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Monitoring Environment Safety Control Automation for Coalmine based on WSN-IoT

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Abstract

Miners' safety is indeed a critical issue, encompassing various challenges that put their health and lives at risk. Mining processes often emit hazardous and toxic fumes, posing serious risks to the health and safety of workers involved in these operations. This issue places significant strain on the mining industry, as it must continually work to mitigate these risks and ensure the well-being of its workforce. The research focuses on detecting temperature, fire, and harmful gases in coal mines using sensors in a Wireless Sensor Network (WSN) module. The detected data is then transmitted through a serial interface and sent to the corresponding location through the IoT cloud using Zigbee. The device provides an early warning system that assists miners in saving their lives before any fatalities occur. This is achieved through the establishment of a wireless sensor network using IoT technology. The proteus tool is used for designing the proposed work.

Keywords: Temperature Sensor, Zigbee, Wireless Sensor Node

1. Introduction

The Internet of Things (IoT) refers to the concept of network-connected devices that can sense and collect data from the surrounding environment. This data is then transmitted over

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the Internet, where it can be processed and utilized for various purposes. The Internet of Things (IoT) involves connecting physical devices such as gas sensors, temperature sensors, and fire sensors with embedded sensing and communication capabilities. This technology is widely used as a solution to various global problems. IoT applications include financial systems, infrastructure management, health monitoring, environmental monitoring, and emergency notification systems, all of which are increasingly relying on IoT-based systems. In this work, IoT is used to control hazards in the underground coal mine's environmental parameters.

2. Literature Survey

In [1], a coal mining safety system is designed using Node MCU and the thinker.io platform to transmit data. In [2], the researchers proposed a system for coal mining safety using Arduino, which integrates gas sensor modules, fire sensors, humidity/temperature sensors, LEDs, and a buzzer. These sensors are connected to an Arduino Uno board and integrated using IoT technology. In [3], the authors reviewed early warning and fault diagnosis systems for coal mine ventilators. The research discusses and examines various types of faults that can occur in coal mine ventilators, analyzes the causes of these failures from different perspectives, and summarizes the common consequences of ventilator failures. In [4], a coal mine safety system using IoT was designed. The system includes a WSN and Raspberry Pi controller, which controls ventilation demand based on atmospheric conditions to ensure the safety of mine workers within the mining area [16].

3. Methodology

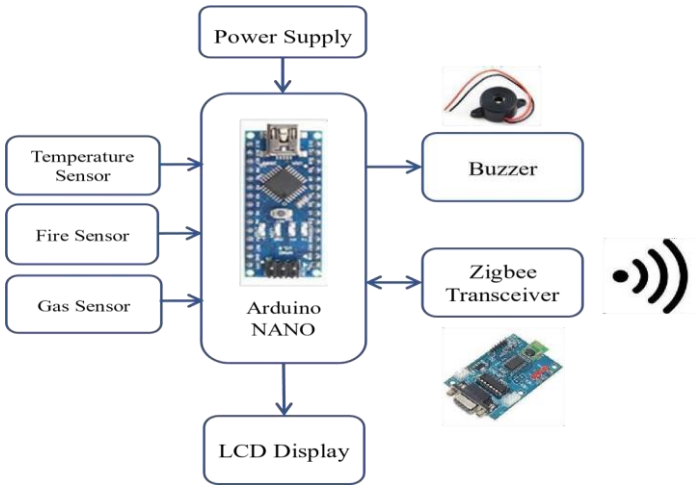

Figure 1. WSN Module

Figure 1 is a visual representation of a system that shows the major components involved and how they are interconnected in the system.

The block diagram consists of a temperature sensor, fire sensor, and gas sensor used to acquire physical parameters. The temperature sensor monitors the environment's temperature, while the gas sensor detects the presence of harmful gases. The fire sensor detects fires. The Arduino Nano acts as the microcontroller and the system's core, processing sensor data and controlling the system. The buzzer serves as the alert system [5,6]. The Zigbee transceiver enables wireless communication between the Arduino Nano and a central monitoring station [7,8, 9]. Monitoring environment safety, control, and automation in coal mines using Wireless Sensor Networks (WSN) and Internet of Things (IoT) involves the deployment of sensor nodes throughout the mine to collect data on various environmental parameters. These parameters include temperature, humidity, gas concentration (e.g., methane, carbon monoxide), air quality, and potentially other factors relevant to safety and operational efficiency [11,12].

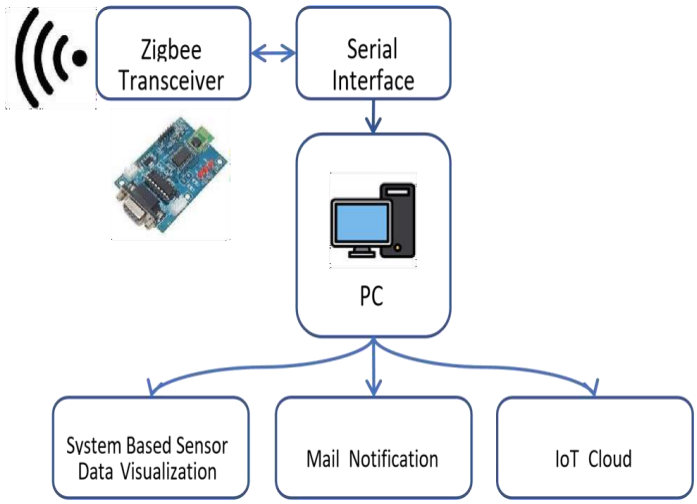

Figure 2. Base Station Module

The base station module is a central component in a wireless sensor network (WSN) that collects data from sensor nodes and coordinates network activities. The following components are in the module. Zigbee Transceiver is used to receives data from sensor nodes and sends commands to them. Microcontroller which is Arduino Nano is used to process the physical data received from sensor nodes and perform necessary actions which is monitoring the temperature and gas level. Ethernet/Wi-Fi Module allows the base station to connect to a local network or the internet for data transmission and remote monitoring [13,14]. User

Interface is allowing users to interact with the base station, view sensor data, and configure settings. Networking Component manages the network topology, communication protocols, and data routing within the WSN as shown in Figure 2.

4. Result and Discussion

In Proteus, virtual sensor nodes can be created to simulate the deployment of sensors throughout the coal mine. These virtual nodes can be programmed to collect data on temperature, humidity, gas concentration, and other parameters. The communication between the sensor nodes and the central monitoring system can be simulated using Proteus' built-in support for wireless communication protocols such as Zigbee [15]. It allows for the simulation of automated safety control mechanisms, such as triggering ventilation systems or shutting down operations. These mechanisms can be activated based on the analysis of sensor data as shown in Figure 3 and 4.

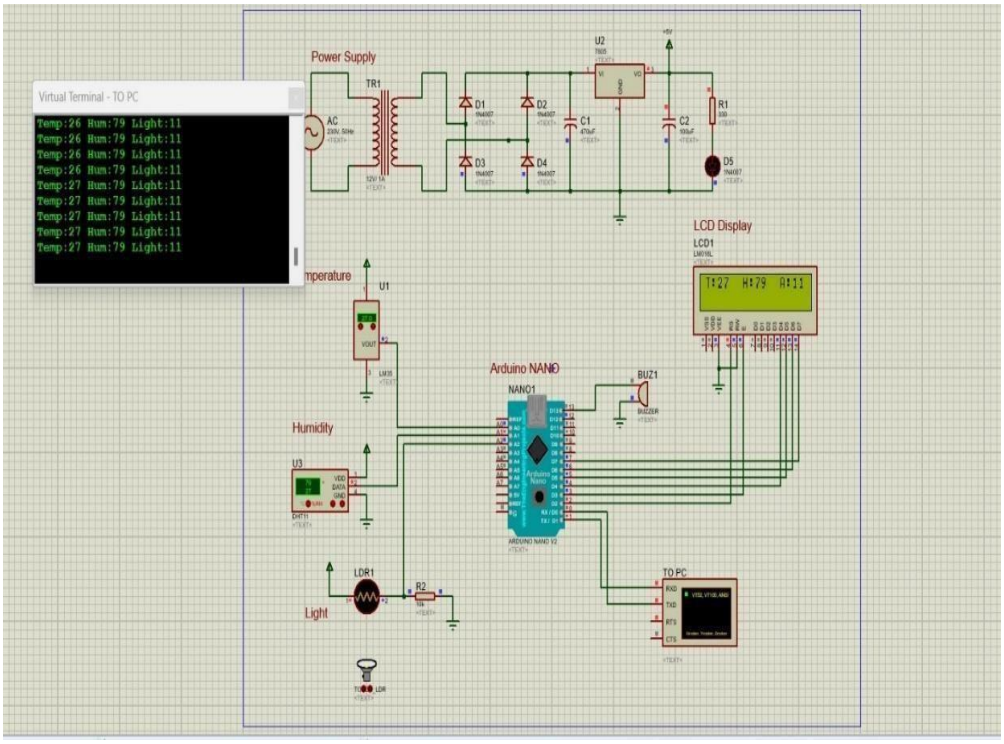

Figure 3. Environment Monitoring (Transmitter 1)

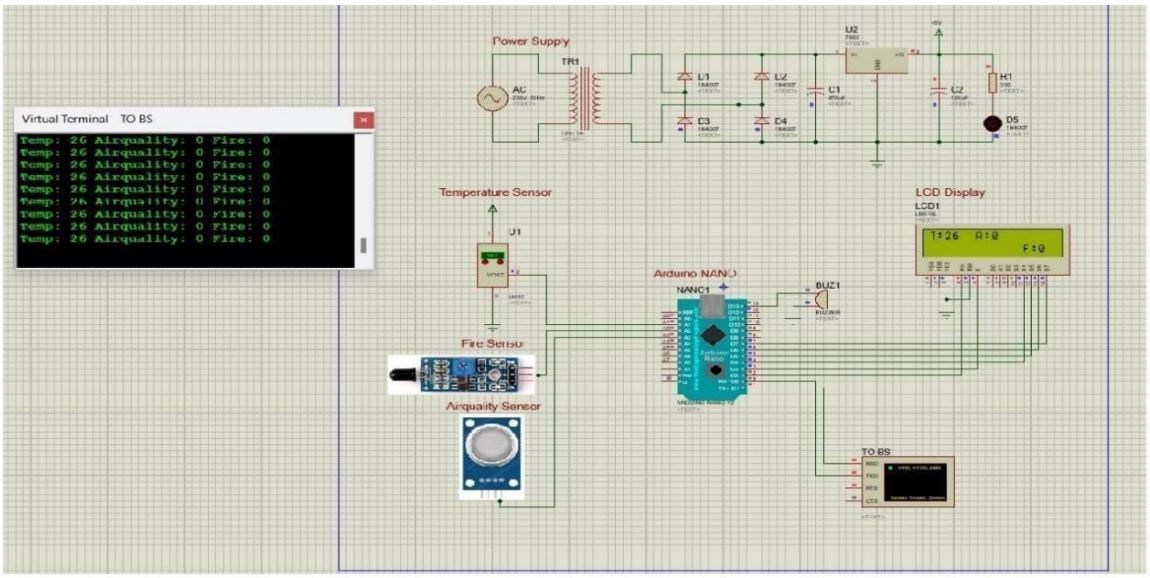

Figure 4. Coalmine Monitoring (Transmitter 2)

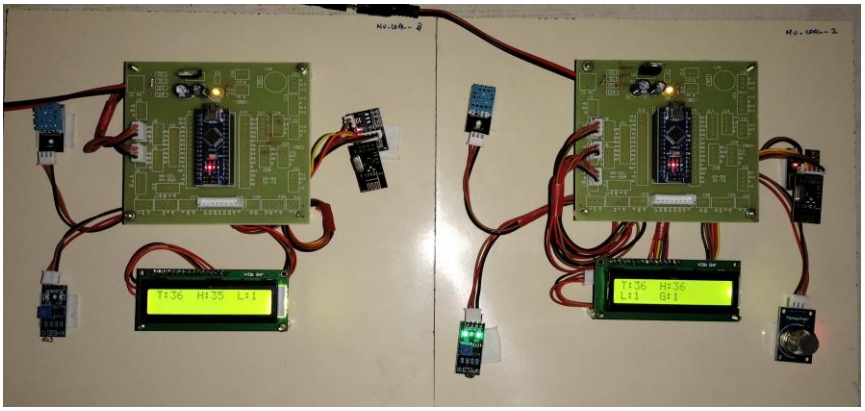

Figure 5. Hardware Output of Transmitter

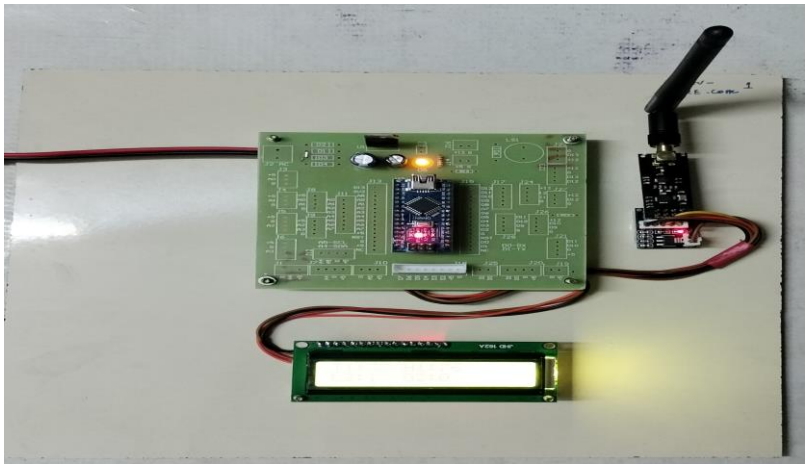

Figure 6. Hardware Output of Receiver

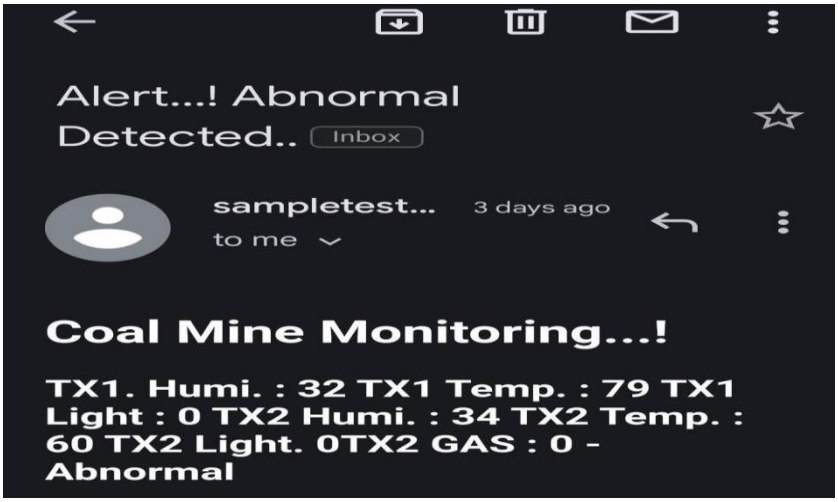

Figure 7. Mail Notification

The figure 5,6 and 7 represents the Hardware output for environmental monitoring and coalmine monitoring and mail notification and Table 1 shows the components of hardware and software used in this work.

Table 1. Hardware and Software Components

S.No	Components Used	Specifications
1	Serial Interface	UART
2	Zigbee Transceiver	2.4 GHz ISM band
3	Temperature Sensor	LM35
4	Fire Sensor	TCRT5000
5	Gas Sensor	MQ-2
6	Arduino Nano	Arduino Nano 3.0

5. Conclusion

This work provides a clear and precise monitoring of the underground mine by developing a real-time monitoring system. When sensor values exceed the threshold level, an alarm is triggered to alert the miners in the mining area. This system is designed to help miners save their lives by alerting them before any accidents occur.

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