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Research Article

Design and construction of a GSM based gas leak Alert system

J. Tsado[1], O. Imoru[2*] and S.O. Olayemi[3]

[1*,2,3]Department of Electrical and Electronics Engineering, Federal University of Technology, Minna, Niger State, Nigeria.

This paper presents the design and construction of an SMS based Gas Leakage Alert System. Two gas sensors (MQ-6) were used to detect gas leakages in a particular location; their outputs are then interfaced with an 8051 microcontroller programmed in assembly language. A dedicated GSM phone with a line is connected through relays to the output of the microcontroller. The GSM phone is configured to send gas leakage alerts in the form of a short message service (SMS) message indicating the location to another GSM phone to enable prompt necessary action. The system enables monitoring of gas leakages in remote locations and thereby leads to a faster response time in the events of a leakage condition.

Keywords: Gas leaks, MQ-6 sensors, GSM, microcontroller, SMS alert

INTRODUCTION

Natural gas is an energy source that is commonly used in homes for cooking, and heating. Mokhatab and Poe (2012); Asche et al (2012); Hartley PR. et al. (2012) revealed that the natural gas is also used industrially for heating and driving machinery. It is primarily composed of methane. (Methane is a highly flammable chemical compound). A leakage of natural gas can be dangerous because it increases the risk of fire or explosion. Local gas companies `work hard to provide adequate warning in the event of a gas leak. Because methane—and therefore, natural gas—does not have any odour, the gas company adds a warning “rotten-egg” smell (mercaptan or a similar sulfur-based compound) that can be easily detected by most people. However, people who have a diminished sense of smell may not be able to rely upon this safety mechanism. Also the leak might occur at a time when no one is in the vicinity which increases the risk of an explosion. A gas detector can be an important tool to aid early detection of gas leaks. Earlier research work with the same objective was implemented by Priya KP.et al (2014) using ARM 7 processor. Rajitha S and Swapna T(2012); Jolhe BD et al (2013); Ashish S (2013); HaqueMD et al (2014);Tanvira I. et al (2014) offered different gas leakage detective systems which send Short Message Service (SMS) and simultaneously alerts the customer using a GSM module. Such systems that keep monitoring the leakages of any flammable gasses and protects sudden accident. Ramya V and Palaniappan B (2012) implemented such type of detective device using two hazardous gases (LPG and Propane) with an embedded system.

*Corresponding author: Engr. Ayo Imoru, Department of Electrical and Electronics Engineering, Federal University of Technology, Minna, Niger State, Nigeria. Email: aymorus@gmail.com, Tel.: +2348039157086

The advantage this has over others is that it provides quick response rate and has faster diffusion of the critical situation than the manual methods. All the reviewed works aimed at developing systems capable of detecting gas leakages and sending an SMS alert to the user. However, the gas leakage detective system presented in this paper is implemented in a different approach. The system enables monitoring of gas leakages in remote locations and thereby leads to a faster response time in the events of a leakage condition.

SYSTEM DESCRIPTION

The block diagram is shown in Figure 1. The system comprises of MQ-6 gas sensors for detecting gas leakages. The outputs of these sensors are connected to 555 timers in monostable configuration. According to (Berlin and Larsen, 1978; Berlin and Valberg, 1978;Camenzind and Kash, 1978; Melchert, 2008), the detail of applications of the 555 timer can be obtained. The outputs of the timers are connected to the microcontroller. The microcontroller on receiving input, under the control of the program sends out an alert in the form of SMS over the GSM network with the aid of the GSM modem to the user's phone number.

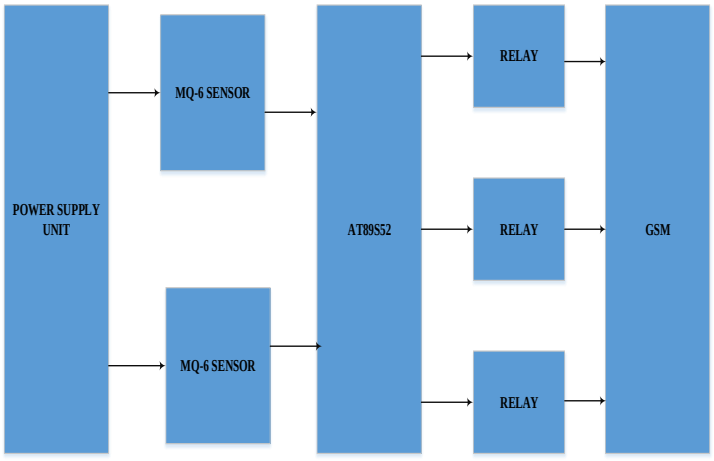

Figure 1. Schematic Diagram of an add-drop System

Power Supply Unit

The power supply unit was designed to supply voltages of 12V and 5V. This was achieved by rectification. The power supply unit comprises of the following:

- A step down transformer
- A bridge rectifier
- Filtering capacitor
- Voltage regulators

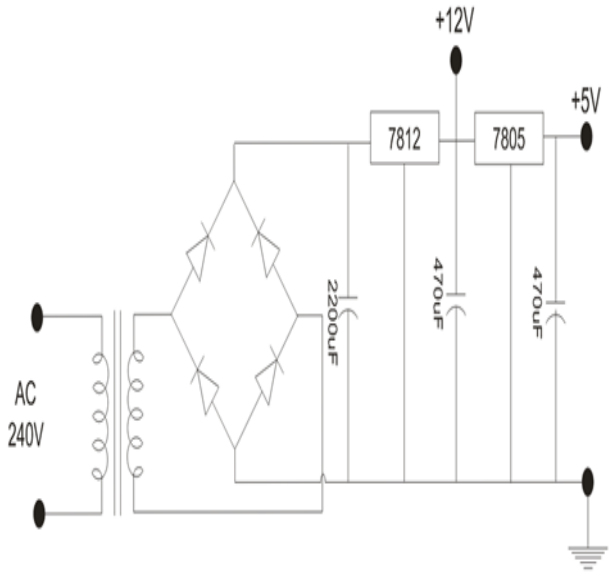

Figure 2. Power Supply Unit

The step down transformer steps down voltage from the utility power supply of 230V AC to 12V AC. The bridge rectifier rectifies the voltage to 12V and 5V for use by the various components in the system. Figure 2 shows the schematic of the power supply unit. The details areavailable in appendix A1.

Sensing Unit

The sensing unit consists basically of the MQ-6 gas sensors and the 555 timers. The outputs of the gas sensors are interfaced with the timers which provide timing and sensitivity functionality.MQ- 6 is a high sensitivity Liquefied Petroleum Gas (LPG) sensor which detects the gas leakage. It is a semiconductor type sensor with very low conductivity, fast response time and stable long life. However, it is not only has sensitivity to LPG, but also to slightly sensitive to polluted fluid like cigarette smoke and alcohol. The concentration range of MQ-6 gas sensor is 200ppm-10000ppm. It is sensor with 6 pins, out of which 2 pins are used for providing heating current and the other 4 pins are used for fetching the signals. Figure 3a and 3b shows the MQ-6 gas sensor and the typical sensitivity characteristics for several gases. A supply of 5V is required to power the sensor and it has different resistance value in different concentration. For an example, if we calibrate the MQ-6 gas sensor to the 1000ppm of propane concentration in air, then the resistance value would be approximately 20kΩ. The change in the resistance value with respect to the concentration is shown in figure 3b.

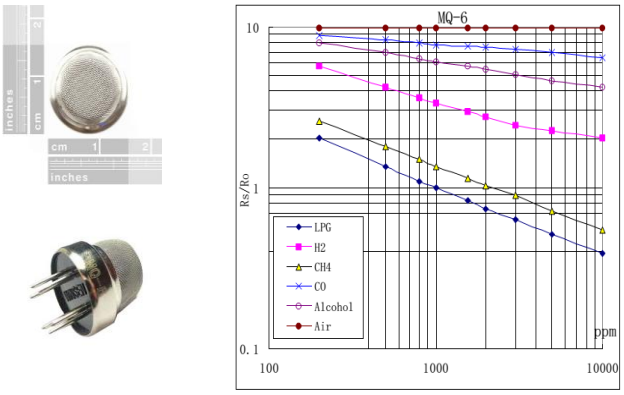

Figure 3(a). MQ-6 Sensor (b) Typical sensitivity characteristics of the MQ-6 for several gases.
In their: Temp: 20°C,
Humidity: 65%,
O2 concentration 21%
RL=20kΩ, Ro: sensor resistance at 1000ppm of LPG in the clean air. Rs: sensor resistance at various concentrations of gases.

Microcontroller Unit

The unit is subdivided into two parts, the software and the hardware part. Beetner et al. (2000) discussed how Keil Software can be used to provide the software development tools for 8051 based microcontrollers. With the Keil tools that can be obtained in "C51 Development Tools (2008)". It was possible to generate a HEX file from an Assembly language commonly used in embedded applications for virtually every 8051 derivative. The supported microcontrollers are listed in the micro-vision, a screenshot of the software is shown in figure 4.

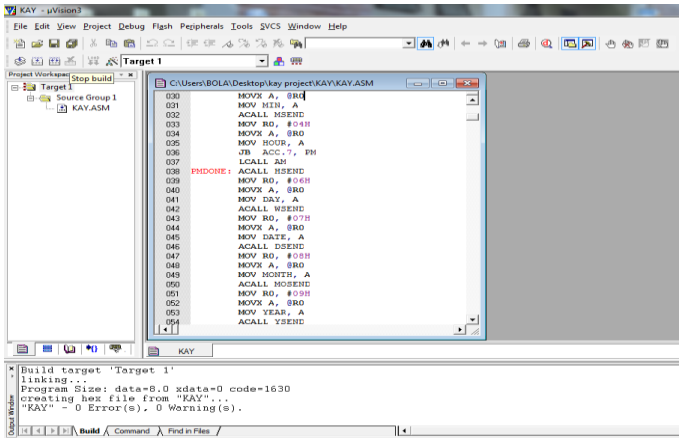

Figure 4. Micro-Vision Debugger Window

This software was used to simulate the code and be sure the code is free of syntax errors and logic errors and finally helped in generating the HEX file which was burnt on the microcontroller chip to perform the control function. The hardware is essentially the microcontroller. It is a single chip containing a microprocessor, memory (RAM & ROM), input/output ports, timers and serial ports and it is designed for embedded control applications. From (Kleitz, 1997; Ayala, 2004; Sahu and Mazumdar, 2012), we understood that the prime use of a microcontroller is the control of a machine or system using a fixed program stored in the ROM and this program does not change over the lifetime of the system. The chip used in this design belongs to the Intel 8051 microcontroller family. The core of the 8051's slot CPU is made up of 8 bit register, 4 kilobytes of ROM, 128 bytes of RAM, 2 timers, 32 I/O pins, 1 serial port.

Alert Unit

The alert unit is the GSM phone that sends SMS alerts. Three of the terminals on the keypad of the phone are controlled by relays connected to them. The relays receive signals from the microcontroller. The microcontroller sends signals to the relays for 50ms and then waits for another 1s before sending another signal. With these signals the relays perform the function of controlling the phone to access SMS alerts already stored on the phone and sending it to a specified number on the phone.

SOFTWARE DEVELOPMENT

According to Beetner (2000), the software needed to run the control process of this system was developed using Assembly language in the Kiel micro vision window. The program code was then written into the chip. Kiel micro vision is an Integrated Development Environment (IDE) that helps write, compile, and debug embedded programs. Upon successful completion of the program, it was then simulated using the integrated debugger in the Kiel micro vision. Figure 5 shows the flow chart of the program.

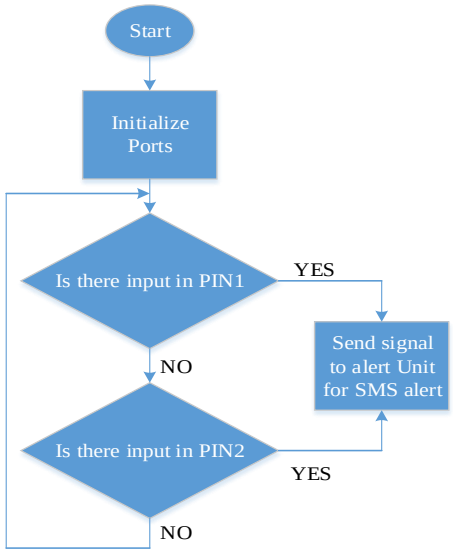

Figure 5. The system flowchart

CONSTRUCTION

The system was constructed in modules as designed and later put together on completion to simplify construction, testing and maintenance. A prototype of the system was initially constructed on a breadboard and when it was found to be working properly was then transferred to a veroboard. The entire system circuit as shown in figure 6 was laid out carefully to minimize error and to ease troubleshooting. After testing the work was finally cased. The detail of circuit diagrams and essential figures are presented in the appendices.

Figure 6. Cased work

TESTING AND RESULTS

Hardware and software portions used were separated into units while developing the entire system. Building and testing smaller sections of the system made it more manageable and increased efficiency by decreasing debugging time. The power supply unit in the figure of appendix A was first tested to ensure it could supply the required power to the circuit.

The sensing unit was also tested before interfacing it with the microcontroller and it was found that it was capable of delivering an output signal wherever there was a gas concentration at its input. The sensors were tested with the help of the gas from a simple disposable lighter.

After it was confirmed that the sensing unit delivers output in response to gas at the input, the outputs at both the sensors were conditioned and fed to the microcontroller. The microcontroller monitors the sensors and on receiving signal it sends another signal to the relays of the alert unit. These relays controlled the necessary terminals of the phone in figure 7 required to send the alert. After the whole system unit had been coupled, the gas leak alert system was tested as a functional unit and was found to be working.

Figure 7. Message sent to end user

CONCLUSION

A GSM based gas leak alert system with multiregional sensors has been designed, constructed and tested. The result obtained from the tests carried out shows that the system is capable of sending SMS alerts whenever there is gas concentration at the inputs of the gas sensors. Hence this system can be used in homes and public buildings such as hotels and restaurants. Further modifications can be implemented on the system. One of such modifications is to provide the system with a dual power supply i.e. include a battery power supply source in addition to the utility power supply. Also a battery charging and monitoring unit can be incorporated to charge the phone's battery can be used in homes and public buildings such as hotels and restaurants. Further modifications can be implemented on the system. One of such modifications is to provide the system with a dual power supply i.e. include a battery power supply source in addition to the utility power supply. Also a battery charging and monitoring unit can be incorporated to charge the phone's battery.

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Appendix A: **Power Supply and Complete Circuit Diagram**

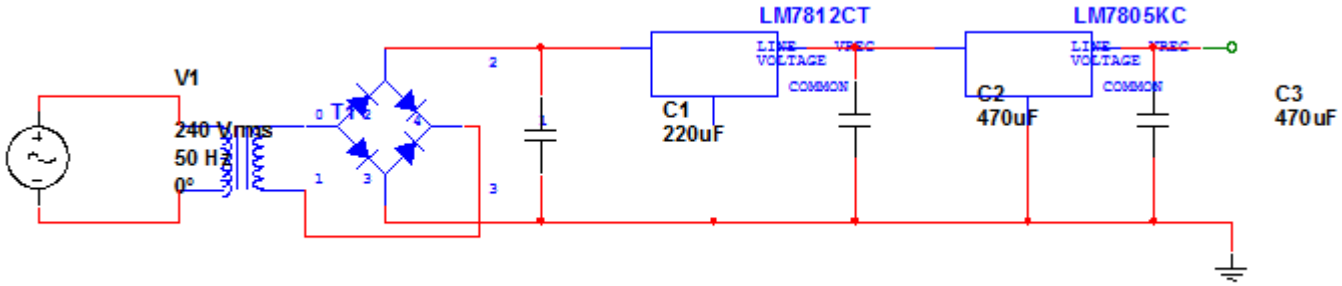


Figure A1: Power Supply

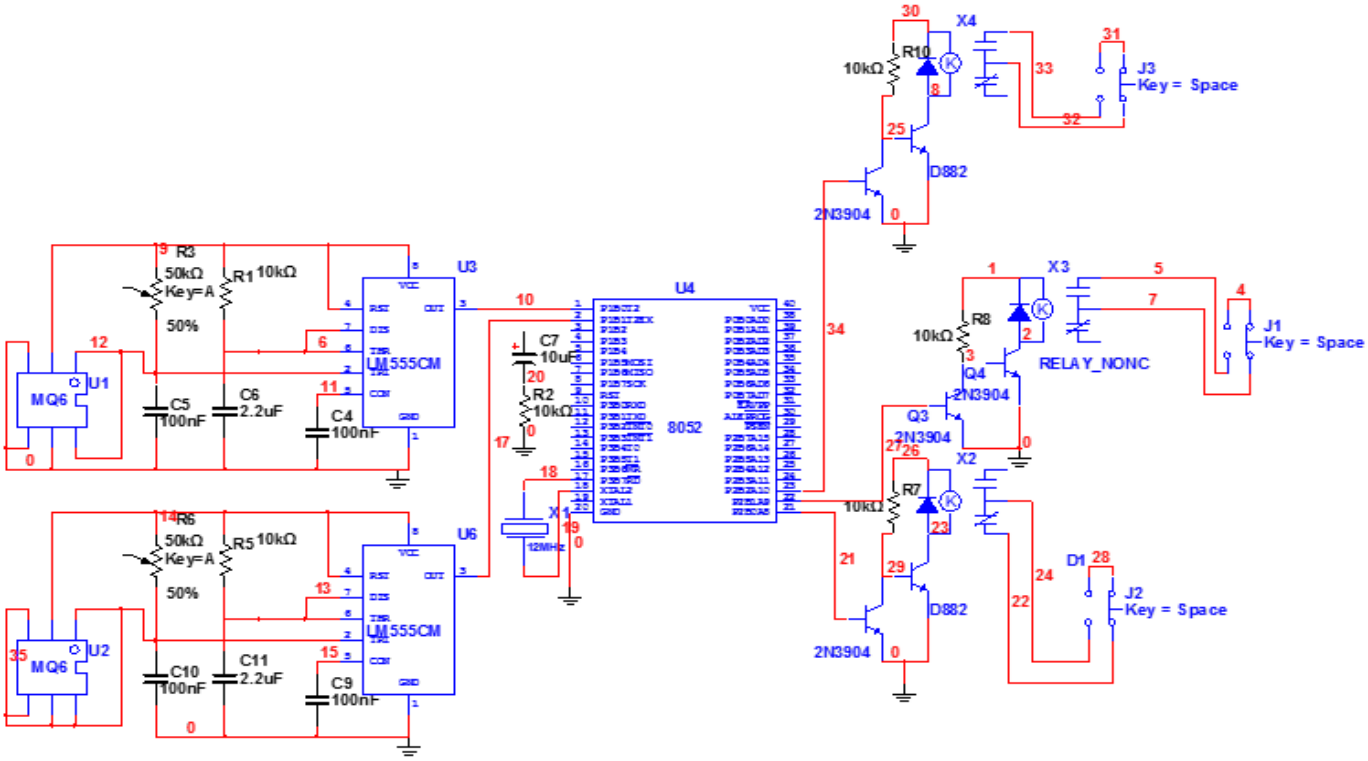
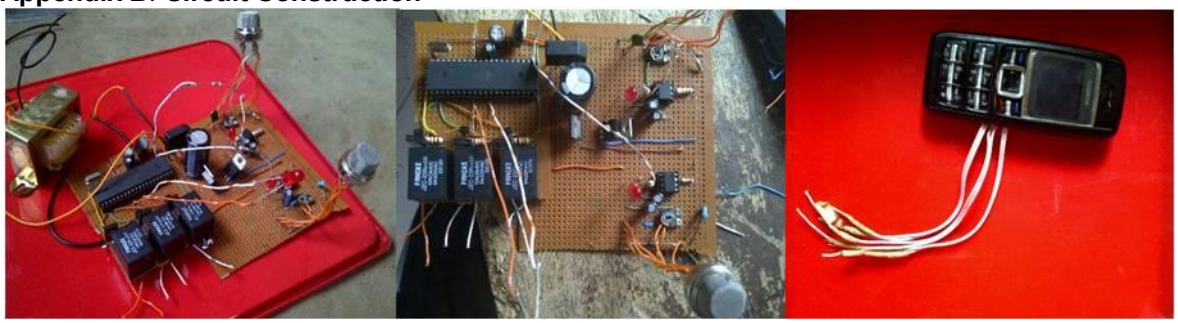


Figure A2: Complete Circuit Diagram

Appendix B: **Circuit Construction**



Main circuit while under construction GSM modem

Figure B: Circuit Construction