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ATmega328 MC Based Air Pollution Monitoring System

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Abstract: ***With increasing urbanization, air pollution monitoring is emerging as one of the global challenges of critical importance, as air contamination leads to multitude of adverse effects on environment, ecosystem and human health. Air pollution poses a health hazard and causes millions of deaths all over the world, every year. Air pollution monitoring is represented by a standard parameter known as Air Quality Index (AQI). The major limitation of the air pollution monitoring is that there are limited number of pollution monitoring stations. Any gas can be termed as a pollutant when it reaches high enough concentration to harm the living beings, flora and fauna on earth. The present work proposes to monitor air pollution due to major pollutants such as CO_2, NO_2, CO, dust, methane and propane on a continuous basis. The sensors which are electrochemical are used for monitoring air pollutants, with the sensors interfaced to the ATmega 328MC controller based Arduino Uno board. Arduino IDE and LabVIEW are used as a software toolkit for coding. Theconcentration of pollutants in PPM (Parts per Million) are displayed on LCD. This helps in disseminating awareness about air quality to general public to enable them to take necessary preventive and curative measures for their well-being.***

Keywords: ATmega328 MC, Electrochemical Sensors, Arduino IDE, LabVIEW.

I. INTRODUCTION

Air pollution is one of the critical problems resulting due to fast-growingpopulation and urbanization in most parts of the country. Air pollution is characterized as the presence of poisonous synthetic substances or mixture of substances in air, at concentrations that poses a health hazard. For example, global warming is caused due to ozone layer depletion due toincrease inconcentration of pollutants**.** Further**,** various gases are connected to the cause of "Greenhouse Effect", where gases retain more heat and increase the temperature resulting in global warming[1].The Air Quality Index (AQI) is a parameter used by government agencies to educate people about pollutants and its concentration levels. AQI is proportional to concentration of the pollutants and is represented as numbers counting from 1 to 10. The number 10 indicates high level concentration of pollutants, posing risk to human health. The major limitation of the air pollution monitoring is that there is a limited number of pollution monitoring stations used in laboratories with complex equipment technology [2]. The major pollutant that causes ozone layer depletion is CO_2 generated by numerous processes. Another example of hazardous gas is methane.For human health, safety medical standards has been proposed that, pure air is a combination of gases, which consist of about 78% nitrogen, 21% oxygen and less than 1% CO_2,and other gases [3]. The air pollutants can be solids, liquids, or gases and can be natural or man-made and may be primary or secondary, which are emitted directly or indirectly. Primary pollutants are formed from a process, such as motor vehicle exhausts consisting of CO gas. Secondary pollutants are indirectly emitted by forming a layer in air and interacting with the primary pollutants. Ground level ozone is an example of a secondary pollutant. In developing countries, air pollution has significant implicationson public health, environment and economy at large.Studies have shown the importance of having knowledge of small level pollution information and human exposure to those air pollutants. Due to less availability of conventional monitoring systems of air pollutionand limited data, a real time system with high space and time resolution is needed [4].

A wireless system is proposed for the measurement ofthe levels of hydrogen sulphide (H_2S), temperature, and humidity [5]. A comprehensive pollution monitoring system is needed to sense a wide range of pollutants like CO_2, NO_2, CO, dust, methane and propane on a continuous basis.

The proposed work aims to develop a pollution monitoring system that monitors air pollutants continuously,making the overall system flexible and feasible. This enables easy communication with the system to take precautionary measures in order to avoid health hazards.

The paper is organized as follows: Section II introduces the hardware and software requirements and their integration to develop the air pollution monitoring system. While Section III describes the experimental setup of the proposed system, Section IV presents results and discussion. Section V outlines the conclusions of the work.

II. AIR POLLUTION MONITORING SYSTEM (APMS)

A portable device is designed and developed to measure the concentrations of air pollutants in any location, or floor of an industry. The measurements are taken using different electrochemical sensors in terms of parts per million (PPM).

While Arduino Uno controller provides the interface with electrochemical sensors, the LabVIEW tool kit

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interface with the computer system. The results are simulated in Arduino IDE and are displayed in front panel of LabVIEW using serial data communication.The block diagram of Air Pollution Monitoring System (APMS) consisting of an array of electrochemical sensors is as shown in Figure 1.

A. APMS: Hardware:

1) Arduino Uno:

Arduino Uno, designed around ATmega328 microcontroller,is a single board microcontroller interactive with its surroundings and is open source hardware. It has 14 computerized I/O pins of which 6 can be utilized as Pulse Width Modulation outputs, an In-Circuit Serial Programming (ICSP) header, USB, 6 analog inputs, and a reset. The board is associated with a PC connected to AC-to-DC converter or battery or USB link.

2) MQ2 Sensor:

MQ2 gas sensor is used to detect the presence of Liquid Petroleum Gas (LPG), Propane, Hydrogen, Methane and other inflammable steam. Sensor is reactive to combustible gases and smoke. Smoke sensor is given 5 V to power up and generates an output voltage that is proportional to the amount of smoke in its vicinity. The sensitivity of the sensor can be controlled using a potentiometer. The sensor is coated with SnO_2 which is of high resistivity when air is absent, gives an analog resistive output in the presence of smoke.

Fig. 1. Block Diagram of Air Pollution Monitoring System

3) NO_2 Sensor:

The NO_2sensor has a silicon pellistor (combination of pellet and resistor) structure consisting of two embedded planar heater meanders coated with noble metal catalyst and are fixed with a pair of micro machined diaphragms for detection and compensation. Meander provides a two-way application i.e., it acts as a resistance thermometer and an electrical radiator. The device is fixed on PCB using a wirewhose open end is encompassed within a plastic. When the sensor temperature is raised to around 400 – 500°C, the sensor interacts with the combustible gas and the device gets heated up even more.

The heating of meander is influenced by the variations in thermal conductivity and temperature of air in the presence of inert gases like CO_2. To compensate for the temperature changes and to avoid oxidation of combustible gas, a second latent device is utilized. The compensator is made similar to detector device to incorporate a catalyst in the covering layer, to avoid oxidation. To identify the difference in their resistances, two devices having diverse emissivity are utilized in circuit to output a unique slope resistance. To acquire the best temperature execution, parallel connection of compensator and a resistor is preferred.

4) CO_2 Infrared Sensor:

The CO_2 infrared sensor, enclosed within a carbon dioxide analyser,works on the principle of photoionization where the concentration of gas is proportional to the amount of infrared light absorbed. There is insufficient energy of photons to cause ionization, hence the energy is converted to kinetic energy which heats the gas and increases the speed of the molecules.

5) Dust Sensor:

An optical dust sensor is designed to sense dust particles in which a diagonal arrangement of phototransistor and an infrared emitting diode is made to detect the light reflected by the dust in air. It detects fine particles like ash, chalk powder and is used in air purifier systems. The dust sensor produces an analogoutputvoltage proportional to measured dust density, with a sensitivity of 0.5V/0.1mg / m^3 and with a pulse pattern thatdistinguishes smoke from house dust.

6) Liquid Crystal Display (LCD):

A 16 X 2 LCDdisplays each character as 5 X 7-pixel matrixhaving 16 characters per line of total two lines.

B. APMS: Software:

1) Arduino Integrated Development Environment (IDE) Software:

Arduino software is easy to code and edit. Embedded C programming is used for coding in Arduino IDE and gives access to a large Arduino library.

2) LabVIEW:

LabVIEW graphical programming is used for automated test applications like Data Acquisition (DAQ), debugging, automated multithreading

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application, hardware management and interface and application user interface.

The LabVIEW block diagram of APMS is shown in Figure 2 and Figure 3. In LabVIEW, graphic results are obtained on the front panel for results analysis.Figure 4 shows the front panel window of APMS which acts as user interface for Virtual Instruments (VI) and has controls and indicators.

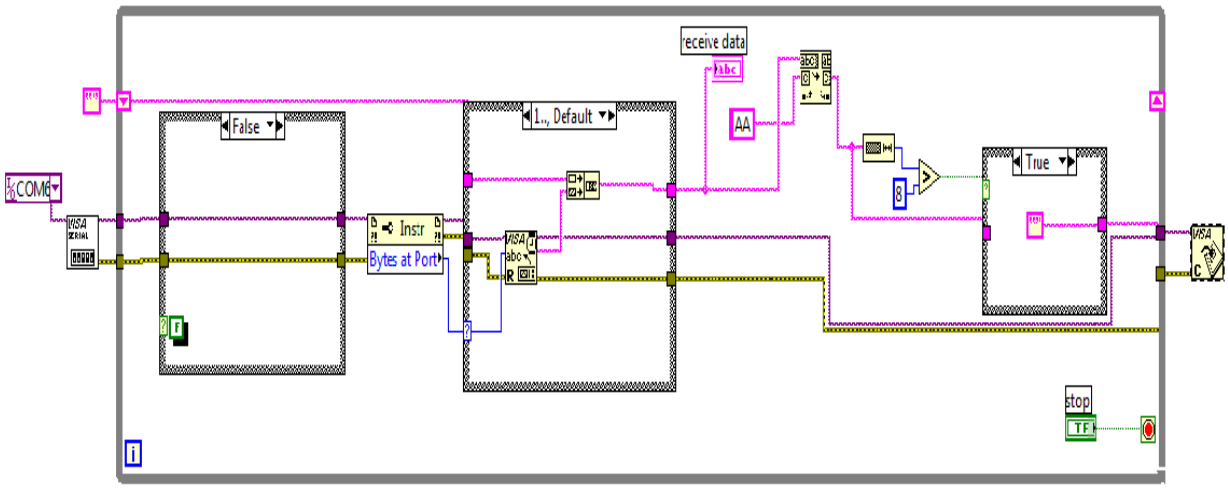

Fig. 2. LabVIEW Block Diagram of Air Pollution Monitoring System

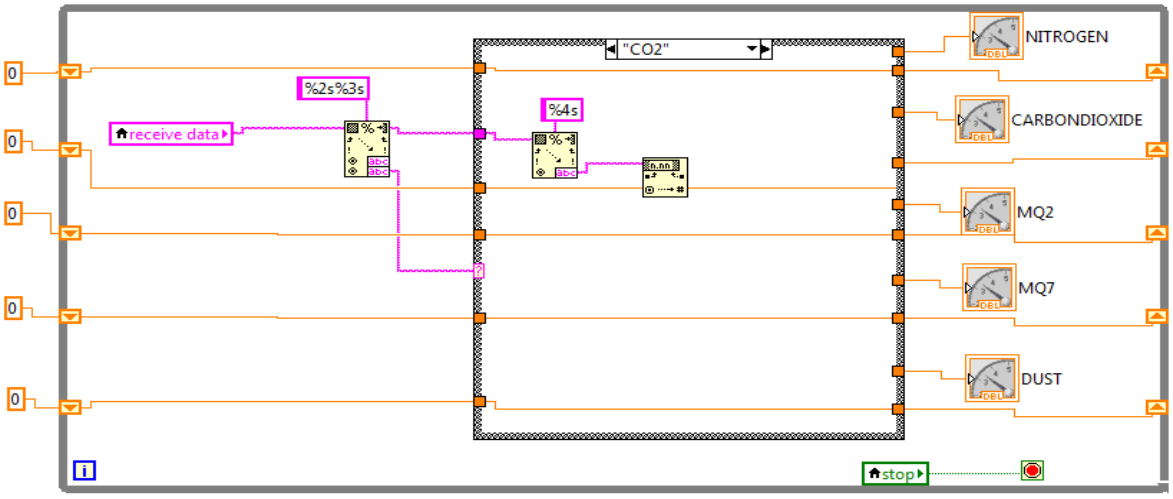

Fig. 3. LabVIEW Block Diagram of Air Pollution Monitoring System for Different Gases

Fig. 4. LabVIEW Front Panel of APMS

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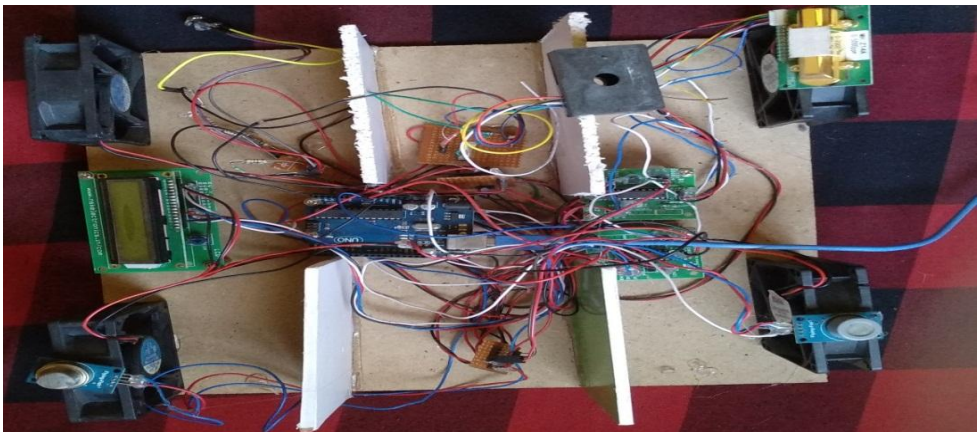

Fig. 5. Hardware Model of Air Pollution Monitoring System

III. APMS: EXPERIMENTAL SETUP

A prototype of the APMS is shown in the Figure 5. The air pollutants that are monitored are methane and propanecalibrated in one MQ2 sensor, CO calibrated in MQ7 sensor, CO_2 calibrated in MH-Z14A sensor, NO_2 calibrated in Mics-2714 and the dust calibrated in GP2Y1010AU0F. The sensors are interfaced to the Arduino Uno controller using Arduino IDE software and the output is visualized in serial monitoring window along with LCD. Furthermore, the serial data fromthe Arduino IDE is passed on to the LabVIEW software tool for the graphic display of the pollutant and the output is visualized in serial monitoring window along with LCD.

IV. RESULTS AND DISCUSSION

Fig. 6. Display of Concentration of Various Gases on APMS

The concentration of air pollutants such as CO, CO_2, methane, propane, NO_2 and dust are displayed in 16X2 LCD. The system continuously monitors the variations in gas concentrations and displays the results. In Figure 6, the gas concentrations are displayed such that NO_2 is 5792 PPM, MQ2 (Methane and propane) is 39 PPM, MQ7 (CO) is 80PPM, CO_2 is 805 PPM.The pollutant values are obtained from a location in Bangalore 10 A.M. Figure 7 shows the bar chart presentation of pollution levels. The pollution levels at any location and time can be obtained with the APMS portable device.

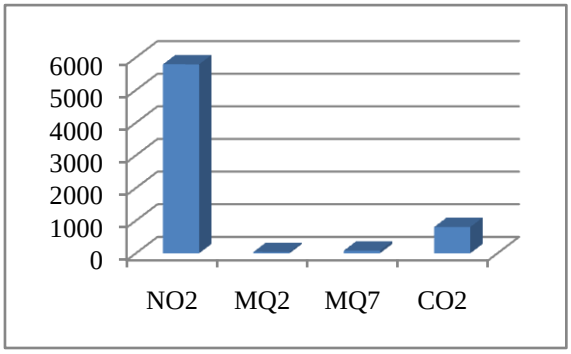

Fig. 7. Concentrations of Various Gases at Bengaluru

V. CONCLUSIONS

A prototype of Air Pollution Monitoring System (APMS) is developed to monitor the pollution levels and its working is successfully demonstrated.The concentrations of pollutants such as CO, CO_2, methane, propane, NO_2, and dustin a location in Bengaluru are displayed onAPMS.The proposed APMS generates real-time data so that environmental parameters can be stored in a database and analysed. This data can be of immense value for policy formulation by Government.Continuous display of pollution levels in various locations in a city and at different times of the day can bring in awareness among the general public.

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