Advanced Warning and Safety System for Worker at Confined Spaces

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ABSTRACT

Numerous toxic substances and gases that are present in the atmosphere can cause serious harm to human health. If the level of such gases surpasses the human body's tolerance limit, a person may be in danger or perhaps perish if the quantity is sufficiently high relative to sustainability. The quantity of dangerous gases in regions where people live, such as homes and industrial areas, must be detected and measured by a gas detection and measurement system in order to deal with this kind of problem. Because there are more poisonous gases present in industrial settings, there is a higher chance that one of those gases will cause an accident. As a result, several types of gases are present in these places as exhaust gases. Therefore, a gas monitoring system is necessary for improved human life protection. In order to establish a monitoring system and estimate the number of people, it may be more efficient to measure these gases from a remote, safer location using wireless communication tools and components. Indication is delivered to mobile phones using GSM module if oxygen concentration levels are low or poisonous gas levels are high. The number of people and other gaseous parameters are displayed using LCD module.

Keywords: Gas sensing, GSM,MQ Gas sensors

1 Introduction

Toxic gas leakage is currently the main reason for industrial accidents and worker fatalities. Environmental pollution, which harms both human and animal health by reducing oxygen levels and increasing harmful gas concentrations like sulfur hexafluoride, ammonia, carbon monoxide, and nitrogen trifluoride, is also a result of industrial pollution. These gases are the main cause of the increase in pollution in the environment. Industries that operate with chemicals are mostly responsible for releasing these environmental contaminants. The management of industries solely has an eye on profits and places the least amount of importance on environmental safety, which has an impact on the air quality and the health of industrial workers who live nearby. As the population grows and relies more heavily on the production of energy from coal, gas, and oil to satisfy need, harmful pollutants are released day by day. Around 1.1 billion people worldwide breathe in poor air, and 7 million people die every year as a result. Industries were created by individuals or business owners that were solely focused on making money. They pay little attention to the safety of the environment, the workers, or the general public. Industries are typically found outside of cities. However, some companies are situated in the center of towns and cities for logistical or raw material supply reasons. Gas leak incidents are caused by things like human error and mechanical issues. By utilising sensors and automation, gas leakage and dangerous gas detection in and around companies may be successfully managed.

The proposed system has a number of features to control the door of a specific location with respect to a clean environment. If any toxic gas or low oxygen concentration level is detected, the door will automatically close. The system also monitors the number of people entering and leaving the space and displays the values through an LCD display. All types of gas values, including CO_2, NH_3, and Carbon monoxide values, and

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the concentration of oxygen are also collected and displayed on the LCD display. An information is sent to control room using an integrated GSM module if the conditions are found to be unsafe.

2 Project Retrospective

During the Industrial Revolution, when the use of fuels like coal was beginning to show great promise, gas detection technology was first developed. Sir Humphry Davy created the first gas sensor, the flame safety light or Davy lamp, in 1815 to find methane in coal mines.

Dr. Oliver Johnson's invention of the catalytic combustion (LEL) sensor in 1926–1927 marked the beginning of the modern age of gas detection. To help prevent explosions in gasoline storage tanks, he started working on a method to identify flammable air mixtures. The possibility of unsafe working conditions for employees has virtually disappeared thanks to advancements in gas detection technology when the equipment is properly maintained.

It has been more over 5000 years since the first entry to confined space. Conventional methods like restricting entry or improving ventilation are the methods used in confined space. Advancement in gas detection sensors and automation systems gives rise to new safety mechanisms which can reduce or detect the occurrence of accidents.

3 Design

The whole system for warning and safety system for workers at confined space is designed as per the block diagram [fig. 1.]

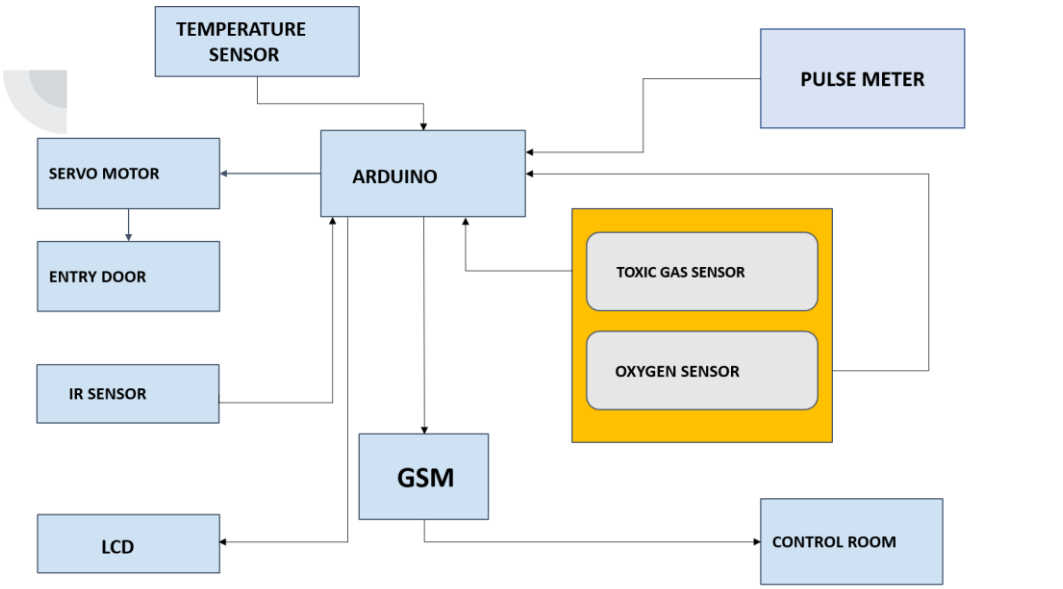

Figure 1: *Block diagram*

System consists of pulse meter, gas sensors, servomotor, LCD display and IR sensors all together connected to Arduino working as a central unit.IR sensors on the entry door connected to LCD display via Arduino. Which will show the number of persons entering to the confined space and leaving from there.MQ gas sensor monitors the concentration of gases inside the confined space, according to that entry and exit to the confined space controlled by servomotor which is connected to the entry door. Pulse meter take the pulse level of the worker to monitor the health condition of workers. All the components are working by the control and instructions by Arduino given through its running code. Complete circuit diagram designed in proteus is given [fig. 2].

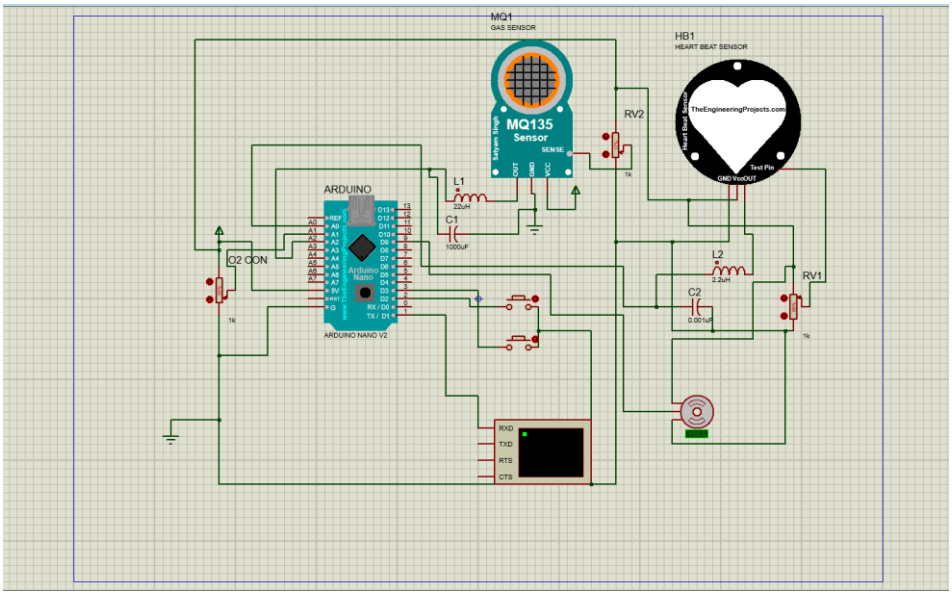

Figure 2: *Circuit diagram*

4 Methodology

The Arduino UNO microcontroller will be powered by a 12V SMPS board. The MQ gas sensor which detects toxic gases, and the oxygen sensor are integrated into the analog port of the Arduino and converted to digital values using an internal AD converter [2]. The temperature measuring sensor is also given to the analog port of Arduino. All of these values along with temperature are displayed through LCD displays. If any sensors indicate above the threshold level, the servo motor will automatically close the door and the information is sent to the control room using an integrated GSM module. If IR1 sensor detected first and then IR2 sensor detected, the person count will increase, and in the event that the condition takes the reverse, the count will decrease. The heartbeat rate of a person entering the confined space is monitored using a pulse sensor which helps to identify whether the person have any kind of serious heart issues or may at a risk of so when he/she get entered to the space and the inner region of the confined space can be monitored visually at the control room using a camera.

4.1 Microcontroller and Sensors

The microcontroller board in use is the Arduino UNO, which is based on the ATmega328P. It is a simple yet powerful tool for building electronic projects and prototypes. The board can be used to control a wide range of electronic components such as LEDs, motors, sensors, and displays. It is also compatible with a variety of shields, which are expansion boards that can be plugged into the Arduino board to add additional functionality.

An electronic device that detects infrared radiation in its environment is called an IR (infrared) sensor. The wavelength of infrared radiation is longer than that of visible light but shorter than that of radio waves. IR sensors are often used to detect and measure heat, motion, and proximity. They work by detecting the amount of IR radiation emitted by objects in their field of view and then converting this into an electrical signal that can be analyzed and used by other devices.

The temperature and humidity of the area are also measured using a DHT11 sensor. The DHT11 is a straightforward, in- credibly cost-effective digital temperature and humidity sensor. It generates a digital signal on the data pin and uses a capacitive humidity sensor and a thermistor to detect the air's humidity (No analogue input pins are required). Although very simple to use, data collecting calls for exact timing.

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A pulse sensor is a tool used to gauge a person's pulse rate. It works by detecting the changes in blood volume in the capillaries under the skin, which occurs with each heartbeat. A typical pulse sensor consists of a light source, a photodetector, and signal conditioning circuitry. The light source is usually an LED that emits light of a specific wavelength, typically in the visible or near-infrared range. The photodetector is a device that detects the amount of light that is transmitted or reflected by the tissue under the sensor. The photodetector signal is amplified, filtered of any noise or interference, and converted into a digital signal that can be handled by a microcontroller or computer via the signal conditioning circuitry. To use a pulse sensor, the sensor is typically attached to a finger or earlobe using a clip or strap. The light from the LED penetrates the tissue and is absorbed or reflected by the blood in the capillaries. The photodetector then measures the amount of light that passes through the tissue, which varies with the blood volume changes. The signal conditioning circuitry processes the signal to extract the pulse rate, which is then displayed on a screen or sent to a computer or other device for further analysis.

4.2 Gas Sensing

Toxic gas detection is done with the use of MQ gas sensors [3]. The type of gas that the sensor is able to detect depends on the sensing material that it contains. Usually, modules with comparators are supplied together with these sensors. A specific gas concentration threshold value can be defined for these comparators. When the gas concentration goes over this point, the digital pin swings upward. It is possible to measure the gas concentration using the analogue pin.

The MQ-135 gas sensor can identify airborne levels of NOx, NH3, CO2, Benzene, Alcohol, and Smoke [1]. The digital pin of the MQ-135 sensor, which enables it to work with or without a microcontroller, is particularly beneficial when searching for a certain gas [8]. It is necessary to use the analogue pin to measure the gases in PPMs (parts per million). The majority of well- liked microcontrollers can work with the analogue TTL, which is powered by 5 volts [5].

4.3 Person Counting

The person counting mechanism is done mainly by using two IR sensors connected with the microcontroller. There is an Obstacle Detection LED present on the IR Sensor that will turn on when there is any obstacle passage between the IR LED, which is the IR Emitter and the IR Photodiode, which is the IR Detector. The human eye is unable to see infrared waves. Infrared radiation is located between the visible and microwave portions of the electromagnetic spectrum. The wavelengths of infrared radiation are typically between 0.75 and 1000 m. These infrared radiations are emitted by the IR LED and will hit the obstacle. The IR receiver receives some of the radiation that is reflected. The IR receiver's reception intensity controls the sensor's output. The voltage and resistance of the photo- output diode vary in direct proportion to the amount of IR light received [4].

Next, the Microcontroller checks the input ports where the 2 IR Sensors are connected to the same. The output of the phototransistor is always at high voltage when there is no break between the IR LED and the phototransistor of the first sensor pair.

Now, the compiler views a changeover as a disturbance to detect the passage of a person between the IR LED and the phototransistor, such as when a logic low level is received at the first input port then on second. The count number increases from zero count in accordance with the algorithm, indicating that a person has entered, and this count value is displayed on the LCD. Like this, for every person entering the counter is incremented by one [6]. A person passing between the IR LED and the phototransistor is detected by the sensors and if there is a changeover, such as when a logic low signal is received at the second port and then on first the count value decreases in accordance with the algorithm, suggesting that someone

has left the space, and this value is shown on the LCD. Like this, for every person leaving the counter is decremented by one. The value that is displayed on the LCD at an instant of time indicates the number of people left inside the space.

4.4 GSM Module

A GSM module is a device that enables communication over the Global System for Mobile Communications (GSM) network. It is essentially a miniature cell phone without a display, keypad, or battery. A GSM module typically consists of a SIM card slot, an antenna, a power supply, a microcontroller, and a set of interfaces for connecting to other devices. The SIM card stores the module's unique identification number, which is used to establish a connection with the network. The antenna is used to transmit and receive signals over the net- work. The microcontroller in the GSM module is responsible for processing the communication between the module and the network [7].

4.5 Servo Motor

For precise motion control, servo motors are a common type of motor used in robotic and industrial applications. It is typically used to control the position of a mechanical system, such as a robotic arm, a camera gimbal, or an aircraft control surface. The components of a servo motor are a motor, a feedback mechanism, and a control circuit. The motor is usually a DC motor or a brushless DC motor, which provides the torque to rotate the output shaft. A potentiometer or an optical encoder is frequently used as the feedback device, which informs the control circuit of the output shaft's location. The control circuit changes the motor's speed and direction to move the output shaft to the intended position by comparing the desired position to the actual position as determined by the feedback device. Applications like robotics, manufacturing, and automation that need for precise motion control frequently employ servo motors. In addition to their precise control of motion, servo motors also have the advantage of being able to hold their position even under load, which makes them ideal for applications that require stability and precision. They are available in a range of sizes and torque ratings, and can be controlled using a variety of interfaces, including PWM signals, serial communication, or USB.

5 Result and Discussion

A complete system for ensuring the safety of workers at confined space is designed and implemented. Arduino considered as central unit and all the components are connected to it. MQ 135 gas sensor containing sensor part will detect the presence of gases like CO_2, NH_3, and CO which are considered as toxic gases at confined space and also detect the presence of oxygen gas along with its concentration. The condition safety mainly depends upon the oxygen concentration in between 19.5 and 24 percentage as per universal safe oxygen level. If the concentration of gases are at safe condition the door connected with servo motor will rotate 90 degree and open the entry door and allow the workers to enter the confined space [fig. 3]. IR sensors connected at the entrance to confined space are detecting presence of objects to count the workers who enter to confined space ,and also decrease the count while leaving workers from confined space. The servo motor remains closed when the condition is unsafe, [fig. 4] and alert message passed to registered mobile number assumed as control room via GSM module. DHT 11 temperature sensor monitor the correct temperature level and display it. Pulse meter clearly take the pulse level of each one while entering to confined space and anytime worker feel tired and show the pulse level on LCD display which shows the condition of workers while working at confined space. The project act as completely advanced safety system for workers.

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5.1 Hardware results

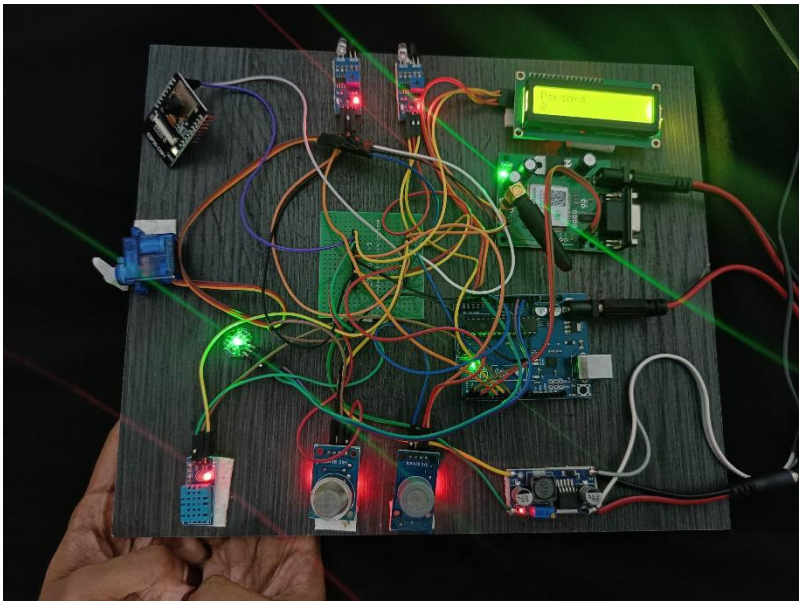

Figure 3: *Safe condition*

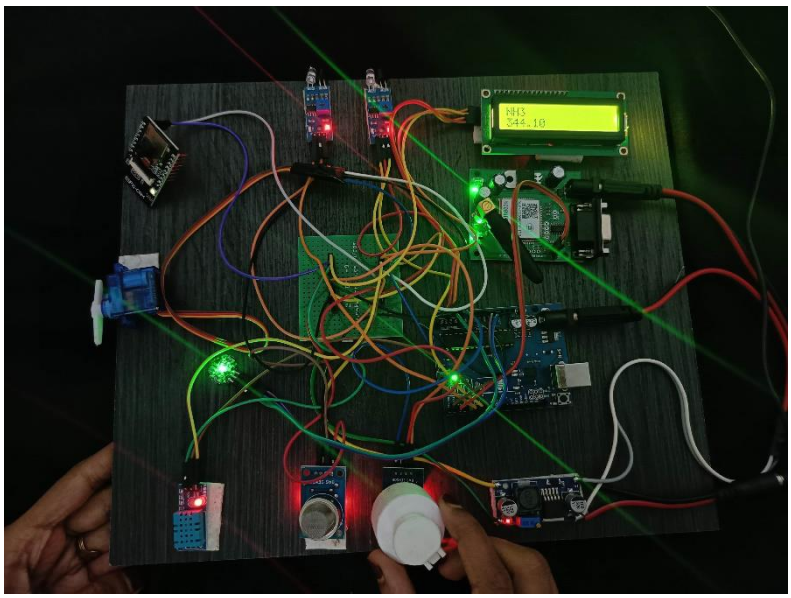

Figure 4: *Toxic condition*

5.2 Software results

Simulation of the project done in Proteus software using Arduino IDE for compiling the running code for Arduino. The gas sensor library monitors the concentration of gases inside the confined space and display on the virtual monitor and according to concentration of toxic gases servo motor allows the entry to the confined space only when the condition is safe inside the workspace [fig. 5].

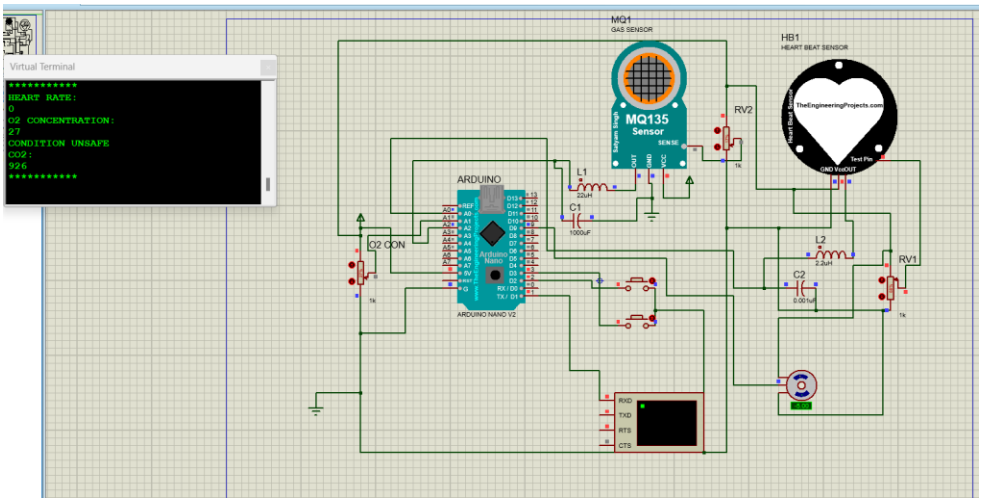

Figure 5: *Simulation circuit with virtual display*

6 Conclusion

Working in confined spaces can lead to a number of issues owing to toxicity, hypoxia, or other reasons. Asphyxia, breathing difficulties, and even death can result from it. By evaluating confined spaces, it is possible to provide a warning system for harmful circumstances, which benefits the workers by ensuring a secure working environment. When dangerous conditions are discovered, a warning signal is delivered, and the gases present in the workplace are sensed and evaluated. The workers can determine whether the area is secure enough for them to perform their jobs or not.

7 Declarations

7.1 Acknowledgement

We want to sincerely thank NSS College of Engineering Palakkad for giving us the resources and facilities we needed to finish this project. We also like to express our gratitude to Harikrishnan A. I., an associate professor in the department of electronics and communication engineering who served as our project's mentor, for his leadership and insightful advice. Finally, we'd want to express our gratitude to everyone in our team for their efforts and commitment in finishing this project.

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