DESIGN AND CONSTRUCTION OF AN AUTOMATIC FIRE CONTROL SYSTEM

BY

FRANCIS, AGWU CHUKWUEMEKA

(EE/08/1718)

A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY, YOLA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING.

DECEMBER, 2012

DECLARATION

I hereby declare that this project constructed and the report written by me and it is a record of my own research work. It has not been presented before in any previous application for a bachelor's degree. References also made to published literature have been duly acknowledged.

.. **Date:...................................**

Francis Chukwuemeka Agwu

The above declaration is confirmed by

..

Date:..................................... **Engr. A. Yahya**

CERTIFICATION

This project entitled **"Design and Construction of an Automatic fire control system"** by **Francis Chukwuemeka Agwu (EE/08/1718)** meets the regulations governing the award of the bachelor's degree of the Modibbo Adama University of Technology, Yola and is approved for its contribution to knowledge and literary presentation

.. **Date:....................................**

Engr. A. Yahya

.... **Date:....................................**

Engr. I. M Visa
(HOD)

.... **Date:...................................**

Prof. E. E. Omizegba
(External examiner)

DEDICATION

This Report is dedicated to Almighty GOD who gave me the privilege, wisdom, guidance and has seen me through this period of my undergraduate and project.

ACKNOWLEDGEMENTS

My profound gratitude goes to God Almighty the one who was, who is and will forever be for his protection and kindness over me throughout course of my degree program. A million thanks goes to Mr. Idris for his willingness to teach and support during the course of this design and construction and also Engr A.S Kadalla for his guidance during the period of this project.

I sincerely appreciate my parents for their support all through the days. My sincere gratitude also go to my parents Mr and Mrs Francis U. Agwu, my sisters Ngozi, Chinyere, Amarachi,

I want to say a very big thank you to my aunty and her family, Mrs Christy Umar for her concern during this challenging period.

I sincerely appreciate all my lecturers for equipping us with the necessary skills to face any challenge today, tomorrow and forever. My love goes out to my very special friends Nwachukwu Emmanuel Prince, Owuama Chinemerem, Chike Echebiri and Owuama Ihuoma. Not forgetting my very special friends, all the students of electrical/electronics engineering especially the present 500L students of **MAUTECH**, you" guys" have been a special set of people.

ABSTRACT

This Project **“Automatic Fire Control System ”** is a reliable system that could detect the presence of fire by sensing the gaseous state of the environment (smoke) and also comparing it with the temperature of the environment, it then triggers a sprinkler which extinguishes and an alarm after confirming the presence of smoke and sudden rise in temperature in the environment indicating the presence of fire. In accomplishing the detection and extinguishing of fire, a temperature sensor and a smoke sensor is used as the sensing components while an LED, buzzer are used for alarming the presence of fire in the place the detector is situated and also a sprinkler used as the extinguishing device which sprinkles water around the area the detector is situated.

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CHAPTER ONE: INTRODUCTION

1.0 BACKGROUND OF STUDY

The value of early fire detection is immeasurable in protecting human life and property. Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and smoke.

It is understood that every fire start with a smoke and the cost of fire which gets out of control is high. There is a risk of fire outbreak in every building thus the menace of fire outbreaks impose on human lives and properties are enormous, Fire in its most common form can result in conflagration, which has the potential to cause physical damage through burning. Hence there is a need to minimize the incidence of loss of lives and properties from smoke and fire out breaks.

The need to safeguard lives and properties from fire disasters has led to the invention of an automatic fire control system using a smoke detector, a heat sensor and a water sprinkler. A smoke detector is one of the numerous ways of detecting fire outbreak at an early stage. Other systems that are used to detect fire outbreak at an early stage include the flame detector, explosive detector etc. while a water sprinkler is the most common way of extinguishing fire. An automatic fire control system is a circuit designed to control a sprinkler which produces water, when it detects the presence of smoke and excessive heat.

1.1 PROBLEM STATEMENT

The incidence from fire outbreaks in our homes, offices, industries is on the increase and items been destroyed by fire, however, are gone forever. An uncontrolled fire can obliterate an entire room's contents within a few minutes and completely burn out a building in a couple hours. The step toward halting a fire is to properly identify the incident place of the fire by detecting the primary constituents of fire which include smoke, heat and air and extinguish the fire by the use of water or any other extinguisher.

1.2 OBJECTIVES

In order to protect lives and properties there is need to install an automatic fire control system. This circuit is designed to detect smoke which the characteristic smell of smoke is usually the first indication that an incipient fire is underway using a smoke detector or sensor and a heat sensor which serve as a confirmatory device that a fire exist since smoke and heat are primary constituents of fire . The circuit after detecting the smoke and heat activates a sprinkler which sprinkles water around the area the fire is detected to extinguish and prevent anymore spreading or transformation of the fire.

1.3 SIGNIFICANCE

This system finds application in every building that stands the risk of a fire outbreak. These includes homes, filling station, large and small scale industries, store houses, school campus, airports, hospitals just to mention a few, excluding excessive dusty areas, areas with combustion particles, fluorescent light fixtures.

This system is useful in the academics especially in the field of electrical and electronics engineering since it provides all necessary design and parameters, component values and gradual procedure for realizing a workable fire control system.

1.4 SCOPE

This project is designed such that the main aim is achieved as it operates under necessary Conditions, but there are still limitations and restrictions.

The circuit is constructed with materials that are cheap and readily available thereby making the cost of the system low and easily acquired. This will enable the use of the system throughout every category of person and firm. Coupled with the low cost, the size of the system is also small enough for convenience in installation.

The system is also designed to sprinkle water based on the area covered by the sprinkler. The sprinkler sprinkles water only when the smoke and heat sensor detects the combined presence of smoke and heat.

CHAPTER TWO: LITERATURE REVIEW

2.0 EVOLUTION OF FIRE FIGHTING

Fire control was quite rudimentary until the 17th century. The key breakthrough in fire controlling arrived in the 17th century with the first fire engines. Manual pumps, rediscovered in Europe after 1500 (allegedly used in Augsburg in 1518 and in Nuremberg in 1657 [2], were only force pumps and had a very short range due to the lack of hoses. German inventor Hans Hautsch improved the manual pump by creating the first suction and force pump and adding some flexible hoses to the pump. In 1672, Dutch artist, and inventor Jan Van der Heyden's workshop developed the fire hose. Constructed of flexible leather and coupled every 50 feet (15 m) with brass fittings [1]. The length remains the standard to this day in mainland Europe whilst in the UK the standard length is either 23m or 25m. The fire engine was further developed by the Dutch inventor, merchant and manufacturer, John Lofting (1659–1742) who had worked with Jan Van der Heyden in Amsterdam [2].

In the United Kingdom, The first horse-drawn steam engine for fighting fires was invented in 1829, but not accepted in structural firefighting until 1860, and ignored for another two years afterwards. Internal combustion engine fire engines arrived in 1907, built in the United States, leading to the decline and disappearance of steam engines by 1925 [2].

The first automatic electric fire alarm was invented in 1890 by Francis Robbins Upton (US patent no. 436,961). Upton was an associate of Thomas Edison, although there is no evidence that Edison contributed to this project [3].

In the late 1930s the Swiss physicist Walter Jaeger tried to invent a sensor for poison gas [3]. He expected that gas entering the sensor would bind to ionized air molecules and thereby alter an electric current in a circuit in the instrument. His device failed: small concentrations of gas had no effect on the sensor's conductivity. Frustrated, Jaeger lit a cigarette—and was soon surprised to notice that a meter on the instrument had registered a drop in current. Smoke particles had apparently done what poison gas could not; Jaeger's experiment was one of the advances that paved the way for the modern smoke detector.

The first truly affordable home smoke detectors were invented by Duane D. Pearsall and Stanley Bennett Peterson in 1965, featuring individual battery powered units that could be easily installed and replaced. The first units for mass production came from the manufacturing mind of Stanley B. Peterson in 1975 at Duane Pearsall's company in Lakewood, Colorado, named Corporation [3].

2.1 THE PINNACLE LASER TECHNOLOGY SMOKE DETECTOR

The Pinnacle Laser Smoke Detector is a device that senses the earliest particles of combustion. And that provides early warning of fire. Its high sensitivity is balanced with high stability to minimize false alarms. Like an ionization detector, Pinnacle quickly senses a fast flaming fire. Like a photoelectric detector, it quickly senses a slow-smoldering fire. But unlike these detectors, Pinnacle can quickly identify both types of fire [4].

2.1.1 SPECIFICATIONS OF THE PINNACLE

- Voltage Range: 15 – 32 volts DC peak
- Standby Current (max. avg.): 230μA @ 24 VDC (without communication)

  330μA (one communication every 5 seconds with LED enabled)
- LED Current (max.): 6.5mA @ 24 VDC (on)
- Height: 1.66″ (4.2 cm)
- Diameter: 4.0″ (10.2 cm)
- Shipping Weight: 5.6 oz. (159 g)
- Operating Temperature Range: –10°C to 55°C
- Relative Humidity: 10% – 93% non condensing
- Velocity Range: 0 – 4000 fpm (0 to 20.3 m/s)

2.1.2 WORKING PROCEDURE OF THE PINNACLE

The principles of laser detection are similar to those of photoelectric technology. In a photoelectric smoke detector, an LED emits light into a sensing chamber that is designed to keep out ambient light while allowing smoke to enter. Any particles of smoke (or dust) entering the chamber will scatter the light and trigger the photodiode sensor. Pinnacle works on the same light-scattering principle, but with 100x greater sensitivity. This ultra-sensitivity is due to the nature of the laser itself, which is literally amplified light (the word “laser” is an acronym for “Light Amplification by Stimulated Emission of Radiation”) [4]. Using an extremely bright, controlled laser diode, the laser beam is transmitted through the chamber to a light trap which eliminates any reflection. If a particle of smoke (or dust) enters the chamber, light from the laser is scattered and the detector, using its patented algorithms, checks the nature of the scattered light to determine whether the source is dust or smoke. If a determination of smoke is made, the alarm is signaled.

2.1.3 PERFORMANCE OF THE PINNACLE

- Pinnacle achieves dual goals of high sensitivity and high stability by using an extremely bright laser diode 10,000 times brighter than a standard LED coupled with an optical amplifier that further concentrates the light into the photo sensor.
- It has a laser beam with a narrow focus which reduces the reflected light in its sensing chamber and results in a high signal to noise ratio.
- It incorporates extensive on-board software processing including multi-alert drift compensation, internal self diagnostics, and superior transient signal rejection algorithms which help to reduce false alarm caused by large airborne particles such as moist, small insects.
- It provide detection in ranges of sensitivity from 0.02–2% per foot which are

Alarm level 1	0.02%/ft. smoke (0.06 %/m)
Alarm level 2	0.03%/ft. smoke (0.10 %/m)
Alarm level 3	0.05%/ft. smoke (0.16 %/m)
Alarm level 4	0.10%/ft. smoke (0.33 %/m)
Alarm level 5	0.20%/ft. smoke (0.66 %/m)
Alarm level 6	0.50%/ft. smoke (1.65 %/m)
Alarm level 7	1.00%/ft. smoke (3.24 %/m)
Alarm level 8	1.50%/ft. smoke (4.85 %/m)
Alarm level 9	2.00%/ft. smoke (6.41 %/m)

2.1.4 TESTING OF THE PINNACLE

The pinnacle has been recorded tested at several telephone switching stations in the United States and Europe to determine performance levels under a variety of conditions. The product was tested in clean rooms and telecommunications facilities and tests performed and observed by independent fire industry professionals. Some of the tests were conducted as head-to-head comparisons with the prevailing technologies of the day for those types of facilities [4].

2.2 D2 Duct Smoke Detector

D2 Duct Smoke detectors designed for use in air duct systems are used to sense the presence of smoke in the duct. Model D2 Duct Smoke Detector utilizes photoelectric technology for the detection of smoke [7]. This detection method, when combined with an efficient housing design, samples air passing through the duct allowing detection of a developing hazardous condition.

2.2.1 SPECIFICATIONS OF THE D2 DUCT DETECTOR

- Operating Temperature: –4° to 158° F (–20° to 70° C)
- Storage Temperature: –22° to 158° F (–30° to 70° C)
- Humidity: 0% to 93% Relative Humidity Non-condensing
- Air Velocity: 100 to 4000 ft./min. (0.5 to 20.3 m/sec.)
- Rectangular Footprint Dimensions: 14.38 in L x 5 in W x 2.5 in D (37 cm L x 12.7 cm W x 6.36 cm D)
- Square Footprint Dimensions: 7.75 in L x 9 in W x 2.5 in D (19.7 cm L x 22.9 cm W x 6.35 cm D)
- Weight: 1.8 pounds; 0.82 kg

- Power supply voltage: 8.5-35 VDC
- Input capacitance: 0.1 μF max.
- Reset Voltage: 2.5 VDC min.
- Reset Time (with RTS451/RTS151): .03 to 0.3 sec.
- Reset Time (by power down): 0.3 sec. max.
- Power Up Time: 35 sec. max.
- Alarm response time: 15 sec.
- Peak standby current: 120μA
- Average standby current: 60μA
- Max. alarm current: 130 Max

2.2.2 WORKING PROCEDURE OF THE D2 DUCT DETECTOR

D2 Duct smoke it includes a light source (incandescent bulb or infrared LED), a lens to collimate the light into a beam, and a photodiode or other photoelectric sensor at an angle to the beam as a light detector. In the absence of smoke, the light passes in front of the detector in a straight line. When smoke enters the optical chamber across the path of the light beam, some light is scattered by the smoke particles, directing it at the sensor and thus triggering the alarm [8].

2.2.3 PERFOMANCE OF THE D2 DUCT SMOKE DETECTOR

The D2 model detector is approved for an extended air speed range of 100 to 4000 feet per minute (0.5 m/s to 20.3 m/s) and an operational temperature range of −4°F to 158°F (−20°C to 70°C) [7].

- At power up the sensor will take approximately 30 seconds to initialize with LED showing an alternating red blink every 5 seconds.
- During standby the LED on the sensor flashes approximately every 5 seconds.
- On detection of smoke in the duct the led turn solid red and detector alarm is set.

2.3 1400 DIRECT WIRE IONIZATION SMOKE DETECTOR

System Sensor 1400 dual-chamber ionization smoke detectors utilize state-of-the-art unipolar sensing chambers. These detectors are designed to provide open area protection, and to be used with compatible UL-listed, 2-wire control panels [6].

2.3.1 SPECIFICATIONS OF THE DIRECT WIRE DETECTOR

Diameter:	5.5 inches (140 mm)
Height:	3.12 inches (80 mm)
Weight:	0.7 lb. (310 g)
Operating Temperature:	0°C to +49°C (32°F to 120°F)
Latching Alarm:	Reset by momentary power interruption.
Operating Humidity:	10% to 93% Relative Humidity, Noncondensing
System Voltage:	12/24 VDC
Maximum Ripple Voltage:	4 Volts peak to peak
Start-up Capacitance:	0.02 µA Maximum
Standby Ratings:	8.5 VDC Min, 35 VDC Max, 100 µA Max

Alarm Ratings:	4.2 VDC Min at 10 mA, 6.6 VDC Min at 100 mA
Reset Voltage:	2.5 VDC Minimum
Reset Time:	0.3 S Maximum
Start-up Time:	35 S Maximum

2.3.2 WORKING PROCEDURE OF THE DIRECT WIRE DETECTOR

The 1400 direct ionization smoke detector uses a radioisotope such as americium-241 to produce ionization in air; a difference due to smoke is detected and an alarm is generated. It is more sensitive to the flaming stage of fires than optical detectors, while optical detectors are more sensitive to fires, in the early smoldering stage [8]

The radioactive isotope americium-241 in the smoke detector emits ionizing radiation in the form of Alpha particles into an ionization chamber that is open to the air and a sealed reference chamber [8]. The air molecules in the chamber become ionized and the ions allow the passage of a small electric current between charged electrodes placed in the chamber. If any smoke particles pass into the chamber the ions will attach to the particles and so will be less able to carry the current. An electronic circuit detects the current drop, and sounds the alarm. The reference chamber cancels effects due to air pressure, temperature, or the aging of the source.

2.3.2 PERFORMANCE OF THE DIRECT WIRE DETECTOR

It has an LED that provides a local visual indication of the detector's status. The LED blinks every ten seconds as an indication that power is applied to the detector and lights continuously in alarm, the smoke detector has a latching alarm feature [6].

2.4 GRAPHICAL COMPARISM

Below shows graphical comparism of both the Pinnacle (uses laser), D2 Duct (uses photoelectric), 1400 Direct wire ionization smoke detector systems using a UL Heptane fire test and UL gasoline test [4] .

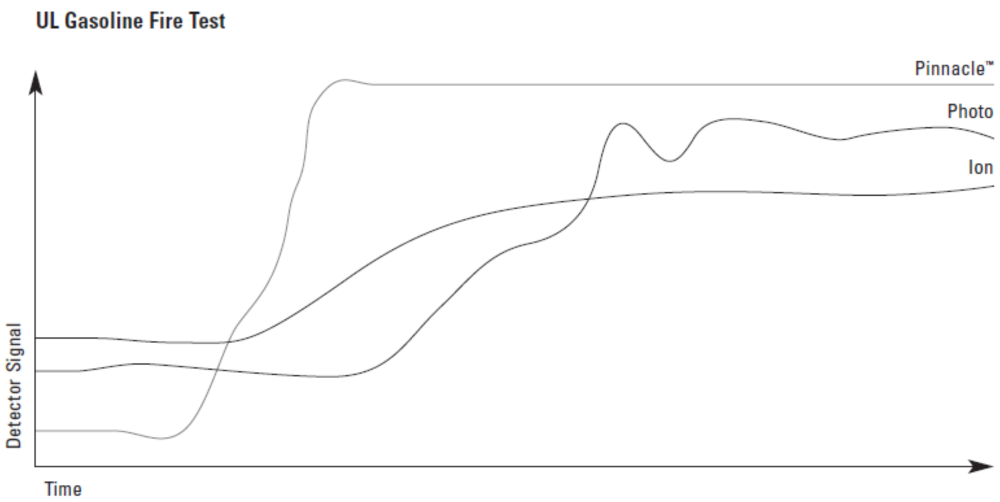


Fig 2.1 Graphical Response to UL Gasoline Fire Test

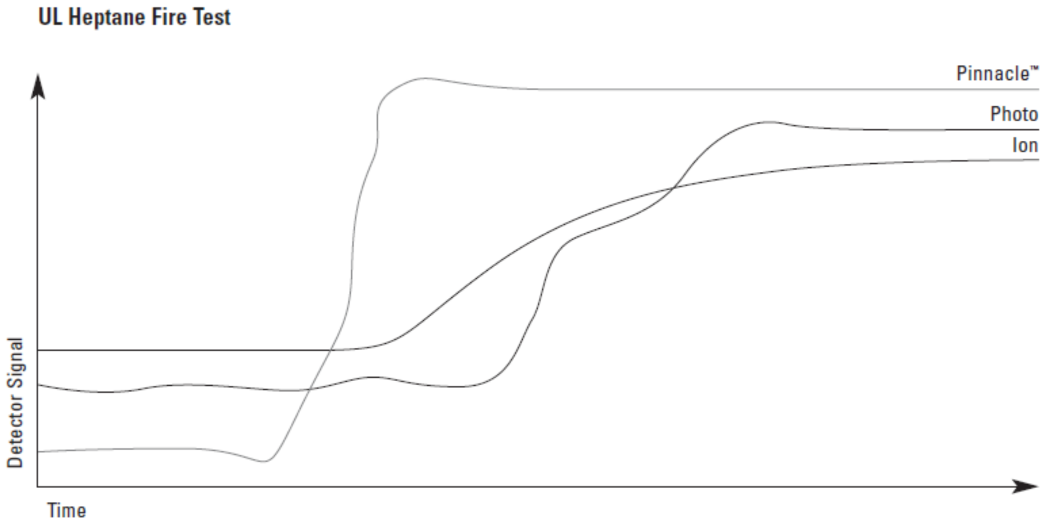


Fig 2.2 Graphical Response to UL Heptane Fire Test

CHAPTER THREE: DESIGN AND CONSTRUCTION PROCEDURES

3.0 SYSTEM DESCRIPTION

The various subsystem of this project consist of the power supply unit, smoke sensor, temperature sensor, microcontroller, pump/sprinkler, display and relay driver, buzzer/Led. The choice of component selected depends on the project requirements. Standard approximation of values was used in the calculated values. Below, shows the block diagram of the whole system.

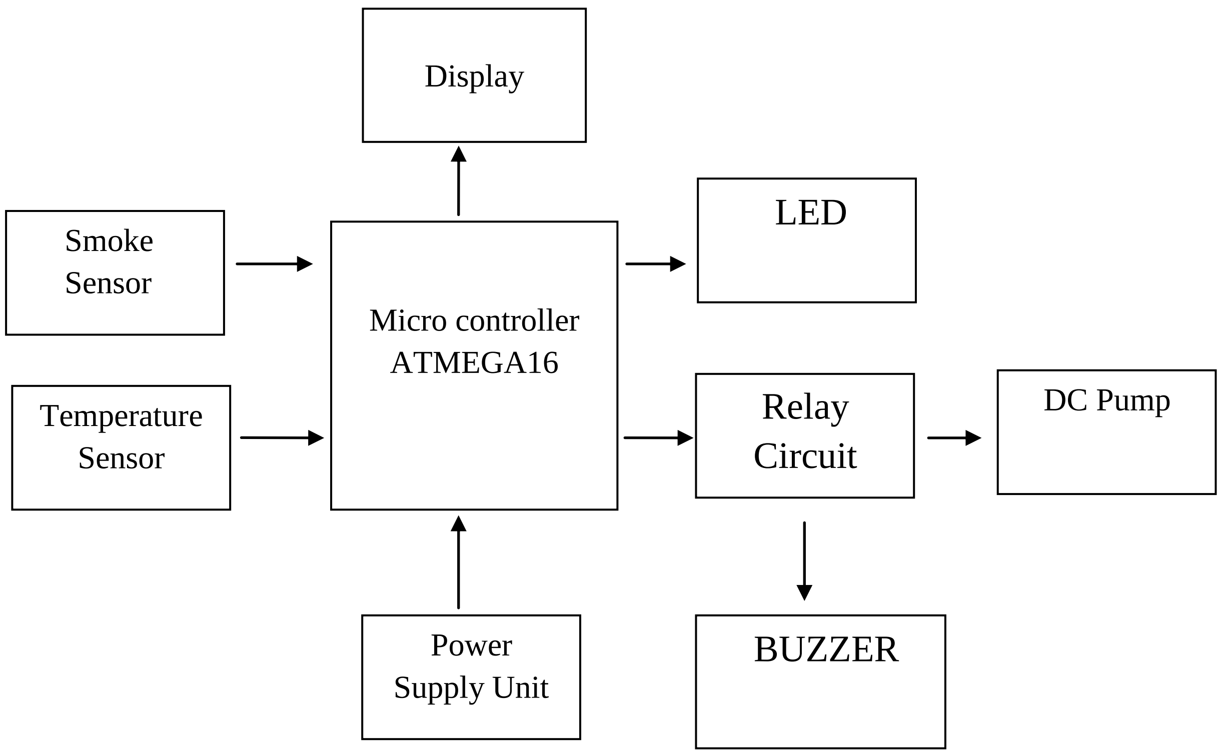


Figure 3.1 Block Diagram of an Automatic Fire Control System.

3.1 THE POWER SUPPLY

The complete electronic device or system requires a D.C voltage source for its operation. Therefore for the purpose of this design, an alternating (A.C) voltage source of 220V is used where the A.C voltage is converted to D.C voltage by rectification. Thus the process of converting the A.C voltage to the D.C voltage was accomplished with the help of a rectifier, filter and voltage regulators using voltage divider theorems. The main function of the voltage divider is to provide the various D.C voltages needed by the different electronic components in the system.

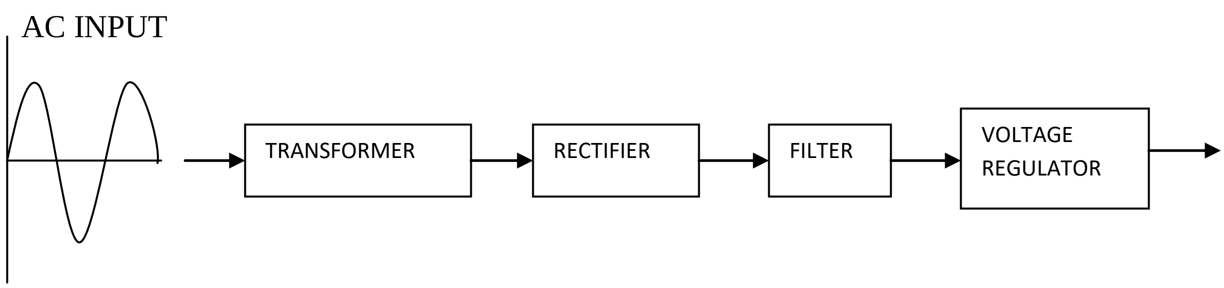


Fig 3.2 Conversion and stepping down of the voltage .

The power supply to the system requires two outputs:

- A 5V output each required to supply the micro controller, smoke sensor, temperature sensor.
- A 12V output required by the relay for the sprinkler/pump

3.1.1 TRANSFORMER

A 220/12V step down transformer with 6A rated current was selected

Primary voltage of the transformer = 220

Secondary voltage of the transformer= 12V

From the transformer ratio equation K = turns ratio

$$k = \frac{N_2}{N_1} = \frac{E_2}{E_1} = \frac{V_2}{V_1} = \frac{I_1}{I_2} \quad (3.1)$$

$$K = \frac{12}{22O} = 0.055$$

$V_2 = 12v$, $V_1 = 220v$, $I_2 = 6A$, $I_1 = ?$

$$I_1 = \frac{V_2 I_2}{V_1} = \frac{12 \times 6}{220} = 327mA \quad (3.2)$$

Input impedance of the transformer

$$Z_1 = \frac{V_2}{I_2} = \frac{240}{327 \times 10^{-3}} \quad (3.3)$$

=672Ω

Output impedance of the transformer

$$Z_2 = \frac{V_1}{I_1} = \frac{12}{6}$$

=2Ω

Input power $P_1 = V_1 I_1$ ………………………………………… (3.4)

$= 220 \times 327\text{mA} = 71.94\text{W}$

Out put power $P_2 = V_2 I_2$ …………………………………….. (3.5)

$= 12 \times 6\text{A} = 72\text{W}$

3.1.2 RECTIFIER

The process of deriving DC power from an AC source is called **rectification**. This stage is just after the transformer, a rectifier circuit employs the use of diodes to convert AC voltage to DC voltage. These circuit are categorized into Half Wave Rectifier and Full Wave Rectifier. For the rectification of this project, the bridge rectifier for full wave rectification is used because of its high output.

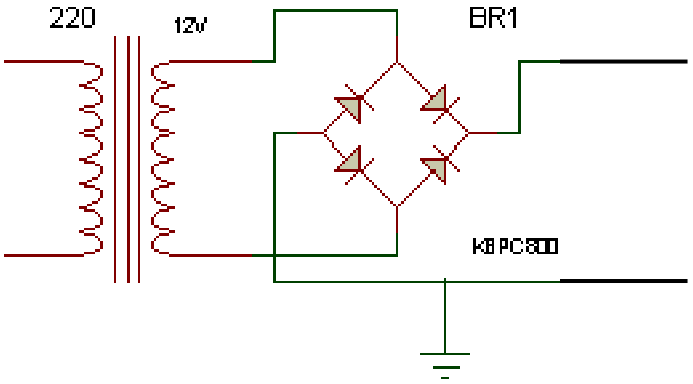


FIG. 3.3 Rectifier circuit

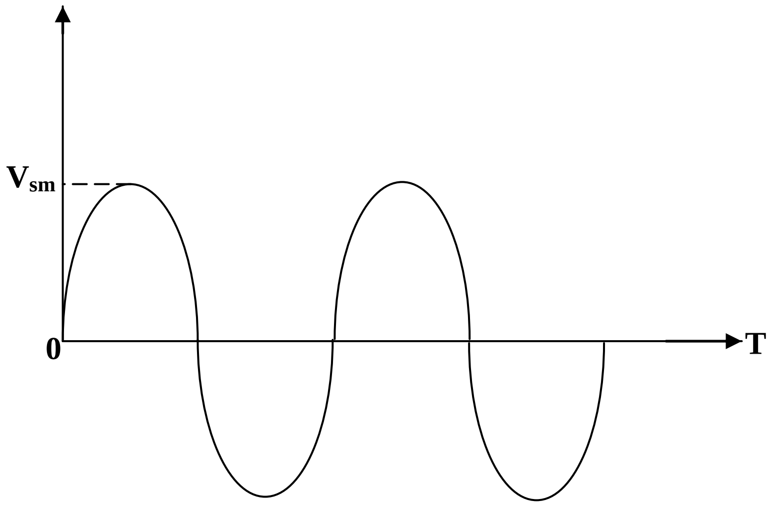
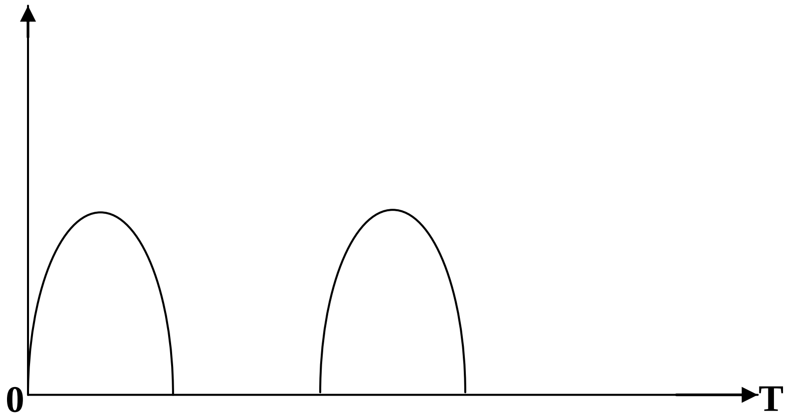


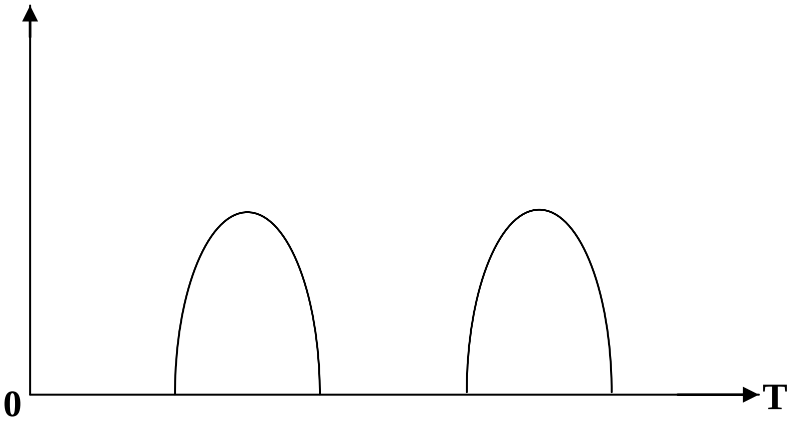
Fig 3.4 Input

Fig 3.5



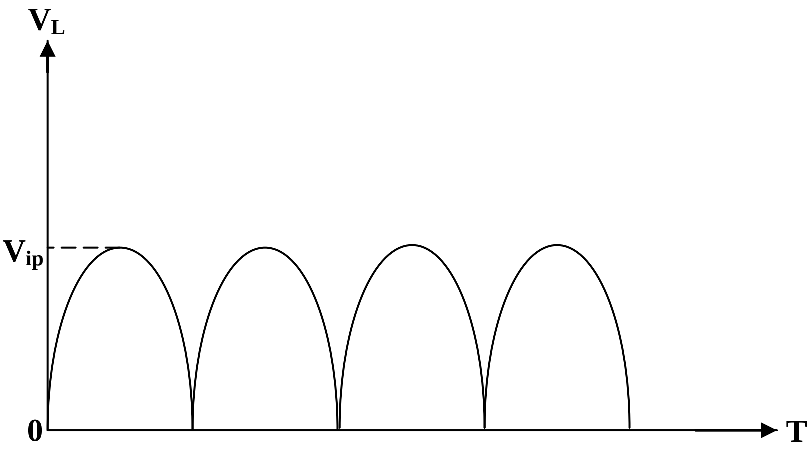
Output of D_1

Fig. 3.6



Output of D_2

Fig. 3.7



Total output waveform

3.1.3 FILTER CIRCUIT

The main function of the filter circuit is to minimize the ripple content in the rectifier output. The output of the rectifier is postulating, it has a DC value and some AC component called **ripples.** This type of output is not use for driving sophisticated electronic devices. The devices require a steady DC output that approaches the smoothness of a battery's output. For the purpose of this project, a shunt capacitor filter is used.

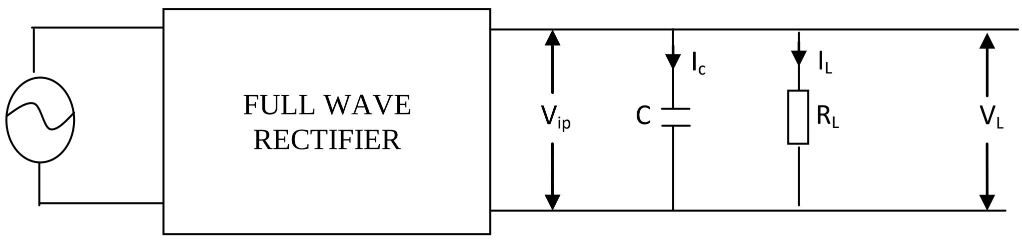


Fig. 3.8 Shunt capacitor filter

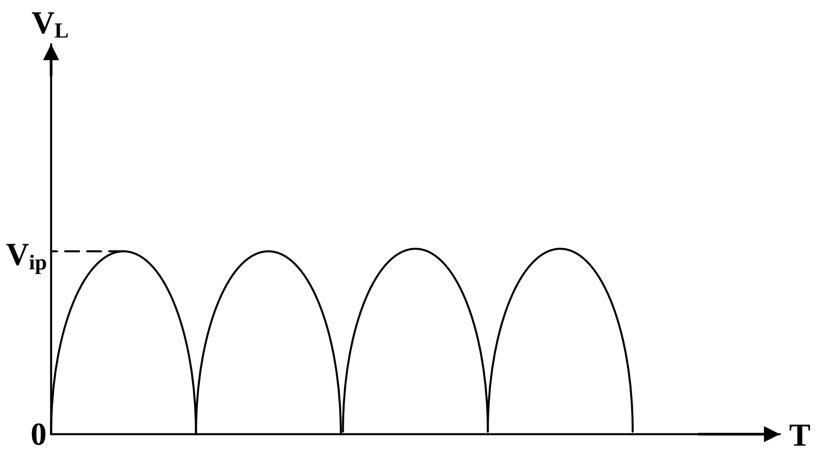


Fig. 3.9 Without filter

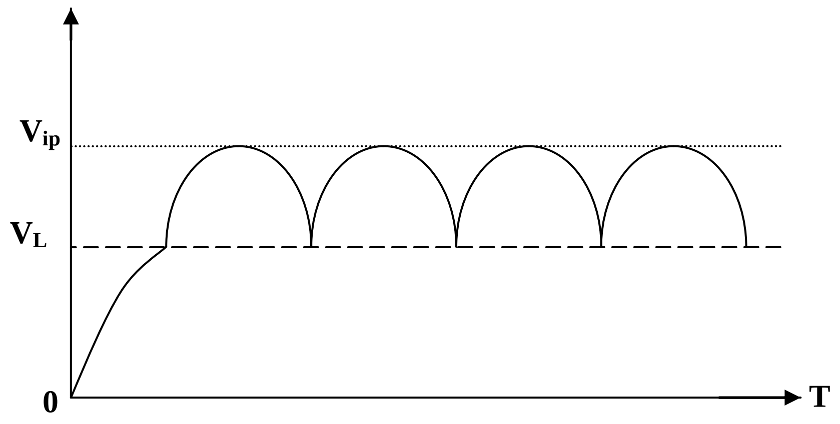


Fig.3.10 With filter

In the circuit above a suitable single capacitor (C) is connected across the rectifier in parallel with the load R_L to achieve the filtering action. This type of filter is known as Capacitor Input Filter and depends on the operation of a capacitor. When connected across a pulsating DC it tends to smooth the voltage pulsation.

When positive half cycle of the ac input is applied, D_1 is s forward bias and hence is turned on, C quickly charges up to peak value of input voltage V_{ip}. After being fully charged, the capacitor holds the charge till input AC supply to the rectifier goes negative.

During the negative half cycle, the capacitor attempts to discharge. Hence, it discharges through R_L and its voltage decreases. During this period the capacitor maintains a sufficiently large voltage across R_L.

The ripple factor is given by;

V_L = rms value value of load voltage

V_{LM} = maximum value of load voltage

$V_{L(dc)}$ = average value of load voltage =12V

$V_{S\ M}$ = maximum value of transformer secondary voltage

I_{dc} = the output current of the capacitor = 6A

F = frequency in Hz = 50Hz

$$V_L = V_{LM}/\sqrt[2]{2} = 0.707\ V_{LM} \ldots \quad (3.6)$$

$$V_{L(dc)} = 2\ V_{LM}\ /\ \Pi \ldots \quad (3.7)$$

$$V_{LM} = \frac{3.142 \times 12}{2} = 18.8V$$

$$V_L = \frac{18.8V}{\sqrt[2]{2}} = 13.29$$

$$V_{L(ac)} = \sqrt{V_L{}^2 \times V_{L(dc)}{}^2} \ldots \quad (3.8)$$

$$V_{L(ac)} = \sqrt{176.6 - 144} = 5.71V$$

Ripple factor (γ) $= \frac{V_{L(ac)}}{V_{L(dc)}} = \frac{5.71}{12} = 0.48 \ldots$ (3.9)

Ripple factor (γ) $= \frac{I_{dc}}{4\sqrt{3}FCV_{ip}} \ldots$ (3.10)

Where V_{ip} = peak secondary voltage – (2× threshold voltage of diode in bride rectifier)

Peak secondary voltage = (peak primary voltage × $\sqrt{3}$) - (K)

$= (220 \times \sqrt{3}) \times (0.055) = 20.96V$

$V_{ip} = 20.96 - (2 \times 0.7) = 19.557V$

Therefore $C = \frac{I_{dc}}{4\sqrt{3}F\gamma V_{ip}} = \frac{6}{4\sqrt{3} \times 50 \times 0.48 \times 19.557} = 1845\mu F$ ……………… (3.11)

Hence an electrolytic capacitor of capacitance greater than 1845µF (i.e.4700µF) was selected for better filtration bearing that the higher the value of capacitor the lesser the ripples.

3.1.4 REGULATOR

The device is powered from a voltage of 220V AC mains electricity supply to the suitable low voltages required. Three of LM7805 voltage regulators were used in this design to step down the voltages in order to obtain the desirable D.C output voltages needed by the electronic components used in the system. The 12V D.C voltage output directly from the transformer after being filtered was used as the operating voltage of the relay while each of the LM7805 provides an output 5V D.C which is used as the operating voltage for the microcontroller, smoke sensor, temperature sensor respectively. The rectifier circuit diagram is shown below.

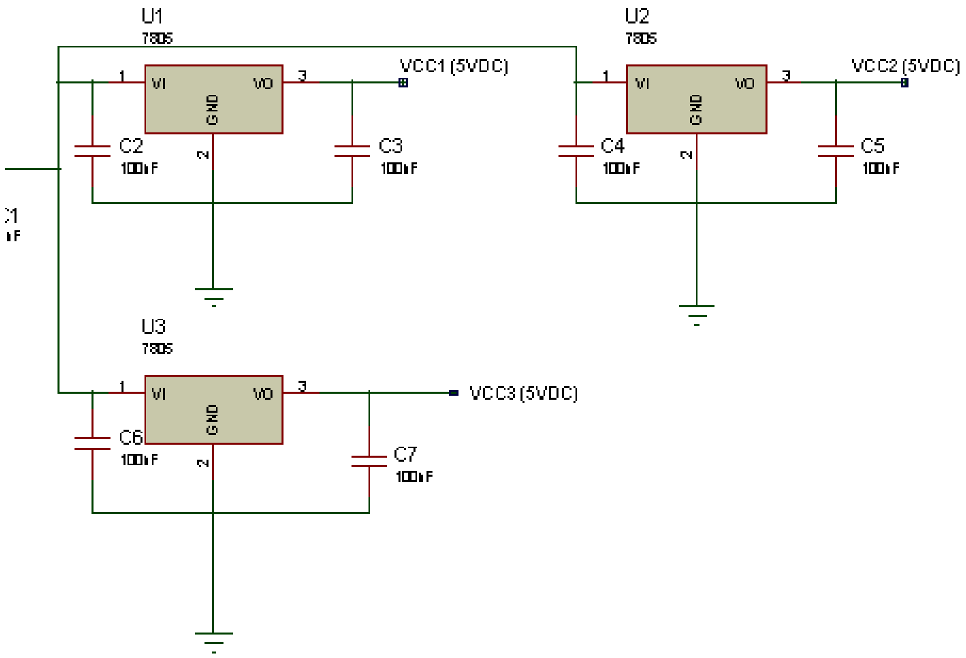


Fig 3.11 Regulator circuit.

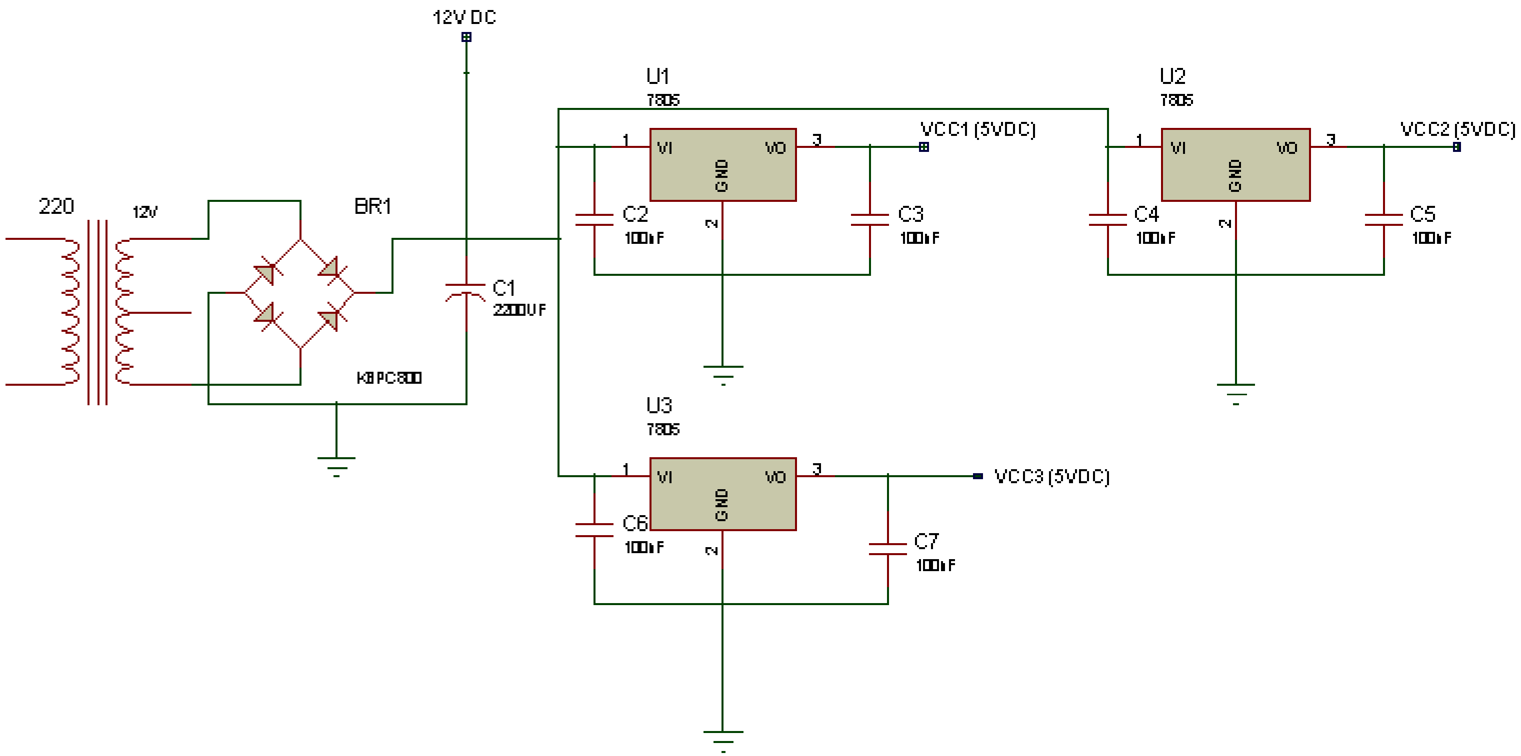


Fig. 3.12 Power Supply Circuit Diagram

3.2 THE SENSORS

The system comprises of two different types of sensors namely; smoke sensor and the Temperature sensor. The smoke sensor senses smoke and generates signal which serve as an input to the microcontroller, also the Temperature sensor senses the temperature of the environment of which at a certain temperature rise it interrupt the microcontroller.

3.2.1 TEMPERATURE SENSOR

The temperature sensor used is LM35DT which is a precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. It is used with single power supply, as it draws only 60µA from its supply, it has very low self-heating less than 0.1°C in still air. The LM35DT is rated to operate over a −55° to +150°C temperature range [9].

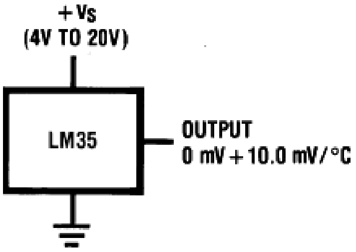


Fig 3.13 Configuration

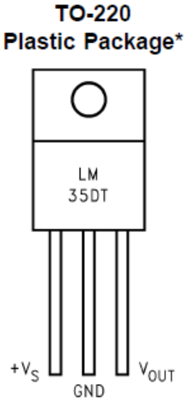


Fig 3.14 Physical view

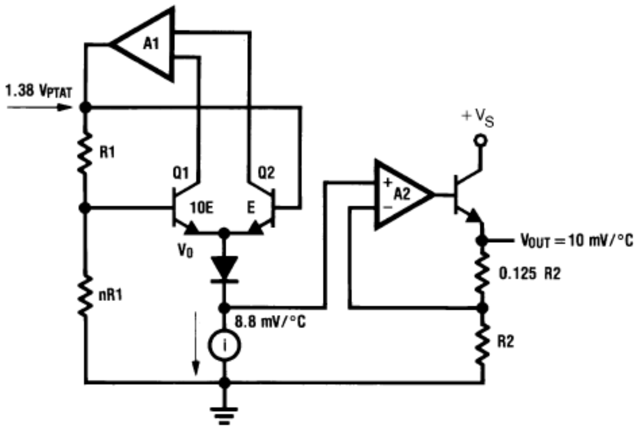


Fig 3.15 Internal circuit

3.2.2 SMOKE SENSOR (MQ-2)

MQ-2 gas sensor is a gas sensing device which senses gases including smoke. The sensitive material of the sensor is Tin Dioxide, which with lower conductivity in clean air, When the target combustible gas exist, The sensor's conductivity is more higher along with the gas concentration rising.

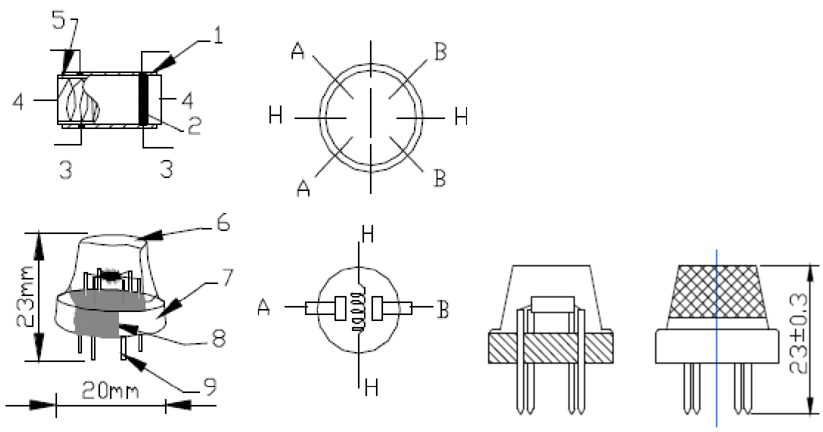


Fig 3.16 Internal structure of smoke sensor

	|Part	Material
1	Gas sensing layer	Tin Dioxide
2	Electrode	Au
3	Electrode line	Pt
4	Heater coil	alloy
5	Tubular ceramic	Aluminium Dioxide ($AL_2 0_3$)
6	Anti-explosion network	Stainless steel gauze (SUS316 100-mesh)
7	Clamp ring	Copper plating Ni
8	Resin base	Bakelite
9	Tube Pin	Copper plating Ni

TABLE 1: Parts of the Smoke Sensor.

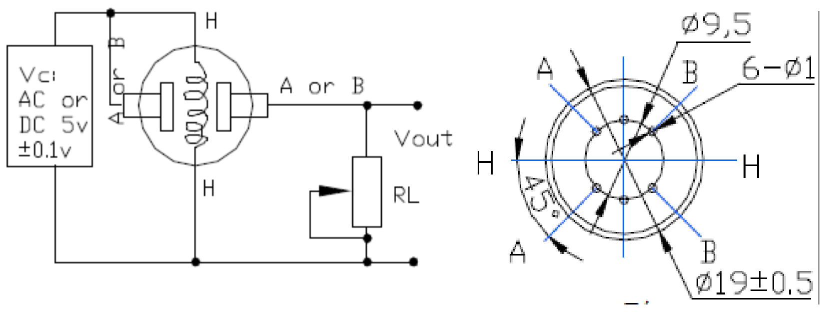


Fig. 3.17 Configuration of Smoke Sensor.

Structure and configuration of smoke sensor, compose of micro AL_20_3 ceramic tube, Tin Dioxide (SnO_2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped smoke sensor have 6 pins with 4 of the pins (A or B) are used to fetch signals, and other 2 are used for providing heating current [10]. Specification of the smoke is shown in appendice 4

3.3 MICRO CONTROLLER (ATMEGA16)

ATMEGA16 microcontroller is a low-power CMOS 8-bit microcontroller with 16KB In-system programmable flash based on the AVR enhanced RISC architecture, by executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing an optimize power consumption versus processing speed. The ATmega16 provides several features, these features can be further explained in appendice 3.

The microcontroller serve as the control part of the system of which it receives signal from both the smoke sensor and temperature sensor, switches on an LED when smoke is sense and also checks if the signal from the temperature sensor has surpassed the reference temperature and then switches on both the buzzer alarm and the sprinkler system if the reference temperature is surpassed, also it sends signal to the LED display, displaying the temperature of the environment at any instant of time. The input/output port used are shown as connected in the circuit diagram in Fig 3.20 below.

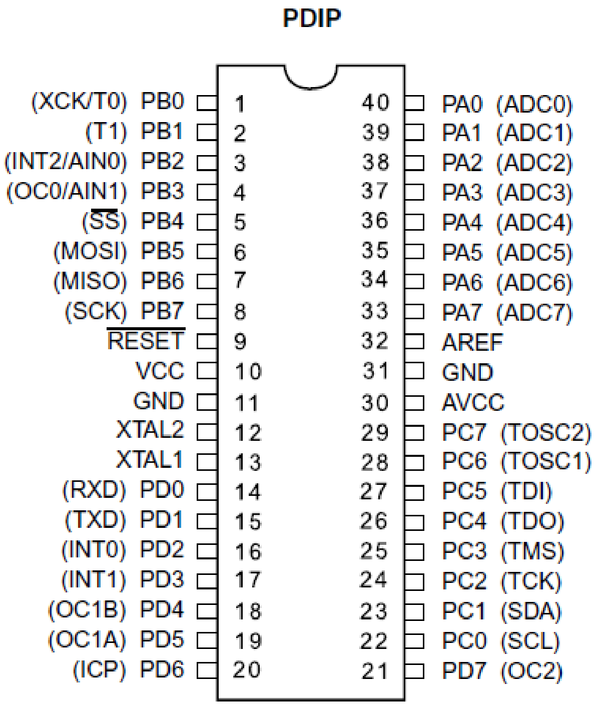
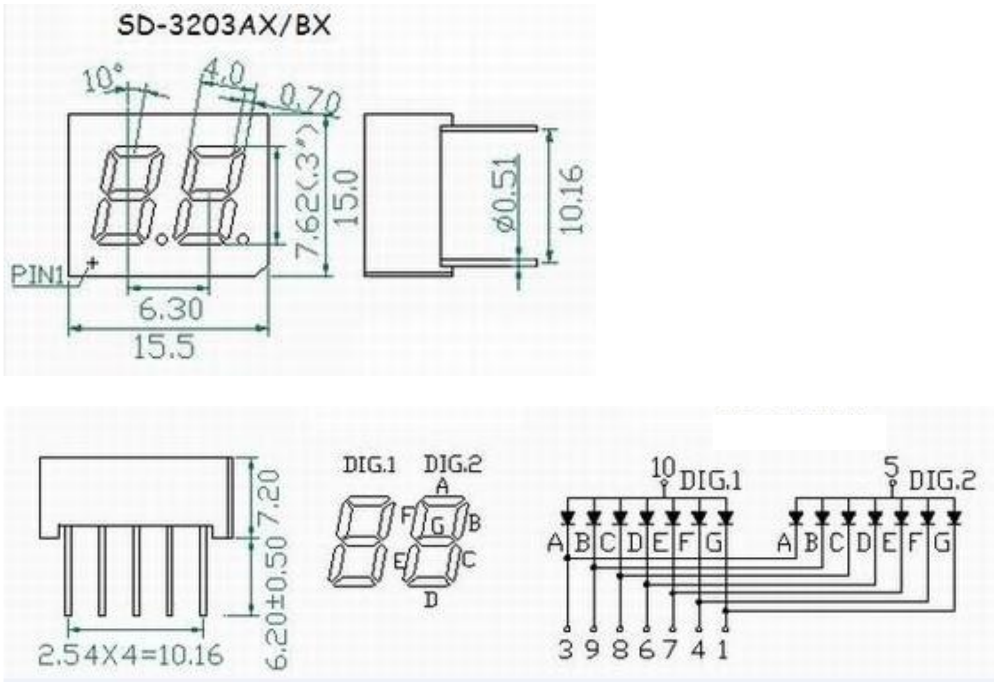


Fig. 3.18 Pin configurations of ATMEGA16

3.4 SEVEN SEGMENT DISPLAY

The display is a Common Anode 0.56 Inch (14.20mm) LED display which comprises of one 7-segment two digit display which display digit and one 7-segment one digit display which is placed upside and displays the ^{o}C sign. A bipolar junction BC557 PNP transistor for common anode display is use in order to sink or drive the required current. The microcontroller output interface, outputs the value for a specific display by enabling only its common pin transistor, and the digit driven by that common pin becomes active and also to give the impression that both displays are active at the same time and avoid flickering the digits are cycle through in quick succession and keep each of them lit for 5ms.



fi

Fig 3.19 Internal structure of the Seven Segment display

3.5 LED AND BUZZER

The LED serve as an indicator whenever the smoke sensor senses smoke in the environment which indicates with the Led emitting a red light, while the buzzer produces sound after the smoke sensor senses smoke and the temperature senses heat, the LED were connect as shown in the circuit diagram in Fig 3.20.

3.6 RELAY CIRCUIT

During the construction, transistors configured in a common emitter mode as shown in the circuit diagram in Fig 3.20, with it operating in the active region was used as a relay driver to drive components such as buzzer and also the relay which is connected to the pump. The relay is connected to DC pump acting as the switching device which switches the DC pump ON when it receives signal from the micro-controller after the smoke sensor and the temperature sensor senses smoke and a high temperature respectively.

3.7 PUMP/SPRINKLER

The Pump used is a 12V 3.6A dc pump with a sprinkler attached to the end of a pipe which is also attached to the water outlet of the pump, the area which the water sprinkles depends on the type of sprinkler and also the pressure of the Pump. The pump is configured as shown in the circuit diagram shown in Fig 3.20

3.8 CASING

The casing, housing of the entire circuit is a cuboid box made from plastic with several points on the box bored to accommodate and hold the LED, Temperature sensor, smoke csenbsor, Display and the buzzer. The casing is measured 30cm × 30cm × 15cm.

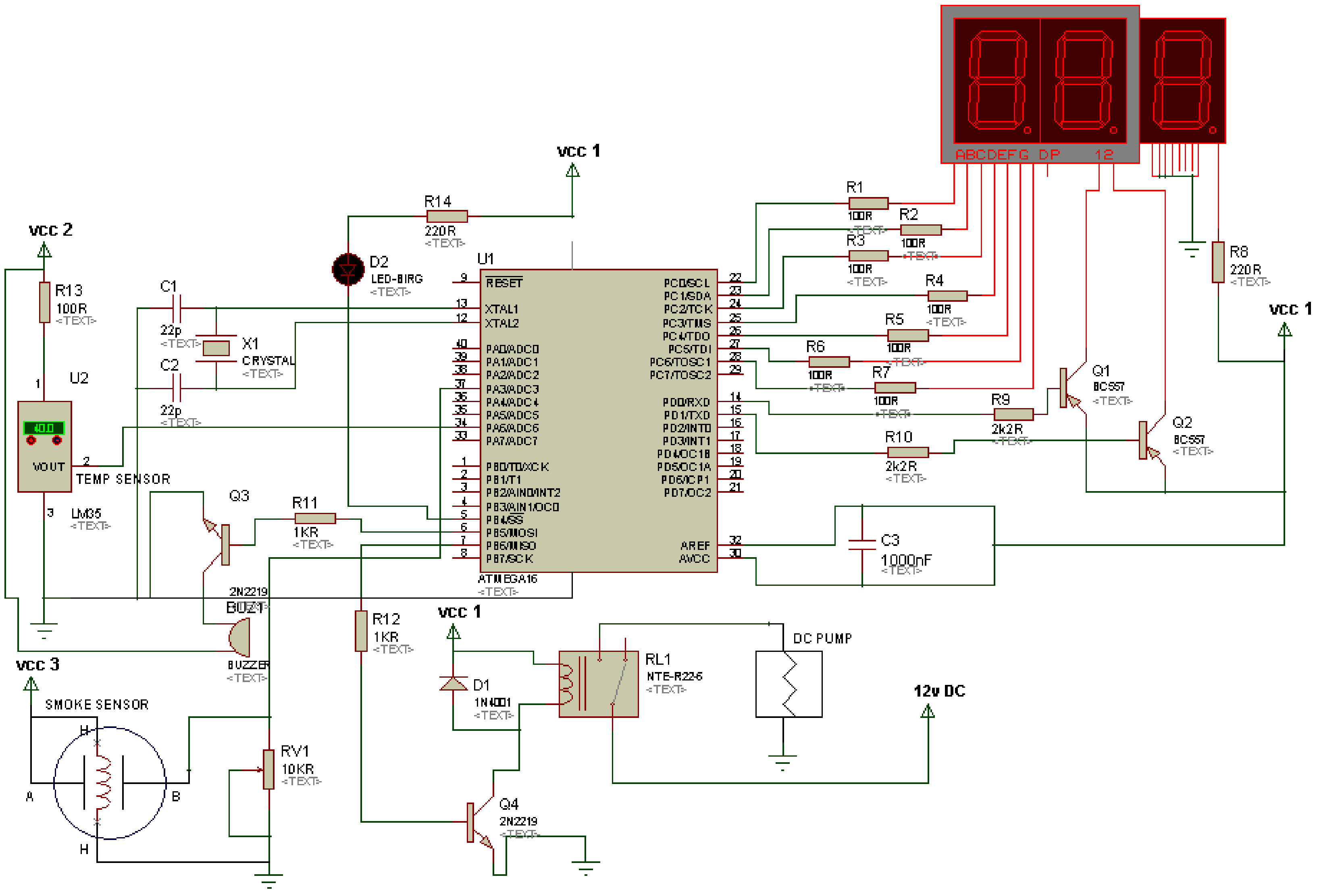


Fig 3.20 Circuit Diagram

CHAPTER FOUR: PERFOMANCE AND COST EVALUATION

4.0 PERFOMANCE

The system was first tested on a breadboard before assembling on a vero board and performance of the system the system carried out base on each block as in the block diagram in Fig 3.1.

4.1.1 POWER SUPPLY

- And oscilloscope and multimeter with the wave form as shown in Fig 4.1 and the output voltage found to be 12V AC
- After the rectification and filtering the outputs were monitored and also tested with a multimeter and an oscilloscope with the waveform as shownin Fig 4.2 and the output voltages found to be 5V DC from the rectifier and 18.85V DC from filter output.
- The output after rgulation using a multimeter and the output found to be 5V dc fom each of the regulators

4.1.2 TEMPERATURE SENSOR

The Temperature was observed to measure temperature of the environment sending the signal to the micro-controller and displayed on the LED display, test done using the temperature of the room and compared with a thermometer during the pick hours of the day and abserved for 3hrs and was found to be 34^{o}C both on the thermometer and the temperature sensor. When subjected to high temperature using the heat produced from a burning gas lighter placed under the sensor for 45secs it was found to increase gradually with it indicating a temperature of 64^{o}c.

4.1.3 SMOKE SENSOR

When connected as in Fig 3.7 and tested using a multimeter with the gas from a burning gas ligther and a burning paper with the following parameters were gotten:

For gas lighter: V c=5V, RL=10k Ω, VH=5V, VRL=5V

Sensing resistance $(RS) = \left(\frac{Vc}{VRL-1}\right) \times RL$.................................... (4.1)

RS = $\left(\frac{5\text{v}}{2\text{v}-1}\right) \times (10 \times 10^3) = 50\text{K}\Omega$

For burning paper: V c=5V, RL=10k Ω, VH=5V, VRL=2V

Sensing resistance $(RS) = \left(\frac{Vc}{VRL-1}\right) \times RL$................................... (4.2)

RS = $\left(\frac{5\text{v}}{2\text{v}-1}\right) \times (10 \times 10^3) = 12.5\text{K}\Omega$

When tested after construction it was found that the regulator LM7809 was heating due to the current drawn from the regulator and a heat sink applied to the regulator which later stabilized the temperature of the regulator.

4.1.4 PERFORMANCE AND TESTING OF OTHER DEVICES

After construction and test carried out using burning the following results where gotten

- It was found that the microcontroller was working properly, controlling several devices as programmed to work.
- The buzzer produced sound indicating the presence of fire.
- The LED blinked severally indicating the presence of smoke.
- The LED Display displayed the value as detected from the temperature sensor.
- The Pump/Sprinkler switched on after the the microcontroller confirmed the presence of fire receiving signal from both the temperature sensor and the smoke sensor.

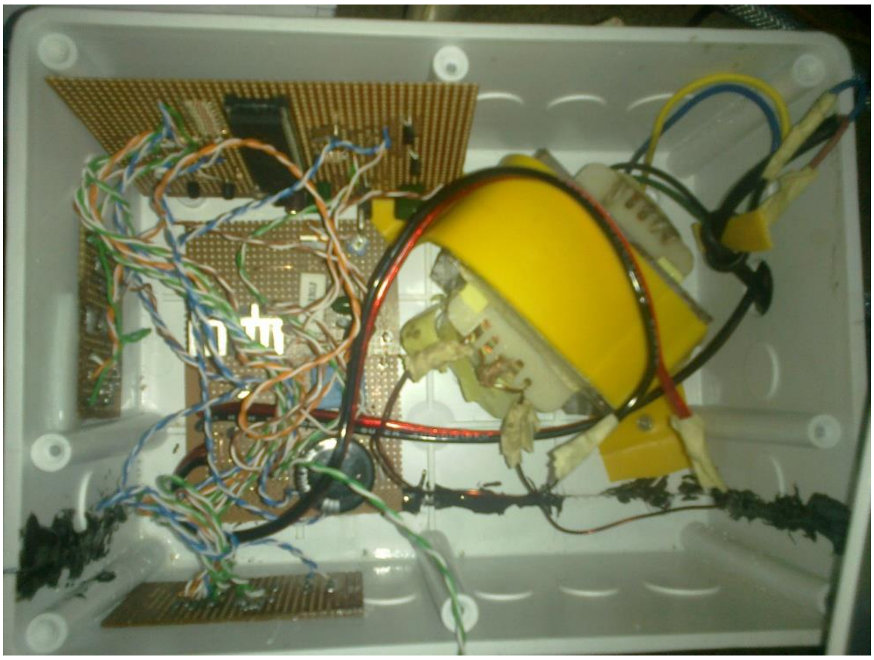


Plate 4.1 Automatic Fire control system overview.

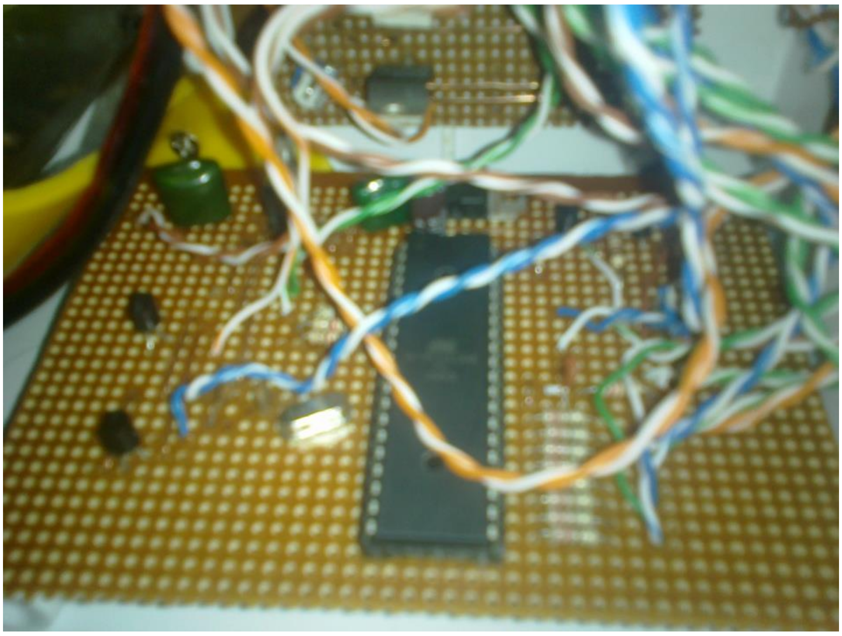


Plate 4.2: Microcontroller view onboard.

Plate 4.5: System Testing.

4.2 COST EVALUATION

The table below gives the overall cost of components.

S/N	COMPONENT NAME AND RATINGS	UNIT USED	COST PER UNIT (~~N~~)	TOTAL COST (~~N~~)
1	MQ-2 Gas sensor	1	2000	2000
2	Temperature sensor	1	150	150
3	DC Pump	1	5000	5000
4	0.1 µF ceramic capacitor	4	20	80
5	LED (red)	1	20	20
6	Dual 7 Segment display	1	200	200
7	Single 7 Segment display	1	100	100
8	BC557 PNP transistor	3	50	150
9	2K2Ω Resistor	2	10	20
10	220Ω resistor	2	10	20
11	10kΩ variable resistor	1	30	30
12	2N2222 NPN transistors	2	50	100
13	Buzzer	1	50	50
14	Dc relay	1	80	80
15	1KΩ resistor	2	10	20
16	22pF capacitor	2	10	20
17	100Ω resistor	8	10	80
18	Crystal oscillator	1	50	50
19	1N4001 Diode	1	10	10
20	1N5401Diode	4	20	80
21	12v step down transformer	1	1200	1200
22	5V LM7805 regulator	3	40	120
23	2200µF polarised capacitor	1	100	100
24	Vero board	1	300	300
25	ATMEGA16 microcontroller	1	1800	1200
26	Casing	1	3000	3000
27	0.1µF tantalum capacitor	2	50	100
28	Transformer	1	2000	2000
	Total cost			16,280

CHAPTER FIVE: CONCLUSIONS

5.0 SUMMARY

The careful arrangement of this projectreport has been done to reflect the layout of the project on board, according to the design. The overview of the work is reflected in chapter one , relevant works carried out that is related to the project is contained in chapter two, chapter three present the design and construction of the project where analysis of various component were done, also containing the procedures which involves mounting of component on vero board. Chapter four contains the performance, test and cost evaluation of the project.

In carrying out this work, several problems were encountered such as unavailability of some of the components needed for the construction and exact calculated values as proposed in the design stage.

5.1 CONCLUSIONS

The question proposed at the inception of this study has been significantly answered and its objective also significantly achieved.

The project work affords the opportunity of encountering some constructional hindrances such as unavailability of preferred materials, parity between theoretical and practical behaviours of components.

5.2 RECOMMENDATIONS

The project was carried out base on research on the major constituents of fire and therefore making the device a good combatant in fire outbreak. There is room for improvement and modification and further research can be carried out to improve and expand the project's application and technology.

Further technological improvement such as incorporating an SMS alert system to the device alerting owners and users of the device when there is fire outbreak in cases where there is fire outbreak and no one is around the place the device is positioned.

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APPENDIX A

PROGRAM CODE

```
/*

Project:        Automated Fire Extinguisher

Device:         ATMEGA16A

Language:       C

Designed By:    ..................

Company:        ..................

*/



#include <built_in.h>

/*port definitions

7-seg data port    = PORTC

7-seg_hun Enable   = PORTA0

7-seg_tens Enable  = PORTA1

7-seg_unit Enable  = PORTA2

Flash LED pin      = PORTB4

Buzzer signal pin  = PORTB5

Pump control pin   = PORTB6
```

```
*/
//Bit Variables
sbit LED  at PORTB.B4;
sbit Buzz at PORTB.B5;
sbit Pump at PORTB.B6;
sbit unit_EN at PORTA.B0;
sbit ten_EN at PORTA.B1;
sbit hun_EN at PORTA.B2;
char disp = 1;
char Units = 0;
char Tens  = 0;
char Hundreds  = 0;
unsigned short int adc_Data = 0;
unsigned short int temp = 0;
unsigned short int smoke = 0;

unsigned short int Seven_Seg_Data[10] =
{0xC0,0xF9,0xA4,0xB0,0x99,0x92,0x82,0xF8,0x80,0x90};
char smoke_state_LED = 0;
```

```
char status;

char pump_time = 0;

char Buzz_rate = 0;

char LED_time  = 0;

char fire_check_time = 0;

char fire_check_state = 0;




void ADC_Rd(void);

void display(void);



void TIMER1_COMPA() iv IVT_ADDR_TIMER1_COMPA                    //Timer1A
Compare Match

{

if(smoke_state_LED == 1){

LED = ~LED;                                       //ON LED

  }

else{LED = 1;}

if(fire_check_state == 1){
```

```
if(fire_check_time < 40){

fire_check_time ++;

if(fire_check_time >= 40){fire_check_time = 0;}

if(temp >= 40){

Buzz = ~Buzz;

if(Pump != 1){Pump = 1;}

 }

else{

if(Buzz == 1){Buzz = 0;}                              //disable buzzer

   }

     }

        }

if((Pump == 1)&&(pump_time < 20)){

pump_time++;

  }

else{

if(Pump == 1){

Pump = 0; Pump_time = 0;

   }
```

```
    }

      }

//INTERRUPT SERVICE ROUTINE FOR TIMER_2 COMPARE MATCH

void Timer2_Compare() iv IVT_ADDR_TIMER2_COMP     //Timer2 Compare Match
(6.667 (20/3)msec)

{

display();

}


void ADC_Rd(void){

 //Get ADC data

adc_Data = ADC_Read(6);

temp = adc_Data/2;

Hundreds = temp/100;

Tens = (temp/10)%10;

Units = temp % 10;

adc_Data = ADC_Read(3);                    //detect smoke

smoke = adc_Data;

if(smoke >= 400){
```

```
smoke_state_LED = 1;  fire_check_state =1;

   }

else{

smoke_state_LED = 0;

if(fire_check_time > 0)

{       }

else {fire_check_state = 0;}

     }

         }



//Dispaly on 7 seg

void display(void)

{

switch(disp){

case 1 :{

PORTC = 255;                                   //Port Cleared

unit_EN = 1; ten_EN = 1; hun_EN = 1;             //All 7-seg disabled

PORTC = Seven_Seg_Data[Units];

unit_EN = 0;                                   //Enable unit Display at PortB.0
```

```
disp = 2;
break;                                  //Exit from loop
 }
case 2 : {
PORTC = 255;                                    //Port Cleared
unit_EN = 1; ten_EN = 1; hun_EN = 1;             //All 7-seg disabled
PORTC = Seven_Seg_Data[Tens];
ten_EN = 0;                                 //Enable Tens Display at PortB.1
disp = 3;
break;
   }
case 3 : {
PORTC = 255;                                    //Port Cleared
unit_EN = 1; ten_EN = 1; hun_EN = 1;
if(Hundreds>0){                                     //All 7-seg disabled
PORTC = Seven_Seg_Data[Hundreds];
hun_EN = 0;                                     //Enable Hundreds Display at PortB.2
}
else{
```

```
PORTC = 255;

unit_EN = 1; ten_EN = 1; hun_EN = 1;

  }

disp = 1;



break;

  }

      }

            }

void main()                                    //Main Program starts here

{

DDRB.B2 = 0; DDRB.B3 = 0;                              //Analog inputs

DDRB.B4 = 1; DDRB.B5 = 1; DDRB.B6 = 1;                  //PORTA  set as Input

DDRA.B6 =  0; DDRA.B4 =  0;

DDRA.B0 = 1; DDRA.B1 = 1; DDRA.B2 = 1;                  //PORTB  set as Output

DDRC    =  0xFF;                               //7_seg data PORT  set as Output

PORTC   =  0xFF;                               //PORTC  Initialized

PORTB.B4 = 1; PORTB.B5 = 0; PORTB.B6 = 0;

unit_EN = 1; ten_EN = 1; hun_EN = 1;
```

```
OCR2    =  72;                                  //Enable Timer2 Compare Match (6.667
(20/3)msec with 1024 prescale

OCR1AH = 0x54;

OCR1AL = 0x60;

TCCR2      =      (((1<<WGM21)|(0<<WGM20))|((1<<CS22)|(1<<CS21)|(1<<CS20)));
//Start Timer2 with 1024 Prescalar

TCCR1A = 0;

TCCR1B = ((1<<WGM12)|(1<<CS12)|(0<<CS11)|(0<<CS10));                    //Enable
Timer1 compare matchA (0.5 sec)   at 256 prescaler

TIMSK  = ((1<<OCIE2)|(1<<OCIE1A));

asm  {sei}                                      // set Global Interrupt Enable



 while (1){

ADC_Rd();

delay_ms(500);

 }

   }
```