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A Micro-Controller Based Biogas Leakage and Fire Detection System

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ABSTRACT

Most biogas units in the rural area have no smoke or fire alert safety mechanism. This has always resulted in indoor air pollution and or property damage in case of fire incidence. This unfortunate incident are preventable by installing a simple automated device to alert the owner in the event of smoke or fire for necessary action. This study focuses on a biogas leakage alarm system that alerts the owner via a buzzer, SMS, and call. The device uses an MQ-2 sensor to detect ignitable gas spillage and smoke. This high signal monitored by the Arduino Uno also leads to red LED lighting when the set smoke threshold is exceeded. The systems are portable and can be positioned in an appropriate position in the kitchen. This device is highly recommended in all the kitchens using biogas or firewood to alert the user in case of smoke indoor air pollution or fire breakout.

Keywords : Arduino, Buzzer, Biogas, SIM900, MQ-2 Sensor.

I. INTRODUCTION

Natural gases are widely used in industries and homes for cooking. Biogas technology has been modernized using portable digesters resulting in onsite production and utilization. Hence, leakages and explosions are possible. This necessitates a real-time monitoring and alert system to avoid losses (Mujawar *et al.,* 2015).

Traditionally, gas leakage detection is monitored by a wired sensor network whose power and operational cost are high (Ding *et al.*, 2011). To deal with these demerits, wireless sensor devices are highly proposed. The high-power requirement of wired sensor networks is simplified using short-range wireless communication like Bluetooth, Wi-Fi, and Zigbee. In modern methods, Zigbee technology is employed in gas spillage monitoring applications for real-time detection (Mujawar *et al.,* 2015).

Hina *et al.,* 2014 proposed a framework that, alongside observing and identification of gas spillage, constant information is made accessible through continuous feed over the web. They have utilized the Xively IoT stage to give online sensor information over the internet. The proposed paper by Ashish *et al.,* 2013 introduced a structure that identified gas spillage as well as alarms and turned off the primary gas supplies. It alarms by sending SMS with the assistance of the GSM module. Asmita, Prabhakar and Kayalvizhi, 2017 proposed a gas spillage detector framework that utilizes IoT innovation, which additionally has smart alarming methods like calling, sending SMS and email to the concerned user. The framework likewise cuts of the primary force flexibly of the house or building utilizing transfers when the concentration of the gas reaches a lower blast limit. The framework sends the sensor readings to the cloud for further investigation(Asmita, Prabhakar and Kayalvizh, 2017).

Globally, fire mishaps and dangers brought about by gas spillage have been a great challenge in businesses and households (Adekitan *et al.,* 2018). Fire accidents and blasts emanating from gas spillage from valves, burners, or the gas cylinders were reported by Adekitan *et al.,* 2018. The most tragic LPG accident resulted from undetected gas spillage in 1984 in San Juanico, Mexico City.

Smart Gas Detection

Smart systems are frameworks that incorporate components of detecting, incitation, and control for different investigations, and for settling on proper choices dependent on the accessible data, in a way that advances flexibility and versatility of the framework. In most cases, the system smartness is attributed to self-ruling activities that incorporate; networking capabilities, closed-loop control, and energy efficiency(Akhras, 2000). A brilliant framework ought to have a high level of dependability, productivity and manageability with a clever operational administration framework (Akhras, 2000).

The study by Mujawar, Bachuwar and Kasbe, 2015, researched on wireless flammable gas detection units for household use. The system sends an alarm to the control unit, which, in return, notify the user.

In a research study by Carmela and Ana, 2017, a gadget was invented to distinguish and quantify CH_4 gas incombustible gas store zones. The gadget measured the air and water quality, as well as any parameter changes because of gas spillage in the water or air. The detection unit quantified CH_4 and CO_2 gases in the surroundings. The gadget uploads the sensor data to an MYSQL databank on Raspberry Pi 3. A research investigation by Falohun, Oke, and Abolaji, 2014 presented an LPG detection unit utilizing an MQ-9. The study built up an implanted framework that activates a buzzer and multiple LEDs to caution occupants in case of a gas spill. An android based programmed gas monitoring unit was created by Mujawar, Bachuwar and Kasbe in 2015 which had a response action robot. In the event of gas spillage, the portable robot in a flash deciphers the information and sends it to a mobile phone through remote Bluetooth correspondence. An application based on the Android working framework that gets data from the robot and controls its movement via Bluetooth. Mujawar, Bachuwar and Kasbe, 2015, proposed a remote LPG spillage detection system based on a graphical user interface and an internet browser for response action.

MQ-2 gas sensor

Tin dioxide (SnO_2) is the sensitive material utilized in the MQ-2 gas sensor due to low conductivity in clean air. At the point when the LPG spill is identified, the sensor's conductivity rises and increments proportionately as the degree of gas spillage increments. The detection scope of the MQ-2 gas sensor is 300-5000 ppm (Hanwei sensor, 2019). MQ-2 is broadly utilized because of its wide identifying extension, quick response time and high stability (MQ-2 Datasheet).

Micro-controller unit

An *Arduino UNO* micro-controller was employed for gateway and a sensor node. These devices are open-source based on the flexibility of the hardware and software. Windows, Macintosh and Linux operating systems support the *Arduino* software based on C programming language and can be expanded through C++ libraries (Wheat, 2011). One of the micro-controller board used in this study is an *Arduino UNO* based on the ATMEL microcontroller (ATmega328). It has 14 digital input/output pins (of which six can be used as PWM outputs), six analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The hardware consists of an ATMEL ATMEGA328-P PV microcontroller, an 8-bit device from the AVR family with advanced RISC architecture and DIP28 encapsulation, which has 32KB of Flash, being 512Bytes for the bootloader, having a low power consumption.

Module GSM/GPRS SIM900: The module (Figure 1) has GSM and GPRS technology, with which you can make calls, send and receive text messages and even use the internet from a mobile phone chip, with all these features functions coupled to an *Arduino m*icro-controller; we can get various functionality.

Figure 1 : An *Arduino Uno* R3 board, MQ2 sensor and a GSM SIM 900

In these modern times, it is vital to monitor environmental parameters at the institution and domestic levels. The main disadvantage of the analog detection systems is a human error resulting from manual reading. Another major drawback is the storage of data leading to low accuracy. Therefore, there is a need to research smart systems that are fully automated, accurate and have enough storage memory. The device should be cheap and portable (Sipani, Patel & Upadhyaya, 2017).

Therefore, this work aims at designing a cheap, portable and efficient methane, smoke detection system with a fire alarm unit based on IoT using the *Arduino UNO* module in conjunction with the SIM900 module and the high-sensitivity smoke and methane MQ2 sensor.

II. METHODOLOGY

The following material was used in this study; *Arduino UNO* R3 board, GSM SIM900 module with a 2A power supply, a flame sensor and an MQ-2, as shown in figure 1. A block diagram of the developed project program is shown in figure 2. The block flow diagram shows how the sensors, LCD and SIM900 are connected to the *Arduino* board.

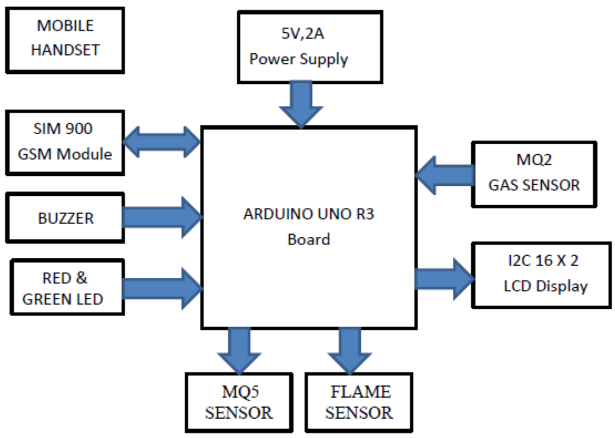


Figure 2 : A block diagram of *Arduino* based methane, Smoke & Fire Detection

Systems Development

To make a prototype, we made use of development boards that could lead to a final product with an accessible price. This requisite led our work to ATMega based boards (Arduino) (Roberts, 2015 and Air Liquide Brasil LTDA, 2010), given its reliability, robustness, and low price. Another choice was the SIM900 GSM Module, which has a complete cell phone that can make calls, send messages and even connect to the Internet. With the already given gas sensor, we could build the alarm system as described by Wilmar & Humberto, 2019). The design and development of this project are divided into two main parts which are hardware architecture and software details. In the hardware architecture, the design of the circuit was constructed and the prototype of the project was built in DipTrace 3.3. While in software development, the whole complete prototype was operated via programming codes.

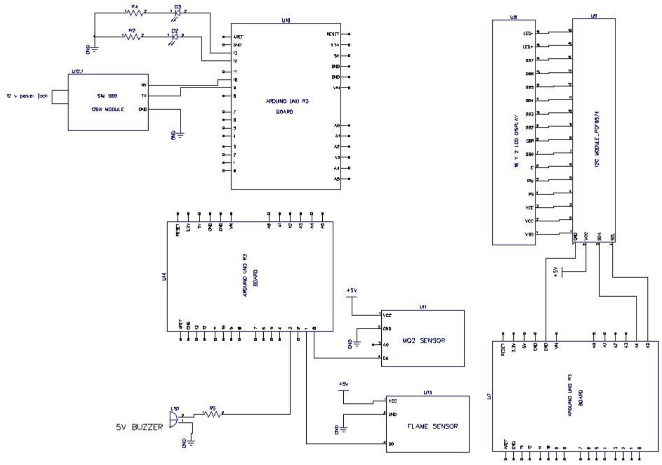


Figure 3 : A diagram of the prototype schematic.

Gas and Smoke Detection

Biogas containing 78% methane was released near the MQ-2 sensor for detection purposes while smoke was passed near the sensor until a red LED on the sensor lit. A smoke threshold was set at 350ppm with slight methane leakage being detected. For the fire sensors, a flame from a gas lighter was held near the flame sensor as described for the smoke sensor. The set up was then placed in a kitchen set to detect and alert the user.

III. RESULTS AND DISCUSSIONS

Testing was carried out by releasing LPG into the atmosphere around the sensor, as previously described by Rhonnel and Israel, 2019. The gas detector and response unit detected methane and raised the alarm after changing from a green LED to a red LED.

The actual device connections are shown in figure 4. The project operates in such a way that a call is made when the methane leaks with a display in the serial monitor alerting the user to take safety measures. A call is made in case a flame sensor detects aflame with a display on serial monitor and LCD screen with a message that flame is detected.

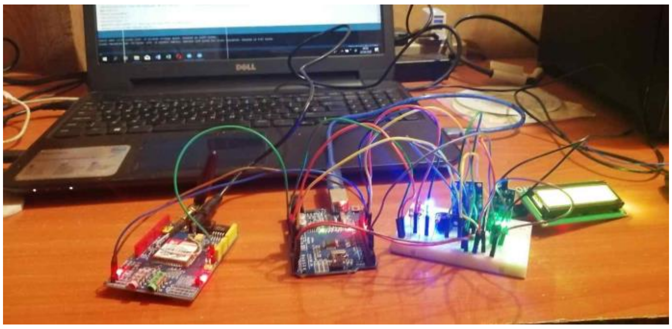
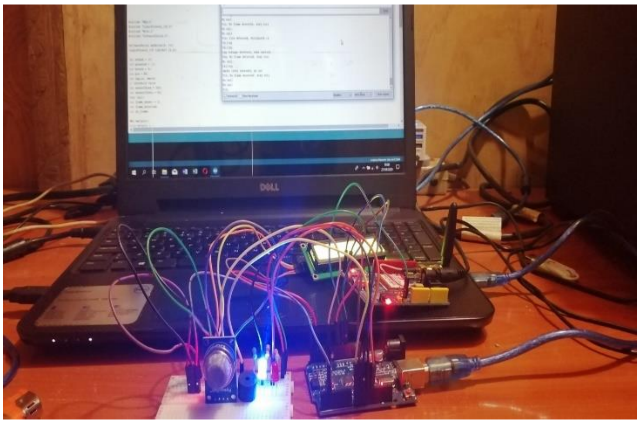
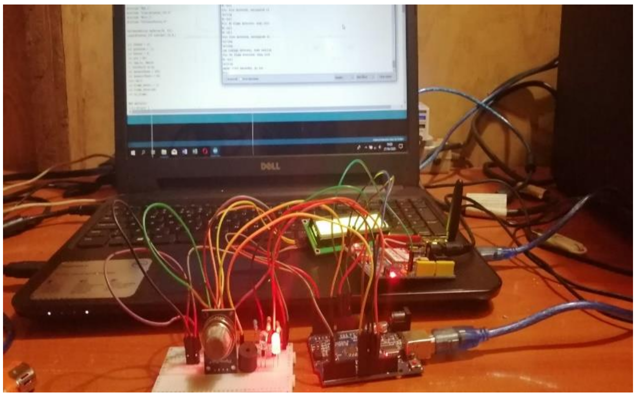


Figure 4: Biogas leakage and flame detector alarm system

In the event the smoke level exceeds the set threshold, a call is made with the message that the user must go out. As shown in figure 5, a red LED is lit as a warning in case of smoke, LPG leakage or fire is detected while a green LED is lit when all is well.



(a)



(b)

Figures 5: LED display when (a) all is running well (b) in the event of smoke, fire of methane leak

IV. CONCLUSION

This article describes an environmental alert system in the biogas utilization environment like kitchens. Methane leakage, fire outbreak and smoke sensing can be effectively solved using the open-source micro-controller like *Arduino*. The system detects the level of methane gas and smoke in the air and if it exceeds the safety level place, a call to a pre-registered number as it alerts the onsite user via an audio-visual alarm. Though the system is still under development and validation; nonetheless, the initial outcomes at the laboratory scale demonstrate the suitability of *Arduino* micro-controller for biogas safety sensing.

V. ACKNOWLEDGMENT

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