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Indoor Air Quality Monitoring System using IoT: A Review

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Abstract

Air quality monitoring systems can be used in any place like office, home, industries, mines etcin offices the air quality decreases due to the constant use of devices like PCs, laptops, printers release a lot of CO2 and very minute quantities of other harmful gases like CFCs In places like coal mines specific harmful gases like CO, H2S are released which can cause death even with very less exposure. They can be used in Hospitals, ICUs to monitor the air for particles of any infectious diseases and also in Agriculture to check for harmful particulates. They can be attached to devices like air purifiers, vents, exhaust fans to automatically purify the air in a place. The MQ135 sensor provides the PPM which is in our surroundings, MQ2 CO sensor and MQ7 gives a signal if CO or any flammable gases are present. Node MCU is a cheap module which has WIFI built into it. 2 Node MCUs are used so that they can connect wirelessly as WIFI server and client and enable the wireless connection of sensors and LEDs which will represent door exhaust fans etc., Thing speak will be used to upload the data into cloud.

Keywords: *IAQ; Indoor Air Quality; Harmful gases; MQ2;MQ7; MQ135; Node MCU ;WIFI server.*

1. Introduction

As the pollution levels are increasing, % of harmful gases in the atmosphere are increasing which even affect the indoor environment average person spends most of their time indoors so poor indoor air quality (IAQ) poses a great risk to their health.We are using many devices in our home, work environment etc which release harmful gases hence decreasing the quality of air indoors Prolonged inhalation of these harmful gases may cause problems like nausea, fatigue, lung cancer and other diseases.

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Each year there is a loss of production due to the presence of harmful gases in work environment. Air quality systems are very essential to monitor the quality of air and take measures whenever the air quality reaches an undesirable state in a home, office or any other work place, these systems can warn us whenever there is a poisonous gas leaks in a building or whenever these is a fire and take measures.

In both developed and developing countries, prolonged exposure to low-quality air is a major public-health risk. Pollutants linked to poor air quality are said to be responsible for almost 2.5 million untimely deaths per year all over the world. Almost 1.5 million of these deaths are due to contaminated indoor air, and it is estimated that more than half of the world's population is exposed to poor indoor air quality. Because of its link to industrialisation, public health issues linked with poor air quality immoderately affect different countries air pollution is believed to be responsible for one-third of all premature deaths. Once airborne pollutants have been identified, taking remedial action to enhance air quality is frequently simple.

2. Existing Work

In Control & Automation (ICCA), 2017 13th IEEE International Conference, Xiaoke Yang, Lingyu Yang, and Jing Zhang proposed A WiFi-enabled indoor air quality monitoring and control system [1]. The paper presents us with an economical air quality monitoring system powered by solar energy using ZigBee. Schools can use this system to sense CO, NO2, dust particles, temperature and humidity in real time. This system allows schools to monitor air quality of the surroundings using desktop or laptops using a LabVIEW-based application, and it sends out an alarm if the air quality parameters are over permitted ranges. The sensor network's testing results showed that it can give accurate air quality readings over a wide range of CO, NO2, and dust concentrations.

M.F.M Firdhous, B.H Sudantha, and P.M Karunaratne proposed an IoT enabled proactive indoor air quality monitoring system for sustainable health management [2]. The paper introduces us to a indoor air quality monitoring system which sense and track ozone concentrations at the vicinity of a photocopy machine using IOT. An experimental device which has a semiconductor which can detect ozone was placed near a photocopy machine. This system has been set up to collect and transmit data to a gateway through Bluetooth every

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5 minutes, which communicates with a processing node through WIFI. The sensor is calibrated using industry-standard methods. The suggested air pollution control system has an additional capability when pollution levels exceed a predefined threshold value, it gives a warning

R du Plessis, A Kumar, and GP Hancke have put forward a proposal in the Industrial Electronics Society, IECON 2016 - 42nd Annual Conference of the IEEE, A wireless system for indoor air quality monitoring [3], This paper tells us about a wireless air quality monitoring system that is placed in a closed space to detect CO2, CO, temperature and measure them with the help of their system. This system can be used as a monitoring component in a HVAC system or can be used as a standalone air quality monitoring system.

Sujuan Liu, Chuyu Xia, and Zhenzhen Zhao have put forward a proposal. This work proposes a power efficient real time air quality monitoring system based on LoRa at Solid-State and integrated circuit technology (ICSICT), 2016 13th IEEE International Conference. This system can be installed at various locations at monitoring area to establish a sensor network. A single-chip MCU, various particle and gas detecting sensors, a solar battery, and a GUI are included in the system. As LoRa transmits data to central monitoring unit, which is subsequently saved in the range of about 2 kilometers, according to range testing conducted in an open environment. The TX power is about 110mA, which is far lower than other wireless technologies. The system has a user-friendly graphical user interface. The system is economical, has high coverage, with a long device battery life, and it is easy to operate, the system is based on LoRa technology, GUI, and Solar PV- battery portion. The goal of this paper is to present a model that can asses the health impacts caused by indoor and outdoor air pollutants, as well as informing the human in advance about the risk they can face. This work is being focused on allergic patients because they can be alerted about the risks in advance, allowing them to protect themselves with necessary precautions. The design includes sensing, processing, power, display, and a communication unit, among other things. By using sensors to measure Air Quality Parameters, this effort will combine electrical engineering approaches with environmental engineering understanding.

Sneha Jangid and Sandeep Sharma proposed an embedded system solution for air quality monitoring in the 2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom) [5]. The purpose of this study is to propose a system model that

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can be used to assess the health effects of indoor and outdoor air pollution, as well as to inform individuals about the risks they may face. We're focusing our efforts on allergy patients because this model will inform them.

3. Proposed Work

The Air quality monitoring is done with only the MQ135 sensor and with an extra sensor which only monitors and displays the air quality in our work we want to add a new feature that is to use components like doors exhaust fans wirelessly so that these components will do their work whenever a certain pollution threshold has crossed, while uploading the pollution level data to thing speak cloud.

4. Block diagram

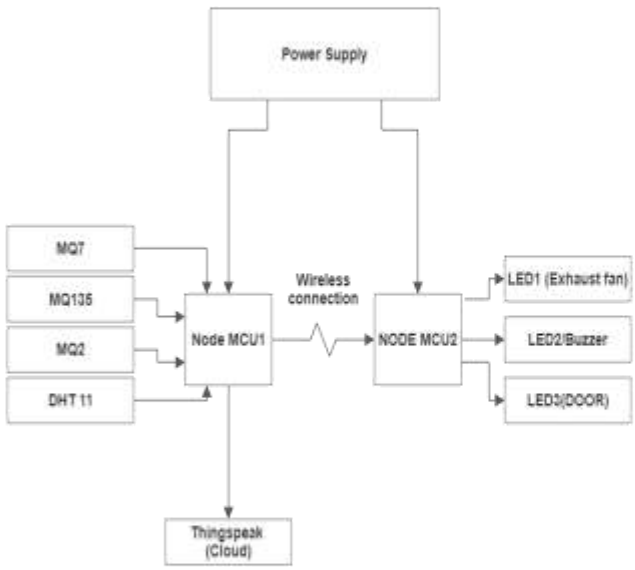

Fig1: Block diagram of the proposed model

In this System we use two node MCUs, DHT11 sensor, MQ7, MQ135 and MQ2 sensors, 3 LEDs and cloud platform thingspeak.

Here the first Node MCU is connected to the sensors and the data of CO, flammable gases and pollution level is sent to thingspeak and the second Node MCU respectively. The second Node MCU collects the data and activates the different mechanisms as per the threshold levels, for eg: If the pollution is less than normal the exhaust fan activates, or when the

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flammable gases have crossed the threshold both the doors and buzzer LED will on indicating the danger and prompting the people in the location to move away. The same happens when the pollution levels are dangerously high.

5. Component description

5.1 Node MCU

Fig 2: NodeMCUESP8266WifiDevelopmentBoard

Node MCU is a single-board microcontroller. NodeMCU was developed by ESP8266Open-source Community. It works on XTOS Operating system and it is powered by USB. It has 128Kb Memory, storage of 4Mb. RFID is connected to Node MCU. So it can control Servomotor and display accordingly. We are using Arduino IDE to program it andlanguageusedis Embedded.

5.2 MQ135

Fig 3:MQ135 Sensor

The MQ135 Sensor is used to detect the PPM of the gases but it cannot detect which gas is

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present in the environment, for this purpose we are using two more sensors those are MQ2 and MQ7 sensors

5.3 MQ7 Sensor

Fig 4: MQ7 Sensor

This Carbon Monoxide (CO) gas sensor detects the concentrations of CO in the air and ouputs its reading as an analog voltage. The sensor can measure concentrations of 10 to 10,000 ppm.The sensor can operate at temperatures from -10 to 50°C and consumes less than 150 mA at 5 V.

5.4 MQ2 Sensor

Fig 5:MQ2 Sensor

The MQ2 sensor is used to detect flammable gases, SnO2 strip acts as the sensitive material in

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MQ2 sensor, it has a low conductivity in clean air. When the target combustible gas is present the sensor's conductivity increases along with the presence of the gas. MQ-2 gas sensor is highly sensitive to LPG, Propane and Hydrogen, it can also be used to detect Methane and other combustible gases, it is economical.

5.5 CD4051B Multiplexer

The CD405xB multiplexers are digitally controlled analog switches having a low ON impedance and a low OFF leakage current. They dissipate extremely low quiescent power over the full VDD – VSS and VDD – VEE supply-voltage ranges, independent of the logic state of the control signals. We used this module to connect the Sensors MQ135, MQ7 and MQ2 to Node MCU since it has only 1 Analog pin.

Fig 6:CD4051B Multiplexer

CD4051B should be connected to NodeMCUasshowninTable 1.

Table1: ConnectionsforCD4051BtoNodeMCU

CD4051B	**NodeMCU**
3.3 V	3V3
RST	D3
GND	GND
Common	A0
A pin	D0
B pin	D1
C pin	D2

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5.6 DHT11 Sensor

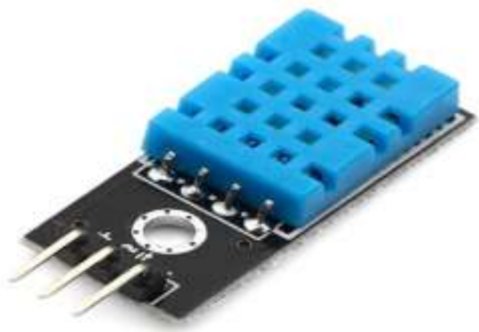

Fig 7:DHT11 sensor

DHT11 Temperature & Humidity Sensor is a temperature &humidity sensor complex with a calibrated digital signal output. By using an exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures a long stability and accuracy. This sensor has a resistive-type humidity measurement component and an NTC temperature measurement component, and it connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness

6. Data Flow

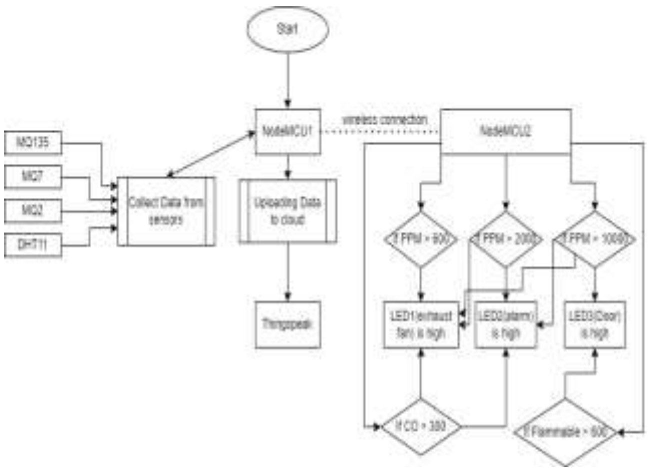

Fig 8: Flow chart

First the NodeMCU1 is setup with power source and all the sensors are connected to it. These sensors take the input data and send them to the NodeMCU1 through CD4051 multiplexer, the NodeMCU1 processes this data and sends then to cloud and NodeMCU2. The NodeMCU2 processes this data and runs a specific condition on them if the data meets this

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condition a reaction is taken place. The reactions are as follows, When the PPM value exceeds 600 mark then an LED1 in place of exhaust fan is activated and runs until the pollution level reaches to normal, When the PPM value exceeds 2000 mark LED1 and LED2 which is in place of alarm will get activated, LED2 keeps on blinking until the pollution decreases than 2000 PPM, When PPM value is exceeds 10000 mark then this situation is treated as an emergency so LED1 LED2 and LED3 which is in place of doors will activate and won't stop blinking until the pollution level reaches below 1000 PPM , When the CO value exceeds the 200 mark then it is treated as an semi emergency since the CO levels can hurt the people inside the room, as a reaction both LED1, LED2 and LED3 will activate but LED2 will blink by taking a 3 seconds break and LED1 will be blinking until the CO pollution level falls below 200 , When the flammable gases level exceeds 200 mark the same happens except it will be treated as emergency and the LED2 will blink with 500 millisecond intervals.

7. Result Analysis

The sensors are in pre heating, we have to wait a minute before they get heated so that these sensors can take some accurate inputs.

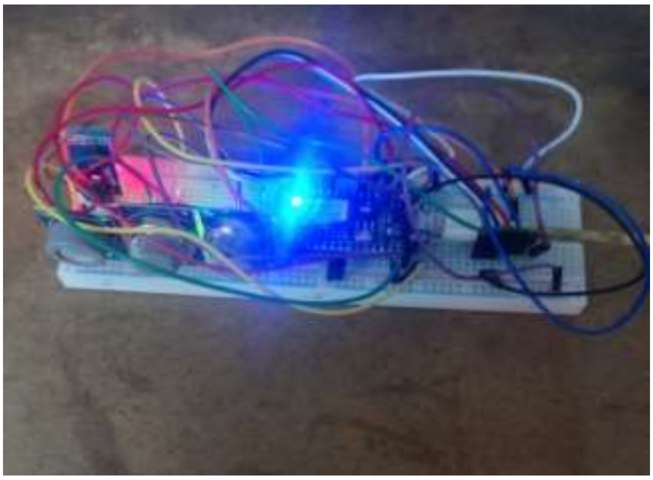

Fig 9: the NodeMCU1 setup.

Soon the NodeMCU1 will start transmitting the data when connected to WIFI. After connecting to WIFI the data will get uploaded to thing speak cloud.

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Fig 10: Serial printing of values

The values will be updated in thing speak for every 15 seconds so we can't see the values getting updated constantly.

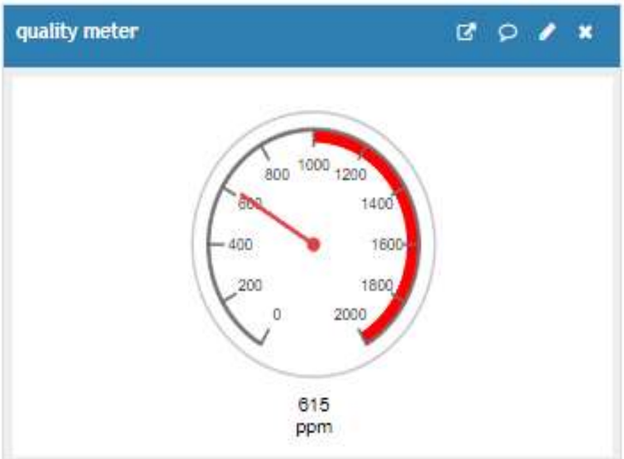

Fig 11: PPM Field values in thing speak

The PPM value will change for every 15 seconds in think speak but will constantly get updated in NodeMCU2. When PPM crosses 600 LED1 is switched on at the NodeMCU2 setup.

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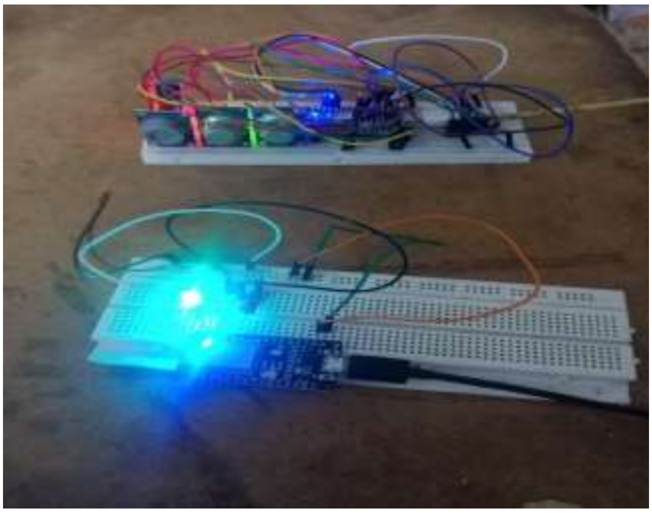
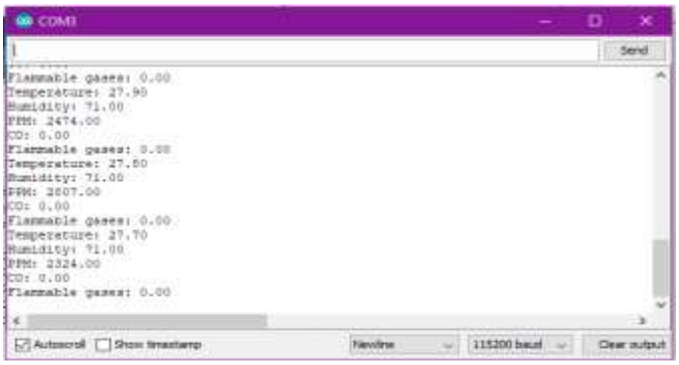


Fig 11: LED1 is high when PPM is more than 600

The LED representing exhaust fan is activated to throw the indoor pollution. Now when PPM crosses 2000 the LED2 alarm will activate along with LED1



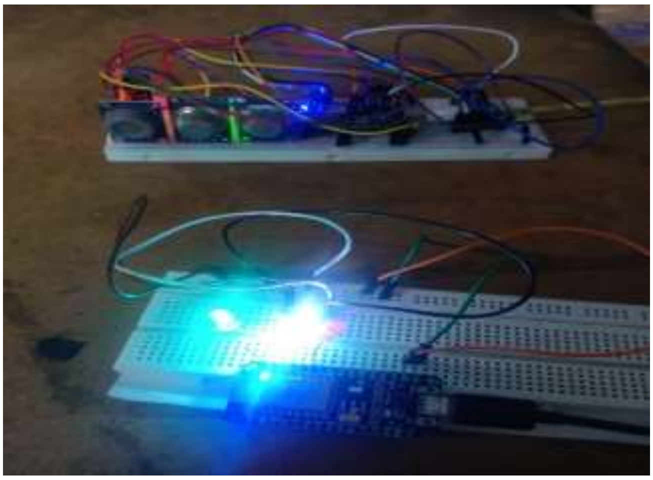


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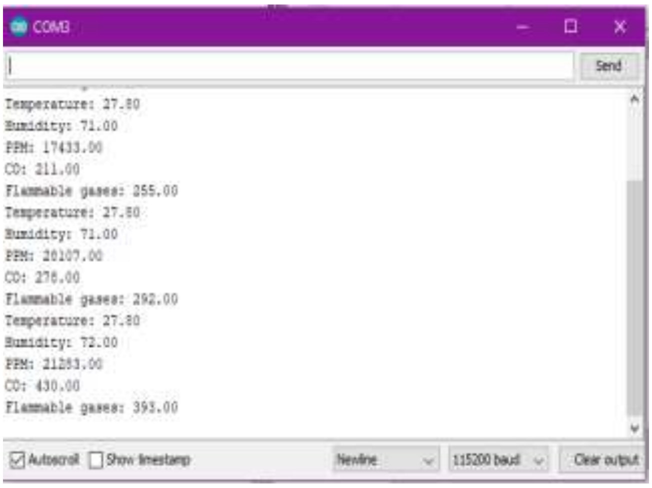
Fig 12: The LEDs are high when PPM crosses 2000

When PPM crosses 10,000 or when CO levels are high or when flammable gas levels are high whenever CO and flammable gas levels reach higher level automatically the PPM level also raises so all the three LEDs will activate indicating that there is an emergency situation.



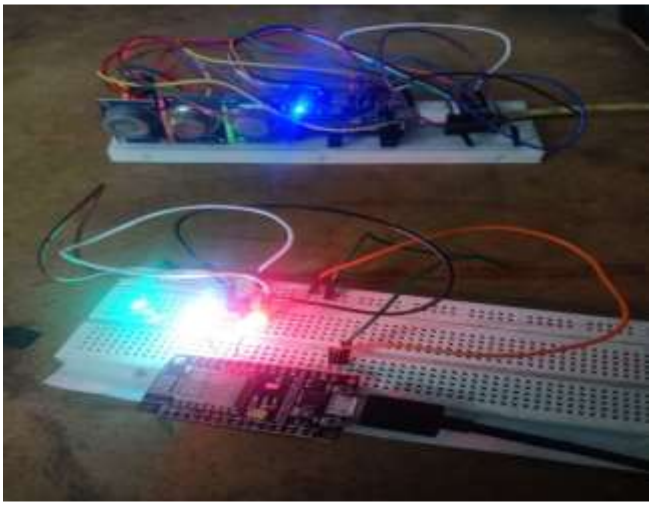


Fig 13: all three LEDs are on indicating that there is very high pollution and suggesting a immediate vacation of the room

8. Conclusion

In this paper, we proposed a better way to provide indoor air quality monitoring which is efficient and can be used in many ways for eg: Offices, Research centers; Factories, Greenhouses etc. We can add many other components to this module like water sprinklers, air purifiers etc. since it is wirelessly connected the only problem is with the inaccuracy of the MQ sensors as they cannot be 100% accurate in detecting gases and MQ135 sensor alone can't detect multiple gases and it need help from other sensors from its family like MQ2,MQ7,MQ4 etc. for the present time these are the only gas detecting sensors available maybe more sophisticated sensors might be available in the future.

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