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Air Quality Monitoring System Using Wireless Sensor Node

Afrah Mohammad

PG Student [EC], Dept. of ECE, Anjuman College of Engineering and Technology, Nagpur, India

ABSTRACT: The main objective of this project is to devise a simple low cost microcontroller based air pollution monitoring system using wireless technology which finds presence of various gases like CO2, SO, NO,etc and parameters like humidity ,temperature ,etc. , displays it on LCD and forwards it to remote user. This project is developed by using PIC 16F877A Microcontroller, SIM 900 GSM Module, JHD204A LCD display and gas sensors. The advantage of using GSM based technology is that GSM based communication network is distributed over a large area and have almost reached to every part of this 21st century world. GSM technology also do provide users with high quality signal and channels, giving them access to high quality digital communication at reasonable cost.

This embedded system can prove to be useful for anyone who wish to monitor the quality of air at a location without being physically present there .The main advantages of the research are that the system may be able to collect the pollution levels throughout the 24 hours of the day and that the data so collected may serve as a data base which can be used for various analysis whenever required .The system may offer pollutant levels of a particular industry and this estimation may serve as an enchiridion to the government for allowing or disallowing a particular industry to be set up in a particular area.

KEYWORDS: Air pollution, Microcontroller, Embedded system, Pollutant levels, GSM, Monitoring system

I.INTRODUCTION

Environmental pollution is a concomitant of□industrialization andits hazardous effects are enhanced□by meteorological factors; hence, large cities are usually the□centers of acute pollutionproblems. Because industrialization will continue, it is therefore necessary to determine a□safe pollution level and to operate all industrial concerns□in sucha way thatthe pollution concentration is continually kept below this level despite the stochastic variation of theatmospheric conditions.□

Air quality monitoring and analysis is the need of the hour. Air quality measurements can also be processed and presented in real-time to end users to spread environmental awareness. The monitoring of pollution level in the atmosphere is of significance especially to those residents living in a city. Reasonable sitting air quality monitoring stations is an important task for environmental protection authorities and department, involving: (1) Ensuring that the air quality standard is achieved; (2) planning and implementing air quality protection and air pollution control strategies; and (3) preventing or responding quickly to air quality deterioration. Therefore, the environmental protection department need to site air quality monitoring stations effectively. Bulky air quality monitoring stations are traditionally used for measuring the concentrations of certain pollutants of interest. These stations are large in size, costly, require frequent maintenance and calibration and have high power requirement. They are also powered by the mains power grid. Researchers have devised pollution models based on emission distribution and have also developed an auto calibration method for air quality sensor networks based on mobile sensors. Such wireless network has been put to use to assess air pollution problems. The specific objective of the research is to develop an air pollution monitoring system which is able to measure the level of different gases in atmosphere and forward that information wirelessly to base station, where this information can be stored, processed, and analysed and presented to the end user.

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II.LITERATURE REVIEW

In [6], an actual deployment of a wireless sensor network is described. The purpose of the sensor network is to monitor and analyze air quality in Doha. Small scale wireless sensor stations communicate with a backend server to relay their measurements in real-time. Data stored on the server is subjected to intelligent processing and analysis in order to present it in different formats for different categories of end users. This paper describes a user friendly computation of an air quality index to disseminate the data to the general public. In addition, it describes data presentation for environmental experts using dedicated software tools, e.g. the R software system and its Open Air package. Analysis and assessment of real measurement data is also performed in the paper.

In [8] an Environmental Air Pollution Monitoring System (EAPMS) for monitoring the concentrations of major air pollutant gases has been developed, complying with the IEEE 1451.2 standard. This system measures concentrations of gases such as CO, NO_2, SO_2, and O_3 using semiconductor sensors. The smart transducer interface module (STIM) was implemented using the analog devices ADuC812 micro converter. Network Capable Application Processor (NCAP) was developed using a personal computer and connected to the STIM via the transducer independent interface. Three gas sensors were calibrated using the standard calibration methods. Gas concentration levels and information regarding the STIM can be seen on the graphical user interface of the NCAP. Further, the EAPMS is capable of warning when the pollutant levels exceed predetermined maxima and the system can be developed into a low cost version for developing countries.

III.SYSTEM MODEL

Our air pollution monitoring System is an automated version of monitoring the quality of air and sending the information to a distant database wirelessly. Our system has got almost all things automated so that we get an advantage of this concept ie the real time direct measurement of the air quality through GSM/PC. Maintaining backup of sent data is easy and can be done within a few seconds. This model uses gas sensors, GSM module (SIM900), LCD JHD 162A and a PIC 16F877 microcontroller. The GSM module is connected to PC through RS232 cable.

Figure 1: System model

The system model is shown in Figure 1 which says about the connectivity of all mentioned devices. The LCD is attached to PIC 16F877 to simultaneously display the measured temperature; through which we can experimentally

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check whether the data that is being sent is correct.

IV. SYSTEM HARDWARE ARCHITECHTURE

Our air pollution monitoring System is an automated version of monitoring the quality of air and sending the information to a distant database wirelessly. Three to four wireless sensor stations will be deployed at three to four different places. These sensors will record the pollutant levels of gases like CO, SO and NO and relay the information through Internet/GSM network to the base station. The data received at the base stations will be arranged in a data base. The data so collected will then be processed and it involves validation, verification, standardization, normalization, aggregations and transformations. After the data is suitably processed the data prediction and analysis will be carried out. Finally, conclusion, regulations and recommendations will be proposed. The communication protocol will serve as a mediator between the end user and the data base server.

Figure 2 shows the block diagram of a basic air pollution monitoring system, in which three to four wireless sensor stations are to be deployed at three to four different places.These sensors will record the values of different parameters like temperature, humidity, CO, O3, NO2, H2S and relay the information through Internet/GSM network to the base station. The data received at the base stations will be arranged in a database. The data so collected will then be processed and it involves validation, verification, standardization, normalization, aggregations and transformations. After the data is suitably processed the data prediction and analysis will be carried out. Finally, conclusion, regulations and recommendations will be proposed. The communication protocol will serve as a mediator between the end user and the data base server.

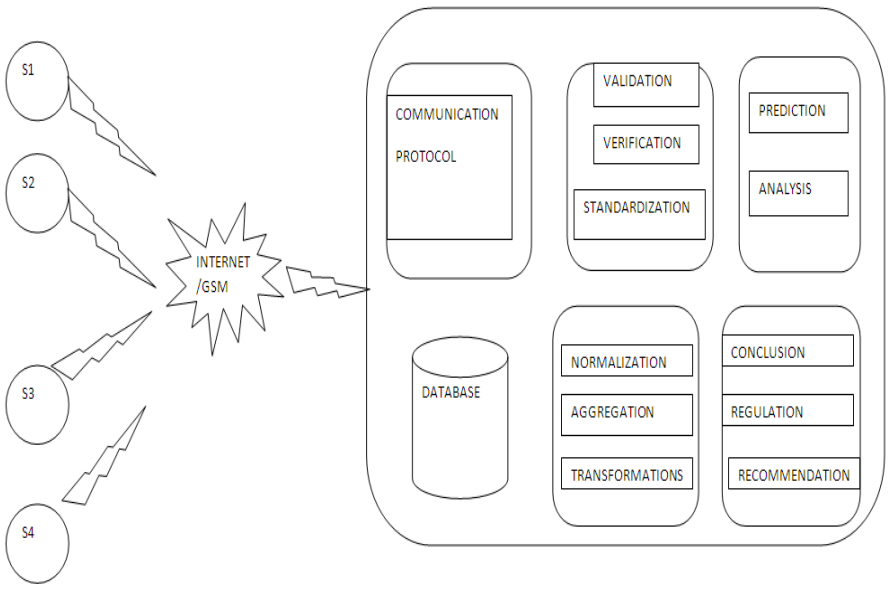

Figure 2: Block diagram of basic air pollution monitoring system

The proposed system is designed by integrating the following hardware modules shown in figure 3. As the figure 3 shows, the system consists of a PIC16F877A microcontroller integrated with a sensor array using analog ports. The hardware unit is also connected to a GPS module and a GSM-Modem using the RS-232 interface. Each of these components is described below:

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1. PIC16F877A microcontroller

The PIC16F877A microcontroller is the main component of a pollution detection unit. The operating system that runs inside the chip coordinates the substances measurement process, the acquisition of the GPS coordinates and the data transmission to the central server. The microcontroller is mounted on a development board that provides an RS232 serial communication to the GSM modem and GPS receiver and a parallel connection to the gas sensors. The connection between the gas sensors and the PIC16F877A microcontroller can't be made directly because of the very small output voltages provided by the sensors (mA). This problem is solved by using auxiliary electronic circuits for signal conversion like OA (Operational Amplifiers) and transistors.

2. Sensors Array

The sensor array consists of three air pollutions sensors including Carbon Dioxide (CO2), Nitrogen Dioxide (NO2), and Sulphur Dioxide (SO2). The resolution of these sensors is sufficient for pollution monitoring. Each of the above sensors has a linear current output in the range of 4 mA–20 mA. The 4 mA output corresponds to zero-level gas and the 20 mA corresponds to the maximum gas level. A simple signal conditioning circuit is designed to convert the 4 mA–20 mA range into 0–5 V to be compatible with the voltage range of the built-in analog-to-digital converter in the PIC microcontroller.

3. GPS Receiver

The GPS module provides the physical coordinate location of the mobile-DAQ, time and date in National Marine Electronics Association (NMEA) format. NEMA format includes the complete position, velocity, and time computed by a GPS receiver where the position is given in latitude and longitude. The data packet from the GPS-Module includes an RMS Header followed by UTC time, data validity checksum, latitude, longitude, velocity, heading, date, magnetic

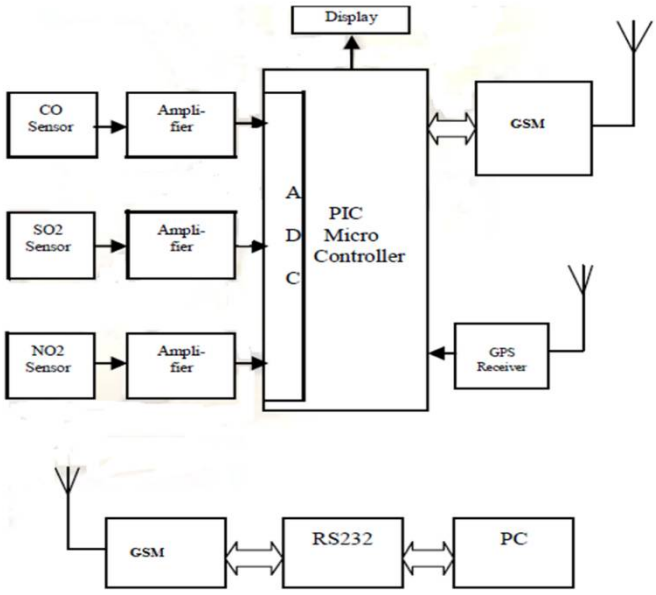

Figure 3: Block Diagram of Proposed Air Quality Monitoring System

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variation and direction, mode, and checksum. The only information required for the proposed system is date, time, latitude and longitude. The GPS modem is interfaced with the microcontroller using the RS-232 communication standard.

4. GSM Modem

The GSM net used by cell phones provides a low cost, long range, wireless communication channel for applications that need connectivity rather than high data rates. Machinery such as industrial refrigerators and freezers, HVAC, vending machines, vehicle service etc. could benefit from being connected to a GSM system. This application note describes how to use an AVR to control a GSM modem in a cellular phone. The interface between modem and host is a textual protocol called Hayes AT-Commands. These commands enable phone setup, dialling, text messaging etc. This particular application connects an AVR Butterfly and Siemens® M65 cellular phone using a RS232 based data cable. Most cellular phones could be used, except Nokia® phones using F or M-bus.

5. Central Server

The Central-Server is an off-the-shelf standard personal computer with accessibility to the Internet. The Pollution-Server is connected to the GSM Modem via RS- 232 communication standard. The air pollution information sent from GSM transmitter is collected to the GSM receiver and then the data is saved to database of central server.

Clients such as the municipality, environmental protection agencies, travel agencies, insurance companies and tourist companies can connect to the Central-Server through the Internet and check the real-time air pollutants level using a normal browser on a standard PC or a mobile device. The Pollution- Server can be physically located at the Environmental Protection Agency (EPA) or similar government agencies.

V. SOFTWARE MODULE

The program is written in Embedded C in MPLAB IDE. MPLAB is an Integrated Development Environment (IDE) for the development of embedded applications on PIC microcontrollers and is developed by microchip technology. MPLAB support project management, code editing, debugging and programming of Microchip 8-bit,16-bit and 32-bit microcontrollers. The HEX file is dumped into the PIC 16F877 microcontroller using Top Win programmer

VI. RESULT ANALYSIS AND DISCUSSION

The gas sensor senses the pollutant levels in an area and the data is sent to MCU. Crystal-oscillator generates frequency of 11.0952MHz used for operation, the data is stored in EPROM chip which is simultaneously displayed on LCD. Microcontroller stores the digital data after converting the analog data from sensor unit through ADC, for some delay unit of time and resets the reading in MCU as well as in LCD.

After the sensors sense the pollutant levels, the LCD displays the output as shown in figure 3.

Figure 3: LCD frame showing pollutant levels

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After the data has been processed by PIC and transmitted over the GSM, it is fed to the database and the pollutant levels are displayed on the front end created in visual basic.
The following figure 4 is of a VB frame showing the pollutant levels.

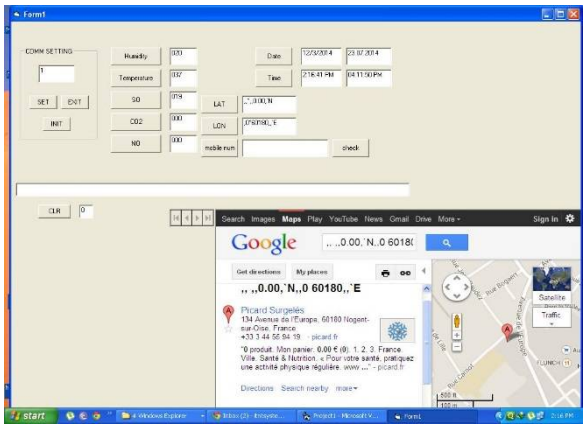

Figure 4: VB frame

VII.CONCLUSION

The project deals with designing a simple and low cost weather monitoring system using gas sensors, LCD JHD204A,GSM SIM900 and PIC 16F877 microcontroller unit to monitor the quality of air of the desired location and transmit it to a distant location wirelessly. The designed product module is at prelim stage and designed only for air quality monitoring but can be enhanced for monitoring other different type of environmental and climatic behaviour of a location, which also can be cost effective.

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