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Original Article

Mitigating Threats Issued to Life and Properties by Gas Leakage Through Arduino Microcontroller Technology

Ike Innocent[1], Karim Usman[2], Odey John[3]

[1,3]*Department of Computer Science, Nigerian Army College of Environmental Science and Technology (NASME), Makurdi, Benue State*

[2]*Department of Mathematics and Computer Science, Benue State University, Makurdi*

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Abstract *- A smoke detector is a device that senses smoke. Smoke detector response based on optical density, temperature rise, and gas velocity thresholds. This research work aimed to construct a gas leakage alarm using GSM notification for the monitored use of gas only. It was achieved using cost-effective materials. It is capable of increasing a sense of security because it can only be operational at the push of a power button to ON, and it commences sensing and saves cost. It attempts to proffer a lasting solution to the long-lingered difficulties and inconveniences with gas usage in an unprecedented manner. Experimental data were used to evaluate recommended alarm thresholds and to quantify the associated error. Results: With few exceptions, less than 50 percent of the predicted alarm times occurred within ± 60 seconds of the experimental alarms. At best, errors of 20 to 60 percent (in under-prediction) occurred for smouldering fires using an optical density threshold. For flaming fires, errors in predicted alarm times were common on the order of 100 to 1000 percent in over-prediction of the experimental alarms. This paper addressed the construction of a gas leakage alarm using GSM notification that receives input from sensors and delivers it to the microcontroller. The microcontroller, in turn, instructs the gas sensor to trigger the buzzer and GSM module to alert the user about gas leakage in a given environment where it is installed. This type of gas detector ensures high security, easy operation and reduced cost. A gas leakage alarm system is a self-dependent system, and it does not need to be operated manually. It is found to be very useful in life when developed appropriately. When applying these approximation methods, great care must be exercised to ensure that the uncertainty in the predicted alarm times is appropriately considered.*

Keywords *- Gas Leakage, Security, Sensor, Microcontroller, Buzzer, Arduino Uno, Adapter, Module, Potentiometer and Photovoltaic.*

1. Introduction

The introduction should provide a clear statement of the problem by introducing the concepts and the background of the problems with their relevance to the earlier works in the chosen area. Security is the extent of protection against danger, damage, loss and crime. Security is a form of protection that includes structures and processes that provide or improve security as a condition. Security systems, hence, monitor the state of a property and access of persons unto and around the property (Anusha & Rajendra, 2019). Gas leakage has been a major problem in the industrial sector, residential premises and gas-powered vehicles like compressed natural gas buses and cars. Due to the leakage of gas produces hazardous and toxic impacts for human beings and also for other living creatures.

A gas leakage alarm system is a device that detects the presence of gases in an area, often as part of a safety system. This kind of system detects a gas leak or other emissions and can interface with a control system so a process can be automatically shut down. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to detect the leakage for security reasons and make choices on what to do afterwards. This device is important because many gases can harm organic life, such as humans or animals (Steve, 2003; Shahewaz and Rajendra, 2020).

Gas leakage alarm systems can be used to detect combustible, flammable and toxic gases and oxygen depletion. This device is used widely in industry and can be found in locations such as on oil rigs to monitor manufacturing processes and emerging technologies such as photovoltaic. They may be used in firefighting.

Gas leak detection is the process of identifying potentially hazardous gas leaks by sensors. These sensors usually employ an audible alarm to alert people when a dangerous gas has been detected. Exposure to toxic gases can also occur in operations such as painting, fumigation, fuel filling, construction, excavation of contaminated soils, landfill operations, entering confined spaces, etc. Common sensors include combustible gas sensors, photoionization detectors, infrared point sensors, ultrasonic sensors, electrochemical gas sensors, and semiconductor sensors.

More recently, infrared imaging sensors have come into use. All of these sensors are used for a wide range of applications and can be found in industrial plants, refineries, pharmaceutical manufacturing, fumigation facilities, paper pulp mills, aircraft and ship-building facilities, hazmat operations, waste-water treatment facilities, vehicles, indoor air quality testing and homes (Pravalika & Rajendra, 2019). However, a special gas sensor called the MQ-5 sensor module will be used for the design of this work. The importance of designing a global system for mobile communication-based gas leakage alarm system is to have a more independent device which, when it detects any smell of gas, will send an alert to the homeowner and also signal to the buzzer and timer will set a time for a period to trigger the alarm. (Mior, 2009).

Disasters caused by a gas explosion in different places today is mind-blowing; industries, homes and offices that use gas products, including the environment where gases are situated, encountered a whole lot of threats caused by broken pipes, cylinder explosion, and fire outbreak among others (Sanjay et al. 2019). Due to the leakage of gas produces hazardous and toxic impacts for human beings and also for other living creatures. This research will be a device used to mitigate the threats issued to live and properties by providing a platform where gas can be detected automatically without human aid.

2. Materials and Methods

A gas detector is a device that detects the presence of gas in an area, often as a part of a safety system. It detects gas leaks or other emissions and can interface with a control system so a process can automatically shut down. A gas detector can alarm operators in the area where the leak is occurring, giving them the opportunity to alert.

2.1. Types of Gas Detectors

2.1.1. Electrochemical

This type of gas detector works by allowing gases to diffuse through a porous membrane to an electrode that is either chemically oxidized or reduced.

2.1.2. Catalytic Bead

These sensors are commonly used to measure combustible gases that present in explosion hazards when concentrations are in lower explosion limit (LEL) and upper explosion limit (UEL).

2.1.3. Photoionization

Photoionization detectors (PIDS) use a high-photon-energy UV lamp to ionize chemicals in simple gas. If the compound has ionization energy below that of the lamp photons, an electron will be ejected, and the resulting current will be proportional to the concentration of the compound.

2.1.4. Infrared Point

Infrared (IR) Point sensors use radiation passing through a known volume of gas; energy from the sensor beam is absorbed in certain wavelengths, depending on the properties of the specific gas. For example, carbon monoxide absorbs wavelengths of about 4.2-4.5 μm. The energy in this wavelength is compared to a wavelength outside the absorption range; the difference in energy between these two wavelengths is proportional to the concentration of gas present.

2.1.5. Infrared Imaging

Infrared image sensors include active and passive systems. For active sensing, IR imaging sensors typically scan a laser across the field of view of a scene and look for backscattered light at the absorption line wavelength of a specific target gas.

2.1.6. Semiconductor

Semiconductor sensors detect gases by a chemical reaction occurring when the gas comes in direct contact with the sensor. Tin dioxide is the most common material used in semiconductor sensors, and the electrical resistance in the sensor is decreased when it comes in contact with the monitored gas. The resistance of the tin dioxide is typically around 50 kΩ in the air but can drop to around 3.5 kΩ in the presence of 1% methane. This change in resistance is used to calculate the gas concentration.

2.1.7. Ultrasonic

Ultrasonic gas leak detectors are not gas detectors. It detects the acoustic emission created when a pressured gas expands in a low-pressure area through a small orifice (the leak).

2.1.8. Arduino Uno

This is an open-source platform for building electronics projects. It is a physical programmable circuit board, often called a microcontroller and Integrated Development Environment (IDE), used to write and upload computer code to the physical board.

2.2. Arduino (Microcontroller)

Arduino (microcontroller) is a prototype platform (open source) based on easy-to-use hardware and software. It consists of a circuit board, which can be programmed and readymade software called Integrated Development Environment (IDE), which is used to write and upload the computer code to the physical board.

Fig. 1 Arduino Uno

Buzzer is a device that sounds; specifically, an electronic signaling device that makes sounds (buzzing). A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input, such as a mouse click or keystroke. Such buzzers are used in gas alarms, burglar alarms, etc. In this detector, the buzzer gives the output sound when the sensor detects the LPG gas. So the buzzer serves as the audio output of the detector. (Kwon et al. 2008).

Fig. 3 The block diagram Buzzer

Microcontroller for developing a software environment for writing programs for the board. The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as pulse width modulation outputs), 6 analog inputs, a 16 MHz crystal oscillator, a universal serial bus connection, a power jack, an In-circuit serial programming header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a universal serial bus cable or power it with an alternating current-to- Direct current adapter or battery to get started. UNO Microcontroller is programmed using an Arduino Integrated Environment or rather Arduino Software [Integrated development environment]. This Integrated development environment helps in writing an instruction code for the Arduino. Arduino can interact with buttons, light-emitted diodes, motors, speakers, global positioning system units, cameras, the internet, and even your smartphone or television! (Abe, 2022; Usman, Abe and Igagwu, 2022).

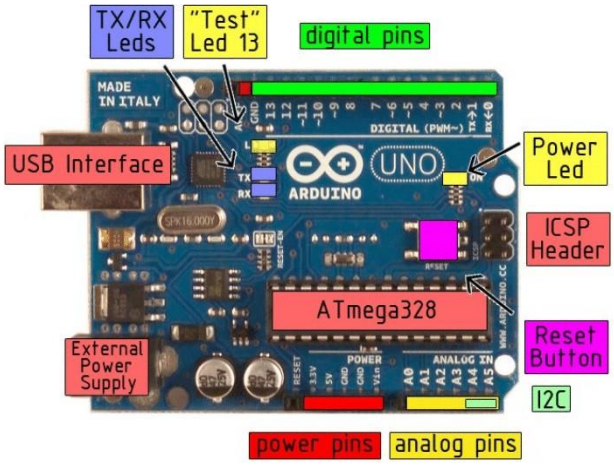

Fig. 2 The block diagram of the microcontroller

2.2.1. Alarm System

An alarm system is a device designed to detect intrusion, such as unauthorized entry into an area or place such as schools, homes etc. It is a device or series of devices that emit or transmit an audible or remote visual or electronic alarm signal intended for security purposes.

2.2.2. G S M Notification

This is the use of a global system for mobile communication to signal various events by short message system and to call.

2.2.3. Ways of Notification

S M S are sent using either the standard GSM–based SMS or gateway SMS module used to signal various events by sending short messages and calling (Kaveeya 2020)

2.2.4. Arduino

The Arduino is fed a 9v from a power source which it then converts to its operating voltage of 5v. It decodes the signal received from the 12 VDC adapter via the sensor. The Arduino instructs the buzzer based on the signal to drive the sensor. The sensor, in turn, pulls the load. The mechanical components used to carry out the design and construction of a gas alarm system using GSM notification is the case used as a cover.

3. System Architecture

The main focus is to design and construct gas sensors using an Arduino microcontroller. Arduino is a microcontroller by which many instruments can be made; from these, the "Gas sensor" will be made. In this authentic model, a gas sensor model, i.e. MQ-5 gas sensor, is used for sensing LPG gas from the environment and allows the user to be aware of the leakage of that. For being aware, a buzzer is used to be aware of and interrupt the user to the hazards of the consumption of the destruction of gas leaking. This module will effectively detect LPG leakage for domestic purposes, factories, petrol pumps etc.

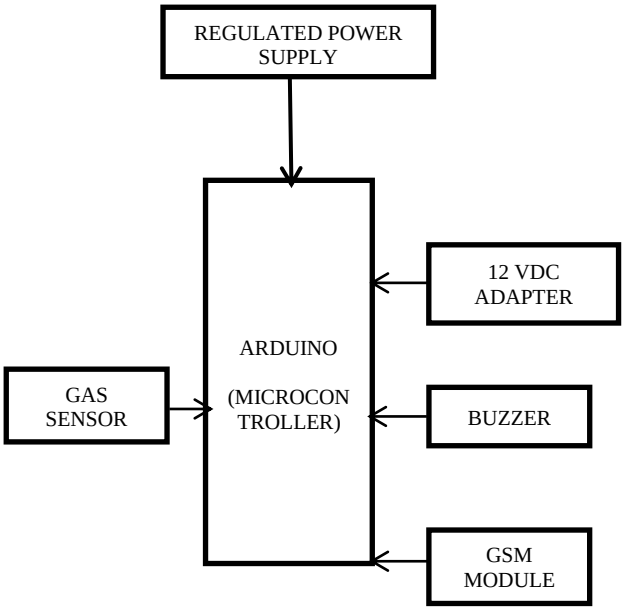

Fig. 4 Microcontroller System Architecture for smoke detection

4. Results and Discussion

4.1. Construction Procedure and Testing

In building this project, the following procedures were properly considered,

- Proposing of the entire materials / Components needed
- Resistance check of the components bought with the help of an ohmmeter before making the necessary connection with the components
- Drafting a schematic diagram or arranging the materials/components.
- Testing the completed system to see if the design works and
- Finally, implementation of the design of the project.

Having procured all the materials, we processed the arrangement of the components into the Vero board, and proper soldering of the components followed. The components were all soldered into the board, after which it was correctly confirmed done.

5. Design Principle

5.1. Casing and Packaging

The casing of this research comprises internal and external packaging. Internal parts of the circuit were soldered and fixed inside the case. Then after that, followed by external components such as indicators, LCD and switch.

5.2. Assembling of Sections

After providing the casing and finishing the construction of the sections of this system, the assembling into the casing followed. The sections were properly laid out and assembled into the casing, where the general coupling and linkages into the peripheral devices took place. Finally, the indicator and switch were carefully brought out from the internal part of the casing through the holes made on the body of the casing, and the input cable plug outlet mounted on the body of the casing where power source terminals will be connected to.

5.3. Testing of System Operation

In this stage, the system was due for testing and operation. The system operation was tested, where all its required performance was maintained.

First, the device was connected and switched ON with the toggle switch; then, the system was set for operation. The indicator light is also connected, whose function mainly indicates the presence of a power supply in the system.

During testing, a 12VDC adapter was used to see its efficiency, accuracy and threshold; fortunately, the goal was achieved correctly.

5.4. Problems Encountered

Every engineering work goes with one or more problems, which enhances research and probably technological advancement for engineers while endeavoring to resolve such problems. Therefore the project on discussion suffers some noticeable drawbacks, which include:

5.5. Mechanical Problem

We found it difficult to install all the external components. But after the effort was made, the aim was later achieved. We found it difficult to select the right gas sensor that will be used to control the sensation of gas in residential settlements, offices and oil rigs, as the case may be.

5.6. Maintenance

Hardware maintenance is the testing and cleaning of equipment. Software maintenance updates operating systems and application programs to add new functions and change data formats. It also includes fixing bugs and adapting the software to new hardware devices. In the maintenance literature, it is generally recognized that maintenance can be grouped into three categories:

5.6.1. Corrective Maintenance

Maintenance tasks are intentionally withheld until an asset stops working or starts failing. Maintenance is the performance as necessitated.

5.6.2. Preventive Maintenance

Maintenance tasks are performed at regular intervals based on industry-expected equipment life spans and failure patterns.

5.6.3. Predictive Maintenance

Maintenance is conducted only when it is confirmed necessary through the use of non-destructive tests that detect failure conditions before their occurrence.

5.7. Construction Procedures

It is a step-by-step approach in construction and design in other to achieve the mechanical hardware that can be used to load the software program, which can actually do the job of the gas alarm using GSM notification; below are the figures.

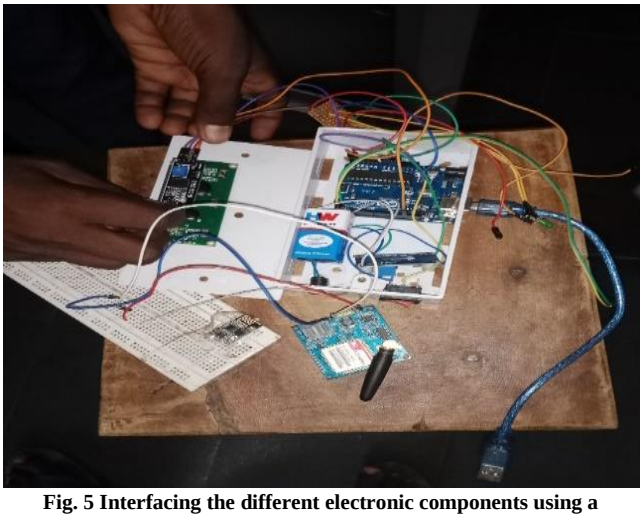

Fig. 5 Interfacing the different electronic components using a breadboard

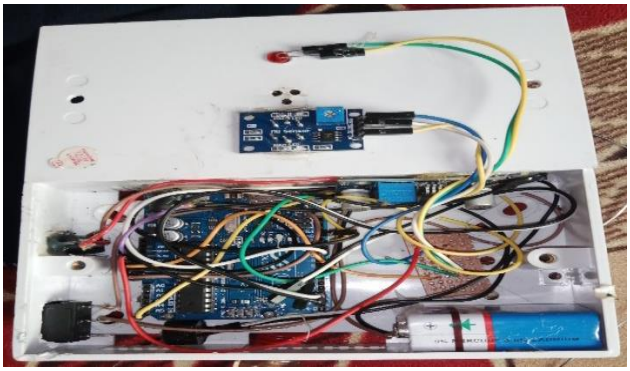

Fig. 6 Implementing the functional interfaced devices on the parterres for testing and confirmation

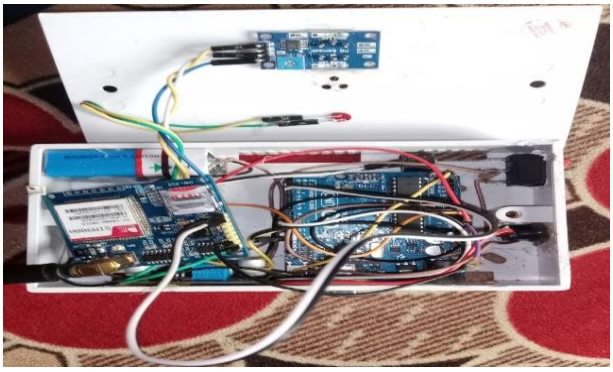

Fig. 7 Integrating GSM module with other devices to implement SMS notification

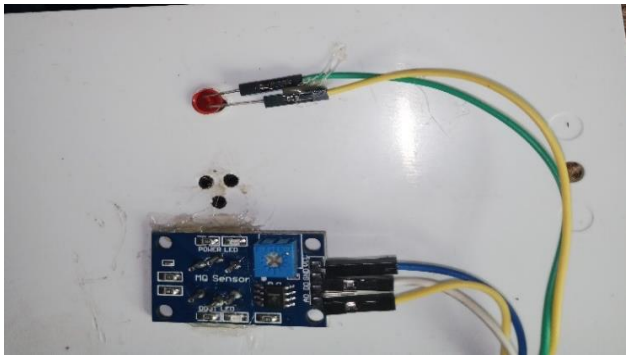

Fig. 8 Addition of MQ-5 gas sensor and LED indicator to the entire circuit

Fig. 9 Connection of switch and adapter port for powering the Arduino microcontroller board

Fig. 10 Creating access point for microcontroller port for easy access to load program via universal serial port

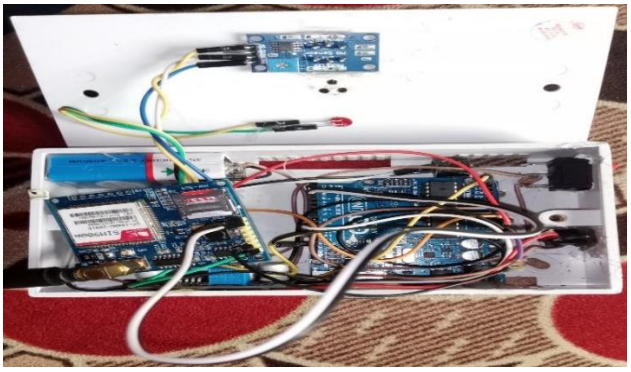

Fig. 11 All electronic devices are completely interfaced and ready for testing

Fig. 12 Complete gas leakage detector device ready and encased in a parterres

Fig. 13 Functional gas detector with mobile phone receiving short messages service signal via GSM module

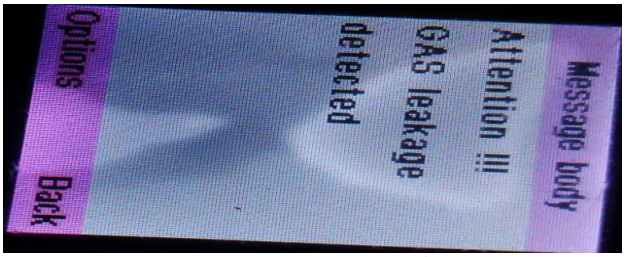

Fig. 14 Mobile phone displaying message sent from the gas detection device via SMS

6. Conclusion and Future Work

This Research Work aimed to construct a gas leakage alarm using GSM notification for the monitored use of gas only. It was achieved using cost-effective materials. It is capable of increasing a sense of security because it can only be operational at the push of a power button to ON, and it commences sensing and saves cost. It attempts to proffer a lasting solution to the long-lingered difficulties and inconveniences with gas usage in an unprecedented manner.

This paper addressed the construction of a gas leakage alarm using GSM notification that receives input from sensors and delivers it to the microcontroller. The microcontroller, in turn, instructs the gas sensor to trigger the buzzer and GSM module to alert the user about gas leakage in a given environment where it is installed. This type of gas detector ensures high security, easy operation and reduced cost. The gas leakage alarm system is a self-dependent system, and it does not need to be operated manually. It is found to be very useful in life when developed appropriately.

The following are recommended for further research: Manual operation in case of power failure: You can quickly and easily switch the device from electric to emergency operation. Using powerful sensors to increase the effective distance from 5 meters above. AC current and DC current can be used to eradicate the problem of power failure.

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