# A Wireless Sensor Network: A Dynamic System for Gas Leakage Detection

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## ABSTRACT

This paper highlights application of the wireless sensor network (WSN) technology for long-duration and large-scale gas leakage detection and it's monitoring. A WSN based microcontroller equipped with a gas sensor was used for gas leakage detection. The proposed design includes: an Arduino microcontroller, gas Sensors (MQ-2), and X-Bee. The key purpose of this dynamic system is to avoid damages and hazards associated with the gas leakage. The sensor node collects the gas leakage data thereby locating the specific area of the sensor node. The collected information was further sent to the monitoring section or server to update the data. A specific Lab VIEW programme was created to configure and supervise the operation and the sensing measurements on the network used. X-Bee sends the data information from gas sensor to the data monitoring system that is displayed on LabVIEW. The reliability and productivity of the system are key concerns and influence the design choices for the system hardware and software. We conclude with a discussion of long-term challenges for WSN technology in gas leakage detection era and outlined our future vision.

## General Terms

Methodology for gas leakage detection and monitoring System

## Keywords

Arduino, Wireless Monitoring, XBee, Sensors, LabVIEW.

## 1. INTRODUCTION

In day to day life, environment has the most significant impact pertaining to the health issues. The environment and industry air quality issues are therefore of importance to enhance the awareness and responsibilities regarding the threat on the environment towards public health. Most of the dangerous gases such as refrigerant gas and liquefied petroleum gas (LPG) is colourless and odourless compounds that are produced by incomplete combustion and need to be detected in order to inform the safety situation continuously. The detector device can detect only when there is a sufficient concentration of the leaking gas. A monitoring system that detects and displays extremely minute (ppm) gas concentration is therefore of importance wherein viewing can be made feasible in some another remote computer or GSM network or internet server [1] advantaging the users such that they can monitor and control the situation of the room or the place where leakage occurs from a safe distance.

The literature so far reported is on Wired Sensor Network (WSN) for monitoring the gas leakage detection that exhibit complexity in hardware as well as software designing. Also, the cost and power requirement for wired network is significantly high. The GSM/GPS based wireless monitoring systems were also came into existence however, these system cover less area and GUI was also not so much effective [2].

This short communication therefore, describes the design and development details of a reliable smart wireless gas sensing system consisting of the Arduino board and XBee development kit based on the IEEE 802.15.4/XBee Wireless Personal Area Network (WPAN) standards to build a low-power, low maintenance, and self-organizing WSN. Small size, low power consumption, low cost and long battery life are the benefits of using XBee.

The Arduino board (ATmega328) has the easy interface advantage with the XBee module and programming (in C) of the microcontroller can be effectively done. It has the library for interfacing with the analog or digital inputs and outputs.GUI created using LabVIEW is more efficient and exhaustive. [3]

## 2. SYSTEM ARCHITECTURE AND DISCUSSION

A block diagram of a proposed gas leakage monitoring and control system is given below.

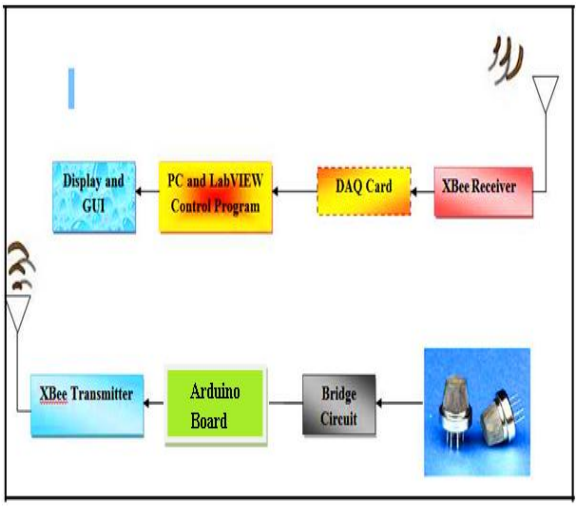



**Fig 1.System architecture of a gas leakage monitoring and controlling system**

The system comprised of sensor nodes and a communication system that allows the data to reach a server. The sensor nodes collect the data autonomously and the data network is used to pass the data to the gateway node, which then forwards it to a sensor network server.

The hardware part of the system consists of:

i) The sensing system, ii) Arduino Board and iii) XBee.

Arduino is a device that acts similar to a perfect microcontroller unit and has some special features with high performance ability. It offers an open-source electronic prototype platform with simple and flexible access and easy use of hardware and software [4]. The sensing circuit system consists of a liquefied petroleum gas (LPG) sensor, (MQ- 2) that detects the presence of a specified gas in the surrounding area [5] and XBee transfers the sensor data read from Arduino port to a computer in a wireless mode.

## 2.1 Wireless sensor node

Figure 2 shows the node prototype which is an Arduino board that serves as a sensor node. It would be better if one or two line representation of an embedded system and RF unit are added.

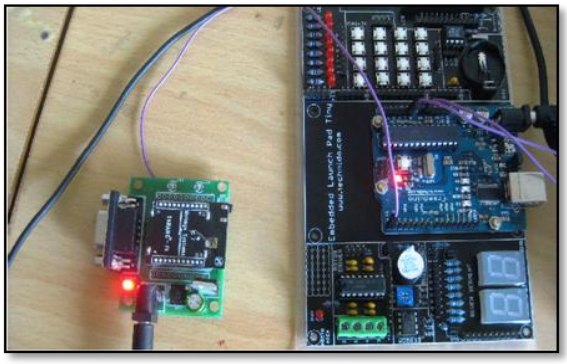


**Fig 2: Wireless sensor node.**

## 2.2 Gateway node and server

The gateway node receives the data sensed and processed by a sensor node. The architecture of this node is similar to sensor node except sensor interfacing part. The sensed data can then be sensed or received through a personal computer system that makes interface with DAQ card.

## 2.3 Gas exposure and alerting

The gas sensing sensor is a semiconductor oxide that senses a gas concentration with a corresponding change in its resistance, which then was converted into the real analog world using Whetstone's bridge. The experimental set up is shown in fig. 3.

Fig.4 shows response (volt) of a MQ-2 sensor for various gas concentrations. It is seen that the response is more or less linear for low concentration of gas, while it deviates from linearity (increasing) for higher concentration of leakage gas.

**Fig 3: Experimental setup for gas sensing.**

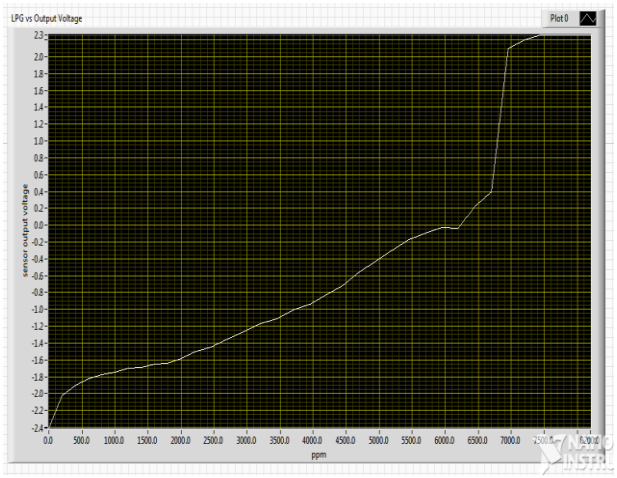



**Fig 4: Variation of voltage with gas concentration (ppm) (MQ-2 sensor wired with a Whetstones Bridge)**

## 3. PROGRAMMING TOOLS

We propose a following programming tool for detecting and sensing processes as shown in fig.5.

The flowchart of a gas sensor module is as under:

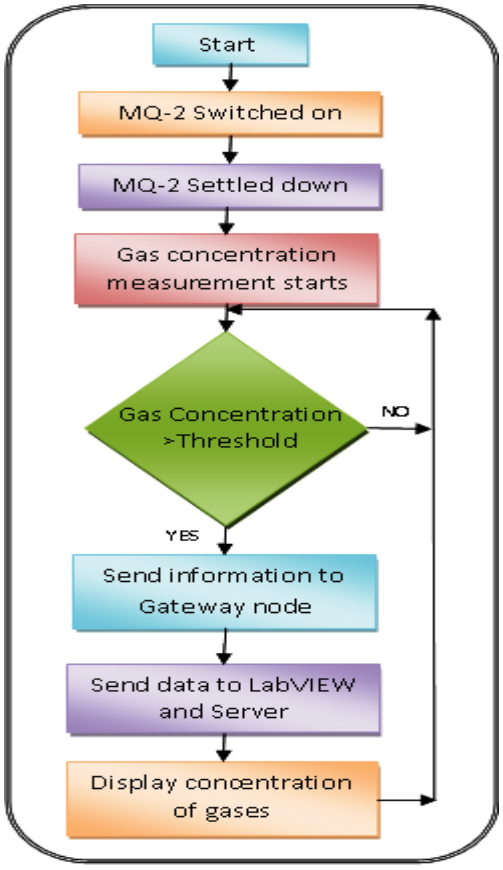
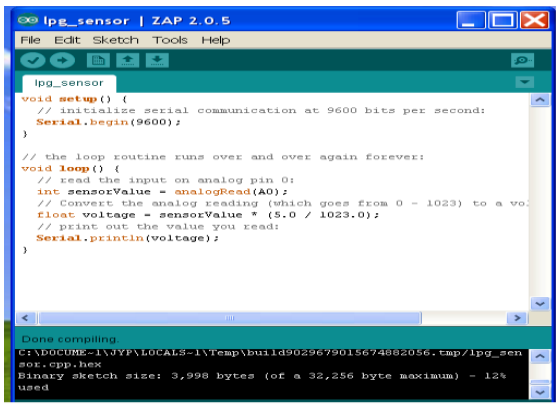



**Fig 5: Flowchart of a gas monitoring and controlling system.**

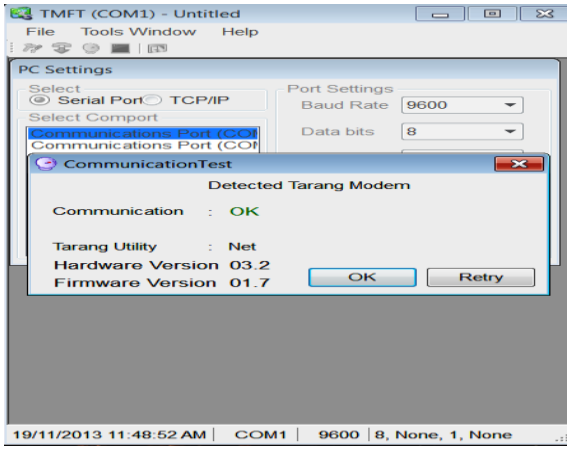
The software components are:

i) an Arduino programming ii) the XBee programming and iii) the LabVIEW design.

The Arduino software is employed to write a programme for the Arduino board microcontroller. The data from sensor to LabVIEW monitoring system and alarm system are controlled by the Arduino. In addition, Arduino also triggers the alarm system when it detects the threshold value that has been set up. Moreover, it will send the data to the computer in LabVIEW without any wire connection with the help of XBee device. This is shown in fig.6 (a). For the data transfer, XBee was programmed with TMFT 2.6 as shown in fig. 6(b).




(a)




(b)

**Fig. 6(a, b): Arduino programming.**

The LabVIEW Graphical User Interface (GUI) was used to monitor the level of a gas concentration. It offers unrivaled integration with thousands of hardware devices and provides hundreds of built-in libraries for 14 advanced analysis and data visualization – all for creating virtual instrumentation [6-7].

## 4. SIMULATION RESULTS

The proposed model of a wireless gas sensing/detecting, monitoring and controlling system with six sensor nodes is shown in fig.7. The area covered by the node is about 100 $m^2$. The resulting node deployment area and simulation area [8] are shown as below.

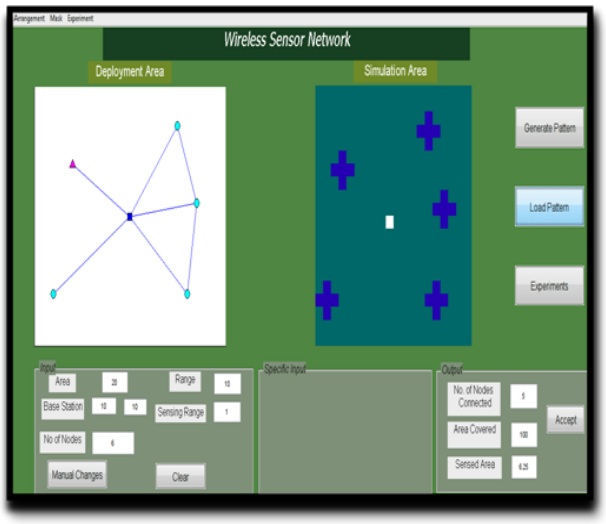



**Fig7: Simulation results of gas monitoring system.**

The LPG detection using LabVIEW can be demonstrated as below.

When the LPG gas was detected in the environment, the front panel will display the detection otherwise front panel doesn't show any detection.

As shown below yellow colour indicates no gas concentration, whereas green colour indicates gas detection, while reading of the output voltage from the gas sensor shows the value of concentration and level of dangerousness in red LED. When a person perceives the

gas leakage information in advance they can follow the safe path, accordingly preventive measurements can be deployed.

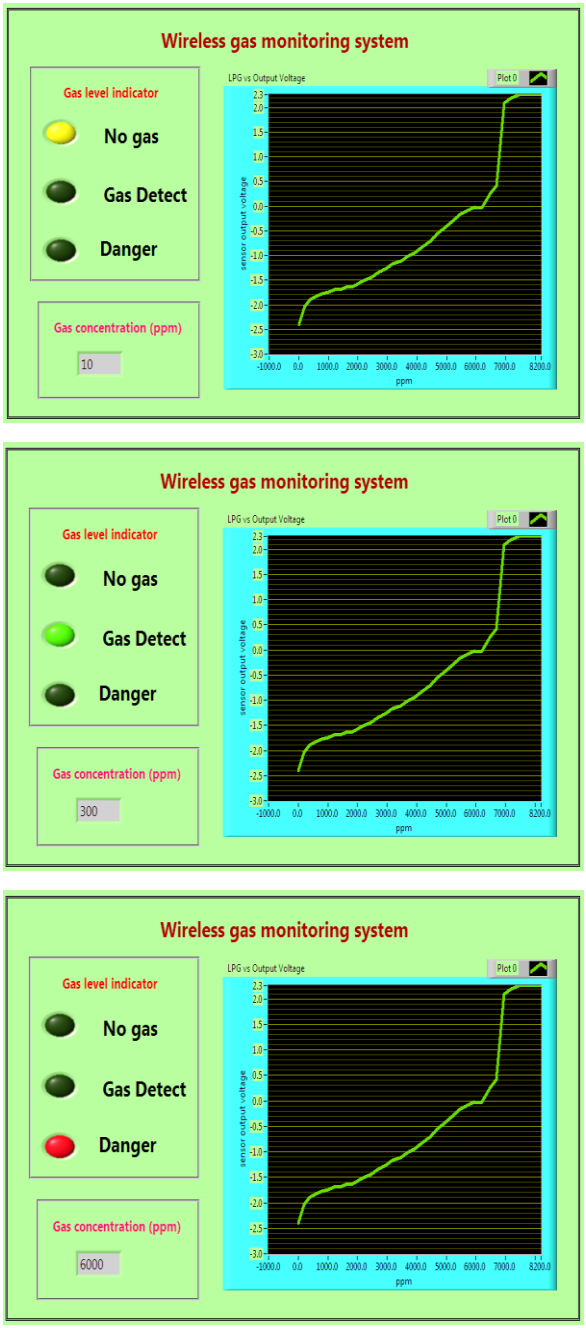



**Fig.8: LabVIEW demonstration of LPG gas detection.**

## 5. CONCLUSIONS

A dynamic system to account for the gas leakage detection, its accurate location identification and control monitoring for the safety production in any risky area is developed. This can smartly be achieved with low-power consumption and with low cost-low maintenance device. 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. Our current interest is to extend this work; can be extended from a star network to a mesh network which will be useful for deployment of the sensor networks in densely populated areas, like in buildings with multiple rooms and multiple floors.

## 6. ACKNOWLEDGMENTS

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