International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 12 | Dec 2021 www.irjet.net p-ISSN: 2395-0072

An Automated Monitoring System for Observing Harmful Gases in the Industrial Field

Abdelrhman Elmahi Makki Ismail[1], Asare Francis Sakyi[2], Ahmed Elkhalil[3], Mossalam Hassan Khamis[4], Riyad Haider Yousif Gumma[5]

[1-2]Final Year Bachelor's Student, Dept. of Mechanical and Electrical Engineering, University of Electronic Science and Technology of China, Chengdu, China
[3-4]PhD Candidate, Dept. of Information Science and Technology, Southwest Jiaotong University, Chengdu, China
[5]Mechanical Eng., Dept. of Building Materials, Emirates Specialities CO.LLC, Dubai, United Arab Emirates

---***---

Abstract - *Using a harmful gas monitoring system and taking the proper action in the situation of detecting harmful gases may assist avoid an explosion or worker exposure to toxic gases. In recent years, accidents concerning harmful gas have become more prevalent in industrial regions globally. Consequently, toxic gasses are released into the atmosphere, posing significant health problems. In the interest to ensure healthy livelihood and the safeness of people in such places, this paper proposed an automatic monitoring system for observing and releasing the early warning of toxic gases in the industrial field. The monitoring system consists of sensors to monitor the harmful gasses in the workplace environment, Zigbee, and GSM module as communication gateways.*

Key Words: **Wireless sensor network (WSN), Toxic gas monitoring, Automatic system, Microcontrollers, Embedded Systems.**

1. Introduction

Health problems have been growing faster, especially in urban areas of developing countries where industrialization and the growing number of factories lead to a release of a lot of gaseous pollutants [1]. With the boom of mechanization and automation, embedded instrumentation systems have adapted to suit many applications [2]. Therefore, to prevent gas pollution, protect people's lives and health, we must have a modern management and monitoring system [3].

The field of an embedded instrumentation system opens space for emerging wireless communication technology to exchange information from a remote location, which overcomes the limitations of the traditional telemetry system [4]. Modern semiconductor technologies produce promising features such as small size and low power consumption, great configurability, flexibility in design. These features can be developed for dedicated tasks in the embedded system like signal processing, storage, and wireless connection [5].

Wireless Sensor Networks (WSN) connect the actual and virtual domains [6]. It can monitor zones where a wired system cannot be established at a fine resolution over enormous scales.

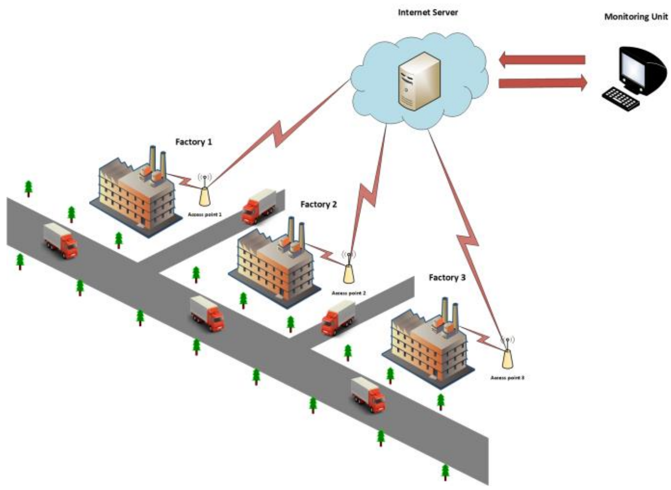

Fig -1: System model

WSN covers wide applications such as automation technology, agricultural management, air pollution tracking, medical services, security [7]. Air pollution increment in the environment, including Carbon monoxide gas (CO), Carbon dioxide gas (CO_2), and Isobutane gas (C_4H_{10}) that leads to many harmful problems such as depletion of the Ozone layer effect on wildlife, acid rain, and global warming thus, affect humans and the environment.

1.1 Related Work

Many studies highlight the importance of monitoring air pollution, which requires continuous monitoring and control. Several systems have been proposed based on wireless sensor networks for monitoring pollution in the air. This section summarizes some of the current findings in this area.

Dan et al.[8] proposed a mobile air quality and pollution monitoring scheme suited for urban areas. They used a microcontroller, gas sensors, a mobile unit, a temporary memory buffer, and a web server with internet connectivity. The public can access polluted zones information data via an online web interface that is updated in real-time. However, instead of using a global positioning system (GPS), the system relies on the position tracking capabilities of mobile telephony networks. In this regard, Snehal and Priya [9] described a real-time web-based geographic pollution monitoring system. They utilized an atmega16, a serial communication port for transferring data to a computer system and google maps. Different colors have been used on google maps to highlight the amount of pollution in the meant area. The system characterizes the pollution level according to the user prerequisite. However, overlapping colors might occur in the case of a wide range of gases. Therefore, Shilpa and Kulkarni [10] designed an air pollution monitoring system using smartphones and applied the MAX232 protocol for connecting Bluetooth modems. Corrective measures were taken when air pollution exceeded a predetermined threshold level. Also they suggested a web-based air pollution monitoring system using smartphones. The temperature and smoke are controlled, and the webserver is designed to show the parameters. However, the design lack an alarm system, besides the limitation of Bluetooth modules in transmissions.

1.2 Motivation and Contribution

Industrialization began to take control of the globe in all spheres. Consequently, the pollution level of infectious gases in the atmosphere is rapidly growing. Pollutants in the atmosphere damage the ecosystem, affecting the health of humans. Whereas numerous approaches are suggested to monitor the pollution level in the environment, it remains an issue for specific factories and industries to use it. We outline our contribution as follows:

- We present an automated monitoring system as shown in fig-1, for observing harmful gases in the industrial field.
- We designed a system to monitor the harmful gases that cause deterioration in the industrial and nearby environment, such as (CO),(CO_2), and (C_4H_{10}), temperature, and humidity.
- We deployed an alarm system for the employee to avoid the harmful gases released by the industries.

2. Methodology

Indoor air quality monitoring, such as factories and gas stations, includes measuring various air parameters at the workplace. This paper describes a low-cost and reliable system to monitor indoor air quality and health problems caused by air pollution in these places, collect and use the data to avoid such issues.

2.1 System Model

As shown in fig- 2 and fig- 3, the system consists of the main node(base station)and sub-nodes (sub-node1, sub-node2, sub-node3). A base station is a unit that supervises sub-nodes and gateways and performs processing of the data collected from sensors. Additionally, it creates relevant information from the provided data and then makes appropriate actions in response to abnormal circumstances. All the sub-nodes have the same component. The sub-nodes include MQ-7, MQ-135, MQ-6, and DHT11 to acquire CO, CO2, C4H10, temperature, and humidity. Then, the microcontroller processes the measured data collected by sensors and changes it into a more viable form to access at the base station and users. In this design, Zigbee acts as a gateway for the communication between the sub-nodes and the base station. While the base station employs the GSM module to send text messages marks an extra precaution for the level of toxic gases. Temperature and humidity values are also transmitted via a short-range communication to the LCD. Therefore, the component of the system shown as follows:

- Arduino Mega 2560
- Wireless X-Bee (Zigbee)
- GSM SIM 900A
- Liquid crystal display (LCD)
- CO gas sensor (MQ-7)
- CO_2 gas sensor (MQ-135)
- Isobutane detection sensor (MQ-6)
- Temperature and humidity sensor (DHT11)

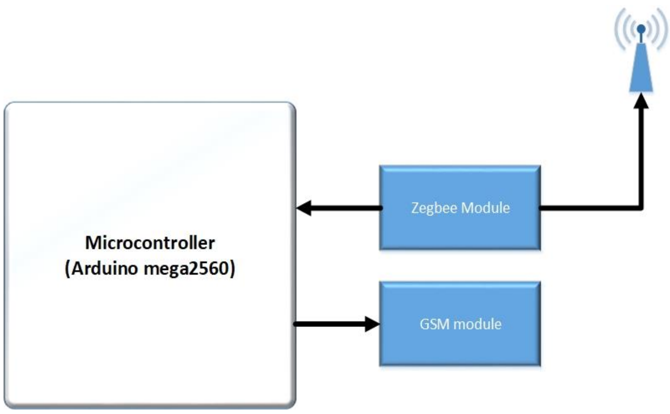

Fig -2: Block diagram of the main node

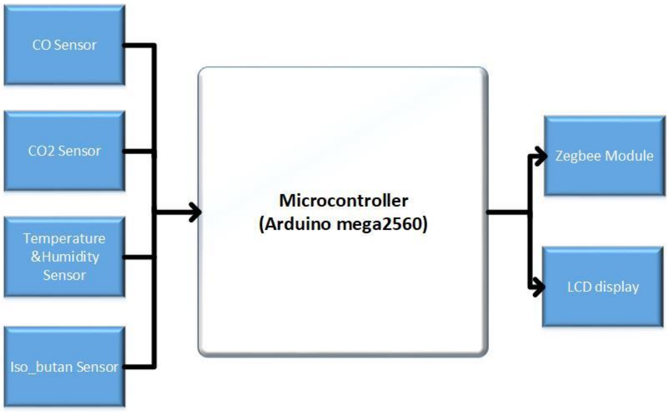

Fig -3: Block diagram of the sub-node

As dedicated in fig- 4 and fig- 5, the main node sends frames to specific sub-nodes. The main node receives gathered data from a specific sub-node via ZigBee. Then, the GSM module is used as a preventive measure to send a message to the department head upon the arrival of any gases and dangerous situations. When any gases exceed the permissible level in the sub-node, the system operates an alarm to alert the employees.

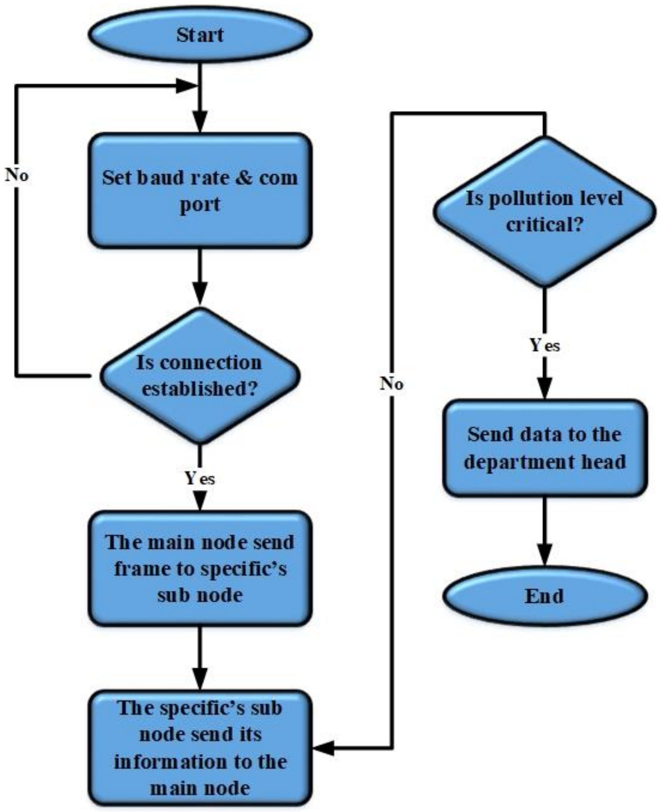

Fig -4: Flow chart of the main node

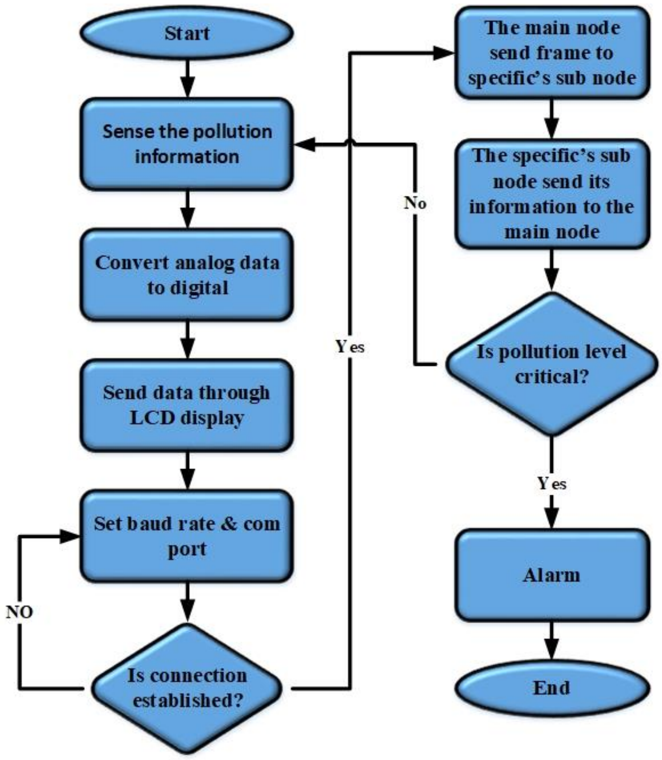

Fig -5: Flow chart of the sub-node

3. Results and Discussion

As shown in fig- 6, the main node sends a frame with (* node ID #) to each node. In this scenario, generally, all nodes can receive that frame. However, only particular node responses depend on their identification number. Then, the meant node sends back its information, including the node ID, temperature, humidity, CO gas, CO_2 gas, Isobutane gas, and the end of the frame as dedicated in fig- 7. Fig- 8 shows that the main node obtains the sub-nodes information and stores all that data in the EEPROM. Finally, as described in fig- 9, the main node transfers all received data to the base station. The GSM module sends a message to the head of the department in case of an increase in any of the gases. That message contains inter alert and the status of each of the gases, and the node ID.

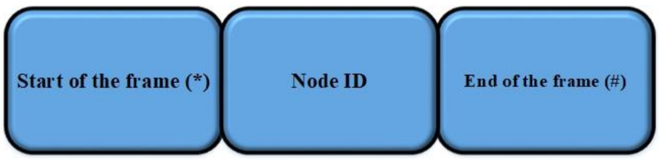

Fig -6: The frame sent by the main node

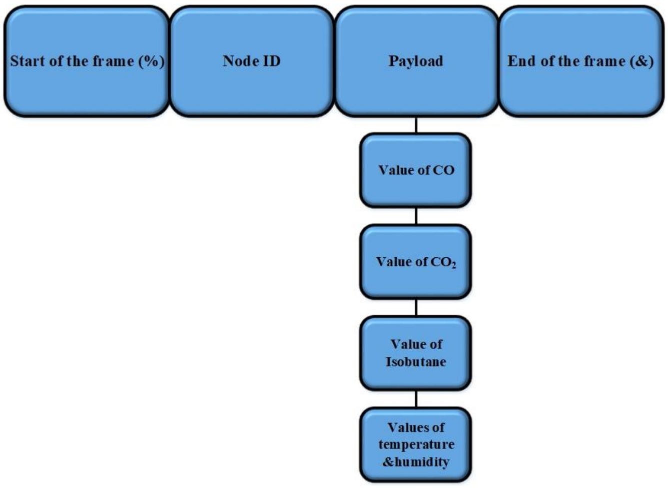

Fig -7: The frame sent by the sub-node

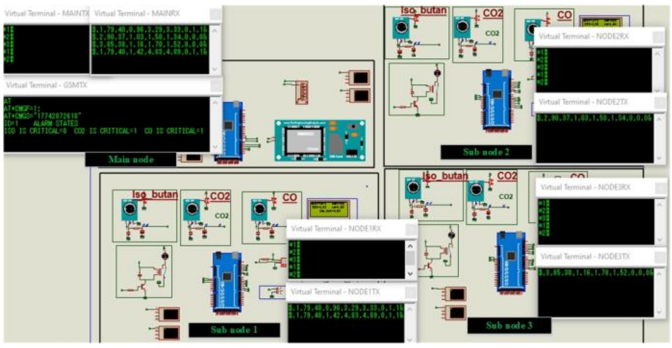

Fig -8: Simulation result

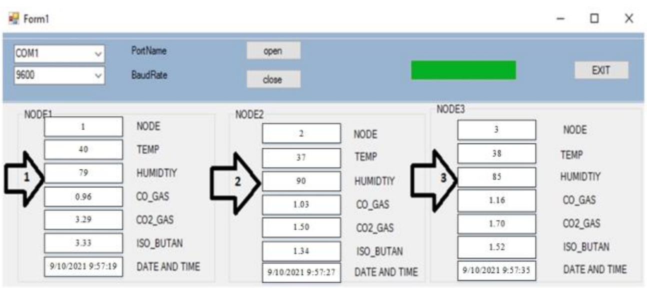

Fig -9: Base station

4. Conclusions

In this work, a proposed method based on a wireless sensor network technology to design and implement a simple, inexpensive, and easy movement remote air factors monitoring system consists of three sensors nodes located in different places to measure all of the surrounding air factors via four sensors: temperature and humidity sensor, (CO) sensor, (CO_2) sensor, and (C_4H_{10}) detection sensor, and transmit the measured characteristics to a wireless receiver board (X-Bee) connected to the RS-232 port of the PC on the base station. The simulation result shows the main station's pollution information and displays it on the host PC's monitoring screen. This system is more accurate, simple, less used of a complex circuit, highly flexible and open to further development.

References

[1] P. Mannucci, and M. Franchini, "health effects of ambient air pollution in developing countries, " International Journal of environmental research and public health, vol. 14, no. 9, 2017, p. 1048.

[2] D. Valencia, S. Fard, and A. Alimohammad, "An artificial neural network processor with a custom instruction set architecture for embedded applications, " IEEE Transactions on Circuits and Systems I: Regular Papers, vol. 67, no. 12, 2020, pp. 5200-5210.

[3] G. Spandana, and R. Shanmughasundram, "Design and development of air pollution monitoring system for smart cities, " Second International Conference on Intelligent Computing and Control Systems (ICICCS), 2018, pp. 1640-1643.

[4] M. El-Abd, "A review of embedded systems education in the Arduino age: lessons learned and future directions, " International Association of Online Engineering, 2017.

[5] K. Dewald, and D. Jacoby, "Signal processing in embedded systems, " IEEE Latin America Transactions, vol. 11, no. 1, 2013, pp. 664-667.

[6] A. Qasem, "Toward Secure Non Deterministic Distributed Wireless Sensor Network Using Probabilistic Key Management Approaches, " Journal of Information Assurance and Security, vol. 6, no. 1, 2011, pp. 010-018.

[7] C. Alippi, G.Anastasi, M. Di Francesco, and M.Roveri, "Energy management in wireless sensor networks with energy-hungry sensors, " IEEE Instrumentation \& Measurement Magazine, vol. 12, no. 2, 2009, pp. 16-23.

[8] T. Dan, P. Traian, V.Andrei, T.Razvan, and T.Nicolae, " Mobile Sensors in Air Pollution Measurement, " IEEE, 2011, pp. 166-170.

[9] S. Snehal, K. Priya, "Design and implementation of real time web based geographic polution monitoring system, " IEEE, 2015, pp. 0447-0450.

[10] K. Shilpa, A. Kulkarni, "Web based air pollution monitoring system (Air pollution monitoring using smart phone), " International Journal of Science and Research (IJSR), vol. 5, no. 3, 2016, pp. 266-269.

Biographies

Abdelrhman Elmahi Makki Ismail is currently a final year bachelor's student in Mechanical design manufacturing and automation at the University of Electronic Science and Technology of China.

Asare Francis Sakyi is currently a final year bachelor's student in Mechanical design manufacturing and automation at the University of Electronic Science and Technology of China.

Ahmed Elkhalil is currently pursuing a Ph.D. degree from the School of Information Science and Technology, Southwest Jiaotong University, Chengdu, China.

Mossalam Hassan Khamis is currently pursuing a Ph.D. degree from the School of Information Science and Technology, Southwest Jiaotong University, Chengdu, China.

Riyad Haider Yousif Gumma received a B.S. degree in 2016 from the School of Mechanical and Automation Engineering, China University of Petroleum, Beijing, China.