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LPG Leakage Detector and Controlling Device

Sharmin Akter Urmee[1*], Janifar Afiat Wafa[1], Taibaton Nesa Shimu[1], Mahabub Hossain[1], Shahed Mahmud[1], Md. Rakibul Islam[1]
[1]Department of Industrial & Production Engineering, Rajshahi University of Engineering & Technology
E-mail:* sharminurmee.ruet14@gmail.com,

Abstract

Nowadays it has become a common phenomenon that due to LPG (Liquefied Petroleum Gas) leakage a huge loss of property even life loss occurs. To avoid these losses we made an LPG Leakage Detector and Controlling Device which will provide security with an alarm when the sensor will sense LPG, additionally there will be a red LED light to visualize the leakage. Finally, it will automatically turn off the controlling valve of the LPG leakage source avoiding ignition or blasts. Previous works only identified and notified leakage but did not include automatic controlling which makes our work unique. We analyzed the feasibility of the product, required components, and cost-related factors and the final product was prepared. Experiment results show that the device can work in a practical situation with lower response time and preciseness. This can be implemented as a life savior avoiding accidents in houses, offices, restaurants, and industries.

Keywords: LPG, MQ-6 Sensor, Servomotor.

1. Introduction

Individual homes, small businesses, and other structures are most frequently affected when an internal leak builds up gas inside the structure. Frequently, the blast is powerful enough to significantly damage a building but leave it standing. In these cases, the people inside tend to have minor to moderate injuries. Occasionally, the gas can collect in high enough quantities to cause a deadly explosion, disintegrating one or more buildings in the process. A LPG leakage detector and controlling device is a device that detects the presence of LPG in an area and turns off the LPG supplying knob in case of leakage. We have intended to use this device to use mainly in household purpose and industries, offices and restaurant where LPG is supplied. Due to leakage of LPG and with ignorance of the user, ignition causes a massive explosion which may cost the life of the operator. This detection and controlling process are designed to detect LPG by using a sensor. Whenever there will be a fixed concentration of LPG the sensor module will provide an indication to the sound system which will alarm in the audible sound limit and switch on the LED light to alert the user which will provide safety to the user from a life-taking accident and a signal from the microcontroller will turn on the stepper motor which will turn off the LPG supplying knob.
Our objective in this project is to provide a visual and auditory signal to aware the user about the leakage to avoid an accident and also to supply a signal for starting the motor to prevent the source to leak any kind of gas and hence provide security to that place.

2. Literature review

One of the most common types of energy source used in domestic is propane in which liquefied gas contains. Though safety issues are considered by the company, leakage of gas has become a very common accident which can cause damage to human lives and property. A low cost, power-efficient centralized LP LPG Leakage Detector and Controlling Device system. The system has two main devices: the gas detector and the centralized alarm unit. The gas detector that is located close to the gas usage point (gas cylinder) is a battery operated device that is designed to operate up to 6 months with two AA-size alkaline batteries [1]. An LPG detector was designed in which the MQ-5 sensor is used, which gives a signal to the microcontroller. Microcontroller after getting the signal, the buzzer started ringing and in display, the concentration of gas is shown. This model used for both low and high concentration of Gas leakage [2].
In another study the authors measured low concentration gas which is measured by MQ-6 sensor which sends the signal to the microcontroller. In this paper, author use GSM programming to receive the notification of gas leakage [3]. Another paper presented a gas leakage alert system to detect the gas leakage and to alarm the people onboard. The paper presented LPG leakage detection and alert system. The system triggers LED and buzzer to alert people when LPG leakage is detected [4].

A security alert which can be provided by GSM module. In this paper author mention that MQ-5 sensor was used to detect the leakage of Gas and it gives the signal to the microcontroller and LCD shows the gas concentration and Buzzer provides an altering sound [5]. An LPG gas leakage sensor circuit was presented in a paper that detects the outflow of LPG gas and the circuit is a gas sensor module SEN 1327. QM 6 gas sensor is used in the SEN 1327 module. The output signal from the SEN 1327 gas sensor module is used to drive a 555 timer based astable multi vibrator circuit. The SEN-1327 gas sensor module from Rhydo LABZ was used in this circuit. Interfacing with the sensor module was done through a 4-pin SIP header [6].
In our project we have provided both audible and a visual alarming system. Where the buzzer will create audible sound and red LED light will provide visual alarm. An LCD will be provided to show the gas concentration and danger level. For controlling the leakage from the source a servo motor will be arranged with the cylinder knob to turn off the gas supply from the cylinder.

3. Methodology

A. We have first analyzed the required components according to the prepared circuit board. Each of the component details was listed and checked for the suitability in the project. Then we surveyed in the local market about the components availability and desired specifications.
B. The cost was a major concern as we needed to prepare the project in the most cost effective way for obtaining optimum output from the project. Finalizing the procedures the parts were purchased from the market.
C. The PCB was made ready using copper clad board where liquid soap was applied on the copper clad board so that no impurities can remain on the board. It was ribbed with steel wool and until it gets shiny. Finally, it was cleaned with a cloth. Then the toner was transferred to the board using heat. After washing and etching method the toner was removed. Drilling and soldering the components to the PCB the final project was prepared.
D. Finally, the performance of the total system was experimented to check the performance of motor, LED, Buzzer, LCD whether they work appropriately or not.

4. Working principle

We have prepared a block diagram for better understanding of the project working procedure. The block diagram is shown in the fig. 1 below.

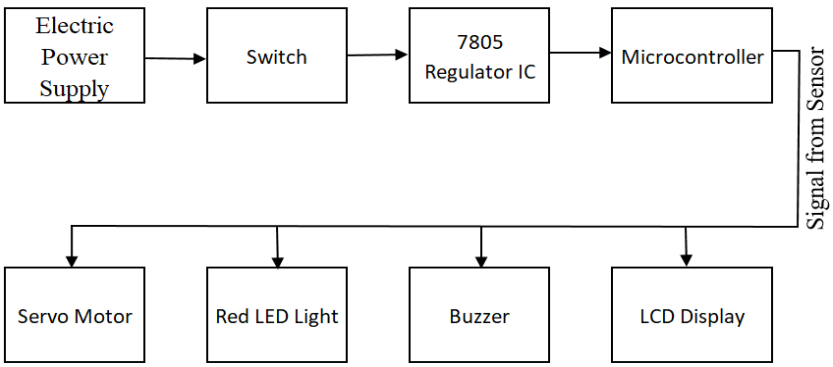

Fig. 1. Block diagram of a LPG leakage detector and controlling device

A. The AC/DC adapter is used to supply DC power from the AC power source to the main circuit. As the adapter supplies ripple current, a 7805 IC is used to smooth the input voltage and provide +5 V to the entire circuit. For storing charge and supplying it to the IC when the voltage is below 5+, two capacitors of 10 µF is used.
B. From the power circuit board, two outputs were taken through jumper wires: one to the microcontroller board and another to the motor circuit board. All the components are parallelly connected so that every part can operate at 5V but with different amperes as necessary.
C. The variable potentiometer has three-pin. One is a phase, another is grounded, and the middle pin connected to the microcontroller. When the position of the potentiometer regulator changes, different resistance work on the microcontroller different references are obtained to compare with the sensed value from the sensor.

D. The MQ6 sensor according to its datasheet can detect LPG. The sensor converts the gas concentration into specific voltage with its module. According to concentration sensed by the sensor, the output pin of the sensor module gives a changed voltage signal to the microcontroller which is proportional to the gas concentration. This signal acts as the analog input of the microcontroller.
E. If the gas concentration is lower than the set reference (danger) value then the microcontroller will signal a high voltage to the green LED indicating no danger of leakage and the green LED will lit on.
F. But if the sensed concentration is higher than the reference value (means LPG leakage) it will lower the green LED voltage and higher the red LED and buzzer voltage resulting the red LED on and an audible sound from the buzzer. Simultaneously the LCD will show the LPG value and!!Warning!! Written on the display.
G. At a time another high voltage signal will be provided to the servo motor from the microcontroller which will turn off the LPG gas cylinder knob within 64 steps each rotating the knob by an angle of 5.626 degrees with a stride ratio 1/64. Thus the device will detect LPG leakage and control it.

5. Visualization of the product

Fig.2 shows the proposed aesthetic view of the product. Here the assumed height is 13 cm and width 8 cm. ABS plastic is selected as the casing material by performing the TOPSIS method of material selection. We have used SolidWorks 2015 SP0 (64-Bit) for our design. We designed as less space possible, white colored to make heat resistant, electric wire to provide power from electricity. Fig. 3 shows the final setup of our device. It should be installed at the lower part of the area, as LPG gas is heavier than other gas in the environment. So for better performance it should be placed at the lower part of the specific area.

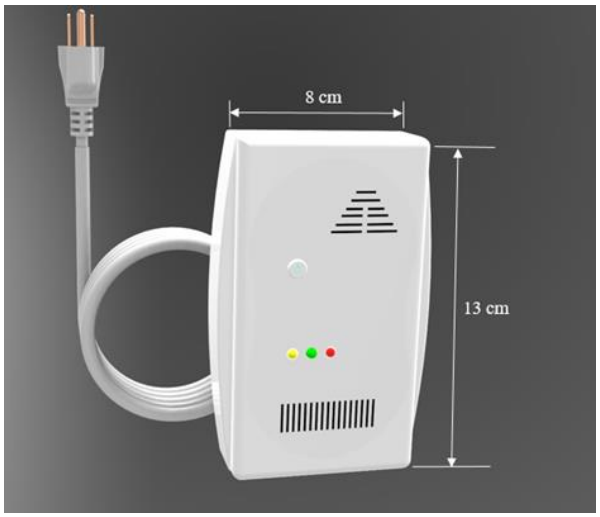

Fig. 2. Proposed aesthetic view of the product

Fig. 3. Set up of LPG detector device

And Figure 4 shows the circuitry diagram of our product. Here all the internal connections are shown. Connections from power supply to the microcontroller, then from the microcontroller to the LED light, buzzer and stepper motor all are shown in the figure.

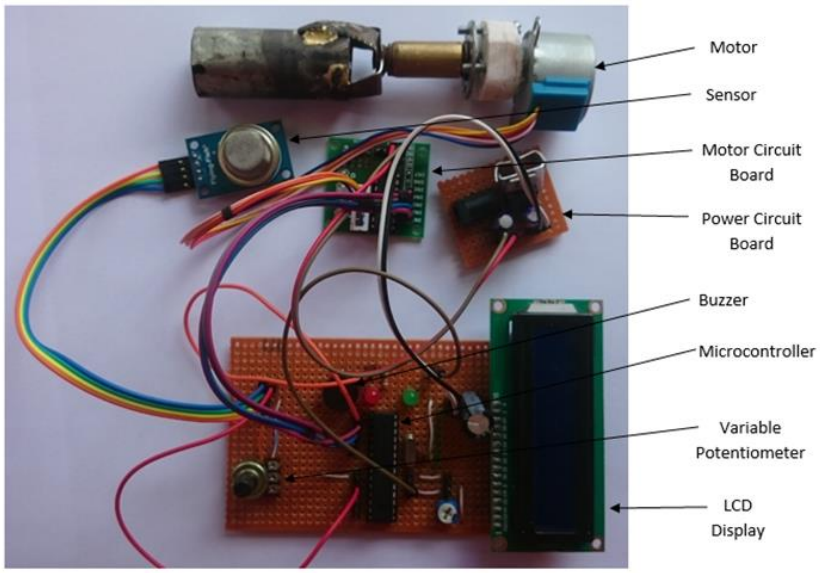

Fig. 4. Internal circuitry of the product

6. Main components

The MQ-6 sensor, microcontroller circuit board and stepper motor is the main component of the project. A small description of the components are given below:

6.1 MQ-6 gas sensor

We have used an MQ-6 gas sensor that is a device that can detect and respond to electrical signals. It is a semiconductor sensor that can detect the presence of LPG in the environment at concentrations from 300 ppm to 10,000 ppm. It can detect in a high gas sensitivity and can give a fast response. The fig. 5 shows an MQ-6 gas sensor.

Fig. 5. MQ-6 gas sensor

6.2 Stepper motor

We have used a 5V dc brushless stepper motor for precise positioning and turning off the LPG cylinder knob. The full rotation was divided into 8 steps. The stepper motor was used for obtaining a high torque to turn the knob off because normal DC motors don't have very much torque at low speeds. Fig. 6 shows a stepper motor.

6.3 Microcontroller circuit board

This was prepared to control the output according to the sensor input. The microcontroller compares sensor input with the set reference value that can be altered according to desire. The microcontroller circuit board is shown in the fig. 7.

Fig. 6. MQ-6 gas sensor

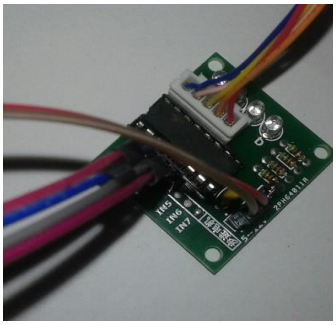

Fig. 7. Microcontroller circuit diagram

7. Product parts with specifications and Cost

After analyzing the market we have selected the required components at its best price. The required components name and their specification along with the price is given below.

Table 1. Product parts with specifications and price

SL No	Components Name	Specification	Price (BDT)
1	Sensor	MQ-6	200
2	Adapter	Input: 100-240V AC 50/60 Hz Output: 9V DC	5
3	Battery	9 Volt	50
4	IC	-	30
5	LED Light	Red, Green	2*3=6
6	Variable Potentiometer	100KΩ	30
7	Fixed Potentiometer	10KΩ	10
8	Rail	Female Rail	50
9	Microcontroller	At mega 8	90
10	Crystal	16MHz	10
11	Fixed Resistor	220Ω	2*1.5=3
12	Buzzer	5 Volt Continuous Tone Buzzer	20
13	LCD Display	LCD	150
14	Capacitor	104 Pico F	20
15	PCB	PCB	100
16	Motor and Motor Driver	5V DC	250
17	Casing Cost (Assumed)	ABS Plastic	300
Total			1324

8. Result

The LPG leakage detector and its control systems are used in the project. The project worked properly, as it detects the gas by the sensor and the leakage is controlled by the motor by turning off the knob of the gas supplying cylinder. For controlling the gas, at first the signal is supplied by the sensor, then the motor started running which generated enough force as well as torque to prevent the source of leak of any kind of gas. The microcontroller is used to detect gas and turning off the gas supply. Our project worked properly. Some experimental data are used to measure the accuracy and sensitivity of the project, which are shown below,

Table 2. Sensitivity analysis

Reference Value (ppm)	Measured Value (ppm)	Percentage of Error (%)	Accuracy (%)
775	757	2.32	97.68
819	808	1.34	98.66
710	694	2.25	97.75

The mean error of this project is 1.97% and the mean accuracy is 98.03%. The project works properly and the accuracy which is achieved is desirable. But we had one problem during the detection as we have experimented using a demonstration small LPG cylinder it does not has pressure for leakage for which reason we had to bring the sensor near the cylinder for detection rather than detecting from a distance.

9. Discussion

If the product is placed in a real-world situation the sensor can detect from 300 to 10000 ppm of the targeted LPG concentration. It will give an alarm, sound the buzzer and start the motor to turn off the LPG supplying knob if leakage happens. The detection can be performed without any interruption or personnel responsibilities and the time required to respond to the leakage is dramatically short which means shorter response time. Thus it is a life-saving device which can save human life, human health, buildings, facilities and equipment from LPG leakage.

10. Conclusion

From just an idea or concept we started our work, which eventually came in the form of a product. Gas leakage detector should be a must-use product for every home, industry or restaurant. There is nothing important than safety in human life. Safety should be the first priority of a persons' life. It becomes more important when the risk becomes life taking. Gas leakage explosion may take persons' life. LPG leakage which will lead to valuable life at risk. So, a gas leakage detector and controlling device is a dire need for every home or industry for the safety of human life, health, buildings, and facilities. Future work may include adding a notification for the failure of the system or sensors features.

11. References

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