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Automatic AQI Monitoring System for Air Purifier Using Arduino

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Abstract: For the air purifier an automatic Air Quality Index (AQI) monitoring system has been designed using Arduino Uno R3. Lots of impurities are available in the air which degrade our health and may leads to severe diseases. So, this system helps in detecting the impurities in the air with a help of ATmega328P chip and MQ-135 sensor. The sensor used for detecting the impurities available in the environment or in a room space based on defined permissible range of AQI values. This system detects the AQI values depending on three conditions. If the value of AQI value is ≤ 50 it lies under normal condition. If the value will rise up to 100 then it indicates the moderate zone but when it rises more than 250 it considered as hazardous zone and buzzers will on continuously. This leads to turn on the Air Purifier turn on automatically without human intervention. The module has been optimized and gets tested over Tinkercad software and its prototype is also developed using multiple electronics components and sensor.

Keywords: AQI, Air Purifier, Arduino, MQ-135, Sensor

Significance Statements: In this letter, development of a system which monitors the AQI value. The sensor integrated with microcontroller unit which gather the respective information and AQI value represents on LCD screen. Based on this value our system work and if value gets higher than 250, it considered as hazardous zone and buzzer will continuously blow. Then without any human intervention this system will turn on the air purifier.

1. Introduction

Due to many harmful gases lead to health failure these days. Air quality monitoring must be required for a healthy atmosphere. AQI monitoring system based on mean absolute error and root mean square error methodology to predict the impurities in air. This particular method is used based on XGBoost framework to predict some environmental parameter [1-2]. Based on AQI value categorization has been done i.e. Good, moderate, Sensitive, Unhealthy and Hazardous. From study it is found that, authors trained the data model using different Machine Learning (ML) technique and observed the accuracy, F-1 score, test accuracy using confusion matrix [3]. Multiple environmental parameters get observed by using different techniques, microcontroller unit and communication mode. For smoke, CO, CO_2, and PM 2.5 parameters, Arduino Uno with wired serial ports is required. Also, implementation can be proposed via wireless medium using Wi-Fi interface [4]. Some authors utilize sensor (EN55 and the Winsen ZPHS01B) for obtaining the real time air quality value and gets communicated via GSM modem to microcontroller and on regular basis. These data get processed for dedicated application [5]. Data of AQI gets trained via different learning model like XGBoost and GBR×4 for validation of mean square error and temporal test [6]. Using an ESP32 microcontroller unit & humidity sensors an AQI model is developed for monitoring environment. The observed real time data gets stored over the cloud storage for the data processing using ML techniques [7]. There should be some variation occurred in the AQI value. Due to ozone and some meteorological factors AQI value gets varied up to 15-20%. Real time measurement of O_3, NO2 and PM 2.5 using Canadian AQHI algorithm which is based on environmental condition and meteorological behaviour. Challenges can be removed through periodic calibration and utilization of correct algorithm [8-9]. Some serious problem like respiratory and cardiovascular problems are caused by smoke, CO & PM 2.5. Based on microcontroller unit and sensors a system has been designed for AQI monitoring. These data get integrated for data processing using different model or algorithm [10-11]. Multiple methods are utilized by authors for analysing the correct AQI value based on accuracy. Multi-scale Quantile Neural Network (MQNN) improves AQI forecasting accuracy and uncertainty estimation using Fourier expansion and quantile learning, supporting effective air quality management. A hybrid TCN–LightGBM framework enhances AQI prediction by combining temporal trend analysis with contextual information, delivering accurate and

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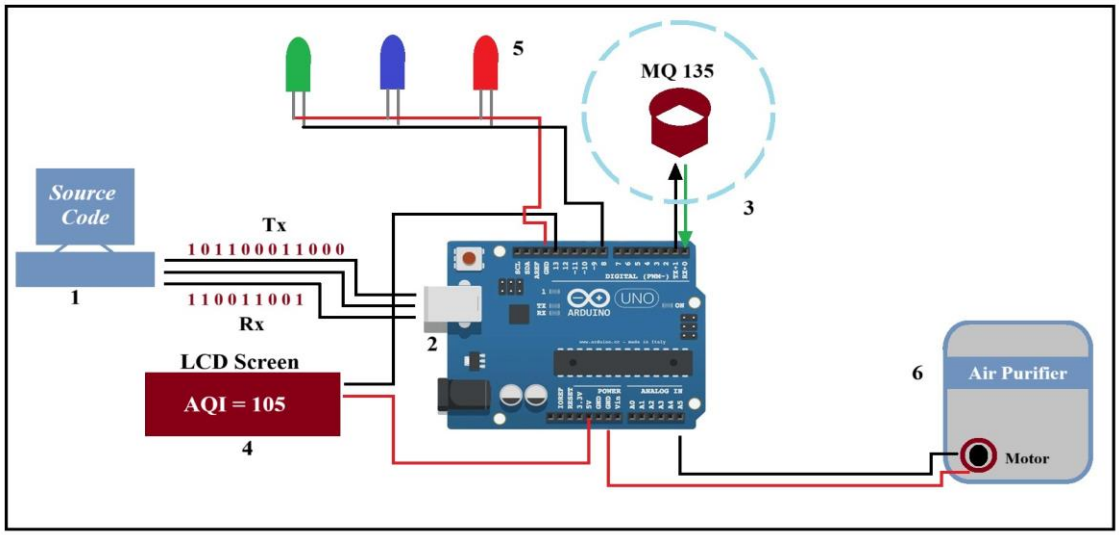
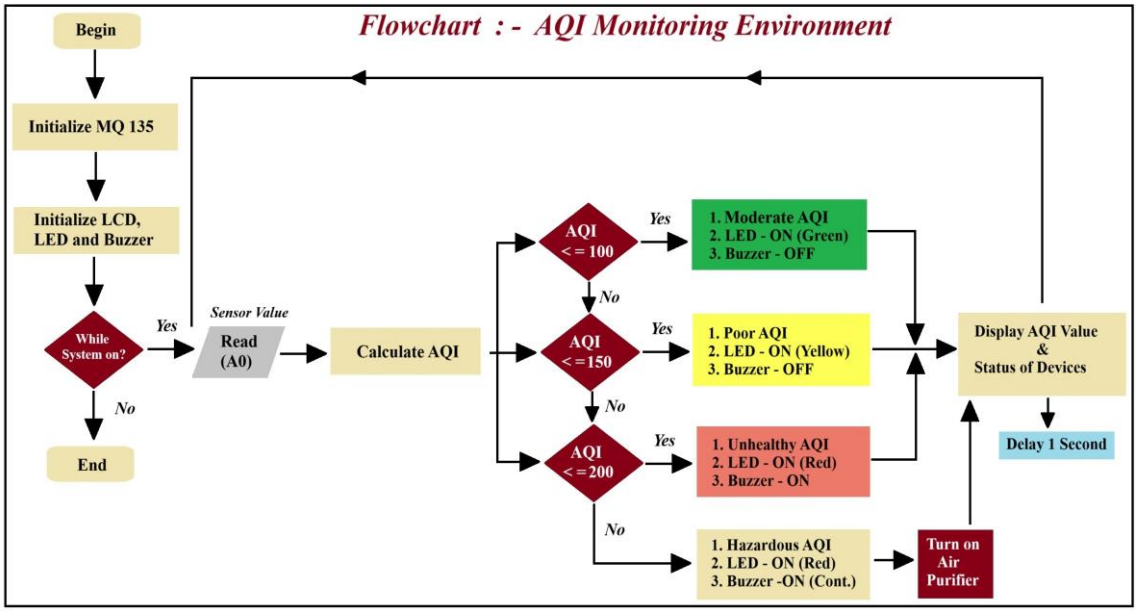
stable forecasts even during unusual pollution events [12-13]. Based on Arduino board and MQ 135 sensor a AQI monitoring system has been introduced. Based on resultant value of AQI categorised into four zone such as Moderate, Poor, Unhealthy and Hazardous.



(a)



(b)

Fig.1. Pictorial representation of (a) Block diagram of proposed system (b) Flowchart of AQI monitoring environment.

2. AQI Monitoring System

Fig.1 (a) shows the block diagram of proposed system. Initially, a source code (1) using procedural language of HLL is framed. This particular code gets loaded over the Arduino UNO board (2). Once code gets loaded over the microcontroller unit detach the USB cable. Then integrate the AQI sensor i.e. MQ135 (3) with the Arduino board for sensing the impurities in Air. 16×2 LCD (4) screen is also gets connected

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for presenting the measured AQI values. There are 3 LEDs (5) also gets connected for indicating the content of impurities available in the air based on defined threshold value. When the value reaches under hazardous level then it indicates danger zone and it automatically turned on the air purifier (6). Flowchart has been designed based on the source code used for the development of this system. Initially, give command to turn on the MQ-135 (sensor), LCD and Buzzer. Depending on the "ON" condition of the system, sensor read the value sensed by the AQI sensor and gets calculated based on the impurities available. Basically, it senses multiple harmful gases such as Ammonia (NH_3), Nitrogen Oxide (NOx), Benzene, CO_2 and smoke particle. Arduino read the data and calculate the value. Depending on observed value device start behaving. If the value lies under ≤ 100 then it is moderate and indicated via green LED. If value does not match with above condition, then it should be more than 100 and lesser than 150. In this case AQI is poor and gets indicated with yellow LED. Next condition is when AQI will be ≤ 200 then it categorized under unhealthy zone and buzzer will be on and red LED indicates the danger zone. When the value reached beyond 200 then buzzer will continuously on and automatically air purifier gets turned on without any intervention. The algorithm used for developing the source code is presented below.

Algorithm: Air Quality Monitoring and Alert Generation
Input: Analog output from MQ-135 gas sensor
Output: Air Quality Index (AQI), LCD display status, LED indication, and buzzer alert
Step 1: Initialize the Arduino microcontroller, MQ-135 sensor, LCD display, LEDs, and buzzer.
Step 2: Continuously acquire the analog voltage generated by the MQ-135 sensor through the analog input pin (*A0*).
***Step 3*:** Convert the acquired sensor reading into a corresponding **AQI** *value*.
Step 4: Classify the **AQI** *value* into predefined air quality categories:

a. Good----(*0–50*): **L**
b. Moderate---- (*51–100*): **M**
c. Unhealthy---- (*151–200*): **O**
d. Hazardous---- (*201–300*): **P**

Step 5: Display the calculated **AQI** value and air quality status on the *16×2* LCD module.
Step 6: Activate the corresponding LED indicator according to the classified AQI level:

a. *Green LED* for **L**
b. *Yellow LED* for **M**
c. *Red LED* for **O**
d. *Red LED* for **P**

Step 7: Compare the **AQI** value with the predefined threshold levels.
Step 8: If the **AQI** value exceeds the safe limit, activate the buzzer alert; otherwise, keep the buzzer in the OFF state.
Step 9: For Hazardous conditions (**AQI** > *250*), generate a continuous buzzer alarm to indicate emergency and activate the Air Purifier
Step 10: Wait for one second and repeat Steps *2–9* to enable continuous real-time monitoring.
Step 11: Continue the monitoring process until the system is powered off.

Using tinkerkad software, all conditions are verified with multiple optimizations. Using Arduino board connection with multiple devices with precision helps in calculating the AQI value. Fig. 2. shows the response of each condition based on defined algorithm. In case 1, LEDs are connected with 220 Ohm resistor for indicating the status of AQI. At LCD AQI is 83 and categorized under moderate. During experiment, increases the smoke particle for observing the next condition. When value increased by 100, poor zone gets indicated using yellow LED in case 2. Case 3, indicating the unhealthy air quality after

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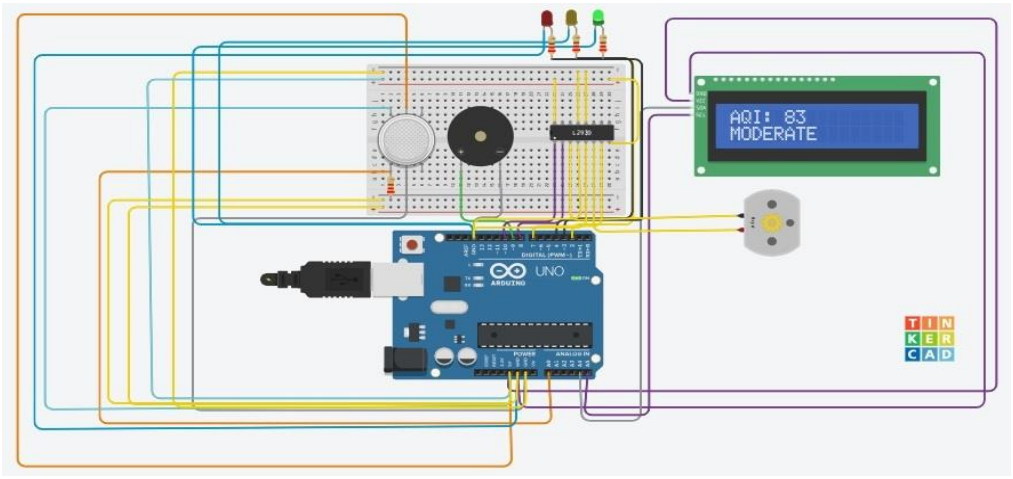
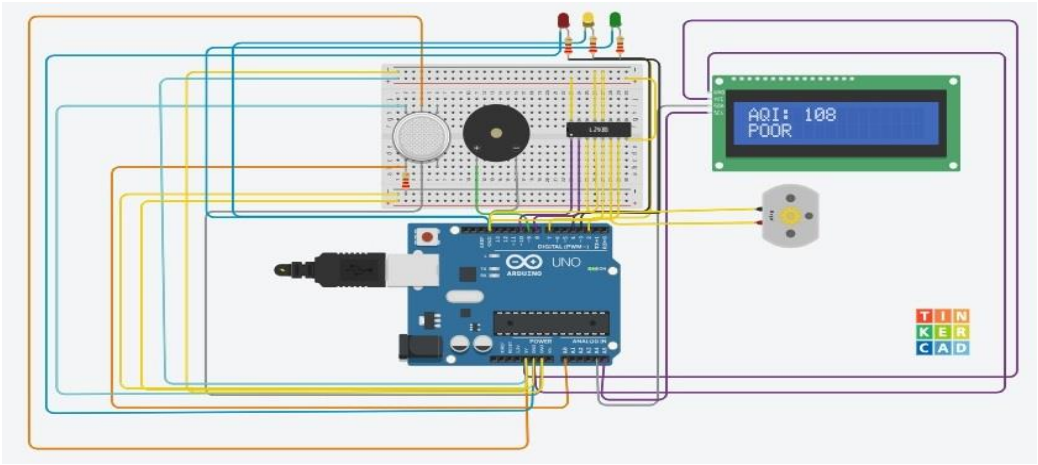
increasing the carbon particle along with smoke. When value reaches more than 200 then it is hazardous condition and case 4 shows the same. Red LED gets turned on and buzzer will continuously on till air

Case 1:



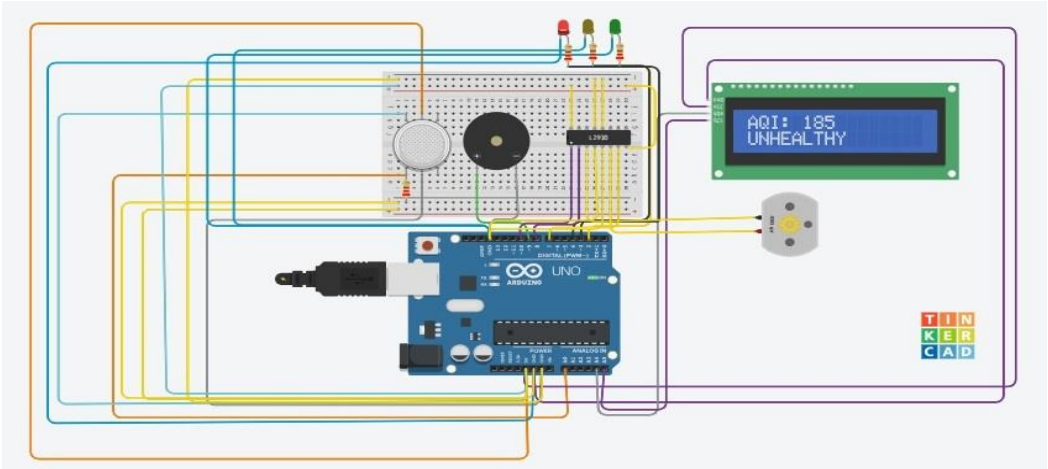
(a)

Case 2:



(b)

Case 3:



(c)

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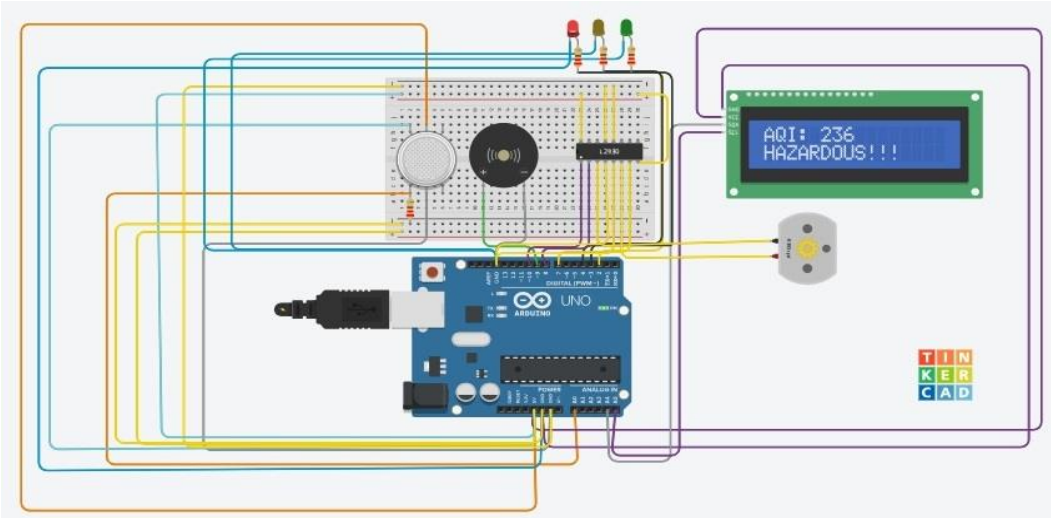
Case 4:



(d)

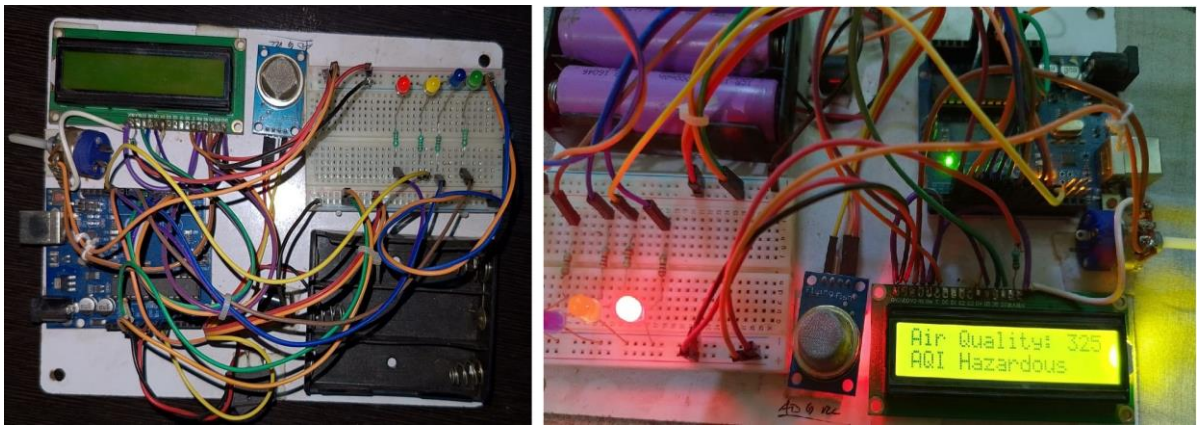
Fig. 2. Experimental responses of AQI monitoring system depending on different cases (a) Case 1 (b) Case 2 (c) Case 3 and (d) Case 4 respectively.

purifier does not gets turned on. After the impact of air purifier system will be in working mode and it signals each case in reverse order till it does not show AQI is normal or moderate in a defined or desirable environment. Table 1. Shows the summarized response of each experimental performed based on these 4 cases.

Table 1: Summarized response of each case

Case	AQI Value	LCD Status	LED Status	Buzzer	Air Purifier
Case 1	AQI: 83	Moderate	Green	OFF	OFF
Case 2	AQI: 108	Poor	Yellow	OFF	OFF
Case 3	AQI: 185	Unhealthy	Red	OFF	OFF
Case 4	AQI: 236	Hazardous	Red	ON	ON

In Fig. 3., hardware developed for AQI monitoring system is presented. Cobination of bread board, multiple LEDs, potentiometer, sensor (MQ135), jumper wire, LCD, Arduino board and lithium battery leads to successful implementation of circuitry for AQI monitoring system (Fig. 3.a). When the system is activated,



(a) **(b)**

Fig. 3: Hardware View (a) Idle Condition (b) Active Condition

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the measured Air Quality Index (AQI) value is 325, as illustrated in Fig. 3(b). This AQI level falls within the hazardous air quality category, indicating severe pollution. Consequently, the red LED is illuminated to signify the hazardous environmental condition.

3. Conclusion

In this letter, an Air Quality Index (AQI) monitoring system is developed using an Arduino board and an MQ-135 sensor. The sensor detects harmful gases present in the surrounding air and transmits the collected data to the processor. Based on the programmed instructions, the processor displays the AQI value on an LCD screen and activates the corresponding LED indicators according to the air quality level. The proposed system can be effectively deployed in real-time environments for continuous air quality monitoring. Furthermore, when the AQI exceeds a predefined threshold value, the system automatically switches on an air purifier to improve the indoor air quality and ensure a healthier environment.

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