Design & Implementation of Microcontroller based Automated Fire Protection System

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Declaration

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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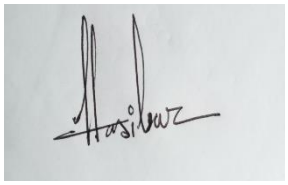

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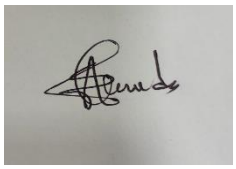
Hasibur Rashid Khan



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ABSTRACT

In this project, we have implemented a smart fire safety system in a building. By using this technique, we can save the life of the people present in the building which is on fire. As we all know that in this kind of situation the thing which will be happening is that the sprinklers will be turned on, but when the current supply will be still on there is chance of short circuit and the fire will get more severe due to this reason. Here we have programed in such a way that the circuit in the building will be tripped and then the sprinklers will be turned on so that the fire in the building is controlled. And another danger is that in major cases people will die because to breathing problem due to the smoke which is formed in due to fire. That's why we will be using exhaust fans to remove the smoke from the building.And for safety issues we will be sending sms to an emergency number, and for confirmation, there will also be a phone call and by this system the Fire service and other emergency service providers will be informed quickly. By using this technique there is a chance of saving lot of people stuck in a building which is on fire. And another advantage is that this technique is not only for the new buildings but also easily implemented to the existing old building easily without having to change the design of the buildings. And the implementation cost will also be less.

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LIST OF ABBREVIATIONS

DC	**Direct Current**
AC	**Alternating Current.**
SIM	**Subscriber Identity Module**
GSM	**Global System For Mobile Communications**
IR	**Infrared Receiver**
IC	**Integrated Circuit**
LED	**Light Emitting Diode**
PCB	**Printed Circuit Board**

CHAPTER I

INTRODUCTION

1.1 Introduction

Under the rather broad heading of fire protection systems, this module will examine the main components of alerting, suppression, and containment features and systems. The primary components we will examine are fire alarm systems, fire detection and notification systems, suppression systems, Air ventilation system, water distribution systems, automatic sprinkler systems and portable fire extinguishers. This module will cover a lot of basic material meant to provide the novice inspector a solid foundation on which to build. As was said in the earlier modules, it is only a beginning.

1.2 Background Study

Due to unplanned and rapid urbanization, fire is a frequent urban disaster in Bangladesh, which leads to an unsafe living and working environment. Numerous residential buildings have been converted to commercial purposes without altering their occupancy uses. Furthermore, many industrial and residential buildings co-exist in the same area without following proper regulations and preventive safety measures. It has been estimated that 80% of Old Dhaka's residential building contains illegal industries or warehouses [1]. Thus, it is gradually causing a significant risk in terms of the occupants' physical and economic aspects.

Recently frequent fire hazards had occurred in the high-rise buildings with mixed occupancy types in Bangladesh. The casualties of fire hazards included losing valuable human lives, properties and suffering from severe burn injuries. Because of enormous employment opportunities, people are gradually inclining to migrate to large urban areas. As a result, they construct high-density buildings, generate urban sprawls and squatters, and build industries, commercial buildings, educational institutions, and healthcare facilities. These structures are placed densely in these cities, as most owners and authorities do not respect the building code. Most of the residents and owners lack primary consciousness and minimum fire drilling knowledge and practice [2]. In maximum cases, they can not understand the depth and extent of calamitous fire hazards. As a result, identifying the reasons and taking effective mitigation measures are not prevalent. Moreover, many unplanned industries are grown in cities adjacent to the residential areas because of poor planning. Utility services such as electricity distribution, gas pipelines were not correctly set-up or managed.

Consequently, central fire management and planning systems are absent. It happened mainly due to a pervasive culture of non-enforcement of the law. Thousands of high-rise buildings had been constructed in the major cities in Bangladesh.

1.3 Objectives

The main objective of this system is to introduce a Automated Fire Protection System microcontroller technology. The supplementary objectives of this project are as follows:

1. Define the micro-controller system.
2. Define fire alarm system.
3. Define air duct system.
4. Define emergency lighting system.
5. Define GSM services.
6. Define suppression systems, including automatic sprinkler systems.
7. Define water supply devices.
8. Define the valves.
9. Identify the various types of devices used in the system.
10. Define the full process.

1.4 Project Organization

In this report, Chapter one covers introduction, background, objectives. Chapter two represents theory, description of the microcontroller, flame & smoke sensor, GSM module, fan , solenoid gas valve, pump and other components. Chapter three describes and working principle of the project. In chapter four we have discussed result and discussion, cost estimation, future modification, conclusion.

CHAPTER II

THEORY OF THE PROJECT

2.1 Introduction

This chapter includes the total over view of the device. In this chapter we have followed-up the theory of Adapter 12V, Arduino Uno, Resistor , Flame Sensor , Gas/Smoke sensor (MQ-2), Pump , Air Duct Fan, Solenoid Gas Valve, Relay , LED , GSM Module (800L) , 3.7v Li-ion battery briefly describe of Microcontroller (ATMEGA 328P), Vero board, and other components. Here we can know that the total system overview of the projects. And we will also know that how the equipment are working with each other.

2.2 Theory

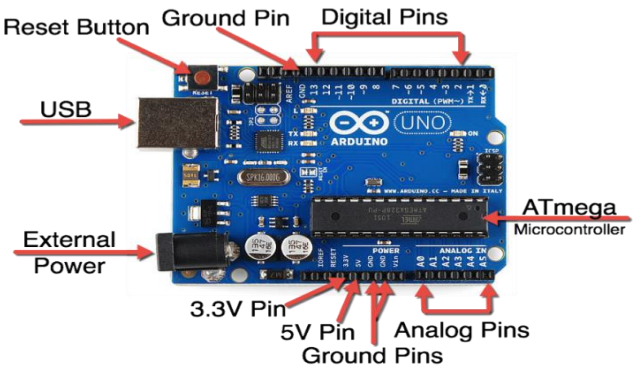
We've developed the system that can handle this critical situation perfectly. Our systems has sensors such as smoke detector, flame sensor to detect fire, Smoke/Gas and on the other hand we are using GSM module to send SMS with an emergency phone call to ensure this message. At the same time our system shutdowns the electricity & Gas supply and turns ON emergency light. And opens the Air Ducts, also triggers the sprinkler with pump support.

2.2.1 Arduino Uno And Adapter 12V

- The 12 Volt Power Adapter, also known as a "Brick", "Desk Wart" and "Floor" supply, provide a regulated 12 Volts DC output. A 12 Volt Adapter Power Supply is enclosed in a plastic protective case that comes with either an attached AC cord, or a mating socket for one of the 3 common IEC cordsets.

- Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language and the Arduino Software (IDE), based on Processing.

Fig: 2.2.1.1 Arduino UNO Pin Diagram



Technical specifications:

Table 2.1: Technical specifications of Arduino UNO

Microcontroller	**ATmega328P**
Operating Voltage	**5V**
Input Voltage (recommended)	**7-12V**
Digital I/O Pins	**14 (of which 6 provide PWM output)**
PWM Digital I/O Pins	**6**
Analog Input Pins	**6**
DC Current per I/O Pin	**20 mA**
DC Current for 3.3V Pin	**50 mA**
Flash Memory	**32 KB (ATmega328P)of which 0.5 KB used by bootloader**
SRAM	**2 KB (ATmega328P)**
EEPROM	**1 KB (ATmega328P)**
Clock Speed	**16 MHz**

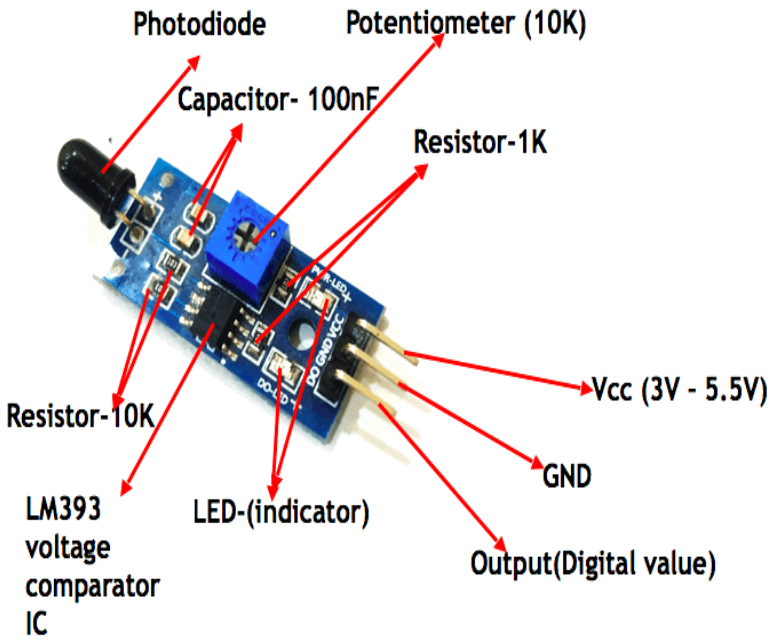
2.2.2 Microcontroller ATMEGA328P

Microcontroller is a compressed micro computer manufactured to control the functions of embedded systems in office machines, robots, home appliances, motor vehicles, and a number of other gadgets. A microcontroller is comprises components like - memory, peripherals and most importantly a processor.

The ATMEGA328P-PN is a popular microcontroller due to it being a major component in the Arduino board products. The ATMEGA328P-PN is the 8-bit RISC heart of the Arduino Uno and Nano, with a maximum clock frequency of 20MHz, 32KB program FLASH, and 2KB of RAM.

2.2.3 Flame Sensor

A flame detector is a sensor designed to detect and respond to the presence of a flame or fire, allowing flame detection. Responses to a detected flame depend on the installation, but can include sounding an alarm, deactivating a fuel line (such as a propane or a natural gas line), and activating a fire suppression system. When used in applications such as industrial furnaces, their role is to provide confirmation that the furnace is working properly; it can be used to turn off the ignition system though in many cases they take no direct action beyond notifying the operator or control system. A flame detector can often respond faster and more accurately than a smoke or heat detector due to the mechanisms it uses to detect the flame.



Specifications

Dimensions	
PCB Size	**32.17mm x 14.12mm**
General Specifications	
Interface	**GPIO (Digital 2 State)**
Range	**760 nm to 1100 nm (Light Wavelength)**
Power Supply	
Phase Voltage	**5V**

2.2.4 Gas/Smoke Sensor (MQ-2)

MQ2 is one of the commonly used gas sensors in MQ sensor series. It is a Metal Oxide Semiconductor (MOS) type Gas Sensor also known as Chemiresistors as the detection is based upon change of resistance of the sensing material when the Gas comes in contact with the material. Using a simple voltage divider network, concentrations of gas can be detected.

Detects: LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide concentra tions anywhere from 200 to 10000ppm.

Here are the complete specifications

Operating voltage	**5V**
Load resistance	**20 KΩ**
Heater resistance	**33Ω ± 5%**
Heating consumption	**<800mw**
Sensing Resistance	**10 KΩ – 60 KΩ**
Concentration Scope	**200 – 10000ppm**
Preheat Time	**Over 24 hour**

2.2.4 GSM Module (SIM 800L)

A GSM modem or GSM module is a hardware device that uses GSM mobile telephone technology to provide a data link to a remote network. From the view of the mobile phone network, they are essentially identical to an ordinary mobile phone, including the need for a SIM to identify themselves to the network. GSM modems typically provide TTL-level serial to their host. They are usually used as part of an embedded system.
SIM800L is a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls. Low cost and small footprint and quad band frequency support make this module perfect solution for any project that require long range connectivity. After connecting power module boots up, searches for cellular network and login automatically. On board LED displays connection state (no network coverage - fast blinking, logged in - slow blinking).

Conditions:

1. **Source Voltage 3.7V – 4V**
2. **Amp Capacity 350mA - Min**

Two antennas!
This module has two antennas included. First is made of wire (which solders directly to NET pin on PCB) - very useful in narrow places. Second - PCB antenna - with double sided tape and attached pigtail cable with IPX connector. This one have better performance and allows to put your module inside a metal case - as long the antenna is outside.

1.1 Specification

Supply voltage: 3.7V - 4V

Power consumption:

Sleep mode < 1.0mA

Standby mode < 18.0mA

GSM transmission (avg): 350 mA

GSM transmission (peek): 2000mA

Module size: 25 x 23 mm

Antenna connector: IPX

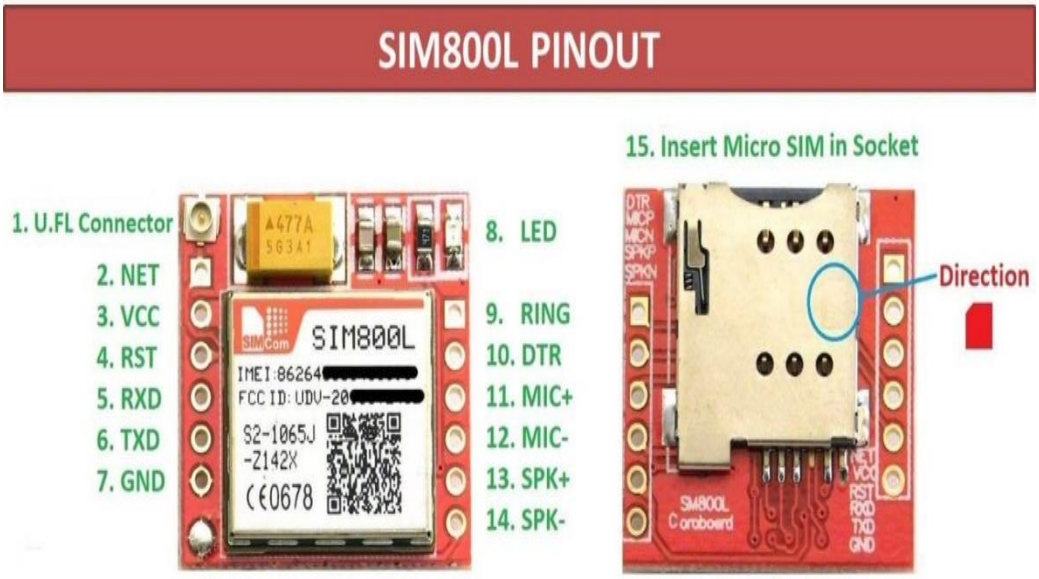
Status signaling: LED

Working temperature range: -40 do + 85 ° C

1.2 Set includes:

SIM800L module
goldpin headers
wire antenna
PCB antenna with pigtail and IPX connector

1.3 Module pinout



2.2.5 Relay

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.

5V Relay Module Pin Configuration

Relay Module Pin Diagram

Normally Open (NO): This pin is normally open unless we provide a signal to the relay modules signal pin. So, the common contact pin smashes its link through the NC pin to make a connection through the NO pin
Common Contact: This pin is used to connect through the load that we desire to switch by using the module.
Normally Closed (NC): This NC pin is connected through the COM pin to form a closed circuit. However, this NC connection will break once the relay is switched through providing an active high/low signal toward the signal pin from a microcontroller.
Signal Pin: The signal pin is mainly used for controlling the relay. This pin works in two cases like active low otherwise active high. So, in active low case, the relay activates once we provide an active low signal toward the signal pin, whereas, in an active high case, the relay will trigger once we provide a high signal toward the signal pin.
However, these modules generally work on an active high signal which will strengthen the relay coil to make contact with the common terminal with the normally open terminal.
5V VCC: This pin needs 5V DC to work. So 5V DC power supply is provided to this pin.
Ground: This pin connects the GND terminal of the power supply.

5Volts Relay Module Components

The components in a 5v relay module include a relay, output terminal, status LED, power LED, input connector & switching transistor.

2.2.6 Pump

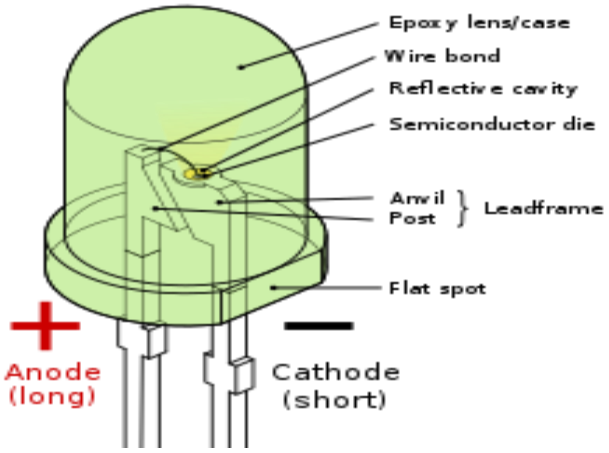
DC motor is any rotary electrical machine converting direct current electrical energy into mechanical energy. Once the motor is on, it creates a magnetic field around it making the rotor spin. When the rotor is in action, it causes the impeller to spin, hence, powers the pump.

2.2.6 Air Duct Fan

A ducted fan is an air moving arrangement whereby a mechanical fan, which is a type of propeller, is mounted within a cylindrical shroud or duct. The duct reduces losses in thrust from the tips of the propeller blades, and varying the cross-section of the duct allows the designer to advantageously affect the velocity and pressure of the airflow.
A jet fan is a stationary ducted fan used to move air through buildings or tunnels.
Ducted fans normally have more and shorter blades than conventional propellers and thus can operate at higher rotational speeds

2.2.7 LED

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current is passed through it. Light is produced when the particles that carry the current (known as electrons and holes) combine together within the semiconductor material.



2.2.8 Solenoid gas valve

Gas solenoid valves are **used to control the flow of a gas through a machine** or in a boiler or industrial heating application, by translating electrical impulses. These impulses open and close a valve, controlling the flow of the gas.

2.2.9 Battery 3.7 volt

A lithium-ion battery or Li-ion battery is a type of rechargeable battery in which lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. Li-ion batteries use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode.
For example, almost all lithium polymer batteries are 3.7V or 4.2V batteries. What this means is that the maximum voltage of the cell is 4.2v and that the "nominal" (average) voltage is 3.7V. As the battery is used, the voltage will drop lower and lower until the minimum which is around 3.0V.

CHAPTER III

DESING & FEBRICATION

3.1 Introduction

In this chapter fully cover with discuss design and fabrication of this project. Here we will discuss about developed block diagram and briefly describe about the circuit description and also learn about working principle. Total project flow chart is also available in this chapter.

3.2 Block Diagram

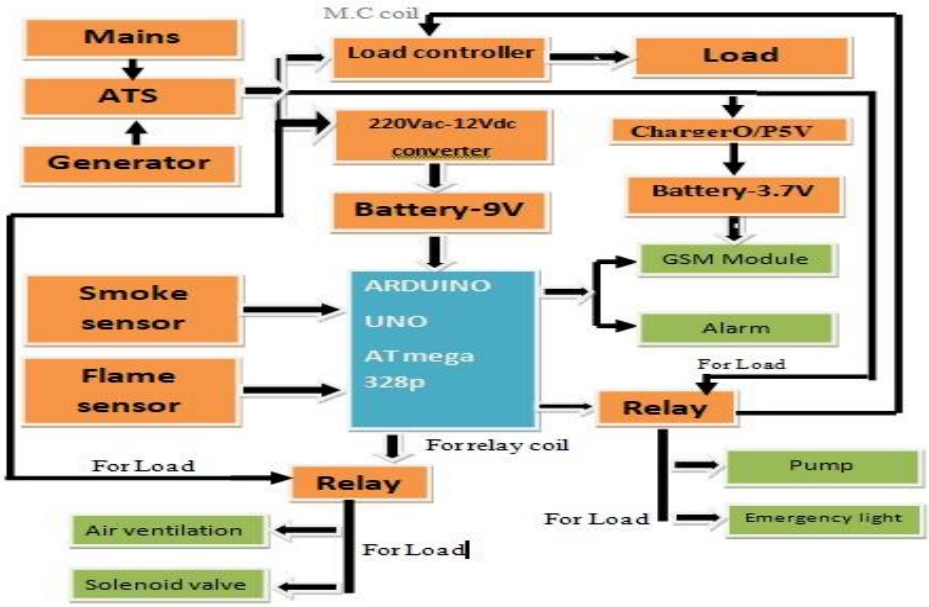


Fig: 3.2.2.1: Block diagram of project

Here's the block diagram of our Microcontroller Based Integration of Renewable Energy system. We can clearly describe the working process through this block diagram. Firstly we have two energy sources to supply electricity. One is the Solar and the other is the Wind. Generally Solar is the first priority of supplying the electricity. Our control system continuously monitors the voltage and the current of both sources. If any unwanted situation occurs such as under voltage of a sources, or power failure of any of those sources, our system immediately switches the supply line to another sources that has no problem and vice versa. If both of the sources lose their voltage to the minimum threshold voltage, it combines the two sources. A voltage stabilizer keeps the output load voltage always stable as the loads need. All processes, voltages, current and current source is shown in a LCD display.

3.3 Circuit Description

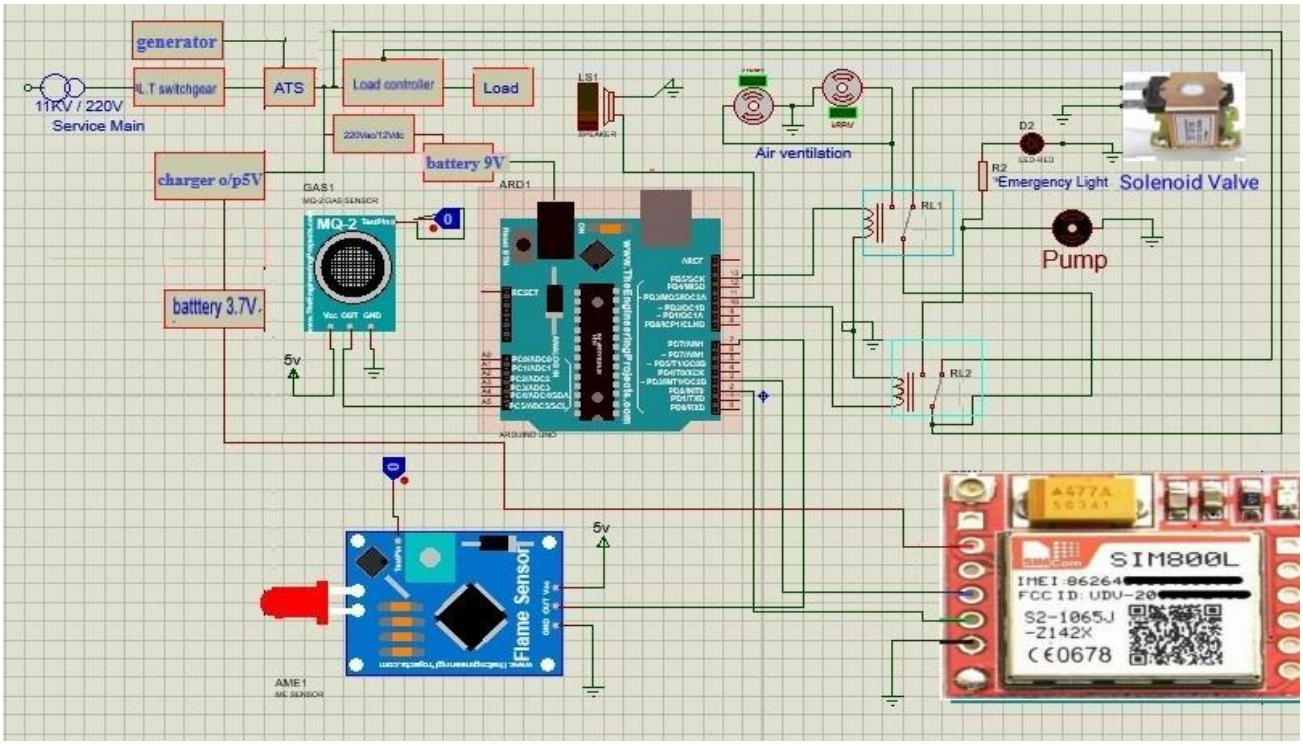


Fig: Circuit diagram of the Project

As we can see there are two input sources which are connected to ATS (Automatic Transfer Switch). ATS is used to give an output which will switch the lines between mains and generator from the ATS. Our connection will be connected to the main load through the load controller and we will be connecting another line Form ATS to a converter which will be giving us 12 volt dc. This 12 volt dc is connected to a 9 volt rechargeable battery and this battery provides power to the arduino UNO and another 220 volt line which is parallelly connected to the converter. This line will be used for a charger this charger, charges the 3.7 volt battery which is used for GSM module sim800L. Now coming back to our Arduino UNO there are two inputs, one is smoke sensor which is connected in pin number A5 in arduino UNO and another is flame sensor which is connected in pin number D7. Smoke and Flame sensors are powered from arduino and now comes the GSM module sim800L, as we described it early at that it takes power from 3.7 volt lithium ion battery it has two point first one is RX which is for receiving and second one is TX which is for transmitting RX is connected to pin number 3 and tx is connected to pin number 2. Buzzer is connected to Pin Number 11. Next there are two relay numbers: one relay coil is connected with pin number 13 and number two relay coil is connected to pin number 10. As we know there are three points nc, no and common. Common pin is parallelly connected to ATS output line. NC point is connected to solenoid valve and another point is connected to air ventilation system now comes the second relay. Its common pin is also parallel connected to the

ATS output line and its NC is connected with a load controller. Load controller is used for controlling the load and another point is connected to pump and emergency lights parallelly.

3.4 Overview of Automated Fire Protection System

The Automated Fire Protection System can be defined as a smart electrical system. That combines electrical, mechanical & digital communication technology. Automated Fire Protection System is capable of providing safety from multiple harmful sources, like from fire, smoke & short-circuit etc.

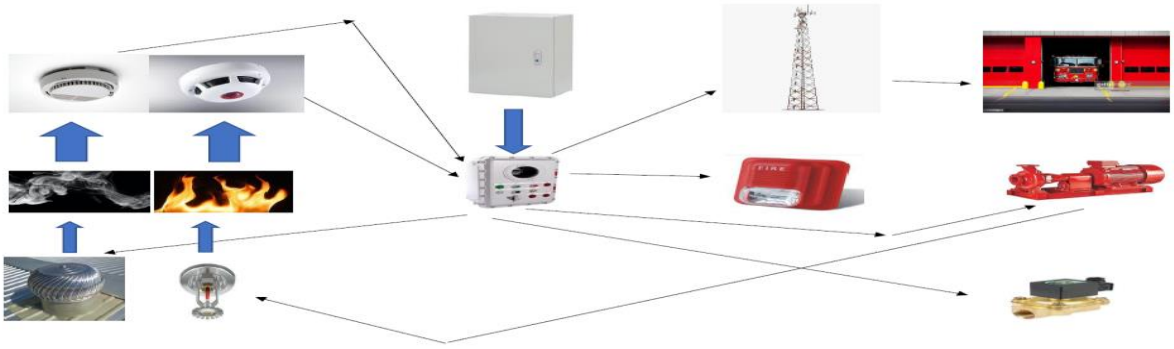


Fig: 3.4.4.1: Overview of Automated Fire Protection

3.5 Working Principle

Automated fire proction system is a service which can be very useful in our life. Now lets describe the working process :
The full system runs in Auxilary power source.
At first, if there is any kind of smoke detection in the building, the smoke sensor will be acitivated if the smoke is in range (ADJUSTABLE). Then it will pass the signal to Arduino UNO. Arduino UNO will provide the output to buzzer, solenoid gas valve, also to air ventilation system. After getting the signal buzzer & air ventilation will be turned on and the solenoide gas valve will cut the gas services throughout the building.
Now if there is any kind of fire detection in the building the flame sensor (ADJUSTABLE) will pass the signal to Arduino UNO.
Again Arduino UNO will provide the output to relay to cut the main electicity line and will give power to the emergency service light. For extra support the GSM module will inform the nearest fire service through sms & phone call. And it will be sending sms frequently after 10 mins (ADJUSTABLE). At the same time sprinkler will be trigerd, it will be supported by a pump for better water supply and pressure.
For leaving the building, emergencey exit will be used.
When the detectors dosent detect Fire or smoke, the process will shutdown after 5 mins (ADJUSTABLE). **Image of the project is given below.**
NOTE : IF FIRE GETS DETECTED BEFORE SMOKE THE FULL PROCESS WILL BE TURNED ON. EVEN IF THERE IS NO SMOKE DETECTION.

3.6 Image of the Project

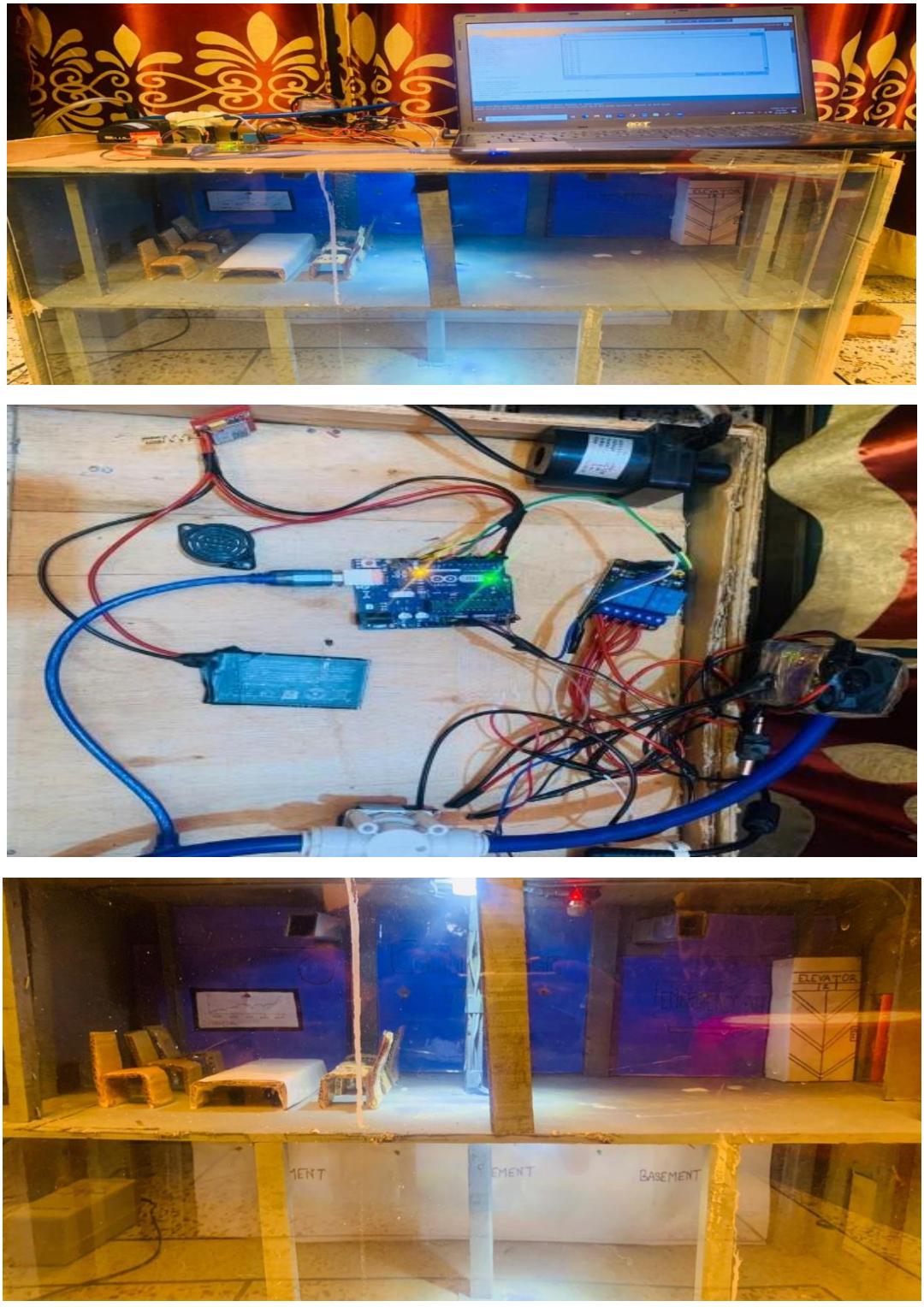


Fig: 3.6.6.1: Three Real images of the project

3.8 Used Materials

1. **Microcontroller (Arduino) - 1 pcs**
2. **Power Supply 12V - 1 pcs**
3. **Battery 3.7V - 1 pcs**
4. **Relay 5.0V - 2 pcs**
5. **Smoke Ditector (MQ2) -1 pcs**
6. **Flame Sensor - 1 pcs**
7. **Buzzer - 1 pcs**
8. **GSM (SIM800L) - 1 pcs**
9. **Fan 1.6W - 2 pcs**
10. **Pump - 1 pcs**
11. **Light 1.5W - 2 pcs**
12. **LED - 8 pcs**
13. **Resistor 1K - 8 pcs**
14. **Charger 3.7V - 1 pcs**
15. **Solenoid Valve - 1 Pcs**
16. **Pipe 8mm - As needed**
17. **Wires - As needed**

3.9 Conclusion

In this chapter we have discussed the block diagram,circuit discription, working principle, flow chart also show the real image of the project and others. In the later part of this paper we discussed the result & discussion of the project to make the concept clear to anyone.

Chapter IV

RESULT & DISCUSSION

4.1 Introduction

This chapter contains the results obtained and discussion about the project. We have also covered discussions about advantages, disadvantages and limitation of current version of the protection system.

4.2 Result

- Due to increase in population, buildings are increasing too. If somehow a fire accident happens in the building, this automated system can be very useful to save many life. And this is also very important for the building.

4.3 Advantags of Automated Fire Protection

- **Activates automatically (without human intervention) within the first few minutes of a fire breaking out**
- **Sends an immediate, automatic alert to the local fire department**
- **Improves the chances of survival by limiting the spread of flames and the production of smoke**
- **Limits damage to the building**
- **Limits the risk of financial loss due to shutdowns in the case of a workplace fire**
- **Generally lower insurance premiums for buildings protected by an automatic protection system.**

4.4 Disadvantages of Automated Fire Protection

- **Electrical instruments can be damaged during the water spray.**
- **Need to winterize the system during colder months.**
- **They may also become damaged during routine yard maintenance, such as mowing, and require complete replacement.**

4.5 Discussion

By implementing above systems there are various benefits.
An understanding of the automated fire protection systems, in our protection which is importance. Our fire department depends on these systems for the basic needs of fire protection and fighting fire. Our ability to identify the various components of these systems and to inspect them for operational readiness may mean the difference between life and death should the systems be needed.

4.6 Cost Estimation

SI	Particulars	Specification	Qty.	Unit Price	Total Price
1	Arduino Uno		1	350	350
2	Microcontroller	ATMEGA328P	1	350	350
3	Flame Sensor		1	200	200
4	Smoke Sensor	MQ2	1	180	180
5	Adapter 12V	230V/12V, 1Amp	1	280	280
6	Battery	3.7V	1	250	250
7	Relay	5V	2	100	200
8	Fan	1.6W	2	60	120
9	Buzzer		1	80	80
10	GSM	SIM800L	1	900	900
11	Pump	8W	1	250	250
12	Light	1.5W	2	80	160
13	Led		8	5	40
14	Resistor	1K	8	1	8
15	Charger	3.7V	1	100	100
16	Solenoid Valve	6.5W	1	250	250
17	Pipe	8mm	**As Needed**	50	50
18	Wire		**As Needed**	50	50
19	Soldering Cost				20
20	Others				500
				Total	**4338**

Table:4.1: Cost Estimation

4.7 Applications

Fire protection system plays an important role in modern smart technologies. Following are the most common applications of safety technology.

4.8 Conclusion

An Automated Fire protection system helps us to lower the damages, to save lifes and also the equipments. It helps the fire fighters also to put the fire out.

Chapter V

CONCLUSION

5.1 Conclusion

This project is very important in our life. A fire accident can change everything. This kind of automated fire protection system can help us to fight with it. We need this kind of protection in every sectors. But in some case it needs to be upgraded. But in our building this system plays a game changing role.

5.2 Future Work

At present we have made this automated system for our buildings. But as we described earlier, the system sometimes needs to be upgraded. As a future work we can develop it for every sectors by including automated fire extinguishers, recorded voice call, automatic dry chemical fire suppressor etc.

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