Simulation and Construction of Liquefied Petroleum Gas Detector Using Microcontroller

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Abstract: **Gas leakages resulting into fatal inferno has become a serious problem in household and other areas where household gas is handled and used. Gas leakage leads to various accidents resulting in financial loss as well as human injuries and/or loss. In this study a simulation and construction of liquefied petroleum gas detector using microcontroller Atmel AT89C51 was carried out. The circuit was simulated using Proteus v8.7 and a prototype of the circuit was constructed on a Vero board. The constructed device was tested by using it to measure flammable, combustible and toxic gases for optimum performance. The device readings were compared with standard measured values. The result shows that, the time of detection and the distance from burner increased when the gas concentration decreased. The device can detect gas at a minimum distance of 0.2m in 35 seconds at 1000mg/m^3 concentration and at a maximum distance of 1.4m at 96s for 225mg/m^3 concentration of gas. Test shows that the system can quickly respond to gas leakage in the kitchen making it very efficient and enabling quick response to avert dangers of fire outburst. Based on the test carried out, it is advisable for the user to place the device 0.6m-2.0m from the gas source and 0.2m to 1m above the floor. This is very important in homes, restaurants and industries that uses gas as it will serve as a protective device for gas detection in terms of gas leakage.**

Keywords: **Gas detector, gas leakage, liquefied petroleum gas, microcontroller, Proteus suit, simulation**

I. INTRODUCTION

Liquefied petroleum gas (LPG) is a hydrocarbon gas as by-product of refining crude oil or processing natural gas. It is an odourless, non-toxic, clean burning, and an environmentally friendly fuel with almost zero level of pollutants [1,2]. It is composed of either propane or butane or as a mixture of the two. Overall, LPG provides less than 2% of the total energy people use but it is still a major alternative to gasoline [1] and its greatest advantage is that it can be easily transported and is a multipurpose fuel used worldwide as an alternative fuel for various applications; residential, commercial, agribusiness, industrial, and autogas [3]. According to Bank Bazaar [4], the advantage of LPG gas for vehicles includes reduction in harmful emission such as oxides of Sulphur, Carbon Dioxide, suspended particulate matter and Nitrogen. Also, its purity is maintained as such ensure that the performance of the vehicle is always consistent and smooth which could improve the life of the engine, reduces noise and vibration. Customers can save up to 40% of the bill as compared to petrol and save up on repeated maintenance costs as well. However, Energy Education [1] maintained that the availability of vehicles that are LPG-fuelled is limited because it involves installing a separate fuel system as the liquid is stored in highly pressurized fuel tanks. In addition, it is harder to find places to refill LPG as it is not as widely used as gasoline or diesel, and fewer miles can be travelled on a single tank of LPG.

According to Energy Education [1], 90% of LPG used in the US comes from domestic and residential use. In the absence of natural gas, LPG is the best alternative fuel used for cooking, water heating, space heating, and drying. In India, nearly 8.9 million tons of LPG were consumed in the six months between April and September 2016 in the domestic sector, mainly for cooking [5]. In Nigeria, the domestic gas utilization has been in the increase, with annual LPG consumption of 635, 452 metric tonnes recorded in 2018 and 840, 594.37 metric tonnes in 2019. In 2020, LPG consumption in Nigeria hit a record 1 million metric tonnes [6]. Cooking with other fuels such as wood or kerosene results in pollution, accumulation of soot, and the heat generated is difficult to control. LPG allows the user to control the level of heat and ensures a clean cooking environment [1,2,4]. However, improper handling of gas can cause explosion that could cause fire accident and heavy disaster. In 1984 San Juanicotragedy in Mexico City test a severe LPG disaster in history of Mexico [7]. A related accident in 2013 was filed by pressure gas safety institute of Japan (KHK). A comparison was made with the previous years discovered 207 recorded accidents that led 52 people injured and 3 people dead. In Chennain India there were over 12 recorded accident in 2014 with so many loss of life and properties [8]. In Nigeria, gas accident is in the increase and many life and properties has been lost. On 10th September, 2018 a gas tanker explosion in Lafia, Nasarawa State, Northern Nigeria, killed 35 people and hundreds injured. In October 2020 an explosion at a gas station in Lagos killed 8 people and razed many buildings. On 16th November, 2021 gas explosion in Lagos claimed 5 persons, injured 10 others and destroyed 12 vehicles and some buildings [9,10,11].

According to Ogbette et al. [12], most gas explosions happen as a result of the lack of gas detector instrument in homes and gas plant stations. In addition, improper use of the gas furnace, or appliance, leakages due to gas lines being hooked up incorrectly, old worn-out, rusty gas lines coming from the street into your home, defective equipment including gas grills, acetylene torches, and other equipment that uses gas as a power or fuel source, violations of codes and standards governing the safe handling of gas or propane, and faulty manufacturing procedures used in building gas tanks for automobiles [12,13]. Therefore, this study carries out a simulation and construction of liquefied petroleum gas detector using microcontroller Atmel AT89C51. The circuit will be simulated using Proteus v8.7 while a prototype will be constructed on a Vero board and tested by using it to measure flammable, combustible and toxic gases for optimum performance.

II. MATERIALS AND METHODS

A. Materials

Some of the major materials and their specifications that were used for the Simulation and Construction of Liquefied Petroleum Gas Detector Using Microcontroller Atmel AT89C51 includes MQ-6 gas sensor, Microcontroller Atmel AT89C51, Relay 12V/10mA, Step down transformer 12V/500mA, Diodes 1N4007, Voltage regulator LM7805, Capacitors 1000µ/35V, Resistors 10k, Buzzer DS1305, Vero board 10/8cm and Jumper wires 0.1mm.

B. Methods

The method that was used in this study is in three (3) parts which includes software design, hardware construction and circuit testing for optimum performance.

B.1 Software Design Method

The software design for the system includes circuit simulation, algorithm, flow chart, and choice of programming language.

B.1.1 Simulation Method

The simulation of the liquefied petroleum gas detector was carried out in Proteus v8.7 and Mide-51 studio programming interface was chosen for the software for this work. The process was carried out according to the block diagram shown in Fig. I. The stages in the implementation includes power supply, gas sensor, microcontroller, relay output driver, alarm, and buzzer unit.

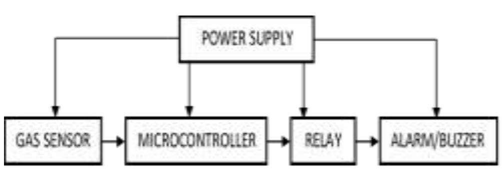

Fig. I Block Diagram of gas leakage detector

1) Power Supply Unit: The power supply stage consists of the transformer, bridge rectifier, capacitor and regulator. 240V/50Hz A.C. mains supply is fed into the transformer where it is step down to 12V/500mA. It then passes through the rectifier were it is converted to D.C. and is then pass through the capacitor for smoothening. The LM7805 regulator, regulate the voltage to give 5Vdc as the Vcc which is distributed across the system. The transformer current rating depends upon the current needed for the load to be driven, while the input voltage to the ML7805 IC should be at least 4V greater than the required 5V output, therefore it requires an input voltage at least close to 9V. The power supply unit is shown in Fig. II.

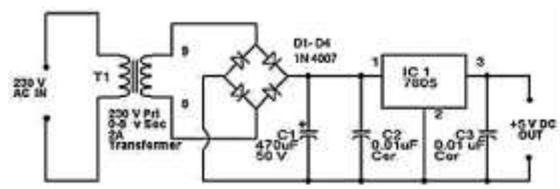

Fig. II The power supply unit [14]

2) The Gas Sensor Unit: The MQ-6 Gas sensor was used in this study which can detect or measure gases like LPG and butane. The gas sensor is an electronic device that detect the concentration of gas within an area. When it senses the concentration of gas, an analog signal from the sensor is converted to digital signal using an in built Analog to Digital convert of the Atmel89C51 microcontroller. The gas sensor unit is shown in Fig. III.

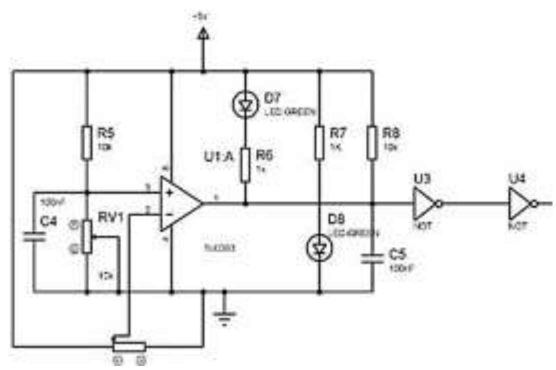

Fig. III The gas sensor circuit

3) Microcontroller Unit: The microcontroller used in this work is the Atmel AT89C51. It is an 8-bit microcontroller which works with the popular 8051 architecture and has a 40 pin IC package with 4Kb flash memory. It has four ports and all together provide 32 Programmable GPIO pins [15]. Pin2 of the microcontroller are connected to the sensor which is configure as port A. The microcontroller is connected to the alarm and is configure as port B of the output not direct but through the photo transistor. The voltage from the sensor is fed into the microcontroller. The microcontroller processes the signal and converts it to a digital signal using it so that the status of the gas leakage can be shown in mg/m3. Based on the program of the microcontroller the alarm module is activated. The Atmel AT89C51 pinout is shown in Fig. IV.

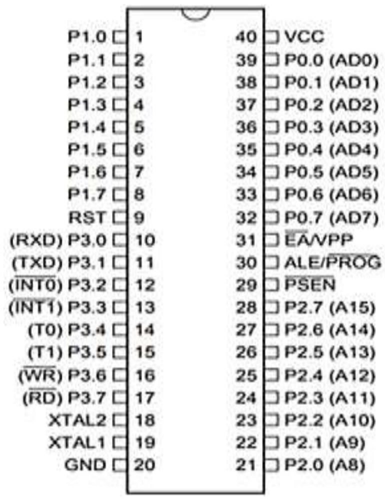

Fig. IV The microcontroller Atmel AT89C51 pinout [15]

4) Relay Output Driver Unit: The essence of this relay unit is to isolate the microcontroller from the output and serve as an output driver. This process aids in trouble shooting and protects the microcontroller from short circuiting and other form of damages that might result from any hardware failure. The relay driver is shown in Fig. V.

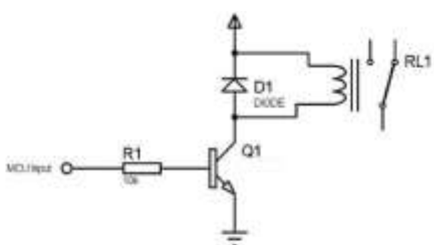

Fig. V The relay output driver circuit

5) Alarm/ Buzzer Unit: The buzzer gives a sound output as notification to the end user each time there is a significant gas leakage. This will alert the user and call for immediate attention so as to avoid any foreseen hazard. The alarm/ buzzer unit is shown in Fig. VI.

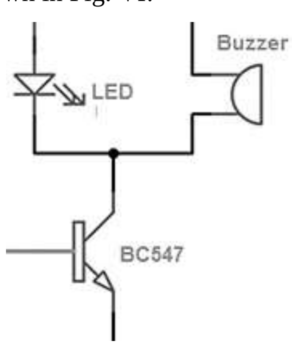

Fig. VI The alarm/ buzzer unit

B.1.2 Flowchart

The flowchart for the liquefied petroleum gas detector is shown in Fig. VII.

B.1.3. Algorithm

The algorithm that explains the system is as follows:

1. Start the program Call ADC value, AD Delay ADC by 10sec
2. Input the data from the sensor, In
3. Check if data, In is greater than AD If. NO, go back to input value If yes, take another value of In
4. Is value of In more than the Risk value?
5. If NO, GO Back to Input value
6. If YES,
7. Call Alarm END

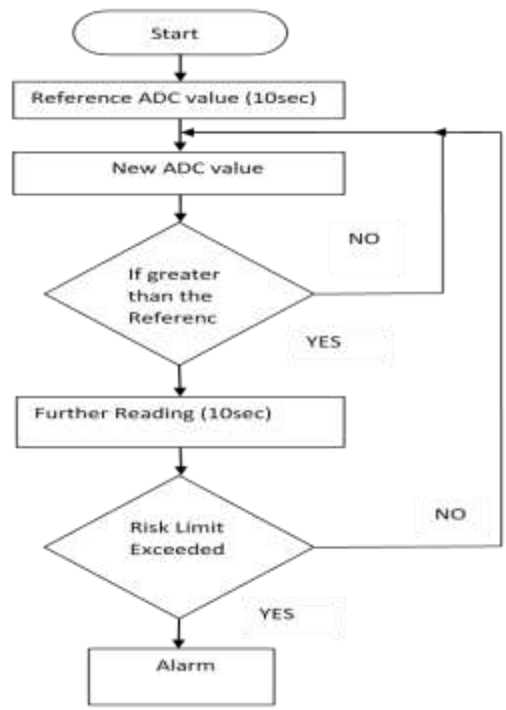

Fig. VII Flowchart of the proposed System

B.1.4. Choice of Programming Language

The Assembly language was written for the work using Mide-51 studio application software which reduces the number of codes to be written and equally generate the hex file. This hex file is what the microcontroller recognizes. The software makes it easier for programming, coding and debugging compare to some of the editors available. The circuit diagram is developed using Proteus professional. Then after which simulation was done.

B.2. Hardware Construction Method

The construction of gas leakage dictator was done according to the block diagram in Fig. 1. The components were first assembled on electronics breadboard to ensure proper terminal connections and then transferred on to a Vero board for permanent soldering using the soldering iron and MBO 1mm wire lead solder at +183°C melting point.

However, too much Lead was avoided to prevent clumsiness and bridging of the component to each another.

B.3. Circuit Testing Method

After successful construction of the device, each unit was tested using appropriate tools and equipment. The continuity test was carried out to identify any open path, short circuit and partial contact. While the power ON test was carried out to check if the components undergo heating in the circuit and to ensure that the voltages at the individual stages are according to the required values or specification. Finally, the device was attached to the LPG cylinder in a closed area and the gas sensing was tested for various percentage of gas leakage.

III. RESULTS

A. Simulation Result

The Simulation was carried out in parts to enable observation of the behavior at different levels and finally carried out on the full schematic system. The simulation performed gives clearly the idea of the hardware implementation. The complete simulated circuit is presented in Fig. VIII.

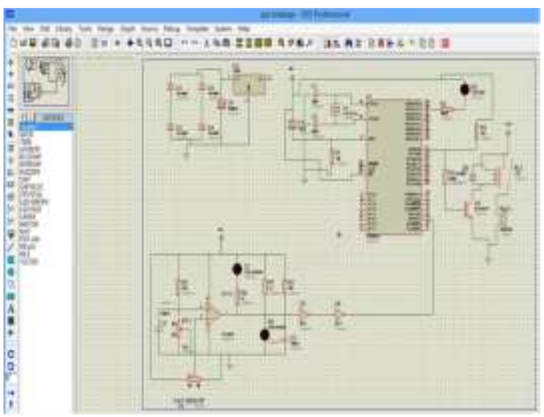

Fig. VIII simulated general circuit of the gas leakage detector

B. Hardware Construction

The construction processes ranging from creation of tracks, drilling of holes, components mounting to full circuit construction was carried out and the results of the constructed device showing the top view is shown in Fig. IX.

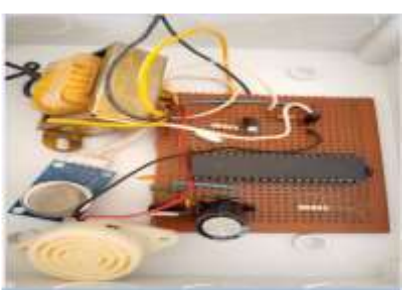

Fig. IX The constructed gas leakage detector circuit

A case was gotten where the entire circuit was mounted follow by other external components such as indicators, switch, and sensor were mounted. A casing measuring 14.7cm x 14.7cm x 5.7cm was finally provided to the system for mechanical protection. It is provided with 2no. of 2.5cm diameter hole for the ventilation. 4no. of 0.25cm diameter hole within 0.5cm diameter groove the edges of its top side for screw lock, 1no. of 0.5cm diameter hole for the power switch tighten by 1.5cm diameter nut. The total surface area of the cuboid was 383.67cm2 with volume of 1231.71cm3. The Orthographic projection has shown its three views (Front, Side and Top) in Fig. X, while the complete packaged device in a casing is shown in Fig. XI:

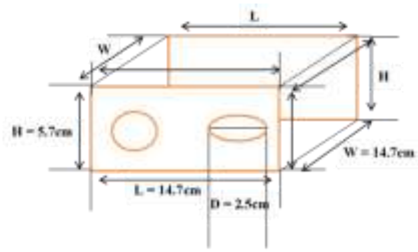

Fig. X The constructed casing for the circuit

Fig. XI The complete device in casing

C. Testing and Analysis

The system testing was carried out in stages: First; the system was powered with the switch which is indicated by the power indicator. Then gas was brought directly to the sensors which energized the circuit thereby powering the alarm. Table I and Fig. XII shows the result of the test that was carried out using the LPG leakage detector. The test shows that the system can quickly respond to gas leakage in the kitchen making it very efficient and enabling quick response to avert the danger. Based on the test carried out, it is advisable for the user to place the device 0.6m – 2.0 m from the gas source and 0.2m to 1m above the floor.

Table I. Gas Detection Test

S/No	**Time of Detection (s)**	**Distance from Buner (m)**	**Gas Concentration (mg/m^3)**
1	35	0.2	1000
2	42	0.4	320
3	60	0.6	300
4	65	0.8	260
5	70	1.0	240
6	82	1.2	230
7	96	1.4	225

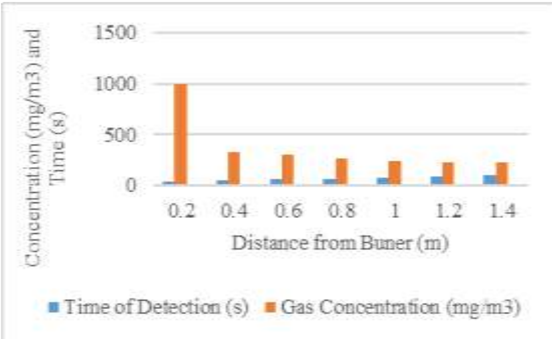

Fig. XII Concentration of LPG detected at different distance and time

IV. DISCUSSION

From the result of the performance evaluation test, it was clearly observed that when the LPG device was tested by placing it at different distances from the gas source, the response time of the LPG system decreased as the distance from the gas source increased and vice versa. Also it was observed that the sensitivity of the gas sensor was very high in clean air. At constant gas concentration, the sensed voltage will always be constant. The gas sensor has a very fast response to gas since the time difference between test results with same concentration is very small while the difference between the sensed voltages is very high. This design is similar to that of Falohun et al. [16] who used Arduino microcontroller with MQ-9 for gas leakage detection. Also in line with Muhammad et al. [17] who designed an Intelligent LPG gas leak detection tool with SMS notification using an Arduino microcontroller and GSM module SIM800L. The present study is also similar to that of Enalume and Obianke [18] who designed and implemented an efficient LPG leakage detector using the PIC18F2520 microcontroller with MQ-6 gas sensor and GSM module with alarm system. However, the design is different from that of Pal-Stefan and Loan [19] who worked on gas leak detection and localization techniques which involve detection done from outside the pipeline by visual observation or portable detectors and were able to detect very small leaks and the leak location, but the detection time was very long. Also different from that of Zhao et al. [20] who worked on leakage detection and analysis of leakage point in the gas pipeline system using SCADA I/F Model and leaks as small as 0.3% of the nominal gas flow were readily detected. The work is also different from that of Shyamaladevi et al. [21] who used the ARM7 processor simulated with Keil software for LPG refill booking and leakage detection to detects the leakage of LPG to alerts the consumer about the leak by SMS and as an emergency measure for the system will turn off the power supply, while activating the alarm.

V. CONCLUSION

This project elaborates the construction of detection system for gas leakage detector. The gas sensor (MQ-6) was carefully chosen to gauge the detection system. Besides, the Atmel89C51 microcontroller has been used to control the entire system. The only one type of software used is Assembly programming language. As the gas sensor senses the gas from the environment to a certain level which is been programmed to the microcontroller and is been coded as the sensor senses the gas to the programmed level it will send the signal to the microcontroller. The hardware construction, it operations is functioning accordingly and smoothly following the procedure, high priority has been given to make the circuit simple but efficient with high reliability.

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