DESIGN AND CONSRUCTION OF A MICROCONTROLLER BASED AUTOMATIC FIRE SPRINKLER SYSTEM CONTROLLER

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2004/18794EE

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE, NIGERIA.

DECEMBER 2009

DEDICATION

This project is dedicated to Almighty Allah and to My Treasured Mum, Mrs Mojisola Awoyemi, My Beloved Brothers, Mr Gbola Awoyemi, Mr Jeleel Awoyemi, Mr Adegoke Awoyemi, My Dear Sisters, Mrs Rike Adekola, Miss Adenike Awoyemi and to My Darling Fiancee, Miss Olaitan Yusuf.

DECLARATION

I, AWOYEMI Adeola, declares that this project was done by me and has never been presented elsewhere for the award of degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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LIST OF FIGURES

LIST OF TABLE

TABLE OF CONTENT

CHAPTER THREE (DESIGN AND CONSTRUCTION)

CHAPTER FOUR (CONSTRUCTION, TESTING)

CHAPTER FIVE (CONCLUSION AND RECOMMENDATION)

CHAPTER ONE

INTRODUCTION

1.1 PREAMBLE

In our country today, services of the Fire service Agency is either not available or often delayed when needed, This has led to Over 80% of fire deaths occurrence in residential occupancies [1]. Therefore a need for an Automatic fire extinguisher arises.

Automatic: As applied to fire protection devices, any device, equipment or system that initiates a system function as a result of a predetermined temperature rise, rate of temperature rise or combustion products, without the necessity for human intervention [2].
Automatic Fire-Extinguisher System: An approved system of devices and equipment that automatically detects a fire and discharges an approved fire- extinguishing agent onto the detected fire [2].
Automatic Sprinkler System: An automatic fire-extinguishing system utilizing water, designed in accordance with fire protection engineering standards. The system includes a suitable water supply and a network of specially sized or hydraulically designed piping installed in a structure or area, generally overhead, to which automatic sprinklers are connected in a systematic pattern [2].

It is possible to extinguish fire at the very beginning within a short time since the extinguisher gets automatically operated at the same time that the fire is being detected by the detector, hence fire related disasters will be reduced drastically.

1.2 OBJECTIVES

The aim of this project is to:

1. Minimize fire risk in residential houses, offices, schools, halls, and public places.
2. It is aimed at reducing the tension and stress undergone by the staffs of fire service agency in the case of any fire outbreak.
3. Enhanced Security of life and properties

1.3 METHODOLOGY

The desired result of this project is for the microcontroller to know when to activate the pump and sprinkler unit and activate an alert system whenever smoke and high temperature of over 60°C is sensed by the smoke and heat detector respectively.

The smoke detector used in this project is a light dependent resistor (LDR). The resistance of an LDR increases with decrease in illumination. Thus, in a smoky region the resistance of the LDR increases leading to a corresponding increase in the voltage thereby given an output from the LM324 quad comparator. This output from the comparator serves as an input of logic state one to port 2.0 of the AT89S51 Microcontroller.

The Heat detector used is this project is a negative temperature coefficient (NTC) thermistor. The resistance of the NTC Thermistor decreases with increase in temperature. Thus, in a region where temperature is high, the resistance of the NTC Thermistor decreases leading to a corresponding decrease in voltage thereby given an output from the LM324 quad Comparator.

This output from the quad comparator serves as the input of logic state one to port 2.1 of the AT89S51 Microcontroller.

The microcontroller has been programmed to Start up an alert system and Control a mechanical switch that's start up a pump which aids the sprinkling of water mixed with a concentrated reducing agent (e.g CO_2) to extinguish the detected fire when both smoke and high temperature are sensed by the senors.

1.4 BLOCK DIAGRAM

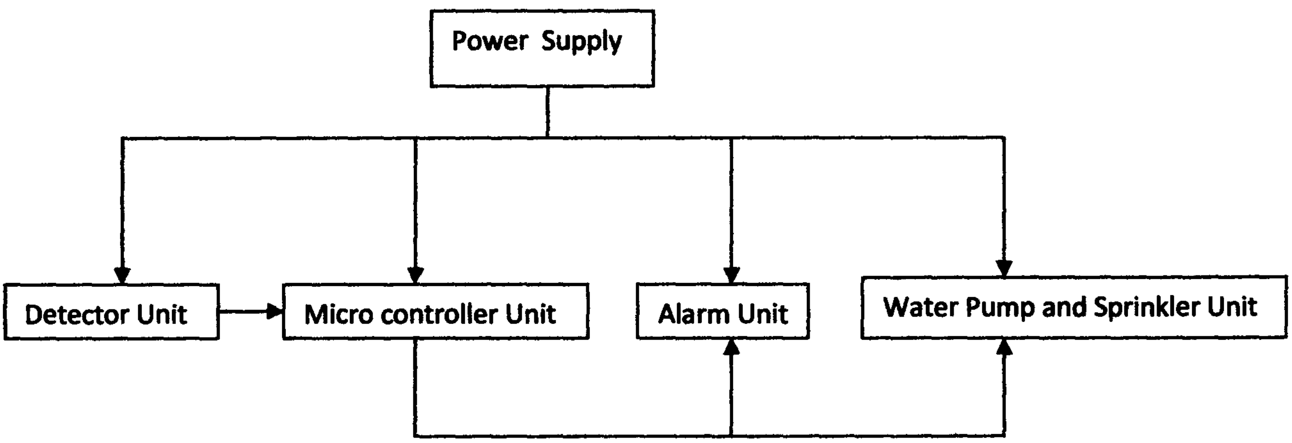

Fig 1.1 **Block Diagram of a Microcontroller Based Automatic Fire sprinkler System controller**

1.5 SCOPE OF WORK

This project work is based on the design and construction of a micro controller based automatic fire extinguisher which incorporates a number of fire detectors, an alert system and a switch which will be used to control a water pump to sprinkle liquid on the detected fire.

1.6 Tools and instruments

The tools & instruments used in the construction of this project are listed below;

I. 240/9V TRANSFORMER

II. BRIDGE RECTIFIER

III. CAPACITORS

IV. 7805 REGULATOR

V. RESISTORS

VI. NTC THERMISTOR

VII. LM 324 Quad Comparator

VIII. LDR

IX. AT89S51 Microcontroller

X. LED

XI. 12MHz OSCILLATOR

XII. TRANSISTORS (1015)

XIII. BUZZER

XIV. 10A RELAY

XV. WATER PUMP

XVI. SPRINKLERS

1.7 Limitations

This project is designed for in door use only. Improper location may cause unwanted alarm. Hence the detector should not be located near heating vents and dark regions.

CHAPTER TWO

LITERATURE REVIEW

2.1 THEORITICAL BACKGROUND

Literature search was conducted to gather reliable information of all types of fire safety system relevant to the protection strategies. The various components used in the designed of this work are explained below:

2.1.1 Transformer

A Transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit [3,4]. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. In summary, a transformer

1. Transfers electric power from one circuit to another.
2. It does so without a change in frequency
3. It accomplishes this by electromagnetic induction and
4. Where the two electric circuits are in mutual inductive influence of each other.

2.1.1 AT89S51 Microcontroller

The AT89S51 is a low-power device manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. The Atmel AT89S51 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications. The AT89S51 provides the following standard features: 4KB of Flash, 128 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, two 16-bit timer/counters, a five-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM con-tents but freezes the oscillator, disabling all other chip functions until the next external interrupt or hardware reset [5,6,7]. The AT89S51 comprises 40 lead pins with it's configuration shown below:

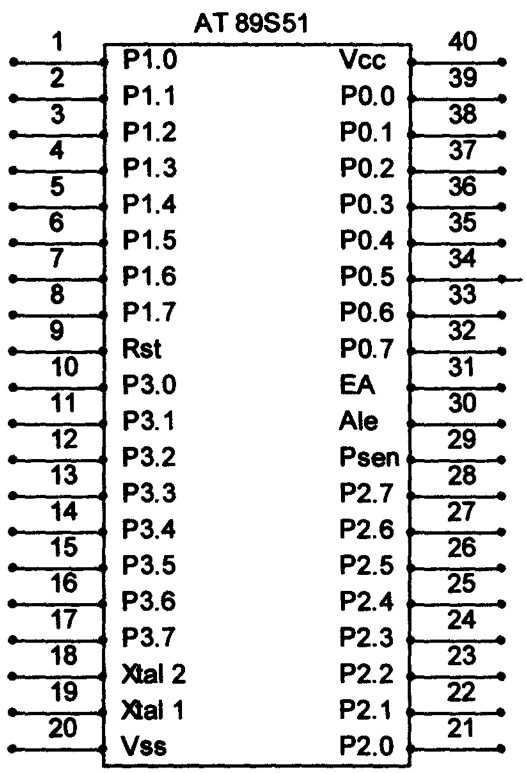

Fig 2.1 Diagram of a AT89S51 Microcontroller

2.1.2 **LM324 Comparator**

A Comparator is a device which compares 2 voltages or current and switches its output to indicate which is larger. An op amp combines both the null detector amplifier and the feedback signal source into one single unit.

A standard op amp operating without negative feedback can be used as a comparator. When the non inverting input (V+) is at higher voltage than the inverting input (V-) the gain of the op amp causes it to output the most positive voltage it can. When the non inverting input (V+) drops below the inverting input (V-) the op amp outputs the most negative it can [8]

The LM324 series consists of four independent high gain internally compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. It is has unity gain and also have a large DC voltage of gain of 100dB [9].

2.1.3 **NTC Thermistor**

A Thermistor is an electronic component that exhibit a large change in resistance with a change in its body temperature. The word "thermistor" is actually a contraction of two word "Thermal Resistor". The NTC thermistor by comparison, offer better sensitivity and accuracy over the operating temperature ranges, smaller sizes with faster response times and can be obtained in a wider assortment of device packages or sensor housings. Glass encapsulated NTC thermistors will also perform in much higher operating and storage temperatures than the solid state devices.[10]

2.1.4 **Crystal Oscillator.**

A Crystal Oscillator is an electronic circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electric signal with a very precise frequency. The most common type piezoelectric resonator used is quartz crystal, so oscillator circuits designed around them are crystal oscillator [3].

2.1.5 **Bridge Rectifier**

A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. This convert the AC voltage into DC voltage [3].

2.1.6 **Buzzer**

A **buzzer** or **beeper** is a signalling device, usually electronic, typically used in automobiles, household appliances such as a microwave oven, or game shows [2]. It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually sounds a warning in the form of a continuous or intermittent buzzing or beeping sound.

2.1.7 **Transistor**

A transistor consists of two P-N junctions. They are capable of amplifying weak signals. Transistors fall into two main classes – *bipolar junction transistors (BJT)* and *field effect transistors (FET)*.

There are many different kinds of NPN or PNP bipolar transistors. Some are used for radio-frequency amplifiers and oscillators; others are intended for audio frequencies. Some can handle high power, and others cannot, being made for weak-signal work. Some bipolar transistors are manufactured for the purpose of switching, rather than[11] signal processing

2.1.8 **Light Dependent Resistor (LDR)**

The voltage across the LDR increases when the light intensity increases and vice versa. There are just two ways of constructing the voltage divider, with the LDR at the top, or with the LDR at the bottom:

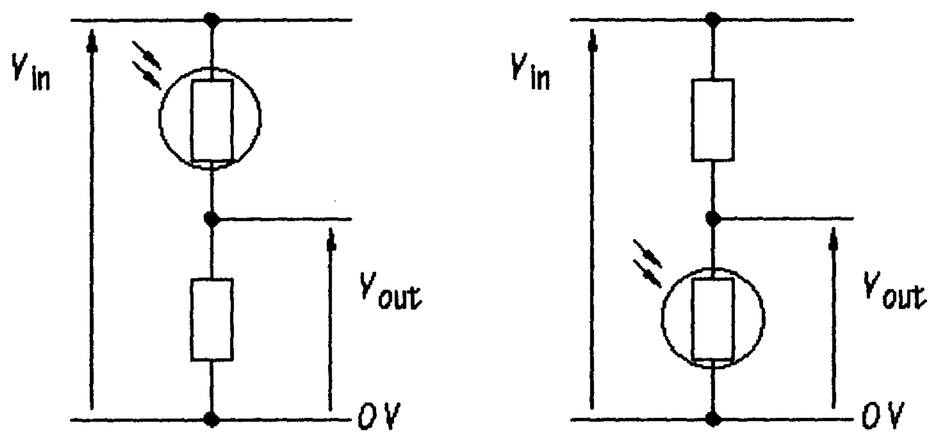

Fig 2.2 Different ways of Connecting an LDR

2.1.9 **Relays**

The magnetic field produced by a coil of current-carrying wire can be used to exert a mechanical force on any magnetic object, just as we can use a permanent magnet to attract magnetic objects, except that this magnet (formed by the coil) can be turned on or of by switching the current on or off through the coil [12]. Basically relay serve as a switch with two major terminals namely normally open and normally close

2.2 HISTORICAL BACKGROUND

The forerunner of the automatic sprinkler first appears in the United States when New England mill owners develop crude, perforated pipe systems to protect their facilities. Although the pipes increase fire protection, they distribute water everywhere (not just on the fire), and the water is delivered by a manually-turned valve requiring someone to be present in order for the system to operate. In 1873, Charles E. Buell invents the first sensitive sprinkler (with a fusible element that operates the sprinkler and does not come in contact with the water) that has a deflector to direct the water spray. In 1875, Henry S. Parmelee invents the first sprinkler that is used widely by industry. This sprinkler has a brass cap that is soldered over a perforated distributor. In 1882, Frederick Grinnell invents a sensitive, metal-disk sprinkler with a toothed deflector that breaks the water into a finer spray. In 1890, Grinnell invents the "glass button" sprinkler (closely resembling today's sprinklers). This sprinkler remains essentially unchanged for several decades. In 1953, The first standard sprinklers are installed. The standard sprinkler sprays all of its water downward at the fire (old-style sprinklers sprayed 40% to 60% of the water upward at the ceiling). This new type of sprinkler is developed based on research findings that fire spread along the ceiling is actually reduced when all of the water is sprayed downward. From 1976-1982, The United States Fire Administration (USFA) sponsors several residential sprinkler research programs. These programs determine that a residential sprinkler must respond quickly, while the fire is in its early stages, to maintain a survivable environment. Also, effective control of a residential fire often depends on a single sprinkler operating. The information acquired from this research guides the sprinkler industry to develop effective residential sprinklers.1989

The first ESFR sprinklers are approved by FMRC. These sprinklers suppress severe storage fires that are beyond the protection capabilities of even large-drop sprinklers. In 1991, FMRC continues studying the effectiveness of ESFR sprinkler systems in even more challenging applications. FMRC anticipates using computer simulation models as the basis for developing early suppression-type sprinklers for broader applications in less challenging fire situations [13]. Many more researches are still in progress till date.

2.3 PREVIOUS WORK

Henry S. Parmelee of New Haven, CT created and installed the first closed head fire sprinkler in 1874 to protect The Mathusek Piano Works. At the time he was the president of piano company [2]. Parmelee invented the closed head sprinkler in response to exorbitantly high insurance rates. Parmelee patented his idea and had great success with it in the U.S. Parmelee called his invention the "automatic fire extinguisher". He then traveled to Europe to show people that there was finally a way to help stop a building fire before everything was destroyed. In 1953 the first standard sprinklers are installed. The standard sprinkler sprays all of its water downward at the fire (old-style sprinklers sprayed 40% to 60% of the water upward at the ceiling). This new type of sprinkler is developed based on research findings that fire spread along the ceiling is actually reduced when all of the water is sprayed downward. ABC dry chemicals came over from Europe in the 1950s, with super-k being invented in the early 60s and the purple-k being developed by The U.S Navy in the late 1960s [2].

The instant brigade constructed in 2004 made use of a single sensor for his fire detection, and his work comprises numerous discrete component [14]. The Design of a Fire and control system constructed in 2008[15] made use of only heat detector with numerous descrete component, and he made use of only water to suppress his fire , not minding the fact that H_2O cannot suppress all types of fire.

2.4 DIFFICULTIES THAT LIMIT PERFORMANCE

Fire Fighting techniques and equipment used to extinguish fires and limit the damage caused by them can be greatly affected by the use of sub standard product in design, therefore, for optimum performance, the Design Engineer must make Quality his first priority. Fire fighting consists of removing one or more of the three elements essential to combustion—fuel, heat, and oxygen [1]. The design "must" eliminate at least one of this element for efficient performance.

2.4.1 Product of Combustion

The product of combustion also goes a long way in limiting the device performance. The products that a fire releases, and the rate at which it releases them, depend on the fuel and on the fire's burning rate [1]. Some fuels will produce more heat than others as they burn, and some will produce different kinds of gases. A fire that burns slowly may produce different products than one that burns quickly. The burning rate also affects the rate at which a fire releases products.

2.4.2 BURNING RATE

Different kinds of fires burn at different rates—one fire may slowly smolder, while another may quickly use up its fuel. The rate at which a fire burns depends on the composition of the fuel, the surface area of the fuel, and the amount of oxygen that is available [1]. Therefore in design, different burning rate must be accounted for. Interrupting the chemical chain reaction is more difficult but is typically done by applying special chemicals, such as halogenated compounds, to the fire. These halogenated compounds are being used less often as they cause damage to the atmosphere's ozone layer.

Most plastics burn at twice the rate of cellulose fuels, such as wood and leaves, because of the different chemical reactions involved. The burning rate of the same fuel, however, can also vary depending on how much of the fuel's surface is exposed to the air. As the exposed surface of a fuel increases in comparison to its volume, the burning rate of the fuel increases as well. When the fuel's gases have more surface area from which to escape, they can come into contact with more air. The increased exposure to air increases the amount of oxygen available for combustion.

CHAPTER THREE

DESIGN AND CONSTRUCTION

This project work consist of different unit which functions together to give the desired output. The block diagram for the successful realization of this project is shown below:

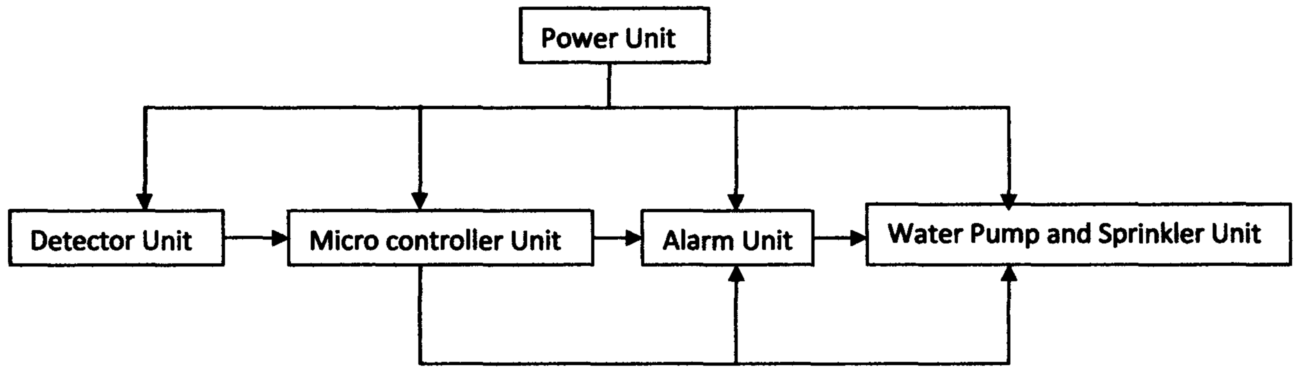

Fig3.1 **Block diagram of an automatic fire extinguishing system**

3.1 Circuit Analysis

For effective design and efficient analysis, the various units below are considered.

i. Power Supply Unit

ii. Fire Detector unit

iii. Microcontroller unit

iv. Alarm unit

v. Pump and Sprinkler unit

3.2 Power Supply unit

Power Supply unit is the unit in which proper voltage and current are being provided to electronic devices. In other words, it is the energy house of this project. The unit comprises;

i. Rectification unit

ii. Filtering unit

iii. Regulator unit

3.2.1 Rectification unit

Rectification is a process of converting an alternating current (AC), which flows back and forth in a circuit, to direct current (DC), which flows only in one direction. A device known as a rectifier, which permits current to pass in only one direction, effectively blocking its flow in the other direction, is inserted into the circuit for the purpose. A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full wave rectification. The single component bridge rectifier where the diode bridge is wired internally is shown below:

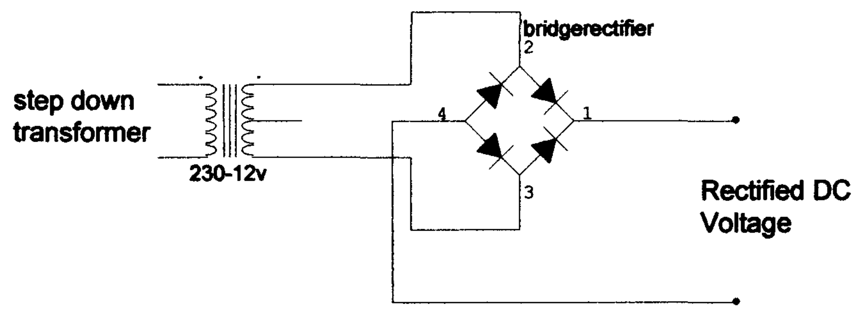

Fig 3.2 Rectified DC Voltage

The 230v from the mains is stepped down into 12v with the aid of the transformer. the voltage passed through the bridge rectifier is the 12v stepped down transformer. After the rectification, all negative voltage are rectified into positive voltage as shown below:

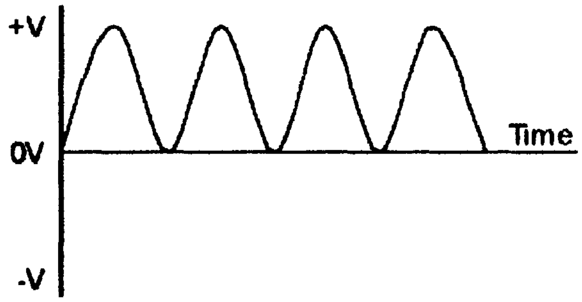

Fig 3.3 **Rectified AC Voltage Wave Form**

3.2.2 Filtering Unit

The rectified direct current (DC) voltage is passed through a smoothing capacitor. The larger the capacitor, the smaller is the amount of ripple in the voltage (encarta). The rating of the capacitor required in order to achieve desired result is calculated below:

Recall, $Q = I \times T = CV$

$$C = \frac{I \times T}{V}$$

$$T = \frac{1}{F}$$

$$C = \frac{1}{V \times F}$$

Given that I (from the transformer) = 300mA

V = 12v

F = 50Hz

$$C = \frac{300}{9 \times 50 \times 10^{3}}$$

C = 0.0006666F

C = 666.67μF

The calculated value of the capacitor is the minimum value of the capacitance needed to eliminate ripples. The higher the capacitance of the capacitor, the better filtering of the ripples. I made use of 1000μF capacitor. The smoothing capacitor shown below requires just one single rated capacitor placed across the output from the rectifier with a voltage rating far above the rectified voltage so that any slight voltage drop would be compensated.

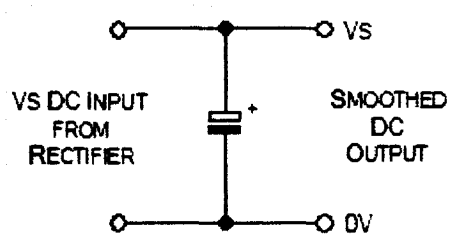

Fig 3.4 Filtered DC Voltage

As the output voltage increases, The capacitor is charged, and as the output voltage falls back to zero, the capacitor releases its stored energy. The resulting voltage across the capacitor is shown below;

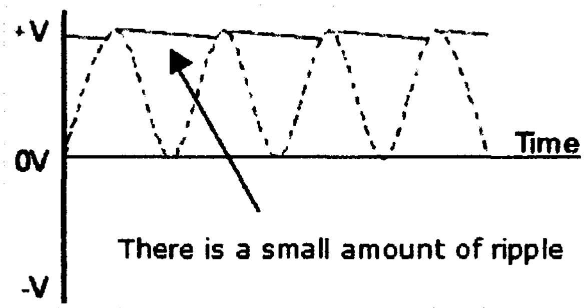

Fig 3.5 **Filtered DC Voltage with Small Amount of Ripples**

3.2.3 **Regulator unit**

More precise control over voltage levels and ripples can be achieved via a voltage regulator [6]. This embedded system is utilizing the 230v rms and 5v dc which is gotten via the use of 7805 voltage regulator. The 7805 regulator IC offer very high level of performance for most application and in addition to this they are very cheap and easy to use. Having only three terminals, i.e. input, output and ground, they require no external components for their basic operation.

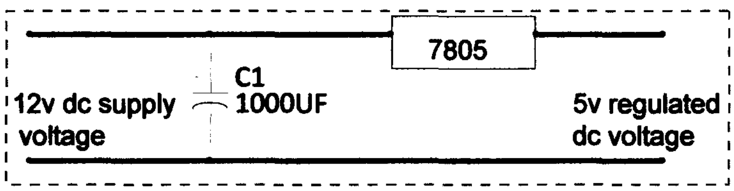

Fig3.6 **Regulator Unit Circuit Diagram**

3.3 Fire detector unit

One of the most important aspects of fire control is a system of locating fires before they are able to spread. Fire detectors used for the successful realization of this work are;

I. Heat detector
II. Smoke detector

3.3.1 Heat detector

Heat detector is a sensing device used for sensing the presence of or changes in temperature. This unit have high sensitivity and very reliable. the unit is made up of ;

I. 5v dc power supply
II. Negative temperature coefficient thermistor
III. Comparator
IV. Resistor

The steps involved in the operation of the heat detector unit is outlined below:

- The 5v power supply energize the circuit.
- The NTC Thermistor operates in such a way that when the temperature goes high, the resistance drops, and consequently drop in the voltage level.
- Thereby, making the voltage across the NTC Thermistor which is connected to the inverting terminal of the comparator to go low.

➢ Due to this voltage drop, the voltage in the non-inverting terminal becomes greater than that in the inverting terminal.

➢ Thus, an output is gotten which will serve as the input to port 2.1 of the AT89S51 Microcontroller. The circuit diagram for the heat detector circuit is shown below:

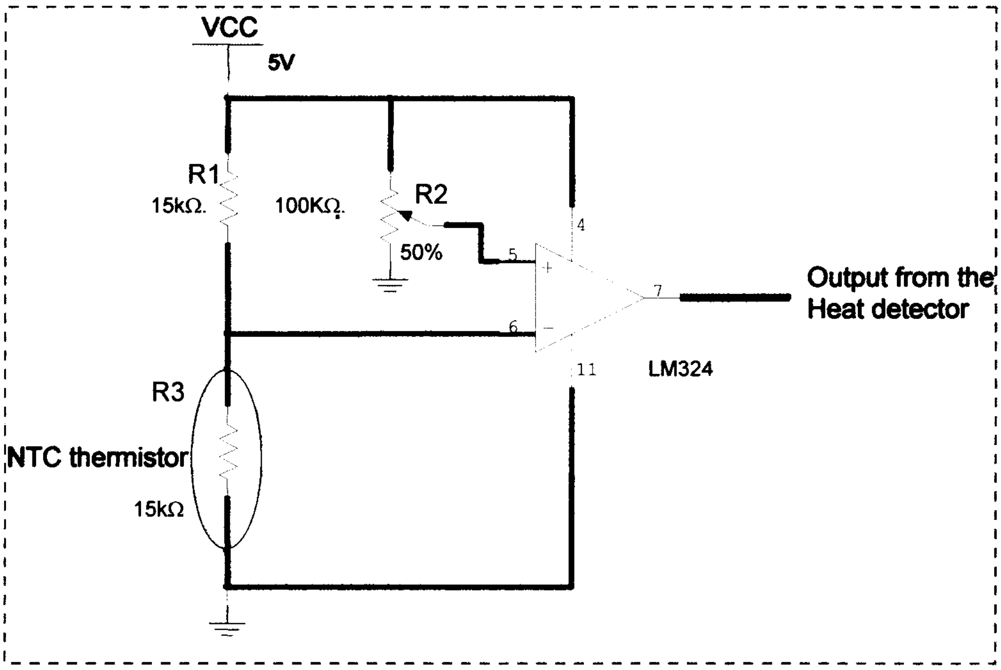

Fig3.7 **Heat Detector Circuit Diagram**

3.3.2 Smoke detector

Smoke detectors sense the early stages of fire. Depending on design, it could either sound a warning so that the occupants of a building may safely escape or perform other task. the unit is made up of;

I. 5v dc power supply

II. Light dependent resistor

III. Comparator

IV. Resistor

The basic steps involved in its operation is outlined below:

- The circuit is energized by the 5v dc power supply
- The light dependent resistor operates in such a way that resistance decreases with decrease in illumination and vice versa
- According to ohm's law: "V=IR" that is, decrease in resistance will cause a corresponding decrease in voltage level and vice versa.
- Thereby, making the voltage across the LDR which is connected to the inverting terminal of the comparator to go low.
- Due to this voltage drop, the voltage in the non-inverting terminal becomes greater than that in the inverting terminal.
- Thus, an output is gotten which will serve as the input to port 2.0 of the AT89S51 Microcontroller. The circuit diagram for the smoke detector circuit is shown below:

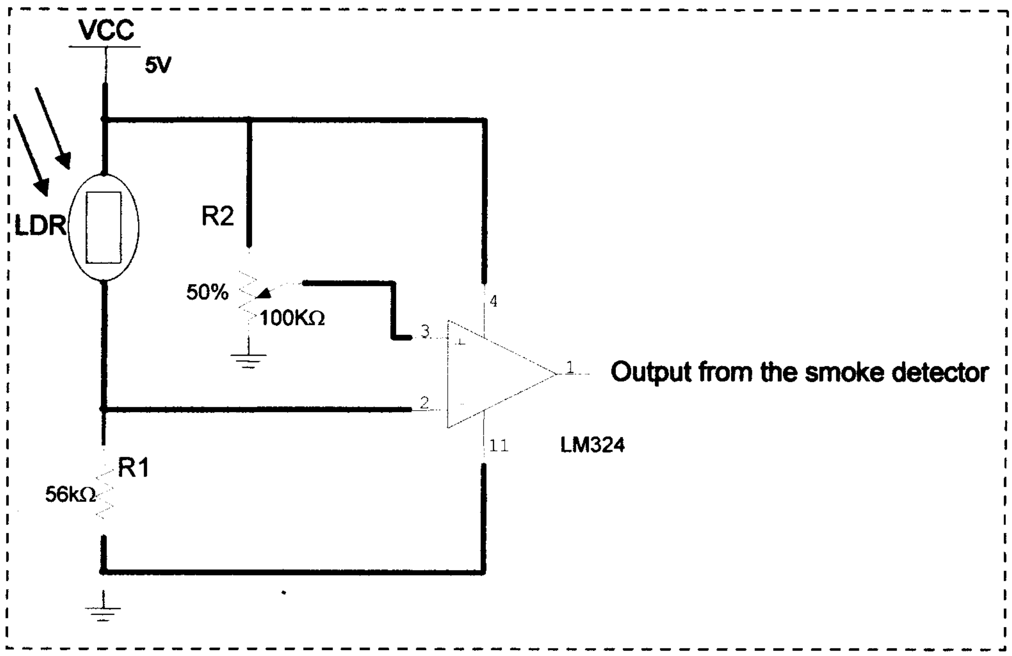

Fig3.8 Smoke Detector Circuit Diagram

3.4 Micro Controller Unit

This unit is the backbone of the entire design. It gets its digital input from the output of the detectors and depending on how the microcontroller is programmed, the desired output is gotten to perform the designer's task. The codes used for programming the AT89S51 and the flow chart of the program are shown below:

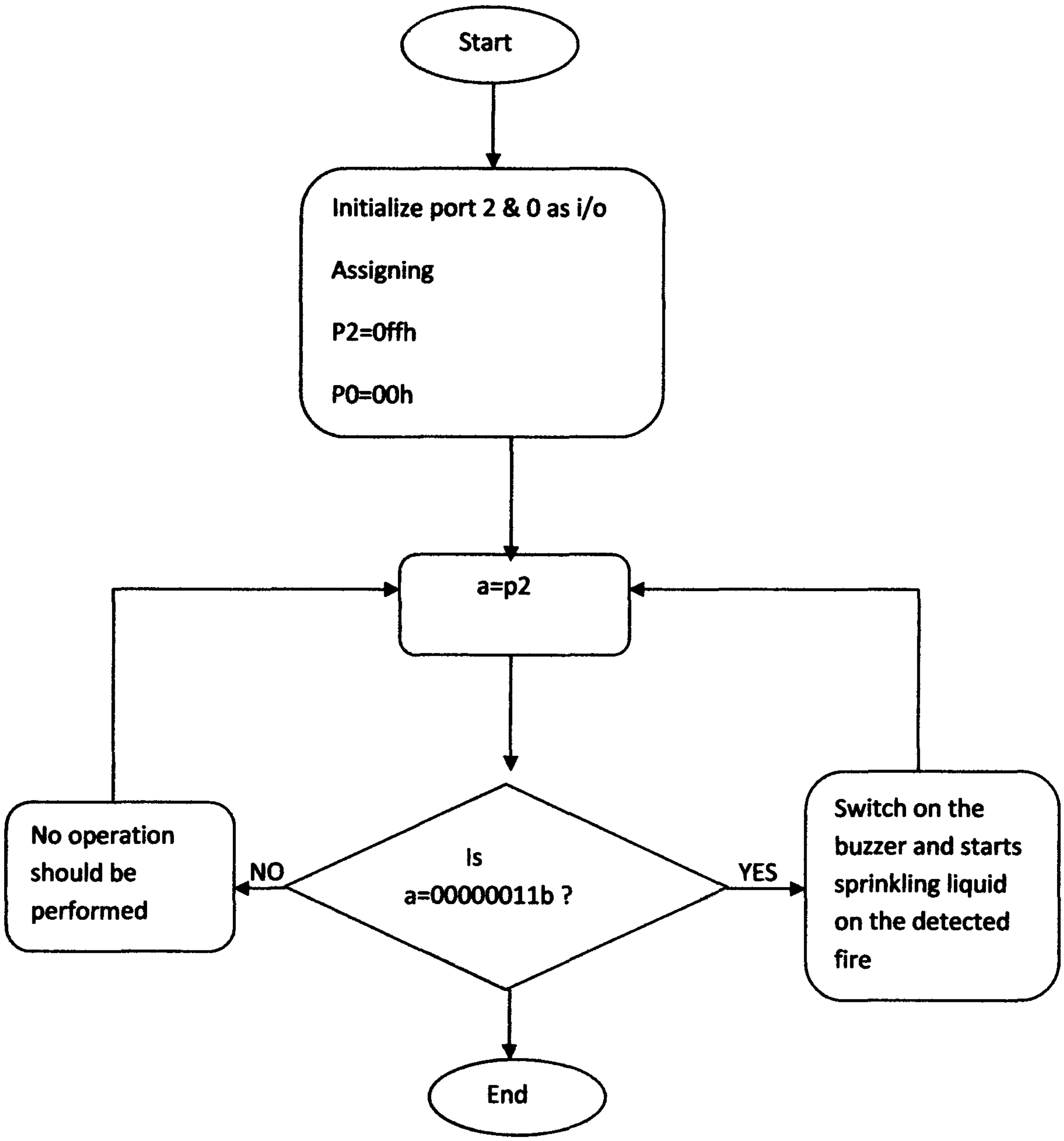

Fig 3.9 Automated Fire sprinkler system controller program flow chart

3.4.1 **Source Code For Automated Fire Sprinkler System**

- ;Program for an automated fire sprinkler system
- START:
- MOV P2, #11111111B
- MOV P0, #00000000B
- Clr A
- CHECK:
- MOV A, P2
- CHECK1:
- CJNE A, #00000011B, CHECK2
- MOV P0, #00000011B
- SJMP CHECK
- CHECK2:
- MOV P0, #00000000B
- RET
- END

3.4.2 Algorithm For A Fire Sprinkler Controller

1. Comment describing the function of the program
2. The beginning of the program
3. Assigning 0ffh to port 2 and declaring it as an input port
4. Assigning 00h to port 0 and declaring it as an output port
5. Clear accumulator A
6. Sub routine named check
7. Move the contents of port 2 to accumulator A
8. Sub routine named check1
9. compare and jump to "check2" if whatever is in acc A is NOT "#00000011B" otherwise
10. Move #00000011B to port 0
11. Short jump to "check"
12. Subroutine named check2
13. Move #00000000B to port 1
14. Return
15. End program

The circuit interconnection for this unit is shown below:

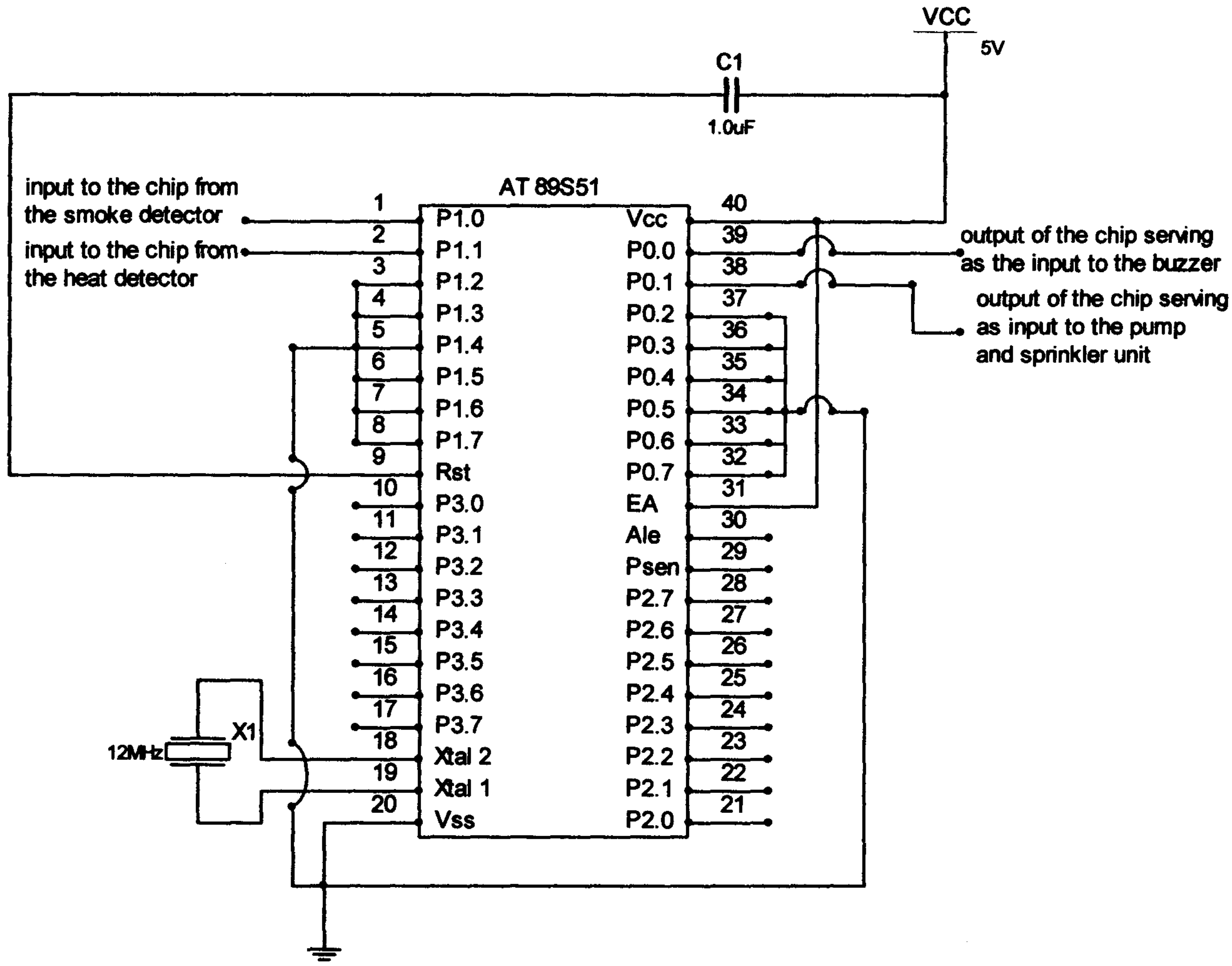

Fig3.10 Circuit Diagram of the Microcontroller Unit

3.5 Alarm Unit

This unit generates the sound when there is an output from the micro-controller, in other words it generate sound when fire is detected by the smoke detector AND the heat detector. The circuit diagram for this unit is shown below:

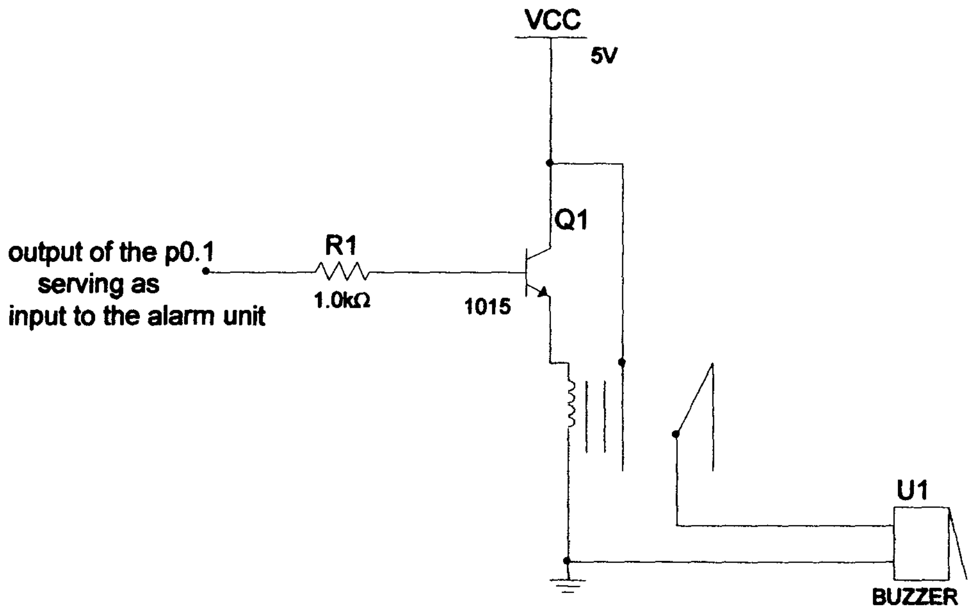

Fig3.11 **Alarm Unit Circuit Diagram**

3.6 Pump and Sprinkler Unit

This unit is responsible for sprinkling liquid on the detected fire. This unit is powered by 230v ac. The unit comprises relay switch, water pump interconnected to the sprinkler head. the unit is activated whenever the output from the micro-controller changes from digital no zero (0) to digital no (1). The base resistance calculation and The circuit diagram of this unit is shown below:

From $Vcc = IcRc + Vce$

At saturation, Vce = 0

Vcc = 5v & Rc = 110 ohms (Rc- Relay resistance)

$$Ic = \frac{5}{110} = 0.045A$$

From hfe (gain) $= \frac{Ic}{Ib}$

From data sheet, Using hfe = 10

$$I_b = \frac{Ic}{hfe} = \frac{0.045}{10} = 0.0045A$$

Vb = Ib Rb

$$Rb = \frac{Vb}{Ib}$$

$$R_b = \frac{4.5}{0.0045}$$

$$= 1K\Omega$$

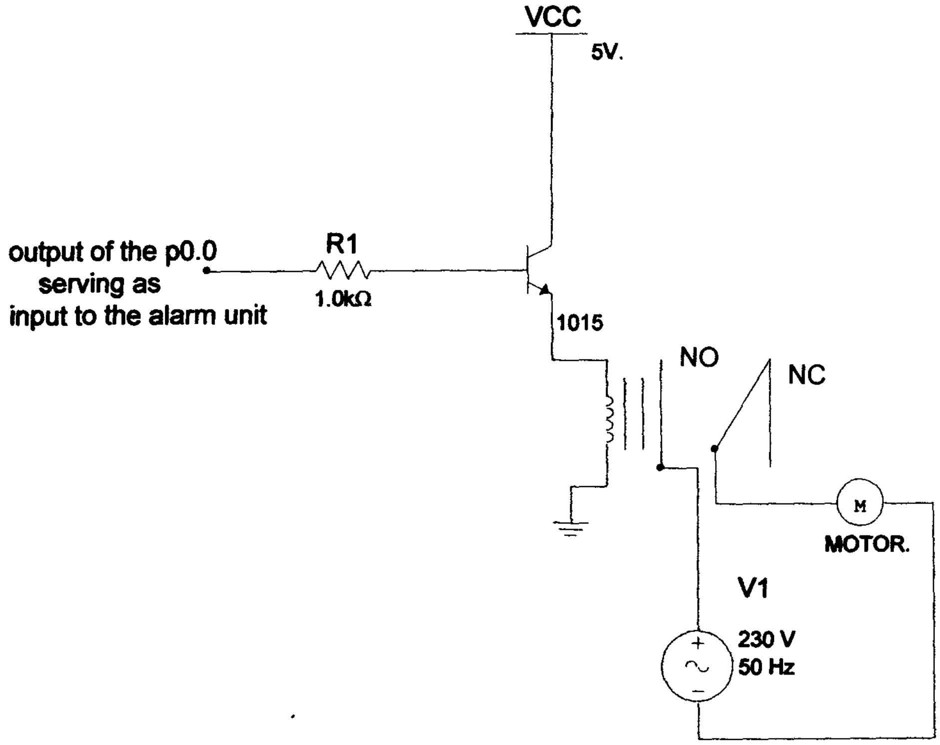

Fig3.12 Pump & Sprinkler Unit Circuit Diagram

The circuit diagram for the successful realization of this project is shown below:

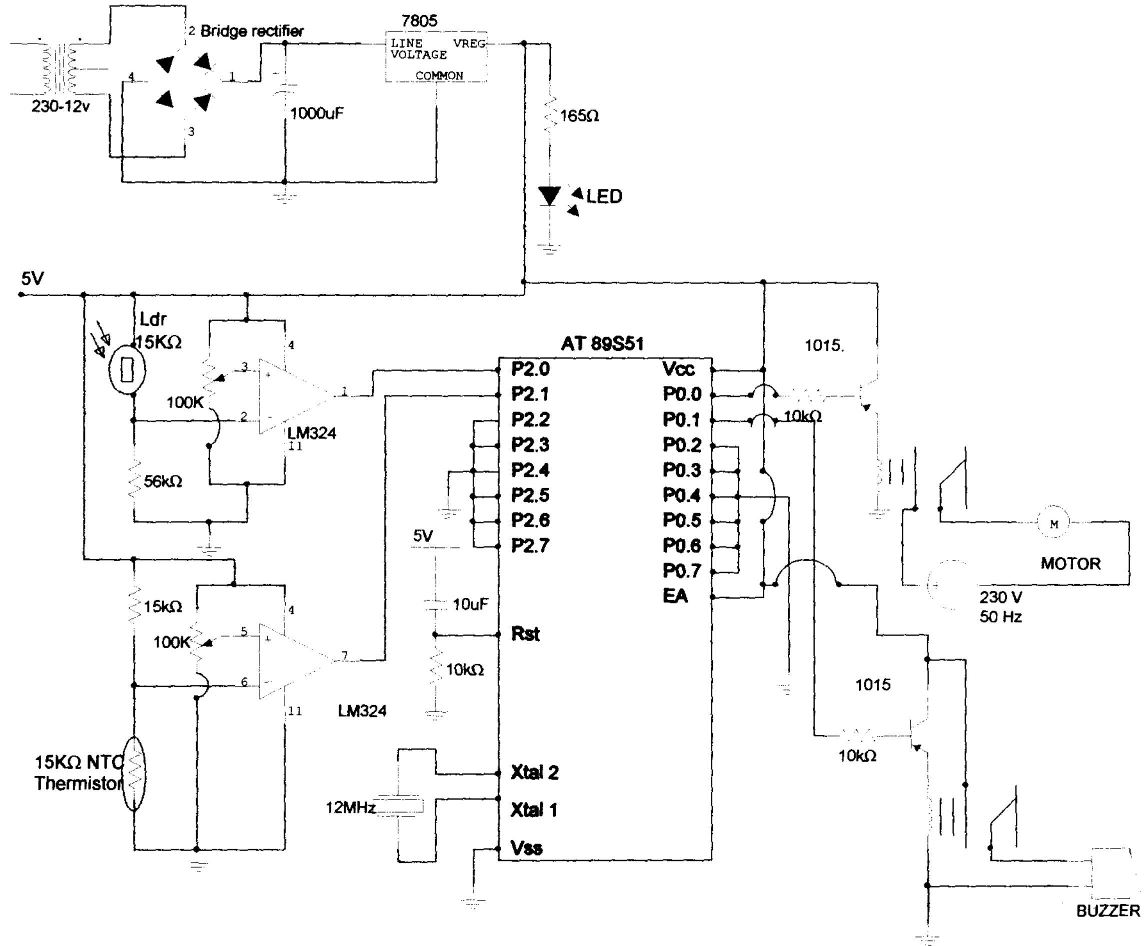

Fig 3.13 **CIRCUIT DIAGRAM OF A MICROCONTROLLER BASED AUTOMATIC FIRE SPRINKLER CONTROLLER**

CHAPTER FOUR

CONSTRUCTION, TESTING AND RESULT

4.1 Construction

The construction of this system is in units, each unit was first considered as a separate entity on the bread board before they were all transferred to a vero board. The whole system was constructed on a –by- vero board. The power supply unit, the smoke detector unit, the heat detector unit, micro-controller unit, the alarm unit and the control circuit for the pump and sprinkler unit were tested independently and simultaneously during the construction process. The construction achieved the desired result in terms of size, weight, shape, packaging.

4.2 Units Connection and Inter-connection

The system was connected to the 230v mains from PHCN. The step down transformer in the power supply unit stepped the voltage down to 12v, rectification was carried out and the voltage was then regulated to give an output of 5v using the 7805 regulator.

The 5v energized the detector unit, microcontroller unit and the alarm unit. The output from the detectors was fed into the input port of the micro-controller which has been programmed to send a signal to the pump & sprinkler unit and the Alarm unit when both detectors gives an output of logic state one otherwise, no signal will be sent. The entire units work in harmony and the anticipated result was gotten.

4.3 Testing

The design was tested on breadboard and the program was simulated using an application software named, Edsim. The program was burnt into the AT89S51 Micro-controller chip using a programmer and inserted into the circuit on the bread board, the circuit was tested, and the circuit behavior was in accordance with the anticipated result. The entire design was then transferred to the vero-board and the component that made up each of the unit were sequentially tested as the system implementation progresses

The entire system was then powered, only the heat detector was activated, measurement was taken and it was observed that no output was gotten. Secondly, the heat detector was deactivated and only the smoke detector was activated, measurement was taken and again it was noticed that no output was gotten. Since the system was programmed to behave as an AND gate, output was only gotten when both the heat detector and the smoke detector was activated, the output was then measured and recorded. The result obtained and the calculation that was carried out for the successful realization of this project are shown below:

Smoke Detector;

Expected voltage at the non inverting terminal = 2.5V

Resistance of the LDR at normal lightening condition = 32kΩ

From voltage divider rule;

Expected voltage at the inverting terminal of the comparator

$$= \frac{56K\Omega}{86K\Omega} \times 5V = 3.18V$$

Result obtained;

The voltage at the non inverting terminal = 2.5V

The voltage at the inverting terminal = 3.0V

When this unit was activated, that is when smoke was sensed the output from the comparator was measured to be 3.1V

Heat Detector;

Expected voltage at the non inverting terminal = 2.5V

Resistance of the NTC Thermistor = 15kΩ

From voltage divider rule;

Expected voltage at the inverting terminal of the comparator

$$= \frac{15K\Omega}{30K\Omega} \times 5V$$

=2.5V

Result obtained;

The voltage at the non inverting terminal = 2.5V

The voltage at the inverting terminal = 2.7V

When this unit was activated, that is when high temperature was sensed the output from the comparator was measured to be 3.1V

This behavior could be seen in the truth table shown below:

Table 4.1 Truth Table of the Project Design

OUTPUT FROM THE SMOKE DETECTOR	OUTPUT FROM THE HEAT DETECTOR	OUTPUT FROM THE AT89S51 CHIP
0	0	0
1	0	0
0	1	0
1	1	1

4.5 Results

Output from the bridge rectifier = 11.8v

Output from the 7805 regulator = 4.8v

Output from the heat detector when heat was applied =3.1V

Output from the smoke detector when it was activated = 3.1V

Output was only gotten from the alarm unit and sprinkler unit when both detectors are triggered.

Port 1.0 and port 1.1 gave an output of 4.5v which is enough to trigger the buzzer and also to energize the coil of the relay, which then switch from normally open to normally closed, thereby completing the circuit. As a result of these, the water pump & sprinkler unit is activated and the extinguishing liquid is sprinkled on the detected fire. All these process takes place in milli seconds

4.6 Precautionary Measures

A number of precautions were observed in the design and construction of this system. The various action taken to protect against un-wanted circuit behaviors are listed below:

I. All Components used for the design were tested Before Soldering Them On The Vero-Board

II. All Un-Wanted Lead found on the vero board Was Melted And Sucked Away Using Lead Sucker in order to avoid bridging

III. I Ensured Proper Component Placement On The Board So As To Get The Desired Result

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Delayed detection of fire often leads to loss of life and properties. This design detects fire by sensing both smoke and high temperature of over 60°C, initiate alarm and begin suppression within moments after flames appear. The control of this processes is generally instantaneous. Proper installation of this device will enhance security of life and properties by minimizing fire risk in residential houses, offices, schools and halls.

5.2 Recommendation

- Future Design should incorporate additional power supply.
- More detector unit and Display showing activation temperature.
- Future design should work efficiently and effectively in the kitchen without false activation.

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