International Journal of Engineering Sciences & Emerging Technologies, Mar. 2016.
ISSN: 22316604 Volume 8, Issue 5, pp: 213-221 ©IJESET

DEVELOPMENT OF WIRELESS GAS SENSING SYSTEM FOR HOME SAFETY

T.H.Mujawar, M.S.Kasbe, S.S.Mule and L.P.Deshmukh
Department of Electronics Science, Solapur University, Solapur, M.S. India

ABSTRACT

Present work is based on the development of a system for LPG gas leakage detection. To develop such a hazardous gas leakage detection system, the wireless sensor network system is the only solution today and is a novel class of computing and made up of a large amount of inexpensive sensor nodes deployed in a monitored region. The sensor nodes were developed using an arduino microcontroller. The deployment of the WSN is done using various interconnected nodes across the region. Each node consists of a low cost Arduino Microcontroller, XBee radio communication module and sensors which measure data substantial to detect a disaster. The nodes were established by deploying the star topology and implemented to monitor the room where the gas was leaking. The system was tested using LPG and the buzzer was activated as a result of change in concentration. The results are displayed on the front panel of LabVIEW.

KEYWORDS: *LPG, Arduino, XBee, Wireless Sensor Network, Star topology, buzzer.*

I. INTRODUCTION

In human's daily life, environment has the most significant impact on their health issues; the environment and industry air quality issues are critical concerns to increase the awareness and responsibility regarding the threat on the environment towards public and workers health.

Jan et al [1] has applied wireless sensor network for carbon monoxide detection and autonomous counter measurement system for a mill. The CO sensor module is connected to a TelosB node and interfaced with ZigBee wireless connectivity to the central controller. The system comprised of the central controller, a high-end PC, connected to the TelosB wireless sensor module via USB and to the actuator circuit through RS232. Somov et al [2] developed a wireless sensor network system for smart gas (CO) monitoring. The recent addition in wireless gas sensing system is a GPS based WSN systems [3]. Hence, entire working of a Wireless Sensor Network is dependent on the sensor nodes. Present work is based on the development of WSN for LPG gas leakage detection and the sensor nodes were developed using an arduino microcontroller. The Wireless Sensor Nodes, by designing both hardware and firmware and calibration are ready for establishment. Moreover, the co-ordinator node was also designed and made available for the system. The system was implemented with a star network topology consisting of five nodes. Four nodes were used for the detection of gas leakage and one node was used as a co-ordinator node to alert the users by sending SMS on their mobile phone. The data acquired from rest of the nodes (except the co-ordinator) were transmitted wirelessly using ZigBee protocol to the co-ordinator node and was kept on the web server for accessing the data through internet from anywhere. The PCB design and its layouts for WSN nodes are shown in fig.1.1 (a, b).

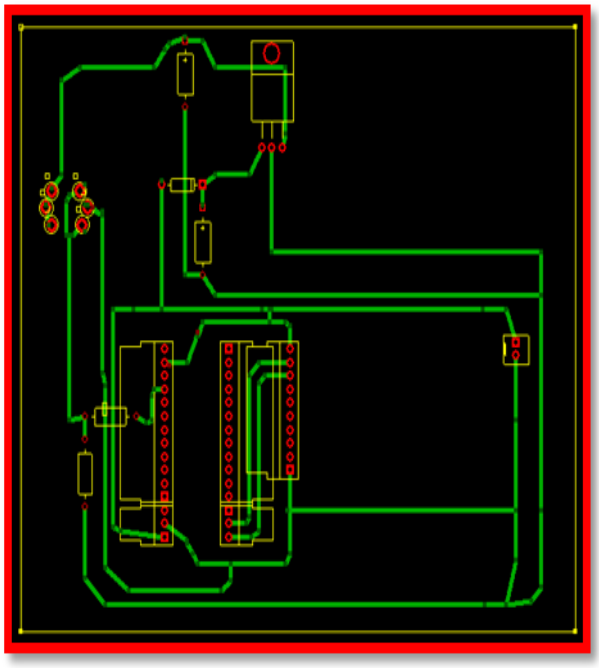

Fig.1.1. a) PCB layout of a wireless gas sensing system.

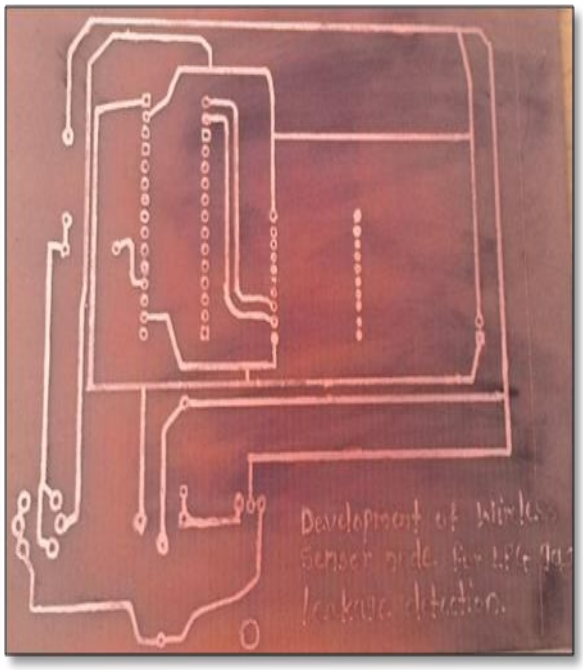

Fig. 1.1.b) PCB layout of a wireless gas sensing system.

II. METHODOLOGY

Our system focuses more on the detection and monitoring of the LPG gas leakage. The microcontroller will continuously receive the data from the sensor in an analog packet of data. The microcontroller will process the data and convert it into ppm. The converted data will be displayed on the front panel of the LabVIEW [4]. Whenever the reading of the sensors exceeds the limit set, it will automatically send an SMS alert wirelessly using GSM network to the numbers (mobile) as being set on the source code. The methodology shows the step by step taken in order to complete the gas sensing and monitoring by a wireless gas sensing system. It also includes the planning, the development in the design and the continuous monitoring of the system.

2.1 The calibration of wireless sensor node

Calibration is an essential process to be undertaken for electronic instrumentation. It is a simple process that consists of reading the standard and test instruments simultaneously when the input quantity is held constant at several values over the range of test instrument. While calibrating, it is customary to take readings both in ascending and descending orders. Hence, to represent the values of the parameters one should calibrate the system precisely, so that the exact values could be outputted from the system under investigation. Each wireless sensor node is designed for monitoring of LPG leakage detection of wireless gas sensing system. The process of calibration is discussed through the following procedure.

2.1.1 Calibration of wireless senor node for mq-2 gas sensor

The calibration of Wireless Sensor Node is carried out to find out a relationship between output voltage (sensor) and gas concentration in ppm. For precise calibration, the LPG gas of different volumes is applied to the sensor. This is done using 250cc air tight gas chamber [5-6]. The LPG was inserted in it using a standard medical syringe.

Fig. 1.2. Experimental arrangement of Wireless Sensor Node for LPG leakage measurement.

The relationship between gas concentration and sensors output voltage can be calculated by using following formula.

$$\text{Gas concentration} = \frac{10^6}{\text{Volume of gas chamber (250 cc)}} \text{ x Volume of gas inserted}$$

The data obtained using this formula is tabulated as follows.

Gas concentration (ppm)	sensor output voltage (volt)
0	0.3
50	0.6
100	0.8
150	0.95
200	1.05
250	1.1
300	1.2
350	1.28
400	1.33
450	1.45
500	1.51
550	1.58
600	1.72
650	1.91
700	2.3
750	3.0
800	3.5
850	4.1
900	4.2
950	4.35
1000	4.4
1050	4.5
2000	4.5
2050	4.51

A graph is plotted as gas concentration (ppm) vs sensor output voltage (fig.1.3).

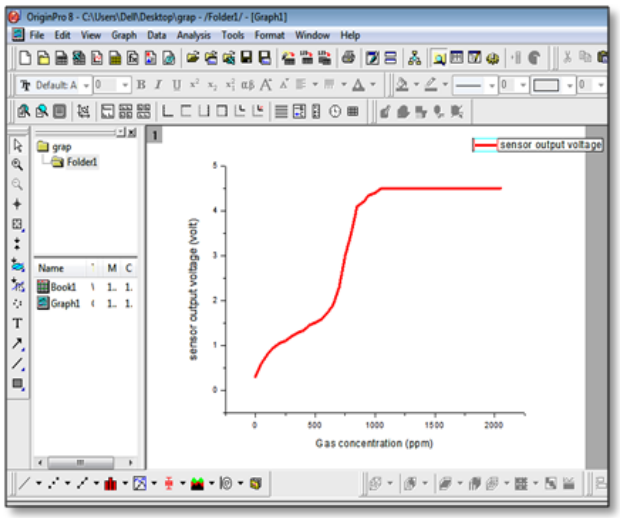

Fig. 1.3. Plot of gas concentration vs sensor output voltage.

III. HARDWARE IMPLEMENTATION OF WSN NODES

The LPG which is a highly flammable mixture of hydrocarbon gases, used as a fuel in many applications like homes, hostel, industries, automobiles, vehicles because of its desirable properties that include high calorific value, which produce the less smoke and soot and does not cause much harm to the environment. Natural gas is another widely used fuel in homes. Both gases burn to produce clean energy; however there is a serious problem associated with their leakage in the surroundings. The gases being heavier than air do not disperse easily and may lead to suffocation when inhaled. Also gas leakage into the air may lead to explosion. These days explosion of LPG gas has been increased and to avoid this, there is a need for the system to detect and also to prevent leakage of LPG. Gas leak detection is the process of identifying potentially hazardous gas leaks by means of various sensors. These sensors usually employ an audible alarm to alert people and SMS alert to the users when a dangerous gas leaks.

The LPG which is a highly flammable mixture of hydrocarbon gases, used as a fuel in many applications like homes, hostel, industries, automobiles, vehicles because of its desirable properties that include high calorific value, which produce the less smoke and soot and does not cause much harm to the environment. Natural gas is another widely used fuel in homes. Both gases burn to produce clean energy; however there is a serious problem associated with their leakage in the surroundings. The gases being heavier than air do not disperse easily and may lead to suffocation when inhaled. Also gas leakage into the air may lead to explosion. These days explosion of LPG gas has been increased and to avoid this, there is a need for the system to detect and also to prevent leakage of LPG. Gas leak detection is the process of identifying potentially hazardous gas leaks by means of various sensors. These sensors usually employ an audible alarm to alert people and SMS alert to the users when a dangerous gas leaks.Fig.1.4 depicts the circuit schematic of a wireless sensor node. To design a wireless sensor node for LPG gas leakage measurement, MQ-2 gas sensor is employed. Sensitive material of MQ-2 gas sensor is SnO_2, which has lower conductivity in clean air. We have calibrated the system for 1000 ppm H_2 and LPG concentrations in air and used a load resistance of about 20KΩ. As the conductivity increases, and resistance of sensor changes with the concentration of combustible gases, a simple electronic circuit can be used to convert the change in resistance to change in concentration of the combustible gases (fig.1.5).

Model No.	MQ-2
Sensor Type	Semiconductor
Detection Gas	Combustible and smoke
Concentration range	300-10000 ppm
Load Resistance	Adjustable
Sensing Resistance	2 KΩ - 20 KΩ

The typical characteristics of a MQ-2 sensor are as follows:

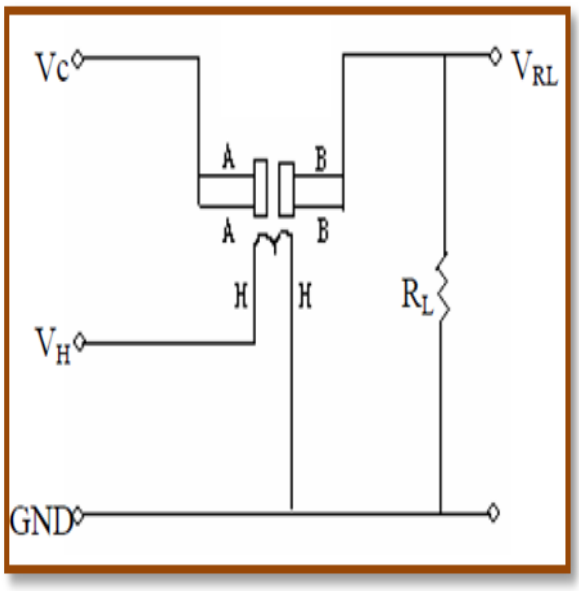

Fig.1.5. An electronic circuit to convert the change in resistance to change in gas concentration**.**

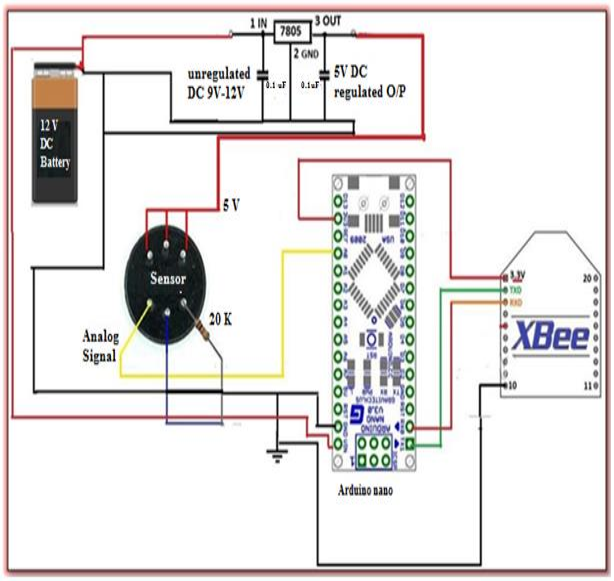

Fig.1.4. The circuit schematic of a wireless sensor node.

3.1 Hardware implementation of co-ordinator node

The circuit schematic of a co-ordinator node is shown in fig. 1.6. The hardware of the co-ordinator reveals the interfacing of it to the personal computer. The wireless sensor networks allow faster deployment and installation of various types of sensor nodes because many of these networks provide self-organizing, self-configuring, self-diagnosing and self-healing capabilities to the sensor nodes [7]. It also offers mobility and flexibility in connectivity which promotes network expansion when needed.

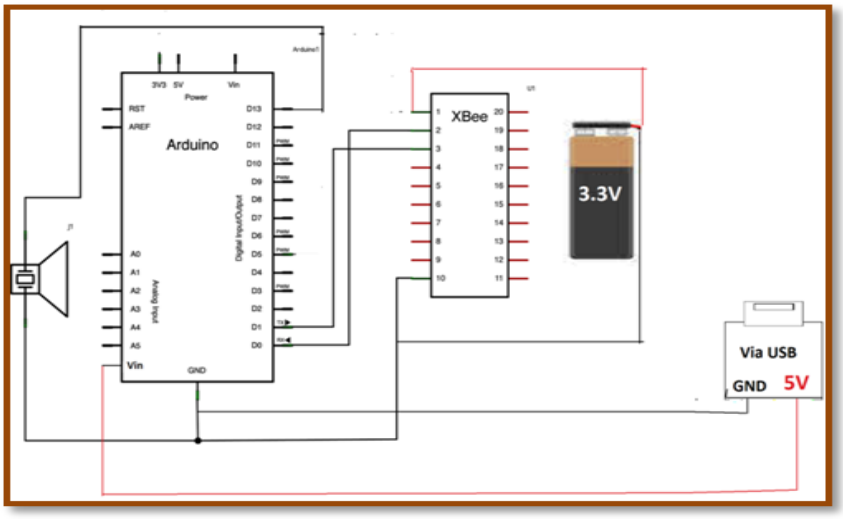

Fig.1.6. The circuit schematic of a co-ordinator node.

Moreover, an arduino UNO and nano microcontrollers can be employed to build WSN nodes. The RF module XBee was used in both sensor and co-ordinator nodes for secured data transmission and reception. The leakage detection of LP gas can be made alert to the user by activating the buzzer.

IV. STAR TOPOLOGY IMPLEMENTATION

The ZigBee was used in star topology that makes all the devices attached to a central control unit (fig.1.7). The range of ZigBee network was increased using multiple routers. The use of ZigBee module has complexity in identifying the nodes connection however, in case of any breakdown; it finds an alternate route to execute the command without affecting itself.

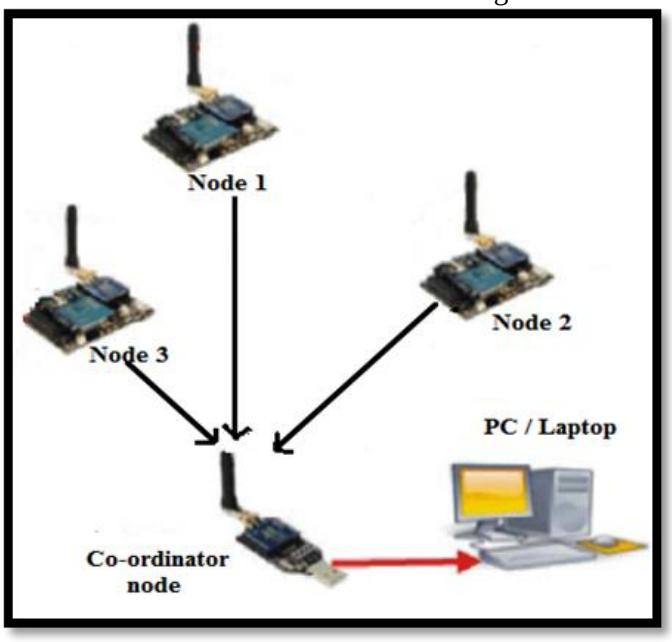

Fig. 1.7. Star topology implementation of ZigBee.

V. ALERT SYSTEMS

Liquid petroleum gas (LPG) is a mixture of propane and butane which is highly flammable chemical. It is versatile in nature and hence used for many applications such as in heating, domestic and industrial purposes and automobile fuels. Another widely used fuel in the home is the natural gas. Leakage of these gases in the air is the serious problem. The gases being heavier than air do not disperse easily and it may lead to suffocation when inhaled [8]. The gas leakage in the air causes explosion. The natural gas and LPG burn produce clean energy but there is a serious problem about their leakage. In recent years due to explosion of LPG, numbers of accidents have been increased. Hence, Gas leakage detection and its alerting are equally important. The leakage of gas alerts in many ways. The proposed system alerts the leakage of gas by buzzer.

5.1 Buzzer

An alarm is connected to a digital pin. Alarm indication alerts the peoples by providing the long beep. Instead of leaving voice alert, long beep has higher frequency range that travels a long distance. The buzzer is connected to arduino pin 13 as shown in fig. 1.8.

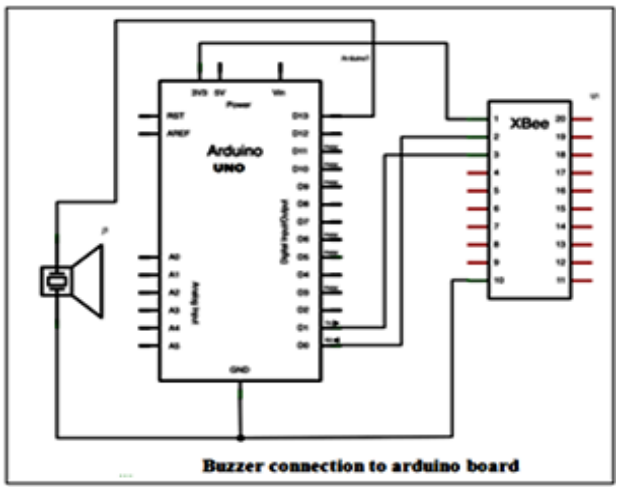

Fig. 1.8. Buzzer connection to arduino board.

VI. RESULTS

6.1. Monitoring of the wireless gas sensing system

The LabVIEW GUI was used to monitor the leakage level of the gas concentration. The gas leakage response for wireless gas sensing system was plotted in LabVIEW for two conditions:

a) When gas leak detected in a room

The LabVIEW front panel will display the response when gas leakage is detected in the room. The threshold value given for this sensor is according to the OSHA standard. As the PPM value reaches to 400 ppm, then gas is detected in the room and is displayed on LabVIEW (fig.1.9).

b) When gas leakage in dangerous condition

When the response of the gas leakage is in dangerous condition, it is immediately displayed on the monitoring system using LabVIEW as follows. As the dangerous condition occurs, BUZZER initiates and an alert SMS is send to the users to prevent any disaster. This is shown in fig. 1.10.

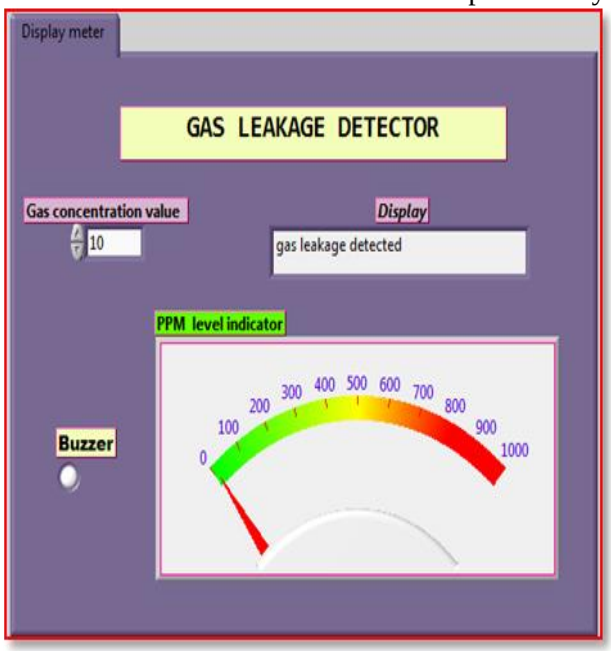

Fig. 1.9.GUI of gas leakage detection.

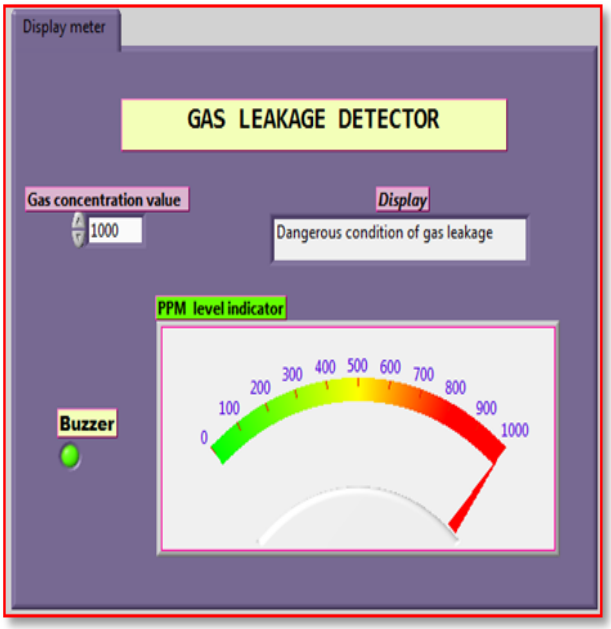

Fig. 1.10. GUI of gas leakage in dangerous condition.

VII. CONCLUSIONS

The wireless sensor networks allow faster deployment and installation of various types of sensor nodes because many of these networks provide self-organizing, self-configuring, self-diagnosing and self-healing capabilities to the sensor nodes. It also offers mobility and flexibility in connectivity which promotes network expansion when needed. Moreover, an arduino UNO and nano microcontrollers can be employed to build WSN nodes. The RF module XBee was used in both sensor and co-ordinator nodes for secured data transmission and reception. The leakage detection of LP gas can be made alert to the user by activating the buzzer. The proposed system can immediately respond to the leakage of LPG/CNG in the surrounding areas and alerts the observer. The system also can monitor the gas leakage sensitively, collect the data from a scene of the accident and therefore locate the leakage point and display it on the PC.

ACKNOWLEDGEMENTS

We are very much thankful to the School of Physical Sciences, Solapur University, Solapur for providing the facilities to carry out these types of work. Encouragement by our T.F. and SSR group (Physics) is highly acknowledged.

REFERENCES

[1]. M. F. Jan, Q. Habib and M. Irfan, (2010) "Carbon Monoxide Detection and Autonomous Countermeasure System for a Steel Mill using Wireless Sensor and Actuator Network", 6 405-409.
[2]. A. Somov, A. Baranov, A. Savkin, D. Spirjakin, A. Spirjakin, R. Passerone, (2011) "Development of Wireless Sensor Network for Combustible Gas Monitoring", Sensors and Actuators A: Physical 171 398–405.
[3]. L.Wang and Q. Xu, (2010) "GPS-Free Localization for Wireless Sensor Network", Sensors, 105899-5926.
[4]. Mujawar, T.H., Bachuwar, V.D., S.S.Suryavanshi,(), "Air pollution monitoring system in solapur city using Wireless sensor network system", Proceedings published by International Journal of Computer Applications® (IJCA),Vol. CCSN, No. 1, pp.11-15.
[5]. Mujawar, T.H., Bachuwar, V.D., Kasbe, M.S., Shaligram, A.D. and Deshmukh L.P., **"**Wireless sensor network system: gas leakage detection and monitoring", International Journal of Current Research,7(2015) pp.18445-18450.
[6]. Mujawar, T.H., Bachuwar, V.D., Kasbe, M.S., Shaligram, A.D. and Deshmukh L.P., "Development of wireless sensor network system for LPG gas leakage detection System", International Journal of Scientific & Engineering Research, 6(2015) pp 558-563.
[7]. F.Nack, "An Overview on Wireless Sensor Networks", Institute of Computer Science (ICS), Freie University, Berlin, (2010)1-8.
[8]. S.Rajitha, T.Swapna, (2012), Electronics and Communication Engineering, AP, India.

AUTHORS

Mujawar T.H is a research scholar working for Ph. D. degree in Electronics. She obtained master degree from Shivaji University, Kolhapur. Her area of research is the development of Wireless sensor network for hazardous gas detection and alert system. She has qualified both SET and NET exam. Presently, she is working as an Assistant Professor at Solapur University, Solapur (India). She published 8 research papers in the International Journal, presented 5 research papers in International conferences, 3 research papers and 4 poster presentation in National level seminars.

Kasbe M.S is obtained master degree from Shivaji University, Kolhapur. She is research scholar working for Ph. D. degree in Electronics. Her area of research is the E-nose and antenna designing. Presently, she is working as an Assistant Professor at Solapur University, Solapur (India). She published 7 research papers in the International Journal, presented 5 research papers in International conferences, 3 research papers and 3 poster presentation in National level seminars.

Mule S.S is obtained master degree from Solapur University, Solapur. Presently, He is working as an Assistant Professor at Solapur University, Solapur (India). He presented 3 research papers in National level seminars.

Deshmukh L.P is Professor and Director, School of Physical Sciences, Solapur University, Solapur. He obtained his M.Sc. degree in 1981 and Ph.D. in 1986 from Shivaji University, Kolhapur, India. His areas of interest are Sensors and Instrumentation, Thin Films and Solar Cell, Wireless Sensor Network etc. He guided 21Ph.D students and 19 M.Phil students .Also, eight research students are working under his guidance. He has published 140 research papers in national and international journals. He acted as Speaker and Session Chairman, Int. Conf. on Technological Advances of Thin Films & Surface Coatings (Thin Films - 2012), SINGAPORE, Speaker at 6th China Int. Conf. on Surface Engineering (C-ICSE-2011), Xi'an CHINA, as Speaker, Session Chairman and Co-organizer at World Int. Conf. [WCAM - 2012], Guangzhou, CHINA, as Speaker, Int. Conf. [ISEM-2015], Aberdeen, UK.