

Home and Industrial Safety System for fire and gas Leakage detection

Rupali S. Gajare¹, Dr. P. M. Mahajan²

^{1,2}Dept. of E&TC, J.T. Mahajan College of Engineering, Faizpur, MS, India

Abstract This work carried out a fire and gas detection system for home and industrial safety. This system makes use of a microcontroller along with sensing circuit which will detect gas leakage and fire with the help of an alarm system that gives alert about fire or gas leakage. With the installation of a GSM modem SMS are sent to notify the user if there is fire or gas leakage and if the fire occurs the water sprinkler sprinkles water on the affected area to reduce the effect of the fire. An MQ-6 and MQ-9 gas sensors are used to build the system and on testing, the system gave adequate information and timely alert as SMS on detecting the gas leakage. The fire detection can also be carried out by using the IR flame sensor which detects the fire in the working area and alert SMS is sent to the user. Also, excess temperature detection system is implemented using temperature sensor LM-35 to detect the excess temperature beyond the preset value.

Keywords: Atmel ATmega 328 AVR microcontroller, gas sensors MQ-6 and MQ-9, flame sensor, temperature sensor, GSM modem(SIM900), power supply

1. Introduction

Gas leakages and fire outbreaks in industries as well as houses have led to wide destruction and losses in the past. Gas leakages and fire outbreaks both spread widely and lead to even greater loss of life and property if proper action is not taken on time. So here we propose a system that detects gas as well as fire outbreaks and alert us accordingly so that user can take proper action to control it. [1]

In this work, mainly three units used in the proposed system and they are,

- sensor unit
- microcontroller unit
- GSM modem.

For quick and efficient fire detection, flame sensor unit (LM35 temperature detector) have been placed. This unit can easily be incorporated into buzzer unit to sound an

alarm. GSM modem can be configured by standard GSM AT command set for sending and receiving SMS and getting modem status. Depending upon the gas sensor output, the microcontroller can send message to the authorized person.

2. Overview of survey

S. Tseng et al [2] proposed smart house monitor and manager (SHMM) system based on the ZigBee. In this work all sensors (gas and flame sensors) and actuators are connected by a ZigBee wireless network. They designed a simple smart socket, which can remotely control via ZigBee. PC host is used as a data collector and the motion sensing, all sensing data are transferred to the virtual machine in the cloud. The user can use the PC or Android phone to monitor or control through the Internet to power-saving of the house.

Bhattacharjee et al [3] designed a system entitled "Design and Development of a Flexible Reliable Smart Gas Detection System". This system composed of three modules; the base station, wireless sensor array and an intelligent wireless alarm unit, which offers high reliability, flexibility and uninterrupted sensing. These are achieved by incorporating various intelligent protocols like auto sensor calibration, sensor handover, wireless threshold fixation and intelligent alarm mechanism. The sensor node consists of three gas sensors, one temperature sensor and one pyro-electric infrared sensor (PIR) which enhances the sensing intelligence. The sensed data are digitized and processed by the peripheral interface controller (PIC) 16f877A based centralized embedded platform and wireless communication is achieved with a pair of 433 and 315 MHz amplitude shift keying(ASK) wireless module. The encoding and decoding of sensed data offer a high secured gas detection system.

A low cost automotive localization system using GPS and GSM-SMS services was proposed by I. Lita et al. [4] It is concerning "A New Approach of Automatic Localization System Using GPS and GSM/GPRS Transmission", which provides the position of the vehicle on the driver's or owner's mobile phone as a short message (SMS). The

system can be interconnected with the car alarm system that alerts the owner, on his mobile phone, about the events that occurs with his car when it is parked. The system is composed by a GPS receiver, a microcontroller and a GSM phone. In addition, the system can be settled for acquiring and transmitting the information, whenever requested about automobiles status and alerts the user about the vehicle's started engine.

3. Proposed System Architecture

Figure 1 Shows the block diagram of the fire and gas detection system. The system mainly consists of fire and gas leakage detection system, Microcontroller with GSM module and protection circuitry. The hardware of the system mainly comprises sensor section, control unit, network module, and power supply

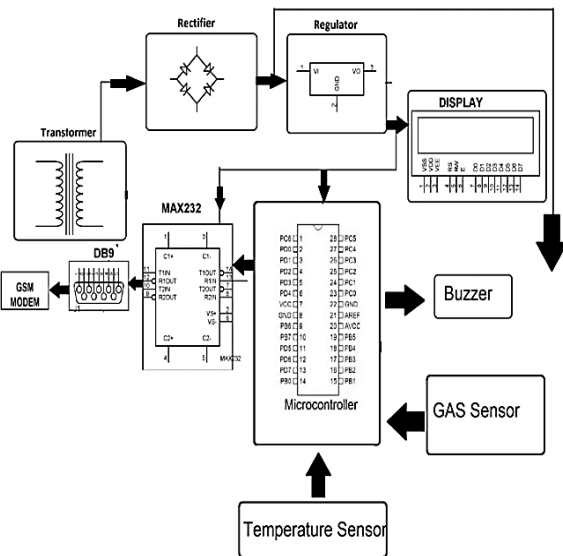


Figure 1 Block diagram of fire and gas detection system

Initially, the microcontroller sends signal to the GSM module and if the GSM module is connected properly with the microcontroller it sends an acknowledgement signal back to the microcontroller. Then if there is any gas leakage in the atmosphere it is detected by the gas sensor unit using MQ sensors. After the sensor unit detects the gas leakage, a signal is sent to the ADC unit of the microcontroller which then sends activation signal to other external devices connected to it such as buzzer, GSM module. And in case of fire leakage the fire flames detected by the temperature sensor and activates the buzzer and water sprinkler. The GSM module gets activated which

sends a warning SMS to the user. At the end, when the gas or fire leakage is successfully stopped then with the help of reset button the whole system is made to reach its initial stage. The MQ-6 and MQ-9 Gas Sensors which detects gas leakage by comparing the concentration of ethanol which is present as a mixture in the LPG and CNG with air. It then gives analog voltage as output. [5]

Sensor Section comprises of a smoke/gas, temperature sensors, comparators and variable resistors. It consists of an IR LED, a photodiode, a potentiometer, an IC Operational amplifier and an LED. IR LED emits infrared light. The Photodiode detects the infrared light. An IC Op - Amp is used as a voltage comparator. The potentiometer is used to calibrate the output of the sensor according to the requirement. [6] The heart of the control unit is ATmega8L, a low power Atmel 8-bit AVR RISC-based general purpose computer. Optimized power consumptions, good processing speed, small physical dimensions, and lower costs make this microcontroller a perfect fit for our purpose. The alert message can be sent to distant remote locations using various wireless networks. GSM module requires a subscriber identification module (SIM) card from a wireless carrier to operate. In this present work, a SIM300 GSM kit has been used.

4. Proposed Software Design

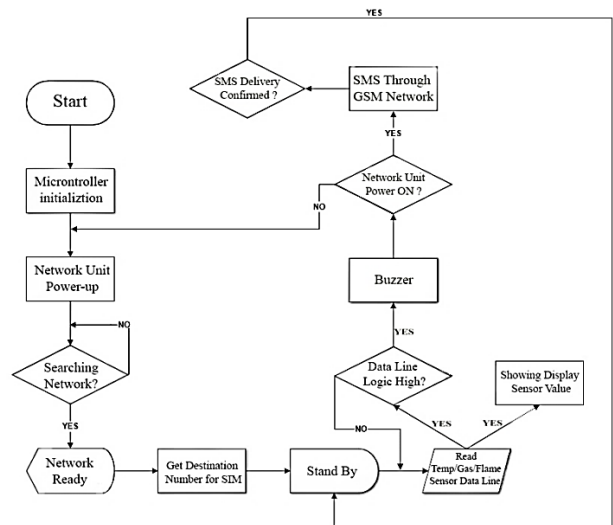


Figure 2 Flowchart of the proposed system

Figure 2 shows the program flowchart. It includes the developed algorithm for the system separate program are written for different interfacing devices such as gas

sensor, temperature sensor, and finally this system is tested by using the hardware after turning power in microcontroller unit is initialized. Then the system is searching for the network. When the network is ready and get the destination number from the system. The sensor data particular (Gas/Temperature/IR sensor) read by the sensor data line. If the sensor data line status logic is high then the system activated the siren and buzzer is on. The network unit power is on and SMS is sent to respective SIM subscriber.

5.Results and discussions

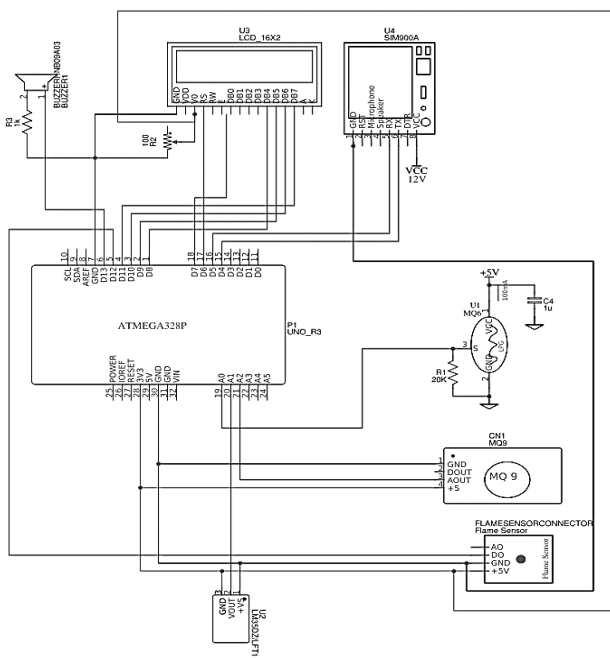


Figure 3 Circuit diagram of the system

The implementation circuit of the proposed system is shown in figure 3 The proposed system is implemented and experimented in various ways-

1. Gas leakage detection testing using gas sensors (MQ-6 and MQ-9)
2. Fire detection testing using flame sensor (IR)
3. Temperature detection using temperature sensor (LM35)

1. Gas leakage detection testing using gas sensors (MQ-6 and MQ-9)



Figure 4. Gas leakage detected by gas sensor

In this experiment, LPG and CNG gases are used for leakage detection. Both the gas leakage is detected by keeping gas pressure in various modes of parts per million (ppm).

Case 1: In the first case, distance between the sensors and the gas cylinders is kept as 1 meter and the ppm value of gas sensor is set as 200.

Table 1 Readings of gas sensor for LPG

G1 (ppm)	G2 (ppm)	Distance (meter)	Set Value of sensor (ppm)	Result
445	392	1.0	200	Alert by G1 & G2
405	345	1.0	200	Alert by G1 & G2
384	310	1.0	200	Alert by G1 & G2
356	264	1.0	200	Alert by G1 & G2
223	131	1.0	200	Alert by G1
193	234	1.0	200	Alert by G2
110	96	1.0	200	No Alert

According to the experiments the average time taken by the system to indicate the alarm is approximate 5.04 sec.

Table 2 Readings of gas sensor for CNG

G1 MQ-6 (ppm)	G2 MQ-9 (ppm)	Distance (meter)	Set Value of sensor (ppm)	Result
309	367	1.0	200	Alert by G1 & G2
312	326	1.0	200	Alert by G1 & G2
265	295	1.0	200	Alert by G1 & G2
212	269	1.0	200	Alert by G1 & G2
289	165	1.0	200	Alert by G1
145	258	1.0	200	Alert by G2
136	52	1.0	200	No Alert

According to the experiments the average time taken by the system to indicate the alarm is approximate 7.39 sec.

Case 2: The second experiment, distance between the gas cylinder and the sensors is kept as 2 meter and the ppm value of gas sensor is set as 200.

Table 3 Readings of gas sensor for LPG

G1 MQ-6 (ppm)	G2 MQ-9 (ppm)	Distance (meter)	Set Value of sensor (ppm)	Result
385	324	2.0	200	Alert by G1 & G2
339	289	2.0	200	Alert by G1 & G2
255	297	2.0	200	Alert by G1 & G2
216	225	2.0	200	Alert by G1 & G2
235	152	2.0	200	Alert by G1
172	213	2.0	200	Alert by G2
185	116	2.0	200	No Alert

According to the experiments the average time taken by the system to indicate the alarm is approximate 5.34 sec.

Table 4 Readings of gas sensor for CNG

G1 MQ-6 (ppm)	G2 MQ-9 (ppm)	Distance (meter)	Set Value of sensor (ppm)	Result
397	458	2.0	200	Alert by G1 & G2
368	431	2.0	200	Alert by G1 & G2
312	369	2.0	200	Alert by G1 & G2
285	342	2.0	200	Alert by G1 & G2
258	174	2.0	200	Alert by G1
198	268	2.0	200	Alert by G2
156	84	2.0	200	No Alert

According to the experiments the average time taken by the system to indicate the alarm is approximate 8.24 sec.

Case 3: Third experiment is taking by keeping distance of cylinders and gas sensors is 1 meter and gas ppm value is kept as 250.

Table 5 Readings of gas sensor for LPG

G1 MQ-6 (ppm)	G2 MQ-9 (ppm)	Distance (meter)	Set Value of sensor (ppm)	Result
415	358	1.0	250	Alert by G1 & G2
388	365	1.0	250	Alert by G1 & G2
387	359	1.0	250	Alert by G1 & G2
294	256	1.0	250	Alert by G1 & G2
256	152	1.0	250	Alert by G1
125	235	1.0	250	Alert by G2
156	62	1.0	250	No Alert

According to the experiments the average time taken by the system to indicate the alarm is approximate 5.59 sec.

Table 6 Readings of gas sensor for CNG

G1 MQ-6 (ppm)	G2 MQ-9 (ppm)	Distance (meter)	Set Value of sensor (ppm)	Result
405	446	1.0	250	Alert by G1 & G2
334	358	1.0	250	Alert by G1 & G2
256	288	1.0	250	Alert by G1 & G2
197	213	1.0	250	Alert by G1 & G2
150	190	1.0	250	Alert by G1
103	155	1.0	250	Alert by G2
36	126	1.0	250	No Alert

According to the experiments the average time taken by the system to indicate the alarm is approximate 7.39sec.

Case 3: In fourth experiment we have taken the distance between the gas sensors and cylinders at 2 meter and gas ppm value is set for 250.

Table .7 Readings of gas sensor for LPG

G1 MQ-6 (ppm)	G2 MQ-9 (ppm)	Distance (meter)	Set Value of sensor (ppm)	Result
468	354	2.0	250	Alert by G1 & G2
361	328	2.0	250	Alert by G1 & G2
359	321	2.0	250	Alert by G1 & G2
249	268	2.0	250	Alert by G1 & G2
236	169	2.0	250	Alert by G1
186	229	2.0	250	Alert by G2
124	97	2.0	250	No Alert

According to the experiments the average time taken by the system to indicate the alarm is approximate 5.35 sec.

Table 8 Readings of gas sensor for CNG

G1 MQ-6 (ppm)	G2 MQ-9 (ppm)	Distance (meter)	Set Value of sensor (ppm)	Result
378	412	2.0	250	Alert by G1 & G2
335	365	2.0	250	Alert by G1 & G2
305	347	2.0	250	Alert by G1 & G2
215	282	2.0	250	Alert by G1 & G2
133	172	2.0	250	Alert by G1
98	122	2.0	250	Alert by G2
45	102	2.0	250	No Alert

According to the experiments the average time taken by the system to indicate the alarm is approximate 8.24 sec.

If LPG gas is introduced near the sensor, it detected by the gas sensor. After initializing the gas leakage detection, the microcontroller sends command to operate the GSM modem. The GSM modem will now send message to the registered mobile number of the user that is predefined by the programmer.

2.Fire detection testing using flame sensor (IR)



Figure 5 The fire is detected by the sensor.

In this experiment to observe the performance and response of the system to the various fire situations and various tests were performed with varying the flame

from low to high. The result of the tests table 9 suggests the system renders desired alert responses under different test conditions reliably.

Table 9 Testing results of the flame sensor output readings.

Case no	Distance (m)	Output of sensor (F)	Result
1	5.0	Low	No Alert
2	5.0	High	Alert
3	2.5	Low	Alert
4	2.5	High	Alert
5	2.0	Low	Alert
6	2.0	High	Alert
7	1.5	Low	Alert
8	1.5	High	Alert
9	1.0	Low	Alert
10	1.0	High	Alert

The sensor senses the fire intensity and feeds the signal to the microcontroller which commands the GSM to send the message to the user about the fire alert in the working area.

3. Temperature detection using temperature sensor (LM35)



Figure 6 When the temperature exceeds the higher limits

To observe the temperature increase in the enclosed surrounding, heater is on higher temperature in the car and observe the temperature sensor output on LCD display. Readings taken from varying distance. The constant temperature is set as 50 °C.

Table 10 Testing results of the temperature sensor output readings at distance= 1 meter

Case no	Distance (meter)	Sensor Output (°C)	Result
1	1.0	75	Temp>50°c (Alert)
2	1.0	60	Temp>50°c (Alert)
3	1.0	54	Temp>50°c (Alert)
4	1.0	50	Temp>50°c (Alert)
5	1.0	45	Temp<50°c (No Alert)
6	1.0	32	Temp<50°c (No Alert)
7	1.0	20	Temp<50°c (No Alert)

Table 11 Testing results of the temperature sensor output readings at distance= 2 meter

Case no	Distance (meter)	Sensor Output (°C)	Result
1	2.0	75	Temp>50°c (Alert)
2	2.0	60	Temp>50°c (Alert)
3	2.0	54	Temp>50°c (Alert)
4	2.0	50	Temp>50°c (Alert)
5	2.0	45	Temp<50°c (NO Alert)
6	2.0	32	Temp<50°c (NO Alert)
7	2.0	20	Temp<50°c (NO Alert)

4. SMS notification via GSM after detecting leakage

Whenever the GSM modem gets the command message, "Alert" from the microcontroller, it will send the message to the mobile number which is stored in the microcontroller. The message is sent to the registered mobile number within 2 seconds. This alarms the user that there is leakage in the particular area. The water sprinkler is on at a time of buzzer in case of fire and exhaust fan is on in case of gas leakage. The buzzer sounds till the leakage is

under control. The messages that are displayed in LCD as shown in figures below:



Figure 7 When GSM modem is connecting



Figure 8 When the modem is connected



Figure 9 When the message is sending to the registered mobile number

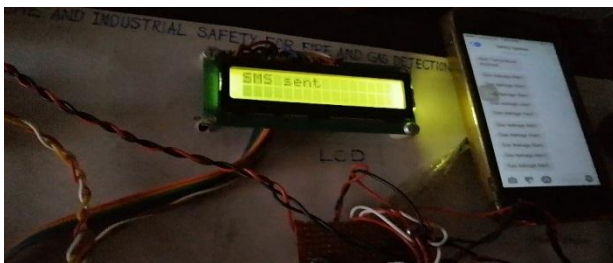


Figure 10 SMS is sent

CONCLUSION

This work is an attempt to provide home and industrial safety systems. This system is tested for various sensor for detecting gas (MQ-6 & MQ-9), excess temperature (LM35) and flame detection (IR sensor). Accordingly, it is noted that average time required to detect LPG leakage is less as compared to CNG at the same PPM. The system also works effectively and gives alert for excess temperature detection above 50°C for any change in condition. SMS have been effectively sent to the respective subscriber.

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