

Development of Gas Leak Detection and Location System Based on IoT

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Abstract: Leakage of gas is a major issue in the industrial sector, residential buildings, and gas-powered vehicles, one of the preventive methods to stop accidents associated with gas leakage is to install gas leakage detection devices. The focus of this work is to propose a device that can detect gas leakage and alert the owners to avert problems due to gas leakages. The system is based on a microcontroller that employs a gas sensor as well as a GSM module, an LCD display, and a buzzer. The system was designed for gas leakage monitoring and alerts with SMS via an Arduino microcontroller with a buzzer and an MQ2 gas sensor. The circuit contains a Microcontroller MQ2 gas sensor, buzzer, LCD display, and GSM module, when the sensor detects gas leakage it transmit the information to the Microcontroller while the microcontroller makes a decision and then forwarded a warning message to the user as SMS to a mobile phone for decision to be taken accordingly. The output of this research will be significant in averting problems associated with gas leakages now and in future.

Keywords: Gas Leakage

I. INTRODUCTION

Gas leakage is a major problem within the industrial sector, residential premises, and gas-powered vehicles like CNG (Compressed Natural Gas) buses and cars where the use of gas has become an important source of energy (STET, 2012) to the afore mention area in this era. The issue of Liquefied Petroleum Gas leakage has been so disastrous that it has resulted in serious harm, including the loss of life and property worth millions of dollars around the world. The catastrophic pipeline explosion has happened in different parts of Nigeria in that resulted into death and injure of many people and loss of property [1]. Gas is the most commonly used fuel in Nigerian homes and industry in which some required measures have to be strategized in other to protect against incidents and accidents such as suffocation and explosion associated with its usage. LPG is a highly inflammable gas made up of a mixture of butane (C₄H₁₀) and propane (C₃H₈) through butylene and propylene and another hydrocarbon present in small quantity, due to the odorless of these chemical ethyl mercaptans is added as an odorant to give a powerful scent so that when leakage occurs it can be perceived [2], however in a situation of the minimum quantity of gas leakage, some people have a poor sensing ability to perceive and so, more reliable and effective device use in detecting gas (gas leakage detector) has to be installed in homes, industries, and vehicles of LPG usage to avoid explosion. LPG leakage refers to several factors such as leakage in the pipe, hose not properly fixed, and hearing of whistling or hissing sound around the cylinder, valve not fitted properly. There are different ways of detecting gas leakage in which there has been existing LPG detector which only sound out an alarm when there is leakage and there is still improvement that could be made to the existing ones, in which a microcontroller activate the alarm and send a message through SMS to the appropriate personnel. The crux of the paper is to create a device that can detect LPG leakage as part of a safety measure and automatically send an SMS to the appropriate personnel and will activate an alarm immediately after gas leakage is detected in other to prevent wastage of the gas and also explosion which could lead to damaging of properties and other calamities [3]. The focus of this work is to design a system that monitors gas leakage in an enclosed system using an Arduino Uno microcontroller and an alarm system are used to alert people within leakages neighborhood while SMS will be sent to the premises owner

or safety organization to towards making decision to avert damages and loss of lives/properties. The objectives among others if the design is implemented are:

- To prevent loss of lives and properties when gas leakages occur
- To enable prompt action by the premises owner and safety organization towards avert problems that may be associated with gas leakages.
- To enable people around the gas leakages premises take action to prevent damages escalation

II. LITERATURE SURVEY

This section presents the review of some studies that are related to gas leakages detection.

2.1. Liquid Problem Gas Detection

Liquid problem gas is a flammable mixture of hydrocarbon gases used as fuel in heating appliances, cooking equipment, and specifically as a vehicle fuel (it is often referred to as autogas). It is an odorless gas due to ethyl mercaptan is added as an odorant to be easily detected when leakage occurs for safety precaution. LPG is made by refining petroleum or wet natural gas and is almost entirely derived from fossil fuels sources being manufactured during the refining of crude oil as theory emerged from the natural state. It was classified as a hazardous material because of its explosive potentials when under pressure, due to this hazardous property leading to fire explosion. The gas detection process was made by the chemically infused paper that change its color when it's been exposed to gas before the development of the electronics gas detector. The electronics leakage detector was an active approach to initial fault detection in other to achieve the utmost safety of humanity and properties as a whole they introduced an android base automatic gas detection).different approaches have been used alongside several research in the detection of leakage and were also implemented alongside some incident toward some decades. The existing leakage detection is optical sensor method, cable sensor, negative pressure, vapor sampling, signal processing, mass volume, and pressure point analysis, in which have been implemented using a different framework. Some groups of researchers have classified the technology as two fitting categories, which are software and hardware method but research continues and to technical nature research effort which led them to three group methods [4].

2.2 Classification of Leakages Detection

There are different classes of leakage detection which have been used to monitor the leakage, several criteria are classified into their classification, some of which are critical principles and abilities needed from humans. The detection is classified into three, which are automated detection, manual detection, and semi-automated detection. Automated Detection involves monitoring of detecting leakage without the help of the operator, once the detector device is installed and been connected to the display of the personnel in charge and can be automatically shut down from the display unit. (SCADA); Manual Detection - These are methods in which the device can only be operated by humans. Like thermal imager or light detection and ranging (Lidar) devices; Semi-automated detection – solutions that necessitate a certain amount of input or assistance in carrying out certain tasks (e.g. statistical or digital signal processing methods) (Batzias et al., 2011). The technology used in leakages detection can be classified into two categories which are, Direct method and the Indirect method The direct method is making use of a handheld detector by the patrol team along the pipeline and in the aspect of the very long pipeline, the airplane mounted optical imaging device is used along the pipeline for measuring gas emanation for fast result [5,6].

2.3 FPGA-GSM Based Gas Leakage Detection

In the work entitled FPGA-GSM Based Gas Leakage Detection Method by [7]. They investigated a simple FPGA based system that detected LPG leakages using the MQ6 sensor. In the event of gas leakage, an automatic warning call is sent to the first response team via GSM to avoid any delays. There is no remote monitoring or any mechanism for mitigating gas leaks, such as automatic shut-off of the gas supply.

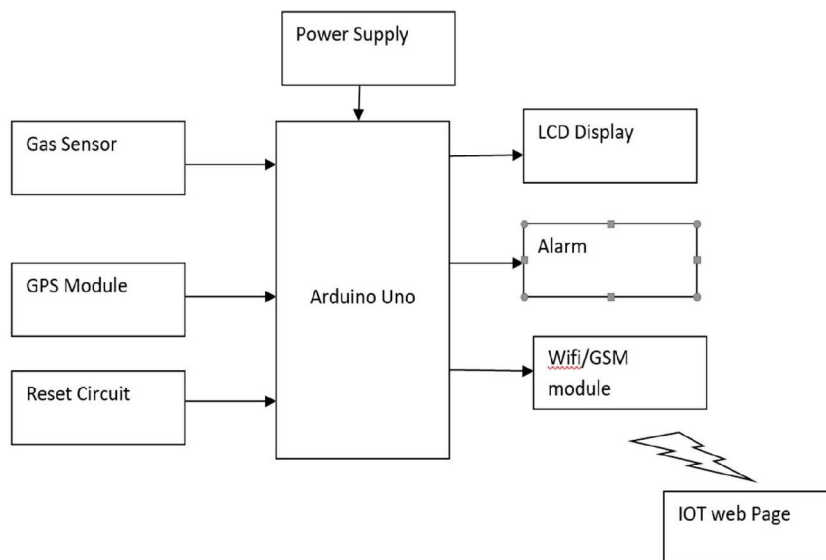
Embedded Real-Time System

For Gas Leakage Detection A domestic applications in residential buildings for an Embedded real-time system for gas leakage detection in which sensor nodes are installed in various households and communicate with a single central node. An alarm is triggered in the event of gas leakage. The concerned personnel is identified and alerted via text messages using the assigned MAC address of the RF module in each sensor unit. The use of exhaust fans is a commonly proposed solution for gas-related accidents, however, this system is only capable of mitigating a possible disaster and not completely averting it, since this approach reduces the risk by expelling gas leakage instead of shutting down the supply [8,9].

Wireless modularization of gas safety devices.

Smart home gas safety management system based on wireless modularization of gas safety devices was designed to allow safety in the homes in other to reduce damages. The system is based on the commercially available intelligent Micom meters, which have enhanced standard gas meters with a built-in microcontroller and a cutoff valve. The system is primarily concerned with detecting fire breakouts, and the existing gas meter has been upgraded to communicate with an external smoke and CO detecting sensor, as well as fire extinguishing modules, which are used to extinguish the fire when the temperature exceeds the threshold. The requirement for an existing Micom meter to construct the enhanced gas and fire safety method is a disadvantage of this system, as it lacks independent application. [10] developed a gas leakage detection and location system based on wireless sensor networks. They used wireless sensor networks to detect gas leakages and ensure product safety in the petrochemical industry. The system emphasizes the importance of developing centralized location software by collecting data from wireless RF sensors in order to precisely pinpoint the location of gas leakage and aid in the response time reduction In spite of the absence of remote monitoring and automatic shutoff, the study emphasizes the importance of inter-node communication in developing a dependable leakage detection system [11].

III. BLOCK DIAGRAM



IV. INTRODUCTION TO ARDUINO

Arduino is an open-source gadget stage based on simple hardware and code. Arduino sheets can recognise inputs such as a light on a sensor, a finger on a catch, or a Twitter message and convert them into outputs such as actuating an engine, turning on an LED, or disseminating something on the internet. Wemay direct the board by sending a series of commands to the board's microcontroller. To accomplish this, we use the Arduino programming language (in the context of Wiring) and the Arduino Software (IDE) in the context of Processing. Arduino was created at the Ivrea Interaction Design Institute as a simple tool for rapid prototyping intended for

students with no prior experience with electronics or programming. As the Arduino board gained popularity, it began to evolve to meet new needs and problems, transitioning from simple 8-bit boards to solutions for IoT applications, wearables, 3D printing, and embedded settings. All Arduino boards are totally open-source, allowing users to create them on their own and eventually customise them to their specific requirements. The software is also open-source, and it is growing thanks to the contributions of users all over the world. Arduino has been used in millions of different projects and applications due to its simple and accessible user experience. The Arduino software is simple enough for beginners to use while yet being flexible enough for advanced users. It is compatible with Mac, Windows, and Linux. It is used by teachers and students to create low-cost scientific equipment, to demonstrate chemistry and physics principles, and to get started with programming and robotics. Designers and architects use it to create interactive prototypes, while musicians and artists use it to create installations and experiment with new musical instruments. Of course, many of the projects displayed at the Maker Faire are built with it by makers. Arduino is a valuable tool for learning new things.



V. INTRODUCTION GPS MODULE

The SKG13BL is a complete GPS engine module that features super sensitivity, ultra low power and small form factor. The GPS signal is applied to the antenna input of module, and a complete serial data message with position, velocity and time information is presented at the serial interface with NMEA protocol or custom protocol.

It is based on the high performance features of the MediaTek MT3337 single-chip architecture, Its -165dBm tracking sensitivity extends positioning coverage into place like urban canyons and dense foliage environment where the GPS was not possible before. The small form factor and low power consumption make the module easy to integrate into portable device like PNDs, mobile phones, cameras and vehicle navigation systems. The Global Positioning System (GPS) is a satellite based navigation system that sends and receives radio signals. A GPS receiver acquires these signals and provides the user with information. Using GPS technology one can determine location, velocity and time, 24 hours a day, in any weather conditions anywhere in the world for free. GPS was formally known as the NAVSTAR (Navigation Satellite Timing and Ranging). The basis of the GPS technology is a set of 24 satellites that are continuously orbiting the earth. These satellites are equipped with atomic clocks and sent out radio signals as to the exact time and location. These radio signals from the satellites are picked up by the GPS receiver. Once the GPS receiver locks on to four or more of these satellites, it can triangulate its location from the known positions of the satellites. It is a higher performance, low power satellite based model. It is a cost effective and portable system which accurately detects the location. The GPS receiver used here is Sky Traq Venus 6 GPS module ST22 which is having TTL logics and also RS232 as option. The GPS receiver is shown in Fig.5. This GPS is used to track the position of the train after the emergency brake is applied in order to avoid the accidents, Global Positioning System tracking is a method of working out exactly where something is. A GPS tracking system, for example, may be placed in a vehicle, on a cell phone, or on special GPS devices, which can either be a fixed or portable unit.

GPS works by providing information on exact location. It can also track the movement of a vehicle or person. So, for example, a GPS tracking system can be used by a company to monitor the route and progress of a delivery truck, and by parents to check on the location of their child, or even to monitor high-valued assets in transit. A

GPS tracking system can work in various ways. From a commercial perspective, GPS devices are generally used to record the position of vehicles as they make their journeys. Some systems will store the data within the GPS tracking system itself (known as passive tracking) and some send the information to a centralized database or system via a modem within the GPS system unit on a regular basis (known as active tracking) or 2-Way GPS.



VI. INTRODUCTION TO GAS SENSOR

A Typical human nose has 400 types of scent receptors enabling us to smell about 1 trillion different odours. But still many of us do not have the capacity to identify the type or concentration of gas present in our atmosphere. This is where Sensors comes in, there are many types of sensors to measure different parameters and a **Gas sensor** is one which comes handy in applications where we have to detect the variation in the concentration of toxic gases in order to maintain the system safe and avoid/caution any unexpected threats. There are various gas sensors to detect gases like oxygen, Carbon Dioxide, Nitrogen, methane etc. They can also be commonly found in devices that are used to detect the leakage of the harmful gases, monitor the air quality in industries and offices etc.

In this article, we will learn more about **gas sensors**, their construction, types, working and how they can be used to measure the required type and concentration of Gas in our atmosphere. There are many types of Gas sensors but the **MQ type gas sensors** are commonly used and widely popular so will focus more on these types of sensors for this article.

6.1 Introduction to Gas Sensor

A **gas sensor** is a device which detects the presence or concentration of gases in the atmosphere. Based on the concentration of the gas the sensor produces a corresponding potential difference by changing the resistance of the material inside the sensor, which can be measured as output voltage. Based on this voltage value the type and concentration of the gas can be estimated.



MQ-6 Gas Sensor

The type of gas the sensor could detect depends on the **sensing material** present inside the sensor. Normally these sensors are available as modules with comparators as shown above. These comparators can be set for a particular threshold value of gas concentration. When the concentration of the gas exceeds this threshold the digital pin goes high. The analog pin can be used to measure the concentration of the gas.

Adaptive driving beams (ADB) are a newer, more technologically advanced type of adaptive headlamp. ADB lights are made up of numerous individuals, very bright LEDs rather than different bulbs for low and high beams. The ability to carefully control the brightness of each LED distinguishes ADB headlights.

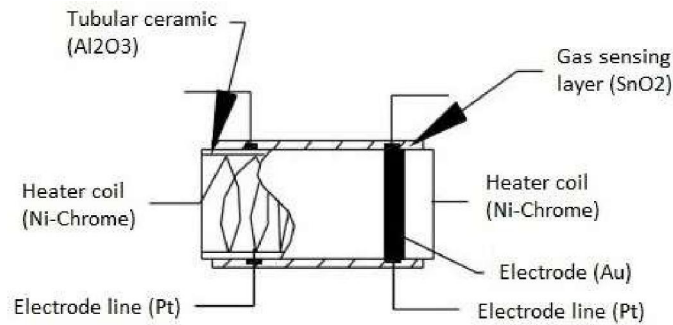
Gas Sensor Construction

Of all the above-listed types, the most commonly used gas sensor is the Metal oxide semiconductor based gas sensor. All Gas sensors will consist of a sensing element which comprises of the following parts.

Gas sensing layer

- Heater Coil
- Electrode line
- Tubular ceramic
- Electrode

The below image illustrates the parts present in a metal oxide gas sensor

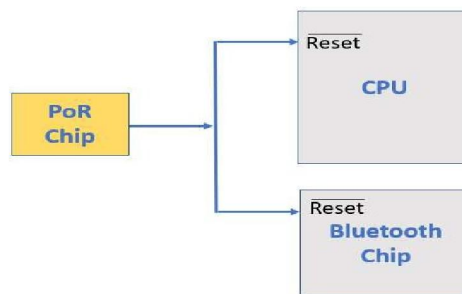


WIFI GSM MODULE

Raven is desktop smartphone and it offers features which require data communication, be it synchronization of contacts, emails and calendar or download and use of applications available on Google Play. You can send and receive data via WiFi or as GSM data. With WiFi you use the broadband internet connection in your company or at home. This makes WiFi faster and cheaper than GSM data. GSM data is suitable as back-up solution in location where WiFi is not available.

Data traffic on your Raven may differ. It depends how you use your Raven. Let us make one example: You synchronize your email, contacts and calendar in your Raven. Then data traffic may reach up to 50 MB a month. However, this depends how frequently you write and receive emails and how big the email attachments are. You can check your own data traffic in Settings, Wireless networks, Data usage (or GSM). Turn WiFi ON: Select **Settings** → **Wi-Fi**. You will see list of WiFi networks available. Select your network and fill in the WiFi password.

Reset circuit

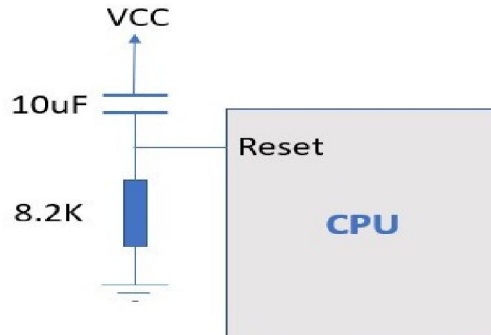


A **power-on-reset** circuit is responsible for generating resetting signals whenever power is supplied to a given electrical device. In such manner, you can determine a known state in which the device always powers up or starts operating.

The risk in not having a power on reset signal is, for example, that your microprocessor will wake up with some random values in its registers and (address) counter, and therefore, the entire circuit will not operate properly. It is mandatory to ensure all digital circuits and chips are getting a reset signal when the supply voltage is stable after power up.

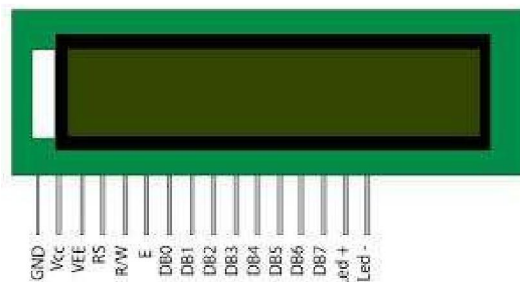
A modern power on reset circuitry utilizes a timer. This onboard timer is only activated when the power supply achieves a predetermined voltage threshold beyond which the reset signal gets triggered and ensures that the system boots properly. Considering the timer to expire after a specific period of time, resulting in the inactivation of the output of the power on reset circuit, leading to the activation of the device as the reset signal dies out. The device can now start operating. The power on reset signal prevents the CPU from running any software until a minimum

level power voltage threshold is met and the clock is stable. A power on reset circuit ensures the system power supply stabilizes at the correct levels, the clocks of the processors settle accurately, and that the loading of the internal registers is complete before the device actually starts working or gets powered up.



In analog power on reset implementation, the time and voltage threshold factors are characteristic of an analog circuit. The time period of the reset state is determined and measured using the charging of a capacitor which is placed in series with a resistor. When power is applied, the current goes via the capacitor and the voltage of capacitor increases slowly. At the beginning, the voltage is lower than the reset input pin threshold voltage and all elements in the CPU are hold in reset mode. And then, the voltage is higher than that threshold voltage, the reset pin gets a “1” and the system initializes. The values of the resistor and capacitor determine the power on reset latency. A power on reset circuit also has good noise immunity which means that in the case that a power supply suffers a minor glitch that passes by quickly enough, it will not result in the production of a resetting signal as the microprocessor will be able to distinguish it from an actual trigger for the reset signal to be activated, unlike a voltage detector. When designing a power on reset circuit, it is also important to ensure that it is only activated when the power source is consistent and constant for a considerable period of time so as to be able to assess the quality of the input power signal. It should also, ideally, be able to deactivate in the case that the power quality is poor.

16-2 LCD Display



LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is 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 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD, A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD.

Set led contrast here. Best way is to use variable resistor such as potentiometer. Output of the potentiometer is connected to this pin. Rotate the potentiometer knob forward and backward to adjust the led contrast.

BUZZER

There are many ways to communicate between the user and a product. One of the best ways is audio communication using a buzzer IC. So during the design process, understanding some technologies with configurations is very helpful. So, this article discusses an overview of an audio signaling device like a beeper or a buzzer and its working with applications



Figure: Buzzer

What is a Buzzer

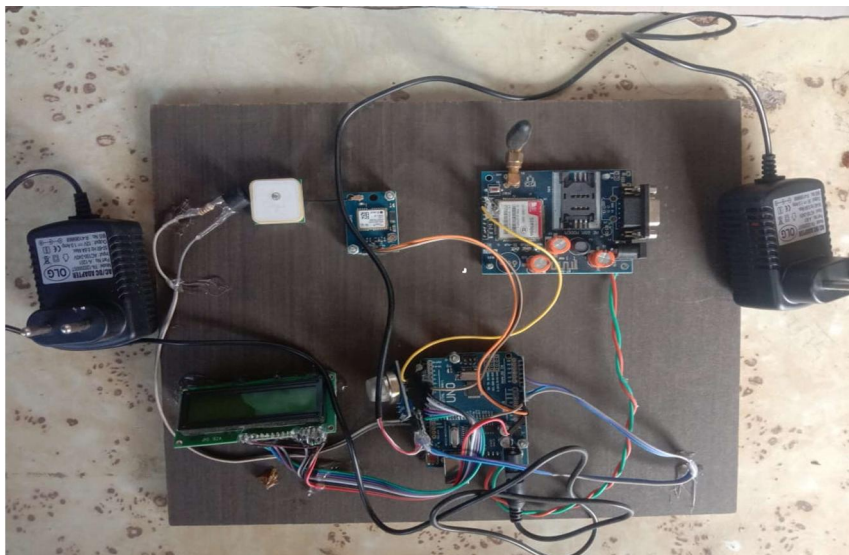
An audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical type. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren.

The **pin configuration of the buzzer** is shown below. It includes two pins namely positive and negative. The positive terminal of this is represented with the '+' symbol or a longer terminal. This terminal is powered through 6Volts whereas the negative terminal is represented with the '-' symbol or short terminal and it is connected to the GND terminal.

Working Principle

The working principle of a buzzer depends on the theory that, once the voltage is given across a piezoelectric material, then a pressure difference is produced. A piezo type includes piezo crystals among two conductors. Once a potential disparity is given across these crystals, then they thrust one conductor & drag the additional conductor through their internal property. So this continuous action will produce a sharp sound signal.

VII. RESULT



VIII. ACKNOWLEDGMENTS

“Perfect and precious guidance, hard work, dedication and full encouragement are needed to complete a project successfully in the life of every student illumination of project work is like engraving a diamond.

We take this opportunity on the successful completion of our project so thank all the staff for their valuable guidance, for devoting their precious time, sharing their knowledge and their co-operation throughout all course of development our project and the academic year of education.

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IX. CONCLUSION

Gas escape could result in severe accidents which ends in material losses and human injuries. Gas escape happens chiefly because of poor maintenance of apparatus and inadequate awareness of the individuals. Thus LPG escape detection is useful to stop accidents and to avoid wasting human lives. This paper presents a LPG escape detection and alert system. This technique triggers buzzer and displays the severity of the escape to alert individuals once LPG escape is detected. This technique is incredibly straightforward nevertheless reliable.

This work presents the design and implementation of gas leakage detection system. Various works on gas leakages detection system was reviewed and presented. I was discovered that some of the existent research don't takes in to considerations the cost effectiveness for the purpose of implementation of gas leakages detection at individual/domestic uses, and not easy to be further modified. This research work had advanced in knowledge as it included an embedded system to alert users via multiple mobile phones for further action to be taken when leakage is detected. The device detects gas leakage using a highly sensitive MQ-2 gas sensor to activate a buzzer that alert people of leakages, and also sent an SMS with the information "Gas Leakage Detected" from the SIM800 GSM Module as a backup to alert the appropriate authority or facility owner of a gas leakage. This design could be adopted, funded, and implemented as it has a great potential of mitigating against accidents associated with LPG leakage

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