Design and Development of RMG Industry's Environment Monitoring and Safety System.

By

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Approved by

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Dedication

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AUTHORIZATION

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EXECUTIVE SUMMARY

This is a project that was built to ensure safety for the worker of ready-made garment industries. In recent past years we have seen many accidents in garments industries. That results loss of countless lives. Many of the workers become injured. Thousands of the families were broke economically. So we would like to ensure workers safety by providing them timely alert. By monitoring the working environment we can also provide them a healthy working environment. Healthy working environment will definitely increase their productivity. By using modern engineering tools we build a system that will not just notify the worker on emergency situations but also continuously monitor their working environment 24 hour day seven days in a week. Also this system will provide information about the working environment to everyone so that worker can have idea about what type of environment are they work in. This system is specifically made for RMG industries because there accident occurs most and causes damage most as well.

PART-A

RMG industries are increasingly adopting advanced technologies to enhance environmental monitoring and safety systems. These technologies, such as IoT sensors, AI-powered analytics, and drones, enable real-time data collection, early detection of hazards, and efficient response to incidents. By leveraging these innovations, RMG companies can improve operational efficiency, reduce environmental impact, and ensure a safer working environment for their employees and surrounding communities. It is very important for countries like us follow the same standards as other countries garment industries. It is important to ensure workers safety as well as inform them in what type of environment they works in. An automatic environment system can fulfill all of the objectives of this project.

Chapter 1 Project Concept and Proposal

1.1 Project introduction

Nowadays, even with lots of scientific advancements, we still have many accidents in ready-made garment industries where fires break out and cause a lot of damage and hurt many people. Most of the time, these fires start because of the machines in the factories. They can spread quickly and destroy everything. So, we came up with an idea for a special system that can notice the smoke from a fire and the heat that goes up when there's a fire. When our system finds out there's a fire, it will let the people in charge know by using different signals, like alarms.

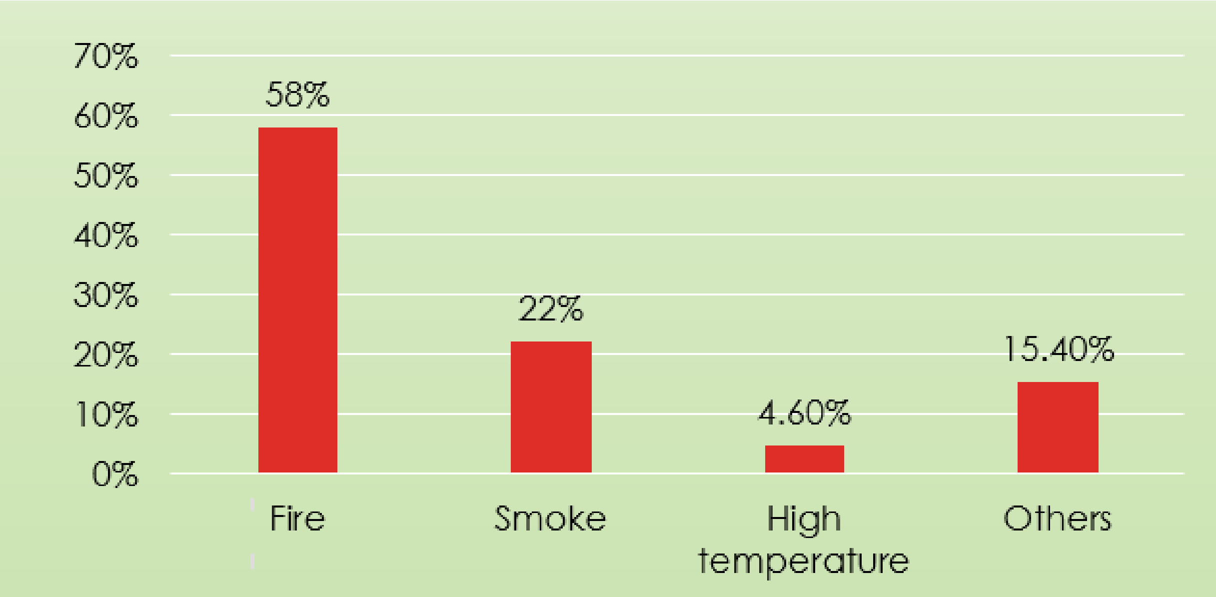


Fig. 1.1 Reasons behind injuries and death in garment industry.

This is not just for factories. We can put this system in other industries as well. Also, in offices where people work, and in places where lots of people gather, like community centers, we can install this system for safety purposes.

Safety alarm systems are like guardians for buildings, factories, and other spaces. They work in two main ways: first, they keep an eye out for signs of a fire, using either manual checks or automatic sensors. If they sense anything unusual, like smoke or a sudden rise in temperature, they immediately raise the alarm. This quick detection is crucial in preventing a small spark from turning into a destructive fire.

The second important role of these systems is to make sure everyone knows about abnormal conditions. They do this by sounding loud alarms, which grab the attention of people in the building, prompting them to evacuate to safety. It's like a fire drill, but for real emergencies. In some cases, these systems can also send signals to the fire department or emergency services so that professional help can arrive quickly.

Those systems not only sense danger but also provide warnings to keep everyone out of harm's way. They are designed to act fast, shutting down machinery and processes that could make the accident worse. This quick response is a bit like hitting a pause button to prevent an accident like fire from spreading.

The effectiveness of these systems depends on the unique features of each building and its purpose. Garment industries need more advanced systems because they have sensitive equipment or have a higher risk of fires. Essentially, these systems are like silent protectors, always on the lookout for any signs of trouble and ready to spring into action to save lives and property. This safety system will be a smart guard for R.M.G. industries. It has a special part called a microcontroller, which is like its brain. This brain will always be monitoring through smoke detectors that can smell smoke and temperature sensors that feel heat. If these detectors notice anything like smoke or a sudden increase in heat, they tell the microcontroller that something might be wrong. When the microcontroller gets this information, it will act fast. It will turn on a screen that shows a warning message and make a loud beep with a buzzer. This loud beep is the alarm that tells everyone in the building that they need to leave quickly and go somewhere safe.

1.2 Literature review

RMG industry security is one of the leading concerns amongst of Bangladesh. An efficient but low-budget automated security and environment monitoring system to prevent accidents by monitoring a particular place of a building and keeping people safe. Fortunately, microcontrollers have opened marvelous realms in the field of domestic digitization, providing expeditious automated systems devoid of complexity and exorbitant costs, which is supportive to the socio-economy, component availability and maintenance skills of technicians in typical developing countries such as Bangladesh. [1]

A common issue in the RMG industry of Bangladesh is the absence of reliable environment monitoring and safety measures. Most importantly factory management is found to be totally unaware of the environment monitoring and safety system in case of fire or ensuring a good working environment. Ready-made garments and fire are closely related to each other in Bangladesh.

Security is a paramount concern in the Ready-Made Garment (RMG) industry in Bangladesh. Addressing this issue requires the implementation of a cost-effective automated security and environment monitoring system to prevent accidents and ensure the safety of individuals within a specific building area. Fortunately, microcontrollers have revolutionized domestic digitization, offering efficient automated systems that are both affordable and user-friendly. This technological advancement is particularly beneficial for socio-economic development, given the limited availability of components and maintenance skills among technicians in typical developing countries like Bangladesh.

Outbreaks of fire in garment factories, we learn some lessons after a disaster, and most often forget about them. Workers had been dying but authorities were not that much concerned until overseas buyers took exception to the large number of deaths and injuries. [2] It is a matter of great shame that we are not giving so much attention about the safety concern for our workers. Despite improvements in the area over the past decade, even today many RMG industry owners are found paying minimum attention to the issue of environmental safety. The RMG industry in Bangladesh faces a prevalent challenge concerning the lack of dependable environment monitoring and safety protocols. A critical issue lies in the complete unawareness of factory management regarding the implementation of an effective environmental monitoring and safety system, particularly in the context of fire incidents and ensuring a conducive working environment. The nexus between ready-made garments and fire incidents is notably pronounced in Bangladesh. Despite learning lessons from past disasters, there tends to be a recurring pattern of oversight. Tragically, worker fatalities occurred without a proportionate level of concern from authorities, with meaningful attention only drawn when overseas buyers raised objections due to the high number of deaths and injuries. It is indeed disheartening that the safety concerns of our workers are not receiving the necessary attention they deserve. Despite advancements in this realm over the past decade, a significant number of RMG industry owners continue to overlook the crucial issue of environmental safety. Since 1990, over 350 workers have lost their lives, and approximately 1500 have suffered injuries in fire-related incidents within

Bangladesh's garment industries. Prior to the year 2000, the country witnessed over a hundred fires in various industries, resulting in the tragic loss of more than 5000 workers' lives. Table 1 provides a snapshot of some recent fire accidents in garment factories in Bangladesh.[2] A predominant cause of fatalities and injuries in the RMG industry stems from smoke entrapment, fire suffocation, and insufficient means of escape within factory premises. This paper centers on crafting and implementing an automated environment monitoring and safety system for the RMG Industry. Utilizing easily accessible electronic components, the design emphasizes simplicity in assembly and maintenance. Simultaneously, the system is engineered to deliver a robust, cohesive, and effective solution to enhance security within the RMG industry.

Since 1990, over 350 workers have died and some 1500 injuries in fire related incidents in garments industries in Bangladesh. Till 2000, there were more than hundred fires in industries in Bangladesh. More than 5000 workers were killed. Table 1 shows that some recent fire accidents in garments factories in Bangladesh. [2] Most of the deaths and injuries are caused by smoke trapped, fire suffocation, or inadequate means of escape in such factories. This paper focuses on the design and development of the RMG Industry's automated environment monitoring and safety system using readily obtainable electronic components that can be easily assembled and maintained, but at the same time, providing a strong, seamless, and efficient solution to RMG industry's security.

Table 1.1: Recent fire accidents in garments factories in Bangladesh [3]

Date	Place	Dead	Injured	Cause of fire	Cause of death
23.02.06	KTS Textiles, Chittagong	91	400	Electric short circuit	Exit locked, fire suffocation, stampede.
06.03.06	Industry at Gazipur	3	-----	Fire panic	Fire suffocation.
Mar. 06	Salem Fashion Wear Ltd.	3	50	Unknown	Exit was blocked by boxes, smoke, and fire suffocation.
3.05. 04	Misco Super Market, Dhaka	9	50	Gas leakage	Fire suffocation.
01.08.01	Kafrul	26	76	Unknown	Smoke and stamped.

08.08.01	Mico Sweater Ltd. Mirpur	28	100	Unknown	Fire smoke and gasses.
2000	Near the Capital	48	70	Boiler burst	Trapped in locked burning industry.
2000	Chowdhury Knitwear, Norshingdi	53	100	Short Circuit	Fire, smoke and stamped.
28.08.00	A garment in Banani	12	45	Unknown	Suffocation, stampede.

The microcontroller-based power failure alert system is intricately crafted to keep users informed about the occurrence and resolution of power failures. While various power failure alarms are available, this project prioritizes simplicity and efficiency. When a power outage is detected, the system activates an alarm sound and illuminates an LED, providing users with a clear and immediate notification [4]. The emphasis on an audible alarm and visual indicator ensures accessibility and user-friendly alerting. This design choice streamlines the notification process, making it straightforward for users to identify and respond to power disruptions, contributing to a seamless and effective user experience.

Technology has advanced to the point where stand-alone systems may now do tasks without the assistance of extra hardware. Modern single-board computers sometimes referred to as microcomputers, run on sophisticated microcontrollers. These sturdy microcontrollers with integrated circuits are capable of managing a wide variety of tasks on their own. They are used in anything from complex industrial gear to common domestic gadgets. The microcontroller market of today has a wide range of models with different architectures and capacities. As a result, choosing hardware wisely requires a thorough grasp of microcontroller principles [5]. The next essay will clarify these notions by offering a thorough analysis of the basic principles and structural underpinnings of microcontrollers.

We are developing an intelligent system to prevent mishaps in industries. It receives inputs from temperature and smoke sensors via a NodeMCU. The NodeMCU alerts users with a buzzer, lights, and LCD if there is smoke or a high temperature. It also notifies authorities by sending a message to a phone [6]. In industries, this easy-to-install solution can avert calamities and save countless lives.

Electronic devices are intelligent and creative because microcontrollers are their brains. They are now utilized everywhere, from home automation to car tracking, and are no longer reserved for tech specialists. Connecting objects to the Internet is essential for the Internet of Things (IoT). This paper describes an interesting application: utilizing the RS232 interface to connect a microcontroller to multimedia [7]. Imagine this at art galleries or museums, bringing history and culture to life through digital education and entertainment, making learning enjoyable.

It describes a temperature control system that employs a microprocessor and an LM35 temperature sensor, which is noted for its linear response to temperature fluctuations. The microcontroller monitors and manages temperature intelligently by comparing the desired set temperature to real-time temperature data from the sensor. The cooling and heating units are then instructed to activate or deactivate, ensuring exact temperature regulation [8]. Hardware validation indicates the system's ability to maintain temperatures between 39 and 41 degrees Celsius. The implementation comprises a simple control knob for setting temperatures within a configurable range, as well as an LCD display for real-time visualization of both set and actual temperatures.

1.3 Standards and codes of practices

As our country lacks any established standards or norms in this area, it will be beneficial to follow IEEE standards.

NodeMCU: This is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi- Fi SoC from Express if Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project and built on the Express if non-OS SDK for ESP8266.

Arduino Uno: The Arduino Uno is a small, powerful microcontroller board that is ideal for a wide variety of electronics projects. It is based on the Microchip ATmega328P microcontroller and is compatible with the Arduino Software IDE. It has a wide range of I/O pins, breadboard compatibility, and USB connectivity. It can be used for robotics, sensors, actuators, interactive art, and home automation. There are many learning resources available for the Arduino Nano.

SMPS: A switched- mode power supply is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source to DC loads, such as a personal computer, while converting voltage and current characteristics.

Relay Module: A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal.

Light: An electric light is a device that produces visible light from electric current. It is the most common form of artificial lighting and is essential to modern society providing interior lighting for buildings and exterior light for evening and nighttime activities. In technical usage a replaceable component that produces light from electricity is called a lamp. Lamps are commonly called light bulbs, for example, incandescent light bulbs.

Buzzer: A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

Full-Wave Rectifier: This type of single-phase rectifier uses four individual rectifying diodes connected in a closed loop-bridge‖ configuration to produce the desired output. The main advantage of this bridge circuit is that it does not require a special center tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below. The filtered full wave rectifier is created from the FWR by adding a capacitor across the output.

LCD: LCD (Liquid Crystal Display) screen is an electronic display module and finds a wide range of applications. A 16x2 LCD display is a very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being LCDs are economical; easily programmable, have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in a 5x7 pixel matrix.

Arduino IDE: The digital microcontroller unit named Arduino Uno can be programmed with the Arduino software IDE. There is not any requirement for installing other software rather than Arduino. Firstly, Select "Arduino Uno” from the Tools, Board menu (according to the microcontroller on our board). The IC used named ATmega328 on the Arduino Uno comes pre burned with a boot loader that allows us to upload new code to it without the use of an external hardware programmer.

By incorporating some international codes and practices, it is very much possible to enhance the safety, reliability, and long-term viability of this safety system.

1. General Safety Standards:

IEC 61508: "Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems" provides a framework for assessing and managing risks associated with safety-critical electronic systems.[9]

ISO 12100: "Safety of machinery - General principles for design, risk assessment and risk reduction" outlines principles for identifying and mitigating safety hazards in machinery and equipment.[9]

2. Electrical Safety Standards:

IEC 60601: "Medical electrical equipment - Part 1: General requirements for basic safety and essential performance" establishes safety requirements for electrical equipment used in medical environments, which can be adapted to industrial systems.

NFPA 70: "National Electrical Code" (US) covers installation and use of electrical equipment to minimize fire risk and ensure safe operation.[9]

3. Environmental Monitoring Standards:

ASHRAE 154: "Ventilation for Minimum Indoor Air Quality and Ventilation Rates" sets minimum standards for indoor air quality (IAQ) in non-residential buildings, including industrial facilities.

ISO 16000: "Indoor air quality" series provides guidance on measuring and assessing various indoor air pollutants.

1.4 Stakeholders' expectations/requirements

We have identified two groups of stakeholders:

1) Bangladesh Garment Manufacturers and Exporters Association (BGMEA).
2) Ready-made garment industries (Winner wears LTD, RAAR sweater limited).

The summarized feedback from surveys of Bangladesh Garment Manufacturers and Exporters Association and several ready-made garment industries is discussed below:

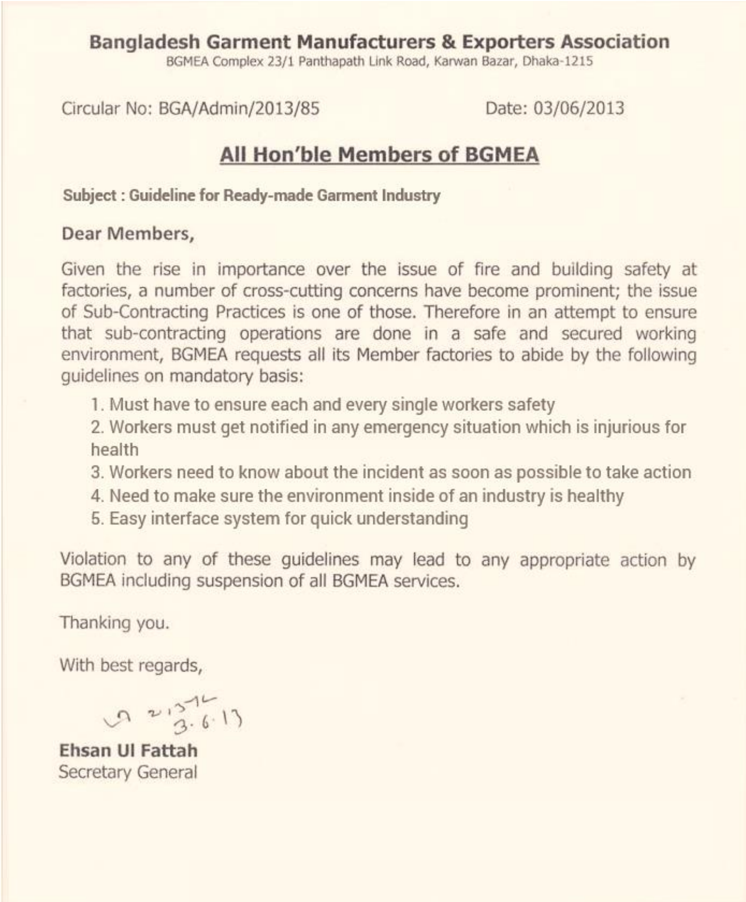
1. Bangladesh Garment Manufacturers and Exporters Association (BGMEA):

The Bangladesh Garment Manufacturers and Exporters Association (BGMEA) officers have also suggested some feedback:

- **Highest quality:** This system must ensure that it will provide top quality service to the workers. It should detect any harmful condition (among fire, smoke, high temperature) which are injurious for human health and notify the works immediately. Make sure there is no delay between that period.

- **Fully automatic:** Once the system is installed it does not require any human intervention. It will continuously do its duty by monitoring the working environment by itself.

- **Easy installation:** This system should be easy to install. Therefore, it will be easier not just to access but also will be beneficial in maintenance and repairing.



Bangladesh Garment Manufacturers & Exporters Association
BGMEA Complex 23/1 Panthapath Link Road, Karwan Bazar, Dhaka-1215

Circular No: BGA/Admin/2013/85 Date: 03/06/2013

<u>All Hon'ble Members of BGMEA</u>

Subject : Guideline for Ready-made Garment Industry

Dear Members,

Given the rise in importance over the issue of fire and building safety at factories, a number of cross-cutting concerns have become prominent; the issue of Sub-Contracting Practices is one of those. Therefore in an attempt to ensure that sub-contracting operations are done in a safe and secured working environment, BGMEA requests all its Member factories to abide by the following guidelines on mandatory basis:

1. Must have to ensure each and every single workers safety
2. Workers must get notified in any emergency situation which is injurious for health
3. Workers need to know about the incident as soon as possible to take action
4. Need to make sure the environment inside of an industry is healthy
5. Easy interface system for quick understanding

Violation to any of these guidelines may lead to any appropriate action by BGMEA including suspension of all BGMEA services.

Thanking you.

With best regards,

3.6.13

Ehsan Ul Fattah
Secretary General

Fig. 1.2 BGMEA requirements.

2. Ready-made garment industries:

The survey of several RMG industries shows that they are interested in installing a system that will ensure their workers' safety. In recent past years there have been some accidents and because of those, several workers lost their lives.

They want to keep the working environment safe and healthy for their workers. An environment monitoring system can assure that by continuously monitoring the working environment. This way the working environment will be safe for the workers.

Also, they suggested some valuable things to us. Those are:

- This system should have the ability to monitor the working environment 24 hours, every day.
- The price of that system should be reasonable so it would be easy for them to buy.
- The output of that system should be clear enough to everybody so that all of them can remain safe.

- The gases occurs accident most: Propane (C_3H_8), Carbon Monoxide (CO), Butane (C_4H_{10}), Ammonia (NH_3), Chlorine (CL_2) and smoke. Therefore, the system must detect those accurately.

1.5 Project requirements

Our project requires various processes and requirements to design and implement. An environment monitoring system is a system that warns the workers when it detects any harmful condition.

We need to follow our stakeholders' requirements. They suggested that we implant our design in a specific place and make sure that the device does not cause any inconvenience in regular work.

The Bangladesh Garment Manufacturers and Exporters Association (BGMEA) said this system cannot be installed without the permission of the industry. They also advised us to consider safety precautions thoroughly. Industries want to get this system at low price, and we decided that we will initially keep the price of the system very low and satisfy stakeholders requirements. Here is a brief description of the project's requirements.

Project Scope: Clearly define the scope of our project and set specific objectives. Determine the input power and receive the information from the sensors and the overall purpose of the system.

Design and Analysis: Focus on designing the working environment monitoring system considering the following aspects:

- **Sensor selection:** Selection of appropriate sensors for this system is very important. With the help of the sensors this system will provide its output.
- **PCB design:** Flawless PCB design is essential for successful system development. The PCB Layout module will receive data from the schematic capture module in the form of a netlist. Utilizing this information, along with its design rules and various design automation tools, it facilitates error-free board design.
- **Microcontroller Simulation:** The micro-controller simulation works by applying a debug file to the microcontroller part on the schematic. It is then co-simulated along with any analog and digital electronics connected to it. This enables its use in a broad spectrum of project prototyping in different areas such as temperature control and user interface design.

- **Mechanical and Electrical Interface:** Create a mechanical link between the electrical appliance and the sensors.
- **Prototype Construction:** Using our design as a guide, construct a working environment monitoring system prototype. This could be a scaled-down model that shows the main operating ideas.
- **Testing and Performance Evaluation:** Test our prototype to evaluate its effectiveness and performance. Include power input, efficiency, and the sensors data in our results report. Compare the results to the predictions made by theory.
- **Safety Measures:** Create a prototype with safety features to avoid mishaps during testing or demonstrations. Make sure there are no short circuits or loose connections, and that all parts are attached well.
- **Documentation:** Keep detailed records of our design decisions, construction process, test results, and any modifications made to the prototype. This documentation will be crucial for our capstone report and presentation.
- **Budget and Resources:** Calculate the budget needed for the materials, tools, and any additional costs involved in building and testing the prototype. Think about the resources we have at our disposal for the capstone project.
- **Ethical and Environmental Considerations:** Think about the project's ethical aspects, such as how it will affect the environment and how it will use resources responsibly. Make sure that our project complies with ethical principles. We will use resources responsibly. Make sure that our project complies with ethical principles.

1.6 Project Management

1.6.1 Project plan

Moving forward with a project requires a suitable project plan. Without a complete plan for the project, a project would fail. The project's outcome can be impacted by the project plan as well. A specific set of tasks must be completed to reach each of the project's numerous milestones.

Table 1.2 Project activity list

PART A

Activity No	Activities	Duration [Week]	Predecessor	No. of Participant
1	Topic selection	1	-	4
2	Discussing and approving the topic idea from the supervisor	1	1	4
3	Prove of social relevance, complex engineering, and design problem	1	2	4
4	Literature Review	2	2	4
5	Slide making and presentation **[Milestone 01]**	2	3	4
6	Identify the stakeholders and create a questionnaire for stakeholders	1	5	4
7	Performing the stakeholder survey and accomplishing the requirements **[Milestone 02]**	1	6	4
8	Identification of the project's social impact and its impact on environmental, health, and safety concerns. Project plan and risk management.	1	7	4
9	Reviewing standards and codes of practice.	1	4, 7	4
10	Project plan and risk management. **[Milestone 03]**	2	7	4
11	Determine the resources specification, set a budget, and analyze the product lifecycle.	1	8	4
12	Project concept and proposal report preparation. (EEE 400A) **[Milestone 04]**	2	9, 10, 11	4

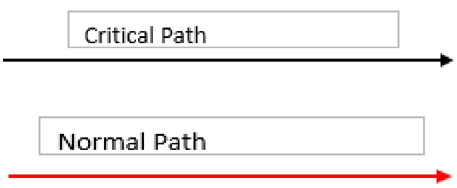
PART B				
13	Preliminary design of the system.	3	12	4
14	Analysis of alternate solutions. **[Milestone 05]**	1	12	4
15	Designing for an internal mechanism	1	13,14	4
16	System circuit design	1	15	
17	Verify preliminary design	2	16	4
18	Prototype design preparing according to real life **[Milestone 06]**	2	17	4
19	Cost optimization.	1	14, 17	4
20	Preparing Report and Submission. **(EEE 400B)**	2	18, 19	4
PART C				
21	Find out required equipment.	1	19	4
22	Draft design preparation	1	20	4
23	Purchase equipment.	1	21	4
24	Implementation.	3	22, 23	4
25	System performance assessment.	1	24	4
26	Design completion based on performance analysis. **[Milestone 08]**	2	25	4

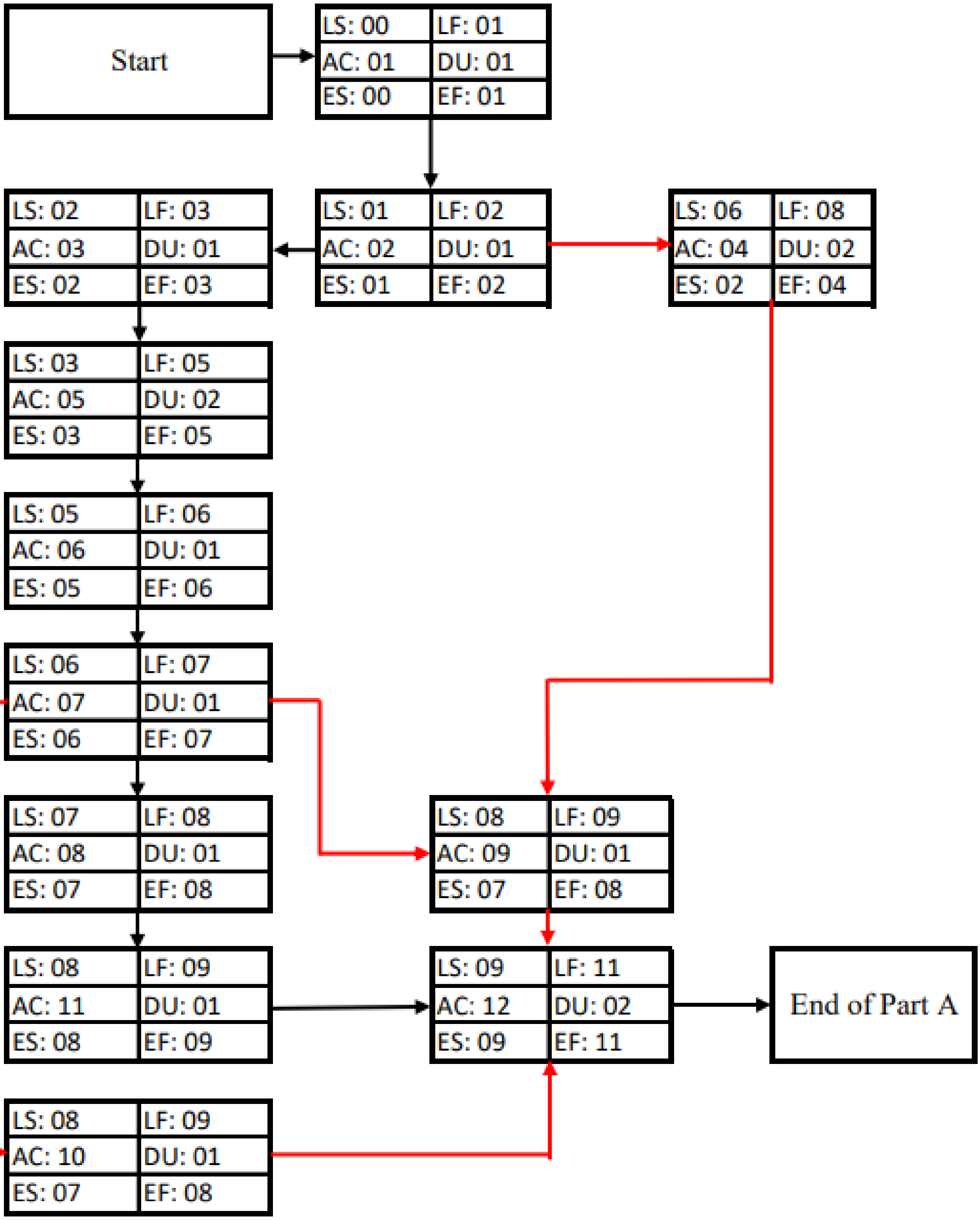
27	Review of the project plan and evaluation of milestone accomplishments.	1	26	4
28	Working product demonstration, cost analysis of the solution's materials, and bill of materials.	3	26	4
29	Verification of Objectives and Complex Engineering Attributes	1	28	4
30	Preparing final report and submission **[Milestone-09]**	2	27, 28, 29	4
31	Project Presentation **[Milestone-10] (EEE400C)**	1	30	4

The Critical Path Method (CPM) diagram will now be developed. We can then assess the schedule flexibility of the appropriate tasks. Additionally, the critical path will be visible. The longest route that needs to be maintained to keep the project on schedule is known as the critical path.

The Forward Pass and Backward Pass diagrams are also included in the CPM diagram, which has.

- ES - Early Start
- EF – Early Finish
- LS – Late Start
- LF – Late Finish
- AC – Activity
- DU – Duration




Start
LS: 00 LF: 01
AC: 01 DU: 01
ES: 00 EF: 01
LS: 02 LF: 03
AC: 03 DU: 01
ES: 02 EF: 03
LS: 01 LF: 02
AC: 02 DU: 01
ES: 01 EF: 02
LS: 06 LF: 08
AC: 04 DU: 02
ES: 02 EF: 04
LS: 03 LF: 05
AC: 05 DU: 02
ES: 03 EF: 05
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AC: 09 DU: 01
ES: 07 EF: 08
LS: 08 LF: 09
AC: 11 DU: 01
ES: 08 EF: 09
LS: 09 LF: 11
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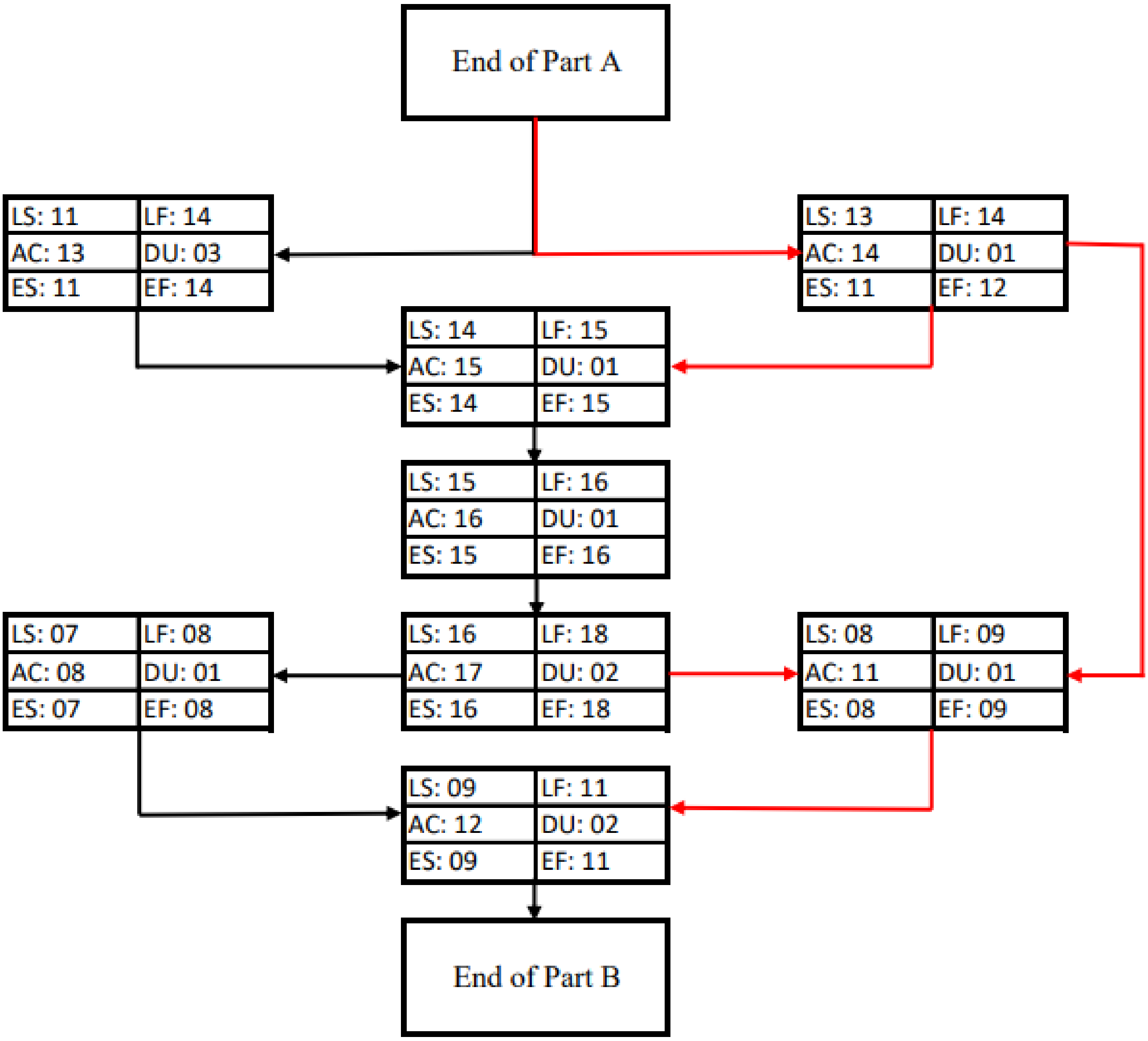
ES: 09 EF: 11
End of Part A
LS: 08 LF: 09
AC: 10 DU: 01
ES: 07 EF: 08



End of Part A
LS: 11 LF: 14 AC: 13 DU: 03 ES: 11 EF: 14
LS: 13 LF: 14 AC: 14 DU: 01 ES: 11 EF: 12
LS: 14 LF: 15 AC: 15 DU: 01 ES: 14 EF: 15
LS: 15 LF: 16 AC: 16 DU: 01 ES: 15 EF: 16
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LS: 16 LF: 18 AC: 17 DU: 02 ES: 16 EF: 18
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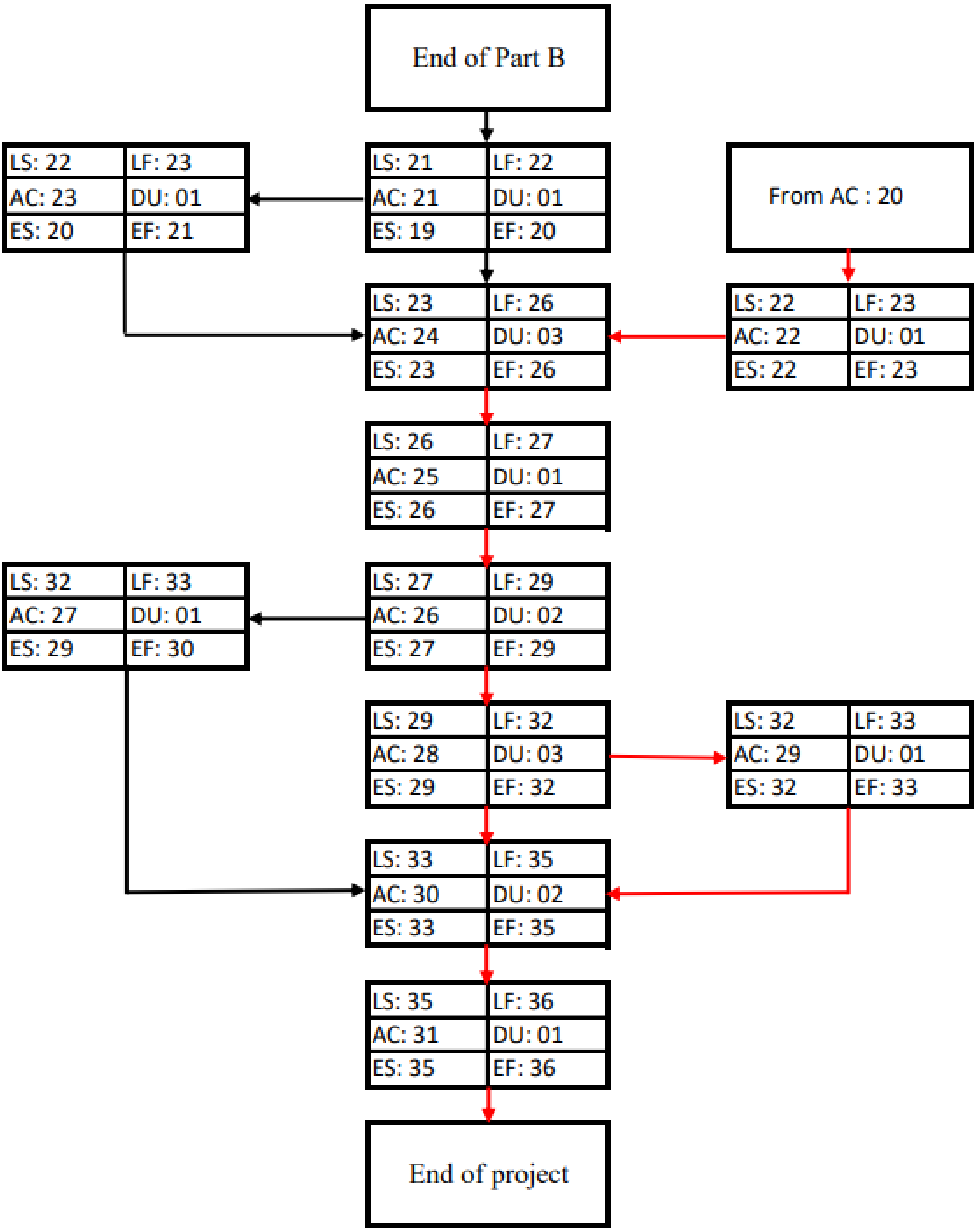

Fig 1.3: CPM Diagram.

Critical path: 1-2-3-5-6-7-8-11-12-13-15-16-17-18-20-22-24-25-26-28-29-30-31

The Project Completion Time: 36 weeks.

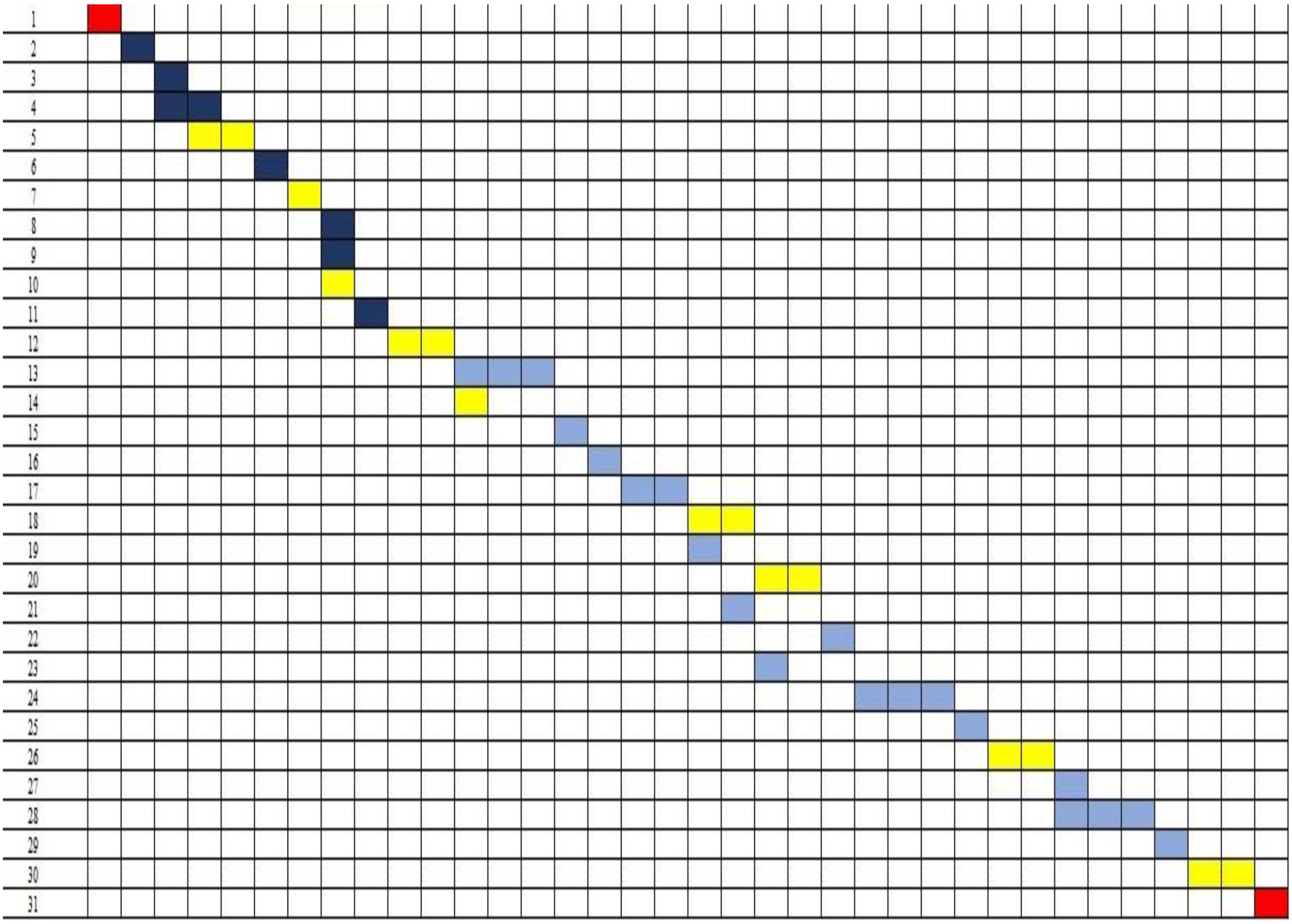

Fig 1.4: Gantt chart

Gantt Chart: A Gantt chart is a chart in which a series of horizontal lines shows the amount of work done or production completed in certain periods of time in relation to the amount planned for those periods. Gantt chart could be seen as a clear graphic representation of the timeline. The Gantt chart for our capstone project is displayed below.

1.6.2 Risk Management

Risk is a negative event that occurs throughout a project. Any risk can arise when working on a project. It can cause an unplanned project delay. The project cannot be implemented efficiently without risk management. We have discovered some risk factors that could have an impact on our capstone project. Afterwards, we will discuss some effective risk-reduction strategies.

Equipment unavailability: The project's equipment may become temporarily unavailable, which could cause it to take longer to complete. Even the production of some critical parts may be delayed for a few reasons. Additionally, there is a chance that certain items will not be offered in our nearby market or that buying local market goods may lead to a lower standard of quality.

- Mitigation Plan: In that case, we need to locate several equipment types that can meet the requirement.

Risk of budget: Although we estimated the project budget based on current market value, component prices are subject to change. Additionally, a component's price may rise due to a lack of supply on the market, which might lead to issues. About carrying out the activity that pertains to that component.

- Mitigation Plan: We will have to manage the extra funds and look for low-cost substitutes for the current machinery that serves the same purpose.

Uncertain Risks: Unavoidable circumstances such accidents, political arrest or financial crises may arise throughout the project, affecting the project time.

- Mitigation Plan: We need to be ahead of time to reduce the project's unidentified hazards.

1.6.3 Required resources and budget.

Our project includes both electrical and mechanical components. We will require various types of hardware and computational resources to finish our project. We will require specialized mechanical knowledge because our project contains mechanical components. Additionally, we will require outside labor for setting up and maintaining the main system. The following is a list of available hardware and computational resources:

Table 1.3 Required resources.

Hardware resources	Computational resources
1. Mechanical parts (PCB board, Buzzer, Display)	1. Proteus
2. Battery	2. Arduino IDE
3. Sensors (fire, smoke, temperature)	3. Solid Works
4. Connecting wire	4. Easy EDA
5. Arduino Uno / NodeMCU	

We must decide on the resources and appropriate budget to complete the project. Giving an accurate number is not possible because the project is currently in state 400-A. We will have to use estimates and make assumptions because there are currently too many unknowns.

<u>For the prototype making rough components price list:</u>

Table 1.4 List of components with price.

No.	Name of Equipment	Quantity	Unit Price (BDT)	Retail Price (BDT)	Maximum Cost (BDT)	Source
01	NodeMCU	1	420	450	550	Daraz website online
02	LCD display	1	200	220	220	Roboticsbd website online
03	MQ-2 smoke sensor	1	300	320	180	Roboticsbd website online

04	DHT11 temperature sensor	1	150	160	180	Roboticsbd website online
05	Relay	2	80	170	170	Patuatuli Electronics Market
06	Buzzer	1	20	25	30	Roboticsbd website online
07	12-volt step down transformer	1	120	120	150	Patuatuli Electronics Market
08	Bridge rectifier	1	25	25	30	Patuatuli Electronics Market
09	PCB	1	80	80	100	Patuatuli Electronics Market
10	Others		400	400	400	Patuatuli Electronics Market
Total				**1970 (BDT)**	**2010 (BDT)**	

<u>According to current market price our estimated installation cost:</u>

Table 1.5 Estimate installation cost.

No.	**Name of Equipment**	**Quantity**	**Unit price (BDT)**	**Total (BDT)**	**Maximum Cost (BDT)**	**Source**
01	Prototype Model	4	1970	7880	8040	Self-Created
02	24-inch monitor	1	8000	8000	8500	Electronics Market
03	Others		1500	1500	2000	
Total				**17380 (BDT)**	**18540 (BDT)**	

ROM Estimation: A Rough Order of Magnitude Estimation is supplied in the beginning of a project and is defined as -25% to +75% of the estimated cost.

Therefore, the ROM estimation will be for our project is 13035 Taka to 30415 Taka.

1.7 Project Product Lifecycle

This is the research phase before a project is introduced to the marketplace. If our project does well commercially, we will require resources to maintain and operate the project. When designing a sustainable product, the needs of the stakeholders must be satisfied. While producing the goods, any standards or codes should be followed. Following the implementation of the prototype, we must concentrate on the product's long-term viability. Our design has many parts like Arduino nano, node MCU, LCD display, buzzer, PCB, Different sensors etc.

Hardware Design:

I. Component Selection:

Microcontrollers: The project utilizes Arduino Nano and Node MCU microcontrollers. The Arduino Nano offers ease of programming and prototyping, while Node MCU boasts built-in Wi-Fi for seamless data transmission. Both possess sufficient processing power and memory for sensor data acquisition and basic analysis.

Sensors: Depending on specific requirements, the system could employ temperature, humidity, dust, gas, and noise sensors. Accuracy, range, and response time are crucial factors when choosing sensors. Regular calibration ensures long-term reliability.

Other Components: A sturdy PCB constructed from fire-retardant FR4 material provides a stable platform for component mounting. A transformer, rectifier, and relay efficiently convert and regulate power while ensuring safety.

II. Connectivity and Communication: Sensor data can be transmitted wirelessly via Wi-Fi or Bluetooth for flexibility and scalability. LoRa WAN offers an extended range for larger factory environments. Secure data transmission protocols like HTTPS prevent unauthorized access and data loss.

III. Durability and Environmental Protection: An IP65-rated enclosure safeguards the internal electronics from dust, moisture, and potential splashes. High-temperature resistant materials like polycarbonate further enhance durability in harsh industrial environments.

Internal components are protected with conformal coating to shield against dust and moisture ingress.

Software Development:

I. Sensor Data Acquisition and Processing: Microcontrollers collect sensor data at predetermined intervals. Filtering algorithms remove noise and outliers, improving data accuracy. Threshold values trigger alarms when environmental parameters exceed safe limits.

II. Alarm and Notification System: Multi-level alarms provide escalating warnings based on the severity of the situation. Visual displays, audible alarms, and SMS/email notifications alert relevant personnel immediately. Integration with existing factory safety systems ensures a coordinated response in emergencies.

III. Data Management and Analysis: Sensor data is stored and retrieved on a secure cloud server, enabling real-time monitoring and historical analysis. Interactive dashboards display environmental trends and identify potential hazards.

Maintenance and Support:

I. Preventive Maintenance: Regular cleaning and calibration of sensors prevent data drifting and ensure accuracy. Consumables like batteries are replaced proactively based on usage. Remote monitoring of key parameters allows early detection of potential issues before they impact system performance.

II. Corrective Maintenance: Modular design facilitates easy component replacement. Trained technicians can troubleshoot and repair hardware and software malfunctions using readily available spare parts.

III. Spare Parts Availability: Partnering with local distributors or maintaining an in-house inventory ensures swift replacement of critical components, minimizing downtime.

Future Development and Scalability:

I. Integration with existing systems: The system can be integrated with factory SCADA systems for comprehensive environmental monitoring and control.

II. New sensor options: Continuous research and incorporation of new sensor technologies like air quality and chemical sensors expand the system's capabilities.

III. AI and machine learning: Implementing AI algorithms for advanced data analysis can enable predictive maintenance, anomaly detection, and even personalized safety recommendations for workers.

Maintenance and improvement: Post product launch and installation, the issue of maintenance must be dealt with. This is a key aspect of the project because it determines the duration that the product will be accessible on the market, our product is intended for industry workers to improve their quality of safety and financial well-being. So, after a certain amount of time maintenance must be done to make sure efficient and long-term use of the product. We can do maintenance in those times when the industry remains off, especially in holydays so there will be no interruption to workers' work. Maintenance checks should be performed more regularly during adverse weather conditions. Anyone with a basic understanding of PCB can clean the circuit. However, highly skilled personnel must be involved to carry out maintenance checks on interior parts. For this reason, a group of people for maintenance should be created. Parts of the product might require to be fixed to replace at times. As a result, the parts must be widely available in the local market. When more pieces of the product become available on the market, we can try to include them in our design. We should continue our research to enhance the design for more effectiveness and performance in the future. The system could possibly satisfy the 100% needs of the stakeholders if we can scale up our idea.

1.8 Impacts of the project

1.8.1 Impacts on society

Industry's environment monitoring and safety system can have both beneficial and harmful effects on society, and these effects can change depending on its location, design, and surrounding social and environmental conditions. With the help of this system Industry workers can be alert on proper time if some accident occurs. Then they can move towards safe places and that will prevent a lot of injuries. This will not just help to save the lives of the industry workers but also will keep the working environment clean. The working environment will be monitored by the system continuously 24 hours a day. As a result of that the environment will be healthier, and a healthier working environment results in production growth. Industry will receive its benefit economically as well. This system will not just satisfy the industry workers but also the owners. A healthy and safe working environment will create interest for the new workers mind joining the industry. This system does not need any human interaction after installation. As a result of that the safety of the workers will not depend on anyone. On the other side as sediment and debris accumulate over time, this system needs frequent maintenance. Although the system will require extremely low input power, both operational costs and downtime may rise as a result. If by accident the wiring connections go wrong then it will start producing false alarm, which is something that nobody wants. This system also needs continuous power supply, although the input power is incredibly low but still without the help of continuous power supply this system will not be of any use.

1.8.2 Effects on environment and sustainability

If the project is executed on a large scale, the environment will be influenced in a variety of ways. The environmental ramifications cannot be overlooked, even though it will address a substantial societal issue, hence mitigating measures must be taken. We will be using batteries and electronics parts in our proposed contraption. To address the environmental issues, it will be wise to use a stage-by-stage approach. Gathering raw materials, creating products, recycling materials, and other phases are included:

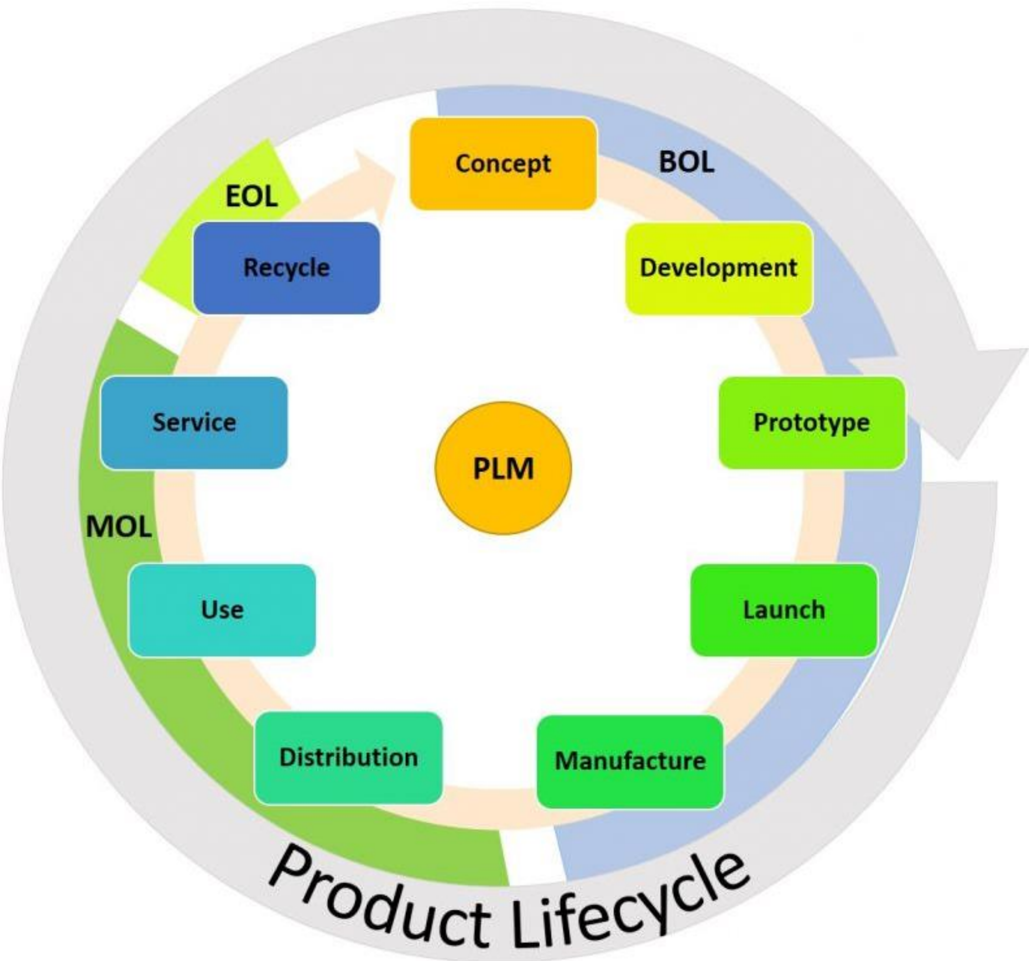

Fig 1.5: Product lifecycle [9].

Step 01: Raw Material Sourcing:

- **Positive Impact:** Safety systems often use materials that are sustainably sourced, such as metals with a low environmental footprint or recycled materials, reducing the demand for virgin resources.
- **Reduced Environmental Impact:** Sustainable raw material sourcing practices can lead to lower energy consumption in extraction and processing, as well as a reduction in habitat disruption.

Step 02: Manufacturing:

- **Energy Efficiency:** Environment monitoring system manufacturing processes typically prioritize energy efficiency, which reduces greenhouse gas emissions and lowers energy consumption.
- **Resource Efficiency:** Sustainable manufacturing practices minimize waste, generation and optimize resource use, contributing to reduced pollution.

Step 03: Product Use:

- **Low Energy consumption:** Safety system requires minimum power from sources, reducing reliance on fossil fuels and mitigating carbon emissions.
- **Longevity:** Well-designed and maintained safety systems have a long lifespan, reducing the need for replacements and conserving resources.

Step 04: Disposal:

- **Recyclability:** Safety systems are often designed with recyclability in mind, allowing for the recovery of valuable materials and minimizing landfill waste.
- **Safe Decommissioning:** Responsible decommissioning practices ensure that different sensors are removed and disposed of properly, reducing environmental risks.

Step 05: Collection:

- **Recycling Programs:** Collection and recycling programs at the end-of-life of the device can help recover materials and reduce the environmental impact associated with disposal.

- **Responsible Take-Back:** Manufacturers may offer take-back initiatives to collect, and recycle their device, promoting sustainable product life cycle management.

Step 06: Resource Recovery:

- **Recycling:** Recovering materials from decommissioned devices contributes to resource conservation and reduces the need for new raw materials.
- **Circular Economy:** Some safety system designs may facilitate the reusing of components or repurposing of the device for other applications, aligning with circular economy principles.

1.8.3 Health and safety issues

To ensure healthy and safety environment, some issues are taken into consideration, the following steps must be followed:

- The battery and all other electrical components will be located near the control room so, if those batteries are not managed properly then the on-duty people can detect that problem and that could be solved quickly.

- We must provide proper insulation, grounding and safety measures should be in place to prevent short circuits because the battery and all other electrical components will be located underneath the PCB.

- The battery that we will use in our project could be overcharged and it could blow up if it is overcharged. The device should feature overcharge protection for safety reasons.

- Additionally, we will put warning signs to keep anybody from messing with or touching the system in any way.

Fig 1.6: Health & Safety [10]

PART-B

With the help of modern engineering tools it is important to verify our concept idea before starting to make that physically. With the help of modern engineering tools we can able to simulate our device. By judging the simulation results we can modify our concept. By adding or changing tools or equipment the required device could become more useful and handy. Simulating a device also provide us a good idea about the device that we are building. All the information about power consumption, usage of various sensors, setting different threshold values for different cases can be monitored easily in this process. With the help of this part the concept of the targeted device become more clear which makes it easier to build.

Chapter 2 Project Design

2.1 Functional design

2.1.1 Considering the objectives, requirements, constraints.

Considering the following objectives:

- Improve Air Quality: Monitor and control smoke, fumes, and airborne contaminants to create a healthier working environment for factory workers.
- Maintain Safe Working Conditions: Detect and prevent fire hazards, electrical issues, and structural problems to minimize accidents and injuries.
- Optimize Resource Consumption: Track and manage energy use, water consumption, and waste generation to promote sustainability and cost reduction.
- Ensure Regulatory Compliance: Meet environmental and safety regulations set by local authorities and international standards.
- Enhance Worker Well-being: Monitor temperature, humidity, and noise levels to ensure a comfortable work environment and reduce worker fatigue.
- Improve Production Efficiency: By maintaining a safe and healthy environment, worker productivity and morale can be boosted.
- Real-time Data and Alerts: Provide real-time data on environmental conditions and potential safety hazards, allowing for immediate response and preventative measures.

Considering the following requirements:

- Safety measures: Creating a prototype with safety features to avoid mishaps during testing or demonstrations. Making sure there are no short circuits or loose connections, and that all parts are attached well.
- Sensor selection: Selection of appropriate sensors for this system is very important. With the help of the sensors this system will provide its output.
- PCB design: Flawless PCB design is essential for successful system development. The PCB Layout module will receive data from the schematic capture module in the form of a netlist. Utilizing this information, along with its design rules and various design automation tools, it facilitates error-free board design.

- Alert Systems: Establish protocols for generating alerts in case of exceeding safety thresholds.
- Control Mechanisms: Integrate systems to automatically address safety concerns.
- Scalability: Design a system that can be easily expanded or modified to accommodate future growth or changes in production processes.
- User Interface: Develop a user-friendly interface for system monitoring, data visualization, and control adjustments.

Considering the following constraints:

- Power Supply: Ensuring a reliable power supply for the system's operation across the entire industry might be a concern.
- Disruptions to Production: Installing and calibrating the system may cause temporary disruptions to factory operations.
- Worker Acceptance: Factory workers might need to adjust to working with the new monitoring system and altering work habits based on its alerts.
- Lack of Standardization: The absence of standardized protocols for RMG industry monitoring systems can create compatibility challenges.
- Infrastructure Limitations: Existing factory infrastructure may limit the placement or effectiveness of certain sensors.
- Sensor Technology: Installing a comprehensive network of sensors can be expensive, depending on the chosen technology and the size of the factory.
- Data Management: Storing and managing real-time data can require significant storage capacity and processing power, leading to ongoing costs.
- System Maintenance: Maintaining the system, including sensor calibration, software updates, and repairs, incurs additional costs.

2.1.2 Applicable standards, codes of practice, health, safety, and environmental considerations.

Standards and codes of practice considerations:

We will follow the standards of an internationally recognized organization. Keeping all these criteria in mind. We have decided to follow the standards provided by:

EC 61508: "Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems" provides a framework for assessing and managing risks associated with safety-critical electronic systems.[9]

ISO 12100: "Safety of machinery - General principles for design, risk assessment and risk reduction" outlines principles for identifying and mitigating safety hazards in machinery and equipment.[9]

ISO 16000: "Indoor air quality" series provides guidance on measuring and assessing various indoor air pollutants.[12]

Fire Safety: Adhere to national fire safety codes (e.g., National Fire Protection Association - NFPA) for proper fire alarm systems, extinguisher placement, and evacuation procedures.[13]

Worker Safety: Implement guidelines set by OSHA (Occupational Safety and Health Administration) for workers safety.

International Standards: For international RMG operations, consider ISO (International Organization for Standardization) standards relevant to environmental management (ISO 14001) and occupational health and safety (ISO 45001).[13]

Industry Best Practices: Look beyond regulations and incorporate best practices recommended by industry associations or NGOs focused on sustainable and safe garment manufacturing.

Air Quality: Standards like WHO (World Health Organization) guidelines for indoor air quality can guide acceptable levels for pollutants like dust, fumes, and VOCs (Volatile Organic Compounds).

Energy Consumption: Consider LEED (Leadership in Energy and Environmental Design) certification or local energy efficiency regulations to optimize energy use.

2.1.3 Health, safety, and environmental considerations.

Worker Exposure: During system installation and calibration, workers might be exposed to dust, fumes, or electrical hazards. Implement proper personal protective equipment (PPE) and safety protocols.

Noise Levels: Installation activities and some sensor operation might generate noise. Minimize noise exposure by using quieter equipment and following noise control regulations.

Ergonomics: Design the system interface to be user-friendly and minimize strain on workers who interact with it. Provide training on proper posture and techniques when using the system.

Electrical Hazards: Ensure qualified personnel handle electrical installations and maintenance to prevent electrical shocks and fires.

Fire Risks: Consider potential fire hazards during installation.

Slips, Trips, and Falls: Maintain clean and organized work areas during installation to minimize tripping hazards.

Maintain open communication with the stakeholders to address concerns and share information about the project's environmental practices.

2.1.4 Analysis of functional block diagram.

Now,

Considering everything as mentioned prior, the functional block diagram can be shown as,

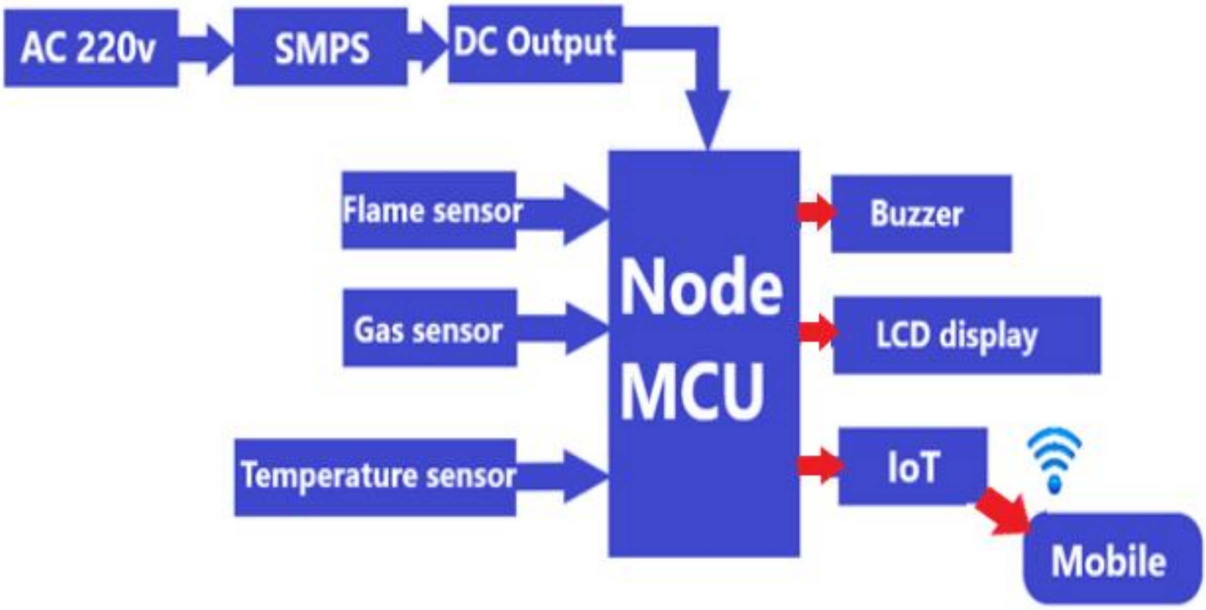

Fig 2.1: Functional block diagrams

NoduMCU: This is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi- Fi SoC from Express if Systems, and hardware which is based on the ESP-12 module.

SMPS: A switched- mode power supply is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source to DC loads, such as a personal computer, while converting voltage and current characteristics.

Buzzer: A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short).

LCD: LCD (Liquid Crystal Display) screen is an electronic display module and finds a wide range of applications. A 16x2 LCD display is a very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being LCDs are economical; easily programmable, have no limitation of displaying special & even custom characters (unlike in seven segments) and animations. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines.

Arduino IDE: The digital microcontroller unit named Arduino Nano can be programmed with the Arduino software IDE. There is not any requirement for installing other software rather than Arduino. Firstly, Select "Arduino Uno" from the Tools, Board menu (according to the microcontroller on our board).

Smoke Sensor Module MQ-2: The MQ-2 sensor module is a versatile tool that detects smoke and various flammable gases like butane (C_4H_{10}), Carbon Monoxide (CO), Propane (C_3H_8), Chlorine (CL_2), Ammonia (NH_3) and smoke. This sensor's concentration range is 200 ppm to 10000 ppm. Its adjustable sensitivity allows to tailor it to the project's needs. While commonly used for industry's security and air quality monitoring, it requires integration with a microcontroller for full functionality.

Temperature Sensor DHT 11: The DHT 11 is a basic sensor that measures both temperature and humidity. It's cheap and easy to use but has limitations. It reads temperature from 0°C to 50°C with ±2°C accuracy and humidity from 20% to 90% with ±5% accuracy.

IC 7805: The IC 7805 is a very common and useful integrated circuit that acts as a voltage regulator. It's specifically designed to provide a steady +5V output voltage, even if the input voltage going into the circuit varies. This makes it a reliable component for powering various electronic devices and circuits that require a stable 5V supply.

TRAN-2P2S: TRAN-2P2S assumes as an ideal transformer, meaning it has no losses due to resistance or leakage. It is a component within Proteus that represents a simple transformer with two primary pins (P) and two secondary pins (S). It's commonly used to simulate ideal transformers in circuit designs.

Bridge Rectifier: A bridge rectifier is a circuit component used to convert an AC signal into a pulsating DC signal. It achieves this by allowing current to flow in one direction while blocking it in the opposite direction. This is typically done using four diodes configured in a specific way.

2.2 Analysis of alternate solution

2.2.1 IoT based upgradable system.

If abnormal situation occurs in the industry, then the Smoke Sensor Module MQ2 is going to detect that and send a signal to the NodeMCU about the situation. Meanwhile the Temperature Sensor DHT 11 will detect the rise in temperature because of the fire or the extreme heat and if the temperature exceeds the given threshold value of the sensor, then the Temperature Sensor is going to send a signal to the NodeMCU as well. After receiving both signals, the NodeMCU is going to perform some specific tasks such as it's going to ring the buzzer and show an alarming message using the LCD unit. The NodeMCU then going to give current in the base of the two BC 547 transistors which will take the transistors in active state thus the relays connected to the transistors are going to go from normally closed to open condition and it will make the indicator lights connected to the relay turn on. Finally, a message will be sent to a specific mobile phone using the NodeMCU notifying the proper authority about the situation.

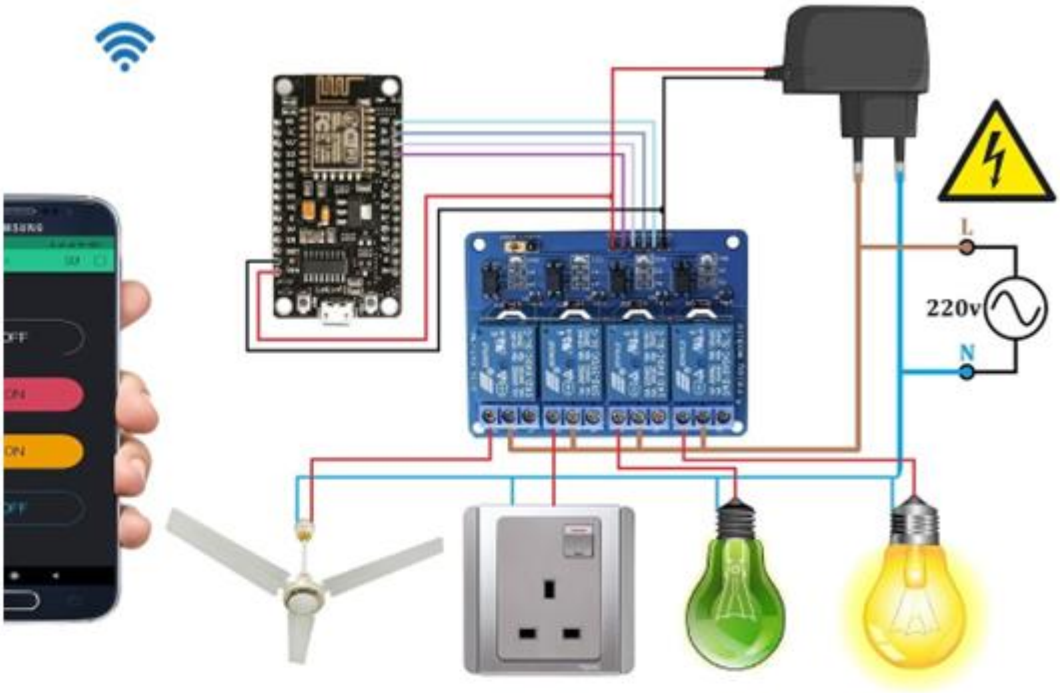

Fig 2.2: IoT system.[14]

2.2.2 Using Arduino Uno:

There are several alternative solutions for our project one of them is to use Arduino Uno. In this design when something occurs in the industry, then the Smoke Sensor Module is going to detect that and send a signal to the ArduinoUno about the situation. Meanwhile the Temperature Sensor will detect the rise in temperature because of the extreme heat and if the temperature exceeds the given threshold value of the sensor, then it is going to send a signal to ArduinoUno. After receiving both signals, ArduinoUno is going to perform some specific tasks such as it's going to ring the buzzer and show an alarming message using the LCD unit. The ArduinoUno then going to give current in the base of the two transistors which will take the transistors in active state thus the relays connected to the transistors are going to go from normally closed to open condition and it will make the indicator lights connected to the relay turn on.

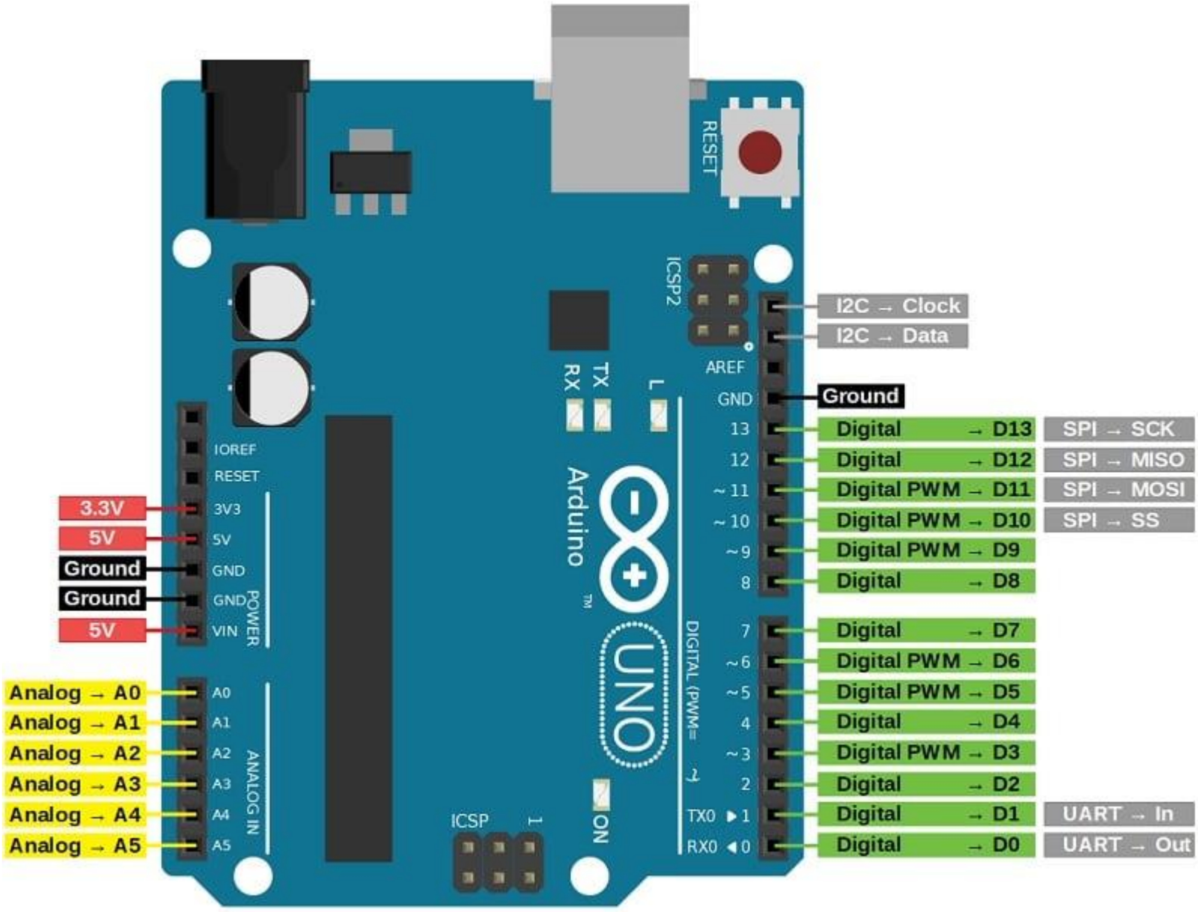

Fig 2.3: Arduino Uno.[15]

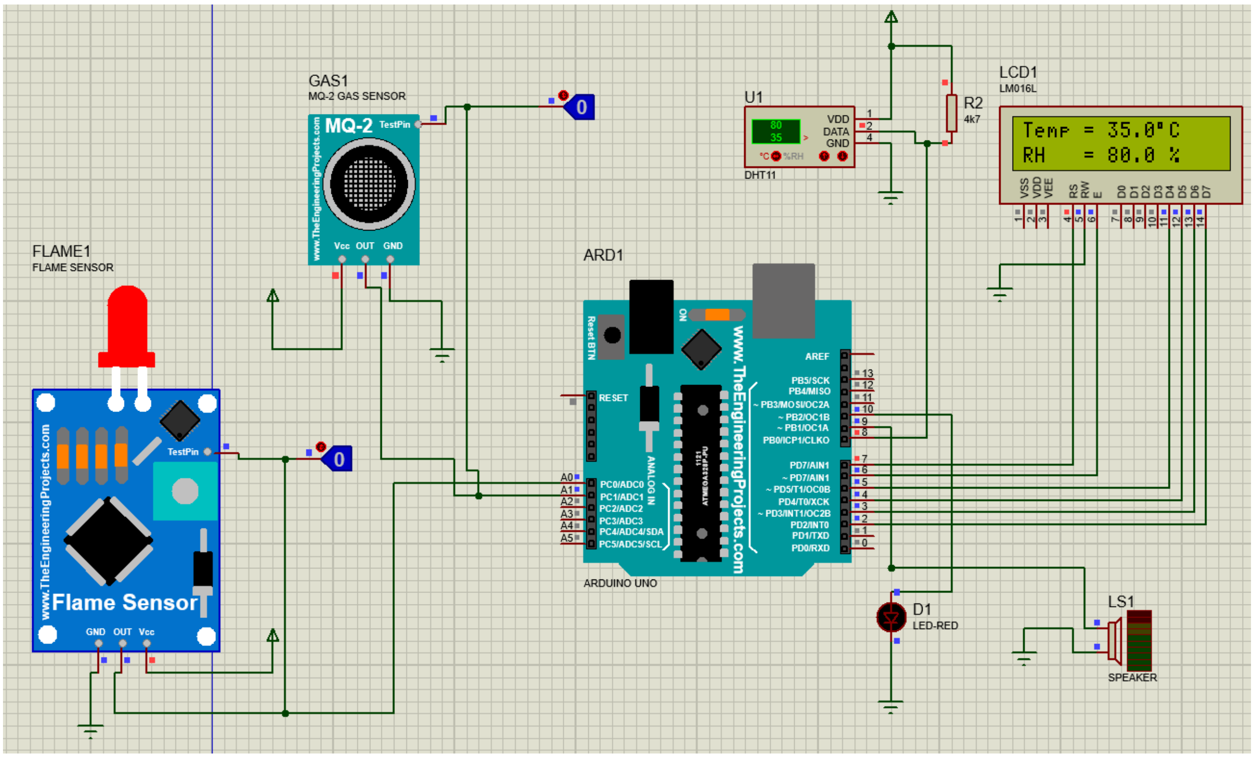

Fig 2.4: Circuit diagram using Arduino Uno.

Both solutions fulfil most of the requirements of this project. The main goal of this project is monitoring the system twenty-four hours a day continuously seven days a week and providing the results accurately. Also, when an abnormal situation arrives then the system should provide that information by using its output. In this system an alarm is used for output. Both solutions can detect accurate room temperature and room humidity by using the temperature and humidity sensors. For both systems a threshold value has been set so that when the temperature touches 36 Degree Celsius or crosses that, then the system will not just provide that information but also provide an alarm to notify the workers. In the case of detecting fire the system will also provide that information and notify the workers using its alarm. In addition, if gas is detected the system will do the same work. It will provide that information by using its alarm and its display.

This diagram is made for better point of view:

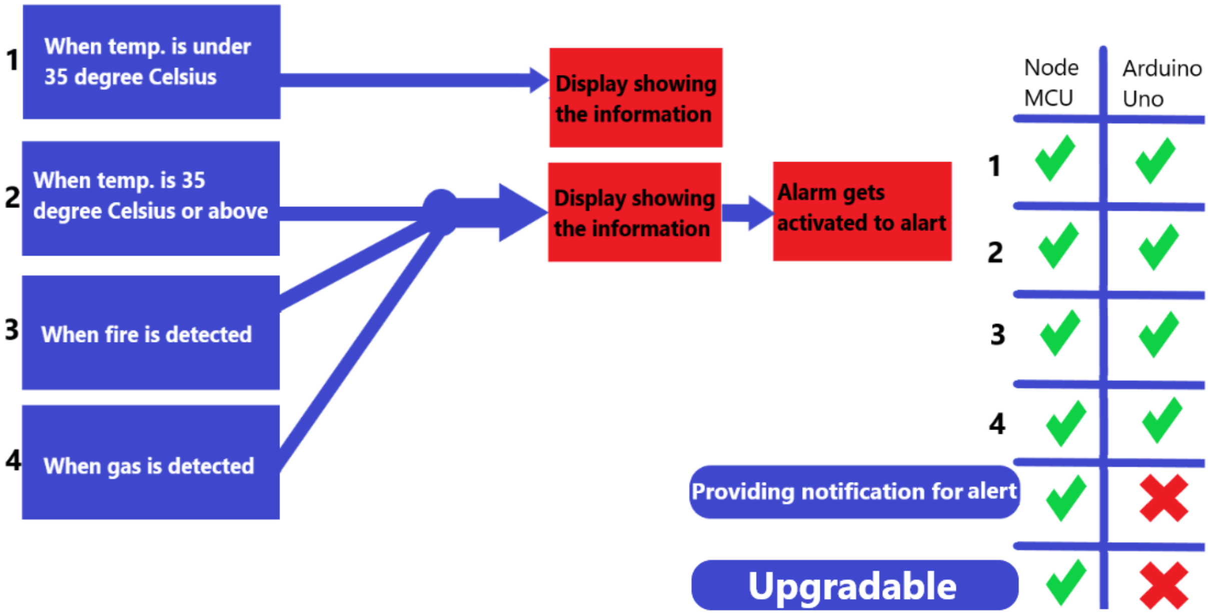

Fig 2.5: Diagram of fulfilling requirements.

From the diagram it is quite simple to understand that the solution with NodeMCU is better for this system. It can provide notification for alerts because NodeMCU has a Wi-Fi module. With the help of that it can send notification to a smartphone, unfortunately Arduino Uno cannot do that. Also, the NodeMCU is an upgradable module, therefore it is possible to add some extra features in future to this system. Unfortunately, Arduino Uno is not upgradable at all.

By judging all the outcomes, it is quite clear that the solution using NodeMCU will be better for this system.

2.3 Refined design

We have selected the IoT based environment monitoring system and for our primary design and Arduino Uno based prototype design based on alternative solution analysis. The justification for selecting these is briefly explained below.

By comparing both of those methods it is quite simple to say that the process which uses IoT based system is the most suitable for our design and implementation. Here are some reasons behind that:

Wireless Communication: The IoT system has NodeMCU, which has built-in Wi-Fi capabilities which allows it to directly send a notification to a designated mobile phone. This eliminates the need for additional hardware or complex wiring for remote alerting.

Lower Power Consumption: Normally, NodeMCU is known for lower power consumption compared to Arduino Unos. This can be crucial for long-term battery operation in an industrial setting.

Potential for Advanced Features: IoT based system can be programmed with more complex logic and functionalities compared to Arduino Unos. This might allow for future expansions in the system.

This is why IoT based solution offers more streamlined, wireless, and potentially more scalable solution for an environment monitoring system in the RMG industry.

PCB Design:

In this part we are going to describe about this system's PCB design. First for an IoT based device we consider NodeMCU V3 ESP8266. Then we connect our required sensors (temperature, fire, gas etc.). We place them on the physical circuit board and connects those sensors with the ModeMCU following the circuit diagram. Each sensor connection must be separated from one to another. Otherwise, those wires will cause short circuit and because of that the device will not work properly. Also, just to get the information about the buzzer we also added a LED as an output.

Proteus simulation:

The simulation of this device has done by using software Proteus. By placing all the equipment's, the connections must be complete as the diagram. After the NodeMCU V3, fire sensor and the temperature sensor need proper coding to run the entire devise properly. In the code the threshold temperature of the temperature sensor is set at 36 degrees Celsius therefore when the temperature moves to 36 degrees Celsius or more the device will not just show the output in the display but also the buzzer will notify the workers. Same for the fire and gas sensors when the sensors detect gas or fire then the device will give its output by using the display as well as the buzzer. Normally the display will show the current temperature and humidity of the environment. For simulation part an LED is added in parallel with the buzzer just to confirm that the buzzer is working properly.

We used Node MCU V3 ESP 8266 and connected that with fire sensor using its pin D5. Same way MQ-2 gas sensor was connected with that by using pin D7. In addition, for changing the temperature as well as the humidity we added DHT11 with the Node MCU by pin D6. For the outputs buzzer was connected by using pin D2 and display by pin Rsv and A1. By passing the transformer, bridge rectifier and a capacitor the input power is provided to the Node MCU V3.

While coding each sensor were connected with the Node MCU V3 very carefully. Each sensor must have to be connected with the accurate pin number of Node MCU.

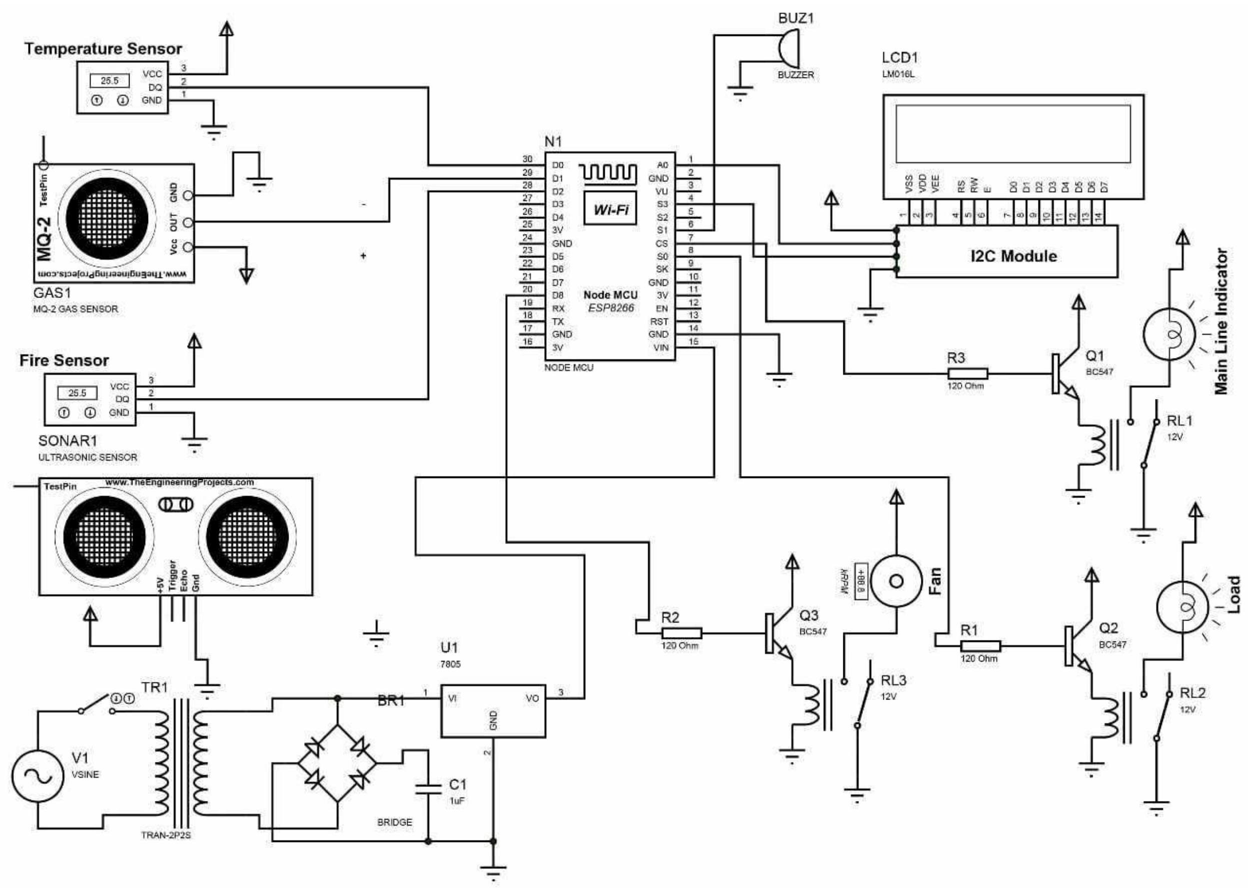

Fig 2.6: Circuit Diagram.

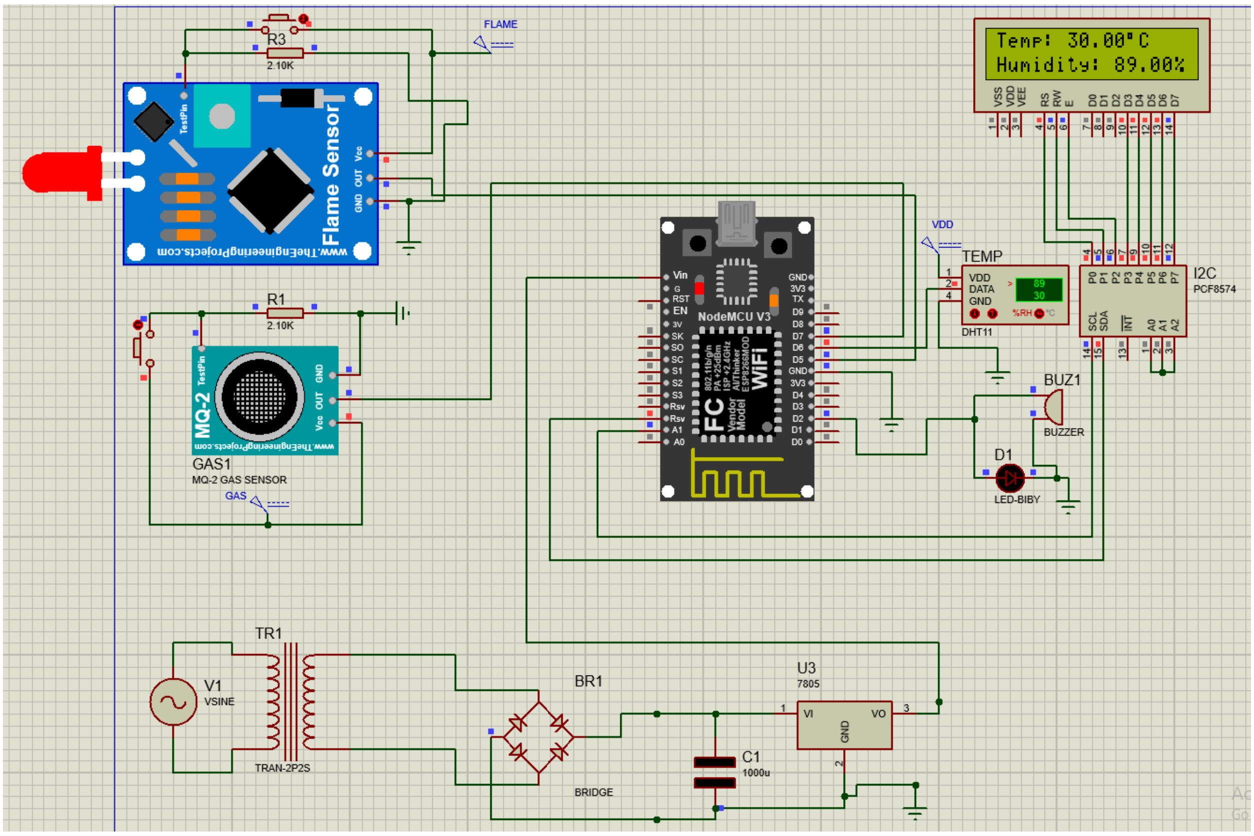

Fig 2.7: Final circuit diagram in Proteus.

Temperature and humidity sensor will show the outputs in the display. This way the working environment will be monitoring continuously.

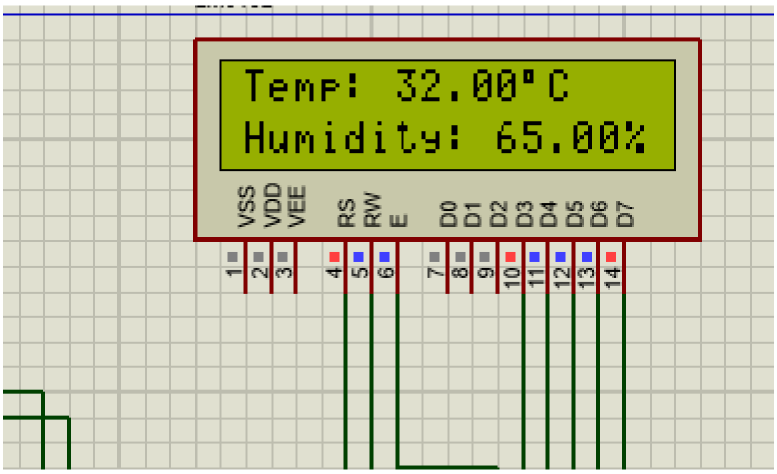

Fig 2.8: Temperature and humidity sensor's output.

When the temperature crosses 36 degrees Celsius, display will provide an alert and the buzzer will notify.

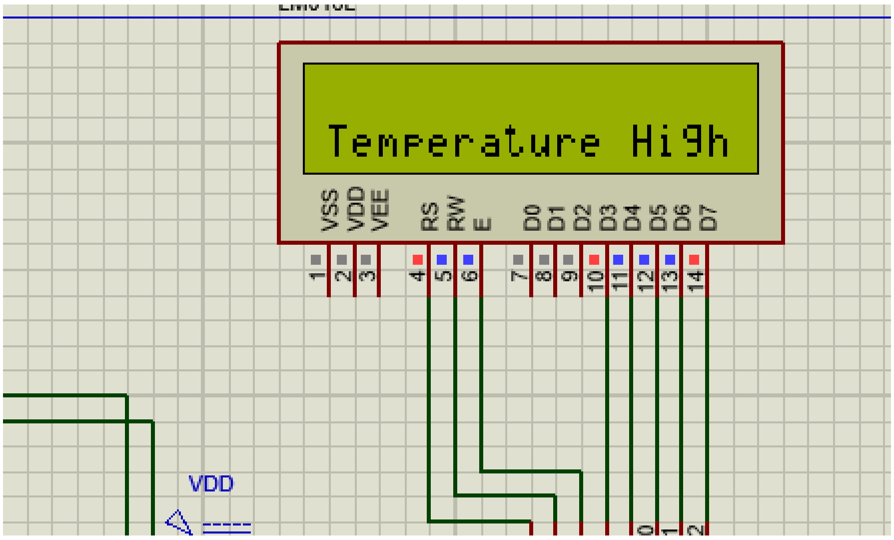

Fig 2.9: High temperature alert.

When the flame sensor detects fire, display will show that information and the buzzer will notify.

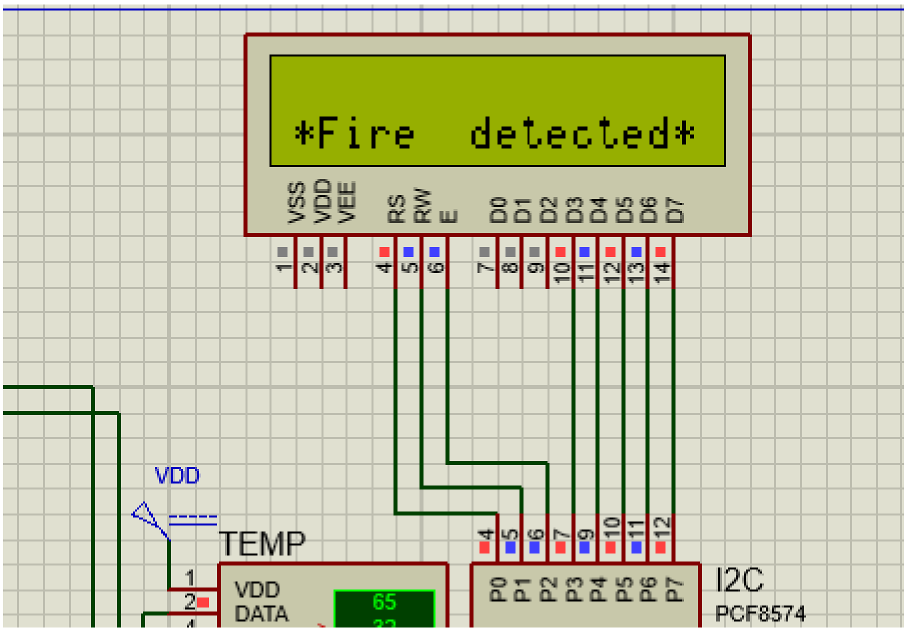

Fig 2.10: Fire detection alert.

When the MQ-2 gas sensor detects gas among butane (C_4H_{10}), Carbon Monoxide (CO), Propane (C_3H_8), Chlorine (CL_2), Ammonia (NH_3) and smoke, display will show that information and the buzzer will notify.

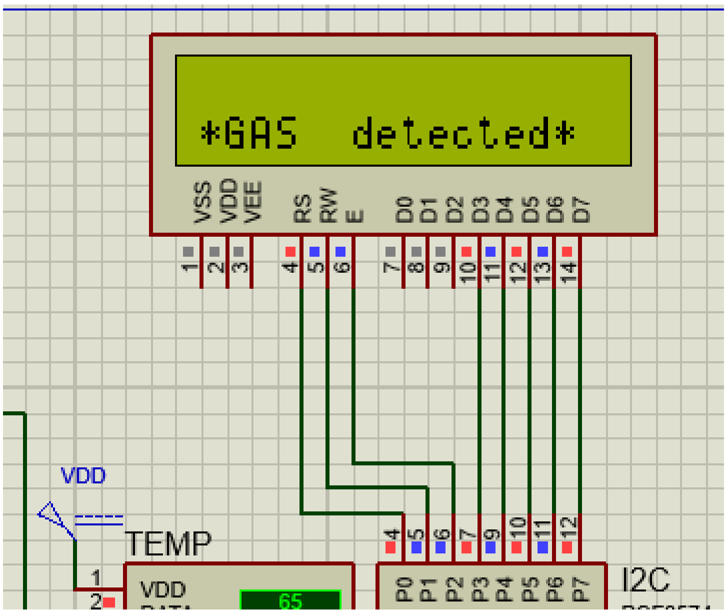

Fig 2.11: Gas detection alert.

LED is connected in parallel with the buzzer just to indicate that the buzzer is working properly.

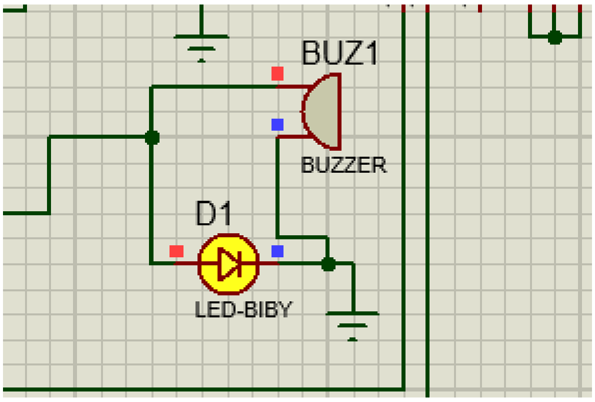

Fig 2.12: LED connected with buzzer.

The main goal of this project is to provide safety to the garment workers. By monitoring the working environment all the time a device can provide a healthy working environment to the workers. Also, when the system detects a critical condition (such as detecting fire, high temperature with humidity and high gas concentration) the system will notify about that problem by using its display and its alarm. This system will monitor the working environment 24 hours a day, seven days a week continuously. This system will not just provide safety to the workers but also ensure a healthy working environment. A healthy working environment will increase production. The designed system above fulfills all our requirements. It will monitor the working environment as well as notify staff about the situation. This system does not need any human interaction after installation, it will continuously do its required job accurately.

Table 2.1: Required features with fulfilling requirements.

Required features	**Fulfilled (✓)/Not Fulfilled (×)**
Continuously monitor the working environment	✓
Continuously showing the results using the display	✓
Notify when temperature cross 35 degrees Celsius	✓
Notify when humidity cross 90%	✓
Notify when fire gets detected	✓
Notify when gas gets detected((C_3H_8, CO, C_4H_{10}, NH_3, CL_2 and smoke))	✓
Notify using the alarm and smartphone when critical condition gets detected	✓
Upgradable, can add more features in future	✓

PART-C

Here in this section we started to build our device physically. After analyzing all the information that we received in our simulation this is the part where we modify our design and start to build that physically. Usually it is easier to build something when we already know the possible results with the help of the simulation results. Typically in this stage design get some changes for better accuracy and better usability. To fulfill all the objectives these steps are extremely valuable. The device have a chance to improve its performance in these steps. This system has multiple sensors and one of its sensors were calibrated. That makes the entire device lot useful compare with before. The accuracy level were improved and interface become easier. In this particular section the device had to face the challenge of staying strong in the complex situations. This help to make the device a strong engineering product that can handle complex matters on its own.

Chapter 3 Demonstration of Implemented Solution and Finalization of Design.

3.1 Development of the prototype

For our prototype, we have included the bridge rectifier, transformer, regulator, and two indicators. The remaining components are the same as those listed in 400-B. We first purchased all the components needed to make the structure's frame, board, and bucket before beginning to build the prototype. The following is a list of the parts used:

Table 3.1 Specifications of the mechanical parts of prototype

Item	Specification	Purpose
PCB		To place the main circuit with other components.
Full wave rectifier		Used for four individual rectifying diodes to connect in a closed loop bridge configuration to produce the desired output
Transformer	AC-230V to AC-12V	To change the value of an alternating voltage.
MQ-2 sensor (calibrated)	DC-5V	To measure the gas concentration in ppm (parts per million)

After creating the main circuit physically we place the circuit in the physical circuit board (PCB). Then we place our components in the PCB according to our design. All the components were placed carefully and efficiently, so that none of them could provide unwanted connections. The PCB Layout module is automatically given connectivity information in the form of a net list from the schematic capture module. It applies all the information, together with the user specified design rules and various design automation tools so that we can assist with error free board design. PCB provides up to 16 copper layers that can be produced with design size limited by product configuration.

Fig 3.1: Step down transformer

Fig 3.2: Buzzer

Fig 3.3: Relay module

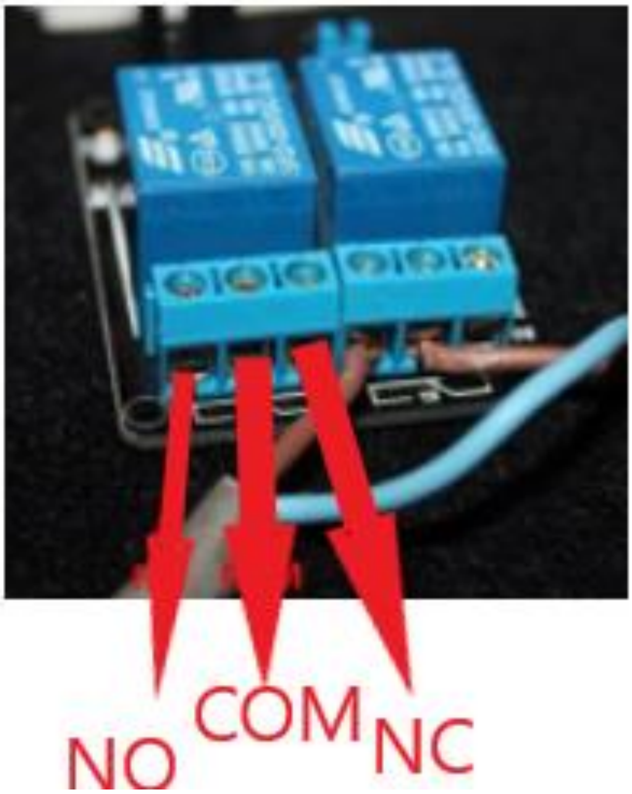

Fig 3.4: Connections (1)

Fig 3.5: Connections (2)

Blynk App– The mobile app developed by Blynk works as a control panel for visualizing and controlling the hardware. It is available for both Android and iOS. The app offers a very productive interface and various different widgets for different purposes. Blynk works on a currency of its own called energy. New users get 2000 amount of Blynk energy with a free Blynk account and this energy is used to buy and deploy widgets in the projects.

Fig 3.6: Blynk App

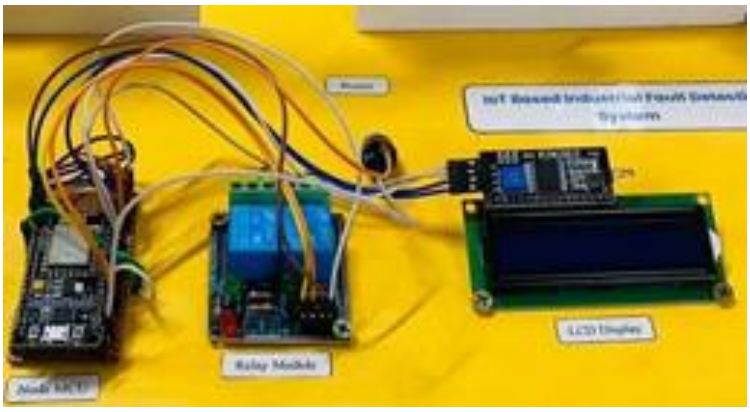

Fig 3.7: After connections

3.2 Performance evaluation of implemented solution against design requirements

For performance analysis, we have calculated 6 different scenarios. In each case our device was working accurately.

Our prototype's recognition performance is shown in the following table.

Table 3.2: Different cases with results.

Case	Result
Temperature under 36 degree Celsius	Indicator & alarm remains off
Temperature is 36 degree Celsius	Indicator & alarm turns on + notification sent to smartphone
Temperature crosses 36 degree Celsius	Indicator & alarm turns on + notification sent to smartphone
Fire detected	Indicator & alarm turns on + notification sent to smartphone
Gas detected (<250ppm)	Indicator & alarm remains off
Gas detected (>250ppm)	Indicator & alarm turns on + notification sent to smartphone

Table 3.3: Different concentration levels for different gases.

Gases	Maximum concentration range of MQ-2(calibrated)
Propane (C_3H_8)	1800 ppm
Carbon monoxide (CO)	50 ppm
Butane(C_4H_{10})	800 ppm
Ammonia(NH_3)	25 ppm
Chlorine(Cl_2)	0.5 ppm

Thus table shows when the temperature remains under 36 degree Celsius then the device will keep the indicator and alarm off. However when that temperature touches or crosses 36 degree Celsius then the alarm and indicator will turn on and notify everyone. Finally when the system detects any gas among Propane (C_3H_8), Carbon Monoxide (CO), Butane (C_4H_{10}), Ammonia (NH_3), Chlorine (CL_2) and smoke than the gas sensor will measure the gas concentration. If the gas concentration those levels or crosses that level then the indicator with the alarm will turn on.

Here is how LM393 fulfills all of them as the flame sensor

• It has quick response time, otherwise fire could get spread through cotton, linen, silk or other textile materials.

• It has higher sensitivity, therefore it can detect flame from a long distance which is extremely important because usually there are many rows of desks are placed one after another and there are multiple columns. It is important to detect flame from such a gathering place like that.

• It is able to detect small flames, therefore the damage could get less if fire gets detected in an early stage.

• This sensor provides analog output, which allows for more detailed monitoring and integration by using advance system.

• This sensor is highly preferred for industrial safety usage for its better accuracy in detecting fire.

DHT-11 temperature & humidity sensor also fulfills the requirement for rmg industry's safety system.

• It can detect both temperature and humidity level, which eliminate the need of separate sensor, it also simplifies integration process and rmg industry requires easy integration process in their safety system.

• DHT-11's digital interface makes it easy to connect directly to microcontrollers and other digital devices, reducing the need for additional circuitry.

• It has small form factor, which makes it easy to install in various locations which is important in RMG industry because usually industry offers little spaces to set sensor.

• It provides real-time measurements of temperature and humidity that allows to monitor working environment inside of a garment industry.

• It is inexpensive and widely available that makes it easy to replace also provide advantage while maintenance.

• It is designed to consume less power, which makes it suitable because here energy efficiency is a concern.

3.3 Finalization of design

Following the performance evaluation outlined in section 3.2, the suggested enhancements for our primary design are as follows,

In this project, we have used a step down transformer to step down the input ac supply to get our desired value and then we used rectifier circuit and filter to get a dc output. Then the regulator IC (integrated circuit) has been used to output a regulated 5V so that we can use it to run the NodeMCU. The readings received from the fire, gas and temperature sensors helped the NodeMCU to make necessary decisions.

Finally we place our circuit to the physical circuit board and then place rest of the components carefully. It was noticed that not a single component could not provide unwanted connections with one another. It was also important that all the components were placed on the physical circuit board efficiently. As compacted the device will be the more efficient and easy to carry the device will be.

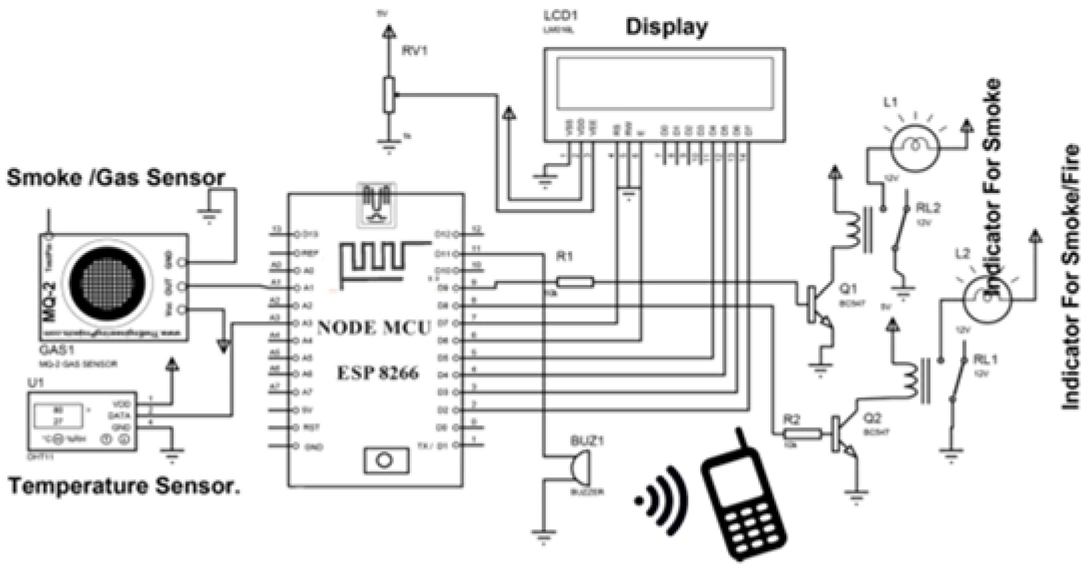

Fig 3.8: Electrical circuit

3.4 Use of modern engineering tools

We have used different types of software and modern engineering tools to implement and simulator our results. The uses if those tools are as follows;

1. Arduino: We have collected the data using Arduino, various sensors and relay module. To take data, we needed to have good expertise with the software and have a decent computer.

2. Microsoft Excel: To use the data in a proper way, we needed to have a basic expertise with the software and have a decent computer.

3. Arduino IDE: The digital microcontroller unit named Arduino Uno can be programmed with the Arduino software IDE. There is not any requirement for installing other software rather than Arduino. To set the temperature and gas level this software was used.

4. Proteus: Proteus is a popular software used for electronic design automation (EDA). It allows engineers to design, simulate, and layout printed circuit boards (PCBs). Key features include schematic capture, circuit simulation, and PCB layout tools, making it a versatile choice for electronics development.

Chapter 4 Review of Milestone Achievements and Revision of Schedule

In our project, there are some milestones. A few of the milestones weren't reached on time. We have put modifications in place to lessen those milestones by altering the project plan.

We have completed our capstone project in 3 semesters. We started 400A on the fall 2023 semester and consider 66 days for completed Part A. But the duration of spring 2024 semester was longer than our plan. Due to this, we got 87 days instead of 66 days for completed 400B. So, as we started our 400B on spring 2024 semester and consider the 80 days for completing, we got in total 109 days. We got more time than our expectation. The 400C started on summer 2024 semester. According to our expectation and project plan, we considered 38 days to complete it. We had to completed all the works including the submission of the report and our project presentation on due time, in total 110 days. As a result, we got 12 days extra to complete 400C. As our capstone project plan does not match 100 percent with our expected duration, we had to revise our project plan according to our semester period. So, we modified the date and time duration of the project plan for part A, Part B and part C according to our fall 2023, spring 2024 and summer 2024 semester period.

Therefore, the revised project plan is given below,

Table 4.1: Milestones

Milestone	Estimated deadline	Acquired date	Duration (days)	On time/delay
Slide making and presentation	17.10.2023	15.10.2023	15	On time
Performing the stakeholder survey and accomplishing the requirements	29.10.2023	27.10.2023	10	On time

Project plan and risk management	05.11.2023	07.11.2023	9	Delay
Project proposal report preparation	12.11.2023	11.11.2023	7	On time
Analysis of alternate solution	17.12.2023	15.12.2023	37	On time
Prototype design preparing	27.03.2023	29.03.2023	57	Delay
Preparing report	29.04.2023	28.04.2023	32	On time
Design completion based on performance analysis	07.05.2024	05.05.2024	12	On time
Preparing final report	11.09.2024	09.09.2024	66	On time
Project presentation	07.10.2024	05.10.2024	29	On time

Project plan and risk management: The project plan and risk management have been delayed due to indecision about the project's conduct and risk mitigation. To meet the deadline, other tasks must be completed in advance.

Prototype design preparing according to real life: The prototype design was delayed due to the need to conduct various alternative analyses to verify the preliminary layout. The team had to learn new things to perform these analyses, which prevented us from finishing on time. As a result, other work had to be completed before the deadline.

Chapter 5 Cost of Solution and Economic Analysis

5.1 Bill of materials cost of solution

The prototype cost is given below:

Table 5.1: Prototype cost

Equipment	Quantity	Price	Total cost (BDT)
PCB	1	150	150
12-volt step down transformer	1	120	120
Relay	2	80	170
DHT11 temperature sensor	1	150	150
Bridge rectifier	1	25	25
MQ-2 smoke sensor	1	300	300
Node MCU	1	470	470
LCD display	1	200	200
Total cost		1495	1585

We used our list of components to build our prototype. We used the parts we planned to make our first model. When we checked the prices, they were cheaper than we thought. But because of problems like COVID-19, the war between Russia and Ukraine, and the war in Palestine, the dollar got stronger. Also, our country were unstable for few months. Those made things more expensive and there weren't enough parts available. So, our model cost more than we expected. The parts we chose became much more expensive. The war and the virus made it hard for companies to get the parts they need**.** This made the parts more expensive. Because of these problems, we had to change some parts in our model. In the future, when our compact design is commercialized, we will replace those components with ones that fully satisfy our criteria.

Table 5.2: Cost of proposed design

Equipment	Quantity	Price	Total cost (BDT)
PCB	1	90	90
12-volt step down transformer	1	220	220
Relay	2	80	160
DHT11 temperature sensor	1	160	160
Bridge rectifier	1	50	50
MQ-2 smoke sensor	1	300	300
Node MCU	1	450	450
LCD display	1	220	220
Total cost		1570	1650

The retail price in this case is 1650 BDT. We are aware that the retail price is typically 60% less than the wholesale price. As a result, 100 BDT is the wholesale price (1650×0.6). The ultimate and final design for any project that can provide the device's small form is the one that is proposed. This above table will provide us with the compact form of our design for our project, which will also appropriately satisfy the needs of the stakeholders. This is the rationale of conducting additional economic analysis utilizing the suggested design table's cost.

5.2 Economic analysis

Bangladesh is a developing country. There are hundreds of garments industries in big cities like Dhaka, Chottogram. Thousands of workers work there most of them without knowing anything about safety. Our main purpose is to provide them safety. The self-life of the components we used here is 5 years. Every component has a lifespan double the length of its guarantee. Therefore, we decided on a 5 year system life time.

Table 5.3: Operational cost

Employee	No. of employee	Salary (BDT)	Salary per year (BDT)
General manager	1	22000	264000
Marketing Manager	1	20000	240000
Technical specialist	3	12000	432000
Technician	4	12000	576000
Salesman	3	8000	288000
Accountant	1	13000	156000
Office rent	-	10000	120000
Total cost			2,076,000

Operation and maintenance cost in per year will be 2,076,000 taka. At first, we want to generate 5000 units annually.

There are a total of 13 employees. We have selected the festival bonus as half of the employee's monthly salary. We want to operate the office centered in Dhaka. Because we manufacture the item without the use of any large machines. So, in Bosila, Mohammadpur, Dhaka, we rent a business unit that is 2500sqft.

Furthermore, we will use digital marketing on social media platforms (Facebook, Instagram, YouTube etc.) through advertisements and page boosting because social media is now widely used and a typical way to contact people. Facebook advertising will be displayed for 20 days every month. The ads will cost 8 dollars per day [16]. So, in 20 days the cost will be (8*20) = 160$ = 18,785 Taka. That means (160*12) = 1920$ which is 2,25,431 Taka. Facebook Boosting costs 16000 Taka per month [17]. Now per year boosting cost (16000*12) = 192,000 Taka. For leaflets distribution, per month 4000 Taka. Per year = (4000*12) = 48,000 Taka. Here, total monthly marketing cost = (18,785+16000+4000) = 38,785 Taka. Also, per year total marketing cost= (38,785*12) = 4,65,420 Taka.

Table 5.4 Utility cost

Description	Unit	Expenditure per month(BDT)	Expenditure per year(BDT)
Office rent	1	15000	180000
Marketing cost	-	38785	465420
Utility bills	-	5000	60000
Meals and refreshments	13	1500	234000
others	-	3000	36000
	Total expenditure	=	9,75,420 Taka

Total annual expenditure, ΔP = O&M Cost + Production cost of 5000 pieces = 2,076,000 + 9,75,420 + (1000*5000)

= 80,51,420 Taka.

Unit selling price = 2,390 Taka.

Annual sell = 5000 units × 2,390 Taka = 1,19,45,000 Taka.

Present value Function is used to know the value of the money in future at today's price.

Present Value Function:

Interest rate, Discount rate, inflation rate of Bangladesh Bank

Discount rate, d = 4% [18]

Interest rate, I = 6% [19]

$$PVF\ (d,n) = \frac{(1+d)^{n-1}}{d \times (1+d)^n}$$

$$= \frac{(1+0.04)^{5-1}}{0.04 \times (1+0.04)^5}$$

$$= 4.451$$

Annualizing the investment:

Interest rate and discount rates were found from the Bangladesh Bank,

Annual Loan Payment, A = P × CRF (i.n)

Here, CRF: Capital Recovery Factor

$$CRF\ (i,n) = \frac{i(1+i)^n}{(1+i)^n - 1}$$

$$CRF\ (6\%,5) = \frac{0.06(1+0.06)^5}{(1+0.06)^5 - 1}$$

$$= 0.234$$

Annual Loan Payment, A = CRF (i,n) × P

= 0.234 × 80,51,420

= 18,84,032.28 Taka/Year.

Annual Saving, ΔA = Annual Sell – Annual Loan Payment – Total Annual Expenditure

= 1,19,45,000 - 18,84,032.28 - 80,51,420

= 20,09,547.72 Taka

First Cost, ΔP = 80,51,420 Taka.

Simple Payback Period = $\frac{\Delta P}{\Delta A} = \frac{80,51,420}{20,09,547.72}$ = 4.006 Years

Life (years)	9%	11%	13%	15%	17%	19%	21%	23%	25%	27%	29%	31%	33%	35%	37%	39%
1	0.92	0.90	0.88	0.87	0.85	0.84	0.83	0.81	0.80	0.79	0.78	0.76	0.75	0.74	0.73	0.72
2	1.76	1.71	1.67	1.63	1.59	1.55	1.51	1.47	1.44	1.41	1.38	1.35	1.32	1.29	1.26	1.24
3	2.53	2.44	2.36	2.28	2.21	2.14	2.07	2.01	1.95	1.90	1.84	1.79	1.74	1.70	1.65	1.61
4	3.24	3.10	2.97	2.85	2.74	2.64	2.54	2.45	2.36	2.28	2.20	2.13	2.06	2.00	1.94	1.88
5	3.89	[illegible]	[illegible]	3.35	3.20	3.06	2.93	2.80	2.69	2.58	2.48	2.39	2.30	2.22	2.14	2.07
6	4.49	$\boxed{4.23}$	$\boxed{4.00}$	3.78	3.59	3.41	3.24	3.09	2.95	2.82	2.70	2.59	2.48	2.39	2.29	2.21
7	5.03	[illegible]	[illegible]	4.16	3.92	3.71	3.51	3.33	3.16	3.01	2.87	2.74	2.62	2.51	2.40	2.31
8	5.53	5.15	4.80	4.49	4.21	3.95	3.73	3.52	3.33	3.16	3.00	2.85	2.72	2.60	2.48	2.38
9	6.00	5.54	5.13	4.77	4.45	4.16	3.91	3.67	3.46	3.27	3.10	2.94	2.80	2.67	2.54	2.43
10	6.42	5.89	5.43	5.02	4.66	4.34	4.05	3.80	3.57	3.36	3.18	3.01	2.86	2.72	2.59	2.47
15	8.06	7.19	6.46	5.85	5.32	4.88	4.49	4.15	3.86	3.60	3.37	3.17	2.99	2.83	2.68	2.55
20	9.13	7.96	7.02	6.26	5.63	5.10	4.66	4.28	3.95	3.67	3.43	3.21	3.02	2.85	2.70	2.56
25	9.82	8.42	7.33	6.46	5.77	5.20	4.72	4.32	3.98	3.69	3.44	3.22	3.03	2.86	2.70	2.56
30	10.27	8.69	7.50	6.57	5.83	5.23	4.75	4.34	4.00	3.70	3.45	3.22	3.03	2.86	2.70	2.56

*Enter the row corresponding to project life, and move across until values close to the simple payback period, $\Delta P/\Delta A$, are reached. IRR is the interest rate in that column. For example, a 10-year project with a 5-year payback has an internal rate of return of just over 15%.

Fig 5.1: Chart to estimate the Internal Rate of Return [20]

Here, the simple payback period is 4.006 years which is between 4.00 and 4.23 in the above chart. So, according to chart in (Figure 5.1) we got the IRR = 13% for 5 years.

Net Present Value (NPV),

NVP = ΔA × PVF (d, n) −ΔP

= 20,09,547.72 × 4.451- 80,51,420

= 8,79,349.02 Taka.

Chapter 6 Conclusion

6.1 Verification of complex engineering problem

Our Project addresses four complex engineering problems.

- P1: Depth of knowledge required-
  - Engineering fundamental knowledge (K3): K3 is satisfied Because of our understanding of electrical machines and the way we employed a transformer to convert the high voltage power to low voltage usable power as input. Additionally, engineering physics was applied in real world ways.
  - Engineering design knowledge (K5):K5 is satisfied, for design and simulation of the circuit and mechanical parts.
  - Knowledge of modern engineering tools (K6): the design and simulation part of the project requires the use of contemporary engineering tools and software, such as Proteus, Arduino IDE, Microsoft office etc.
  - Research knowledge (K8): K8 is satisfied. To complete our project, we had to conduct a lot of study and obtain a lot of publications and research papers, among other things. In the literature review section, we present alternatives to our system and the state of the art by substantiating those findings. For the system design and solution analysis, research was equally crucial.
- P3: Depth of analysis required.-
  - For the implementation of our project, there are several alternative solutions of this project like choosing IoT based system. In that case we have to analysis our selection and choose the most suitable one.
- P4: Familiarity of issues.-
  - Extent of stakeholder involvement and conflicting requirements.
  - In our project, the stakeholders are RMG industries and the BGMEA. As, our Plan is to use this device to provide safety to the workers therefore, our main stakeholders are them. Their requirement is to provide them top quality safety service.
- P6 **:** Extent of Stakeholder Involvement and Conflicting.-

- Here two stakeholders give priority in two different things which are conflicting with one another. BGMEA gives priority to quality product that can provide proper safety to the workers. However, the garments give priority to have quality device with in an affordable price range.

6.2 Meeting the project objectives

Our main objective of this project was to provide safety to the garment workers. Almost every year many workers lost their lives, some gets badly injured. One of the main reason behind that is not receiving any signal to understand that there is an abnormal condition. They do not get enough time to rush into a safe place to save themselves from upcoming danger. Also we want to build a device that can be upgradable and easy to install. This device is also fully automated system that means, after it's installation it do not need any human interference. It will continuously monitor the working environment of the garment industry and notify when it detects any critical condition. This system consumes less power and provide top quality safety to the workers my monitoring the working environment continuously. This device fulfil both of our stakeholder's requirements. The output system of this device also very simple and easy to understand for the workers. By the help of this device one can easily judge the working environment of the garment industry. It will ensure that the workers are working in a healthy and safe working environment. Healthy and safe working environment produces increases productivity. Not just from inside but also with the help of this system a person can monitor the working environment of a garment industry from outside as well with the help of a smartphone. Thus the garments and the workers will be benefited.

Why this system is applicable only in RMG industry?

This system offers many advantages that helps to monitor the working environment as well as it works as a safety system. However this system is useful for ready-made garment industries not any other places such as home, community center, shopping mall, offices etc. There are some reasons behind it:

- This system follows all the rules set by BGMEA (Bangladesh Garment Manufacture and Exports Association). A garment industry follows different rules compared with other places.

- The threshold values this system are running with are taken from different RMG industries, which are different from other crowded places like shopping malls or community centers.
- The gas sensor this system uses is different rather than those are used in home. This sensor can detect Propane (C_3H_8), Carbon Monoxide (CO), Butane (C_4H_{10}), Ammonia (NH_3), Chlorine (CL_2) and smoke. Normally, residential places only need a normal gas detecting sensor that can detect methane (CH_4).
- MQ-2 gas sensor's concentration range in 200 ppm - 10000 ppm. From stakeholders data we get that according to BGMEA, when the gas concentration crosses 250 ppm in rmg industry that could cause harm to the workers. Therefore this system only notify everyone when the gas concentration crosses 250 ppm.
- The National Institute for Occupational Safety and Health's (NIOSH) in the United States recommends a maximum of 1000 ppm of methane gas. Since there are no possibility of any other gasses inside residential area the threshold value should be set by 1000 ppm for home purposes which is different that this system. [21]

APPENDIX A: ACTIVITY CHART

Part-A

Date	Participants	Activity Description	Approx. hrs. spent
03.10.23	Everyone	Meeting with supervisor	25 minutes
04.10.23	Everyone	Initial research	2 hours
05.10.23	Everyone	Complex engineering justification	1 hours
06.10.23	Everyone	Stakeholders identify	1hours
07.10.23	Everyone	Initial brief by supervisor about project	30 minutes
08.10.23	Everyone	Find the complex engineering requirement for our project	1.5 hours
10.10.23	Everyone	Literature review for presentation slides	1 hours
11.10.23	Everyone	More research about topic	1 hours

11.10.23	Tawfik Aziz Rahman, Hasibul Hasan Rafi, Kawsar Zaman	Find alternative solutions	2 hours
12.10.23	Ashik Ahamad Anik	Preparing presentation slide and PPTX animation	2 hours
12.10.23	Everyone	Checking presentation slide	30 minutes
13.10.23	Everyone	Meeting with supervisor to show our presentation slide	30 minutes
13.10.23	Everyone	Correcting and finalize presentation slide	1 hour
18.10.23	Everyone	Rehearsal about presentation	45 minutes
19.10.23	Everyone	Departmental presentation	2 hours
20.10.23	Everyone	Distribution of work for individuals	1 hour
28.10.23	Tawfik Aziz Rahman	Project introduction writing	1 hour 30 minutes
29.10.23	Everyone	Literature review writing	4 hours
29.10.23	Hasibul Hasan, Ashik Ahamad Anik	Impacts on society	1 hour 30 minutes
29.10.23	Hasibul Hasan, Ashik Ahamad Anik	Make questionnaires for stakeholders.	1 hour 30 minutes
30.10.23	Everyone	Made final questionnaires for stakeholders	30 minutes
01.11.23	Everyone	Checking questionnaires for stakeholders by supervisor	30 minutes
03.11.23	Everyone	Visited an industry and engaged with the stakeholder	8 hours
04.11.23	Tawfik Aziz Rahman	Listed the appendix activity chart	2 hours
05.11.23	Everyone	Checked activity chat by everyone	30 minutes

08.11.23	Hasibul Hasan Rafi	Risk management identification	2 hours
09.11.23	Hasibul Hasan, Ashik Ahamad Anik	Prepared project plan	3 hours
13.11.23	Tawfik Aziz Rahman	Effect of environment and sustainability identify	1 hour
15.11.23	Everyone	Stakeholder expectation and requirement	3 hours
15.11.23	Ashik Ahamad Anik	Project requirement finalization	3 hours
16.11.23	Ashik Ahamad Anik	Health and safety issues identify	1hours
17.11.23	Everyone	Local market research and specification	6 hours
19.11.23	Everyone	Finalization of budget	2 hours
20.11.23	Tawfik Aziz Rahman	CPM table and chart making.	4 hours
22.11.23	Everyone	Making Gantt chart for project plan A, B and C	2 hours
24.11.23	Hasibul Hasan, Ashik Ahamad Anik	Standard and codes of practice	3 hours
25.11.23	Everyone	Project Reviewed by EEE400A instructor	1 hour 30 minutes
25.11.23	Kawsar Zaman	Project product life cycle	1 hour
26.11.23	Everyone	Reorganizing tables & figures	1 hour 30 minutes
27.11.23	Everyone	Modified project report	4 hours
28.11.23	Everyone	Organizing the references	4 hours
01.12.23	Everyone	Citing references as IEEE format	4 hours
01.12.23	Everyone	Reorganizing appendices, A, B, & C	4 hours
26.12.23	Everyone	Revised project report	4hours

30.12.23	Everyone	Final editing and checking the report, page numbering, figure numbering	4 hours
02.01.24	Everyone	Submission of the report	------------

Part-B

Date	Participants	Activity Description	Approx. hrs. spent
01.02.2024	Everyone	Group discussion	1 hour
03.02.2024	Everyone	Initial plan of project design	1 hour
04.02.2024	Everyone	Discussion about the software	2 hours
07.02.2024	Everyone	Installation of the Proteus required version	2 hours
10.02.2024	Tawfik Aziz Rahman, Hasibul Hasan Rafi, Ashik Ahamad Anik	Writing functional design (2.1.1)	1 hour
12.02.2024	Tawfik Aziz Rahman, Ashik Ahamad Anik	Writing functional design (2.1.1)	2 hours
14.02.2024	Tawfik Aziz Rahman, Ashik Ahamad Anik, Kawsar Zaman Anik	Writing functional design (2.1.1)	1 hour
18.02.2024	Everyone	Writing functional design (2.1.2)	1 hour
24.02.2024	Everyone	Writing functional design (2.1.2)	2 hours
29.02.2024	Tawfik Aziz Rahman, Ashik Ahamad Anik, Hasibul Hasan Rafi	Writing functional design (2.1.2)	1 hour
04.03.2024	Everyone	Writing functional design (2.1.3)	2 hours

08.03.2024	Tawfik Aziz Rahman, Ashik Ahamad Anik, Hasibul Hasan Rafi	Writing functional design (2.1.3)	1 hour
12.03.2024	Everyone	Writing functional design (2.1.3)	1 hour
14.03.2024	Everyone	Making Functional block diagram.	2 hours
24.03.2024	Everyone	Meeting with supervisor about alternative solution	20 min
26.03.2024	Everyone	Finding alternative solutions	2 hours
30.03.2024	Tawfik Aziz Rahman, Ashik Ahamad Anik, Hasibul Hasan Rafi	List of necessary symbols	1 hour
04.04.2024	Everyone	Coding and simulation	2 hours
06.04.2024	Everyone	Coding and simulation	2 hours
09.04.2024	Ashik Ahamad Anik, Hasibul Hasan Rafi, Kawsar Zaman Anik	Coding and simulation	3 hours
14.04.2024	Everyone	Finalizing the simulation	2 hours
19.04.2024	Everyone	Report finalizing	1 hour
26.04.2024	Tawfik Aziz Rahman, Ashik Ahamad Anik, Hasibul Hasan Rafi	Final checkup	1 hour
04.05.2024	Everyone	Submission of the report	--------

Part-C

Date	Participants	Activity Description	Approx. hrs. spent
06.06.24	Everyone	Meeting with supervisor	25 minutes

16.06.24	Everyone	Discussed About Part C and individual work	2 hours
26.06.24	Everyone	Meeting about generator	1 hours
06.07.24	Everyone	Meeting about prototype development	1hours
16.07.24	Everyone	Initial brief by supervisor about project	30 minutes
17.07.24	Everyone	Visit market to found equipment’s for prototype	1.5 hours
06.08.24	Everyone	Visit market to found equipment’s for prototype	1 hours
16.08.24	Everyone	Visit market to found equipment’s for prototype	1 hours
26.08.24	Tawfik Aziz Rahman, Hasibul Hasan Rafi, Kawsar Zaman	Visit market to found equipment’s for prototype	2 hours
28.08.24	Ashik Ahamad Anik	Buying mechanical equipment’s for prototype	2 hours
16.09.24	Everyone	Buying mechanical equipment’s for prototype	30 minutes
26.09.24	Everyone	Performance evaluation of prototype	30 minutes
28.09.24	Everyone	Finalization of design	2 hours
29.09.24	Everyone	Discussed about report	4 hours
30.09.24	Everyone	Review of Milestone Achievements and Revision of Schedule	4 hours
31.09.24	Everyone	Economic analysis	3 hours

02.10.24	Everyone	Meeting about performance evaluation	1 hour
03.10.24	Everyone	Revised the report	2 hours
06.10.24	Everyone	Rehearsal about presentation	45 minutes
07.10.24	Everyone	Submit the report	-
20.10.24	Everyone	Submit the report after correction	-

APPENDIX B: OTHER TECHNICAL DETAILS

Some questionnaires for the stakeholders

For device users:

Questions for industry owners:

- Do you concern about your workers safety?
- Has there been any accident occurred in your industry before?
- Would the presence of an automated safety system influence your industry workers to feel secure?
- Will it be beneficial if the safety system monitors the working environment 24/7 continuously?
- Do you want to make sure that the worker of your industry works in a healthy environment?
- How much are you willing to pay to buy this system?
- What type of input system do you want for this system?
- What type of gases occurs accident most in a garment industry?
- What is the normal temperature inside your garment industry?
- What is the area of your garment industry (sq/ft)?

Questions For BGMEA:

- What type of accident occurs the most in a garment industry?
- What is the main reason that causes injured workers in an accident?
- Is it necessary that an environment monitoring system should monitor the working environment 24/7 continuously?

- What type of gases occurs accident most in a garment industry?
- What is the normal temperature inside a garment industry?

APPENDIX C. JUSTIFICATION OF COMPLEX ENGINEERING PROBLEM

This table prepared in EEE400A justifies the proposed project as a complex engineering problem

Attribute	Complex Engineering Problems have characteristic P1 and some or all of P2 to P7:	Covered in the project? (Y/N)	Explain/justify
Depth of knowledge required	P1: Cannot be resolved without in depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8, which allows for a fundamentals-based, first principles analytical approach	Y	Our project satisfies K3 (Engineering fundamentals knowledge) as we need knowledge of electrical machines and engineering physics. K4 (Engineering specialist knowledge) is satisfied as we are working on electronics. K5 (Engineering design knowledge) and K6 (Knowledge of modern engineering tools) are satisfied for simulation and design of circuit and mechanical part. K8 (Research knowledge) is satisfied, as various technical research is needed for implementation and design purposes.
Range of conflicting requirements	P2: Involves wide-ranging or conflicting technical, engineering and other issues	Y	Our two stakeholders' priority conflicts with one another.

Depth of analysis required	P3: There is no obvious solution, and abstract thinking and originality in analysis are required to formulate suitable models	Y	There are several alternative solutions of this project such as IoT based solution.
Familiarity of issues	P4: Involves infrequently encountered issues	Y	We need mechanical knowledge to complete this project.
Extent of applicable codes	P5: Are outside problems encompassed by standards and codes of practice for professional engineering	N	N/A
Extent of stakeholder involvement and conflicting requirements	P6: Involves diverse groups of stakeholders with widely varying needs	N	N/A
Interdependence	P7: High level problems including many component parts or sub problems	Y	Our project has both mechanical part and electrical part. Each of these parts has many components like Arduino Nano, relay sensors and batteries.

APPENDIX D. JUSTIFICATION OF COMPLEX ENGINEERING ACTIVITIES

This table prepared in EEE400C describes the complex engineering activities in the project

Attribute	Complex activities mean (engineering) activities or projects that have some or all of the following characteristics:	Covered in the project? (Y/N)	Explain
Range or resources	A1: Involves the use of diverse resources (for this purpose, resources include people, money, equipment, materials, information and technologies)	Y	We needed both money and expert man power to materialize our project.
Level of interaction	A2: Requires resolution of significant problems arising from interactions among wide-ranging or conflicting technical, engineering, or other issues	N	N/A
Innovation	A3: Involves creative use of engineering principles and research-based knowledge in novel ways	Y	Using working environment monitoring system is a new concept for our country.
Consequences for society and the environment	A4: Has significant consequences in a range of contexts; characterized by difficulty of prediction and mitigation	N	N/A
Familiarity	A5: Can extend beyond previous experiences by	Y	The mechanical knowledge which we needed to

	applying principles based approaches		complete our project were not known to us previously as all of us are from electrical background.

APPENDIX E. RUBRICS

Rubrics for EEE400

Table 1: Rubrics for assessment of PO9 (Individual work and teamwork)

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
Individual skills	Actively participates in group discussions and decision making, contributes useful ideas, completes assigned responsibilities thoroughly on time	Participates in group discussions and decision making, contributes ideas, completes assigned responsibilities mostly on time	Somewhat participates in group discussions and decision making, sometimes contributes ideas, completes some of the assigned responsibilities on time	Does not participate in group discussions and decision making, does not contribute relevant ideas, does not complete assigned responsibilities on time
Team skills	Always collaborates with others, always promotes constructive team atmosphere, always identifies and responds to conflicts promptly and positively	Usually collaborates with others, usually promotes constructive team atmosphere, usually identifies and responds to conflicts positively	Sometimes collaborates with others, sometimes promotes constructive team atmosphere, sometimes identifies and responds to conflicts positively	Does not collaborate with others, does not promote constructive team atmosphere, does not identify and respond to conflicts
Leadership skills	Always provides direction to achieve goals, always respects and listens to other members, always plans for	Usually provides direction to achieve goals, usually respects and listens to other members, usually plans	Sometimes provides direction to achieve goals, sometimes respects and listens to other members,	Does not provide direction to achieve goals, does not respect and listen to other members, does not plan

	improvement, always motivates others	for improvement, usually motivates others	sometimes plans for improvement, sometimes motivates others	for improvement, does not motivate others
Multidisciplinary activities	Fully understands and appreciates the multidisciplinary nature of the project activities, shows interests and participates in activities in disciplines outside of own	Mostly understands and appreciates the multidisciplinary nature of the project activities, participates in activities in disciplines outside of own	Somewhat understands and appreciates the multidisciplinary nature of the project activities, participates in some activities in disciplines outside of own	Does not understand or appreciate the multidisciplinary nature of the project activities, does not participate in activities in disciplines outside of own

Table 2: Rubrics for assessment of PO8 (Ethics)

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
Individual skills	Always approaches situations with consideration of equity, always behaves inclusively	Mostly approaches situations with consideration of equity, mostly behaves inclusively	Sometimes approaches situations with consideration of equity, Sometimes behaves inclusively	Does not approach situations with consideration of equity, does not behave inclusively
Accountability	Always understands about accountability and personal responsibility, always assumes responsibility of own actions	Mostly understands about accountability and personal responsibility, mostly assumes responsibility of own actions	Sometimes understands about accountability and personal responsibility, sometimes assumes responsibility of own actions	Does not understand about accountability and personal responsibility, does not assume responsibility of own actions
Proper use of others' works	Always recognizes the need for due acknowledgment of others' works, intellectual property and copyrighted materials, and acts accordingly	Mostly recognizes the need for due acknowledgment of others' works, intellectual property and copyrighted materials, and mostly acts accordingly	Sometimes recognizes the need for due acknowledgment of others' works, intellectual property and copyrighted materials, and sometimes acts accordingly	Does not recognize the need for due acknowledgment of others' works, intellectual property and copyrighted materials, and does not act accordingly
Professionalism	Fully understands the role of the engineer in protecting public interests, fully understands and is aware of relevant codes of ethics	Mostly understands the role of the engineer in protecting public interests, mostly understands and is mostly aware of relevant codes of ethics	Somewhat understands the role of the engineer in protecting public interests, somewhat understands and is somewhat aware of relevant codes of ethics	Does not understand the role of the engineer in protecting public interests, does not understand or is not aware of relevant codes of ethics

Rubrics for EEE400A

Table EEE400A: Rubrics for assessment of the project concept and proposal

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
PCP_PI1: Able to identify a suitable complex engineering design problem (1a) [sec-1.1, Appendix C] (CO1/PO12, P1)	Demonstrates an ability to explore a topic thoroughly, and to identify a suitable complex engineering problem	Demonstrates an ability to explore a topic, and to identify a reasonably suitable complex engineering problem	Demonstrates an ability to somewhat explore a topic, and to identify a somewhat suitable complex engineering problem	Demonstrates minimal or no ability to explore a topic, or to identify a suitable complex engineering problem
PCP_PI2: Engages to stay up to date on the relevant topic (2b) [sec-1.2] (CO1/PO12, P1)	Demonstrates thorough engagement to stay up to date on the relevant topic	Demonstrates engagement to stay up to date on the relevant topic	Demonstrates some engagement to stay up to date on the relevant topic	Demonstrates minimal or no engagement to stay up to date on the relevant topic
PCP_PI3: Identifies the regulatory requirements, standards, and codes of practice (2a) [sec 1.3] (CO2/PO3, P5)	Identifies all the relevant regulatory requirements, standards, and codes of practice	Identifies most of the relevant regulatory requirements, standards, and codes of practice	Identifies some of the relevant regulatory requirements, standards, and codes of practice	Does not identify any of the relevant regulatory requirements, standards, and codes of practice
PCP_PI4: Explains the objectives, project requirements and constraints of the solution considering the expectations of the stakeholders (2c) [sec-1.4, 1.5] (CO2/PO3, P2, P6)	Clearly explains the objectives, project requirements and constraints taking into account all the expectations of the stakeholders	Explains the objectives, project requirements and constraints taking into account most of the expectations of the stakeholders	Somewhat explains the objectives, project requirements and constraints fully taking into account some the expectations of the stakeholders	Does not explain the objectives, project requirements and constraints and/or does not take into account any expectation of the stakeholders

PCP_PI5: Prepares project management plan, setting up milestones and considering risks and contingencies (2d) [sec-1.6.1, 1.6.2] (CO3/PO11)	Prepares a comprehensive project management plan, clearly sets up milestones, thoroughly considers risks and contingencies	Prepares a project management plan, sets up milestones, considers risks and contingencies	Prepares a project management plan, sets up a few milestones, attempts to considers risks and contingencies	Prepares a unclear/incomplete project management plan, does not set up milestones, does not consider risks and contingencies
PCP_PI6: Identifies required resources and prepares a realistic budget (2e, 2g) [sec-1.6.3] (CO3/PO11)	Identifies all resources and prepares budget that covers all applicable areas of the project including room for contingency	Identifies most resources and prepares budget that covers most applicable areas of the project including room for contingency	Identifies some resources and prepares budget that covers some applicable areas of the project	Cannot identify resources and cannot prepare a budget addressing major applicable areas of the project
PCP_PI7: Explains how to sustain and maintain the product/service in business if the solution is successfully commercialized. (2h) [sec-1.7]	Clearly explains how to sustain and maintain the product/service in business if the solution is successfully commercialized.	Explains how to sustain and maintain the product/service in business if the solution is successfully commercialized.	Somewhat explains how to sustain and maintain the product/service in business if the solution is successfully commercialized.	Does not explain how to sustain and maintain the product/service in business if the solution is successfully commercialized.
PCP_PI8: Considers the impact of the solution on society including health, safety, cultural, and legal issues (2f) [sec 1.8.1, 1.8.3] (CO4/PO6)	Considers all the impacts on society including health, safety, cultural and legal issues	Considers most of the impacts on society including health, safety, cultural and legal issues	Considers some of the impacts on society including health, safety, cultural and legal issues	Does not consider any impact on society including health, safety, cultural and legal issues
PCP_PI9: Considers the impact of the solution on environment and sustainability	Considers all the impacts on environment and sustainability. If necessary, proposes	Considers most of the impacts on environment and sustainability. If necessary, identifies	Considers some of the impacts on environment and sustainability	Minimal or no consideration of impacts on environment and sustainability

over the entire product life cycle. Proposes mitigating solution if needed. (2f) [sec 1.8.2] (CO5/PO7)	solutions to mitigate negative impact	impacts which need mitigation		

P1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8, which allows for a fundamentals-based, first principles analytical approach

P2: Involves wide-ranging or conflicting technical, engineering and other issues

P4: Involves infrequently encountered issues

P6: Involves diverse groups of stakeholders with widely varying needs

Rubrics for EEE400B

Table 1: Rubrics for assessment of the Design Report

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
DR_PI1: Develops a functional design considering applicable standards, codes of practice, health, safety, and environmental considerations. (1a) [sec-2.1] (CO2/PO3, P2, P7)	Appropriately partitions the problem into sub problems, considers all relevant engineering standards and codes where applicable, involves all health, safety, and environmental issues in design	Partitions the problem into sub problems, considers most relevant engineering standards and codes where applicable, involves major health, safety, and environmental issues in design	Partitions the problem into sub problems to some extent, considers some relevant engineering standards and codes where applicable, involves some health, safety, and environmental issues in design	Does not usefully partition the problem into sub problems, does not consider relevant engineering standards and codes, health, safety, and environmental issues not inv
DR_PI2: Formulates and evaluates alternate solutions (1b) [sec-2.2] (CO1/PO2, P1, P3)	Effectively formulates multiple solutions that functionally meet most requirements, compares and evaluates alternate solutions, extracts valid conclusions	Formulates multiple solutions that functionally meet most requirements, partially compares and evaluates alternate solutions, conclusions in line with analysis	Formulates multiple solutions that functionally meet some requirements, attempts to compare and evaluate alternate solutions, conclusions somewhat in line with analysis	Does not formulate multiple solutions, no attempt to compare and evaluate alternate solutions, conclusions not based on analysis
DR_PI3: Prepares and refines design with analysis and/or simulation of the system for implementation (1c, 1d) [sec-0] (CO2/PO3, P1)	Performs all design calculations, produces detailed design, analyzes and/or simulates to verify that the design satisfies all requirements.	Performs most design calculations, produces design with some details, analyzes/simulates to verify that the design satisfies most requirements. Design is refined	Performs some design calculations, produces design with a few details, attempts to analyze/simulate the design to verify satisfaction of requirements. Design is	Does not perform design calculations, detailed design not produced, analysis/simulation not done to verify satisfaction of requirements. Design is not refined to facilitate implementation.

	Design is skillfully refined to facilitate implementation.	to facilitate implementation.	somewhat refined to facilitate implementation.	

P1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8, which allows for a fundamentals-based, first principles analytical approach

P2: Involves wide-ranging or conflicting technical, engineering and other issues

P3: There is no obvious solution, and abstract thinking and originality in analysis are required to formulate suitable models

P7: High level problems including many component parts or sub-problem

Rubrics for EEE400C

Table 1: Rubrics for Final report of EEE400C

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
FR_PI1: Discusses how the prototype of the solution is developed. [sec 3.1]	Comprehensively discusses how the prototype of the solution is developed with the help of appropriate figures, photos and diagrams	Discusses how the prototype of the solution is developed with the help of appropriate figures, photos and diagrams	Somewhat discusses how the prototype of the solution is developed with the help of appropriate figures, photos and diagrams	Poorly discusses how the prototype of the solution is developed with the help of appropriate figures, photos and diagrams
FR_PI2: Evaluates performance of the developed system as per requirements. Finalizes design based on performance evaluation (1a and 1b) [sec 3.2, sec 3.3] (CO1/PO4, CO3/PO3)	System meets all requirements or the students can identify and explain clearly when deviation from requirements occurs. Revises design with appropriate technical analysis if necessary to achieve compliance with all specification and requirements	System meets major requirements. Students can identify and explain most deviations from requirements. Revises design with technical analysis if necessary to achieve compliance with most specification and requirements	System meets some requirements. Students can identify and explain some deviations from requirements. Revises design with some technical analysis if necessary to achieve compliance with some specification and requirements	System does not meet most requirements. Students cannot identify and explain most deviations from requirements. Design not revised to achieve compliance.
FR_PI3: Finalizes design based on performance evaluation (1c) [sec 3.3] (CO3/PO3)	Revises design with appropriate technical analysis to achieve compliance with all requirements finalized in 400B	Revises design with technical analysis to achieve compliance with most requirements finalized in 400B	Revises design with some technical analysis to achieve compliance with some requirements finalized in 400B	Does not revise design with technical analysis to achieve compliance with any requirement finalized in 400B
FR_PI4: Selects and uses appropriate modern	Carefully selects and skillfully uses modern engineering tools	Selects and uses modern engineering tools with	Selects and uses modern engineering tools knowing	Selected and used modern engineering tools are mostly

engineering tools for modeling, simulation and/or performance evaluation throughout the project (EEE400 A, B, C) [sec 3.4] (CO2/PO5)	knowing all the relevant limitations of the tools	some degree of care and skill knowing major relevant limitations of the tools	some relevant limitations of the tools	not appropriate. No knowledge of relevant limitations of the tools
FR_PI5: Achieve the milestones set in the project proposal revises the schedule appropriately to complete the project within the deadline (EEE400 A, B, C) [Chapter 4] (CO4/PO11)	All milestones are reached on time or corrective measures are appropriately taken to revise the schedule to complete the project within deadline	Most milestones are reached on time or corrective measures are taken to revise the schedule to complete the project within deadline	Milestones are somewhat reached on time or some corrective measures are taken to revise the schedule to complete the project within deadline	Milestones are mostly not reached on time. Corrective measures are not taken to revise the schedule to complete the project within deadline
FR_PI6: Prepares the bill of materials and estimates the cost of the system [sec 5.1] (CO5/PO11)	Prepares bill of materials considering all the project components and/or parts and the cost is accurately estimated	Prepares bill of materials considering most the project components and/or parts and the cost is estimated	Prepares bill of materials considering major project components and/or parts and the cost is reasonably estimated	Prepares bill of materials ignoring important project components and/or parts and the cost is not reasonable
FR_PI7: Performs economic analysis to calculate suitable economic parameter(s) to evaluate the economic prospect of the proposed project [sec 0] (CO5/PO11)	Evaluates the financial prospect of the project through detailed and thorough analysis. Interpretation is clear	Evaluates the financial prospect of the project through analysis. Provides interpretation	Evaluates the financial prospect of the project through analysis.	Does not evaluate the financial prospect of the project through analysis

Table 2: Overall rubrics on report writing

Communicates the main ideas in written form [Overall] (CO8/PO10)	Communicates the main ideas clearly and to the point	Communicates the main ideas	Communicates the main ideas to some extent	Does not communicate the main ideas
Uses illustrations (graphs, tables, diagrams) to support ideas, analysis and interpretation [Overall] (CO8/PO10)	Skillfully uses illustrations to support ideas. Illustrations enhance comprehension of analysis and interpretation	Uses illustrations to support ideas. Illustrations somewhat enhance comprehension of analysis and interpretation	Uses illustrations which are related to analysis and interpretation	Either does not use illustrations or illustrations used are not relevant to ideas, analysis and interpretation
Uses citations and references [Overall] (CO8/PO10)	Citations and references are effectively used to duly acknowledge prior art and other people's works	Citations and references are used to acknowledge prior art and other people's works	Citations and references are used to somewhat acknowledge prior art and other people's works	Citations and references are not used or prior art and other people's works are not acknowledged
Uses a language which is mechanically (punctuation, spelling and grammar) correct [Overall] (CO8/PO10)	The report is free from mechanical errors	The report contains a few mechanical errors	The report contains some mechanical errors	The report contains several mechanical errors

Table 3: Rubrics for oral presentation

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
Communicates appropriately targeting the society at large (CO8/PO10)	Communication is skillfully tailored to appropriately suit the level of target audience	Communication is tailored to suit the level of target audience	Communication is somewhat tailored to suit the level of target audience	Communication is not tailored to suit the level of target audience
Focusses on the creative aspects of the solution with clarity (CO8/PO10)	Creative aspects are clearly articulated and emphasized. Presentation is logically and	Creative aspects are articulated and emphasized. Presentation structure is logical	Creative aspects are somewhat articulated and emphasized. Presentation structure is	Creative aspects are not articulated or emphasized. Presentation structure is not logical

	skillfully structured		somewhat logical	
Above two PIs will assess the sales pitch part of the presentation. Following PIs are for the technical part				
Designs and integrates visual aids (illustrations, demonstrations, props, etc) to support and focus presentation (CO8/PO10)	Visual aids are creatively designed, skillfully used and seamlessly integrated to enhance and focus presentation	Visual aids are designed, used and integrated to enhance and focus presentation	Visual aids are designed, used and integrated to enhance and focus presentation to some extent	Visual aids are not designed, used or integrated to enhance and focus presentation
Completes presentation within the allotted time (CO8/PO10)	Finishes the presentation as prepared within time without rushing or skipping content	Finishes the presentation as prepared within time with rushing or skipping content occasionally	Finishes the presentation as prepared within time with rushing or skipping content a few times	Does not finish the as prepared presentation within time or skips major contents to finish within time
Listens to the questions and answers appropriately (CO8/PO10)	Carefully listens to the questions, answers concisely transitioning skillfully between presentation and Q/A	Listens to the questions, answers to the point transitioning well between presentation and Q/A	Listens to the questions, answers somewhat to the point transitioning between presentation and Q/A in an acceptable manner	Does not listen to the questions, answers not to the point transitioning between presentation and Q/A not in an acceptable manner

Code:

```
#include <dht.h>

#include <LiquidCrystal_I2C.h>

#define Threshold 400

#define DHT11_PIN 6


LiquidCrystal_I2C lcd(0x20, 16, 2);

dht DHT;

int MQ2_pin = 7;

int Flame_pin = 5;

int buzzerPin = 2;


void setup()

{

  lcd.begin();

  pinMode(buzzerPin, OUTPUT);

  pinMode(Flame_pin, INPUT);

  pinMode(MQ2_pin, INPUT);


}

void loop()

{

  //////////////////////////////////////Temprature
Value/////////////////////////////////

  int chk = DHT.read11(DHT11_PIN);

  lcd.setCursor(0,0);

  lcd.print("Temp: ");

  lcd.print(DHT.temperature);

  lcd.print((char)223);

  lcd.print("C");

  lcd.setCursor(0,1);
```

```
  lcd.print("Humidity: ");
  lcd.print(DHT.humidity);
  lcd.print("%");
  delay(10);
////////////////////////////////////Flame////////////////////////
  if (digitalRead(5) == 1 )
  {
    lcd.clear();
    lcd.setCursor(0,1);
    digitalWrite(buzzerPin, HIGH); // Led ON
    lcd.print("*Fire  detected*");
    delay(5000);
  }
  else
  {
    digitalWrite(buzzerPin, LOW); // Led OFF
   lcd.print("Humidity: ");
   lcd.print(DHT.humidity);
   lcd.print("%");
  }
//////////////////////GAS/////////////////////////////////
  if (digitalRead(7) == 1 )
  {
    lcd.clear();
    lcd.setCursor(0,1);
    digitalWrite(buzzerPin, HIGH); // Led ON
    lcd.print("*GAS  detected*");
    delay(5000);
  }
  else
  {
```

```
    digitalWrite(buzzerPin, LOW); // Led OFF
    lcd.print("Humidity: ");
    lcd.print(DHT.humidity);
    lcd.print("%");
  }
  //////////////////////////////////Temperature
Alarm///////////////////////
  if (DHT.temperature >= 35 )
  {
    lcd.clear();
    lcd.setCursor(0,1);
    digitalWrite(buzzerPin, HIGH); // Led ON
    lcd.print("Temperature High");
    delay(5000);
  }
  else
  {
    digitalWrite(buzzerPin, LOW); // Led OFF
   lcd.print("Humidity: ");
   lcd.print(DHT.humidity);
   lcd.print("%");
  }
  }
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References

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