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Design of Gas Detection and Monitoring System using IoT

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***Abstract*— This system is used to identify various gases present in the atmosphere with concentration in ppm. It receives data from three gas sensors MQ-2, MQ-4 and MQ-135 is able to measure up to ten different gases. It gives alarm when gas concentration is above threshold value and also sends notification to mobile through sms with the help of GSM module. If the user is unable to react in time and the gas concentration keeps on increasing and reaches dangerous level then it automatically shuts-off the valve in order to prevent further damage. This system includes Global positioning system so that user can collect the data along with position which can be used to study the air quality index of different locations. Data collected from these sensors are uploaded to the server time to time using ESP 8266 wifi module. By using Thingspeak software open source analysis platform, data can be viewed by the user at any time using internet browser. Thingspeak software generates unique Read and write codes used by arduino program to upload the data via wifi module and internet. It also generates an unique channel id used in Virtuino app so that user can observe the concentration of various gases when required through mobile.**

Keywords :Air Quality, Arduino Mega, DHT11, Gas Concentration, Gas sensors MQ135, MQ2, MQ4, GPS Module, GSM Module, Power Regression, Sensitivity Characteristics Graph, WiFi(ESP8266),

1. INTRODUCTION

Nowadays the air condition is very polluted. In recent years car emissions, chemicals, from factories, smoke and dust are everywhere. To provide adequate environmental and health protection, an effective air quality monitoring system is necessary. This system is simple, reliable and high sensitive to low concentration of gaseous air contaminants such as hydrogen, carbon monoxide, smoke, LPG, CH_4...etc. This system finds out which amount of the air is getting polluted. User can monitor the air pollution remotely with the help of wifi module and internet.

At present as the use of gases and fuels at home and in industries increases, the number of accident that occurs as a result also increases. These accidents are occurred from gas pipelines and gas cylinders. If a cylinder is not maintained or properly monitored, gas leakage from its body or valve may occur in the whole kitchen, room or area. [2] Thus a little spark can ignite which leads to explosion. Therefore proper monitoring and maintenance is a must to avoid these kinds of accidents. Prevention is always better than cure. So a system is implemented through this monitoring, user can identify the danger of an area and takes necessary actions. Especially by using the wireless monitoring it works more affective. In remote areas users need not to go there and examine. This system keeps on monitoring the air quality in terms of concentration of the gases present in the atmosphere. This system can be used in open areas for air quality measurement, it can also be used in home and industrial applications. By measuring the combustible gases i.e. LPG & CNG concentration in industries and home applications users can able to detect the leakage, once the concentration of these combustion gases are more than the normal condition, there might be a leakage. Even if the leakage is in remote location in industries or when no one is there in home and if any leakage occurs, this system keep on measuring the concentration of the gases and once the gas concentration reaches the threshold value then it will immediately send an sms alert to the user and also triggers the alarm so that user can take care of the situation before it leads to accident. Even if the user is unable to react fast or leakage rate is very high, then this system immediately shuts off the valve when the gas concentration is at dangerous level.

II. PROPOSED SYSTEM

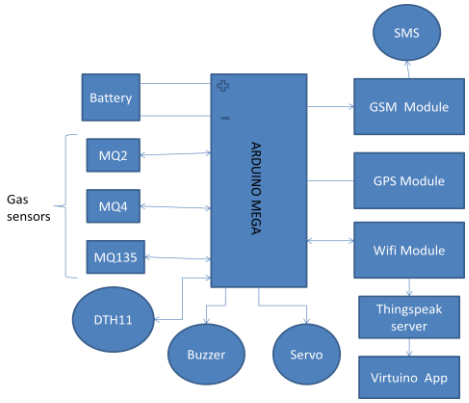

Fig 1 Block Diagram

Fig 1 shows the block diagram of the system. For the detection of Temperature and Humidity DTH 11sensor is used[3] , while MQ2,MQ4 & MQ135 gas sensors are used to detect the concentration of LPG, Alcohol, Propane, Hydrogen, CO and methane, NH4, smoke, CH4. ESP 8266 WIFI module is used for wireless data

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communication between Arduino and Thingpeak server, while GPS module was used to indicate the location from where the values are taken. GSM module sends the notification through an sms. It also has an onsite alarm to alert the user. When the gas concentration reaches dangerous level it will automatically shuts off the valve.

When the gas concentration reaches the threshold values used in the program then it will send an sms alert to the user, so the user will be aware of the situation and takes necessary action to prevent the damage.

SIM900A is a GSM module that functions like phone. It can send a message, call a phone number and use GPRS to send data. A GSM MODEM comprises of a GSM Module along with some other components like communication interface, power supply and some indicators. With the help of this communication interface, we can connect the GSM Module on the GSM MODEM with an external computer (or a microcontroller). [4] SIM900A uses AT command to communicate and control the module. This means if you want to control SIM900A with arduino. The arduino should give an AT Command to control it. AT Command in SIM900A uses Serial port to communicate. As usual, serial needs two pins that is Transmitter (Tx) and a Receiver (Rx). AT command is a command that begin with "AT.

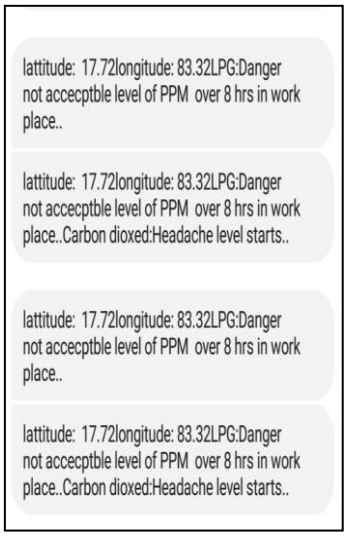


Fig 2.Mobile notification

III. OPERATION

Gas Concentration Detection

When the system was powered up, the computer program continuously asks for the status of the sensor. The program is designed to get the output voltage of each sensor from the microcontroller and calculate each gas concentration and upload it to the server via wifi module.

Gas Sensor

MQ-2, MQ-4 & MQ-135[7] Gas Sensors are designed to detect or measure the following gases: LPG, Alcohol, Propane, Hydrogen, CO and methane, NH4, smoke, CH4. The sensor based module version has a digital pin and an analog pin which is TTL driven and works on 5V. For the measurement of a particular gas or multiple gases, read the analog values with the analog pin of the module (0-5V). The analog output voltage provided by the sensor changes in proportional to the concentration of smoke/gas. The greater the gas concentration, higher the output voltage, while lesser gas concentration results in low output voltage.

Arduino reads analog voltage from the sensor, Arduino has 10 bit converter means there are 1024 distinct values. i.e 2^{10}=1024

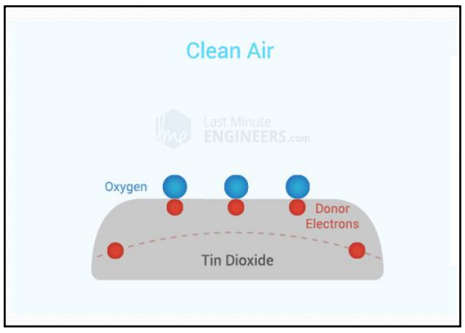
Output value= (Input value/1023)*Max Output value.

Here we are mapping output voltage (0-5V) into integer value between 0 and 1023.Ex (511.5/1023)*5=2.5V.

a)Sensing materials:

The tubular sensing element inside the sensor is made up of Aluminum Oxide (AL2O3) based ceramic and has a coating of Tin Dioxide (SnO2) [6]. The Tin Dioxide is the most important material being sensitive towards combustible gases. However, the ceramic substrate merely increases heating efficiency and ensures the sensor area is heated to a working temperature constantly. So, the Nickel-Chromium coil and Aluminum Oxide based ceramic forms a Heating System, while Platinum wires and coating of Tin Dioxide forms a Sensing System.

b) Actual working principle of the sensor: When tin dioxide (semiconductor particles) is heated in air at high temperature, oxygen is adsorbed on the surface. In clean air, donor electrons in tin dioxide are attracted toward oxygen which is absorbed on the surface of the sensing material. This prevents electric current flow. In the presence of reducing gases, the surface density of absorbed oxygen decreases as it reacts with the reducing gases. Electrons are then released into the tin dioxide, allowing current to flow freely through the sensor.



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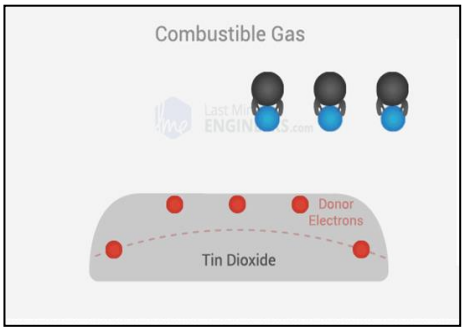
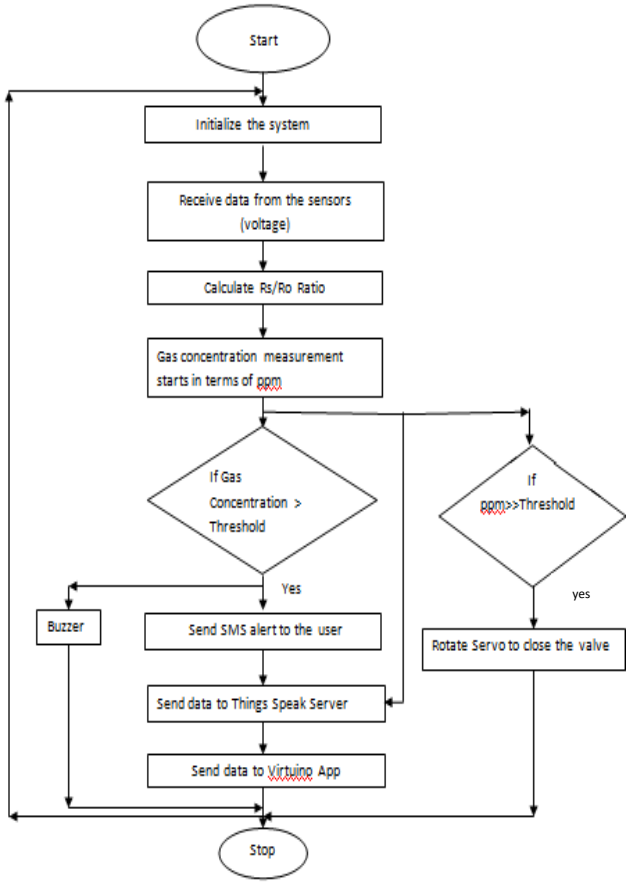


Fig 3. Gas Sensor Working

Flowchart for proposed system



1V. SENSOR AND NETWORK DESIGN

Gas Measurement Approaches : The measure of a particular gas or multiple gases requires some sophisticated approaches. To measure gas concentration in ppm. Following steps has been followed.

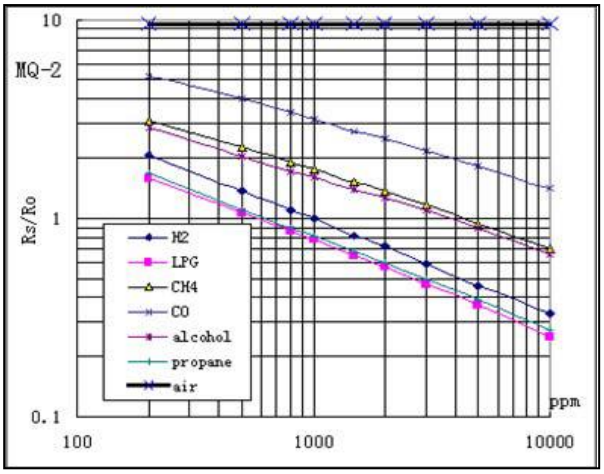


Fig 5. Sensitivity Characteristics of the Gas sensor

i) Analysis of MQ2 gas sensor graph[5]

Above the fig shows the sensitivity characteristics to different gases. From this we can observe that two parameters are used to form these curve. The concentration of different gases is expressed in ppm with respect to Rs/Ro value. X axis represents gas concentration in ppm while y- axis represents. Rs represent resistance of the sensor and Ro represents the resistance of the clear air.

CALCULATION

By determine the value of Rs/Ro ratio of gas we can compare with the curve of a corresponding gas. It involves two steps; the first one is determination of Ro that is the resistance of the surrounding air. The Ro is determined by dividing Rs that is sensed resistance of the surrounding air with the Ro that is resistance of the clear air which is 9.5 for MQ2 gas sensor:

$$\therefore \text{Ro} = \frac{\text{Rs of the surrounding air}}{\text{Ro of the clear air}} \quad \ldots\ldots\ldots (1)$$

The Rs is determined using following equation:

$$\therefore \text{Rs} = (\text{Vc}/\text{VRL}-1)\times\text{RL} \quad \text{(from data sheet)} \quad \ldots\ldots(2)$$

Finally the ratio that is Rs/R0 is determined. It describes the behaviour of the sensor at different gas concentration. From the sensitivity characteristics for every gas curve we note down different points an equation can be derived. The values in table correspond to Rs/Ro with respective to ppm. [5]

Here we take propane sensitivity characteristics as an example. For all the remaining gases the procedure is same.

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Gas Concentration in ppm	Rs/Ro Ratio
200	1.6
500	1.1
800	0.85
1000	0.8
2000	0.6
3000	0.5
5000	0.38
10000	0.26

Table 1.MQ-2 Sensitivity characteristics to Propane

After extracting the values from sensitivity curve it was observed that power function gets the best fit for the extracted data. By using excel we draw the curve for the above values. The trend line shows the closest equation that describes the curve.

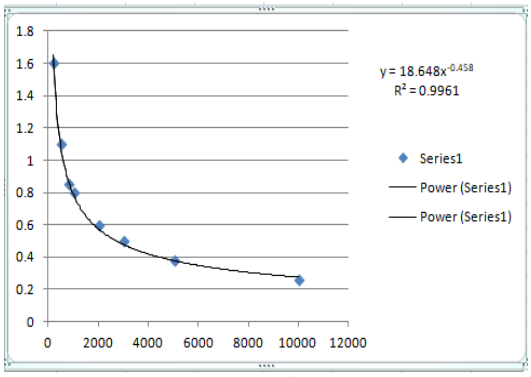

Fig 6.Trendline for Propane

By using this power regression we can relate the relation between two variables Rs/Ro and ppm. We programmed in such a way arduino receive the signal from the gas sensors and produces a voltage proportion to the gas concentration. Then convert this voltage in to resistance of sensor Rs then find out the ratio Rs/Ro.by substituting the Rs/Ro value in the equation obtained from the trend line we can find out the concentration of the gas in ppm.

Equation obtained from trend line $y = 18.648x^{-0.458}$ here y represents Rs/Ro and x represents gas concentration in ppm. We need gas concentration after re arranging the equation we get

$$ppm = \left(\frac{Rs/Ro}{18.648}\right)^{\frac{1}{-0.458}} \quad \text{.....(3)}$$

The general sensitivity is roughly same for all the gases detected by the sensors. For better results gas sensors must be pre heated for 48 hours.

$$R^2 = 0.9961$$

R squared is an indicator of how well our data fits the model of regression. It is square of the correlation co efficient r. If R^2 of 1 indicates that the regression predictions perfectly fit the data.0.9961 indicates very strong correlation in the equation. More closer to the value 1 has best correlation. Same procedure carried out for all the gas and extracted the formula using power regression.

V.INTERNET OF THINGS

Internet of Things (IoT) describes an emerging trend where a large number of embedded devices (things) are connected to the Internet. These connected devices communicate with people and other things and often provide sensor data to cloud storage and cloud computing resources where the data is processed and analyzed to gain important insights. Cheap cloud computing power and increased device connectivity is enabling this trend.

a)ThingSpeak

ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. With the ability to execute MATLAB® code in ThingSpeak you can perform online analysis and processing of the data as it comes in. ThingSpeak is often used for prototyping and proof of concept IoT systems that require analytics. In thing peak we create a new channel for our project. In that we need to select what are the fields to be displayed for analysis using Matlab it also perform multiple parameter plot. It generates unique read code, write code and channel id. We programmed our arduino in such a way to use these codes generated in think speak to upload the data via wifi module and internet. We can observe through web or we can also import this data for further analysis.

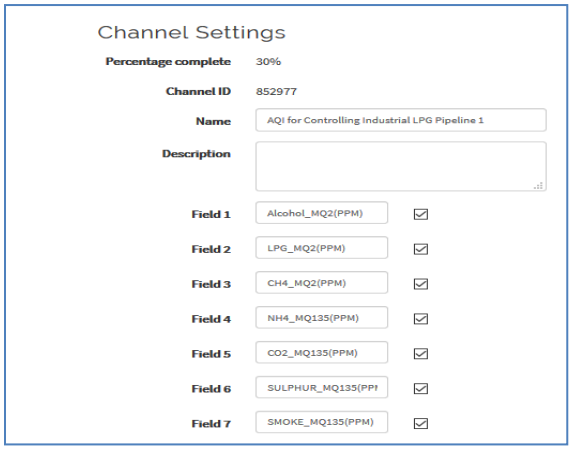

Fig 7.Thing speak channel setting

b)Virtuino App

Virtuino is an Android app for monitoring sensors or control electrical devices via Bluetooth, local wifi or Internet.Control at the same time more than one Arduino boards Visualize your Arduino project.Create visual interfaces with widgets like LEDs, buttons, switches, value displays, instruments, regulators etc.

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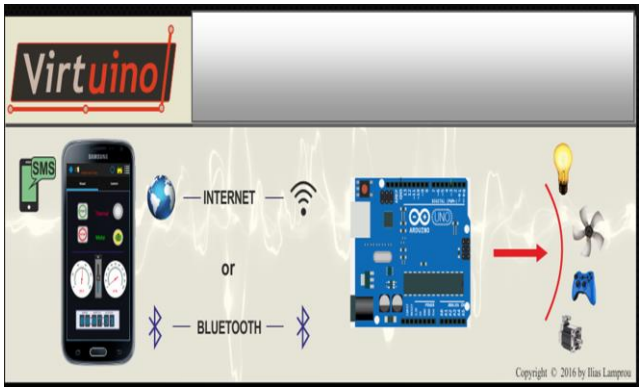


Fig 8. Virtuino App

3)Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs),16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

d)Wifi Module

ESP8266 is a UART to WiFi module which provides an easy way to connect any small Microcontroller platform like Arduino to Internet wirelessly. Since ESP8266 super cheap, and super easy to work with it become one of the leading platforms for the Internet of Things. You can use AT commands to connect to WiFi networks and open TCP connections without running TCP/IP stack. It also includes 32Bit Microcontroller which can be programmed to act as a standalone WiFi connected Embedded Platform.

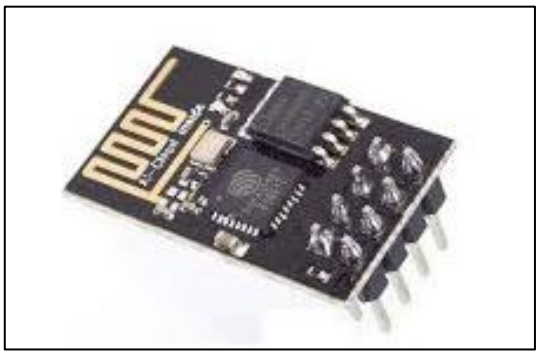
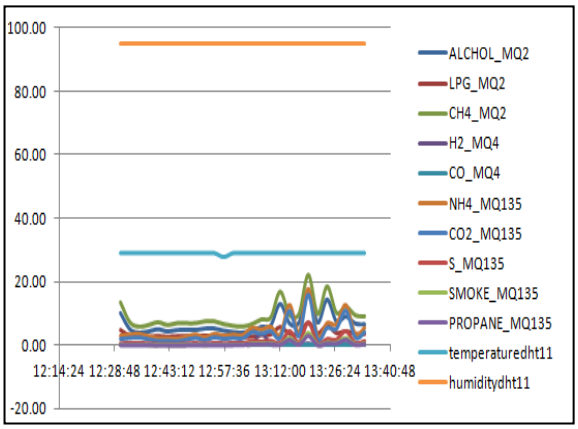
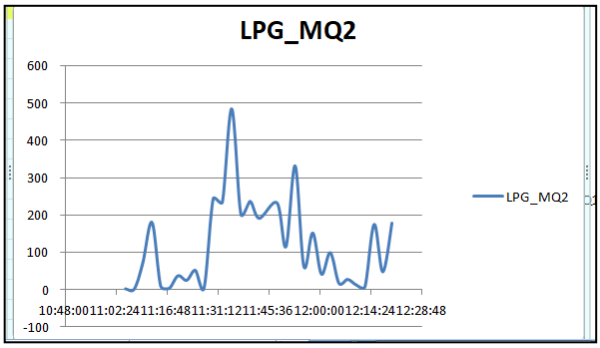


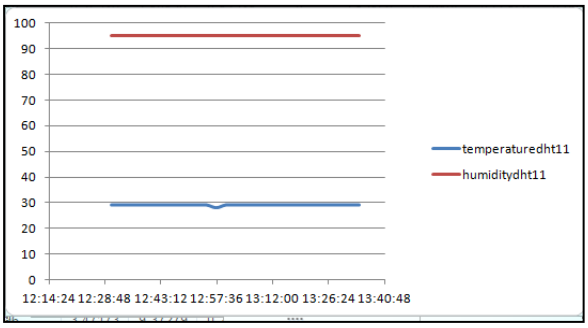
Fig 9. Wifi Module

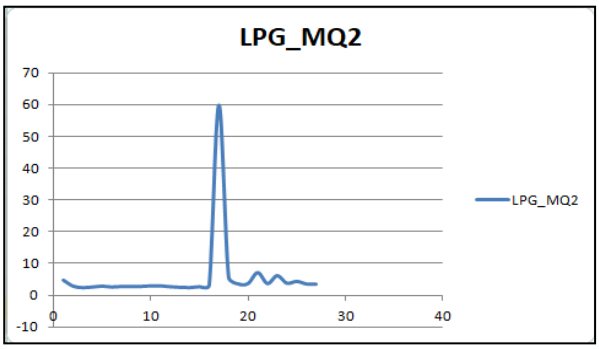
VI.RESULT

The below graphs represent the response of the system detection. The amount of gas present in the environment is detected by the sensor as an amount of concentration with respect to time. [8] This detection depends how far the sensor is from gas source. Samples are taken in normal room atmosphere and also with available sources for test like portable cigarette lighter & mosquito coil.









VII. CONCLUSION

The developed air quality monitoring and visualization system accurately measured the concentration of pollutants in atmosphere. The sensor has been integrated with IoT framework which has efficiently been used to measure and monitor the pollutants in real time. The data's are automatically stored in the database; this information can be used by the authorities to take prompt

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actions. It also helps the normal people to know about the amount of pollutants in their area. It also notifies the user through SMS if the gas concentration is more than normal condition it also shut off the valve when concentration reaches to dangerous level without further damage. It is able to successfully detect temperature and humidity which can be used for further study. This system is portable with battery power so that user can carry it to any place. System is reliable in handling hazards within the concerned area. User can find out the air quality at any location it is also included with GPS module. So if user takes readings at different locations it can be used compare air quality among different locations. It also gives access to the user to keep an eye on the hazardous location where frequent manual check is not possible.

VIII. FUTURE SCOPE

This system is monitoring only ten gases and hence can be expanded by considering more parameters that cause the pollution especially by the industries. By uploading on the webpage for the common man, it helps them to know about the pollution in their area. This system consumes more power, by replacing the power source with an solar power then it will definitely improve the reliability of the system.

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