Carbon Dioxide (CO2) & Carbon Monoxide (CO) Monitoring System

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MINI LAB PROJECT REPORT

This Report Presented in Partial Fulfillment of the course **CSE224: Digital Logic Design Lab in the Computer Science and Engineering Department**

DAFFODIL INTERNATIONAL UNIVERSITY
Dhaka, Bangladesh

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DECLARATION

We hereby declare that this lab project has been done by us under the supervision of **Amir Sohel**, **Lecturer (senior scale)**, Department of Computer Science and Engineering, Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere as lab projects.

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COURSE & PROGRAM OUTCOME

The following course have course outcomes as following:.

Table 1: Course Outcome Statements

CO's	Statements
CO1	Recall theoretical knowledge of digital logic and concepts of Integrated circuit (IC) to design, construct, and test basic digital circuits and systems in a laboratory setting.
CO2	Apply appropriate laboratory equipment and tools to measure and verify the behavior and performance of digital circuits and systems.
CO3	Develop a system/prototype for real life application based on the knowledge gained from the course.

Table 2: Mapping of CO, PO, Blooms, KP and CEP

CO	PO	Blooms	KP	CEP
CO1	PO1	C1, C2,P1,P2	K1,K2,K3	EP1
CO2	PO2	C2,C3,P1,P2,A2	K3,K4	EP2
CO3	PO3	C3,P1,P2,P3,A1,A2	K5	EP3

The mapping justification of this table is provided in section **4.3.1**, **4.3.2** .

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Chapter 1

Introduction

This chapter explains, discusses its purpose and potential outcomes, and assesses its feasibility and relevance. It also draws attention to current research gaps and expected outcomes of the proposed system.

1.1 Introduction

Carbon dioxide (CO_2) and carbon monoxide (CO) are important air pollutants that are harmful to human health and the environment. To improve outdoor and indoor air quality and maintain public safety, these gases must be monitored. To meet the growing demand for reliable air quality monitoring solutions, this project seeks to provide a complete monitoring system that can detect and measure the amount of CO and CO2. A system that monitors CO_2 and CO provides immediate measurements of these gases, allowing for educated choices to reduce potential dangers. Different tools that follow global criteria from organizations like the WHO and EPA are used in this initiative. These devices, intended for meeting regulations and conducting research, consist of portable handheld and fixed air quality monitors that can measure pollutants like PM (PM2.5, PM10), gases (O3, NO2, SO2, CO), and VOCs (Higgins et al., 2024; Mistry et al., 2022) [1]. Sensors and IoT solutions now enable the implementation of these systems in various environments such as industries, homes, and cities, allowing for a proactive approach to air quality management. This report covers the creation and execution of a monitoring system for CO_2 & CO, emphasizing its importance, practicality, and anticipated results.

1.2 Motivation

Landscape and energy Air peace and its effects on the environment and the human rights Pollution control Energy control Metropolitan, environmental environment and confined space believe that CO_2 and CO boundaries can cause such effects as poisoning by accidents. Besides preventing these risks, establishing efficient monitoring will contribute to the development of broad endeavors aimed at combating climate change and promoting sustainable living. This undertaking originates from a noble cause of applying technology for the betterment of society with special reference to the environment. Carbon monoxide is an acute poisonous gas which is formed from the incomplete combustion of carbon containing fuels. Rol Energy control Metropolitan areas, environmental environments and confined space believe CO_2 and CO boundaries and can have effects such as unintended poisoning. In addition to mitigating these hazards, building a robust monitoring system will support larger initiatives, which will help fight climate change and advance sustainable living. This endeavor stems from a commitment to use technology for the benefit of society and the environment.

Carbon monoxide is toxic and colorless gas produced from incomplete combustion of fuels. Such blood concentrations as low as 1.5 to 3 percent can cause severe health risks that include nausea, dizziness, and in the worst-case death. CO poisoning is one of the most common type of accidental poisoning; and more common in places with weak ventilation systems that use heating, gas, stoves or car exhausts.

There is thus need to develop a real-time system that monitors levels of CO in the environment to facilitate early identification of poisoning cases.

Carbon dioxide, not in itself evil since it is a naturally derivative of respiration and combustion, has been determined to be a leading cause of climate change when emitted in gross amounts from factories and cars. In addition, concentrations of CO_2 in a sealed environment like workplaces or houses can result in atrocious air quality which affects one's energy levels, pronounces headaches, and decreases intelligence. Finally by monitoring level of CO_2, this brings a mileage towards a good management of air complication which makes living healthier and sustainable at the long run.

Our project in particular is concerned with the design of an Effective and inexpensive monitoring of these gases due to environmental issues as well as safety of our selves. Compact, accurate and scalable solutions can be implemented based on the recent development in sensor technology and systems using IoT, which make the implementation of such monitoring systems possible. Studious point out the importance of large-scale of such systems by preventing the effects of climate change and minimizing the adverse health effects that arise from the exposure to toxic gases (EPA, 2021; WHO, 2021)[3].

1.3 Objectives

The major objectives of this project are to develop and implement a dependable system for monitoring and quantifying present levels of carbon monoxide (CO) and carbon dioxide (CO_2). High precision, scalabilities are the objectives of this system, therefore, can be applied in different surroundings including public places and homes.

carbon monoxide toxication – a dangerous state which develops as a result of exposure to this Gas.) It will also produce audible or flashing alarms when CO concentration rises to dangerous levels to warrant evacuation or a correction. This is especially critical within homes having gas appliances, any industrial facility where combustion occurs, and any locality that has high emission from automobiles. As for this project another goal, it is the reduction of the incidence of carbon monoxide poisoning – a dangerous condition which results from the effect of CO on the human body. of carbon monoxide (CO) and carbon dioxide (CO_2) in real time. High precision, scalability are the goals of this system, which makes it suitable for various settings, such as public areas and households.

carbon monoxide poisoning, a life-threatening condition caused by exposure to CO. The system will give alarm that is audible and visual in form when concentrations of CO is high enough to cause harm to human beings so that corrective measures can be taken immediately. This is especially important in households that use gas appliances in their homes, industries that use combustion processes and places where emissions from vehicles are high. The prevention of carbon monoxide poisoning, a life-threatening condition caused by exposure to CO. The system will provide early warning alerts when CO concentrations reach hazardous levels, enabling prompt evacuation or corrective actions. This is particularly vital in homes with gas appliances, industries with combustion processes, and areas where vehicular emissions are concentrated.

The goal of this project is to allow people and organisations to be able to take preventive measures when it comes to Air quality through real and relevant data that they can easily access. It also seeks to remind people and motivate a multi-stakeholder approach in attaining sustainable environmental and/or healthier living through clean air.

1.4 Feasibility Study

The success of a carbon dioxide (CO_2) and carbon monoxide (CO) monitoring system is made possible due to recent innovative developments in sensor advancements, IoT integration, and the demand for proper air quality management. Thus, the important questions of feasibility and value, primarily technical, economic, social, are considered in this work while proposing the system.

Technical Feasibility: Available sensor technologies allow using compact, low power consumption, and high sensitivity elements for the continuous measurement of CO_2 and CO concentrations. These sensors can be connected to IoT platforms, for monitoring in a remote sense, storing data as well as issuing real-time warnings. The use of microcontrollers and IoT modules enables design for scale and flexibility of the designs by supporting homes, industries and public areas. The developed system employs commercially tested hardware and software platforms, thereby making their application less problematic.

Economic Feasibility: The ability to keep costs low is attributed by the use of inexpensive sensors as well as the open-source electronics platforms. Internet of Things solutions cut back on the amount of underlying hardware necessary, decreasing cost of installation and recurrent expenditures. Scalability makes it possible to implement on small homes or big industries without a big difference in cost implications. Also, it saves on costs which would be incurred in cases of health risks that would have been caused by the fertilizer, or penalties which may be incurred for polluting the environment.

Social Feasibility: The presence of technical publications highlighting different adverse effects that CO_2 and CO pose to human health as well as the environment make it possible to adopt such systems. The project is therefore in conformity with international endeavours to address climate change and enhancement of indoor air quality. It also copes up with important public health issues especially where there is inadequate or poor air circulation and high automobile pollution.

Bethe carbon dioxide and carbon monoxide monitoring system is a feasible idea. It integrates conceptually new ideas, economic rationality, and major societal bene ts so it is a 'real world' instrument of signi cane and utility for enhancing air quality and environmentally responsible lifestyles. This feasibility makes it generalizable and acceptable in all types of settings [2] [4].

1.5 Gap Analysis

This project is the successful development and implementation of a CO & CO_2 monitoring system . In other projects, different gases (NO,O_3,NH_3) were determined, Relative Humidity, Temperature in addition to carbon dioxide and carbon monoxide, which was not possible in this project

A great number of currently existing CO_2 and CO monitoring systems are developed for industrial use and are very expensive for using them in small houses and apartments. This limited access to the general public and other struggling businesses as they risk the dangers of unhealthy air quality as well as gas poisoning (Smith et al., 2020). Such costs need to cater for the development of affordable and scalable solutions to fill this market need efficiently.

Most of them do not incorporate the current IoT technologies for Real-time monitoring and control remotely. Despite the steady and gradual adoption of IoT in all its possible fields, the specification of this technology for gas monitoring systems presents some challenges. Communication and notification in real-time could have improved response time during lifespan events (Brown & Lee, 2021).

The good public is not well informed that there is need to constantly monitor these gases. Despite this, users of the installed systems have the limited understanding of data analysis to act proactively (World Health Organization [WHO], 2021). This gap could be filled by an easy-to-navigation interface with the actionable insights on it in order to enable the users to make the right decisions[2] [5] [6].

1.6 Project Outcome

This project detecting and measuring carbon dioxide (CO_2) and carbon monoxide (CO) concentrations in parts per million (ppm) on an LCD display. We can see carbon dioxide (CO_2) level is below 1000 ppm and carbon monoxide (CO) level below 10 ppm in real time. The system will be cost-effective and scalable, suitable for use in public, commercial and residential environments. Furthermore, it provides practical perspectives helpful in improving air quality management strategies, which will increase awareness of air quality challenges. In addition, it will present an opportunity to develop air pollution control research and Internet of Things-based environmental monitoring systems, which will open the door to more advanced approaches to environmental problems.

The proposed carbon dioxide (CO_2) and carbon monoxide (CO) monitoring system is expected to deliver significant outcomes, enhancing public safety, environmental sustainability, and technological advancement. This system will provide real-time monitoring, accurate detection, and early warning mechanisms for hazardous levels of CO_2 and CO in diverse settings such as homes, industries, and public spaces.One key outcome is improved air quality management. By providing continuous and precise monitoring of CO_2 levels, the system will enable users to maintain healthier indoor environments. Elevated CO_2 levels often lead to reduced cognitive performance and fatigue, and this system will help mitigate such issues by empowering users to take corrective actions, such as improving ventilation.

Another critical outcome is the reduction in the incidence of carbon monoxide poisoning. CO is a highly toxic, odorless gas that poses severe health risks, especially in poorly ventilated areas with combustion processes. The system's ability to issue audible and visual alerts in real-time will enable users to respond promptly, preventing potentially fatal incidents.

In conclusion, the CO_2 and CO monitoring system will provide a cost-effective, reliable, and user-friendly solution to address critical air quality and safety challenges. Its successful implementation is expected to benefit individuals, communities, and industries by fostering healthier living environments and contributing to broader environmental goals.

Chapter 2

Proposed Methodology/Architecture

The system's suggested methodology, including requirement analysis, design specifications, and overall project planning, is thoroughly described in this chapter. It describes the procedures used in the creation of the CO_2 and CO monitoring system.

2.1 Requirement Analysis & Design Specification

2.1.1 Overview

This section covers the functionalities of each component used in this project including Arduino Uno, MQ7 sensor that measures CO, MQ135 sensor that measures CO2, LCD to show output, some wires and breadboard for connection.

- **Arduino Uno**: Different pins on the Arduino Uno are used for different purposes. Vin, 3.3V, 5V, and GND are the names of its power pins. When an external power source is used, Vin is the Arduino's input voltage. 5V is the regulated power source that powers the board's microprocessor and other parts. The on-board voltage regulator generates 3.3V. 50mA is the maximum current draw. The ground pins are GND. To reset the microcontroller, use the reset pin. Six analog pins, numbered A0 through A5, are used to supply analog input between 0 and 5 volts. The 14 input/output pins, designated D0-D13, are capable of being utilized as either input or output pins. TTL serial data is received and transmitted via two serial pins: 0 (Rx) and 1 (Tx). Pins two and three can cause an interruption according to its two external interrupts. Eight-bit pulse width modulation (PWM) output is available on pins 3,5, 6, 9, and 11. SPI communication uses four SPI pins: 10 (SS), 11 (MOSI), 12 (MISO), and 13 (SCK). Pin 13 has an integrated LED that may be turned on. The pins for TWI communication are A4 (SDA) and A5 (SCA). And an AREF pin to supply the input voltage reference. It functions as the processing unit of the system, essentially reading sensor data and controlling outputs.

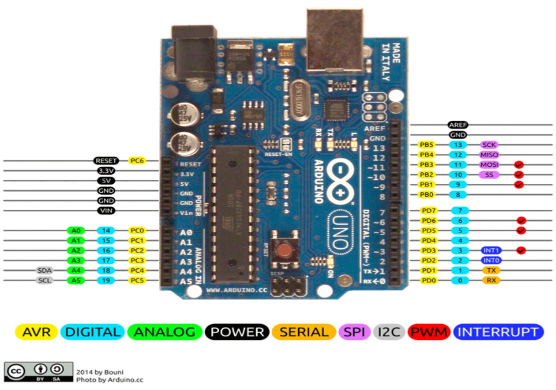

Figure 2.1: Arduino Uno

• **MQ7 sensor**: The carbon monoxide sensitivity of the MQ-7 gas sensor is high. The sensor, which is inexpensive and appropriate for a variety of applications, can be used to identify various gases that include CO. It is extensively utilized in portable CO gas detectors, industrial CO gas alarms, and home CO gas leak detection systems. Using a straightforward electronic circuit on a breadboard, it is simple to communicate with an Arduino or Raspberry Pi. A0 Analog output, D0 Digital output, GND Ground, and Vcc Supply (5V) are the initial pins from left to right.

Figure 2.2: MQ7 sensor

- **MQ135 sensor**: The MQ135 air quality sensor, a member of the MQ gas sensor series, is frequently used to identify smoke and dangerous gases in the air. A brief explanation of how to use an MQ135 air quality sensor for gas measurement and detection is provided in this section. The gases approaching the sensing element are ionized and absorbed by the sensing element as a result of this current, which is referred to as heating current. This modifies the sensing element's resistance, which modifies the amount of current flowing out of it. A0 Analog output, D0 Digital output, GND Ground, and Vcc Supply (5V) are the initial pins from left to right.

Figure 2.3: MQ135 sensor

- **LCD Display:** LCD which is known as Liquid Crystal Display is explained in this section. The functionalities of a 16x2 LCD are given below. Pin 1 is used to link the microcontroller unit's or power source's GND terminal. Pin 2 connects the power source's supply pin to the display's voltage supply pin. Pin 3 connects a variable POT that can supply 0 to 5V and controls the display's difference. Pin 4 connects to a microcontroller unit pin and toggles between the command and data registers, returning either 0 or 1. Pin 5 is attached to a microcontroller unit pin to receive either 0 or 1. It toggles the display between the read and write operations. Pin 6 is connected to the microcontroller unit and is always held high in order to carry out the Read/Write process. Data is sent to the display via pins 7–14, sometimes known as the data pins. Two-wire modes, such as 4-wire and 8-wire modes, are used to connect these pins. Only four pins, such as 0 to 3, are connected to the microcontroller unit in 4-wire mode; in 8-wire mode, eight pins, such as 0 to 7, are connected. Pin15 is the LED's +ve pin, which is linked to +5V. GND is connected to pin 16, which is the LED's -ve pin.

Figure 2.4: LCD (16x2)

- **Breadboard**: A rectangular plastic board with numerous tiny holes in it is called a breadboard. To prototype (i.e., construct and test an early version of) an electronic circuit, such as this one with a battery, switch, resistor, and LED (light-emitting diode), these holes make it simple to insert electronic components. Contemporary breadboards are made of plastic and are available in a wide variety of sizes, shapes, and even colors. Although there are larger and smaller sizes available, "full-size," "half-size," and "mini" breadboards are the most likely to be seen. Additionally, the majority of breadboards have tabs and notches on the sides that let you join several boards together. For many novice projects, however, a single half-sized breadboard is adequate.

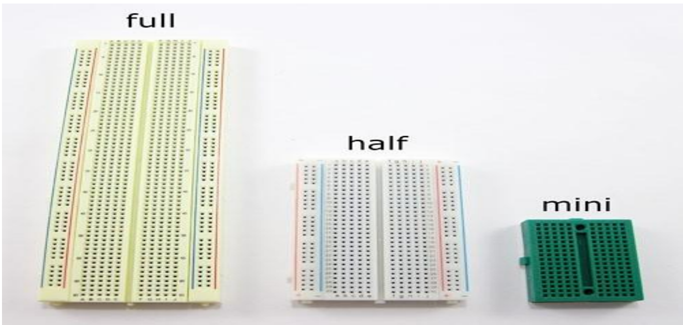

Figure 2.5: Breadboard

- **Wire:** A wire is a flexible metal strand that is typically cylindrical in shape. In an electrical circuit, wires are used to create electrical connectivity between two components. They have very little resistance to current flow. An insulated covering of various colors covers the wires.

Arduino Uno gets the readings that are sent from the sensors. At that point this information is prepared in arrange to decide if the CO2 or CO levels surpass the most extreme constrain. It shows the readings at the same time on the LCD display. Whereas showing readings it appears if the level is great, terrible, or dangerous.

2.1.2 Proposed Methodology/ System Design

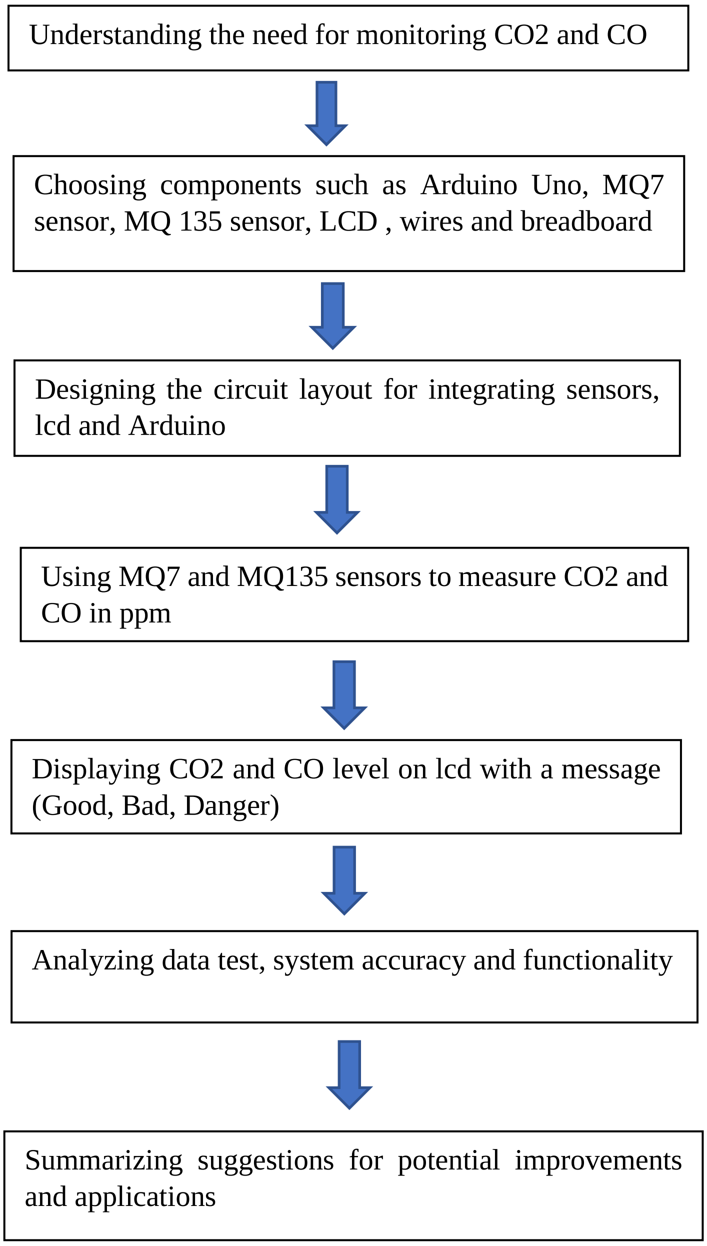

Figure 2.5: System design of the project

2.1.3 Circuit Design

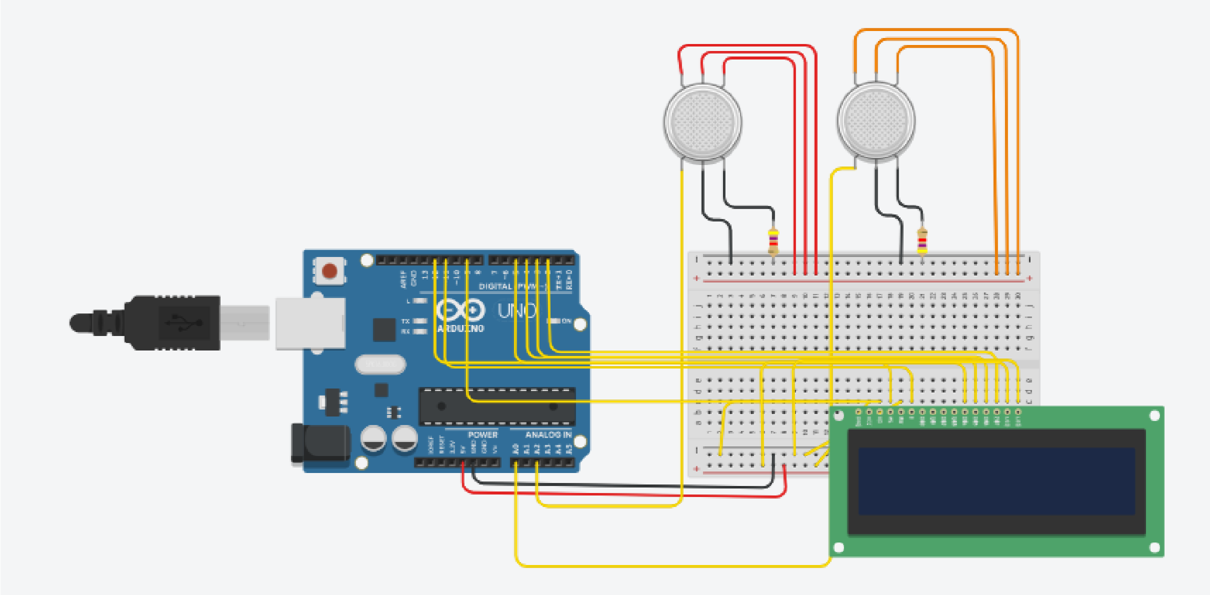

Fig 2.6: Circuit diagram

2.2 Overall Project Plan

The generally venture arrange diagrams the efficient prepare that was taken after to make the CO2 and CO observing framework. The project's necessity examination and plan determination stage started with recognizing the fundamental equipment and program components. Utilitarian and non-functional criteria were created together with a comprehensive framework design.

Then, as portion of the component determination and framework integration stage, the Arduino Uno R3, MQ7, MQ135 sensors, an LCD, a breadboard, and cables were obtained. Each component was checked freely for usefulness some time recently being collected utilizing a breadboard for prototyping. The improvement and usage phase's essential center were composing and uploading the application to the Arduino Uno R3. The sensors were designed to identify CO2 and CO levels, and the LCD was set up to show the readings. The testing and approval prepare guaranteed the rightness and unwavering quality of the framework beneath an assortment of scenarios. Cautious thought was given to the sensors' exactness and the system's capacity to raise a caution at the preset limits.

The last step in the documentation and introduction stage was to compile all of the comes about, strategies, and discoveries into a comprehensive report. An arranged introduction that incorporates charts and pictures to help in understanding was utilized to outline the system's plan, usage prepare, and results. This organized methodology guaranteed the extend was completed effectively.

Chapter 3

Implementation and Results

This chapter outlines a step-by-step implementation of this CO2 and CO monitoring project, evaluates the performance under different environments and discusses the obtained results, insights, and limitations.

3.1 Implementation

This project was constructed using Arduino Uno, MQ135, and MQ7 sensors and a 16x2 LCD where Arduino uno acts as the central control unit for reading and processing sensor data, MQ135 sensor and MQ7 sensor detect CO2 and CO in the air respectively, and LCD used to display the CO2 and CO levels in real-time. Here are the details steps that describe how the components were connected with Arduino uno. MQ135 and MQ7 sensors have 4 pins: A0, D0, GND, and VCC. Analog pin A0 of the MQ7 sensor was connected to the A0 pin of Arduino Uno. Analog pin A0 of the MQ135 sensor was connected to the A2 pin of Arduino Uno. VCC and GND pins of the sensors were connected to the 5V and GND of the breadboard respectively. The VSS pin of the LCD was connected to the GND of the breadboard and the VDD pin of the LCD was connected to the GND of the breadboard. Contrast pin V0 was connected to the D9 pin of Arduino uno.RS pin of the LCD was connected to the D12 pin of Arduino uno and the E pin of the LCD was connected to the D11 pin of Arduino uno. The RW pin of the LCD was connected to the GND. Data pins D4, D5, D6, and D7 of the LCD were connected to the Arduino uno pins D5, D4, D3, and D2 respectively. Pin 15 (Anode pin) and Pin 16 (Cathode pin) were connected to the 5V and GND of the breadboard respectively. And VCC and GND pins of the Arduino uno were connected to the 5V and GND of the breadboard respectively. Once sensors and LCD are connected to the Arduino Uno, the code is used to measure the CO2 and CO levels. To run the code firstly, set up the necessary components for the program then Prepares the sensors, LCD, and microcontroller for operation then continuously monitor CO2 and CO levels, display results, and evaluate air quality. To write and upload the code to the microcontroller Arduino IDE was used. For LCD communication the Liquid Crystal library was installed in the Arduino IDE.

Pseudocode that outlining the core functionality of the system is given below:

Define constants for sensor pins and LCD control pins

Initialize variables gas, co2lvl, colvl respectively for gas readings, CO2 level, and CO level

Define LCD pins(rs, en , d4,d5,d6,d7)

Define custom byte patterns for smiley and sad faces

FUNCTION setup()

Initialize LCD control pins as OUTPUT

Set LCD contrast level and backlight level using analogWrite

Initialize sensor pins as INPUT

Initialize LCD with dimensions (16x2)

Display "CO2 & CO Meter" on LCD

Display "Warming coil" FOR i FROM 0 TO 100:

Create custom characters for smiley and sad faces

FUNCTION loop()

Read CO2 sensor value using analogRead

co2lvl = Map co2lvl from range [0, 1023] to [400, 5000]

Print CO2 level to the LCD and Serial Monitor

ifco2lvl is between 400 and 1000 Print "Good" on LCD with smiley character

if co2lvl is between 1000 and 2000 Print "Bad" on LCD with sad character

else Print "Danger!" on LCD

Wait for 3 seconds and Clear the LCD

Read CO2 sensor value using analog Read

colvl = Map gas from range [5, 1023] to [0, 100]

Print "CO level: " colvl and " ppm" on LCD

Print CO2 level to the LCD and Serial Monitor

If colvl is between 0 and 9 Print "Good" on LCD with smiley character

If colvl is between 10 and 25 Print "Bad" on LCD with sad character

Else Print "Danger!" on LCD

Wait for 3 seconds and Clear the LCD

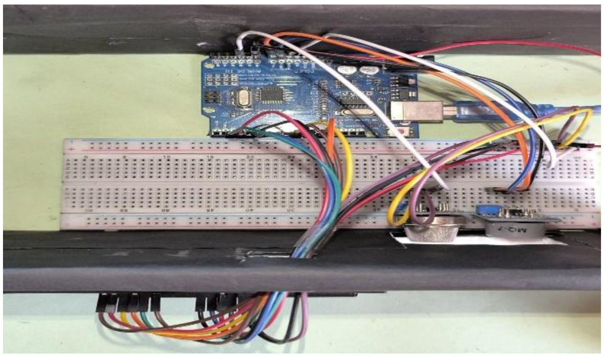

Fig:3.1 Circuit

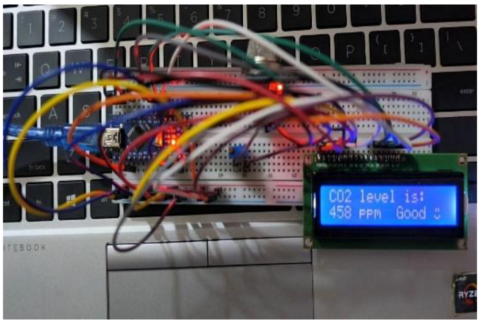

Fig:3. Output

3.2 Performance Analysis

This CO_2 and CO monitoring system's accuracy, responsiveness, stability, and robustness were tested under varied environmental circumstances in order to assess its performance. The CO_2 sensor MQ135 was first calibrated by deducting the sensor's minimum analog value to ensure its accuracy. The raw analog values from the MQ135 and MQ7 sensors were mapped using mapping function to convert into ppm values, allowing clear interpretation. The MQ135 sensor was set up to efficiently detect CO_2 levels between 400 and 5000 ppm. Similarly, the MQ7 sensor was set up to efficiently detect CO levels in the range of 0 to 100 ppm. Responsiveness of the system was tested by creating artificial variations in air quality, such as exhaling near the MQ135 sensor to simulate increased CO_2 levels or for CO detection exposing the MQ7 sensor to smoke. Every 3 seconds the results updated, which ensure near-real-time monitoring. Stable sensor output was balanced by this delay. However, as was discovered during testing in various weather circumstances, environmental factors like temperature and humidity could slightly affect the sensor performance.

3.3 Results and Discussion

The obtained results from the CO_2 and CO monitoring system demonstrated its ability to measure air quality within its intended range. Based on thresholds, the system effectively divided the air quality as Good, Bad, or Danger. CO_2 levels were categorised as "Good" when they were 400–1000 ppm, "Bad" when they were 1000–2000 ppm, and "Danger" when they were more than 2000 ppm. For CO, "Good" corresponded to levels between 0 to 9 ppm, "Bad" was observed for levels below 9 ppm, and "Danger" was displayed for concentrations above 25 ppm. From these thresholds users received insightful and useful feedback. The system's successful performance in indoor settings showed its potential as a cost-effective way to monitor the quality of the air in homes and workplaces. However, some issues were observed such as before providing stable readings, the sensors needed to warm up, and sensitivity to environmental factors like humidity and temperature may cause small accuracy fluctuations. The outcomes verify that the system meets its goals of giving clear feedback and real-time air quality monitoring.

Chapter 4

Engineering Standards and Mapping

This chapter discusses how this project align with engineering standards, its impact on life, society and environment, ethical aspects, and a sustainability plan.

4.1 Impact on Society, Environment and Sustainability

4.1.1 Impact on Life

Carbon dioxide (CO_2) and carbon monoxide (CO) monitoring make a difference in people's lives and protect their health, increase safety, and raise ecological awareness. They are mostly colorless but they do pose very serious effects provided they are not well controlled. Carbon dioxide is an normal constituent of the atmosphere but when its concentration rises it is lethal especially in enclosed spaces. High levels of CO_2 in the body can cause common distressing symptoms such as dizziness and fatigue and could possibly result in respiratory failure. Such monitoring aids in prevention of air pollution in homes, administrative buildings and industries, by identifying areas where high level of CO_2 is present and recommending such actions as increasing air exchange rates.

While carbon monoxide is colorless and odorless, it can kill people without their realizing it. This non-emulsifying, transparent gas, appearing as a result of incomplete combustion, tends to build up quickly in inadequately aired spaces. Inhalation of CO leads to a variety of effects depending on its concentration; these range from mere headaches, confusion and dizziness to unconsciousness and death. Through early monitoring systems tragedies are averted since it not only alerts the occupants to leave or increase ventilation. They are particularly relevant in mining, manufacturing and transport industries since areas of exposure are more pronounced. Thus, they prevent long-term diseases among the workers, increase output, and decrease legal risks for employers, and maintain the quality of fresh air. Also these monitoring systems play an important role in environment by facilitating the control of CO_2 emissions. In the context of climate change they are helpful in the sense that they act as parameters to help cut down on greenhouse gases as regarded under sustainability initiatives.

In general, carbon dioxide and carbon monoxide monitoring systems are essential equipment for protecting human lives, improving the safety situation, and promoting a healthy planet. Thus, incorporating mentioned technologies into our lives, we build safer and healthier environments also improving the state of the world environment.

4.1.2 Impact on Society & Environment

Systems installed for monitoring carbon dioxide (CO_2) and carbon monoxide (CO) are essential tools that protect the population and the environment based on essential safety characteristics of humanity and civilizational needs related to global climate change.

In society, these systems promote safety in that people are protected from the toxic effect of these gases. Most fatalities are caused by carbon monoxide – an invisible, odorless gas which is lethal at low concentrations, which results in thousand poisoning cases each year. CO monitors are used in homes,

offices, cars to prevent any gases from leaking from appliances, engines and the like, and providing an alarm once it detects. Also, high levels of CO_2 such as those found in facilities with high occupancy or inadequate ventilation, can also reduce efficiency, even at the cognitive level. This way, the functioning of monitoring systems maintains appropriate air quality and recommends better living and working conditions. In the environmental terms, carbon dioxide monitoring facilitates global struggle against climate change. Industrial monitoring systems offer information on emissions that can be accessed in real-time thus helping industries, governments or researchers in the identification of sources and ways in which they can reduce emissions. This is important for attaining climate objectives for instance the Paris COP 21 agreement age related goals.

In industrial terms, they promote a culture of stewardship to the external environment. Thus, their aim at meeting the stipulated emission rates make the businesses adopt appropriate technologies that are friendly to the environment. Furthermore, the application of similar systems make people more aware on the quality of air in their surrounding environment, and also influence other people to use renewable energy and make the environment more energy efficient. Altogether, carbon dioxide and carbon monoxide monitoring systems are the interface between personal protection and worldwide responsibility. Do more than save lives; they also enable societies to make decisions that can mitigate pollution and fight climate change to create a healthier world and establish a more sustainable future.

4.1.3 Ethical Aspects

Carbon dioxide (CO_2) and carbon monoxide (CO) monitoring systems can be claimed to solve main ethical issues by focusing on human health, safety, and environmental friendliness. These systems correspond to the principles of ethics of life, clean air, and the responsibility of the planet.

The first important ethical issue is the affirmation of human life. CO is a colorless and odorless gas which can lead to illness or death after even a brief period of exposure. CO_2 is universally considered as hazardous only at much higher concentrations but will lead to some impairment of brain function and general well being. Measures of monitoring these risks make it possible to timely detect all these risks and consequently, minimize harm — an indication of the moral obligation for risk minimization. Lack of implementation of such technologies such as those applied in homes, work places, schools et.c raises an ethical issue box of denying a basic right of safety. Another important dimension of ethical concern is equity and /or availability. These monitoring systems should be made cheap and accessible to all people in society but more so vulnerable groups of people who are most likely to exposed to the dangers. Providing equal access means that a person is fair and just in decision making processes.

Interestingly, from an environmental perspective, these systems are essential to ethical stewardship. CO_2 emissions have been deemed hostile to the environment, ecosystems and the next generation in the global warming crank. These monitoring systems can serve the purpose of allowing people and companies as well as governments to monitor and limit their emissions something that is an ethical responsibility on preserving the planet and encouraging sustainability. Further, many organizations that implement monitoring systems are equally committed to ethical responsibility because they protect their workers and meet emission standards. Lack of such frameworks is equivalent to negligence in regard to human and environmental concerns in management of business organizations. Such uptake, as argued in this paper, is an indication of their corporate social responsibility to present and future generations.

4.1.4 Sustainability Plan

Carbon dioxide evaluates a sustainability plan for stationary and portable monitoring systems of CO_2 and carbon monoxide with important predictors of efficiency, environmental reuse impact, and distribution coverage. The latter needs to be aware that such systems are not only vital for safety purposes but also play a role in the longtime strategy of sustainable development and climate action.

The first of the steps under sustainability plan is the employment of energy consciousness and environmentally friendly characteristics in the monitoring equipment. New possibilities include the addition of low power sensors in gadget designs, better integration of renewable energy technologies such as solar energy into these devices. It is suggested that manufacturers pay much more attention to re-processable materials in their production so that any waste which might impact the environment at the end of the product's life cycle may be reduced to the minimum. Thus, wider monitoring system application becomes possible if it is not very expensive in comparison with the given functionality, and if such systems will be installed in underprivileged districts. This is because public awareness campaigns can be used to inform communities on the need to have these systems in place, and then encourage them to do what is necessary to protect their selves and the environment.

Connectors with smart technologies and IOT platforms promotes sustainability because maintenance, prediction, and utilization of energy are performed in real-time. For example, smart systems such as AC control or lighting control systems can adjust ventilation or the alarm systems only at the right time thus saving power. From system-environment viewpoint, information gathered by these systems can be used for emissions control and minimization. The governments and industries can leverage this information to set and implement bending emission rate by policies and strategies that will in one way or another help the government to meet climate goals of the world. Last but not least, sustainability third its social aspect, including flexibility and dynamism. Software as well as sensors need subsequent updates to maintain efficiency and applicability when the conditions change or advance in the future.

A comprehensive sustainability plan aiming at energy efficiency and accessibility, environmental responsibility and technological innovation guarantees CO_2 and CO monitoring systems will help create a safer and healthier world.

4.2 Project Management and Team Work

This project was constructed by a team of five members, each member made a distinct contribution to the system's design, implementation, and testing.

Circuit Contribution in implementation :

Student's Name	Work
Shahriar Ahammed	Carbon Dioxide (CO_2) Sensor Connection
Md Moniruzzaman Rifat	Arduino connections
Kohinur Akter	LCD Display Connection
Sinthea Alam	Carbon Monoxide (CO) Sensor Connection
Sanjida Benthey Akther Sumaiya	Code implementation

Report writing part:

Student's Name	Writing part
Shahriar Ahammed	Chapter 4 (4.1- 4.2)
Md Moniruzzaman Rifat	Chapter 1
Kohinur Akter	Chapter 2
Sinthea Alam	Chapter 5
Sanjida Benthey Akther Sumaiya	Chapter 3, Chapter 4(4.3)

Product’s Cost:

Product’s Name	**Price**
Arduino Uno R3	1,050 Tk
16 X 2 LCD Display	210 TK
MQ135 sensor	200 TK
MQ7 sensor	180 Tk
Breadboard	130 TK
Jumper Waire	80 TK
Others	300 TK
Journey Cost	150 TK
	Total = 2,300 TK

4.3 Complex Engineering Problem

4.3.1 Mapping of Program Outcome

In this section, Program Outcome (PO's) is mapped with Course Outcome(CO's) and provide a justification of how PO's are attained and indicate the sections and pages where and how they attained.

Table 4.1: Justification of Program Outcomes

PO's	**Justification**
PO1: Engineering Knowledge	The project shows good understanding of basic engineering principles. It requires knowledge of Sensors (MQ135 and MQ7) ,Arduino uno, LCD Display. This project needs knowledge how sensors are used to obtain raw outputs, then the analog output is fed to analog input which is then converted to digital, how to map each raw value to the gas concentration in ppm. It involves knowledge of interfacing sensors with the Arduino uno and configuring a 16x2 LCD for output. This project reflects a good knowledge of digital logic and electronics. Section 2.1.1(page 5-7) explains basics of components and section 3.1(page10-11) explains the integration and use of these components.
PO2: Problem Analysis	This project involves processing the raw data from the sensors and converting it into CO2 and CO values, expressed in ppm. Calibration (subtracting baseline offsets) and mapping functions involve problem-solving techniques. Analytical skills are further demonstrated by classifying air quality according to predefined thresholds for safety standards. Section 3.2 and 3.3 (page 12) discuss the calibration and use of sensors and other tools, describe the feedback mechanism how the system classifies air quality utilising sensor data.
PO3: Design/Development of Solutions	CO2 and CO detection project is a real-life prototype used for potential utilization as a real-time feedback mechanism to assess indoor air quality. The project involves creating a user-friendly solution by displaying air quality levels and feedback (Good, Bad, Danger) on the LCD which is in line with developing solutions that are innovative and deployable as the project. This is a hands-on project built using of knowledge gained from the course and by analyzing problem related to the system. Section 3.3(page 12) describe the feedback mechanism how the system classifies air quality utilising sensor data.

4.3.2 Complex Problem Solving

In this section, Complex Problem Solving(EP's) are mapped with Program Outcome (PO's) and Course Outcome(CO's) and provide a justification of how EP's's are attained and indicate the sections and pages where and how they attained.

Table 4.2: Mapping with complex problem solving.

EP1 Dept of Knowledge	EP2 Range of Conflicting Requirements	EP3 Depth of Analysis
This project involves understanding and addressing the specific requirements to conduct experiments effectively. It explains the basics of MQ7 and MQ135s sensors, how they measure gases. Explain Arduino Uno, and LCD procedure, Arduino programming to detect CO and CO_2 levels., how the MQ7 and MQ135 sensors sense gases and how to communicate them to Arduino. and using an LCD to display your results. The system was developed leveraging theoretical knowledge previously gained in Digital Logic Design. Section 2.1.1(page 5-7) explains basics of components and section 3.1(page10-11) explains the integration and use of these components.	This requires understanding and dealing with competing requirements when choosing and utilising lab tools and equipment, especially when there are obstacles such as sensor limitations, environmental conditions, or calibration requirements. The goal of this project is to focus on balancing the need for accurate sensor readings while considering environmental factors that can affect sensor calibration. It also entailed choosing the appropriate equipment (sensors, Arduino uno) and examining how they interact with each other to ensure accurate and reliable measurements. Section 3.2(page 12) discuss the calibration and use of sensors and other tools.	To measure CO2 and CO levels and categorize them into Good, Bad and Danger this project require deep analysis. This project also involve analyzing sensor data (from both MQ7 and MQ135 sensors), sensors output, environmental factors and calibration to ensure that system is accurately monitoring the air quality and providing real-time feedback based on the readings. Section 3.3(page 12) describe the feedback mechanism how the system classifies air quality utilising sensor data.

Chapter 5

Conclusion

This chapter provides an overview of the results obtained during the project, addresses limitations encountered, and outlines future directions for improving CO2 and CO monitoring systems. The results demonstrate the potential of using advanced technologies to enhance environmental monitoring.

5.1 Summary

This project focuses on developing a cost-effective and scalable system for real-time monitoring of carbon monoxide (CO) and carbon dioxide (CO_2) levels. The system is designed to provide accurate measurements, which are displayed on an LCD screen for easy interpretation. Addressing the need for reliable air quality monitoring, the project aims to increase public safety, improve environmental conditions, and raise awareness of the harmful effects of air pollution on health and the environment. Its accessibility and adaptability make it suitable for a variety of applications, including residential, industrial and public settings. Furthermore, this initiative supports sustainable living practices and lays the foundation for future advancements in environmental monitoring and pollution control technologies.

5.2 Limitation

Although this scheme exhibits significant potential in monitoring CO_2 and CO levels, it has some limitations that limit its overall effectiveness and wider applicability. A primary limitation is the focus on carbon monoxide (CO) and carbon dioxide (CO_2) alone, excluding other important air pollutants such as nitrogen dioxide (NO_2), ozone (O_3), and ammonia (NH_3). These pollutants are essential indicators of air quality and are often present in urban, industrial and agricultural areas. .Without the ability to monitor a wide range of pollutants, the system provides a partial picture of air quality. System accuracy is another concern, as environmental factors such as temperature and humidity can affect the performance of its sensors. Fluctuating environmental conditions may introduce errors or require additional calibration efforts, complicating its deployment and maintenance. Furthermore, although the system is scalable and adaptable to different settings, its effectiveness may be reduced in large or highly dynamic environments where pollutant sources and ventilation patterns are more complex. This may limit its usefulness in industrial areas or urban areas with heavy traffic. Cost is also an important issue, especially for low-resource regions. Although the project aims to be affordable, integrating advanced sensors and Internet of Things (IoT) capabilities increases production costs, making the system less affordable for communities or organizations with limited budgets. Likewise, its reliance on a continuous power source makes it remote or off-grid . This makes it challenging to deploy in locations where stable electricity may not be available. Another limitation is the absence of advanced features like data analysis and machine learning. These technologies can improve systems by enabling predictive capabilities, anomaly detection and deeper insights into air quality trends over time. Without these capabilities, the system primarily serves as a real-time monitor rather than a

comprehensive tool for active air quality management. To increase its potential, future iterations of the project will address these limitations by expanding pollutant detection capabilities, improving sensor reliability, reducing costs, incorporating energy-efficient designs for remote use, and integrating advanced analytics and machine learning, there will be more sophisticated functionality.

5.3 Future Work

Future work on cO_2 and CO monitoring systems will focus on several key areas with the aim of improving the overall performance, usability and accessibility of the technology. One of the most significant areas of development is enhanced sensor technology, which will aim to develop sensors that are not only more cost-efficient but also more durable, with the ability to self-calibrate to maintain accuracy over time and reduce the need. For manual adjustment or frequent maintenance. These improvements will ensure that the system consistently delivers reliable data while reducing operational costs. Another important focus is the integration of machine learning, which will enhance the system's ability to predict air quality trends, detect anomalies and predict potential environmental changes based on historical data. By applying machine learning algorithms, the system can become more intelligent, allowing for real-time adjustments and proactive action to address air quality issues before they escalate. This will make the monitoring system more responsive and able to provide deeper insights into air pollution dynamics.In parallel, efforts to improve scalability and network expansion will enable the system to operate across large, interconnected networks of devices. This means that multiple monitoring units can communicate with each other in real-time, extending coverage and ensuring that air quality data is accessible across large areas – whether in urban areas or large industrial areas. A well-integrated network will also enhance the system's ability to operate in confined spaces where multiple sensors can collaborate to provide a comprehensive understanding of air quality at different locations. Reducing the overall cost of the system is also a key focus to ensure that the technology remains accessible to communities and organizations in resource-limited areas. By reducing costs, the system can be deployed more widely, especially in areas where environmental monitoring is most needed but lacks financial resources. To further promote sustainability, integration with renewable energy sources will explore using solar energy or other green energy options, especially in remote or off-grid areas, to power the system. This will eliminate the need for a continuous electrical supply and in the long run will make the system more eco-friendlier and more cost-effective. Finally, mobile and cloud integration will allow users to remotely access real-time data, making the system more user-friendly and increasing engagement. By incorporating mobile apps or cloud-based platforms, users can monitor air quality from anywhere, receive pollutant level notifications and make informed decisions about air quality management. These remote access authorities or organizations, real-time monitoring can help make data-driven policy decisions based on data. Together, these improvements will make CO_2 and CO monitoring systems more efficient, scalable and sustainable, enabling them to meet the growing demand for environmental monitoring and contribute to public health, safety and environmental protection. These advances will ensure that systems can adapt to different environments, accessible to diverse populations and capable of providing more accurate, actionable data.

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