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GSM Based Gas Leakage Warning System

Tanvira Ismail[1], Devoleena Das[2], Jyotirmoy Saikia[3], Jyotirmoy Deka[4], Rajkumar Sarma[5]

Assistant Professor, Department of ECE, Don Bosco College Of Engineering & Technology, Guwahati, India[1]

B.Tech Student, Department of ECE, Don Bosco College Of Engineering & Technology, Guwahati, India[2, 3, 4, 5]

Assam Don Bosco University

Abstract: The leakage of dangerousand flammable gas like LPG in cars, service stations, households and in storage tanks can bedetected using the gas sensor unit. This unit can be easily integrated into aunit that can sound an alarm. The sensor has great sensitivity and rapid response time. This sensor can also beused to sense other gases like iso-butane, propane and even cigarette smoke. The output of the sensor goes LOW as soon as the sensor senses any gas leakage in the atmosphere. This is detected by the microcontroller and buzzer is turned on. After a delay of few milliseconds, the exhaust fan is also turned on for throwing the gas out and the main power supply is turned off. A message 'LEAKAGE' is sent to a mobile number that is predefined.

Keywords: MQ6 (gas sensor), GSM module, GSM network, Short message service, LPG gas

I. INTRODUCTION

Gas leakages are a common problem in households and industries. If not detected and corrected at the right time, it can also be life threatening. Unlike a traditional gas leakage alarm system which only senses a leakage and sounds an alarm, the idea behind our solution is to turn off the main power and gas supplies as soon as a gas leakage is detected apart from sounding the alarm. In addition to this, a message is sent to an authorized person informing him about the leakage.

There are mainly three units, in this circuit: sensor unit, microcontroller unit and GSM modem.For detecting dangerous & flammablegas leaks in any closed environment such as a car, house, service station or storage tank, a gas sensor is used which detects natural gas, LPG and coal gas. This sensor can also be used to sense other gases like iso-butane, propane and even cigarette smoke. This unit can easily be incorporated into an alarm 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.

II. OBJECTIVE

- To detect the leakage of LPG gas in aclosed environment, if any.
- To inform the user about the leakage of gas via SMS.
- To activate the alarm unit to inform neighbours about the gas leakage.
- To switch on the exhaust fan as a primary preventive measure against gas leakage.
- To turn off main power supply after gas leakage.

III.CIRCUIT SOLUTION

A. Block diagram

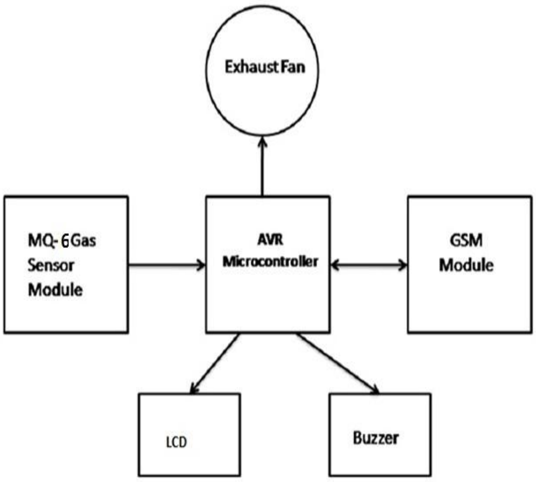


Fig 1: Block diagram

Initially, the microcontroller sendssignal 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 gassensor unit using MQ-6 sensor. After the sensor unit detects the gas leakage, a signal is sent to the ADCunit of the microcontroller which then sends activation signal to other external devicesconnected to it such as buzzer, GSM module, and exhaustfan.

The GSM modulegets activated which sends awarning SMS to the user and turns on the exhaust fan. At the end, when the gas leakage issuccessfully stopped then with the help of reset button thewhole system is made to reachits initial stage.

The MQ-6 Gas Sensor is a semiconductor type gas sensor which detects gasleakage by comparing the concentration of ethanol which is present as a mixture in the LPG with air. It then gives analog voltage as output. MQ-6 is a SnO_2 sensor.

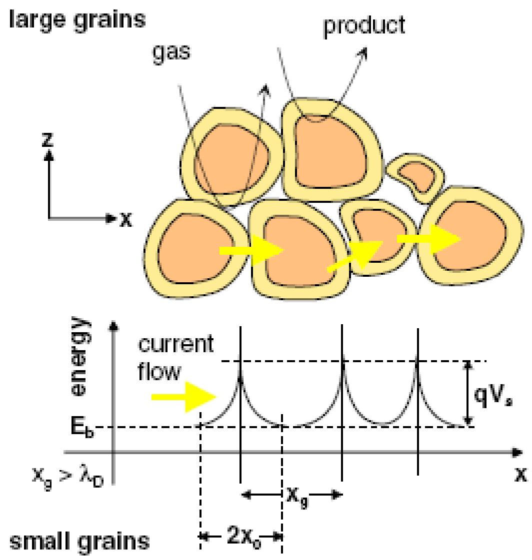


Fig 2: Schematic representation of a porous sensing layer with geometry and energy band. $\lambda_D$is the Debye length, $x_g$is the grain size and x_0 is the depth of the depletion layer.

Tin oxide sensors are generally operated in air in the temperature range between 200 and 400°C. At these temperatures it is generally accepted that the conduction is electronic; it is also acceptedthat chemisorption of atmospheric gases takes place at the surface of the tin oxide. The overall conduction in a sensor element,whichdetermines the sensor resistance, is determined by thesurface reactions, the resulting charge transfer processes with the underlying semiconductingmaterial and the transport mechanism from one electrode to the other through the sensinglayer (the latter can even be influenced by the electrical and chemical electrode effects). Forexample, it is well known that oxygen ionosorption as O^{-2}or O^{-} will result in the building of a negative charge at the surface and the increase of the surfaceresistance [8, 9–11]. It is also considered that reducing gases like ethanol react with the surfaceoxygen ions, freeing electrons—the sensing step—that can return to the conduction band. Thetransduction step, i.e. the actual translation of this charge transfer into a decrease of the sensorresistance, depends on the morphology of the sensing layer [7]. The resultis that, even for exactly the same surface chemistry, the dependence of the sensor resistanceon the concentration of ethanol can be very different for compact and porous sensing layers [7].

In our case, the sensing layer consists of single crystalline grains with a narrow sizedistribution [12]. Due to the fact that the final thermal treatment is performedat 700°C, the grains are just loosely connected. Accordingly, the best way to describe theconduction process is to consider that the free charge carriers (electrons for SnO_2) have toovercome the surface barriers appearing at the surface of the grains as shown in Fig 2[7].

Due to the narrow size distribution it is also quite probable that a mean-field treatment sufficesand there is no need for Monte Carlo simulations or percolation theory. One can easily modelthe dependence of the resistance on the ethanol concentration bymaking the following assumptions,supported by the already established knowledge in this field:

- The reaction of ethanol takes place just with the previously adsorbed oxygen ions (welldocumented for the temperature and pressure range in which the gas sensors operate).
- The adsorption of ethanol is proportional to the ethanol concentration in the gas phase.

On the basis of the above assumptions one can combine quasi-chemical reaction formalism withsemiconductor physics calculations and one obtains power-law dependences of the form

$$R \sim p^{n}_{\text{ethanol}} \qquad (1)$$

where the value of n depends on the morphology of the sensing layer and on the actual bulkproperties of the sensingmaterials[7]. The relationship describedby equation (1) is well supported by experiments.

For the effect of water vapour on the resistance of tin oxide based gas sensors there are a couple of ideas, briefly presented below. There are three types of mechanisms to explain the experimentally proven increase of surface conductivity in the presence of water vapour. Two, direct mechanisms, are proposed by Heiland and Kohl [13] and the third, indirect, is suggested by Morrison and by Henrich and Cox [14, 15].

The *first mechanism* of Heiland and Kohl attributes the role of the electron donor to the 'rooted' OH group, the one including lattice oxygen. The equation proposed is

$$H_2O_{gas} + Sn_{Sn} + O_O \Leftrightarrow (Sn^{\delta+}{}_{Sn}{-}OH^{\delta-}) + (OH)^{+}{}_{O} + e- \qquad (2)$$

where $(Sn^{\delta+}{}_{Sn}{-}OH^{\delta-})$ is referred to as an isolated hydroxyl or OH group (dipole) and $(OH)^{+}{}_{O}$is the rooted one. In the first equation, the donor is already ionized. The reaction implies the homolytic dissociation of water and the reaction of the neutral H atom with the lattice oxygen. The latter is normally fixing two electrons and then consequently being in the $(2-)$ state. The built-up rooted OH group, having a lower electron affinity, can become ionized and become a donor (with the injection of an electron into the conduction band).The *second mechanism* takes into account the possibility of the reaction between the hydrogen atom and the lattice oxygen and the binding of the resulting hydroxyl group to theSn atom. The resulting oxygen vacancy will produce, by ionization, the additional electrons.

The equation proposed by Heiland and Kohl [13] is

$$H_2O_{gas} + 2Sn_{Sn} + O_O \Leftrightarrow 2(Sn^{\delta+}{}_{Sn}{-}OH^{\delta-}) + V^{2+}{}_{O} + 2e-. \qquad (3)$$

Morrison, as well as Henrich and Cox [14, 15], consider an indirect effect more probable.This effect could be the interaction between either the hydroxyl group or the hydrogen atom originating from thewatermolecule with an acidor basic group,which are also acceptor surfacestates. Their electronic affinity could change after the interaction. It could also be the influenceof the co-adsorption ofwater on the adsorption of another adsorbate which could be an electron acceptor. Henrich and Cox suggested that the preadsorbed oxygen could be displaced by water adsorption.In any of these mechanisms, the particular state of the surface plays a major role, due to the fact that it is considered that steps and surface defects will increase the dissociative adsorption. The surface dopants could also influence these phenomena; Egashira *et al* [16] showed by TPD and isotopic tracer studies combined with TPD that the oxygen adsorbates are rearranged in the presence of adsorbed water. The rearrangement was different in the case of Ag and Pd surface doping.In choosing between one of the proposed mechanisms, one has to keep in mind that:

- In all reported experiments, the effect of water vapour was the increase of surface conductance.
- The effect is reversible, generally with a time constant of the order of around 1 h.

It is not easy to quantify the effect of water adsorption on the charge carrier concentration, n_S(which is normally proportional to the measured conductance). For the first mechanism of water interaction proposed by Heiland and Kohl (‘rooted’, equation (2)), one could include the effect of water by considering the effect of an increased background of free charge carriers on the adsorption of oxygen.For the second mechanism proposed by Heiland and Kohl (‘isolated’, equation (3)) one can examine the influence of water adsorption as an electron injection combined with the appearance of new sites for oxygen chemisorptions[17]; this is valid if one considers oxygen vacancies as good candidates for oxygen adsorption. In this case one has to introduce the change in the total concentration of adsorption sites $[S_t]$:

$$[S_t] = [S_{t0}] + k_0 p_{H2O} \quad (4)$$

obtained by applying the mass action law to equation (3). $[S_{t0}]$ is the intrinsic concentration of adsorption sites and $k_0$is the adsorption constant for water vapour. In the case of interactionwith surface acceptor states, not related to oxygen adsorption, one can proceed as in the case of the first mechanism proposed by Kohl. In the case of an interaction with oxygen adsorbates, one can consider that the dissociation of oxygen ions is increased and examine the implications.

The MQ-6 sensor has a sensing range of 300-1000ppm. The response time for measuring LPG gas content is quick.

Whenever there is a gas leakage, the ethanol present in the air is oxidized to acetic acid, which is an organic acid. The resulting chemical reaction will produce an electrical current. The difference of potential produced by this reaction is measured, processed, and displayed as an approximation of overall gas content in the atmosphere.

The MQ-6 has six contacts as shown in Fig 3. There is no polarization on the sensor so any of the two contacts, A or B, can be used interchangeably as Vcc and Ground. The contacts labelled as H are the contacts for the internal heating system.

The internal heating system is a small tube made of aluminium oxide and tin dioxide. Inside this tube, there are heating coils which produce the heat. These coils can draw up to 150mA of current. The alumina tube is covered with tin dioxide, SnO_2. Embedded between SnO_2 and alumina tube is an aurum electrode (Fig 3). When heated, the SnO_2 becomes a semiconductor and produces movable electrons. These movable electrons allow the flow of more current. When LPG gas molecules contact the electrode, the ethanol present in the LPG chemically changes into acetic acid and produces a flow of current within the tube. The more LPG gas present the more current is produced.

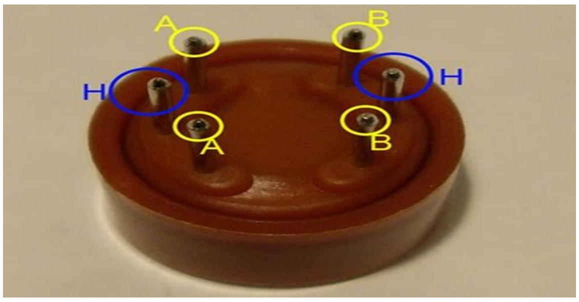


Fig 3: MQ-6 Contacts

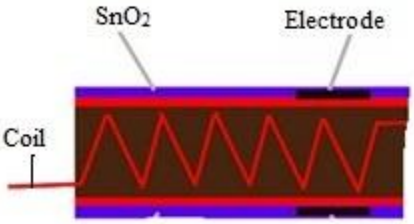


Fig 4: Heating Tube Source

The current, however, is not what is measured when measuring the output, what is measured is the voltagebetween the output of the sensor and the load resistor. Also,inside the sensor there is a variable resistor across contacts A and B [Fig3]. The resistance between the contacts A and B will vary depending on the amount of LPG present. As the amount of LPG increases, the internal resistance will decrease and thus, the voltage at the output will increase. This voltage is the analog signal transmitted to the ADC of the microcontroller.

The GSM module is used to send an SMS to the user’s cell phone number. When gas leakage is detected by the gas sensor, the microcontroller sends a signal to the GSM module which then sends a message to the user. These SMSs are saved in the microcontroller memory.Multiple SMSs can also be sent to the user, police, fire stationetc.

Fig 5: GSMmodem (SIM 900)

Two stepper motors have been used which are connected to thestepper motor driver IC (L293D). A 12V external DC supply is given to the stepper motor. The mainpurpose of the stepper motors are to turn off the main power and gas supply. One motor is used to turn off the main power supply by attaching it to a main switch in such a way that when a motor rotates 60º, then immediately power supply turns off. On the other hand, the second motor turns off themain gas supply. A mechanically coupled stepper motor is connected to the main gas knob, so that when motor rotates 180º thenimmediately the knob closes.

B. CIRCUIT DIAGRAM

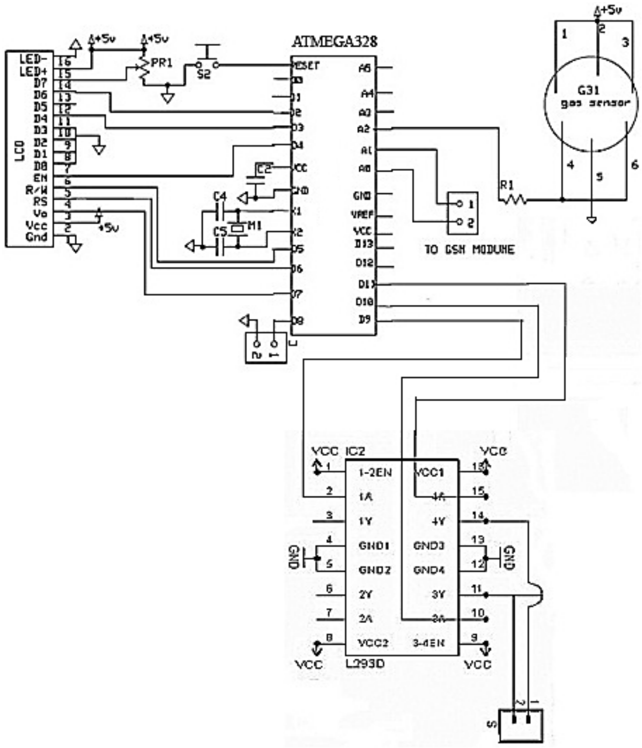


Fig 6: Circuit diagram

Whenever there is LPG concentration of 300 - 1000 ppm in the atmosphere, the OUT pin of the sensor module goes high. This signal drives timer IC 555, which is wired as an astablemultivibrator. The multivibrator basically works as a tone generator. Output pin 3 of IC 555 is connected to LED1 and speaker-driver transistor SL100 through current-limiting resistors R5 and R4, respectively. LED1 glows and the alarm sounds to alert the user of gas leakage. The pitch of the tone can be changed by varying presetVR1.The MQ carrier board (Fig 4) is compatible with all MQ gas sensor models and reduces the six contacts to an easier to manage layout of three pins.

The three pins are Vcc, Ground and Output. Depending on our choice of positioning of the MQ sensor on the PCB, it will connect both A contacts to the Output pin and A side H contact to Ground, and both B contacts and B side H contact to Vcc.

Testing of the LPG content begins by powering the microcontroller and the MQ-6 sensor.

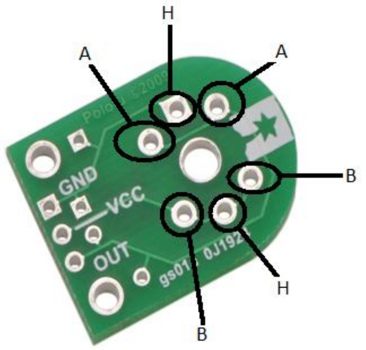


Fig 7: MQ Sensor Board

With the sensor powered, approximately ten seconds are required to allow for the internal heater coil to heat the tin dioxide coating. Ten seconds is an appropriate time frame for the tin dioxide to become a semiconductor. After the ten seconds, the analyser is ready to begin testing to LPG leakage.
When the ethanol molecules make contact with the aurum electrode, oxygen is added to the ethanol and it begins to oxidize. The ethanol is chemically changed, and the result is acetic acid and a bit of water. The oxidation of the ethanol produces an electrical current that will move through the tin dioxide coating.
Conversion Process [5]

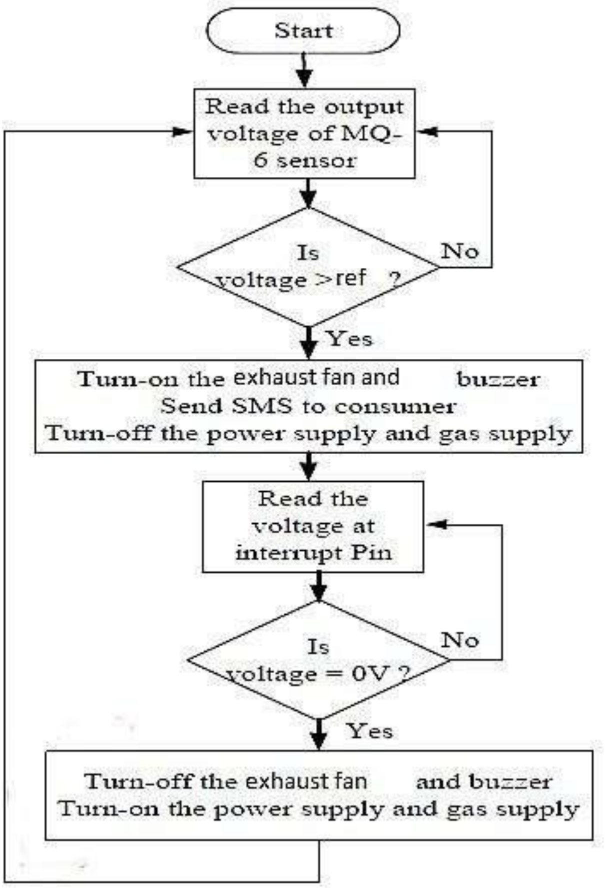
$$\mathbf{CH_3CH_2OH_{(ethanol)}+O_2 \Rightarrow CH_3COOH_{(Acetic\ Acid)}+H_2O} \quad (5)$$
(“Oxidation/Reduction Reactions”)

As the LPG content in the air rises, the resistance between contact A and B will decrease allowing more voltage at the output. The output of the sensor is connected to channel 2 of the ADC present in the microcontroller (ATMEGA328).The transmitter and the receiver pins of the GSM (SIM 900) areconnected to the receiver and transmitter pins of themicrocontroller that will be used to have transmissionofcontrol messages between the two. The programming is made in such a way that whenever circuit is switched on microcontroller sends “AT” command to the GSM modem. If the GSM replies back “OK” signal then it processes the sensor output. Whenever there is leakage the sensor which remains in high state gives a low output which is provided to the microcontroller’s ADC2 channel via inverter and further analog to digital conversion is done within the microcontroller. If the output of the sensor is beyond our predefined threshold value the microcontroller sends activation signal to all other devices connected to it like buzzer, exhaust fan and also sends SMS to the stored number continuously. Once the leakage is controlled the entire set up is brought to its initial stable state by pressing the RESET button.The controlling commands ofthe GSM is also sent from the microcontroller like:

AT+CMGF=1 and the AT+CMGS=”9876543210”

These two commands will enable the GSM to start and is switched to the text mode and send message to the specific number respectively.

IV. SOFTWARE



V. OBSERVATION

The pin configuration of IC LM358 that is used in the gas leakage circuit is as shown in fig 8:

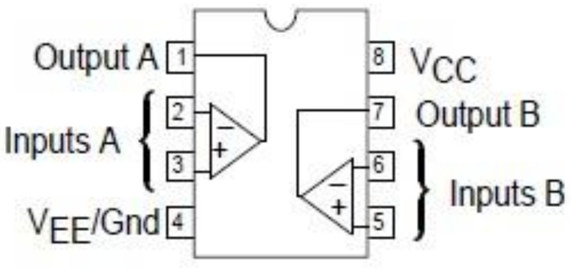


Fig 8: IC LM358

The results obtained by observing the gas leakage circuit are given in table I.

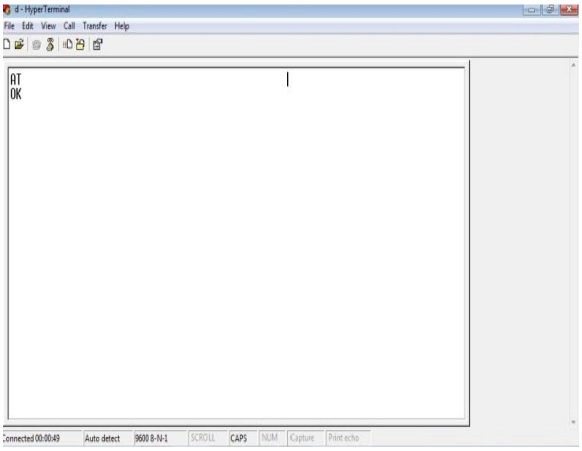
TABLE I: Readings of gas leakage circuit

Pin no.	**In absence of LPG**	**In presence of LPG**	**Pin no.**	**In absence of LPG**	**In presence of LPG**
1	0.88 v	2.85 v	5	0 v	2.95 v
2	2.00 v	2.06 v	6	1.03 v	1.04 v
3	0.19 v	2.04 v	7	0.88 v	4.30 v
4	0 v	0 v	8	4.32 v	4.32 v

In the output,0.88v is obtained in absence of LPG and 4.30v is obtained in presence of LPG.

VI. RESULT AND DISCUSSION

STEP1:For interfacing the GSM modem with the computer, the hyperterminal software is used which creates the hyperterminal window in Windows 7 OS. After installing the software, a window appears where we can select the COM port and then select serial communication for interfacing the GSM modem. Using AT commands in this hyperterminal we can operate the modem.



```
AT
OK
```

STEP2:When the power supply is turned on the SnO_2 gets heated up after 10 sec **(**approx**)**, it becomes a semiconductor and gets ready for the detection of LPG. Pin 8 under this condition provides a voltage output of 0.89V [Table1]

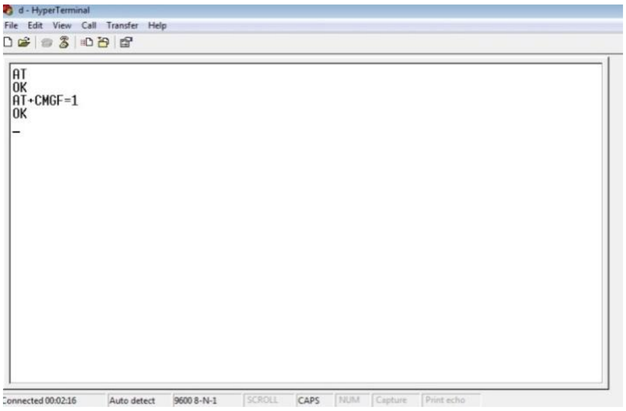
.

Fig 9: Sensor output (in absence of LPG)

Now if the LPG gas is introduced near the sensor, ethanol undergoes conversion [5] and produces a voltage of around 4.24V at the pin 8 of the sensor. [Table I]

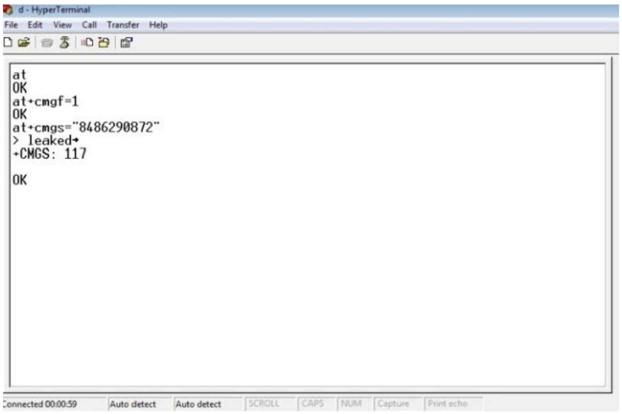
Fig 10: Sensor output (in presence of LPG)

After initializing the gas leakage detection using GSM system, the microcontroller sends command to operate the GSM modem. The GSM modem will now sendmessage to the mobile number of the user that is predefined by the programmer.



```
AT
OK
AT+CMGF=1
OK
_
```

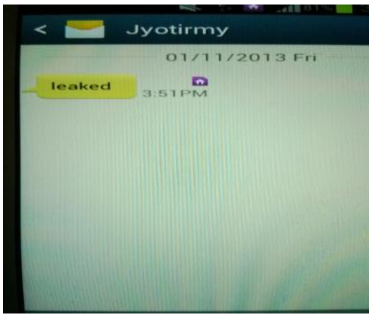
STEP3:Whenever the GSM modem gets the command message, "LEAKED" from the microcontroller, it will send the message to the mobile number which is stored in the microcontroller. This alarms the user that there is leakage in the particular area.



```
at
OK
at+cmgf=1
OK
at+cmgs="8486290872"
> leaked→
+CMGS: 117

OK
```

The following picture shows the predefined user receiving the message “LEAKED”:-



Jyotirmy
01/11/2013 Fri
leaked
3:51PM

Fig 11: Output message received by predefined user

VII. CONCLUSION

Gas leakages in households and industries cause risk to life and property. A huge loss has to be incurred for the accident occurred by such leakages. A solution to such a problem is to set up a monitoring system which keeps on monitoring the leakage of any kind of flammable gases and protects the consumer from such accidents. The present paper provides a solution to prevent such accidents by not only monitoring the system but by also switching off the main power and gas supplies in case of a leakage. In addition to this, it activates an alarm as well as sends a message to the user.

VIII. FUTURE ENHANCEMENT

The solution provided can be further enhanced by displaying in the LCD unit how much amount of gas is leaked. We can also incorporate the location detection feature for the gas leakage area for which SIM900 is purposely used as it comes with added feature of web interfacing by using some extra codes in the microcontroller programming.

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