A WSN-Based Electronic Nose for Gas Leakage Detection System in Thermal Power Station

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Abstract: *Gas leakage can cause major incidents resulting in both human injuries and financial losses. To avoid such situations, a considerable amount of effort has been devoted to the development of reliable techniques for detecting gas leakage. The existing system available for thermal power station environment has drawback in poor detection of all kind of gases with in the stipulated time. The primary goal of this work is to design arduino based electronic nose for detecting hazardous gases using advanced sensor. In order to alert the supervisor of the gas plants about the gas leakage, an SMS notification will be sent. This paper holds even more relevance in the current pandemic situation because industries are facing paucity of workmen due to social distancing rules and a system would enable them to aware of any mishaps at the industrial site. This gas leakage detection system developed will be an alternate for the presently available system that are set in industrial areas. This system can also be used in houses and at work places too. The experiment results shows that the instance response and accurate detection of hazardous gases of the proposed system compared to the existing methods.*

Keywords— Leakage detection, WSN, Gas sensor, electronic nose

1.INTRODUCTION

This technology is growing day by day. With this technology, we have not succeeded to take care of our environment in which we live. Thus, we have polluted the surrounding, thereby decreasing the quality of the environment we live. Even though there are many types of pollution such as water, soil and air pollution, out of these air pollution acts as the major problem as the other can be detected visually and by taste, but the toxic air cannot be detected as it can be colorless and tasteless. These gases have to be monitored such that rise in the normal level of them could be detected and suitable safety measures can be taken. But the present systems available are not so handy, are expensive and hard to implement. So, an embedded system is designed using NodeMCU Microcontroller, for the purpose of sensing toxic gas leakage, which in turn neglects the dangers that have adverse effects on human lives. The toxic gases like carbon monoxide, methane and LPG are mentioned here. The system is reasonable and can be easily implemented in the chemical factories and in localities which is surrounded by the chemical industries or plants. The system also has the provision to provide real-time monitoring of concentration of the gases which is present in the atmosphere. As this method is automatic the information can be given rapidly. Electronic-nose is a system that uses a pattern of responses from an array of gas sensors to identify and examine gas samples. Electronic nose usually includes sample delivery system, detection system and computing system. The sampling system enables generation of unstable compounds and enters into the head space of the detection system. Detection system holds sensors and when it is contrasted with volatile compounds develop a change in electrical properties and it is recorded by changing into corresponding digital values. Computing system works to combine response of all sensors and it performs global fingerprint analysis and provides results and representations which can be easily interpreted. This project plans to deal with electronic-nose that detects harmful airborne chemicals. For example, electronic-nose is used in detection of dangerous gases like ammonia. If ammonia gets leaked, it effectively absorbs the same and gives an alert about the same.

2. LITERATURE SURVEY

This paper [1] provides the design method on both software and hardware. The functionality of the system is divided into three steps. In the initial step, the gas leakage is detected by the gas sensor MQ-6. This detects the gas leakage and gives the signal to the help of ADC. After that in second step microcontroller receive the signal, send by gas sensor. It sends activation signal to other external devices attached with it. Such as two stepper motor IC, buzzer, LCD, GSM module and RF link. In the last step, many tasks have been performed such as buzzer activates simultaneously message display on liquid crystal display screen, GSM module activated, which send warning message to the user. Stepper motor IC (ULN 2003A) to drives the stepper motor attached it, as a result main power and gas supplies turn off. At the end, when the gas leakage is successfully stopped then with the help of reset button the whole system reached to the initial stage.

[2] In this paper a system which essentially detects LPG gas leakage and emphasis by measure such as SMS, buzzer sound, LED blink. This prototype turns out to be price effective and has a high degree of accuracy. In this system 8051 microcontroller is a host. It is connected to the five other modules:MQ6 gas sensor, GSM module, exhaust fan, buzzer, LED pins on one side of the gas sensor are connected to the power supply. On the other side one of the pins is connected to the analog input of the microcontroller and the other two pins are connected to the ground. The remaining modules are connected to the output pins of the microcontroller.

In this paper [3] the system gives real time detective of potential risk area, collect the data leak accident and locate leakage point. This system having protection circuitry consists of exhaust fan and an Liquified petroleum gasses like Liquified Petroleum Gas and propane were sensed and displayed each and every second in Liquid Crystal Display. If these gases exceed normal level, then alarm is generated immediately. In this system MQ-6 gas sensor used to sense poisonous gas and has high sensitivity to LPG and also response to natural gas. This work modifies the existing safety model installed in industries. It offers quick response time and accurate detection.

This paper [4] deals with the detection, monitoring and control system of LPG leakage. Using relay DC motor, the stove knob is automatically controlled. Along with safety measures the system has additional advantage of automatic rebooking of cylinder when the level of gas goes below the normal weight of cylinder. LPG consists of mixture of propane and butane which is highly flammable chemical. It is odorless gas due to which Ethanethiol is added as powerful odorant, so that leakage can be easily detected. There are other international standards like EN589, amyl mercaptan and tetrahydrothiophene which are which are most commonly used as odorants.

The main focus of this paper [5] is an embedded system is designed using PIC 16F877 Microcontroller, for the purpose of detection of hazardous gas leakage, which in turn avoids the endangering of human lives. The hazardous gas like LPG and propane were considered here. If these hazardous gases level exceeds normal level that is LPG>1000ppm> or Propane>10000ppm then an alarm is generated immediately, and a SMS is sent to the authorized user an alert message, which leads to faster diffusion of emergency situation.

In this paper [6] to identify the state-of-the-art in leak detection and localization methods. Additionally, they evaluate the capabilities of these techniques in order to identify the advantages and disadvantages of using each leak detection solution. Distinguish two main categories of method: Hardware based methods and software-based methods. These two categories are sometimes mentioned as externally or internally. Although not often presented in recent literature as a separate category, there is a third class that covers the so-called biological methods.

The main function of this paper [7] is to detect changes in concentration of LPG gas, then PIC controller Immediately activates Buzzer. MQ-6 gas sensor is used to sense the poisonous gas and high sensitivity to LPG and also response to Natural Gas. It is portable gas detector which has long life with low cost. When the power supply of 5V to MQ-6-LPG gas sensor, heat is produced at the coil H in-order to sense the presence of gas. The resistor (RS) is used to reduce the high voltage flowing into the sensor. The sensing resistance of this resistor is 10kohm-60kohm. The sensor detects the concentration of gas within the range of 100000-200ppm.

In this paper [8], the main focus is to present such n outline that can consequently identify and remove gas spillage in defenseless premises. The gas spill sensor is such a gadget which distinguishes the gas spills at beginning levels and cautions the individuals of the same. This paper fundamentally manages the advancement of a straightforward gas spill locator at the underlying stage and after that changing this basic gadget into a most progressive gas identifier framework later on. Gas sensor have been specifically utilized which has high affectability for propane and butane. Gas leakage system consists of GSM module, which sends SMS as soon as gas leakage is detected.

The main purpose of this paper [9] is to detect the gas leakage point in the gas pipeline. A leakage detection model and the solution were proposed based on the three conservation laws in hydromechanics and the state equation, which includes transient simulation model and volume balanced model. Dynamic parameters involved in the model such as pressure, flow and temperature can be acquired through SCADA system. By analyzing the factors influencing leakage position, that leakage and outlet pressure are more important parameters compared to the coefficient of frictional resistance and pipeline diameter. The more leakage increases, the closer leakage point approaches pipeline outlet. Leakage location is closer to outlet when pipeline outlet pressure becomes bigger. Experiments were also carried out according to leakage percentage.

This paper deals with the [10] detection, monitoring and control system of LPG leakage. Using relay DC motor, the stove knob is automatically controlled. Along with safety measures the system has additional advantage of automatic rebooking of cylinder when the level of gas goes below the normal weight of cylinder. In the detection system the MQ6 gas sensor is used which sensible to LPG, isobutane and propane gases. This sensor sends a signal to the microcontroller when gas is being leaked. An alert message is sent through the GSM to the user and a buzzer alarm is activated in the room. This alarm produces huge sound which drops down the attention of user and neighbors in current leak/fire accidents. These alert messages will be displayed on LCD. Simultaneously, LPG regulator fitted to the cylinder is automatically turned off using a relayed DC motor to avoid more leakage from cylinder.

3. EXISTING METHOD

This paper provides the design approach on both software and hardware of the existing gas leakage detection systems. The functionality of the systems is divided into three

steps. In the initial step, the gas leakage is detected by the gas sensor MQ-6, which is used to detect gas leakage in existing method. This detects the gas leakage and gives the signal to the help of ADC. After that in second step microcontroller receive the signal, send by gas sensor. It sends activation signal to other external devices attached with it. Such as two stepper motor IC, buzzer, LCD, GSM module and RF link. In the last step, many tasks have been performed such as buzzer activates simultaneously message display on liquid crystal display screen, GSM module activated, which send warning message to the user. Stepper motor IC (ULN 2003A) to drives the stepper motor attached it, as a result main power and gas supplies turn off. At the end, when the gas leakage is successfully stopped then with the help of reset button the whole system reached to the initial stage.

Microcontroller (AT89C51), GSM Module, ULN 2003A Motor Driver IC, MQ-6, RF (Radio Frequency) Link, Alarm Unit, Liqui Crystal Display (LCD), Stepper Motor, Main Power Supply, Decoder HT12D, Encoder HT12E CNG (compressed natural gas), GSM Receiver.

MQ6 is a semiconductor type gas sensor which detects the gas leakage. The sensitive material of MQ-6 is tin dioxide. It has very low conductivity in clean air. This sensor not only has sensitivity to propane and butane but also to other natural gases, low sensitivity to cigarette smoke and alcohol. GSM module is used to send an SMS to the user cell phone. When the gas leakage is detected by the gas sensor, microcontroller sends a signal to GSM module, in which one of the tasks is send to the text SMS.

Two stepper motor has been used; both are connected to the stepper motor driver IC (ULN 2003A). A 12V external DC supply has been given to the stepper motor. The main purpose of the stepper motor is to turn off the main power supply.

RF transmission system composed of Amplitude Shift Keying (ASK) with the transmitter/receiver (Tx/Rx) pair, operating at frequency of 434 MHz Transmitter modules takes serial input and transmits it through RF. Receiver module receives signals which are transmitted by transmitter module placed away from it.

This system has been tested by taking a small amount of LPG gas near to the sensor. MQ-6 gas sensor detects the LPG gas and sends a signal to the microcontroller. After that microcontroller send an active signal to the other externally connected devices. As a result, a buzzer rings and a message is display on LCD screen. Simultaneously main power and gas supply turns off with the help of stepper motor and GSM module send an SMS. When reset button is initial position. But these systems are not so handy, are expensive and hard to implement.

4. PROPOSED METHOD

This project is intended to employ an Internet of Things (IoT) based system to avoid accidents in industries and monitoring the pollution with the utilization of extended gas sensors. An advanced controller Arduino UNO r3 is planned to be used in this project. The electronic nose was developed in order to mimic human olfaction whose functions have non separate mechanism, i.e., the smell or flavor is perceived as a global finger print. Essentially the instrument consists of sensor array, pattern reorganization modules, and headspace sampling to generate a signal pattern that is used to characterize the smell. The electronic nose consists of three major parts that are detecting system, computing system, sample delivery system shown in Fig 1.

4.1 Components of System Architecture

Electronic nose(E-Nose), MQ7 gas sensor, MQ135 gas sensor, MQ4 gas sensor, MQ2 gas sensor, Buzzer, Wi-Fi module, LCD display.

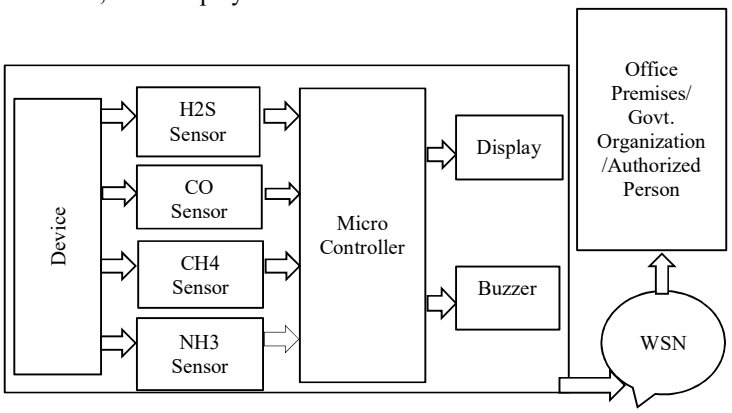

Fig 1. Block diagram of WSN-Based Gas Leakage Detection System

Node MCU

The NodeMCU (Node Micro Controller Unit) is an opensource software and hardware development environment that is built around a very inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains all crucial elements of the modern computer: CPU, RAM, networking (Wi-Fi), and even a modern operating system and SDK. That makes it an excellent choice for IoT projects of all kinds. The node MCU current consumption is ~170mA.

MQ7

MQ-7 Semiconductor Sensor for Combustible Gas Sensitive material of MQ-7 gas sensor is SnO2, which with lower conductivity in clean air. It makes detection by method of cycle high and low temperature, and detect CO when low temperature (heated by 1.5V). The sensors conductivity is higher along with the gas concentration rising. When high temperature (heated by 5.0V), it cleans the other gases adsorbed under low temperature. Please use simple electro circuit, convert change of conductivity to correspond output signal of gas concentration.

MQ-7 gas sensor has high sensitivity to Carbon Monoxide. The sensor could be used to detect different gases contains CO, it is with low cost and suitable for different

application. This sensor has fast response and wide detection range.

MQ-135

The MQ-135 Gas sensors are used in air quality control equipment's and are suitable for detecting or measuring of NH3, NOx, Alcohol, Benzene, Smoke, CO2. The MQ-135 sensor module comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. If you need to measure the gases in PPM the analog pin needs to be used. The analog pin is TTL driven and works on 5V and so can be used with most common microcontrollers.

MQ-2

The MQ 2 gas sensor is used to detector monitor the concentration and/or presence of combustible gases in the air. It features a simple drive circuit, stable, long life, fast response, anda wide scope.[1] Due to its high sensitivity to hydrogen, LPG (liquid petroleum gas), methane, carbon monoxide, alcohol, smoke, and propane; this sensor is traditionally used to help detect gas leaks in many family and industrial practices. This walkthrough will describe how the MQ 2sensor functions and how to set up the sensor for use on a Raspberry Pi.

MQ4

The MQ4 methane gas sensor is extremely used for detecting gas leakage at home or in industries like Methane (CH4) & CNG Gas. Its detection range is 300~10000ppm.an application of this sensor is domestic gas leakage alarm, Nature gas detection gas sensor/ Semiconductor gas sensor. This gas sensor is highly responsive in very little time, so based on the sensitivity requirements; it can be adjusted through a potentiometer. This is an analog output sensor, used like a CNG (compressed natural gas) sensor within the series of MQ sensors.

So, this sensor is suitable for detecting the concentration of natural gas like methane within the air. For this sensor, if the gas concentration increases then the output voltage will be increased. This sensor works with 5V DC and draws 750 Wm around.

Buzzer

A buzzer is or beeper is a signaling device, commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. It operated from stepped-down AC line voltage at 50 or 60 cycles. Often these units were anchored to a wall or ceiling and used the ceiling or wall as a sounding board. Another implementation with some AC-connected devices was to implement a circuit to make the AC current into a noise loud enough to drive a loudspeaker and hook this circuit up to a cheap 8-ohm speaker.

LCD

Here in this project, we used 16×2 LCD. In LCD it has 16 Columns and 2 Rows. There are a lot of combinations available like, 8×1, 8×2, 10×2, 16×1, etc. but the most of the application and projects used one is the 16×2 LCD. So, it will have totally a (16×2=32) 32 characters and each character will be made of 5×8 Pixel Dots. A Single character with all its Pixels is shown in the below picture.

4.2 METHODOLOGY

This system uses limited gas sensors and limited radiation sensor. These sensors will collect the data and transmit using a Wi-Fi module to IoT module. IoT module is used to transmit and receive in high data range. A test is carried out to detect harmful gases and radiation leakage which needs a quick response. An alarm is produced instantly when the level of the gases and/or radiation goes above the normal level. The poisonous gas and radiation monitoring system will realize the control of the poisonous gas and radiation. It improves the ability of the automation and the intelligence of poisonous gas and radiation detection monitoring. The data collected by the sensor will be processed and stored in the remote server, which can be used for further processing.

5. RESULT AND DISCUSSION

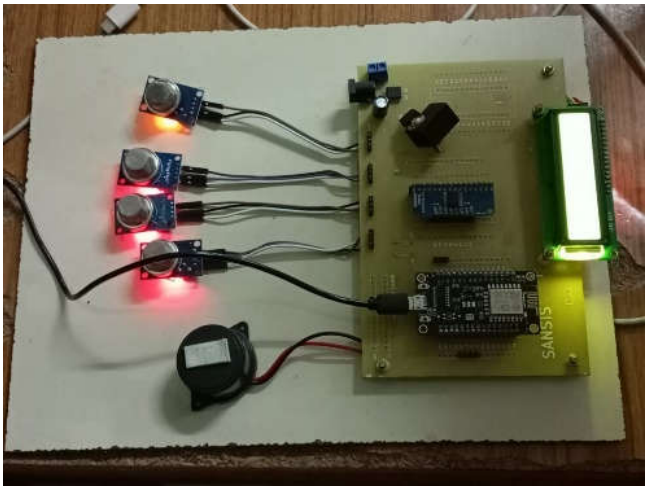

Fig 2. Implementation of Gas Leakage detection system

This model has been tried by using sanitizer, thinner and perfume. MQ7 gas sensor distinguishes the CO gas, MQ2

gas sensor distinguishes the CO methane and Hydrogen gases, MQ4 gas sensor distinguishes the methane gas and MQ135 senses the ammonia. In first test sanitizer has been used for test sample, its result CO gas only reached high level ppm that is 473. Balance gases are not detected high level. In this system only alert a message and alarm sound when it reaches 900 ppm level of gas. This gas leakage detection is shown in the table 1.

Table.1: Gas Leakage Detection of simulated environment

Time	CH4	NH3	CO	H2S
21:39:32	0	377	466	153
21:39:31	0	377	473	153
21:39:30	1	378	423	154
21:39:29	1	378	387	156
21:39:28	0	377	384	158
21:39:27	0	377	343	160
21:39:26	1	378	319	158
21:39:25	1	378	303	159

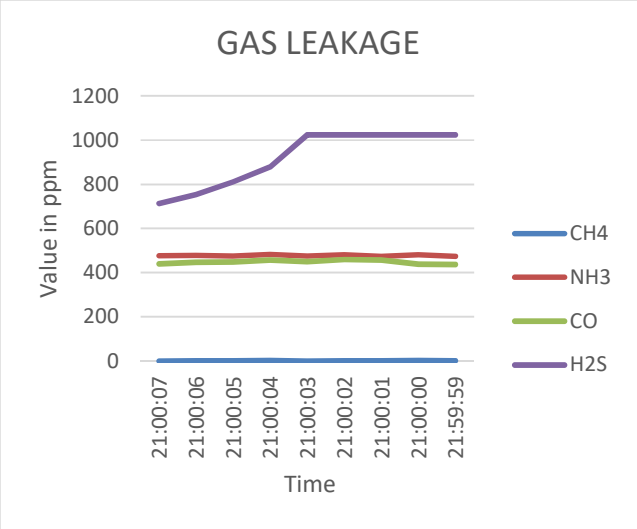

Fig 3. Comparison of Gas Leakage detection with respect to Time (second) for table1

In second test shown in table 2, this model has been tried by using thinner and perfume which contains gases like H2S, CO. MQ-2 gas sensor distinguishes the Hydrogen gas, its level is cross over 900 ppm and thereafter a signal will be send to the microcontroller. Microcontroller send an active signal to other remotely associated device. Therefore, buzzer sounds and a message is shown on 16x2 LCD screen. At the same time alert message like: TOXIC GAS DETECTED!!!!!! will send to the authorized person. And also, we have tested this model to thermal power environment by using a small measure of gas. The proposed gas leakage detector demonstrated a great performance and execution results of the gas leakage for the time of testing. After many observations of the outcome the result was approximately same in many cases.

Table 2: Gas leakage detection of real-time environment

Time	CH4	NH3	CO	H2S
21:00:07	0	476	439	714
21:00:06	1	478	447	753
21:00:05	1	475	448	810
21:00:04	2	482	457	878
21:00:03	0	475	449	1024
21:00:02	1	481	460	1024
21:00:01	1	474	457	1024
21:00:00	2	480	438	1024
21:59:59	1	474	437	1024

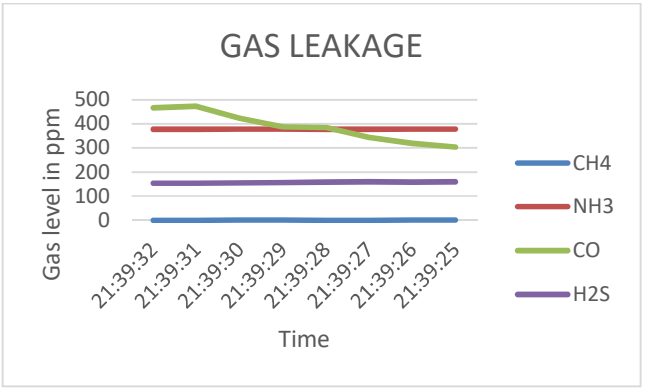

Fig 4. Comparison of gas leakage detection with respect to time for table 2

7.CONCLUSION AND FUTUREWORK

Gas leakage is a major problem with industrial sector, residential premises and mainly thermal power station. A wide variety of leak detecting techniques is available for gas pipelines. Leak detection methods in each category share some advantages and also some disadvantages. For example, all external techniques which involve detection done from outside the pipeline by visual observation or portable detectors are able to detect very small leaks and the leak location, but the detection time is very long. In our project system detected a leak as small as 0.3% of the nominal gas flow. The leakage is detected with the help of MQ-4, MQ-2and MQ-7 gas sensors. Sensor sends a signal to microcontroller. In the next step microcontroller sends an active signal to other externally connected devices. A quick response rate is provided by this system. With the help of this system the critical situations can be solved quickly over the

manual methods which require large amount of time. It has more advantageous function than the existing system thus real-time system.

This monitoring and detection system is proposed mainly to meet the safety standards and to avoid fire accidents because of leakage. This monitoring system can be further enhanced by using Bluetooth and also Display the high alert SMS when high temperature is reached.

REFERENCES

[1] V. Ramya, B. Palaniappan "Embedded system for Hazardous Gas detection and Alerting" International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.3, May 2012

[2] Selvapriya, Sathya Prabha, Abdulrahim, Aarthi K "LPG Leakage Monitoring and Multilevel Alerting System", ISSN: 2277-9655.

[3] Mr. Sagar Shinde, Mr.S.B. Patil, Dr.A.J.Patil "Development of Movable Gas Tanker Leakage Detection Using Wireless Sensor Network Based on Embedded System " ISSN: 2248-9622 Vol. 2, Issue 6, November- December 2012, pp.1180-1183.

[4] Ashish Shrivastava, RatneshPrabhaker, Rajeev Kumar and Rahul Verma "GSM Based Gas Leakage Detection System" e-ISSN: 2320-8163, Volume 1, Issue 2 (may-June 2013), PP. 42-45.

[5] T. Soundarya, J. V. Anchitaalagammai "Control and Monitoring System for Liquefied Petroleum Gas (LPG) Detection" Volume 3, Special Issue 3, March 2014 International Conference on Innovations in Engineering and Technology (ICIET'14).

[6] Zhao Yang, Ming liang Liu, Min Shao, Yingjie Ji "Research on Leakage Detection and Analysis of Leakage Point in the Gas Pipeline System" Open Journal of Safety Science and Technology, 2011, 1, 94-100 doi:10.4236/ojsst.2011.13010 Published Online December 2011.

[7] V. Ramya and B. Palaniappan, "Embedded system for Hazardous gas detection Alerting," in Proc of International Journal of Distributed and parallel system (IJDPS), vol. 3, no. 3, May 2012.

[8] Z. Yang, Z. Xiong and M. Shao, "A New Method of Leak Location for the Natural Gas Pipeline Based on Wavelet Analysis," Energy, Vol. 35, No. 9, 2010, pp. 3814-3820. doi: 10.1016/j.energy.2010.05.034

[9] Sunitha, Sushmita. D," Embedded Control System for LPG Leak Detection and Prevention "ICCCE, 2012 ISBN 978-14675-2248-9

[10] Ding Chengjun, Liu Ximao, Duan ping, "Development on Gas Leak Detection and ISR Journals and Publications Location System Based on Wireless Sensor Networks" Measuring technology.