CONSTRUCTION OF MICROCONTROLLER BASED COMBUSTIBLE GAS LEAKAGE DETECTOR WITH SMS NOTIFICATION AND POWER BACKUP

Ayodele Olaniyan[1] & Olayinka Olaiya[2]
[1]Dept. of Electrical Electronic Engineering, Gateway Polytechnic Saapade,
[2]Dept. of Computer Engineering, Federal Polytechnic, Ilaro, Ogun State
ayodele.olaniyan@gaposa.edu.ng; olayinka.olaiya@federalpolyilaro.edu.ng

Abstract
In recent time, developing countries such as Nigeria has witnessed high demand in gas usage among subscribers. As a matter of fact, combustible gas serves as a better alternative to the use of kerosene but it possess serious problems in household, commercial and other areas where gas is handled and used. This is because gas leakage problem results into various fatal accidents which may include human properties damage, financial loss as well as human injuries and/or loss among others. Therefore the need to develop a system that sense and detect gas leakage becomes paramount. This developed microcontroller based system was implemented. A buzzer is activated to notify the house occupant that there is a gas leakage. And should in case the occupant is not within the vicinity, the system automatic sends a text via short message service (SMS) through the mobile number simulated with the integrated system that gas leakage is detected. The system is also provisioned with power back up to ensure constant operation of system since we are faced with erratic supply of power in Nigeria.

Keywords: Gas leakage detection, Mobile Phone, SMS Alert, MQ2, Microcontroller, SMS Notification, GSM module.

Introduction

Background Study of Gas Leakage Detector

Gas leak detection methods became a concern after the effects of harmful gases on human health were discovered. Before modern electronic sensors, early detection methods relied on less precise detectors. Through the 19th and early 20th centuries, coal miners would bring canaries down to the tunnels with them as an early detection system against life-threatening gases such as carbon dioxide, carbon monoxide and methane. The canary, normally a very songful bird, would stop singing and eventually die if not removed from these gases, signaling the miners to exit the mine quickly.

Before the development of electronic household carbon monoxide detectors in the 1980s and 1990s, carbon monoxide presence was detected with a chemically infused paper that turned brown when exposed to the gas. Since then, many electronic technologies and devices have been developed to detect, monitor, and alert the leak of a wide array of gases.

As the cost and performance of electronic gas sensors improved, they have been incorporated into a wider range of systems. Their use in automobiles was initially for engine emissions control, but now gas sensors may also be used to insure passenger comfort and safety. Carbon dioxide sensors are being installed into buildings as part of demand-controlled ventilation systems. Sophisticated gas sensor systems are being researched for use in medical diagnostic, monitoring, and treatment systems, well beyond their initial use in operating rooms. Gas monitors and alarms for carbon monoxide and other harmful gases are increasingly available for office and domestic use, and are becoming legally required in some jurisdictions.

Originally, detectors were produced to detect a single gas. Modern units may detect several toxic or combustible gases, or even a combination. Wali, R. (2012) &Alka, (2012).

Type of Gas Detector

Classification of Gas Detector can be according to their mechanism of operation (i.e. semiconductors, oxidation, catalytic, photoionization, infrared, etc.). Therefore, Gas detectors can be packaged in two (2) main form factors: portable devices and fixed gas detectors.

Portable Type of Gas Detectors

These detectors are used to monitor the atmosphere around personnel and are either hand-held or worn on clothing or on a belt/harness. These gas detectors are usually battery operated. They transmit warnings via audible and visible signals, such as alarms and flashing lights, when dangerous levels of gas vapors are detected.

Fixed Type of Gas Detectors

This gas detector may be used for detection of one or more gas types. Fixed type detectors are generally mounted near the process area of a plant or control room, or an area to be protected, such as a residential bedroom. Generally, industrial sensors are installed on fixed type mild steel structures and a cable connects the detectors for continuous monitoring. A tripping interlock can be activated for an emergency situation.

Consideration for Choice of Sensors

There are a number of different types of sensors used for gas detection. The choice of sensor depends on:

- The gas to be detected;
- The expected range of concentration;
- Whether the detector is fixed or portable;
- Whether the detector is point or open path;
- The presence of other gases that may affect readings or damage the sensor.

For the same reason MQ-2 Semiconductor Sensor for Combustible Gas is used for this research work.

MQ-2 Semiconductor Gas Sensor

Sensitive material of MQ-2 gas sensor is SnO2, which with lower conductivity in clean air. When the target combustible gas exist, the sensor's conductivity is more higher along with the gas concentration rising. Simple electro circuit must be used to convert change of conductivity to correspond output signal of gas concentration. MQ-2 gas sensor has high sensitivity to Liquid Purified Gas (LPG), Propane and Hydrogen, also could be used to Methane and other combustible steam, it is with low cost and suitable for different application.

Characteristics of MQ-2 Gas Sensor

- It is very sensitive to Combustible gas in wide range
- MQ-2 has a high sensitivity to LPG, Propane and Hydrogen
- Long life and low cost
- It has a simple drive circuit

Application of MQ-2 Gas Sensor

- Domestic gas leakage detector
- Industrial Combustible gas detector
- Portable gas detector

Reviews of Related Works

In the Massachusetts Department of Fire Services, the research developed a system to counter the problems of gas accidents in coal mines and family safety from gas usage through the use of a new infrared detection optics principle. The infrared optics gas detection was high in detection accuracy, long range service life.

A review of gas leak detection techniques was done by Zhijie *et al*., (2011) with a classification of leak detection methods in a gas pipeline to monitor the integrity of a pipeline.

Ashish et *al.* (2013). This is another method which not only detects gas leakage but also alerts (Beep) and turns off main power and gas supplies, and sends an SMS. GSM module is used which alert the user by sending an SMS. This has broader focus beyond kitchen gas leakages.

According to Alka, (2012).This approach also does not make provision for halting further gas leakage. The design of a wireless LPG leakage monitoring system is proposed for home safety. This system detects the leakage of the LPG and alerts the consumer about the leak by SMS and as an emergency measure the system will turn off the power supply, while activating the alarm.

Padma Priya *et al.*, (2014), This approach does not make provision for kitchen gas that uses gas cylinders not supplied by power utility supply, which the commonest is found in developing countries like Nigeria who have not developed such infrastructure.

Above are different authors with their resarch works and different approaches to prevent gas leakages. None of the approaches considered powerback up for the sysem develped in case of power outage. This is because of their enviroment and perculiairity. Nigeria as a developing contry with eractic power supply will require additional power back up in order to maintain constant operation of this system.

Materials and Method

The method adopted for the design and construction of Microcontroller based leakage detector consists of both the hardware and software. Figure 3.1 below shows the block diagram of all the units present in the system designed. That is, the sensory unit which was made up MQ-2 gas sensor, a 16 bit microcontroller PIC 16F877A, Power Supply unit with feature for power backup for switching between AC and DC, LCD and GSM module for SMS notification.

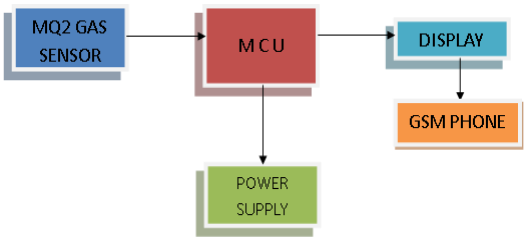

Figure 3.1: Block diagram of Microcontroller Based Gas Leakage Detector with Buzzer and SMS Notification System.

The MQ-2 series of gas sensors use a small heater inside with an electro-chemical sensor. They are sensitive for a range of gasses and are used indoors at room temperature. The output is an analog signal and can be read with an analog input of the Arduino.

The MQ-2 sensor monitors the gas leakage through the commands from the MCU and displays the result on LCD and as well notifies the users through SMS.

Fig. 3.2: MQ-2 Sensor

PIC16F877a is a 40-pin PIC Microcontroller and is used mostly in embedded design and Applications. Few of its features are as follows:

- It has five Ports on it starting from **Port A to Port E**.
- It has **three Timers** in it, two of which are 8 bit Timers while 1 is 16 Bit.
- It supports many communication protocols like:
    - Serial Protocol.
    - Parallel Protocol.
    - I2C Protocol.

It supports both hardware pin interrupts and timer interrupts.

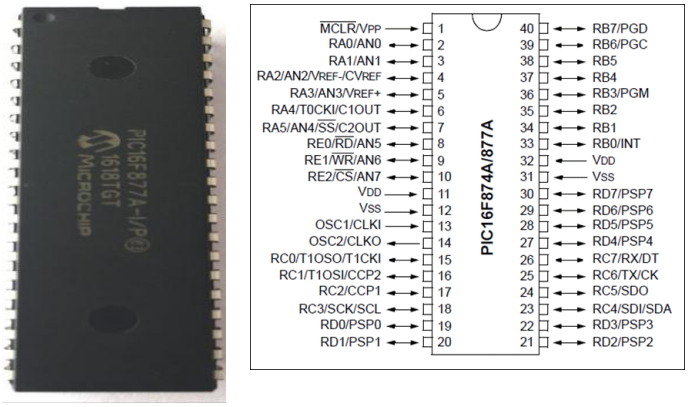

Fig. 3.2: PIC16F877A Microcontroller & 3.2b. Pin Diagram

The LCD will display the numerical features and symbols on the screen. The LCD used in this project is eight bit parallel type and the display size is 16*2. Liquid crystal display is used for displaying the status of the Gas leakage detector. LCD consists of three control pins and eight data pins. Based on the commands given to the control pins, data can be read from or write to the LCD. The eight data pins of the LCD are connected to the PORTB pins RB0-RB7.

Fig. 3.3. The LCD

SIM800L is a quad-band GSM/GPRS module, which works on any of these frequencies GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz. This module is designed to meet almost all the space requirements in user applications such as smart phone, PDA and other mobile devices. SIM800L module has power saving technique with current consumption as low as 0.7mA in sleep module.

Moreover, the GSM Modem can use any GSM network operator SIM card and as well act like a mobile phone with its own unique phone number. The choice of this GSM module is because it can use its RS232 port to communicate and develop embedded applications such as logging, remote control, SMS Control and data transfer easily. That is, SIM800L GSM modem is highly flexible plug and play quad band GSM modem for direct and easy integration for communication to port RS232. It also supports features like Voice, SMS, Data/Fax, GPRS and integrated TCP/IP stack. Fig 3.4 shows the GPRS module with the SIM card.

Fig. 3.4: SIM 800L GPRS Module with SIM card

Fig. 3.5 shows the circuit to generate 5V DC supply from mains supply. For this purpose we used 230V/9V step down transformer followed by a bridge rectifier consisting of IN4001 diodes, low pass filter and 5V voltage regulator LM7805 (IC1). Output from transformer is also used to detect zero crossing. Capacitor C1 is used to filter the output from bridge rectifier to generate unregulated DC supply (Vx) which serves as input for ADC and voltage regulator. C2 and C3 are used for frequency stabilization. This 5V DC supply is used for power supply for various chips in the whole circuit.

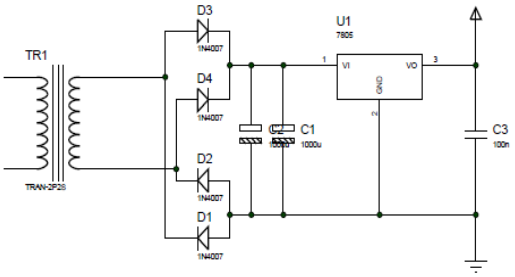

Figure 3.5: Complete Power Supply Circuit

Software Requirement

Proteus Software

Proteus Software is a Virtual System Modeling and circuit simulation application that allows engineers to run interactive simulations of real designs for circuit simulation. The suites combine mixed mode spice circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. Proteus also has the ability to simulate the interaction between software running on a microcontroller and any analog or digital electronics connected to it.

Figures 3.6 depict the simulated circuit diagram of the microcontroller based gas leakage detector designed. This test is necessary in research design to test virtual functionality of microcontroller program to be deployed on the circuit design through simulation environment. This was done to ensure the workability of the system designed before transfer to Vero board or PCB for soldering. Proteus 8 professional was used for the simulation of this system.

The Mikro-C Programmer.

The mikro-C PRO for PIC is a powerful, feature-rich development tool for PIC Microcontrollers. It is designed to provide the programmer with the easiest possible solution to developing applications for embedded systems, without compromising performance or control.

The programs used for this project was loaded inside the microcontroller with Micro-programming development board.

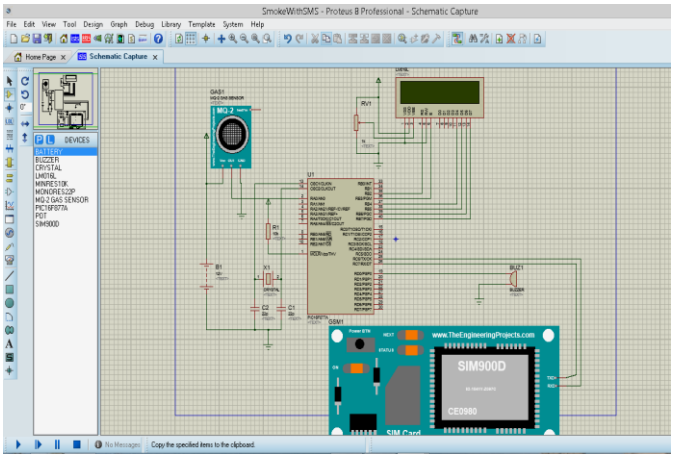

Figure 3.6 Simulated Diagram of the microcontroller based gas leakage detector with SMS Notification.

Figures 3.7 depict the circuit diagram of the microcontroller based gas leakage detector designed after simulation (i.e. from the Power Supply Unit, Relay Circuit, Control Circuit, and Display Unit).

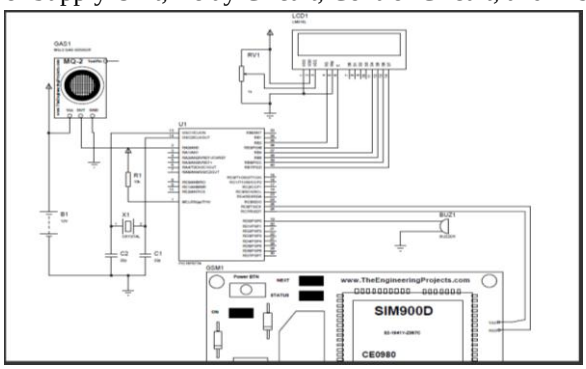

Figure 3.7: Circuit Diagram of microcontroller based gas leakage detector with SMS Notification**.**

Testing and Results

This physical construction of the Gas leakage detector with SMS notification was done according to the prototype the researcher had in mind to meet users need. After which it was packaged in a casing which makes it portable.

This project work was finally tested after construction and cased. It was found to meet the research need.

Figures 4.2a-4.2d below shows the various stages of construction of the system from the arrangement on the PCB board, soldering of all the components on the PCB to the final stage of casing the complete circuit.

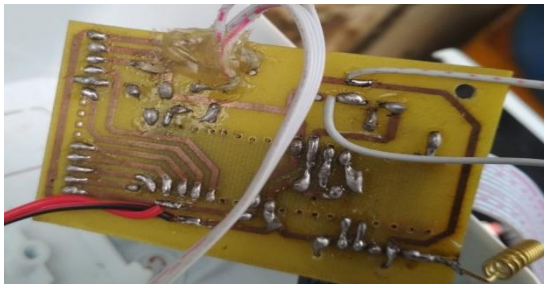

Figure 4.1a: Components layout on Printed Circuit Board.

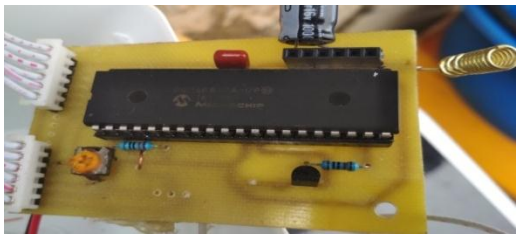

Figure 4.1b: The PCB Showing Microcontroller (16F877A) used and other components.

Figure 4.1c: Showing the Circuit Boxing with Built-in Rechargeable Power Back up

Figure 4.1d: Showing Complete Casing of Gas Leakage Detector

4.2 Testing

Two (2) methods were used before and after implementation to test this system. The first stage was before construction. At this stage, the following test was done;

i) Simulation using Proteus virtual system modeling (VSM) whereby the source code file obtained from the development environment was added to the PIC16F877A program memory and the simulation initiated.

ii) The second method involved loading the source code file obtained from the integrated development environment using the PICkit™3 programmer into the microcontroller's program memory to test the workability of the developed system after casing the Gas leakage Detector.

The next stage was to test workability of the constructed work. The following are the various stages of testing involved.

Initialization Stage

The figure 4.3a shows the status of the designed system after Power ON. At start up, the system initialize by delaying for 10seconds allowing the GSM module to boot and connect to the network. During this process, a set of commands are sent to the GSM module to test if the GSM module is ready for the SMS notification in case of gas leakage.

Figure 4.2a: The Gas leakage detector showing Initialization at Power On.

At Ready Stage

The figure 4.3b below shows the LCD displaying the Gas Detector and no gas detected after initialization has completed. The stages show that system is ready to send a buzz and SMS notification respectively in case of leakage.

Figure 4.2b: The Gas leakage Detector System showing what the system symbolized.

Gas Detection Monitoring Stage

Figure 4.3c&d shows the state of the system when monitoring for gas leakage.

At this stage, the system continually monitors the logic state of MQ2 gas sensor. Depending on the state of the logic. In which it remains at low state once no detection of combustible gas otherwise usually pulled high once the sensor module detects a certain percentage of combustible gas present in the air. Moreover, the sensitivity of gas sensor can be adjusted using the variable resistor provided on the MQ2 gas sensor.

Figure 4.2c: Showing the MQ-2 Gas Sensor embedded with the System

Figure 4.2d: The Gas leakage Detector System with status “no gas leakage detected”

Gas Leakage Detection Stage

At this stage once a high logic state is detected by the system, that is, it has detected a certain percentage of gas leakage. The system buzzer therefore notify the people within the surrounding by making a continuous alert and on the Gas leakage detector screen displays "Gas leakage detected" as shown in figure 4.3e.

Figure 4.2e: The Complete circuit showing gas leakage detected.

SMS Notification Stage

At this stage, as the system display "gas leakage detected" simultaneously with the buzz after sensing a certain percentage of gas leakage. The system as well automatically sends an SMS alert twice (2) through a mobile SIM inserted on a GSM module attached to the system to the dedicated Mobile number for additional notification. This concurrently provides additional means of notification in case of gas leakage as shown in figure 4.3f.

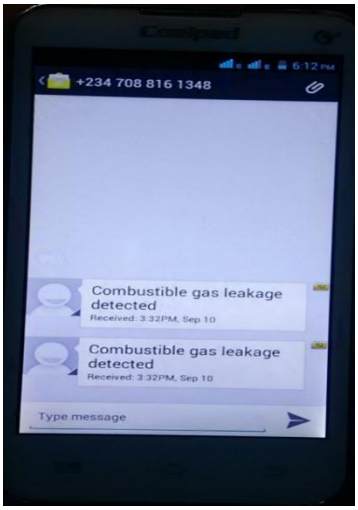

Figure 4.2f: The Mobile phone showing the SMS notification received after leakage Detection.

Gas Leakage Cleared Stage

At this stage, the alarm system is kept on until the area is clear and no gas leakage is perceived by the gas sensor. Once the area is cleared, the system automatically returns to the monitoring state as shown in figure 4.3g.

Figure 4.2g: The Gas leakage Detector System with status "no gas leakage detected".

Performance Evaluation

The performance of the system constructed for detecting gas leakage proved satisfactory and worked as expected after the programme instructions has been loaded into the microcontroller (MCU) with which the Sensory unit relies on for decision making in event of gas leakage. This system is designed with the intention to ensure that the event of gas is intelligently detected, promptly notified and interactively managed. It was built around a timer to accept input from the gas sensor, MQ-2, activate a buzzer and after which an SMS notification is sent to the specified mobile number that alerts the occupant in the event of gas leakage.

Figure 4.3 shows the flowchart that describes how the system programme provides control for this project designed.

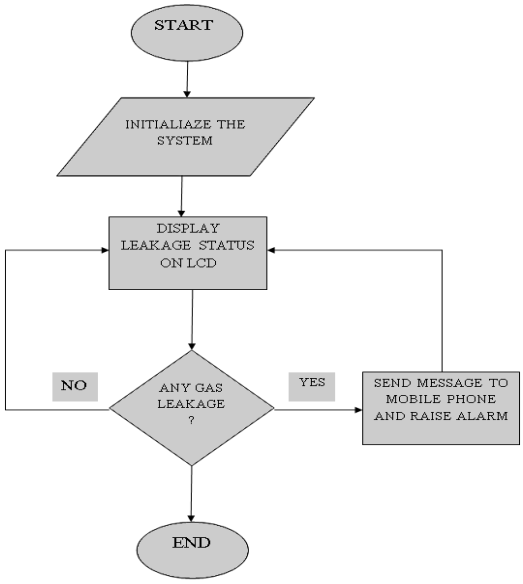

Figure 4.3: Flowchart for Mode of operation of the Constructed Microcontroller Based Combustible Gas leakage Detector System with SMS Notifications and Power Back up.

Conclusion and Recommendation

Conclusively, this system designed met the objectives by effectively detecting the gas leakage through MQ-2 gas sensor; activate a buzzer and simultaneously providing a timely SMS notification to the specified mobile number that alerts the occupant in the event of gas leakage. It was built around a timer to accept input from the gas sensor, MQ-2, activate a buzzer and after which an SMS notification is sent in the event of gas leakage detection. Moreover, the system also provides constant power source by intermittently switches to rechargeable battery bank constructed together with the circuit in case AC supply fail. This additional feature as well has made the system constructed more reliable and efficient as against the existing system. Education is pedagogical to ignorance reduction and national building of safe environment. With the popular saying "Ignorance is a disease", this system developed is believed and considered as an important gadget that is required in every home where the use of combustible gas is unavoidable. It is therefore recommended in every homes and offices for usage as it will reduce the menace of fire inferno in the event of gas leakage detection.

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