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Design And Construction of Microcontroller-Based Fire Detection and Control System

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Abstract- This project presents the design and construction of microcontroller-based fire detection and control system. The system senses dense smoke fumes and high temperatures that lead to fire outbreak with the aid of a sensing circuit made up of a photoelectric smoke sensor and a negative temperature coefficient thermistor, respectively. The sensory circuit is connected to a NPN transistor in parallel to each other, when the OP-Amps output is high the transistor turns on and the base current of the transistor switches on the buzzer once it senses smoke or high temperature and the other output of the transistors is connector to a Peripheral Interface Controller (PIC16F877A) microcontroller. When the microcontroller is set at high pin configuration it sends a message to the fire extinguisher unit, which automatically switches on and then releases 〖CO〗_2 gas in the form of a message. The other end of the microcontroller is interfaced with LCD which serves as monitoring and supervisory station. The sensory and interfacing circuit are both powered using a 5V regulated power supply. This system improves the chances for reducing the risks to life and property.

I. INTRODUCTION

A key aspect of fire protection is to identify fire emergency procedure in a timely manner and to alert the building's occupants and fire emergency services immediately. This is the role of fire detection and alarm systems. Depending on the anticipated fire scenario, information on the building and use type, number and type of occupants, other valuables and every content of the building are critical and require protection by these systems. First, they provide a means to identify a developing fire through either manual or automatic methods and second, they alert building occupants to a fire condition and the need to evacuate. Another common function is the transmission of an alarm notification signal to the fire department or other emergency response organizations.

The control panel is the "brain" of the fire detection and alarm system. It is responsible for monitoring the various alarm input devices such as manual and automatic detection components, and then activating alarm output devices such as horns, bells, warning lights, emergency telephone dialers, and building controls. Control panels may range from simple units with a single input and output zone to complex computer driven systems that monitor several buildings over an entire area. There are two main control panel arrangements, conventional and addressable.

Conventional fire detection and alarm systems were for many years the standard method for providing emergency signaling. In a conventional system one or more circuits are routed through the protected space or building. Along each circuit, one or more detection devices are placed.

Selection and placement of these detectors is dependent upon a variety of factors including the need for automatic or manual initiation, ambient temperature and environmental conditions, the anticipated type of fire, and the desired speed of response. One or more device types are commonly located along a circuit to address a variety of needs and concerns. Upon fire occurrence, one or more detectors will operate. This action closes the circuit, which the fire control panel recognizes as an emergency condition. The panel then activates one or more signaling circuits to sound building alarms and summon emergency help. The panel may also send the signal to another alarm panel so that it can be monitored from a remote point.

Addressable intelligent systems represent the current state-of-the-art in fire detection and alarm technology. Unlike conventional alarm methods, these systems monitor and control the capabilities of each alarm initiating and signaling device through microprocessors and system software. In effect, each intelligent fire alarm system is a small computer overseeing and operating a series of input and output devices. The major difference between system types involves the way in which each device is monitored. In an addressable system, each initiating device (automatic detector, manual station, sprinkler water flow switch, etc.) is given a specific identification or address. This address is correspondingly programmed into the control panel's memory with information such as the type of device, its location, and specific response details such as which alarm devices are to be activated.

Advantages provided by addressable alarm systems include stability, enhanced maintenance, and ease of modification. Stability is achieved by the system software. If a detector recognizes a condition which could be indicative of a fire, the control panel will first attempt a quick reset. For most spurious situations such as insects, dust, or breezes, the incident will often remedy itself during this reset procedure, thereby reducing the probability of false alarm.

If a genuine smoke or fire condition exists, the detector will reenter the alarm mode immediately after the reset attempt. The control panel will now regard this as a fire condition, and will enter its alarm mode [1].

II. LITERATURE REVIEW

Fire detection and control system is a vital device in all industrial and residential areas. Research works have been carried out to solve fire outbreak detection problem and subsequent control of the fire. This was achieved by using some electronic components like temperature and smoke sensors which sense situations that lead to fire outbreak.

A lot of research has been carried out in order to overcome the challenges facing rampant cases of fire outbreak in many industries and residential buildings. Some of such research projects are:

Husseini, (1999) designed, constructed and tested a Phase Locked Loop (PLL) temperature measuring device using PLL (565) IC. Temperature sensing was actualized by using the PLL together with a capacitor. The problem associated with this system was inaccuracy to detect heat at the early stage because heat detectors are very slow.

Qualey, (2001) designed a smoke detector using a response time comparison of the ionization and photoelectric and heat detectors on automatic fire detection. The major problem of this work was that it only detected smoke using smoke sensor and did not provide room for the control systems.

Adamyan, (2003) designed and constructed a smoke detector with the ability to overcome humidity and cross-sensitivity using a photoelectric smoke sensor. Its shortcoming was its inability to sense excessive heat and smoke quickly; thus, the non-linearity of the sensor affected the performance of this project.

Keller, (2005) designed a smoke detector using open acoustic sensor and Negative Temperature Coefficient (NTC) thermistor as the temperature sensor. The thermistor had low range of output resistance which made its response to temperature change to be low.

Elvis, (2011) designed and constructed a fire detection and control system using GSM wireless network. The system sensed dense smoke fumes and high temperature coefficient that lead to fire outbreak with the aid of sensing circuit made up of a photoelectric smoke sensor and NTC thermistor. SMS and data charges made this system inconvenient, because of cost implication.

Balami, (2014) designed and constructed a fire alarm system that uses Positive Temperature Coefficient (PTC) thermistor. This work also had limitations due to its failure to produce the warning alarm at low temperature before reaching the ignition point. For this reason, it was not very effective in preventing the start of fire outbreak because its alarm only came on

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at high temperature when the fire would have already started.

Sani, (2015) designed and constructed a smoke detector using LED as the source of illumination to the LDR. The problem of these project is that the LED did not produce strong illumination and therefore, the sensitivity of the circuit was very poor which made it possible for the circuit to give false alarm.

Recently, there are many types of fire detection and alarm systems in the market but they are so expensive and not cheaply affordable by many building occupants. This design will, however, solve all the mentioned problems which these reviewed designed systems could not solve. The design will provide a supervisory system (comprising of LCD and warning LED), so that early detection can be checked, before it could result to fire outbreak. The sensory unit of the design is made of both temperature sensor, negative temperature coefficient thermistor and photoelectric smoke sensor. A light obscuration smoke detector type employs light emitting diode and light dependent resistor. The system once constructed it can detect and control fire outbreak at the very early stage. At the immediate fire outbreak detection, the fire extinguisher is triggered and the LCD is continuously displaying the output result of the extinguisher performance in controlling the fire. For the purpose of this design, co_(2)or other sprinkling gas will not be considered. This reduces the risk of the life and properties to a reasonable limit.

III. CIRCUIT ANALYSIS AND DESIGN

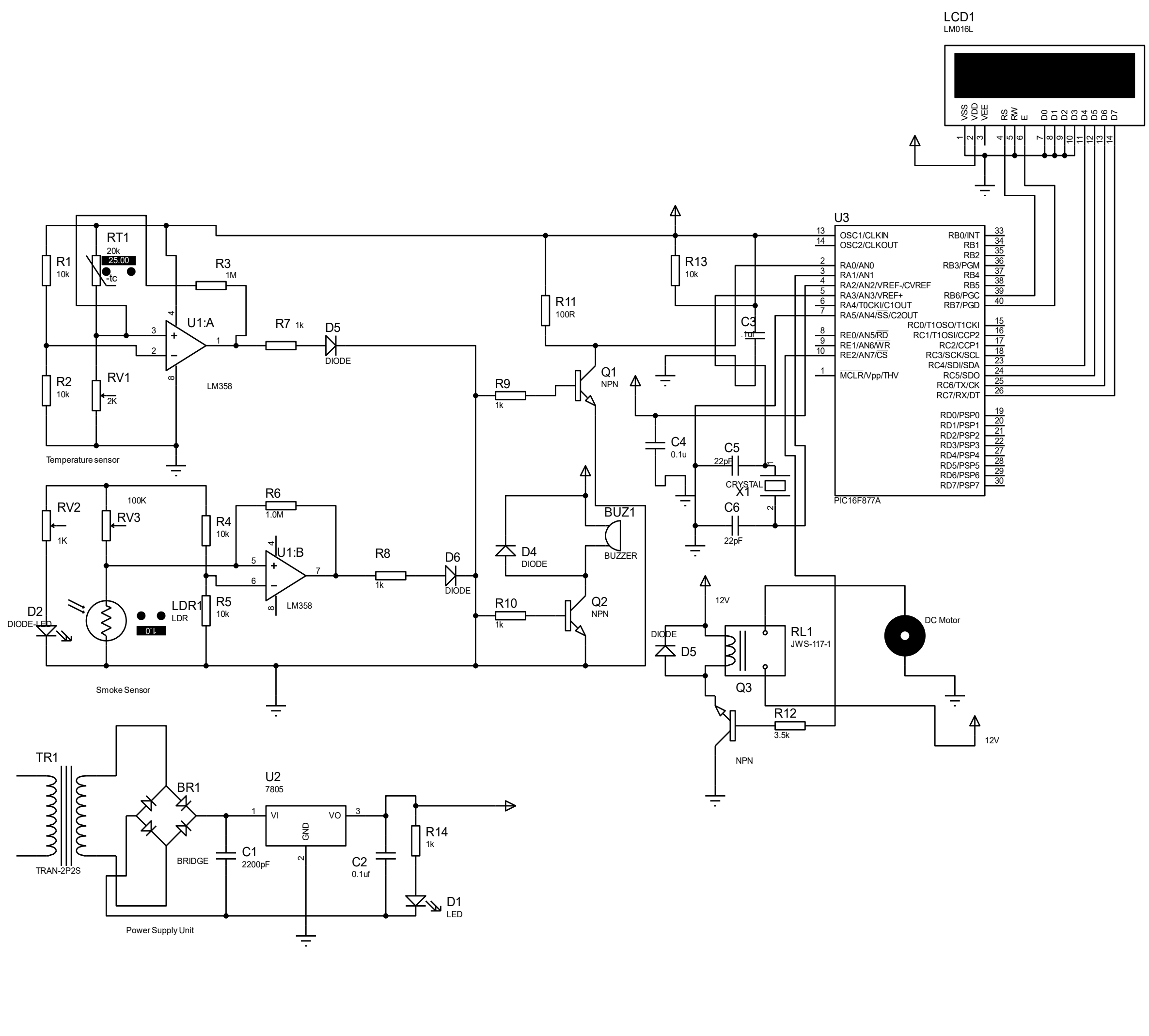

Fig. 3.4: Hardware Circuit Diagram of Fire Detection and Control System.

Circuit Analysis Microcontroller-Based Fire Detection and Control System

The system comprises of two sensory units, the temperature sensor which is made of a variable resistor, a thermistor (NTC), and operational amplifier which is together called LM35 (temperature sensor). This device senses high temperature of above 60°C and the smoke sensor which consists of LED, LDR and LM358 (comparators). It also senses dense smoke which can eventually lead to fire outbreak. The temperature and smoke detection that occur during the light condition, V_+≪V_- and the Op-Amps output remains low and the transistor is switched off. But when V_+≫V_-, the Op-Amps output turns high and since the sensory unit is connected in parallel to NPN transistor. The base current and collector current turn on the transistor and switched on buzzer to produce noise once it senses dense smoke and high temperature and the other output of the transistor is connected to a PIC16F877A microcontroller. The microcontroller is set at high pin configuration at immediate detection of dense smoke and high temperature. It then sends message to the fire extinguisher unit which automatically switched on and send a reply message back to the microcontroller interfaced with the LCD to displays the message and the corresponding temperature values.

Analysis power supply unit

The power supply unit consists of:

i. A 240/12V 500mA step down transformer.
ii. A full wave bridge rectifier.
iii. A capacitor.
iv. A voltage regulator.

i. Selection of transformer

The selection of a transformer used is dependent on the total maximum current of the components used in accordance with their ratings. The current and voltage rating of the basic component used in the project from their respective data sheets are shown in Table 3.1.

Table 3.1: Maximum Current Rating and Voltage of Components used.

COMPONENTS	MAXIMUM CURRENT RATING (mA)	TYPICAL VOLTAGE RATING (V)
LM 358	10	5
LDR	75	5
Microcontroller (PIC)	3.6	5
LED	30	4
Relay	30	12
Thermistor	100	5-12
Transistor	100	5-12
Power diode	20	0.7

Total= 368.6mA

Based on the total current value calculated, a transformer rating of 240/12V, 500mA, and 50Hz was considered appropriate for stepping down AC voltage from 240V to 12V. Hence, the turns ratio of the transformer is calculated as follows [7]:

$$K = \frac{N_2}{N_1} = \frac{V_2}{V_1} \quad 3.1$$

where:

K turns ratio.

N_1 is number of turns on the primary winding.

N_2 is number of turns on the secondary winding.

V_1 is voltage applied to the primary side.

V_2 is voltage at the secondary side.

$$K = \frac{240}{12} = 20:1$$

The power rating of a transformer is [7]:

$$P = I_{rms} V_{rms} \quad 3.2$$

where:

P is average power rating of a transformer.

I_{rms} is the root mean square value of the total output current from the rectifier.

V_{rms} is the root means square value of the total output voltage from the rectifier.

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$P = 500 \times 10^{-3} \times 12 = 6W$

ii. Rectifier circuit;
Since the DC voltage from the bridge rectifier was calculated as 10.08V and basically all the integrated circuits used are powered by a typical supply regulated voltage of 5V, 7805 regulator IC which takes the range of +7V to +35V unregulated voltage as input is considered appropriate. The capacitor C_2 across the output of regulator IC as shown in Fig. 3.1 improves transient response and keeps the impedance low at high frequencies (very small compared to the capacitor filter) and the voltage regulator IC 7805 is normally 0.1 μF.. Thus, C_2 is taken as 0.1 μF..

The light emitting diode connected across the regulated 5V supply acts as a power indicator LED and red LED is selected for good visibility purpose. The resistor R_0 acts as a current limiting resistor and its value is calculated as follows (datasheet of red LED):

i. Maximum forward voltage drop $V_F) = 2.2V$
ii. Maximum forward current $(I_F) = 20mA$
iii. Suggested using forward current = 16- 18 mA
iv. Luminous intensity = 150-200 mcd.

The current allowed passing through the power indicator LED is chosen to be 16mA suggested from the datasheet, thus

$$R_0 = R_{14} = \frac{V_{cc} - V_F}{I} \qquad 3.9$$

$$R_0 = R_{14} = \frac{5 - 2.2}{16 \times 10^{-3}} = 175\Omega = 180\Omega$$

iii. Selection filter capacitors
The capacitor used as the filter is selected based on the following calculations of its capacitance [9]:

$$C_1 = \frac{I_{dc}}{4F(V_m - V_{dc})} \qquad 3.5$$

where:
I_{dc} is the output DC current of the rectifier.
F is the frequency of the rectifier.
V_m is the maximum voltage at the Load.
V_{dc} is the output DC voltage of the rectifier.

But respective parameter values in equation (3.5) are calculated as follows:

From equation (3.4): $V_m = \sqrt{2} \times 12 = 16.97V$

$$V_{dc} = \frac{2V_m}{\pi} \qquad 3.6$$

$$V_{dc} = 2 \times \frac{16.67}{3.142} = 10.8\text{V}$$

$$I_{dc} = \frac{2I_m}{\pi}$$

$$I_{dc} = \frac{2 \times \sqrt{2} \times 500}{3.142} = 450mA \qquad 3.7$$

Therefore, from equation (3.5) when parameter values calculated are substituted C_1 is found to be:

$$C_1 = \frac{450 \times 10^{-3}}{4 \times 50 \times (16.67 - 10.80)} = 900\mu F$$

The voltage of the capacitor is [9]:

$$V_c = (\frac{3}{2})V_{dc} \qquad 3.8$$

$$V_c = \left(\frac{3}{2}\right) \times 10.08 = 15.12V$$

The capacitor value selected is 2200μF, 16V since the ripples decrease more with a higher capacitance value, that is, a higher capacitance capacitor is more effective in reducing the ripples.

iv. Regulator Selection
Since the DC voltage from the bridge rectifier was calculated as 10.08V and basically all the integrated circuits used are powered by a typical supply regulated voltage of 5V, 7805 regulator IC which takes the range of +7V to +35V unregulated voltage as input is considered appropriate. The capacitor C_2 across the output of regulator IC as shown in Fig. 3.1 improves transient response and keeps the impedance low at high frequencies (very small compared to the

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ii. Maximum forward current $(I_F) = 20mA$
iii. Suggested using forward current = 16-18 mA
iv. Luminous intensity = 150-200 mcd.

The current allowed passing through the power indicator LED is chosen to be 16mA suggested from the datasheet, thus

$$R_0 = R_{14} = \frac{V_{cc} - V_F}{I} \qquad 3.9$$

$$R_0 = R_{14} = \frac{5 - 2.2}{16 \times 10^{-3}} = 175\Omega = 180\Omega$$

3.1.2 Analysis Smoke sensor

The sensory unit is designed using the circuit diagram shown in Fig. 3.2

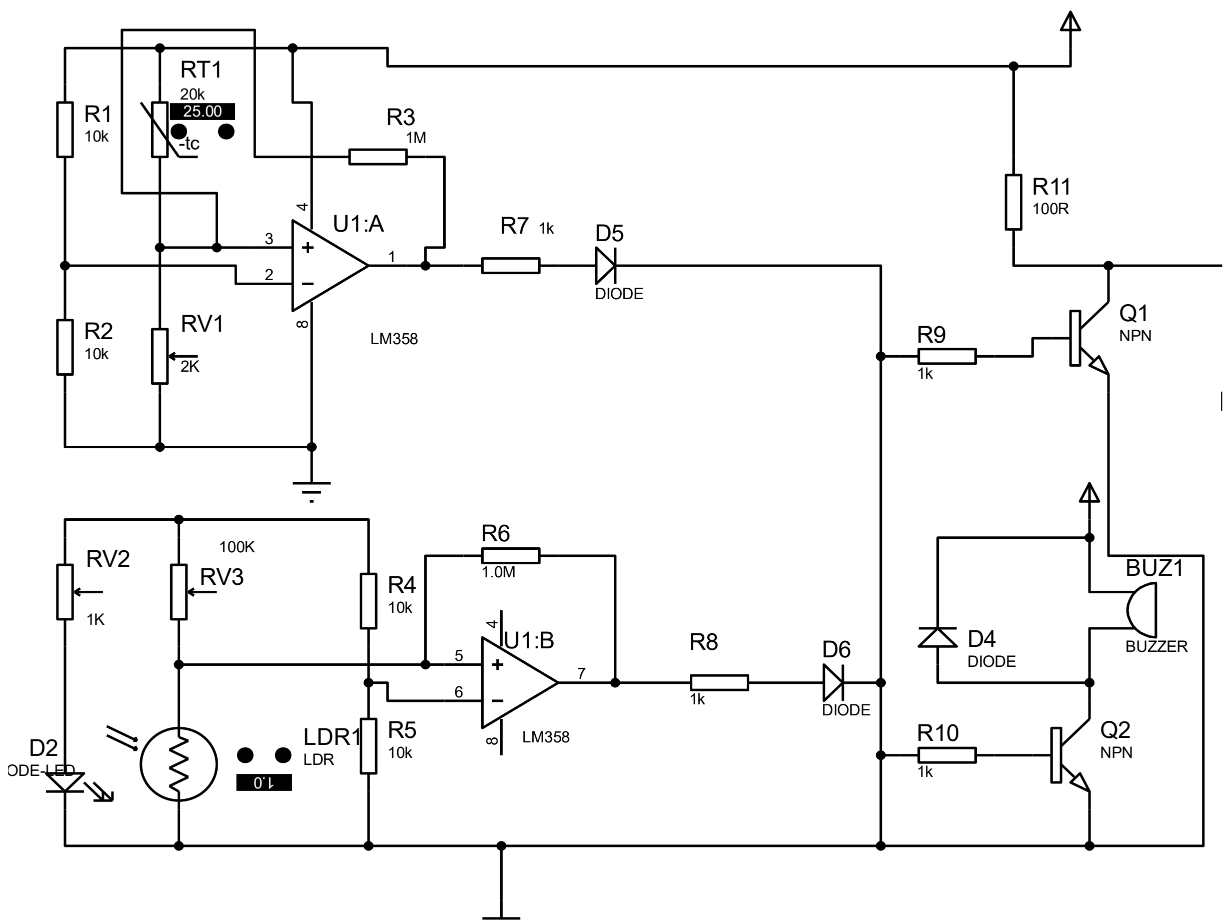

Fig. 3.2: Circuit Diagram of the Sensory Unit.

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3.1.3 Analysis Temperature sensor

The thermistor used as the temperature sensory has the following characteristics, from the data sheet.

i. At room temperature (T = $25^0 C$), $R = 10k\Omega$
ii. Beta value is $\beta = 3380$

Input Stage: This consists of a fixed inverting input and a varying non-inverting input designed as follows:

I Fixed Inverting Input: The inverting input at pin 2 is supplied with a fixed voltage set at half the supply voltage (2.5V). This is achieved by using a simple potential divider network with two equal resistors R_1 and R_2 as shown in Fig. 3.2.

Thus, R_1 and R_2 are 10kΩ each (datasheet). Using two 10kΩ resistors produce small current at the IC and a low voltage gain drain. Current through the potential divider from ohm's law is:

$$I = \frac{V}{R} \quad (3.10)$$

$$I = \frac{5}{(10+10)\times10^{-3}} = 0.25mA$$

II Varying Non-Inverting Input: The thermistor is placed in another potential divider network with a variable resistor to allow the threshold level to be set as shown in Fig. 3.2. The resistance temperature (R_T) characteristics of a thermistor is expressed as [11]:

$$\beta = \left(\frac{T_1 T_2}{T_2 - T_1}\right) ln\left(\frac{R_{T_1}}{R_{T_2}}\right) \quad (3.11)$$

where:
β is the material specific constant.
R_{T_1} is the resistance at given temperature, T_1 (in K).
R_{T_2} is the resistance of the thermistor at the temperature, T_2 (in K).

The temperature sensory unit is designed to trigger at temperature above 60°C (temperature that leads to fire outbreak). From equation (3.11):

$$R_{T_2} = R_{T_1} \exp^{\left(-\frac{\beta(T_2-T_1)}{T_1T_2}\right)} \quad (3.12)$$

Since room temperature $T_1 = 25°C, R = 10k\Omega$ and $\beta = 3380$ when converted from degree to Kelvin, T_1 and T_2 are:

$$T_1 = (25 + 273.15)K = 298.15K$$
$$T_2 = (60 + 273.15)K = 333.15K$$
$$R_{T_2} = 10000exp^{-\left(\frac{3380(333.15-298.15)}{333.15\times298.15}\right)}$$
$$R_{T_2} = 10000exp^{(-1.191)}$$
$$R_{T_2} = 3039.2\Omega \cong 3k\Omega \;\; at\; 60°C$$

Since at room temperature the thermistor resistance is 10kΩ. If the variable resistor is set at a resistance of 3kΩ at room temperature because at 60°C, the thermistor resistance is 3kΩ and the output voltage produced is given by [13]:

$$V_+ = \frac{R_{T_2}}{R_{T_1} + R_{T_2}} \times V_{CC} \quad (3.13)$$

where:
V_+ is voltage required to triggered the output.
V_{CC} is supply voltage.

Then, $V_+ = \frac{3}{10+3} \times 5V = 1.15V$

Here, $V_+ < V_-$ (that is, $1.15V < 2.5V$)

Thus, the Op Amp is not triggered, that is, the output is low. But when $T_2 > 60°C, R_2 < 3k\Omega$ (thermistor resistance) which implies that $V_+ > V_-$, the Op Amp is triggered to produce a high output.

From the datasheet, the Op Amp LM358 used has the following characteristics:

i. For a $V_{CC} = +5V, T_{amb} = 25°C$
ii. Low level output voltage $V_{OL}) = 5mV$
iii. High level output voltage $V_{OH}) = 3.5V$
iv. Large voltage gain, $A_V = 100$.

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The voltage gain of an operational amplifier is expressed as:

$$A_V = 1 + \frac{R_3}{R_2} \tag{3.14}$$

Since $A_V = 100$ and $R_2 = 10k\Omega$, therefore, R_3 from equation (3.14) is calculated as:

$$R_3 = R_2(A_V - 1) \tag{3.15}$$

$$R_3 = 10 * 10^3(100 - 1) = 990k\Omega \cong 1M\Omega$$

Since the greater the value of the feedback resistance, the more the stable the Op-Amp (comparator) will be, then R_3 is selected as $1M\Omega$..

Analysis Smoke sensor

Input stage: Similarly, the fixed inverting and the varying non-inverting inputs of the smoke sensor unit are designed as follows:

I Fixed inverting input: The inverting Pin 6 of Fig. 3.2 is supplied with fixed voltage set a half supply voltage (2.5V). This is achieved by using a simple potential divider network with two equal resistors, R_5 and R_6, respectively as shown in Fig. 3.2. R_5 and R_6 are the same as R_1 and R_2.. That is, , $R_5 = R_6 = 10k\Omega$.

II Varying non inverting input: The Light Dependent Resistor (LDR) is placed in another potential divider network with a variable resistor to allow the threshold level to be as shown in Fig. 3.2.

From the data sheet, the characteristics of the LDR are:

i. Resistance at light condition R= 400Ω
ii. Resistance at dark condition R=100kΩ

In the light condition, this variable resistor chosen with the LDR has a maximum resistance of 400Ω. If the variable resistance is set at 90kΩ, then the potential divider network will give a variable voltage to the non-inverting pin at light condition as follows [12]:

$$V_+ = \frac{R_L}{R_L + R_S} \times V_{CC} \tag{3.16}$$

where:
V_{CC} is supply voltage.
V_+ is varying non-inverting input voltage of the comparator.
V_- is fixed-inverting input voltage of the comparator.
R_L is variable resistor of the LDR in the light condition.
R_S is the set variable resistor.

From equation (3.16): $V_+ = \frac{400}{400+90000} \times 5V = 0.022V$

Since $V_+ \ll V_-$, the output of the Op Amp would be low at light condition and cannot trigger the transistors ($C945_1$ and $C945_2$) to put the LED on.

Similarly, in the dark condition, the voltage required to trigger the Op-Amp is given by [12]:

$$V_+ = \frac{R_D}{R_D + R_S} \times V_{CC} \tag{3.17}$$

where: R_D is the dark condition variable resistor resistance of the LDR.

From equation (3.17): $V_+ = \frac{100}{100+90} \times 5V = 2.63V$

Since $V_+ > V_-$, this output of the Op Amp is high at dark condition and can trigger the transistors ($C945_1$ and $C945_2$) to put the LED on.

For the purpose of high stability of the comparator, R_6 and R_7 is the same as R_2 and R_3.

The Light Emitting Diode (LED) connected opposite to the LDR serves as the light source. For a white LED, it has the following characteristics from the data sheet:

i. Maximum forward current $(I_F) = 30mA$
ii. Maximum forward voltage $(V_F) = 4V$

To avoid over heating due to excessive current and to control the intensity of the light emitted by the LED is variable resistor of maximum resistance of 1kΩ is connected in series with the LED.

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From Ohm's law given by equation (3.10), the current passing through LED is calculated as:

$$I = \frac{5V}{1 \times 10^{-3}\Omega} = 5mA$$

Thus, current passing the LED is selected as 5mA and its resistance is calculated as:

$$R = \frac{V_{CC} - V_F}{I} \tag{3.18}$$

$$R = \frac{5-4}{5} \times 10^3 = 200\Omega$$

Thus, the variable resistor is set at 200Ω for a current of 5mA.

The diode IN4148 used has the following properties from the data sheet:

i. Maximum forward current $(I_F) = 10mA$
ii. Forward voltage drop $(V_F) = 0.7V$
iii. Collector current $(I_C) = 100mA$ (max)
iv. Typical forward current gain $(h_{fe}) = 40$

The diodes D_5 and D_6 connected in series to the output of the Op Amp used current limiting resistors R_9 and R_{10}, respectively. For transistor in the common emitter configuration, the current gain is expressed as [12]:

$$h_{fe} = \frac{I_c}{I_B} \tag{3.19}$$

$$I_B = \frac{I_c}{h_{fe}} = \frac{100\times10^{-3}}{40} = 2.5mA$$

Hence, the base current of the transistor is selected as 2.5mA.

When the Op Amp is at the 'on state' (high level output voltage), the following expression holds [13]:

$$R_4 = R_5 = \frac{V_{OH} - V_F}{I_B} \tag{3.20}$$

$$R_4 = R_5 = \frac{3.5 - 0.7}{2.5} \times 10^3 = 1120\Omega$$

When both the two Op Amp are at the low state the base currents of the two transistors are zero. As shown in Fig. 3.2, the two transistors $(C945_1$ and $C945_2)$ are connected in parallel. Transistor, $C945_2$ switches the voltage at pin 5 of the microcontroller to either high or low.

From data sheet, transistor, C945 characteristics at $(T_{Amb} = 25°C)$ $are:$

i Collector to base voltage $(V_{CBO}) = 60V\ (max)$
ii Collector to transmitter voltage $(V_{EO}) = 50V$(max)
iii Base to emitter voltage at saturation $V_{BE}(sat)$= 1V
iv Emitter to base voltage (V_{EBO})=5.0V (max)
v Collector to emitter barrier voltage $V_{CE(sat)}$ for germanium = 0.3V
vi Collector to emitter barrier voltage $V_{CE(sat)}$ for silicon = 0.7V
vii Collector current $(I_C) = 100mA$ (max)
viii Typical forward current gain $(h_{fe}) = 40$

The current entering the base of the transistor is designed to be equal, thus when both Op Amp output voltages are high [13].

$$I_B = \frac{V_{BB} - V_{BE}(sat)}{R_B} \tag{3.21}$$

$$V_{BB} = V_{OH} - V_F \tag{3.22}$$

$$R_9 = R_{10} = R_B = \frac{V_{BB} - V_{BE}(sat)}{I_B} \tag{3.23}$$

Substituting equation (3.21) into equation (3.22) it becomes:

$$R_9 = R_{10} = \frac{V_{OH} - V_F - V_{BE}(sat)}{I_B} \tag{3.24}$$

$$R_9 = R_{10} = \frac{3.5 - 0.7 - 1}{2.5} \times 10^3 = 720\Omega$$

Due to the market availability, $R_9\ and\ R_{10}$ are both chosen to be 1kΩ since this value is close their to calculated values. From equation (3.19) the collector current is calculated as:

$$I_C = h_{fe} \times I_B = 40 \times 2.5 \times 10^{-3} = 100mA$$

Thus, the current that powers the buzzer connected to the transistor, $C945_1$ is 100mA.

For the transistor, resistance, R_{11} is given as:

$$R_{11} = \frac{V_{CC} - V_{CE(sat)}}{I_C} \tag{3.25}$$

$$R_{11} = \frac{5 - 0.3}{100} \times 10^3 = 47\Omega$$

3.1.1 Overview of Microcontroller (PIC16F877A)

Programmable Interface Controllers (PIC) microcontroller is an electronic circuit that can be programmed to carry out a vast range of tasks. They can be programmed to be timers or to control a production line and much more. They are found in most electronic devices such as alarm systems, computer control systems, phones, in fact almost any electronic device. Many types of PIC microcontrollers exist which are programmed and simulated by circuit wizard-software. PIC is a family of modified Harvard architecture microcontrollers and also made by microchip technology, derived from the PIC1650 originally developed by General Instruments Microelectronics Division.

Application of PIC16F877A

The PIC microcontrollers are commonly used in the following applications;

i Household Appliances: This includes washing machines, remote controls, light control video games, TV tuners, interim and sewing machines.
ii Office Equipment: Such as telephones, fax machines, printers and security systems.
iii Instrument: These include digital thermometers, level meters and multi-meters.
iv Motor Control: Speed control of AC and DC motors, position control using servo-motors and stepper motors.
v Peripheral Devices: Keyboard controllers, modems and plotters.
vi Industry Application: Process control systems and automobile applications.

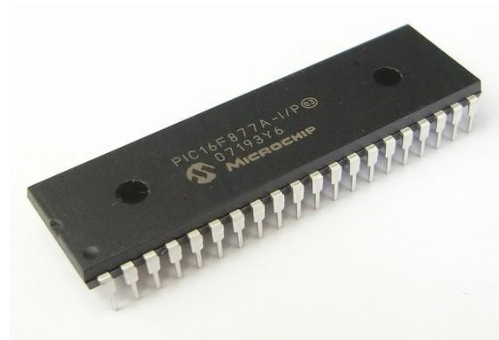

Fig. 2.19: Picture of a PIC16F877A Micro-Controller.

Architect of a PIC16F877A Microcontroller

Fig.2.20 shows the internal architecture and the PIN layout of PIC Micro-Controller as a device:

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes

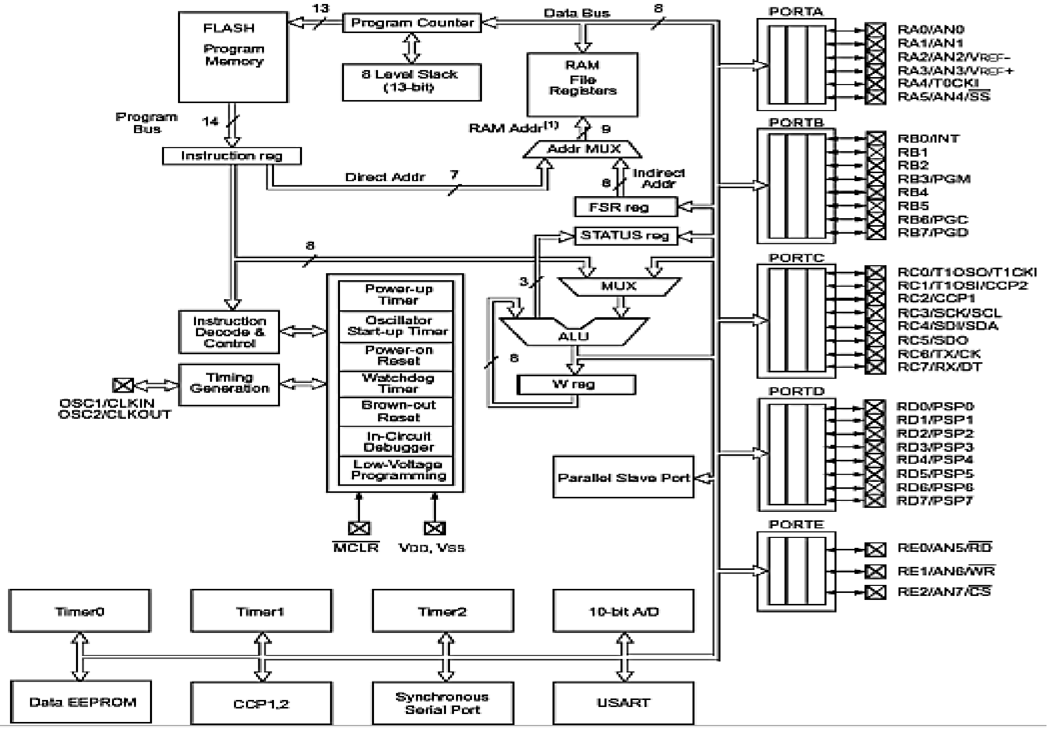

Fig. 2.20: Internal Architecture of PIC16F877A Chip [17].

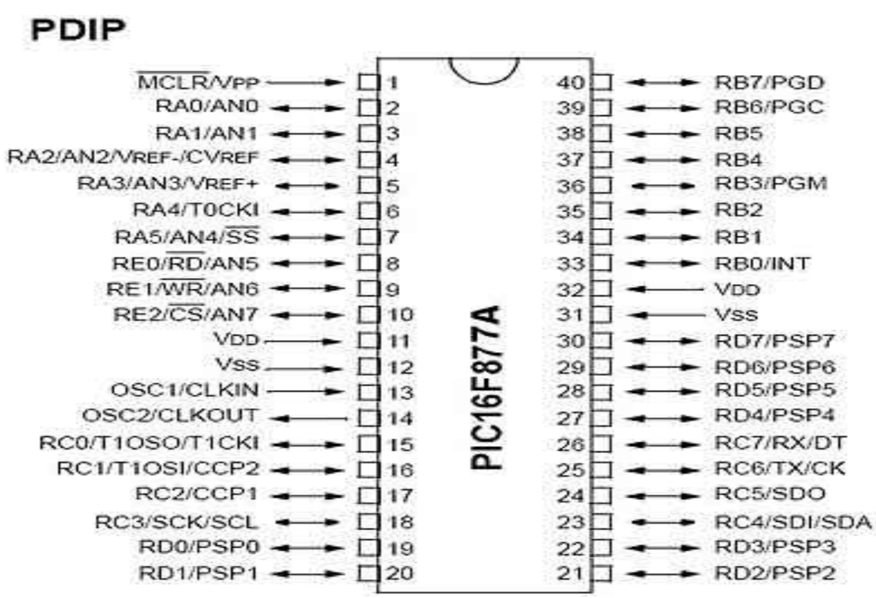

Fig. 2.21: Pin Layout of PIC16F877A Microcontroller.

Applications of Different Parts

The various kind of ports used in a PIC microcontroller are tabulated as follows:

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Table. 2.1: Applications of Different parts of PIC.

Port Name	Number of I/O Pins	Functions
PORTA	6	A/D converter inputs
PORTB	8	External interrupt sources
PORTC	8	Serial ports, timer I/O
PORTD	8	Parallel slave port
PORTE	3	A/D converter inputs

3.1.2 Flow chart

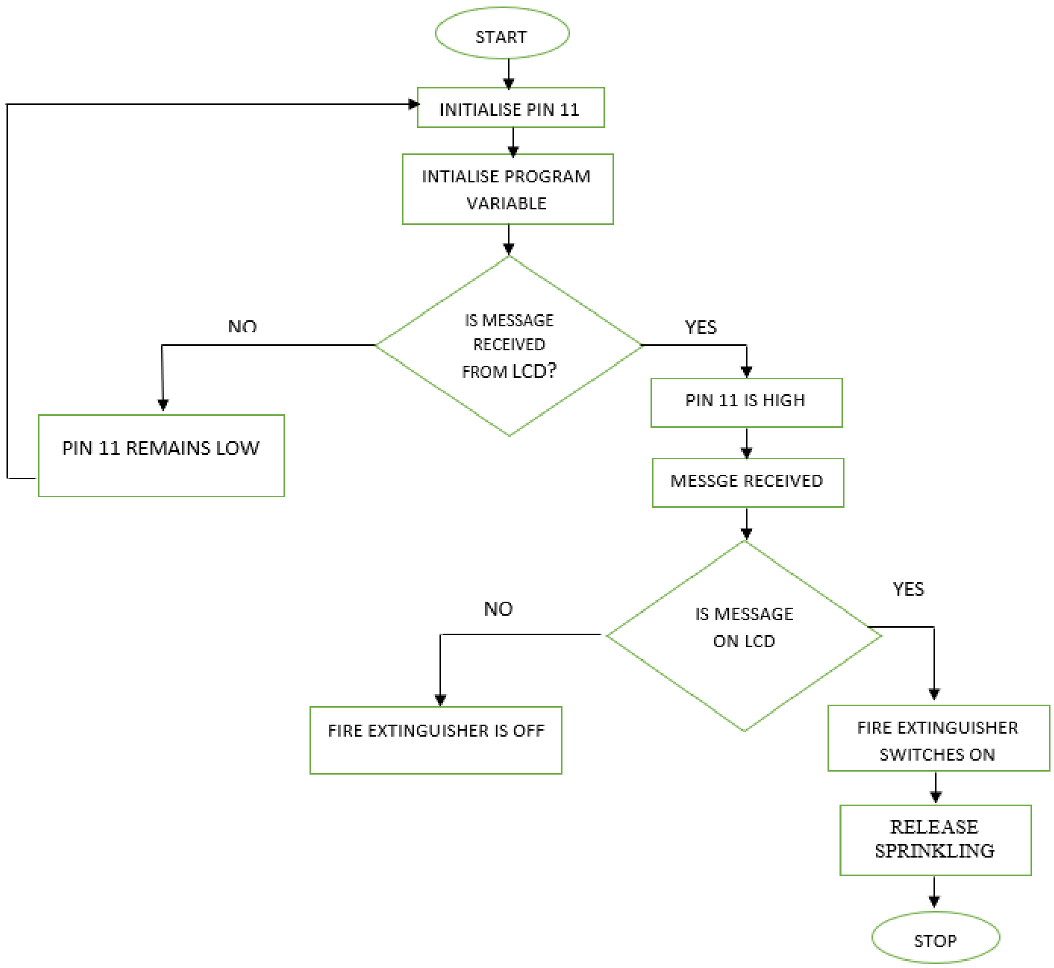

Fig. 3.6: Microcontroller Program Flow Chart for the Fire Extinguisher.

3.1.3 Programming

The software design comprises the development environment used for program coding and the simulation platform employed for circuit validation. In this project, *PROTON Compiler* was utilized for writing, compiling, and generating the executable code for the microcontroller, while *Proteus 8 Professional* was used to simulate and verify the circuit operation prior to hardware implementation. The compiled program was subsequently programmed into the microcontroller's non-volatile memory, enabling the system to execute the predefined control algorithms in accordance with the embedded instructions.

The hardware circuit diagram is thus given in Fig.3.4.

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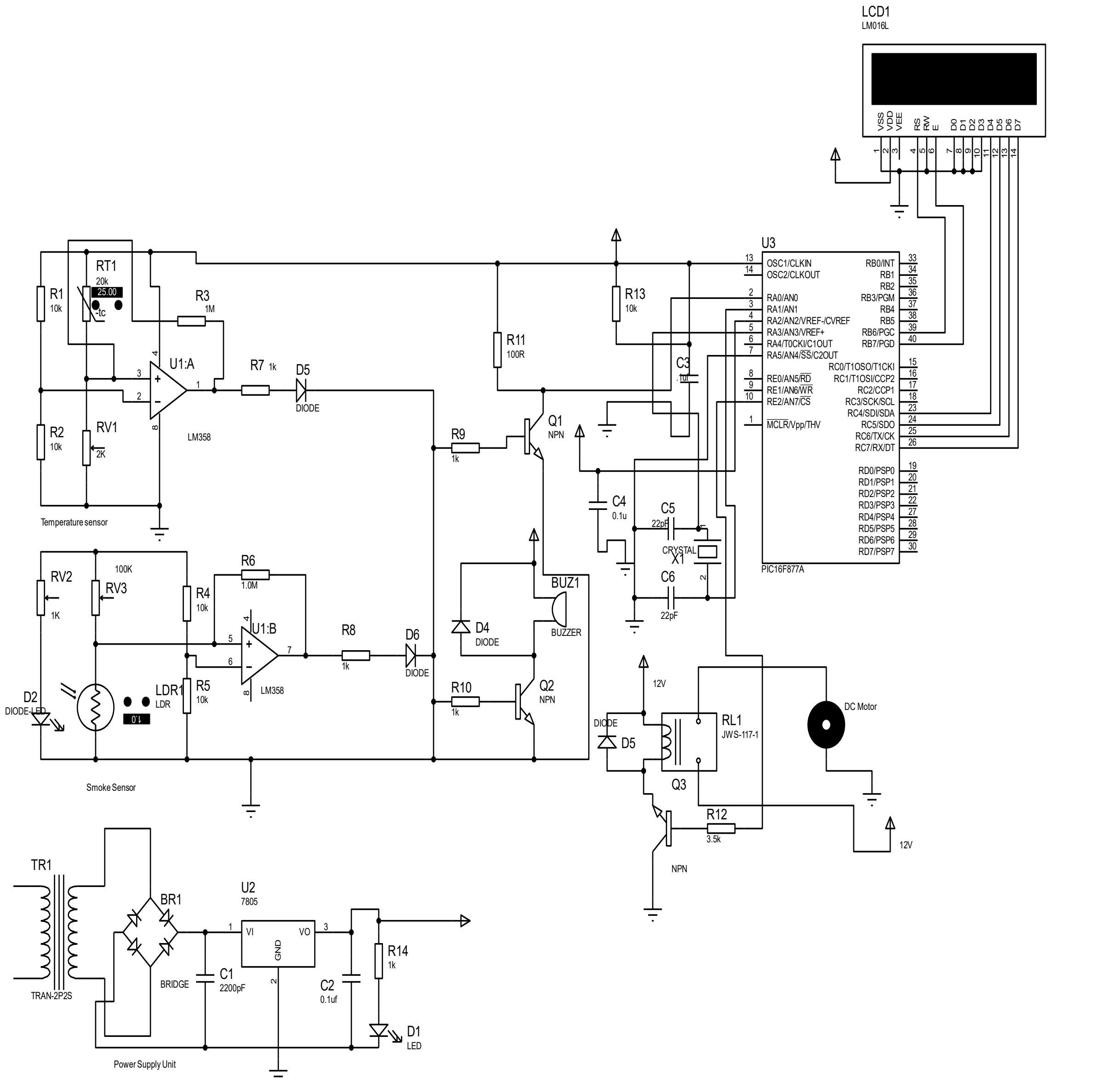

3.1.4 Simulations Model

Evaluate the functional performance of the proposed embedded control system prior to hardware implementation, a comprehensive simulation model was developed using Proteus 8 Professional. The simulation model integrates the microcontroller unit (MCU), input interface circuits, output driver stages, and associated peripheral components to replicate the real-time behavior of the physical system.

The control algorithm was developed and compiled using PROTON Compiler, generating a HEX file which was loaded into the microcontroller model within the Proteus simulation environment. The simulation was conducted to validate logical operation, timing accuracy, signal integrity, and overall system response under predefined operating conditions.

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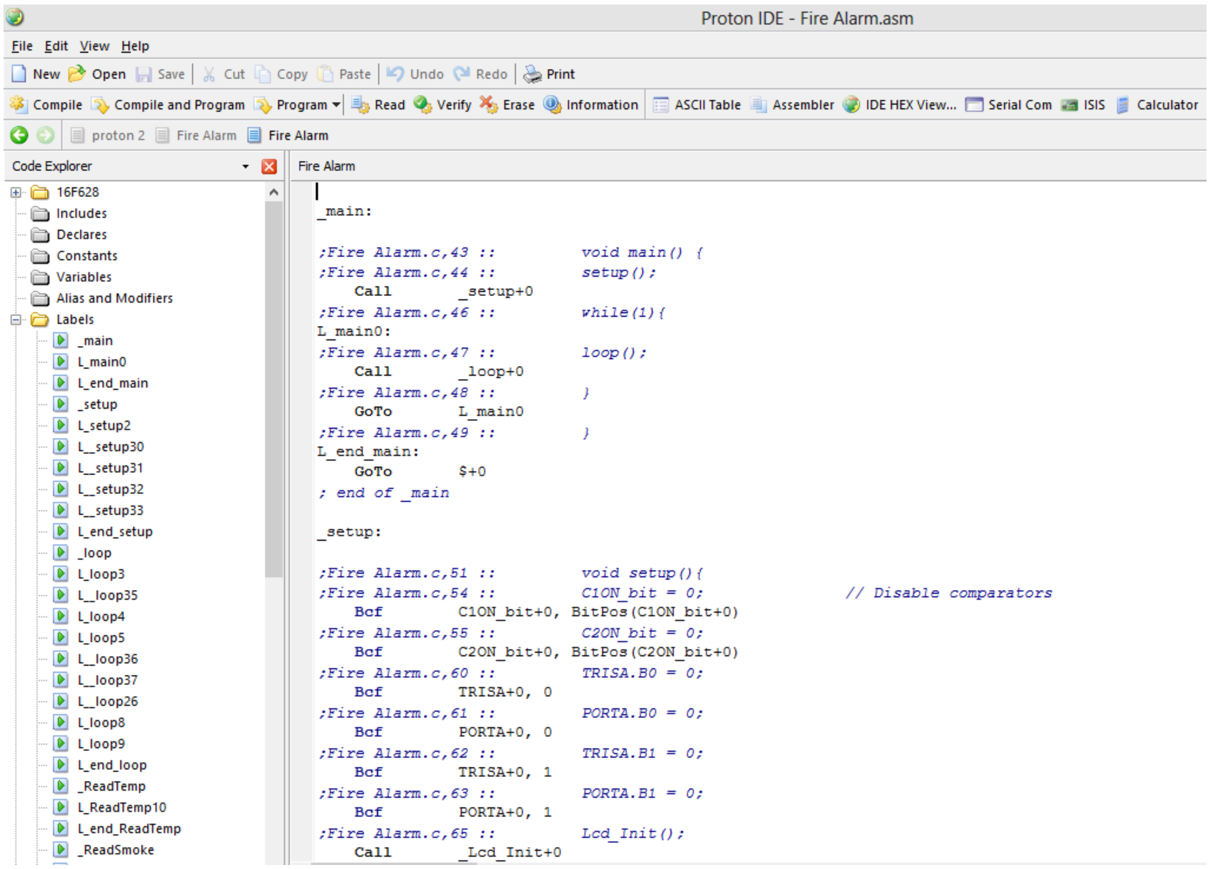

Fig. 4.3: Proteus Proton Compiler

IV. CONSTRUCTION, SIMULATION AND TESTING

This chapter describes the procedures for the construction of the circuit design, simulation and testing of the system hardware and software. The first stage is the design of the circuit using the PROTEUS ISIS software. A program was written in C language and assembled to perform the functions of the circuit was designed for using PIC kit studio. However, the circuit was further tested on a temporary circuit board, that is, the bread board to ascertain its functionality and reliability. After which it was transferred to the permanent Vero board and soldered to achieve final assembly and testing of the circuit.

4.1.1 List of components used

The fire detection and control system was designed, constructed and implemented using a combination of electronic and electrical components to facilitate reliable fire detection, signal processing, alarm activation and control operations.

Table 4.1 List of components and their ratings.

COMPONENTS	MAXIMUM CURRENT RATING (mA)	TYPICAL VOLTAGE RATING (V)
LM 358	10	5
LDR	75	5
Microcontroller (PIC)	3.6	5
LED	30	4
Relay	30	12
Thermistor	100	5-12
Transistor	100	5-12
Power diode	20	0.7
Total Ratings	368.6mA	

4.1.2 Construction on bread board

This is a type of construction that is done temporarily by assembling the various components and units mounted using jumper wires on the bread board for testing to ensure their workability. Plate 4.1 is the

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typical pictures of the assembled components on the breadboard.

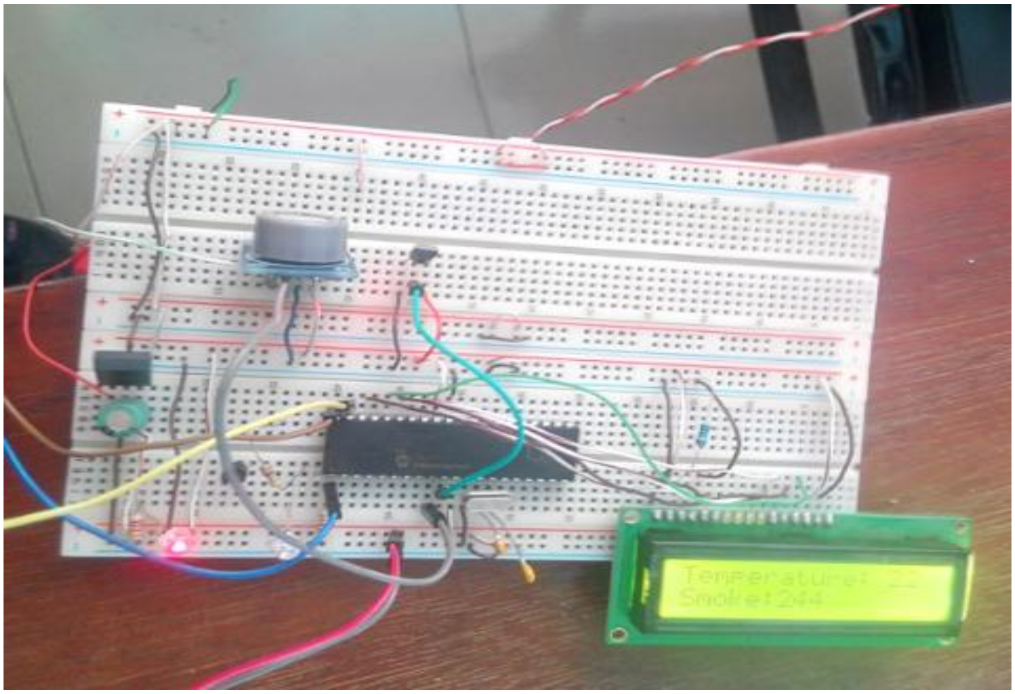

Plate. 4.1: Components Placed Temporally on a Breadboard.

4.1.3 Construction on Vero-board

This is the type of construction that is done permanently on a single compact Vero-board circuit in which all the components are assembled and fixed accordingly. The components and units are then transferred and fixed on the pin soldered terminal of a permanent Vero board and soldered permanently as an integrated system and then sealed in a case for the purpose of protection. Plate 4.2 is the typical pictures of the assembled components on the Vero board.

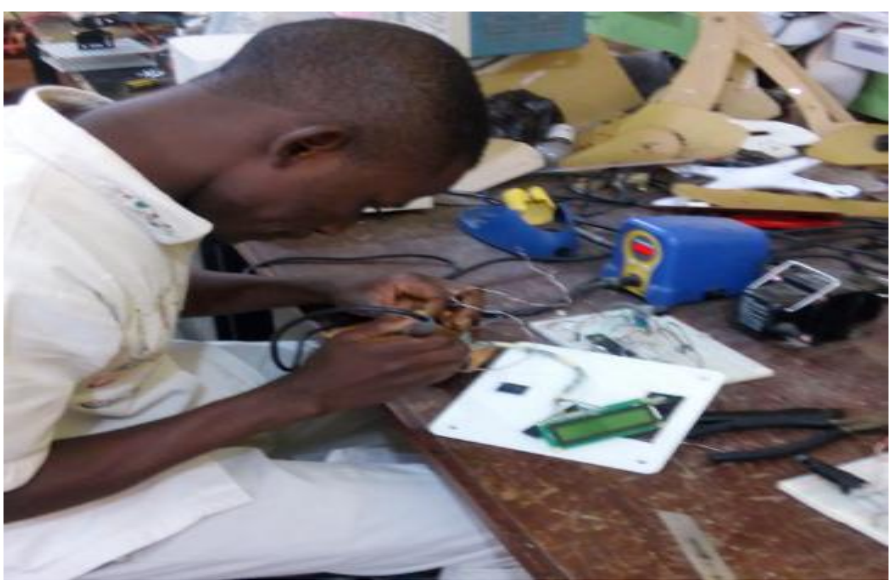

Plate. 4.2: Components Placed Permanently on Vero Board.

4.1.4 Coupling of construction

This is the appearance given to the system hardware. The system hardware was housed in a plastic casing with the following factors taken into considerations:

i. Space occupied.
ii. Portability of the project.
iii. Allowance for heat dissipation.
iv. Ease of insulation, testing and maintenance.
v. Thermal conductivity.
vi. Circuit protection to ensure durability.
vii. The dimensions of the casing are:
viii. Height =6.0cm
ix. Length =15.0cm
x. Width =15.0cm

The Vero-board was perfectly placed on the plastic casing. The system hardware casing is shown in Plate. 4.5.

Plate. 4.5: System Hardware Casing.

4.1.5 Construction testing

The system hardware and software were tested by connecting the built fire detection circuit to microcontroller and LCD. The LCD was connected to the microcontroller displaying the temperatures and the response actions (in form of a message) of the fire extinguisher unit such as co_2 gas or water sprinkler released. The temperature of the LM35 was increased above 60^0c using a hot soldering iron, Fire detection circuit was triggered, and similarly a smoky mosquito coil was there after brought close to the smoke sensor, which also triggered the fire detection circuit. In both cases when the fire detection circuit was triggered the message was sent to the LCD displaying the temperature at room temperature and the temperature at which the fire detection was triggered. And also, the response actions of what the extinguisher unit performed were subsequently displaced in alphanumeric character like co_2 gas released when the extinguisher unit was switched on. The LCD displaying the results serves as the monitoring and the supervisory methods by station staff. The testing of the hardware and programs loading of the fire detection and control system was shown in Plate 4. 4:

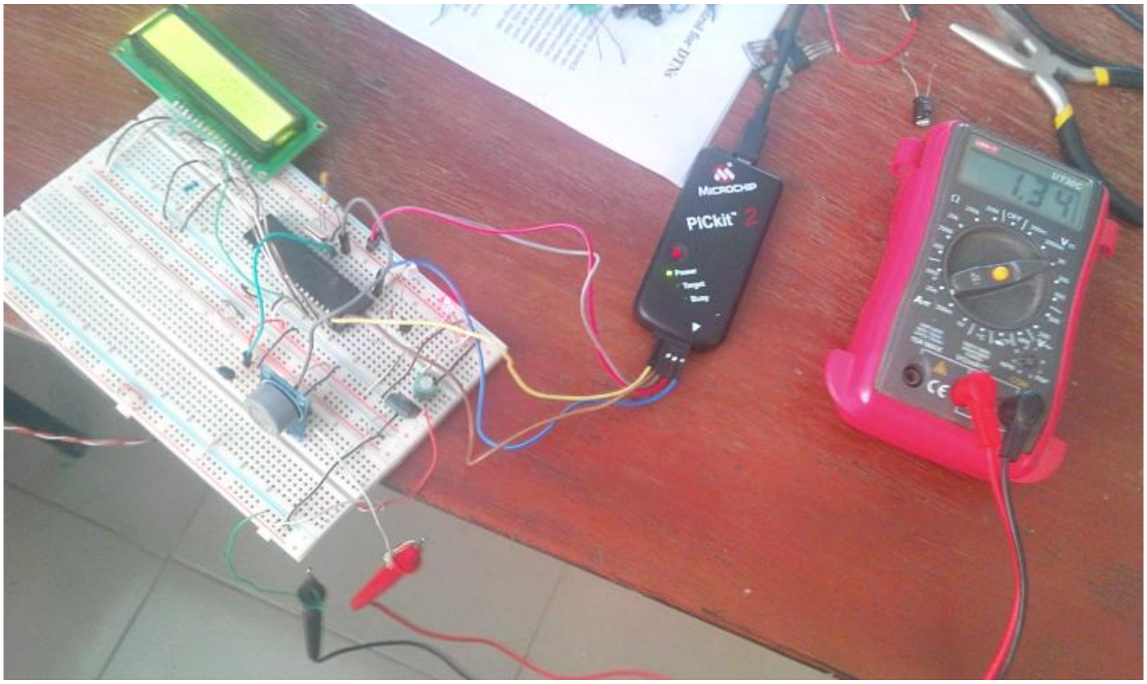

Plate 4. 4: The Hardware Testing and Programs Loading of the Fire Detection and Control System.

V. CONCLUSION

The design, construction, and testing of a microcontroller-based fire detection and control system was successfully carried out. The demonstration of the detection of the source of the fire depends on the detection of the dense smoke fumes by photoelectric smoke detector and temperature above 60°C. The primary objective of the project was to produce a detector circuit which can be interface with the LCD for the purpose of controlling and monitoring of a fire outbreak. The LCD is a device that is reliable and can display programmable, computational result on screen. For this reason, early stage of fire is detected. This project plays a very significant role in the sense that it provides a means of saving people from fire outbreak to a reasonable limit.

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