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GAS LEAKAGE DETECTION SYSTEM FOR DOMESTIC AND INDUSTRIAL APPLICATIONS

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ABSTRACT

Liquefied Petroleum Gas (LPG) is a highly inflammable gas used as sources of energy in automobiles, industries and for domestic cooking. Disaster occurs when LPG leaks and is in contact with the source of fire which may claim lives and destroy properties. Hence, its early detection is essential for preventing disaster. This paper presented smart detection of LPG leakage in domestic homes and industries. The system consisted of MQ-2 gas sensor which sensed the presence of the gas in the air and sent signal to the Arduino micro controller. The micro-controller informed the embedded Global System for Mobile Communication (GSM) module to send message in form of Short Message Service (SMS) to the users to swing into action in a bid to prevent outbreak of fire. Performance tests carried out to evaluate the system showed the capability of the system to concurrently send SMS to different subscribers and produce audible alarm. It was also observed that SMS was sent to users in a timely and efficient manner. The system could be useful in residential homes and industrial premises for preventing fire hazards.

Keywords: liquefied petroleum gas, gas leakage, gas detector, GSM, MQ-2 sensor, users.

INTRODUCTION

Liquefied Petroleum Gas (LPG) consists of a mixture of propane and butane gases (Nuga et al., 2017) which has found useful applications in a number of areas. Its reduced cost, affordability and accessibility have made a number of homes in Nigeria to resort to its use for cooking. Leakage of LPG results from poor handling of the cylinders, ageing of the cylinder, accident and actions of the vandals. Because of its highly inflammable chemical composition, explosion occurs when the leaked gas is in contact with the fire. Hence, there is need for a system that detects the LPG gas in the air before getting in contact with the source of fire. Pioneer works on gas leakage detection dated back to twentieth century where coal miners utilized canary birds to detect the presence of methane in the atmosphere. This mode of detecting methane gas gave rise to today's gas leakage detection system. Previous works in this area include Nuga et al. (2017) which developed gas leakage detection system using PIC 16F877A microcontroller while Sayeda et al. (2021) implemented automated gas leakage and alarm system using PIC16F690 microcontroller. Kasar et al. (2016) constructed automatic LPG detector for monitoring and displaying gas leakage level on liquid crystal display. Muhammad et al. (2022) developed gas leakage detector for factory safety. Musa and Adeyemi (2023) developed Internet of Things

based gas monitoring and leakage detection system. The system utilized ATMeg-32P to coordinate the activities of other components of the system. Dhammadip et al. (2023) utilized microcontroller in conjunction with machine learning algorithm to detect gas leakage. Nnokwe et al. (2022) constructed a prototype for detecting gas leakage and for improving the efficiency of the system. Apeh et al. (2016) implemented gas leakage detection and cylinder shut off system for not only detecting gas leakage but also for closing the gas cylinder. Authors focused in particular on reducing the time taken in transmitting SMS from the system to the user. Though this depends on the availability of the network at a point in time. A system for monitoring gas leakage was developed elsewhere (Huan and Yusnita, 2014) where Zigbee transceiver was used to send data from the gas sensor to the display unit. A gas leakage detector for the disabled and handicapped was developed by Pervaiz and Waqar (2016). Ochagwuba et al. (2022) presented a microcontroller based gas leakage system that could only send alert signal to subscribers on GLO and MTN (mobile carriers) networks in Nigeria. Mobile users on other networks could not receive alert message from the system. It is presented here a versatile gas detection system that caters for mobile users on the popular telecom operators in Nigeria. The system detects gas leakage and sends SMS to the three major mobile carriers in Nigeria which are MTN, GLO and AIRTEL networks.

MATERIALS AND METHODS

Figure 1 depicts the block diagram of gas leakage detection system. It is an interconnection of various subunits which includes power supply, gas sensor, microcontroller, buzzer, GSM module as well as mobile users on MTN, GLO and Airtel networks

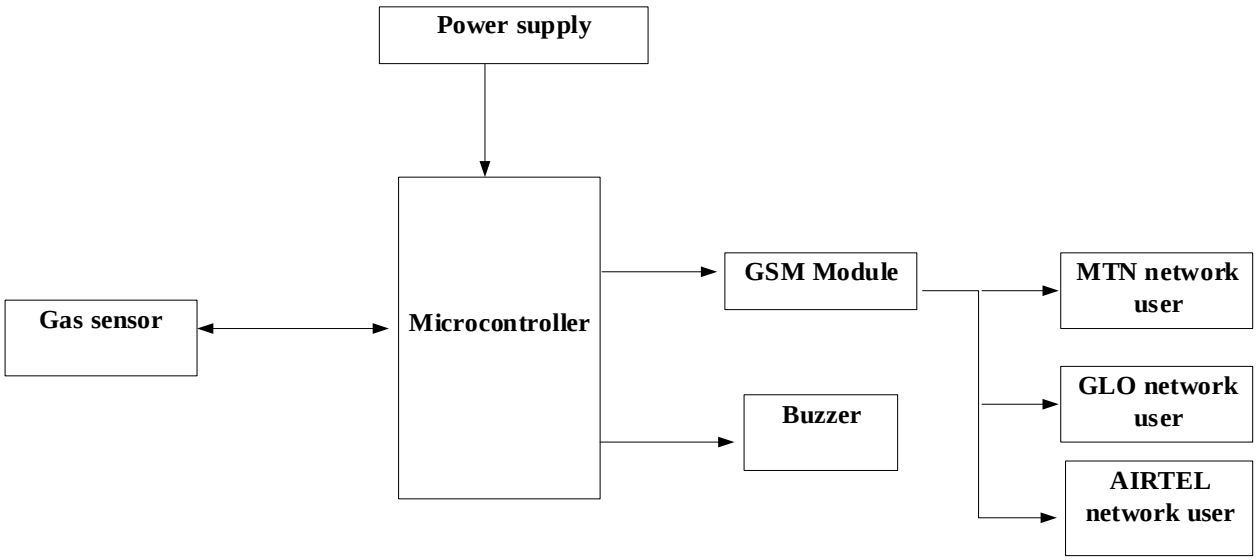

Figure 1: Block diagram of gas leakage detection system

Powers supply

This unit provides required voltage for powering the system. Direct Current (D.C.) rechargeable battery supplies 12V D.C which is regulated to 5V D.C. using 7805 voltage regulator. This is enough to power the arduino microcontroller. Capacitors C_1 and C_2 are used for smoothening and for filtering ripples in the regulated power supply. Figure 2 shows circuit diagram for regulation of D.C power supply.

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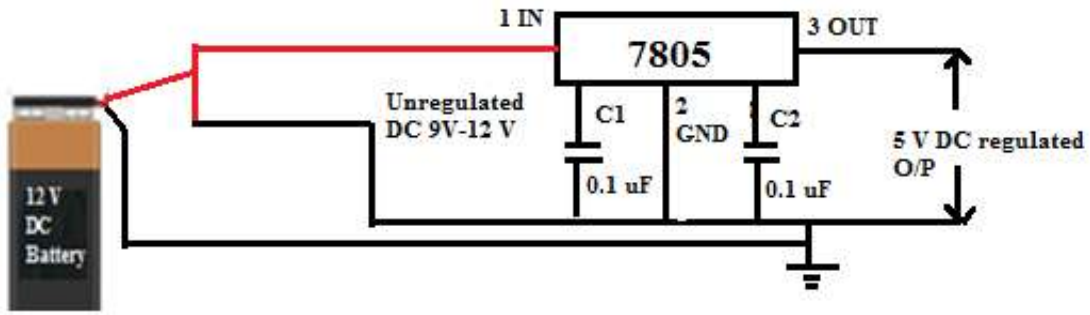

Figure 2: Regulation of D.C power supply

Gas detector

MQ-2 gas sensor is a significant unit in gas detection system. The device is useful for sensing the presence of LPG and for measuring the leakage concentration. It checks if the concentration of the gas in the air is safe and when the safe level is exceeded. In other words, the sensor is an excellent sensitive item in the gas detection system. Figure 3 shows a typical gas detector that consists of three pins.

Figure 3: MQ-2 gas sensor (source: Aderibigbe et al., 2018)

The first pin is the input pin which is connected to the output of 7805 voltage regulator. The second pin is the ground which is connected to the ground of the 7805 regulator while the last pin is connected to the digital side of the arduino microcontroller. Figure 4 shows the gas sensor circuit diagram where the load resistor (R_L) is connected between heating coil terminal and one of the input pins of the gas sensor. Sensitive material of MQ-2 gas sensor is Silicon (iv) oxide (SnO2) which has lower conductivity in clean air. A change of conductivity of this material corresponds to gas concentration and indicates gas level in the air.

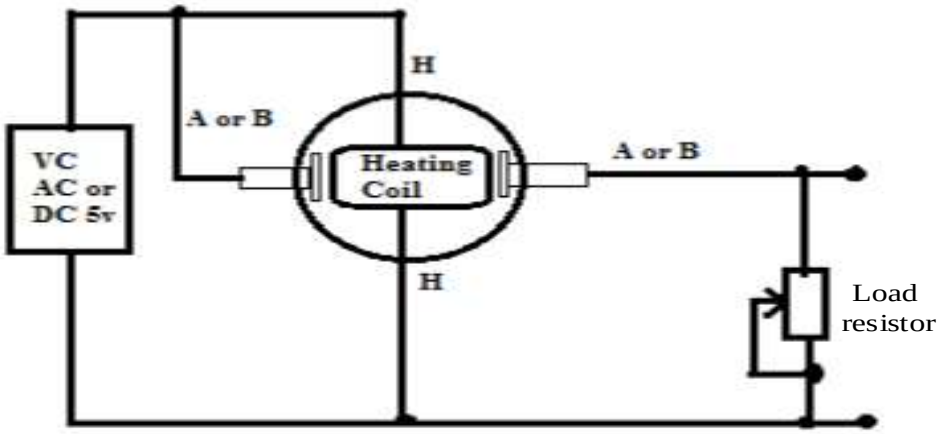

Figure 4: Gas sensor circuit diagram

GSM Module

A quad-band GSM/GPRS module that works on 850 MHz, 900 MHz, 1800 MHz and 1850 MHz frequencies is used. This range of frequencies makes it useful for sending SMS to mobile subscribers on MTN, GLO, and AIRTEL networks in Nigeria. Its tiny chip makes it compatible for space requirements in mobile devices, smart phone and application involving Machine to Machine (M2M) communication. It supports universal asynchronous communication and can communicate effectively with microcontroller via MAX232 driver, activated using AT commands. The module is used to send SMS message to the mobile phone users after detecting the gas leakage. Its shield is programmed using arduino integrated development environment library. The connection of the shield is done in such a way that pins 2 and 3 are terminated on the Arduino Uno board. Pin 2 is connected to the transmitter point of the arduino. Figure 5 shows a GSM Module

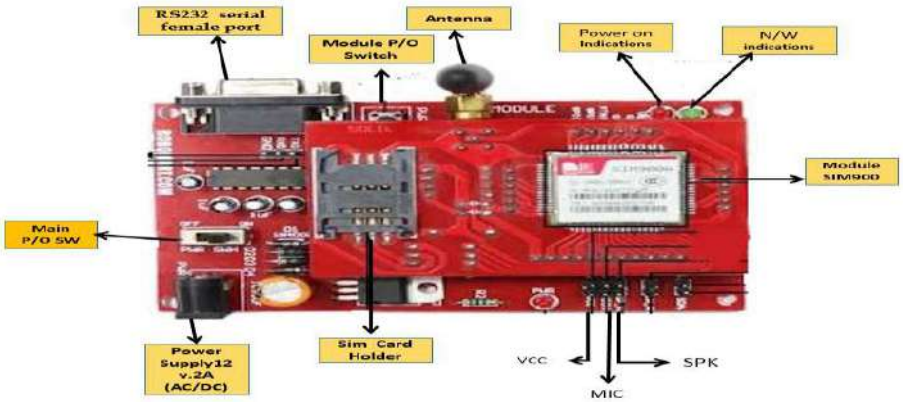

Figure 5: GSM Module.

Micro-controller (Arduino UNO)

The Arduino Uno is an embedded board consisting of 14 digital input/output pins, 6 analog and digital inputs, a 16 MHz crystal oscillator, AT mega 328, a USB connection, a power jack, an in-circuit system programmer header, and a reset button as shown in Figure 6. AT mega 328 belongs to megaAVR family and is designed by Atmel Company. It has a maximum operating frequency of 20 MHz with 23 maximum input and output pins. The microcontroller is programmed using integrated development environment library which has support for C, C++ and Java programming

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languages. Figure 7 presents the flow chart for the operation of Arduino microcontroller. The Arduino micro-controller is designed to receive signal from the sensor, processes it and sends the information to the mobile phone users through the embedded GSM module. As the leakage is detected, the controller sends code word "**Gas Leakage Detected**" to mobile users. Also, it energizes a solenoid valve to stop the flow of gas supply from the cylinder. By shutting off the supply valve, gas flow to the cooker is stopped which prevents fire outbreak.

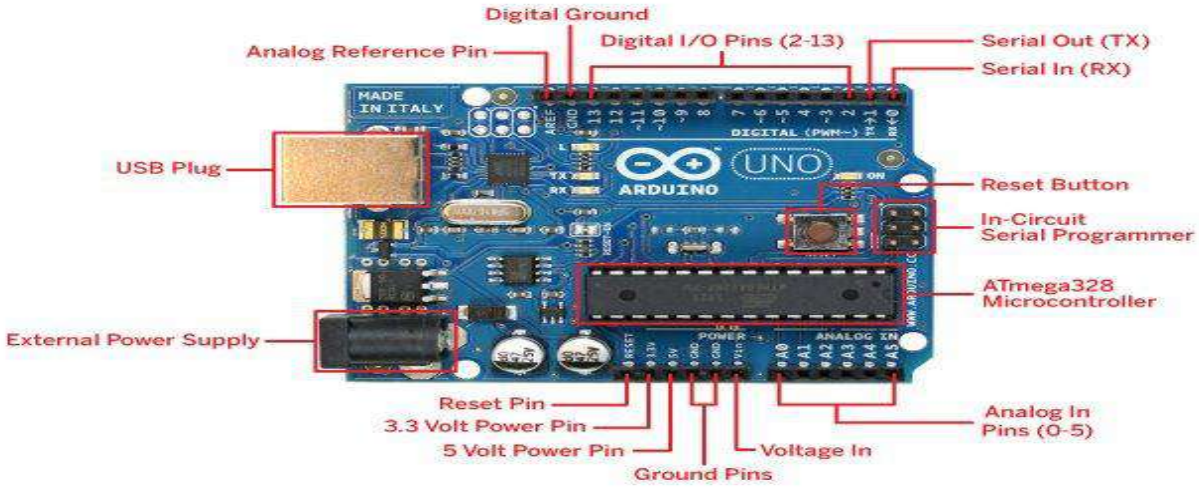

Figure 6: Arduino uno microcontroller (source: datasheet)

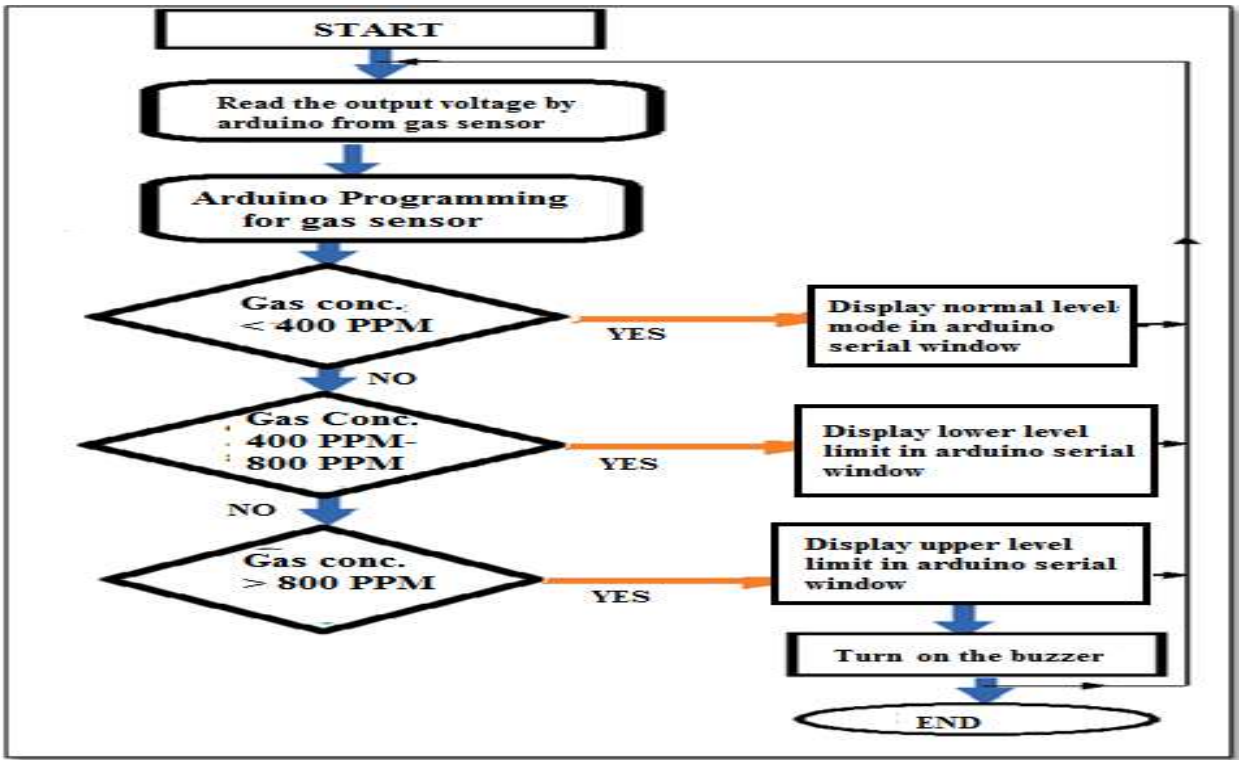

Figure 7: Flowchart of arduino programming for liquefied gas detection.

However, Figure 8 depicts the flow chart for the operation of the gas leakage detection system.

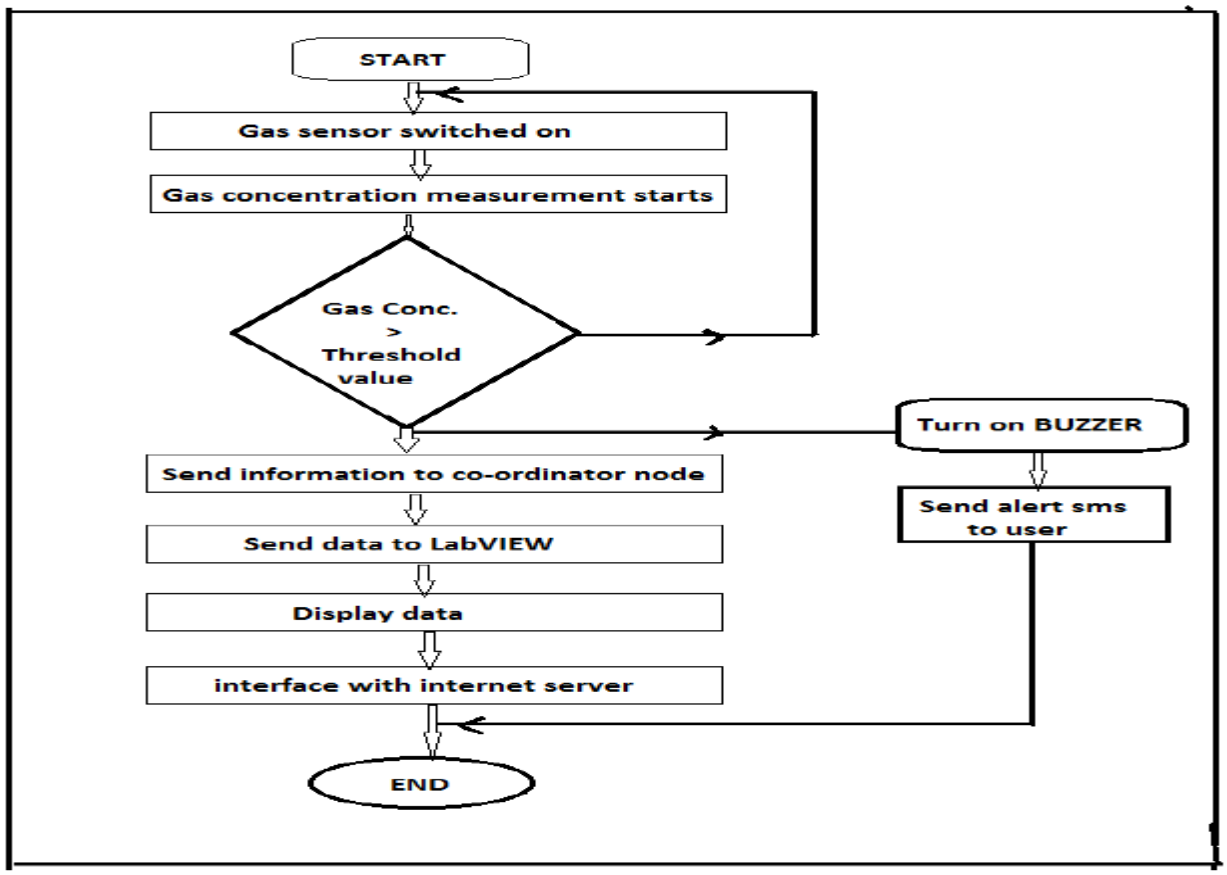

Figure 8: Flowchart of the wireless gas sensing and detection system.

Buzzer

Buzzer is an electronic component that produces sound alarm to notify users of gas leakage. The device generates sound alarm due to transmission of electrical signals. It operates within a voltage range of 5V to 12V D.C.

RESULTS AND DISCUSSION

The performance of the system was tested by carrying out gas leakage tests at a far distance (more than 40km) from mobile users at different period of the day for ten (10) consecutive days. In each day, the average time for receiving distress alert of "**Gas Leakage Detected'"** when gas concentration in the air was greater than 800 PPM was determined. It was found that the three (3) major network subscribers (MTN, Airtel and GLO) received the SMS successfully and the distance had no impact on the performance of the system once the users were active and within network coverage. However, Figures 8-11 assessed the performance of these network subcarriers in transmitting SMS from the system to mobile phone carriers at different times of the day. It could be seen in Figures 8 and 9(a) that MTN delivered the message before any other network both in the morning and afternoon while GLO network was the slowest in message delivery in the two cases. It could be seen in Figure 9(b) that AIRTEL network was faster than other networks in the evening. Figure 10(a) revealed that AIRTEL was also the fastest at 8:34P.M in the night while MTN outperformed others at 10: 49P.M in the night.

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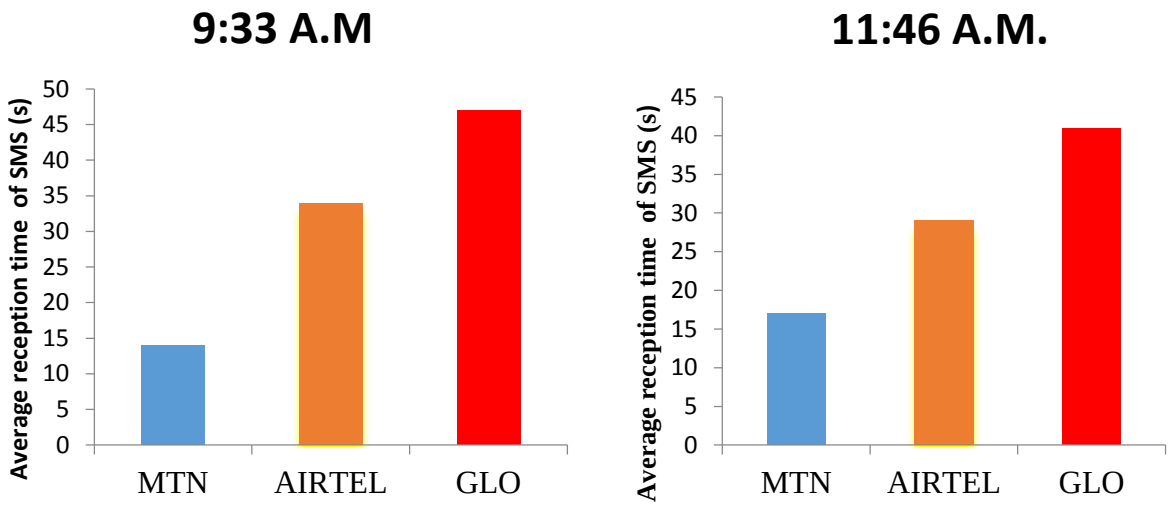
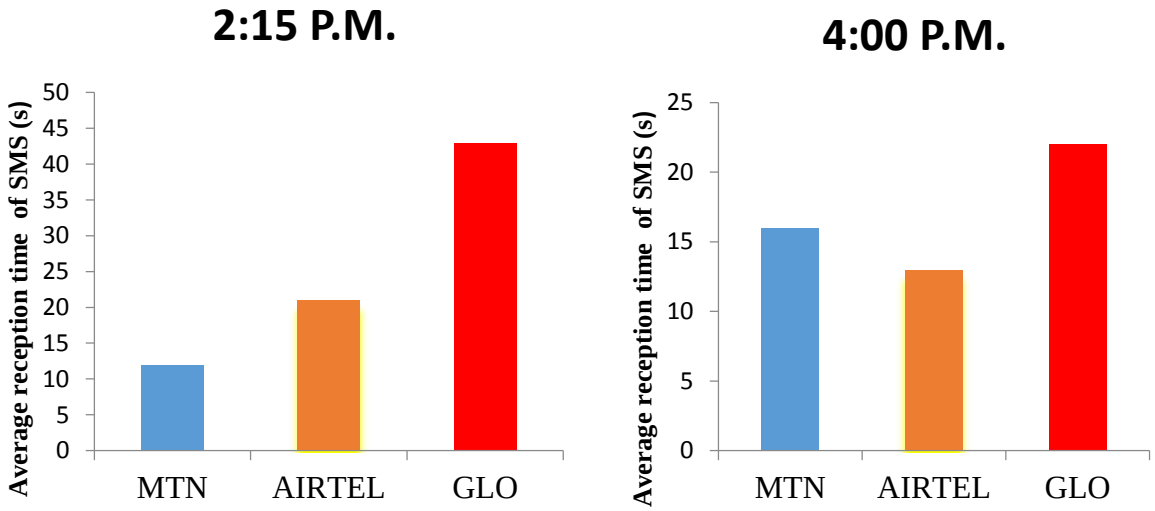


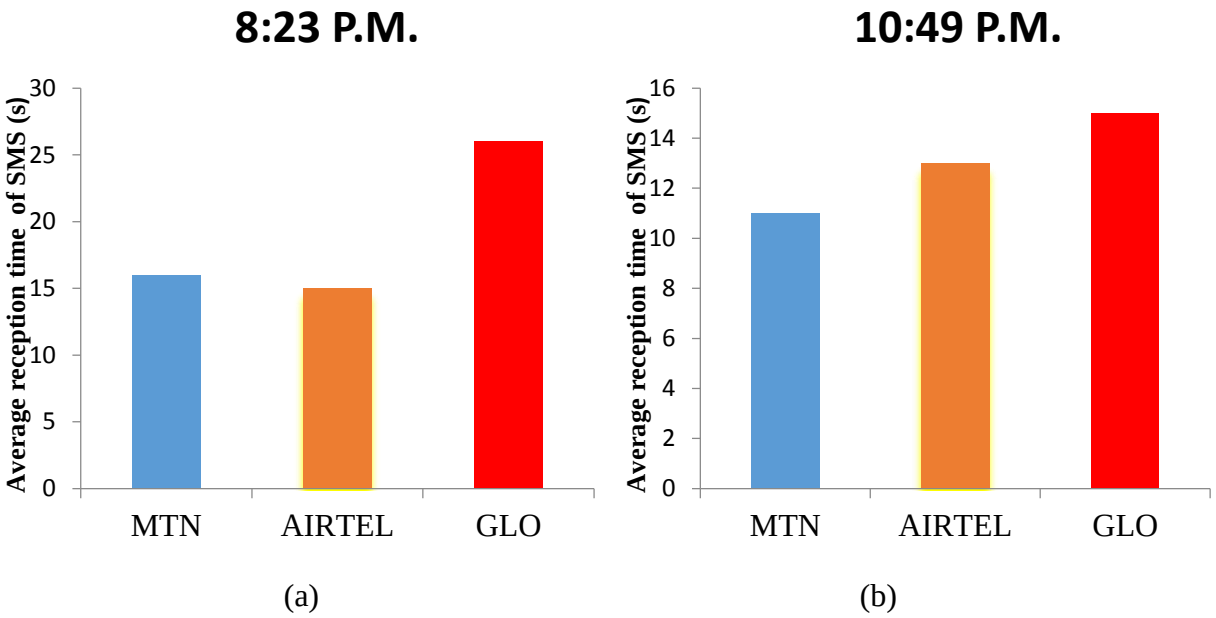
(a) (b)

Figure 8: Average reception time of SMS by mobile users on AIRTEL, GLO and MTN networks in the morning (a) 9:33A.M and (b) 11:46 A.M



(a) (b)

Figure 9: Average reception time of SMS by mobile users on AIRTEL, GLO and MTN networks in the (a) afternoon, 2:15 P.M and (b) evening, 4:00 P.M



(a) (b)

Figure 10: Average reception time of SMS by mobile users on AIRTEL, GLO and MTN networks in the night (a) 8:23 P.M and (b) 10:49 P.M

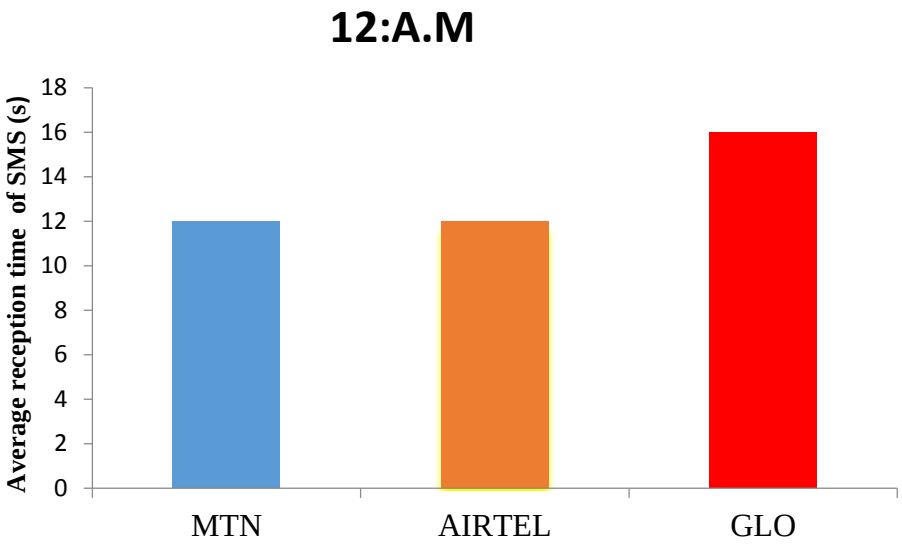


Figure 11: Average reception time of SMS by mobile users on AIRTEL, GLO and MTN networks in the midnight.

Figure 11 revealed that the delivery time of SMS for both MTN and AIRTEL networks in the midnight was the same which indicated that the performance of the two networks was at par at that time.

CONCLUSIONS

Gas leakage occurs due to poor maintenance of gas cylinder, ageing of the cylinder and poor handling by the users. Large concentration of LPG gas in the air not only causes great havoc but is also hazardous to health. This work developed gas leakage detector which utilized MQ-gas sensor to detect excess gas in the air while the microcontroller sent distress alert message to mobile phone users through the embedded GSM module. Performance test carried out on the developed system revealed that the system performed up to the

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expectation and sent SMS successfully to three mobile subscribers on MTN, GLO and AIRTEL networks. It was seen that subscriber on MTN received distress alert message before GLO and AIRTEL users in the morning, afternoon and very early in the night while in the evening and late in the night, AIRTEL was faster than others. Both AIRTEL and MTN delivered the message at the same in the midnight. It was seen in all the cases that GLO network was the slowest to send SMS to phone users. The system is recommended for use in homes and industrial kitchen to forestall fire incidence.

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