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Wireless Sensor Node Design and Development for Hazardous Gas Detection and Monitoring of Air Quality in Industrial Environment using IoT

[1].S. Suryaprakash [2].M. Mathan Kumar [3]N.Vinoth Kumar
[123]Assistant Professor,Electrical and Electronics Engineering DepartmentCoimbatore, India
[1]suryaprakash.s.eee@kct.ac.in, [2].mathankumarbit@gmail.com, [3]vinothkumar.n.@kct.ac.in

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Abstract

Air pollution is increasing exponentially day by day and they have a lasting impact on people's health and ecosystem. Though vehicles contribute to air pollution, Industries are one of the major contributors. To have more profit, industries in greed go on to break some rules regarding their emissions. They leave out toxic gases directly into the atmosphere without even treating and reduce their concentration. When the level of toxic gases in atmosphere increases, it will lead to acid rain or create respiratory problems in people. Even monuments of a country are affected by this air pollution. The major aim of the project is to develop a wireless sensor node network which can be placed in any target industry to monitor their emissions and give proper real time information to the pollution control authority and also alert them, if these emissions exceed the standard critical limits. A server application is developed in this phase to maintain all the sensed data and have a backup over them. They also help the corresponding authorities to know how many times a target industry has crossed its limits. This will help to have a control over the target industry and prevent them from making their hands dirty.

Keywords; *air pollution, wireless sensor node, alert system*

I. INTRODUCTION

As the economy of the India grows, the same is the number of Industry increases with the Industry Air pollution. To regulate air pollution in India, Prevention and Control of Pollution Act was conceded in 1988, later Nation Air Quality Index was launched by Indian Government together with IIT Kanpur (1. Even though, the various acts available in India, Still, it becomes harder for the authorities identify the industry which provides major air pollution. Air Pollution is a worldwide growing threat to human health and nature environment. The major pollutants which contribute to outdoor air pollution are sulphur dioxide, carbon dioxide and toxic gases. Air pollution has led to steep increase in various illnesses and it continues to affect us on daily basis. This is because of not having a standard and proper way to monitor industrial and vehicular emissions.

The summary of the problem statement is as follow

- Some industries emit gases with concentration higher than the critical limit.
- There is no proper way to have an eye on them over 24/7.
- Furthermore, there is no transparency on how many times the industry violated those limits.

The proposed system can able to measure the level of polluting gases in the atmosphere emitted by the industries and to intimate the authorities in case of exceeding pollution emission. The developed system consists of three parts namely Hardware for data acquisition, Cloud Server and User Interface based on LABVIEW.

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II. DISCUSSIONS

The following discussions are about the various findings in the development of a system for air quality monitoring. MovvaPavani has a discussed about the development of Wasp Mote based air pollution monitoring is a light weight-based air quality monitoring with web interface [1]. The development of artificial neural network for prediction of NOx and CO for air pollution monitoring in industrial sites was established by NadjetDjebbri [2]. Due to the reduction of cost of sensor and microcontroller, the implementation of location monitoring in a industrial industry using IOT was designed by Gayathri K [3].

By measuring the five major gas concentration such as carbon monoxide (CO), ozone (O3), Sulfar dioxide (SO2), Nitrogen dioxide (NO2) and airborne material less than 10 micrometre as indicated for AQI.

Always there is a limit in emission of air pollutants to which people are normally exposed in their day to day life. The prescribed India's National Ambient Air Quality Standard (NAAQS) is shown in Table 1.

Table 1. Air Quality Index of Criteria Air Pollutants

AQI CATEGORY	AQI Rating	PM10 (µg/m3)	CO (ppm)	NO2 (ppm)	SO2 (ppm)
Very Good (0-15)	A	0-50	0-2.0	0-0.02	0-0.02
Good (16-31)	B	51-75	2.1-4.0	0.02-0.03	0.02-0.03
Moderate (32-49)	C	76-100	4.1-6.0	0.03-0.04	0.03-0.04
Poor (50-99)	D	101-150	6.1-9.0	0.04-0.06	0.04-0.06
Very Poor (100 or over)	E	>150	>9.0	>0.06	>0.06

The following formula is used for calculating the AQI (Air Quality Index) which determines the quality of air based on the concentration of hazardous gas substance in air.

$$AQI = \frac{\text{Pollutant data observed}}{\text{Pollutant data standard}} \times 100$$

III. PROPOSED DESIGN

The following block diagram discuss about the proposed design of air quality monitoring is shown in Fig. 1.

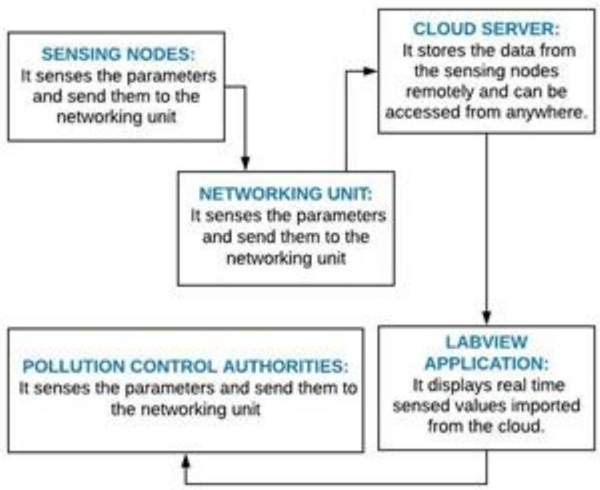

Fig. 1: Block Diagram

The flow chart of the proposed design is shown in Fig. 3

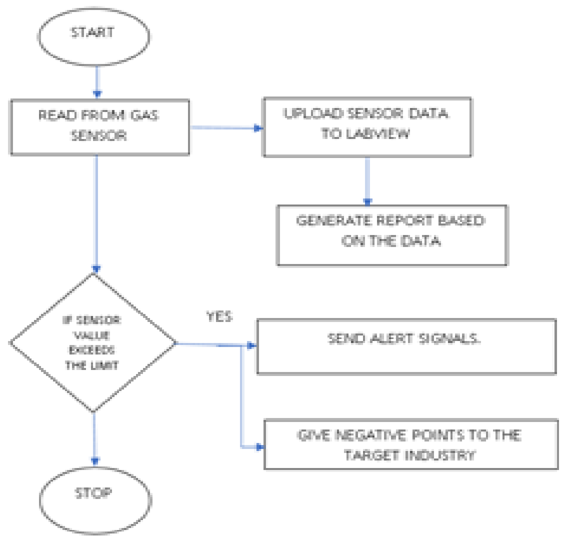

Fig. 2: Flowchart of Proposed Design

A.Sensor Node

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The sensor node is a publisher which involves in measuring the air quality. This system consists of power supply, microcontroller with communication antenna and sensor array. A low-cost microcontroller ESP 8266 (Node MCU Package) has been selected for sensing the sensor data and transmitting to the server using WiFi communication. It acts as a data switching unit between sensor node and cloud. It can upload data into any Fire base cloud when provided with WiFi SSID username and password for connecting to the internet and the link to which the data is to be uploaded. The data is transported based on the MQTT (Message Queue Telemetry) protocol. This protocol is chosen because of its light-weight footprint. This protocol operates on the principle of publish and subscribing mechanism.

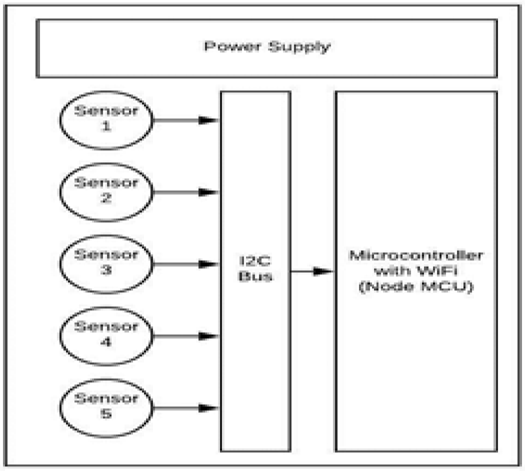

Fig. 3: Block Diagram of Sensing Unit

The block diagram of data sensing unit is shown in Fig. 2. The sensor used in the proposed system are DHT22 (Temperature and Humidity Sensor), MQ-7(Carbon dioxide) sensor, MQ-131 (Ozone Gas Sensor) and a PPD42NJ (Grove particle Sensor). The entire sensor is connected using I2C bus communication with the Microcontroller. ADS1115 is 16-bit higher precision I2C ADC at 860 samples per second. It can be configured as 4 -channels with single ended or two variance channels. The complete Air Quality measuring device is shown in Fig. 3.

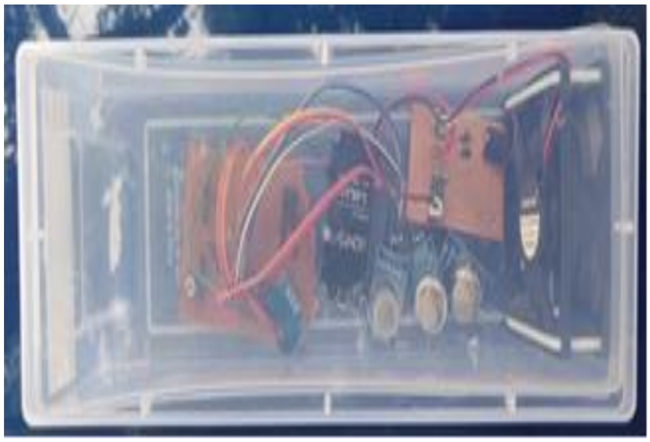

Fig. 4: Air Quality Measuring Device

B.Cloud Server for Data Collection

Firebase is an online cloud storage owned by Google. It also helps in mobile and web application development. It acts as a bridge between sensing nodes and the lab-view application. It retrieves data from the sensors using a networking controller and from the firebase the lab-view application retrieves data by using a proper key entitled to the node.

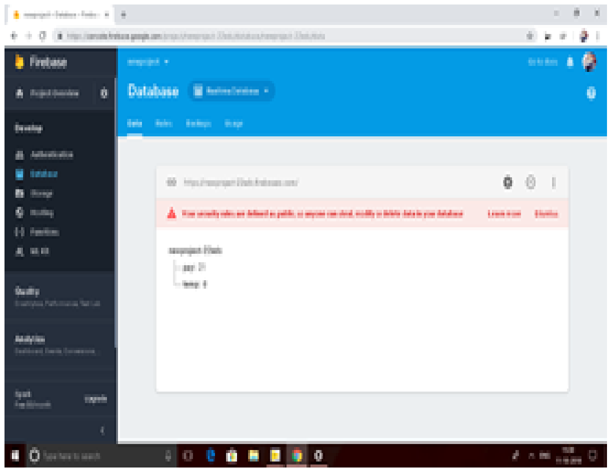

Fig.5: Google Firebase Interface

C.LABVIEW based User Inteface

The graphical programming language developed by National Instruments is used for development of user interface which will acquire the data from the firebase server. LABVIEW is used for connecting directly through devices, analyze, process, control, simulation and report generation. The LABVIEW based analysis system is chosen because of it fast

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and simple construction of graphical user interface that enables to bring up-to-date parameters.

LABVIEW is used to create both front end and back end of the application that displays the data collected from the nodes. It retrieves data from the node through cloud. It will show visual alert in case of any target industry breach the limit. It helps us in creating reports on gas levels with time stamp details. The front and back end is shown in Fig. 6.

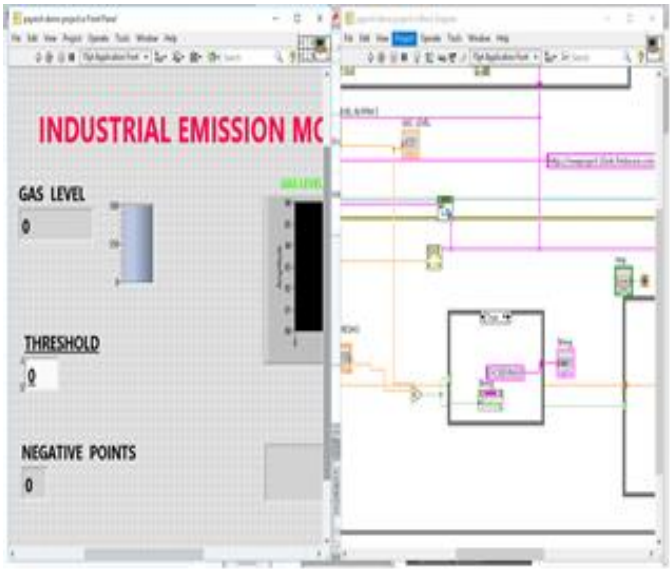

Fig.6: Front End and Back Interface of LABVIEW

The system is developed with an algorithm as when the user goes beyond the AQI of prescribed values, it will show negative points. The negative points were accumulated at the end of month to impose the charges on industry. The sample of the image imposing with negative point and normal condition is shown in Fig. 7.

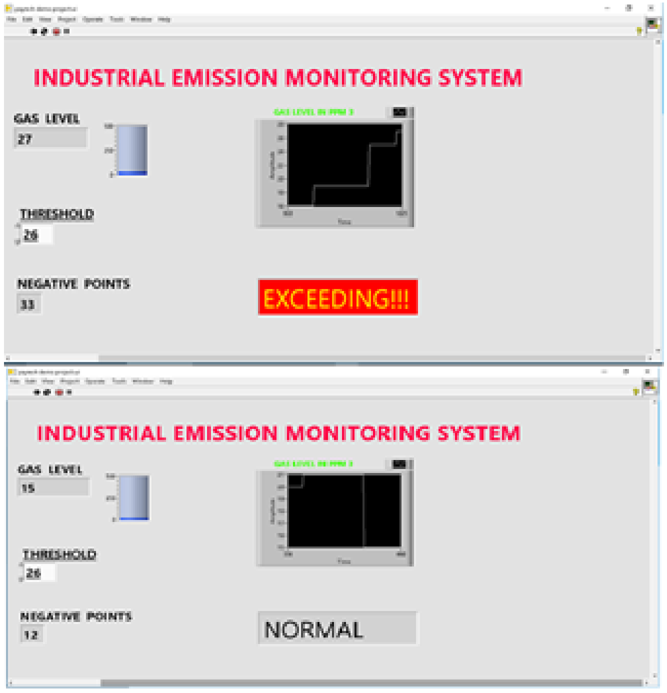

Fig. 7: Sensor Exposing to Differing Conditions

The report generation is available with .txt file extension with date and time is shown in Fig. 7.

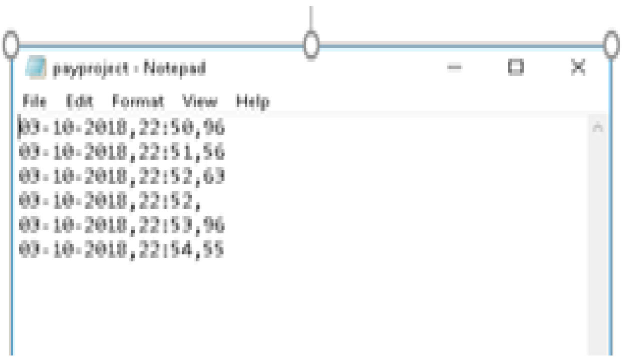

Fig. 7: Report Generation

IV. CONCLUSION AND FUTURE SCOPE

Thus, the proposed system monitors the industrial emission data in real time and displays in the lab-view application. With these systems on, we have a transparency on industrial emissions. Reports on emission data by each industry will come handy during audits. Every time when the industry crosses the standard limit, we can provide them with a negative point. These negative points will be helpful when imposing fines on the industries that break the standard limit. The future scope of the work can be

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extended to report on emission data can be put into data analytics and can devise plans and schemes to help reduce the emissions. Furthermore, we can have anti pollutant box which will release necessary suppressors for the pollutants, when the pollutant level increases beyond the limit.

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