rose above the safe limit. The contact was made by bridging a gap with a conductor or allowing one plate to fall on another. This movement was caused simply by a block of butter which melted as the temperature rose.

It was quite evident that the device was indeed primitive, with little practical importance. But this device subsequently gave way to modern fire early systems and eventually smoke alarm.[12]

In the 1920s another significant development occurred, when several resort fires claimed many lives around the world. The Hochiki Corporation undertook the design manufacturing installation and maintenance of fire alarm systems and produced up to 3.5 million units each year. The first mechanical manual (MM) style was installed in Japan by Hochiki corporation.[15]

In 1969, Kenneth House and Randolph Smith designed the first battery operated smoke alarm. The portable or small sized smoke alarm had low power consumption making further development possible. [22]

Another device that was developed with the fire sensor was the "fire sprinkler". It was a fire fighting and extinguishing device. The fire sprinkler system consist of a body with a channel for liquid supply, a thermally responsive unit with a valve closing the sprinkler outlet and a network of overhead pipes that release foam of fluid or gas automatically through sprinkler units when a predetermined temperature was reached. Most sprinkler systems extinguish with water. They are called wet systems, which use pipes filled with water.[24]

In large buildings, during fire fighting, fire pumps are incorporated into the fire sprinkler units. It is connected to the municipal water system at the intake and to the building's sprinkler systems. It is usually powered by electricity and may require the installation of an emergency generator. The fire pump becomes active when one or more sprinkler units are exposed to heat above their design temperature. The sprinkler unit releases and the water discharges, this will trigger a water flow alarm inside the sprinkler system pipes. The fire pump provides additional water especially pressure to the activated sprinkler heads. Fire pumps are especially useful in high-rise building.[21]

A fire alarm is mostly incorporated into the early installation. It is usually an electro mechanical or electronic bell, klaxon, chime, horn, speaker, strobe light or any other device which warns people in a building of a possible fire or other conditions requiring attention. Fire alarms are often very loud, sounding at between 90 and 100 decibels. Fire fighters have been known to have hearing problems after exposure to alarms over many years.[23] Typically, when a fire alarm is sounded, emergency responders are summoned, the building is evacuated, people gather at predetermined assembly points and a row call is held.

Fire alarms may be automatically activated by smoke detectors, heat detectors sprinkler flow switches, or manually. Manual pull stations and manual call points are sometimes protected by glass which must be smashed to set off the alarm. Protective covers may also be placed over the station to help prevent false alarms

Another recent development is the Early Suppression fast Response (ESFR) sprinkler. It was developed in the 1990's to take advantage of the latest fast-response fire sprinkler technology to provide fire suppression of specific high challenge fire hazards. The sprinklers are specifically designed to fully suppress a fire that is within the design limits of the piping systems.[25]

2.2 Smoke Detectors

Smoke detectors are usually smoke sensing electronic devices. All smoke detectors consist of two basic parts: a sensor to sense the smoke and a very loud electronic horn to wake people up or to merely alert the concerned people.

Smoke detectors may be battery powered or supplied by alternating current (AC) mains. The two most common types are the photoelectric detectors and ionization detectors respectively.[1]

2.3 Types of Smoke Detectors

2.3.1 The Photoelectric Type or Optical Detector

The photoelectric type or optical detector includes a light source, a lens to converge the light into a beam and a photodiode or other photoelectric sensor at right-angle to the beam. In the absence of smoke, the light passes in front of the detector but does not fall on it. When visible smoke enters the beam, some light is scattered by the smoke particles and some of the scattered light is detected by the sensor. An increased output from the sensor sets off the alarm.[12]

Optical detectors are not necessarily confined in a single module, there are some optical detectors that span the width of an area. In such situation, the detector works by using a straight infra-red beam from the transmitter to the receiver. When smoke enters the beam, some light is scattered which results in less light detected by the receiver. A decreased output from the receiver sets off the alarm.[12]

2.3.2 Ionization Detectors

Ionization detectors are cheaper than the optical detectors, it is usually rejected due to environmental reasons because of its nuclear involvement. It involves an ionization chamber and a source of ionization radiation to detect smoke. Inside the chamber is a small amount (perhaps $^{1}/_{5000th}$ of a gram) of americium-241. The radioactive element americium has a half life of 432 years and is a good source of alpha particles.[17] The ionization chamber which is an air filled space between two electrodes, allows a small constant current to flow between the electrodes so that any smoke that enters the chamber absorbs the alpha particles, which reduces the ionization and interrupts this flow of current, setting off the alarm. Hot air entering the chamber changes the rate of ionization and therefore the electric current level, which triggers an alarm.[13]

2.4 The Contrast between The Photoelectric Type And Ionization Detectors

In the 1990s, Texas A & M University did a full scale scientific investigation into the effectiveness of optical and ionization smoke detectors in different types of fire. In the study, it was determined that in a smoldering fire, with its relatively low number of large smoke particles, optical detectors fail 4.06% of the time while ionization detectors fail 55.8% for flame ignition fires which have a large number of small, energetic smoke particles, photoelectric smoke detectors had a 3.99% probability of failure while ionization smoke detectors failed 19.8%. The leading investigation showed that photoelectric smoke detector works faster in response to its counterpart, the ionization type.[12]

CHAPTER THREE

3.1 The Component Choice and Description

The circuit design made use of the complementary metallic oxide semiconductor (CMOS) integrated circuit type. Such logic technique has low power consumption, high compatibility and availability, a wide voltage supply range and less heat production. This class of logic circuits includes chips that perform microprocessor, microcontroller, static RAM and other digital logic operations. CMOS also allows a high density of logic functions to be implemented on a chip. It possesses a wide voltage supply range and are very cheap. The design uses the 4000 series complementary metallic oxide semiconductor (CMOS) mode for implementing logic functions.

3.2 Description of the Components

This project has two input sections, the heat and smoke detector circuits. These two sections have specific sensors and transducers that convert the varying physical and external conditions into the corresponding electrical quantity which yields a predetermined result or output (light and audio alarm and sprinkler unit). Most of the information used was acquired from the internet. The data sheets for each component was obtained from the manufacturer's sites.

3.2.1 The Lm35 Temperature Sensor

The Lm35 temperature sensor is a natural semiconductor precision integrated circuit, whose output voltage is linearly proportional to the Celsius (centigrade) temperature. The Lm35 has an advantage over linear temperature sensors calibrated in Kelvin as the user is not required to subtract a large constant (273) voltage from its output to obtain the convenient centigrade scaling. The Lm35 does not require any external calibration or trimming to provide typical accuracies of ± ¼% at room temperature and ± 3% over a full 0 - 100°C range. The Lm35 produces an output voltage of 10mV for every 1°C temperature increment. Therefore a temperature of 60^0C is recognized as 600mV by the device The output voltage range for the device is 0 – 1V.[4]

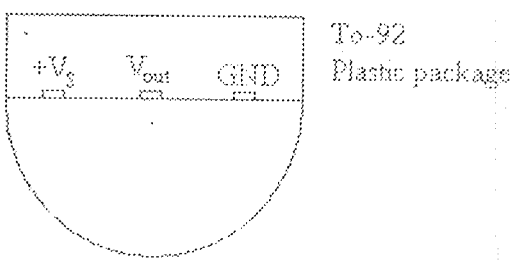


Fig 3.2.1a The Bottom View Of The Lm35

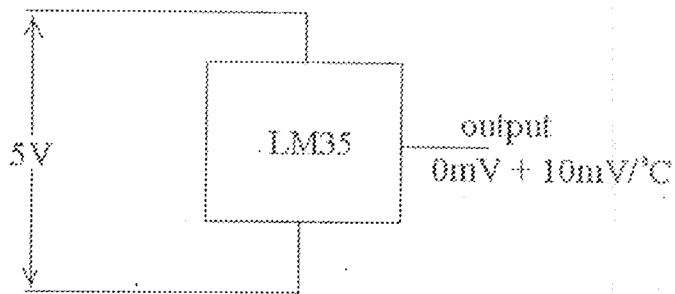
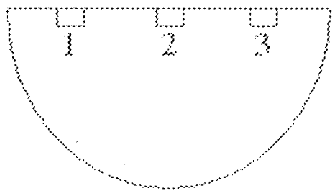


Fig 3.2.1b Typical connection of LM35

3.2.2 The 2SC945 Transistor

The 2SC945 is an NPN transistor designed for audio and low speed applications. Its maximum Collector to Base voltage (V_{CBO}), Collector to emitter voltage (V_{CEO}), Emitter to Base voltage (V_{EBO}), Collector current (I_C) and Base current (I_B) are 60V, 50V, 5.0V, 100mA and 20mA. Its actual power dissipation is 250mW.[2]



1. Emitter
2. Collector
3. Base

Casing SEDEC: T092

Fig 3.2.2 Pin Layout Of A 2SC945 Transistor.

3.2.3 The IN4001 Diode

IN4001 is a typical rectifying P-N diode. Its maximum voltage current ratings are 50V and 1A.It also has a high reliability, low leakage, low forward voltage drop and high current capability.[10]

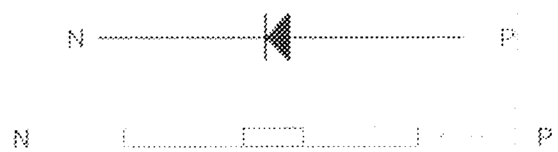


Fig 3.2.3 Pin Layout Of In4001 PN Diode.

3.2.4 The 4060B Oscillator

The 4060B is a 14-stage oscillator/divider CMOS integrated circuit. It is designed with minimum power consumption. It can generate up to 10 frequencies at once and is a good multiple signal source. It has a reset terminal for the output. It is active high. A negative transition clock will advance the counter to the next state. Schmitt trigger action on the input line permits very slow input rise and fall times. Its application includes time delay circuits, counter controls and frequency dividing units.[3]

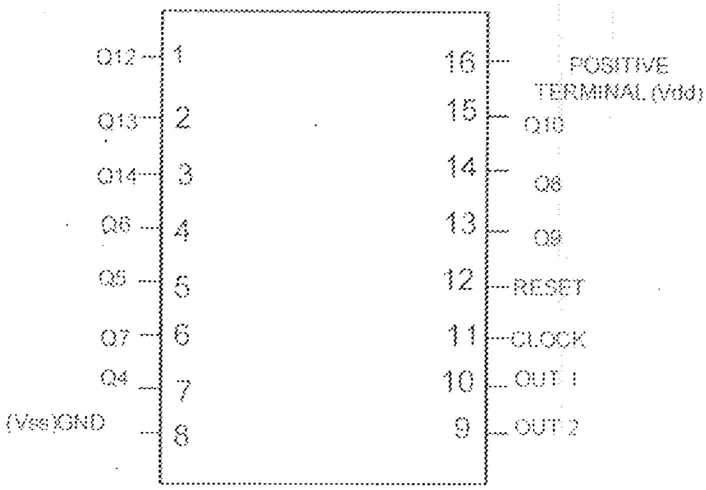


Fig 3.2.4a Pin Layout Of 4060b

Terminal out 1, out 2 and clock are used for RC configuration set-up.

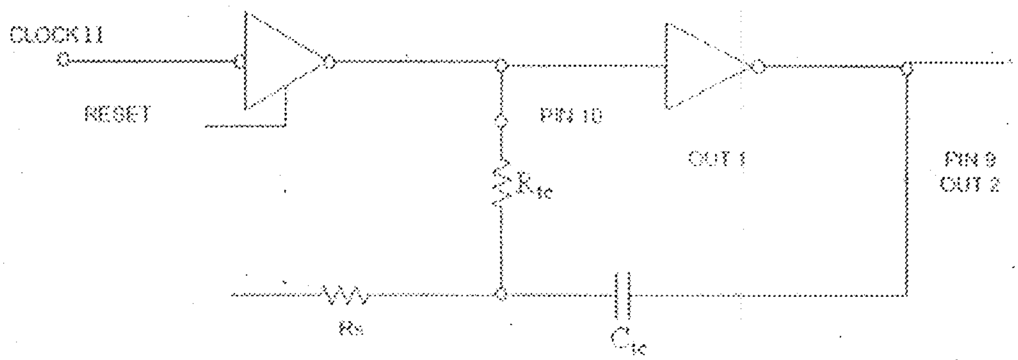


Fig 3.2.5 An Oscillator Circuit Using RC Configuration.

The relation of the resistor-capacitor circuit is given below.

$$f = \frac{1}{2.3R_{tc}C_{tc}}$$

If 1Khz $\leq f \leq$ 100Khz and $2R_{tc} < R_S < 10R_{tc}$

(f in Hz, R in ohms, C in farads)

The formula may vary for other frequencies. The recommended maximum value for resistor is 1MΩ, and the formula is suitable for operation at 10V

Although the 4060B series is a crystal oscillator, the project is limited to its RC configuration application.

3.2.5 The LM339 Comparator

The Lm339 is a single supply quad comparator integrated circuit. It is designed for use in level detection, low level sensory and memory applications in consumer, automotive and industrial electronic applications. It is both TTL and CMOS compatible[5]

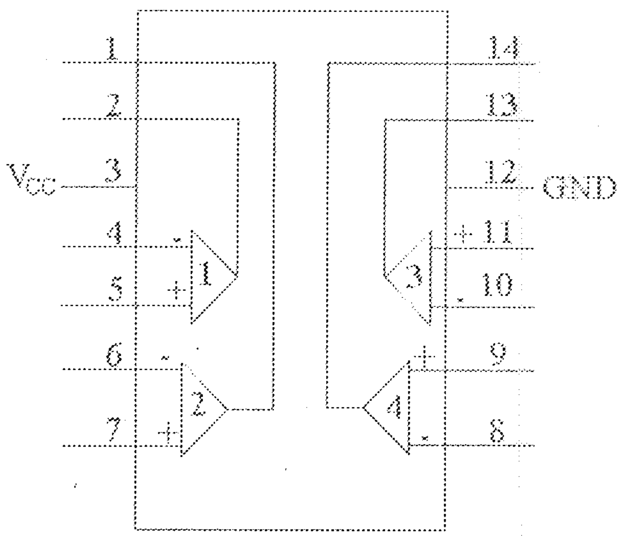
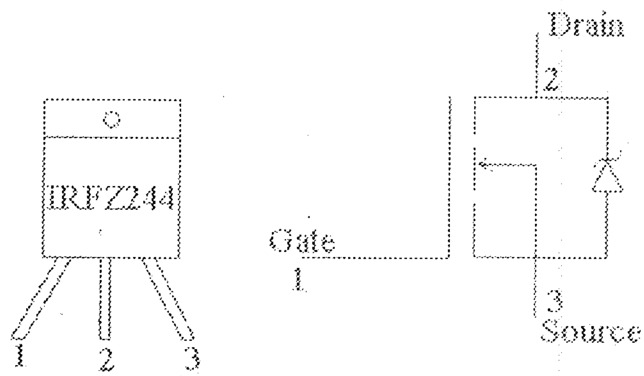


Fig 3 2.5 Pin Layout Of Lm339 Comparator.

3.2.6 IRfZ44

The IRfZ44 is a high and power switching transistor. It uses advanced processing techniques to achieve extremely low on-resistance per silicon area. It has a low drain-source resistance of just 0.0175Ω. It works with a maximum voltage rating of 55V and high current of 49A. It is suitable for high current switching in which the use of transistor would definitely fail. It is quite a good choice for the alarm and sprinkler part of the circuit.[8]



1- gate

2- drain

3- source

Fig 3.2.6 Pin assignment and symbol of IRFZ44

3.3 Design Analysis

This design is divided into seven parts or units which work in accord to perform the fire detection and sprinkling functions.

(i) Power Unit.

(ii) Smoke Sensor Unit.

(iii) Temperature monitoring Unit

(iv) Input / control latch.

(v) Alarm Unit.

(vi) Light Indicator Circuit and

(vii) Sprinkler Unit.

3.3.1 The Power Unit

The main voltage power supply is from a step down 12V AC transformer. The 12V A.C. output from the transformer is connected to a bridge rectifier. The rectifier consists of 4 rectifying diodes (IN4001). The bridge rectifier converts the A.C. output from the step-down transformer into corresponding D.C. power supply.[11]

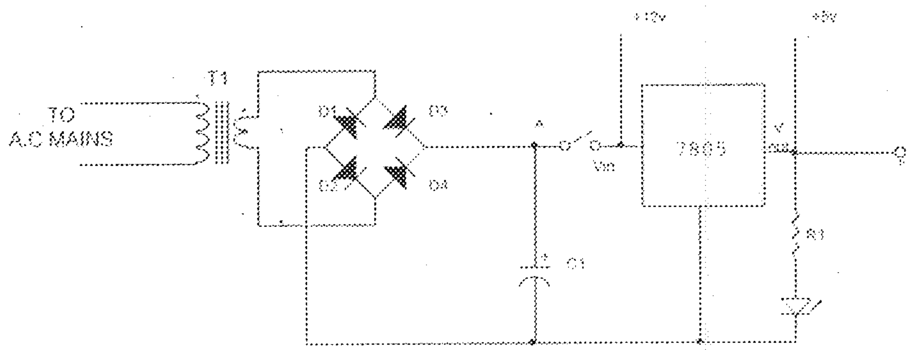


Fig 3.3.1a The Circuit Diagram Of The Power Unit.

In a bridge rectifier circuit, two rectifying diodes are forward biased and the other two reversed biased for every half cycle of the input A.C. voltage. Thus converting the input A.C. voltage into D.C voltage. The rectification does not result into pure D.C. Voltage.[18] It possesses certain level of A.C components. The attribute is normally called a "ripple effect" which is filtered by a. high capacity 2200uf, 25V electrolytic capacitor in parallel with the D.C. supply. This ripple filtering flattens the ripple characteristic of the rectified voltage.[18]

The SW at point A is a switch which closes or opens the circuit. A light emitting diode (LED) indicates the operation of the switch.

The Lm7805 is incorporated into the power unit to provide a regulated voltage of 5V. The output of the regulator is designed to be stable for varying input voltage slightly above 5V and lower than 35V. Thus, the circuit is protected to some extent from voltage-triggered malfunction.[11]

The power indicator is made up of a resistor and a light emitting diode (LED). The resistor causes voltage drop across the light indicator. Normally, LED works at around 2.7V but the power supply from the regulator is about 5V. Therefore the resistor is used to prevent the LED from voltage related damage.

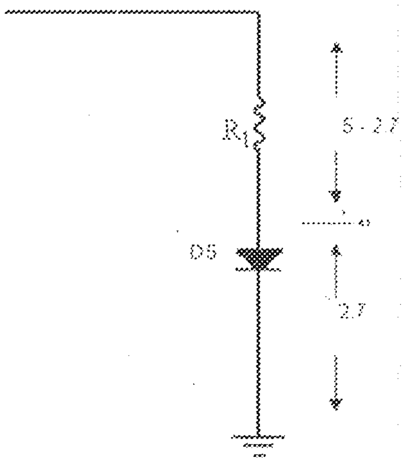


Fig 3.3.16 The Circuit Of A Power Indicator

The required voltage across the LED (D5) is 2.7V, the remaining voltage is across the series resistor (e g. 5 – 2.7 = 2.3V). The typical current associated with the circuit is 3mA.[19]

$$\text{Therefore, } R1 = \frac{V_{R1}}{I_{R1}} = \frac{2.3}{3 \times 10^{-3}} = 766\Omega$$

$$R_1 = 766\Omega$$

But a 1KΩ resistor is chosen. It provides similar results to the 766Ω resistor. , the only significant difference is dimmer light intensity, when a 1KΩ resistor as compared to the calculated value.

3.3.2 The Smoke Sensing Unit

This unit requires both an infrared transmitter and a receiver. The two devices are linked in line but with some sets of obstacles in between. The obstacles cause a cut-off or barrier state for link, so that only the reflection medium could cause an inline situation for the two devices. A medium of gas such carbon-monoxide and the fire flame are good reflecting mediums for the infra-red radiation. The leading beam passes through this medium.

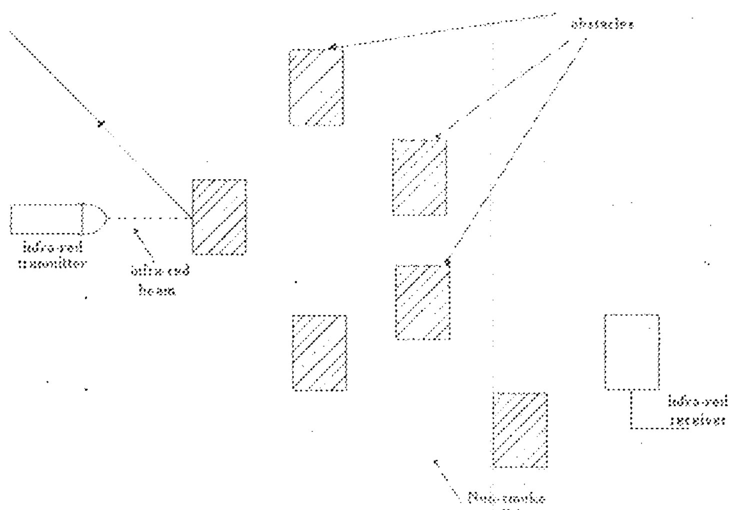


Fig 3.3.2a A non-link condition between an infra-red transmitter and receiver

The infrared transmitter holds the same light emitting diode (LED) configuration with the series 1kΩ resistor in place. The output of the receiver unit is connected to the non inverting input of the comparator ,the other inverting terminal is referenced with the use of a variable resistor across the 5V power supply. At normal condition, the inverting input is greater than the non inverting input and the output of a comparator is a logical 0 .

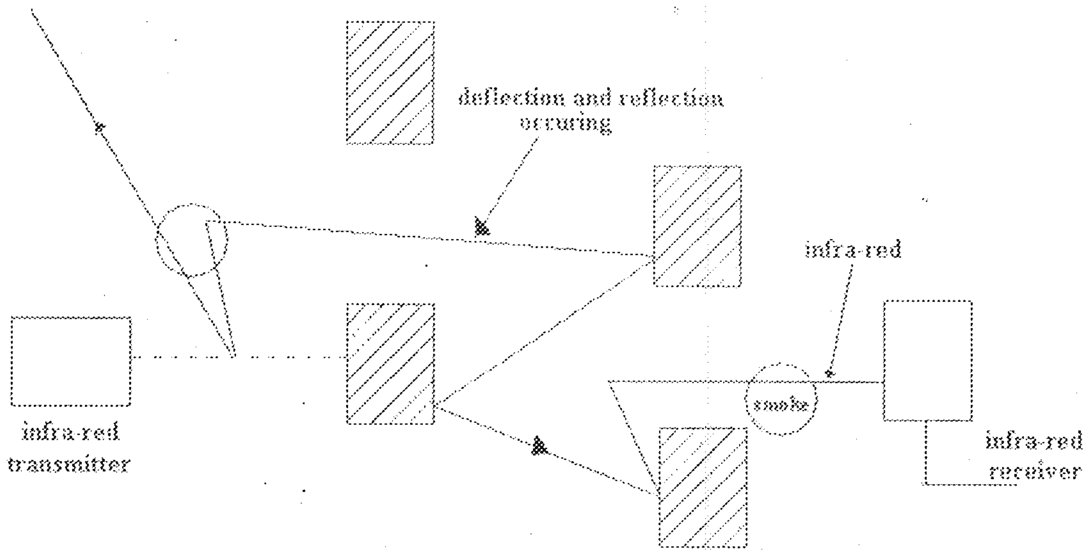


Fig 3.3.2b An in-line condition due to the presence of smoke

On the detection of smoke, the non inverting input becomes greater than the voltage on the inverting side and this results in a logical 1 output for the comparator. The inverting input is referenced at 1.1V.

3.3.3 The Temperature Monitoring Unit

The temperature monitoring unit consists of a linear precision temperature sensor (Lm35). The output of the sensor is stated to have 1°C to 10mV temperature-voltage relationship. Therefore, a temperature of 50°C is corresponding to 500mV or 0.5V at the sensor's output. It provides easy use for a temperature rated circuit with the range of 0 - 100°C.[4]

The output of the temperature sensor is connected to a comparator (Lm339) through the non-inverting input (+). The inverting input (-) is referenced to a particular voltage (0.55V). 55°C is chosen as the referenced temperature of the fire alarm, thus the referenced voltage is 550mV or 0.55V.

The basic operation of the temperature monitoring unit is that the output condition of the comparator is changed from a logical 0 to a logical 1 when the temperature of the sensor is higher than 55°C. At critical temperature, the non-inverting input (+) of the comparator is above the inverting input (-). This results into logical 1 output from the comparator.

3.3.4 The SR Latch

The 4013B is design to store the results from the input (both the smoke and temperature sensing unit) so that even when the smoke source and heat source ids off, the latch still holds the information.

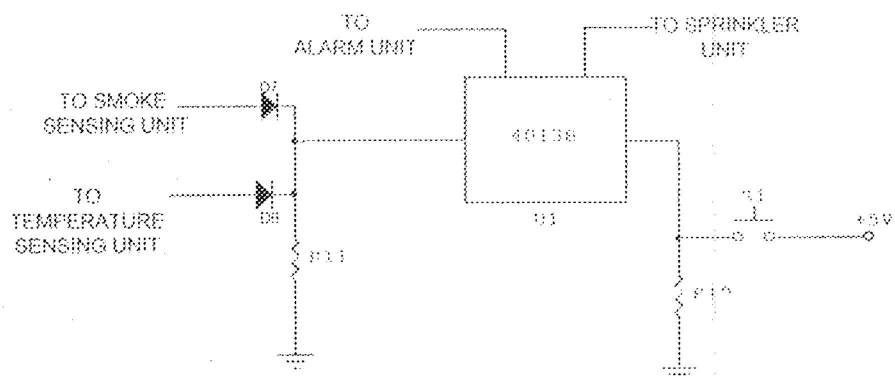


Fig 3.3.4 The input/control latch unit.

The R_{11}-D_6-D_7 circuit is a 2-input diode resistor logic (DRL) OR gate. The OR gate sums up the two inputs from both smoke and temperature sensing units. The input of the device responds to a logical 1 signal. From the data sheet of the flip-flop or latch, when the set input is logical 1 and the reset terminal is at logical 0, the Q output will be a logical 1 and Q~, logical 0. The outputs conditions interchange when the set input is logical 0 and the reset is high.

The output of the 5Ω flip-flop controls the remaining part of the entire circuit. The Q output switches on the DC motor that is associated with the sprinkler's pump unit. The latch holds the control after the detection of the particular condition as long as the reset button is not pressed.[6]

3.3.5 The Alarm Unit

The alarm unit is designed to be triggered ON in response to critical inputs from both temperature detectors and smoke sensors. The unit consists of the 4060B, 4013B and IRf244 MOSFET that perform audio frequency productions, storage functions and audio amplifying operations respectively.

The alarm oscillator 4060B generates two frequencies for the alarm output. The first frequency is very low, while the other is relatively high. The frequency outputs are determined by the RC configurations of the integrated circuit.

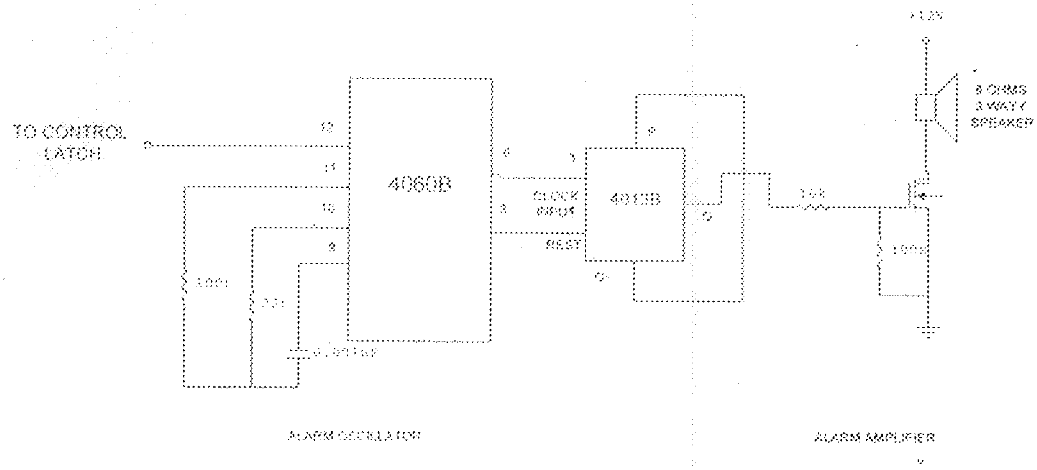


Fig 3.3.5 The Alarm Circuit

From the 4060B integrated circuit's data sheet, the main frequency of operation is given by: -

$$f_m = \frac{1}{2.3 \times 33 \times 10^3 \times 0.001 \times 10\text{-}6} = 13.175\text{KHz}$$

Note: - 33KΩ and 0.001μf are typical values for the RC configuration.

Therefore, $f_{pin\,3} = \frac{fin}{2^{14}} = \frac{13.175 \times 10^3}{2^{14}} = 0.804\text{Hz}$

$$f_{pin\,6} = \frac{f_m}{2^7} = \frac{13.175 \times 10^3}{2^7} = 102.9\text{Hz}$$

A typical alarm requires both high and low frequency components. These two signals are mixed together at the 4013B mixer latch to produce the alarm sound. The higher frequency is fed into the clock input of the 4013B while the lower one is connected to the reset terminal of the latch.

3.3.6 The Light Indicator Unit

The light indicator unit is made up of the NPN switching transistor(2SC945) and the Light Emitting Diode (LED). The light device is forward biased with the NPN device. A 200Ω current limiting resistor is connected in series with the Light Emitting Diode (LED) for the purpose of protection. This resistor is used to prevent the LED from voltage related damage. [19]

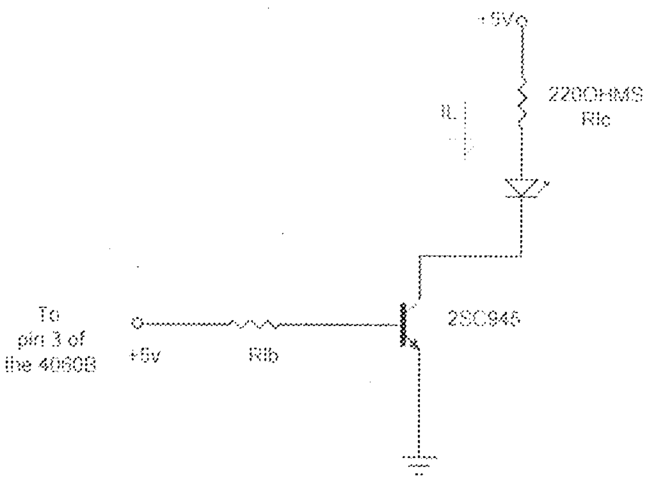


Fig 3.3.6 The Light Indicator Unit.

The 2SC945 transistor has a typical current gain of 100, If a typical current flowing through the Diode-Resistor circuit is 10mA,

$$I_B = \frac{I_C}{hfe} = \frac{10 \times 10^{-3}}{100} = 0.01mA$$

$$I_B = 0.1mA$$

$$R_{LB} = \frac{5 - 0.7}{0.1 \times 10^{-3}} = \frac{4.3}{0.1 \times 10^{-3}} = 43K\Omega$$

$$R_{LB} = 43K\Omega$$

In the circuit, 33KΩ is used. It provides more practical result.

3.3.7 The Sprinkler Unit

The sprinkler unit is designed to pump water from a reservoir onto the fire. It is made up of an N-channel MOSFET switching circuit with a DC electric motor load. The logic control unit sends a high logical level to the GATE terminal of the N-channel device whenever either smoke or unacceptable temperature is detected by the input sensors.

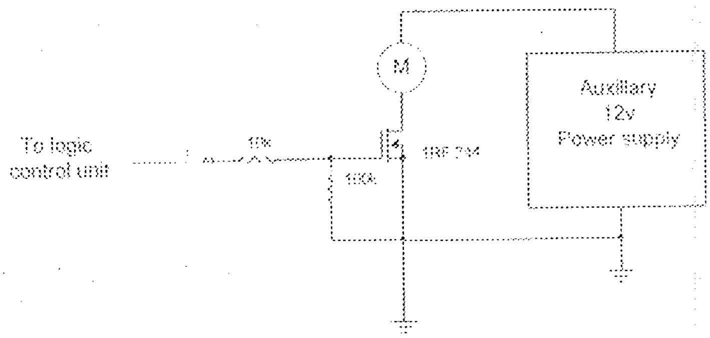


Fig 3.3.7 The Circuit Of A Sprinkler Unit

The electric motor merely pumps water from a reservoir. The circuit is powered by an auxiliary 12V supply unit. This is due to the high current requirement of the D.C. motor. The 500mA current available by the main power supply unit can not serve both the alarm and the sprinkler unit. The circuit malfunctioned when a 5V power supply was used to power the sprinkler unit. Therefore, the 12V auxiliary power unit was added to eliminate this fault. It has the same design concept with the 5V power supply unit.

The sprinkler unit is switched off whenever the control signal from the control logic unit is low. This happens after the reset button is pushed.

CHAPTER FOUR

Construction Testing and Results

The circuit connection of the heat and smoke alarm system was constructed with efficiency and durability in mind.

4.1 Circuit Construction

The circuit construction was performed directly on the Vero board. The permanent connection of the components was carefully done with a moderately heated soldering iron. This is done to avoid heat destruction of the components. Due to the fragile nature of involved integrated circuits (IC), protecting sockets were used for each one of them. The sockets prevent the involved integrated circuit from being destroyed by heat when directly soldered to the Vero board. Also, in a case whereby a bad integrated circuit is detected on the board, replacement of this IC can be instantly done without a problem.

The metallic surface of the Vero board was scraped with a razor blade. This encourages smooth and neat soldering of the components on the Vero board. The power section was then implemented on the Vero board. The electronic sub circuits were interconnected with the use of jumper wires. Related components were placed side by side for ease of connection. Some components such as switches and LED indicators were externally connected (putting the casing into consideration) to reduce the problem of access to these parts.

Every connection was checked and tested before supplying electric power to the complete circuit. The system was checked to detect power short circuits, so as to prevent the destruction of any components. Some wires were glued to the Vero board to prevent them from removal.

4.2 Casing Construction

A black plastic casing was used to package the complete unit. A casing designed for motorcycles was adopted for this purpose. The components of the circuit were positioned at suitable points on the casing. Additional flat plastic was used to cover the under side of the casing. A cone-shaped rubber was made to shield the smoke detector from unwanted or external light sources which might cause false alarm.

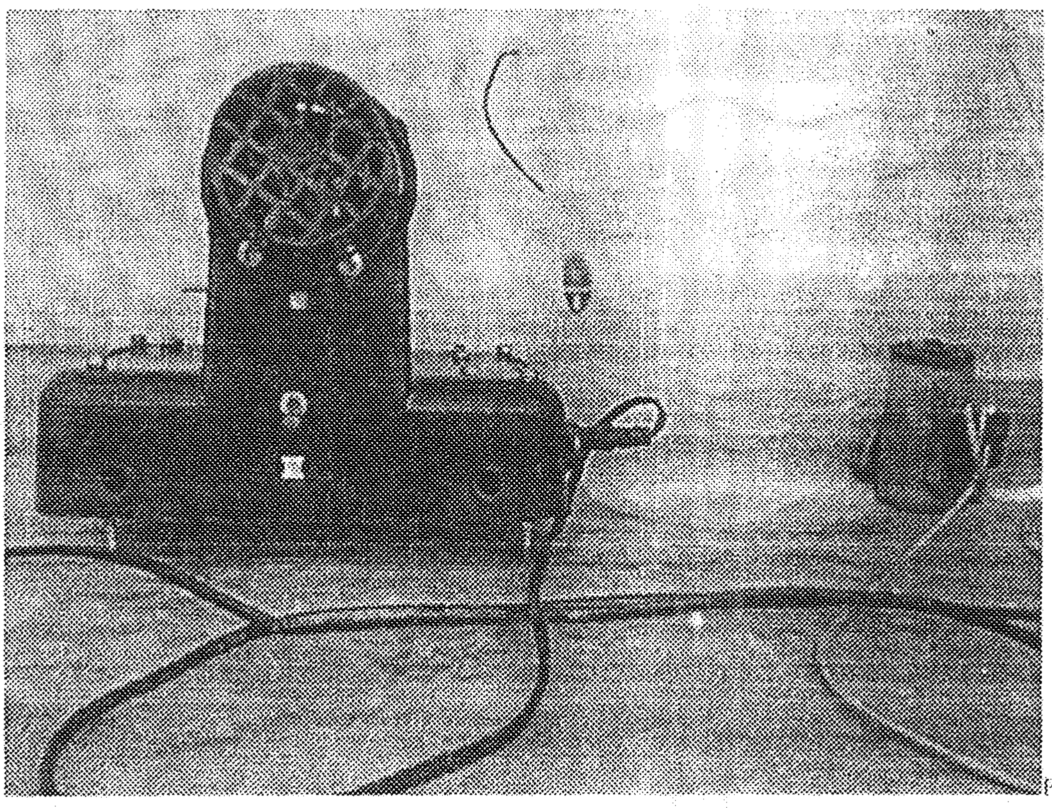


Fig 4.2 The square dimension of the casing.

The power supply unit, the Vero board, the LED and the speaker was secured firmly to the base of the casing with nuts and bolts.

4.3 Problems Encountered

1. The infra-red sensor responds to external illumination which affected the output giving a false alarm. Proper shielding of the sensor from rays of light was done to overcome this problem.
2. The alarm output malfunctioned when the sprinkler unit was connected to the 5V power supply. This problem was solved by using two separate power supply sources.
3. Unavailability of an ideal sprinkler unit which resulted in using the best alternative available.
4. Readjustment or redesigning of the circuit to fit the real target.

4.4 Testing

The smoke detector is quite sensitive and could raise a false alarm when exposed to light .This effect is attributed to the light or infra-red concept of the design. Thus this error was minimized by proper shielding of the smoke sensor.

4.5 Heat Test

A hot soldering iron was placed close to the temperature sensor (the Lm35).the alarm was triggered on when the temperature of the soldering iron was greater than the temperature of the referenced input.

4.6 Smoke Test

A match was lit in front of the smoke detector, and the device's response showed that there was reflection from the infra-red transmitter to the infra-red receiver which triggered on the alarm.

4.7 Discussion of Result

From the tests, the alarm, light indicator and sprinkler units were triggered ON whenever the hot soldering iron was placed close to the temperature sensor and when a match was lit in front of the smoke detector. The LED indicator provided information on the input condition. These outputs stayed on until it the reset button was pressed, this clears the latch and the audio alarm goes OFF.

CHAPTER 5

5.1 Conclusion

The primary objective of this project is to produce a very sensitive detecting circuit that can detect the presence of smoke and heat, give an alarm and activate a sprinkler unit . This can be done through the combination of the infra-red transmitter and an infra-red sensitive receiver and also through the use of a temperature sensor (LM35). The major contribution to this project is in the use of an LM35 temperature sensor instead of a Thermistor. The Thermistor responds to temperature changes through its terminal resistance but has the disadvantage of low sensitivity to temperature change and is more vulnerable under high temperature. Also two separate power supply sources were used in this project. The 5V power supply source was used to supply electric power to the circuit while the 12V supply source was used to supply power to the sprinkler unit.

5.2 Precautions

(i) The integrated circuits sockets were used to protect the integrated circuit(IC) from heat destruction.

(ii) Soldering was quickly made on every electronic component to avoid heat destruction of the component.

(iii) The circuit was tested for any short circuits before it was supplied with electric power.

(iv) Little but enough solder was applied to IC joint to ensure proper contact of the components.

(v) The two power supply units were carefully insulated from each other to prevent power interference.

5.3 Recommendations

Despite the reliability of the design, the circuit can still be imported to enhance its performance.

1. The circuit could be interfaced with a personal computer to enhance its performance.
2. Multiple temperature sensors could be incorporated into a single input for the unit to posses a wider temperature monitoring range.
3. An auxiliary battery supply unit can be used to provide back up for the power supply of the device in the case of power outage.
4. The alarm could be incorporated with a radio remote signaling system to warn people and call fire fighters far away from the fire scene.
5. A microprocessor unit could be used to replace the logic control unit of the circuit to enhance the control performance.

REFERENCE

[1] http://en.wikipedia.org/wiki/smoke detector

[2] www.datasheet.org.uk/search php?q=2SC945+datasheet+$sType=part$ExactDs=starts

[3] www.datasheet.org.uk/search php?q=4060B+datasheet+$sType=part$ExactDs=starts

[4] www.datasheet.org.uk/search.php?q=LM35+datasheet+$sType=part$ExactDs=starts

[5] www.datasheet.org.uk/search.php?q=LM339+datasheet+$sType=part$ExactDs=starts

[6] www.datasheet.org.uk/search.php?q=4013B+datasheet+$sType=part$ExactDs=starts

[7] Theraja B.L. and Theraja A K. "A textbook of Electrical Technology". Revised 23rd edition. Chand & company Ltd, New Delhi 2002

[9] Tocci R.J. and Widmer, N S. "Digital systems: Principles and applications. 7th Edition". Prentice-Hall International Inc. New Jersey 1998.

[10] G. Rizzoni, Principles and Applications of Electrical Engineering, 3rd Ed., McGraw-Hill, New York, 2000. pp. 542

[11] Paul Horowitz and W. Hill, The Art of Electronics, 2nd Ed, Cambridge University Press, New York, 2003. pp. 46

[12] http://experts.about.com/e/s/sm/smoke_detector.htm

[13] http://sciencehowstuffworks.com/smoke2.htm.

[15] http://hochiki.specialbrand.net/aboutus.php?c=company-info

[16] W.D Cooper and A.D Helfrick: Electronic Instrumentation and Measurement Techniques, Prentice -Hall Inc, Englewood cliffs, N.J, U S.A.pp366

[17] http://en.wikipedia.org/wiki/ionization detector

[18] Frank D. Petruzella, Essentials of Electronics: A Survey, pp 448

[19] B.L Theraja, Fundamentals of Electrical Engineering and Electronics, Multicolour illustrative Edition. pp 619

[20] http://www.ti.com

[21] http://www.freepatentsonline.com

[22] http://inventors.about.com/library/bl/bl12_2_s.htm.

[23] http://www.arlignton.k12.ma.us/ahs/ // docs/pondereport/2_06pdf

[24] http://www fresh patents.com/sprinkler

[25] http://www.answers.com/ESFR

[26] http://www.cdc.gov/niosh/fire/pdfs/face9805.pdf

[27] http//;www.wikipedia.org/firecontrol.