Proactive Indoor Air Quality Monitoring System

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Abstract**—**In recent times indoor air quality has attracted the attention of policy makers and researchers similar to that of external air pollution. The indoor environments are confined and closed compared to external environments providing less opportunity for the pollutants to dilute. Our everyday devices emit various solids and gases into the environment during their operation. These emissions contain many substances that are harmful to human health, when exposed to them for a prolonged period of time. Here we propose an air quality monitoring system that allows us to monitor and check live air quality in particular areas through IOT. The System uses air sensors to sense presence of harmful gases/compounds in the air and constantly transmit this data to microcontroller PIC16F877A. The sensors interact with microcontroller which processes this data and transmits it over internet. The gas levels can be viewed through a webpage from anywhere in the world. This allows authorities to monitor air pollution in different areas and take action against it.

Keywords*-indoor air quality, human health, PIC16F877A.*

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I. INTRODUCTION

Air supplies us with oxygen that is essential for our bodies to live. Air is 99.9% nitrogen, oxygen, water vapor, and inert gases. Human activities can release substances into the air, some of which can cause problems for humans, plants, and animals. Air quality can be expressed by the concentration of several pollutants such as carbon monoxide (CO), sulphur dioxide, nitrogen dioxide, and ozone. The threshold values specified by the European Environment Agency for these pollutants are 10, 350, 40, and 120 μg/m3, respectively. Pollution also needs to be considered inside our homes, offices, and schools. Some of these pollutants can be created by indoor activities such as smoking and cooking. Generally, in industrialized countries, the population spends about 80%–90% of time inside buildings and is therefore exposed to harmful indoor pollutants. The process of indoor air quality monitoring involves different technologies namely actual gas sensing, sensor networking, data mining and decision making. There is some prior work on this topic from different points of approach, but this project proposes an indoor air quality monitoring network for assisted living. Accurate measurement of gas concentrations is the key of air quality monitoring. However, this has to be within the budget of the monitoring system aswell. Therefore, it is common to select only a number of target gases and sacrifice a little from the accuracy to bring down the cost while getting data within an acceptable resolution.

Online air quality monitoring can be used in many different applications ranging from quality of life improvement to military operations. Occupancy monitoring is a typical application where the number of occupants is estimated from the amount of carbon dioxide detected in a given environment. This information may be used to effectively control the heating, ventilation and air conditioning system in the building or may be used to remotely spy on the population in the room.

Carbon dioxide, carbon monoxide, methane and butane are the most common gases of interest in built environments. Carbon dioxide is added to the environment in moderate quantities from respiration under normal situations and in excessive quantities from fires under hazardous conditions. Carbon monoxide is mainly added to the built environment from automobiles. A common source of methane is the common garbage collected at designated areas adjacent to buildings. Propane is mainly from cooking and heating gas lines. Any of these gases may be life threatening if gone above the accepted range for a considerable period of time. Therefore, continuous monitoring of each of them is vital in indoor air quality monitoring system.

II. LITERATRURE SURVEY

[1] Paper presents a network for indoor and outdoor air quality monitoring. Each node is installed in a different room and includes tin dioxide sensor arrays connected to an acquisition and control system. The nodes are hardwired or wirelessly connected to a central monitoring unit. To increase the gas concentration measurement accuracy and to prevent false alarms, two gas sensor influence quantities, i.e., temperature and humidity are also measured. Advanced processing based on multiple-input–single-output neural networks is implemented at the network sensing nodes to obtain temperature and humidity

compensated gas concentration values. Anomalous operation of the network sensing nodes and power consumption are also discussed.[2] This paper proposed Smart Indoor Air Quality Monitoring where wireless indoor air quality monitoring is the main objective of this research in order to provide real time information for assisted living. The indoor air quality measured in the built environment provides a continuous stream of information for seamless controlling of building automation systems, and provides a platform for informed decision making. Further, this low power sensor network design provides vital air quality information under emergency and hazardous conditions even without grid power for a reasonable time. The proposed system has carbon dioxide, carbon monoxide, propane and methane sensors. This prototype network was first built using a hardware platform available in the market with industrial grade gas sensors. The concept was verified with actual parameter measurements under different real-life situations. The results reveal that the domestic indoor air quality may be extremely different compared to what is expected for a quality living environment.[3] In this paper, a dedicated, miniaturized, low-cost electronic nose based on state-of-the-art metal oxide sensors and signal processing technique was developed. The proposed device is targeted to thequantification of carbon monoxide and nitrogen dioxide in mixtures with relative humidity and volatile organic compounds by using an optimized gas sensor array and highly effective pattern recognition techniques. The electronic nose was tested in an environment reproducing real operating conditions. Exploiting the unique response patterns of the different sensors in the array and the capability of a simple fuzzy-logic system it was possible to identify and discriminate concentrations as low as 20 ppm for NO2 and 5 ppm for CO in the test gas environment, allowing to reach the necessary sensitivity towards the target pollutants together with the selectivity towards the typical interfering gas species.[4] This paper presents a mobile GPRS-Sensors Array for Air Quality Monitoring. Here, an online GPRS-Sensors Array for air pollution monitoring has been designed, implemented, and tested. The proposed system consists of a Mobile Data-Acquisition Unit (Mobile-DAQ) and a fixed Internet-Enabled Pollution Monitoring Server (Pollution-Server). The Mobile-DAQ unit integrates a single-chip microcontroller, air pollution sensors array, a General Packet Radio Service Modem (GPRS-Modem), and a Global Positioning System Module (GPS-Module). The Pollution-Server is a high-end personal computer application server with Internet connectivity. The Mobile-DAQ unit gathers air pollutants levels (CO, NO2, and SO2), and packs them in a frame with the GPS physicallocation, time, and date. The frame is subsequently uploaded to the GPRS-Modem and transmitted to the Pollution-Server via the public mobile network. A database server is attached to the Pollution-Server for storing the pollutants level for further usage by various clients such as environment protection agencies, vehicles registration authorities, and tourist and insurance companies. The Pollution-Server is interfaced to Google Maps to display real-time pollutants levels and locations in large metropolitan areas. The system was successfully tested in the city of Sharjah, UAE. The system reports real-time pollutants level and their location on a 24-h/7-day basis.

III. EXISTING SYSTEM

The Air quality monitoring system is an unit which has the circuital arrangement which works regarding measuring and analyzing the range of gases in an indoor region. The units involved in the existing methods are sensors, power supply, buzzer, LED display unit.

Issues with Power Consumption

Power consumption is not a major issue as long as the built environment is connected to the power grid where these sensors can directly be fed from it. However, indoor gas condition monitoring is vital in emergency evacuation situations where the mains power may be turned off under high danger situations or by the emergency itself. Each sensor node has its own rechargeable battery which getting charged from the mains power when available, and automatically switches to battery power whenever the mains power is cut off. The chosen Wasp mote sensor hardware can seamlessly transfer from mains to battery, therefore no rebooting will occur during the changeover. An ultralow-power sensor network node is vital in such situations where it can sense and send information on indoor air quality for a longer time without mains power for disaster management team to make correct decisions.
Output was indicated in the LED display, the indication which represent the normal range and danger zone were indicated in the word forms at the LED screen or in units.

Figure 1: Currently Used Air Quality Monitor

Pollution Monitors in Public Places

Scientists have different strategies for calculating air pollution measures. These strategies include:
• Reporting of direct measurements from monitoring stations
• Reporting of sources, such as the locations of industrial facilities or traffic levels on roadways
• Models that may consider either or both of the above types of data along with considerations of weather, topography, and dissipation patterns

None of these directly correspond to population exposure (i.e. the amounts of pollutants that are taken in by people day-to-day), although all can provide useful information. In places where no monitoring data exist, pollutant levels need to be estimated using statistical modeling methods. These methods commonly use known values at nearby locations to estimate pollution levels for locations that do not have data.

Figure 2: Public Display Board for Air Quality Monitoring In Major Cities

IV. PROPOSED SYSTEM

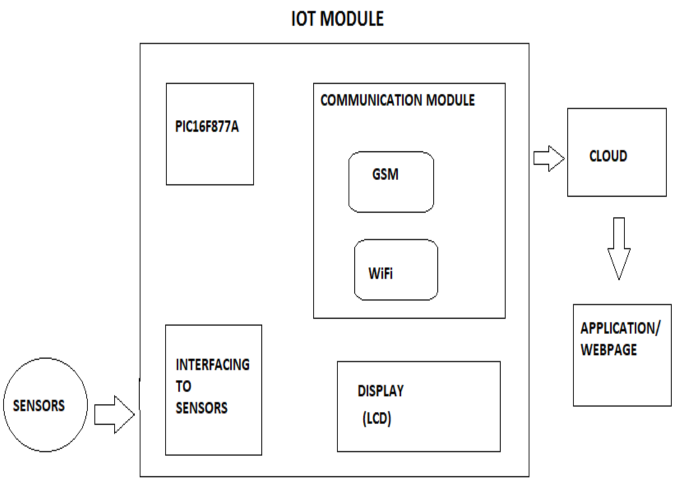

Figure 3: Block diagram of proposed system

Gas Sensor (MQ135)

The MQ-135 gas sensor module consists of a steel exoskeleton under which a sensing element is housed. This sensing element is subjected to current through connecting leads. This current is known as heating current. Through it, the gases coming close to the sensing element get ionized and are absorbed by the sensing element. This changes the resistance of the sensing element which alters the value of the current going out of it.

Figure 4: Gas Sensor (MQ135)

Sensitive for benzene, alcohol, smoke. Output voltage boosts along with the concentration of the measured gases increases. Fast response and recovery. Adjustable sensitivity. Signal output indicators are the features of MQ135 gas sensor.

LCD Display

A liquid crystal display is special thin flat panels that can let light go through it or can block the light. (Unlike an LED it does not produce its own light). The panel is made up of several blocks, and each block can be in any shape. Each block is filled with liquid crystals that can be made clear or solid, by changing the electric current to that block. Liquid crystal displays are often abbreviated LCDs. Liquid crystal displays are often used in battery powered devices, such as digital watches, because they use very little electricity. They are also used for flat screen TV's. They work well by themselves when there is other light around (like a lit room, or outside in daylight). The LCD uses technology called electro-optical modulation. This means it uses electricity to change how much light passes through it.

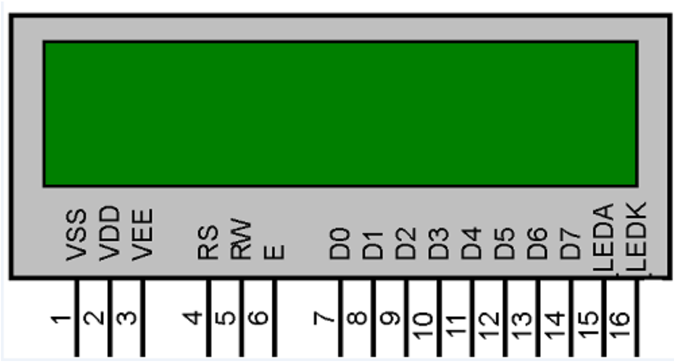

Figure 5: LCD Display

On a character LCD, a character is generated in a matrix of 5x8 or 5x7. Where 5 represents number of columns and 7/8 represents number of rows. Maximum size of the matrix is 5x8. You cannot display character greater than 5x8 dimension matrix. Normally we display a character in 5x7 matrices and left the 8th row for the cursor. If we use the 8th row of the matrix for the character display, then there will be no room for cursor.

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PIC 16F877A

The PIC microcontroller PIC16f877a is one of the most renowned microcontrollers in the industry. This controller is very convenient to use, the coding or programming of this controller is also easier. One of the main advantages is that it can be write-erase as many times as possible because it uses FLASH memory technology. It has a total number of 40 pins and there are 33 pins for input and output. PIC16F877A is used inmany pic microcontroller projects. PIC16F877A also have many applications in digital electronics circuits. PIC16f877a finds its applications in a huge number of devices. It is used in remote sensors, security and safety devices, home automation and in many industrial instruments. An EEPROM is also featured in it which makes it possible to store some of the information permanently like transmitter codes and receiver frequencies and some other related data. The cost of this controller is low and its handling is also easy. It is flexible and can be used in areas where microcontrollers have never been used before as in coprocessor applications and timer functions etc.

ADC (Analog to Digital Convertor)

It is a device that converts a continuous quantity to a discrete digital number. Typically, an ADC is an electronic device that converts an input analog voltage (or current) to a digital number proportional to the magnitude of the voltage or current. This functionality is done by the ADC interface block of the IOT board.

Wi-Fi Module

ESP8266 on-board processing and storage capabilities allow it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. With its high degree of on-chip integration, which includes the antenna switch balloon, power management converters, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area.

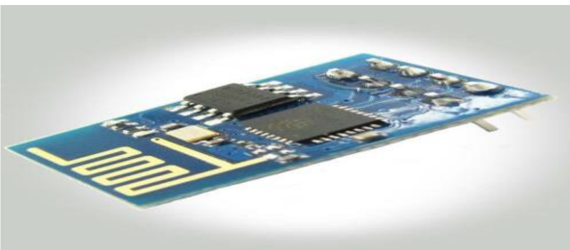

Figure 6: Wi-Fi Module

Power Supply

Digital Power Supply ESP8266EX has two digital pins for power supply, Pin11 and Pin17. For digital power supply, there is no need to add additional filter capacitors. The operating voltage range of digital power supply pins is 1.8V ~ 3.3V.

V. RESULTS AND DISCUSSIONS

In the proposed system MPLAB IDE with Hi-tech C compiler is used to generate source coding in the embedded C language. The source code is then dumped in the controller and it is executed to obtain the output result. The sensor is connected to PIC in the corresponding pin. There are several pins of a port in the controller that are connected to the data pins of the LCD.LCD can be used for displaying output. In our project we make use of web page for displaying the output. The simulation is done using Proteus software which is shown below.

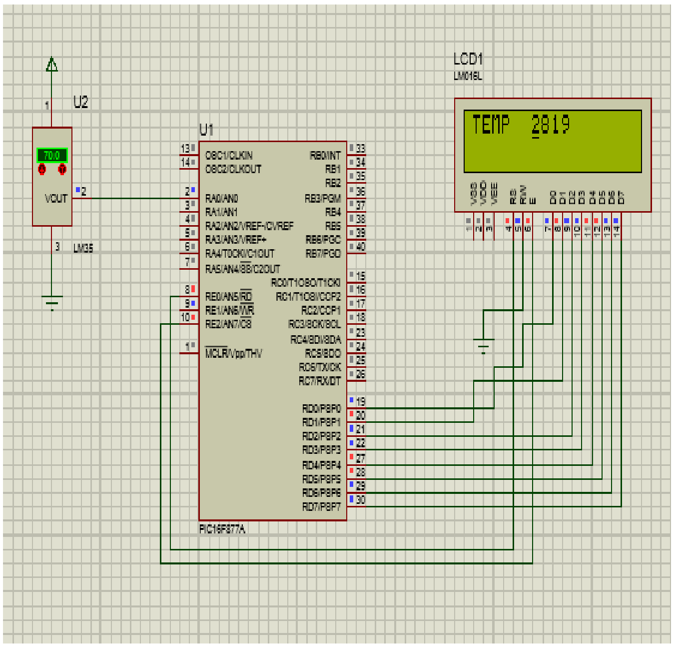

Figure7:Simulation for LCD

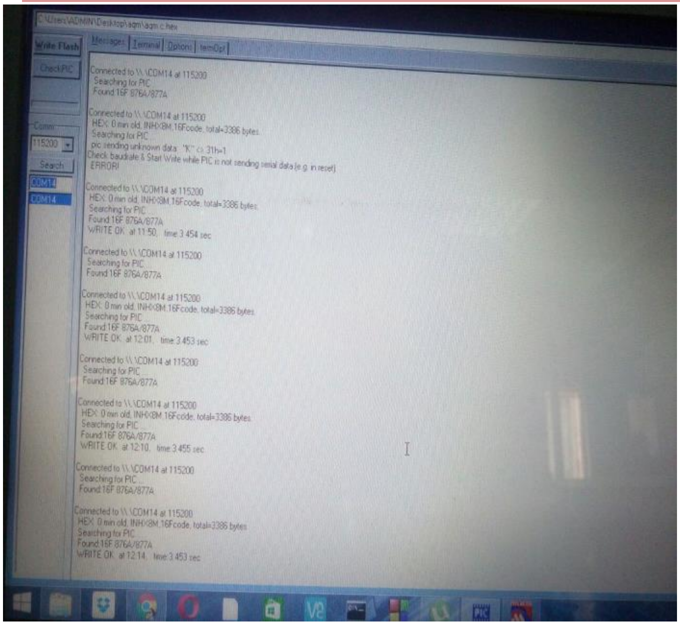

Figure 8:HEX File Upload in PIC

From fig 8 the hex file of the source code which is coded in MPLAB IDE is loaded into the PIC16F877A microcontroller, which is visible in Proteus simulation.

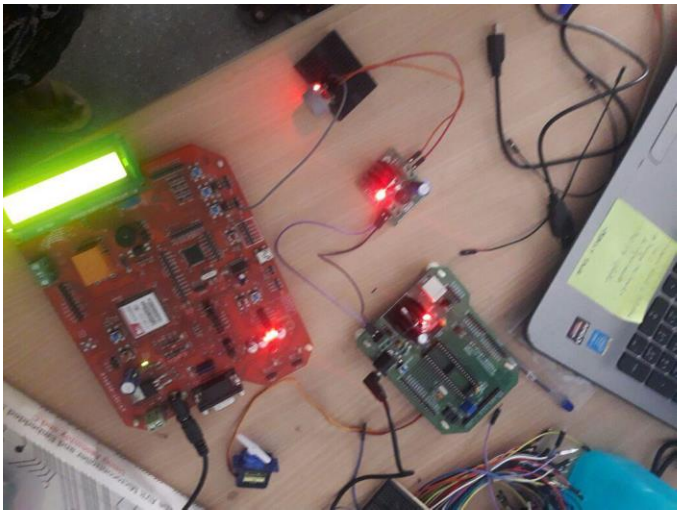

Figure 9: Hardware Module of Proposed System

From fig 9, shows the hardware module of the proposed system. This proposed module consists of gas sensor, PIC16F877A in-built in IOT board, sensor driver circuit and an LCD display. The gas sensor is used to sense the presence of various gases in the indoor environment. The data is displayed on the LCD and also on the web page.

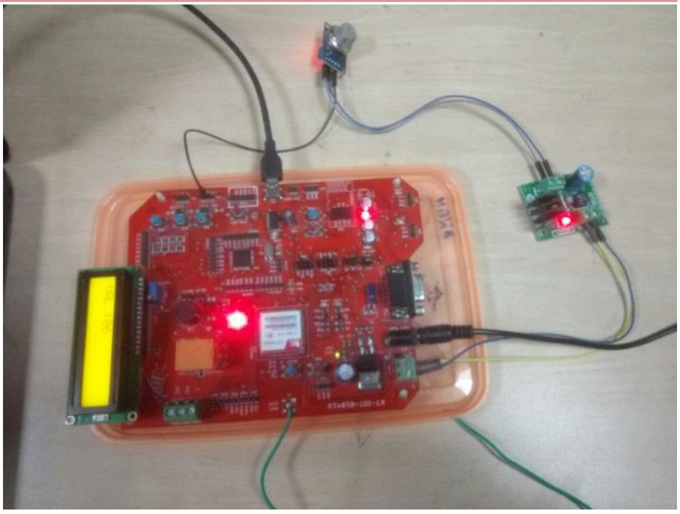

Figure 10: Working Indoor Air Quality monitor

Fig 10 is the final working model of the indoor air quality system. The gas sensor drives power with the help of the sensor driver circuit board. The values sensed by the gas sensor are displayed in the LCD. The board being used is an industrial IOT board manufactured by Krish Tec, Coimbatore. PIC16F877A microcontroller is used in the project as it is cost effective, efficient and gives accurate results.

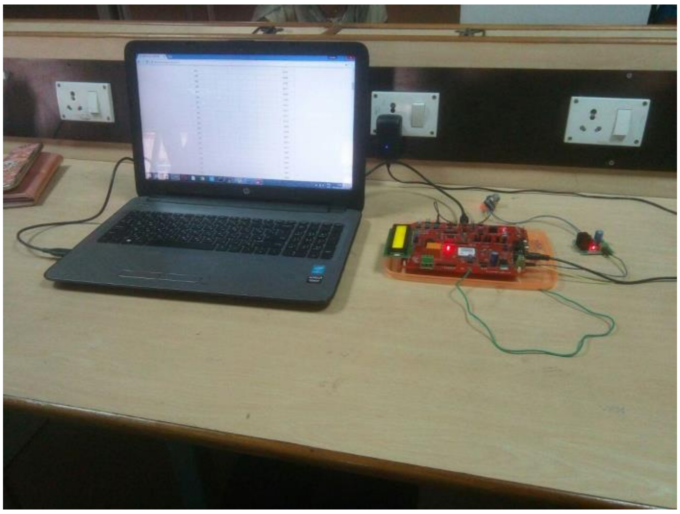

Figure 11: Gas Levels Being Monitored Through Webpage

Figure 12: Real time Webpage Display

VI. CONCLUSION

By deploying sensor devices in the environment, we can bring the environment into real life i.e. it can interact with other objects through the network. Then, the collected data and analysis results will be available to the end user through the Wi-Fi.

This project offers a smart way to monitor our home and work environment through an efficient, low cost air quality monitoring system. This model can be further expanded to monitor various industrial zones for pollution monitoring. The real time monitoring can be very helpful to monitor the air pollution levels of a particular place from anywhere in the world through internet and web page. These can be a blessing especially in case of any fire emergencies or toxic gas outburst.

Future work includes monitoring as well as controlling the air quality using suitable sensors and air filters like CO2 filters, Ozone filter and displaying the results in android applications as well as passing the data to the pollution control board of the organization to take necessary measures to curb pollution in that area.

VII. ACKNOWLEDGMENT

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