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Industrial Environment Monitoring and Device Control Using ARM

Mrs. Aparna V. Pethkar[1], Prof. Savita A. Pawar[2]

[1]Master of Engineering, [2]Assistant Professor
[1]Department of Electronics Engineering MITAOE, Alandi, Pune, M.S. India

Abstract: **This paper deals with industrial environment monitoring and device control using ARM. In industries there is need for data acquisition and supervisory control which overcomes human intervention as well as overall efficiency and safety. This system fulfills all these needs. So, the gas filling plants are used to fill, count & deliver gas cylinder ensuring an automated & efficient batch production. In this system, ARM based microcontroller and wireless sensors are used to control the various devices and to monitor the information regarding ZigBee and GSM technology.**

Keywords: **ARM processor, GSM Module, TCP/IP, Wireless Sensor Network, ZigBee Module.**

I. INTRODUCTION

Computer communication systems and especially the internet are playing an important role in the daily life. Using this knowledge many applications are imaginable. Home automation, utility meters, appliances, security systems, card readers, and building controls, which can be easily, controlled using either special front-end software or a standard internet browser client from anywhere around the world.

The fundamental aim of this project is to establish wireless sensor network between client and server using ZigBee and GSM technology. The system contains two parts.

One is transmitter node and another one is receiver part and transmitter can be any number. The transmitter part consists of various sensors, microcontroller and ZigBee and the receiver part consist of a PC interfaced with ZigBee through serial port. In this project, we deals with monitoring the gas plant related parameters through wireless ZigBee modules. In this system, different sensors are used to measure the parameters like RPM, methane gas, CO gas, humidity & temperature. That will be sent to the local PC first and then to the server PC using TCP/IP protocol. All the parameters are viewed by the PC using program in the receiver side.

Here, the monitor system devices are installed in different places. Sometimes it is not easy to install equipment in some areas for many reasons such as lack of access to power or unable to connect to signal wiring. In addition, tools used for measurements are very expensive. To resolve this problem, a wireless sensor network can be implemented to help in data communications.

Gas industry represents an example of very high complexity in real time production & condition monitoring, where as wireless sensor network solutions can be particularly successful in providing an effective approach to data collection & transport for overall plant efficiency.

Oil & gas companies have been earlier adapter of wireless sensor network technology & have played a key role in driving innovations & defining wireless standard's.

II. FUNDAMENTALS OF WIRLESS TRANSMISSION

The fundamental theory of wireless transmission talked about includes technologies like Bluetooth, WI-Fi, Wi-Max, wireless mobile Ad-hoc network (WMANET), UMB, wireless HART, Bluetooth and ZigBee.
There has been increased interest in wireless sensors in the last few years. This paper provides insight into the properties that make these sensors so attractive, specifically considering their efficiency, data reliability, and the ability to verify the data generated. Some advantages a wireless network presents over traditional information sensing are discussed as well.

Sensor networks are dense wireless networks of small, low-cost sensors, which collect and disseminate environmental data. Wireless sensor networks facilitate monitoring and controlling of physical environments from remote locations with better accuracy [7]. They have applications in a variety of fields such as environmental monitoring, indoor climate control, surveillance, and structural monitoring, medical diagnostics, disaster management, and emergency response, ambient air monitoring and gathering sensing information in inhospitable locations [8, 9, 10, and 11]. Sensor nodes have various energy and computational constraints because of their inexpensive nature and ad-hoc method of deployment. Considerable research has been focused at overcoming these deficiencies through more energy efficient routing, localization algorithms and system design.

III. DEVELOPMENT IN MONITORING GAS PLANT

- A wireless sensor network (WSN) used for an intelligent temperature measurement system. In this system, temperature signals are acquired by digital multipoint thermometers using arm, and transmitted to the advanced RISC microprocessor (ARM) by using Wireless Fidelity (Wi-Fi) technology. Then, they are stored in SD card which is controlled by the microprocessor according to the IIS-bus standard format. The software design of data acquisition is completed in this paper. The progress of transplanting Linux operating system to the ARM hardware platform is described, and the driver programs of SD card and SD Wi-Fi device are developed based on Linux operating system and SD card agreement. A special data storage file system is accomplished for reading and writing SD card. At last, the function of man-machine interaction is accomplished [11].
- A low cost automotive localization system using GPS and GSM-SMS services, which provides the position of the vehicle on the driver's or owner's mobile phone as a short message (SMS) on his request. The system can be interconnected with the car alarm system which 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 additional the system can be settled for acquiring and transmitting the information, whenever requested about automobile status and alerts the user about the vehicle started engine. The system can be used as a low cost solution for automobile position localizing as well as in car tracking system application [12].
- In the wsn designed, wi-fi-based wireless transmission is a process of radio waves behaving between sensor nodes and the u1 after they are transmitted. During the process, there are three types of transmission mechanisms: reflection, scattering and diffraction. Therefore, wireless transmission is also called as multi-path signal transmission. Reflection occurs when radio waves transmitted encounter an object whose dimension is larger than the wavelength. Some of the waves' energy will be absorbed into the obstacle and the remaining energy will be reflected. The energy of the transmitted and reflected waves is a function of the geometric and material properties of the obstacles and the amplitude, phase, and polarization of the incident wave. Scattering appears when radio waves transmitted encounter a large quantity of objects with small dimensions. The reflected energy in a scattering situation is spread into all directions before reaching the receiver. Diffraction occurs when the surface of the obstacle has sharp edges; even secondary waves will appear around the obstacle. Like reflection, diffraction is affected by the physical properties of the obstacles and the characteristics of the incident wave [13].

IV. SYSTEM HARDWARE

A. The System Hardware Design:

Embedded controlled sensor network is the technology used to implement environmental solutions effectively by controlling the device parameters effectively. In this system, ARM7 based microcontroller and wireless sensors are used to control the various devices and to monitor the information regarding the environment using Zig Bee and GSM technologies. Embedded sensor networks are formed by communicating over wireless links without using a fixed networked infrastructure controlled by ARM based microcontroller.

In this system, two ARM7 based microcontrollers are used. One acts as master and other acts as slave. Master controller will process the data received from client and send it to the server PC via serial communication using RS-232 protocol. The server PC will then take help of TCP /IP protocol in order to make this data available for the entire client PCs over the internet.

Client PCs will access data from server by sending the requests. Client PC then processes this data via serial communication to the slave controller via sensor.

ARM7 TDMI: The ARM (Advanced RISC Machine) is a 32-bit microcontroller created by a consortium of companies and manufactured in much different kind of versions. And it is widely used in modems, cell phones, cameras, personal audio, pagers, and many more embedded high end applications. The LPC2148 is a low-power Complementary metal-oxide-semiconductor (CMOS) 32-bit microcontroller used the enhanced RISC architecture. Through executing powerful instructions in a single clock cycle, the LPC2148 achieves throughputs approaching 17 MIPS sustained 25 MHz permit the system designer, to optimize power consumption versus processing speed, operating Voltage range for this microcontroller is - 4.5V - 5.5V[2].

Microcontroller: The microcontroller is the heart of the embedded system. It constantly monitors the digitized parameters of the various sensors and verifies them with the predefined threshold values. It checks if any corrective action is to be taken for the condition at that instant of time. In case such a situation arises, it activates the actuators to perform a controlled operation.

Zig Bee module with LPC2148: Low power Zig Bee 802.15.4 and extended range Zig Bee Pro 802.15.4 use the IEEE 802.15.4 networking protocol for fast point to multipoint and peer to peer networking. The Zig Bee module has low power output of 1mW and the range of this module is up to 100ft (30m) and the range of Zig Bee Pro is up to 1 mile (1.6km). The interface rate is 115.2 kbps. The Zig Bee modules work at the 2.4 GHz frequency. Zig Bee modules have the ability to transmit Digital, PWM, Analog or Serial RS232 signals wirelessly. To communicate over UART or USART, three basic signals namely, RXD (receive), TXD (transmit), GND (common ground) are needed. These modules use direct sequence spread spectrum configuration. Figure 1 shows the interfacing circuit of ZigBee module and ARM-7 microcontroller.

LCD Display Section: This section is basically meant to show up the status of the project. This project makes use of Liquid Crystal Display to display / prompt for necessary information.

GSM module: GSM (Global system for Mobile communication) is a digital mobile telephone system that is widely used in many parts of the world. GSM uses a variation of Time Division Multiple Access (TDMA) and this is the most widely used of the three digital wireless telephone technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. GSM operates in the 900MHz, 1800MHz, or 1900 MHz frequency bands. GSM module is used for long distance control of devices and monitoring environment of industry. Computer communication systems and especially the internet are playing an important role in the daily life. Using this knowledge many applications are imaginable.

Web server: It is a system which hosts a web site and provides services for any requesting clients. The general purpose web servers compose of an operating system, the web pages or the application and a huge amount of memory and sometimes a special hardware.

TCP/IP protocol: This is used for controlling of the apparatus from remote location using internet connection system is good example of interoperable system and highly compatible. This paper is designed to make industrial monitoring and data acquisition. Here, different sensors are used to measure the parameters like speed, methane gas & temperature. These measured data will be sent the local PC first and then to the server PC using TCP/IP protocol.

RS 232: RS 232 is a serial communication cable used in the system. Here, the RS 232 provides the serial communication between the microcontroller and the outside world such as Display, PC or Mobile etc. So it is a media used to communicate between Microcontroller and the PC.

Power supply: In this project, we required operating voltage for ARM controller board is 12V. Hence, the 12V D.C. power supply is needed for the ARM board. This regulated 12V is generated by stepping down the voltage from 230V to 18V now the step downed a.c voltage is being rectified by the Bridge Rectifier using 1N4007 diodes. The rectified a.c voltage is now filtered using a 'C' filter. Now, the rectified, filtered D.C. voltage is fed to the Voltage Regulator. This voltage regulator provides/allows us to have a Regulated constant Voltage which is of +12V. The rectified, filtered and regulated voltage is again filtered for ripples using an electrolytic capacitor 100µF. Now, the output from this section is fed to microcontroller board to supply operating voltage.

B. The System Hardware Structure:

The system contains typical client-server architecture where, the client accesses the server through the LAN router and the Internet. Whenever the client wants to access server, it sends request to the server, this request is taken by router -

connected to the Internet. The web processes the request made and finally connects to the desired web server, access the requested data and sends the data to the client. The purpose of transmitter section is responsible to transmit various parameters, data from sensors through a ZigBee module. Depending on these values, user can modify/control functioning of different sensors using a receiver section

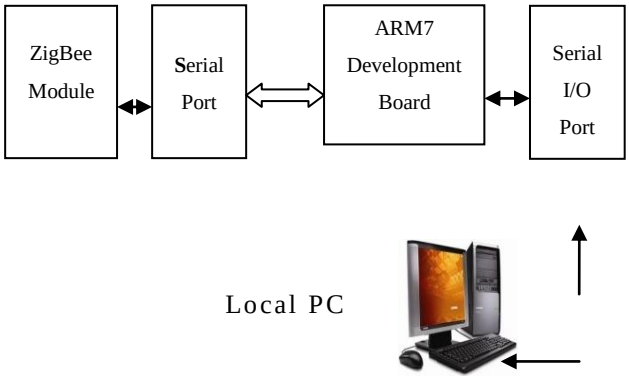

Figure.1: Block Diagram of Master Section

WSN's offer oil & gas companies immediate & measurable benefits, including improved performance, greater flexibility & reduced costs for installation & ongoing maintenance. Gas industry represents an example of very high complexity in real time production & condition monitoring, where sensor network solutions wireless can be particularly successful in providing an effective approach to data collection & transport for overall plant efficiency.

In a Gas plant, several measurement points are required to trace down the local parameters in the different parts of the gas plant to make automation system work properly. Cabling would make the measurement system expensive & vulnerable. Moreover, the cabled measurement points are difficult to relocate once they are installed. Thus, wireless monitoring and control using smart sensor platform consisting of small size is an attractive & cost efficient option.

In this system, the sensors are placed in gas filling plant near the storage tank or all the sensors will be responsible for the data acquisition system so the sensors will continuously sense the parameters and the slave unit will be sending this to master system.

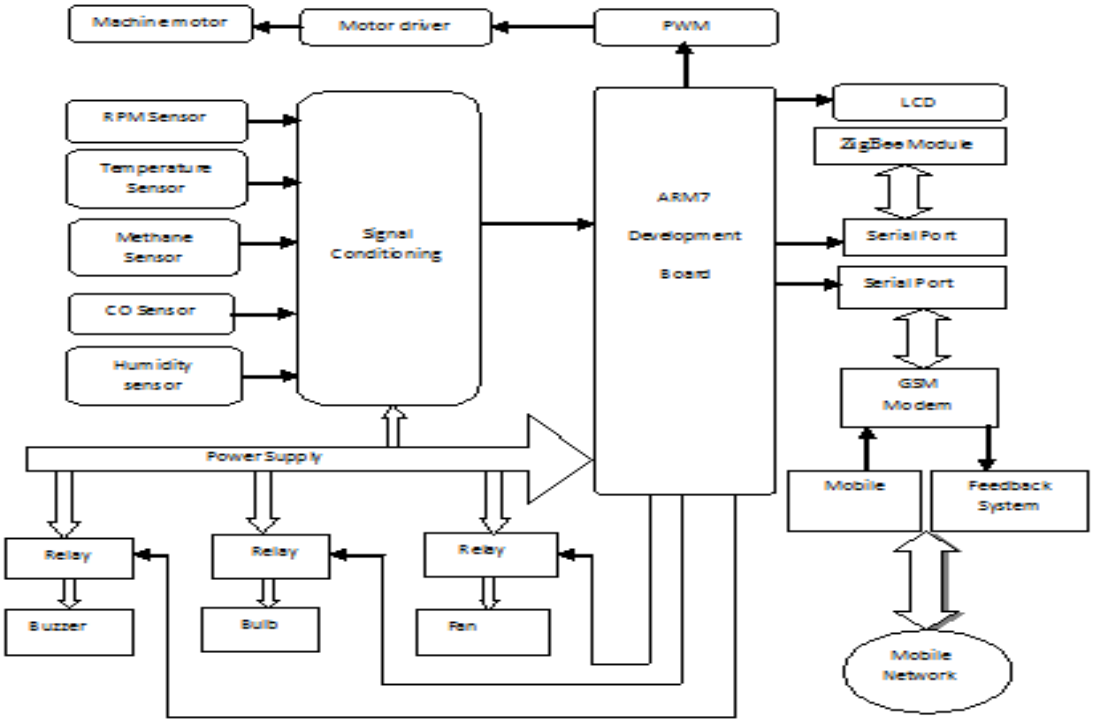

Figure 2: Block Diagram of Slave Section

The overall design implementation is divided into three different modules.

1. Data Acquisition System*:*

In this module, various sensors are used to sense different parameters of Gas plant. These sensors may include:

Temperature Sensor (LM 35):

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in ºC). The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. For LM35, the scale factor is 0.01V/°C meaning the nominal output voltage is 250mV at 25°C and 1.000V at 100°C. It does not require any external calibration or trimming. The most important characteristic of the LM35 is that it draws only 60µA from its supply and produces a low self heating capability. The general equation used to convert from the output temperature to temperature is Temperature (°C) = Vout * 100 °C/V.

Methane and CO Gas Sensor (MQ-4):

MQ-4 is suitable for sensing natural gas and presence of CH4 concentrations in the air. It can detect natural gas concentrations anywhere from 200 to 10000ppm. This sensor has a high sensitivity and fast response time. The sensing element is comprised of a metal oxide semiconductor layer formed on an alumina substrate of a sensing chip together with an integrated heater. In the presence of a detectable gas, the sensor's conductivity increases depending on the gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to gas concentration. The sensor MQ-7 has high sensitivity to carbon monoxide. The detecting range of this sensor is 20 ppm - 2000 ppm of carbon monoxide. The resistivity of this sensor depends on the concentration of the gas. Its resistance varies from 2k-20k ohms. One special property of this sensor is that the heater coil is given pulsating power supply. For 60 sec the heater is given 5 volt supply and for the next 90 sec it is given 1.4 volt supply. The sensor MQ-4 has high sensitivity to Natural Gas and Methane (CH4) and has small sensitivity to alcohol and smoke. The detecting concentration of this sensor is from 200 ppm – 10000 ppm for Natural gas and Methane. The sensor resistance varies from 10k – 60k ohms. These sensors (MQ-4 and MQ-7) are composed by micro Al2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater which are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components.

Humidity Sensor (SY220):

It will sense humidity in air the sensor's output varies the voltage as per the change in humidity levels.

Signal Conditioning Circuit:

This circuit will filter and amplify the signals from all the sensors, so that it can be further used for ADC. The task of filtering and amplifications will be performed by filter circuit and Op-Amps. The function of ADC is to convert the analog signals in to digital format; the output signals from the sensors will be connected to the input channels of ADC. The ADC will convert them into digital format so as to make it readable for microcontroller. All these sensors are connected to the slave section.

2. Server System:

The data from the ADC is then given to microcontroller. The controller will process this data and send it to the server PC via serial communication using RS-232 protocol. The server PC will then take help of TCP /IP protocol in order to make this data available for the entire client PCs over the internet. For this, a software programming is used in order to translate data to TCP/IP protocol server will reply to client PCs requests. It will send the data using TCP/ IP protocol to client. A typical server system is as shown in Fig. 2.

3. Client Access:

Client PCs will access data from server by sending the requests. The client will receive the data from server. Client PCs will have a specially designed GUI (Graphical User Interface) in order to represent data in graphical format. The GUI is created by using software programming. In this way, user can access the data over the internet.

Hardware Structure And Prototype Design

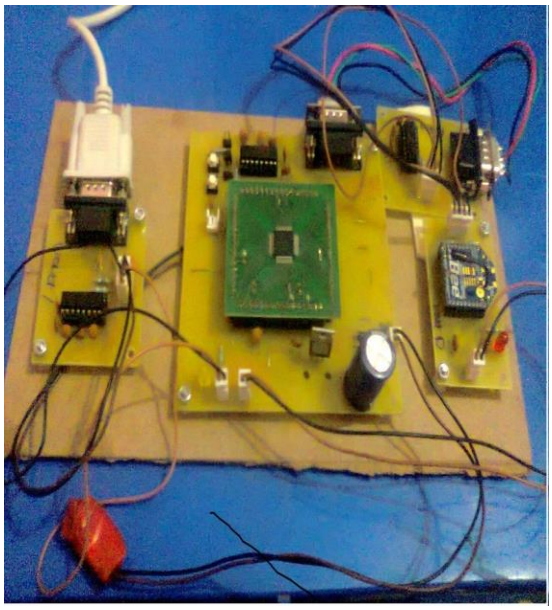

Figure 3: Practical Implementation of Master

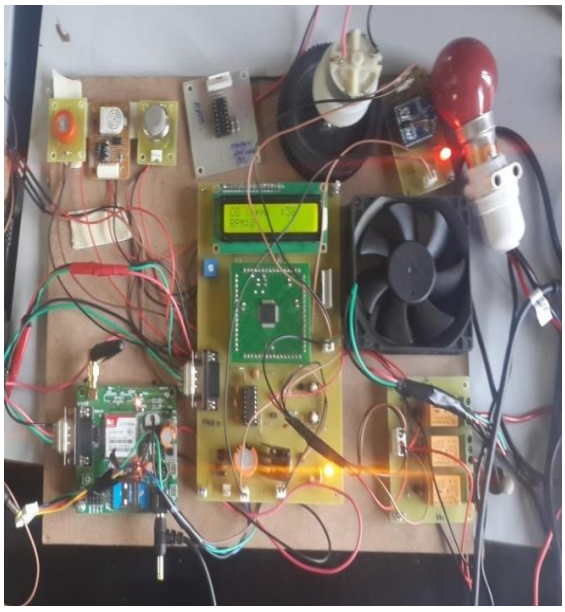

Figure 4: Practical Implementation of Slave

V. EXPERIMENTAL RESULTS OF SENSORS

Wireless Zig Bee module is configured as receiver or base station. It is connected with the host PC via serial port. Data received by host PC is then stored in the data base and most recent value is shown on the screen by the GUI (Graphical User Interface) developed in Embedded 'C'. It shows the RPM, methane and CO gas, temperature, and humidity information of every sensor node. It also sets the threshold of the gas plant by the administrator. This system also displays sensor data on the LCD which is connected to slave sensor nodes. Figure 2 shows the slave sensor node in which five sensors, LCD, Zig Bee module are connected to board.

Temperature Sensor: Temperature is one of important factor to be checked for proper monitoring and controlling of the gas plant. In this system, we had tested the performance of temperature sensor via LM35.The detection range for LM35 is -55^0C to + 150^0C. In this system, when the temperature rises to 40^0C, system will switch on the buzzer and alert notification will send via SMS to user and then exhaust fan will turn on by sending SMS by user.

Table 1: Readings of Temperature sensor

Temperature Sensor (LM35)	
Sensor I/P (^{0}C)	**O/P voltage(v)**
5	0
22	0.16
38	0.32
55	0.48
72	0.64
88	0.81

Table2: Readings of Humidity sensor

Humidity Sensor(SY220)	
Sensor I/P (%RH)	**O/P Voltage(v)**
11	0.5
26	1
42	1.5
58	2
73	2.5
89	3

CO & Methane Gas Sensor: In this system, we tested different CO and Methane sensors. The detection range of MQ-7 is 20ppm-2000ppm & MQ-4 is 200 ppm-10000ppm. When concentration of CO & Methane is too high, then the system will switch on bulb & buzzer.

When the physical input are given to the each sensor, then these sensor parameters are displayed on LCD, as shown in Figure 5 Below.

MQ-4

Methane Sensor(MQ-4)	
Sensor I/P (PPM)	**O/P Voltage(v)**
155	0.5
310	1
465	1.5
621	2
776	2.5
931	3

Table 3: Readings of Methane sensor

MQ-7

Carbon monoxide Sensor(MQ-7)	
Sensor I/P (PPM)	**O/P Voltage(v)**
155	0.5
310	1
465	1.5
621	2
776	2.5
931	3

Table 4: Readings of CO sensor

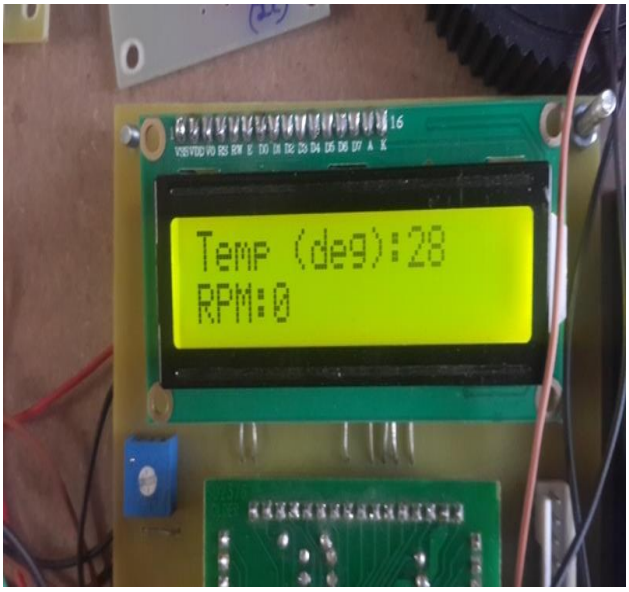

Figure 5: Sensor results displayed on LCD

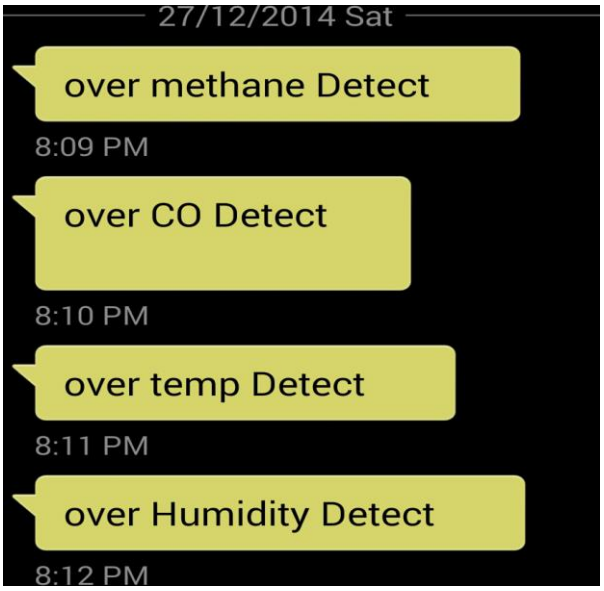

Figure 6: Sensors over detect Messages Displayed on Mobile Screen

When the sensor parameters overcome its set point value, then buzzer will becomes ON and notifications are sends via SMS on mobile. Hence, these messages are displayed on mobile (Refer Figure 6).

VI. SYSTEM SOFTWARE DESIGN

The program of slave sensor node controller is designed to collect the gas, temperature, RPM and humidity information, and communicate with the master node by the wireless ZigBee transceiver module. The master also has to decide whether the gas plant needs to be controlled according the threshold values of temperature and humidity set by the remote computer. All controllers will be at the sleep mode when off work.

Slave sensor parameters displayed on client PC screen. Dock light software is used to display the codes on screen. These codes are then displayed on client PC as shown in Figure 6. When two computers are made in Wi-Fi or LAN connection, then slave sensor parameters are displayed on server PC. By observing these observations master monitors the slave as shown in Figure 7.

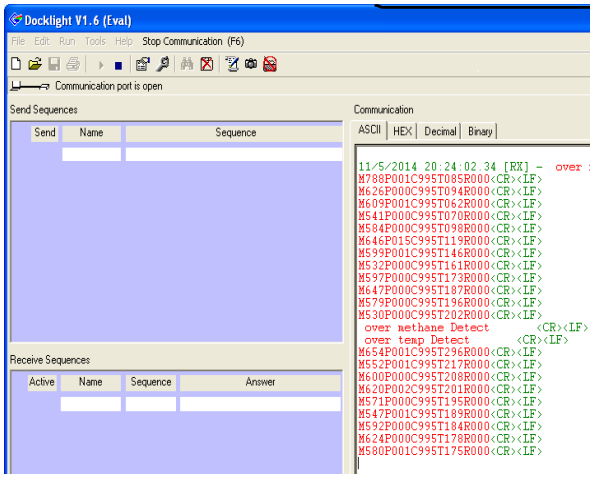

Figure 6: Results displayed on client PC

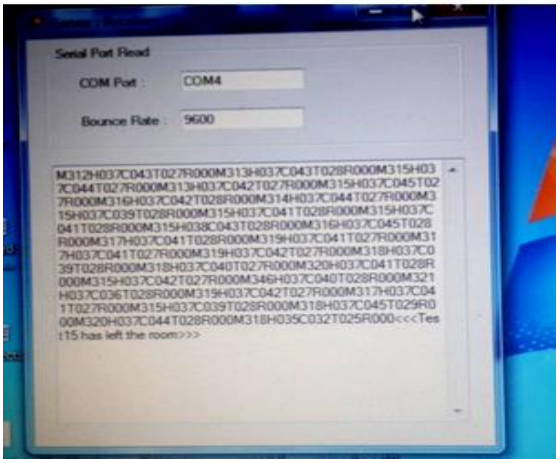

Figure 7: Results displayed on server PC

VII. CONCLUSION

In this paper, automated gas plant control is discussed with advantages of low cost and accuracy. Benefits are improved quality of produce and information gathering can mean the difference between earning profit and suffering fewer losses. In this system, user can view data from anywhere from the world by using web server. Also get SMS on his mobile phone due to GSM technology. Five commercial sensors had been integrated with the system to monitor and compute the level of existence of CO gas, methane gas, temperature and humidity in atmosphere, using information and communication technologies.

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Author's Biography:

Mrs. Aparna Pethkar perusing her M. E. in VLSI and Embedded Systems from MIT Academy of Engineering, Alandi (D), Completed her B. E. (Electronics) from Rajarambapu Institute of Technology, Sakhrale. Her interested areas of Research include Embedded Systems and VLSI.

Mrs.Savita Pawar working as Assistant Professor in Department of Electronics, MIT Academy of Engineering, Alandi (D), Completed her M. E. from Rajarambapu Institute of Technology, Sakhrale. Her area of specialization is Embedded Systems.