WSN BASED COALMINE WORKERS SAFTY SYSTEMS USING IOT

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ABSTRACT:

While there are many other types of hazards, such as earthquakes, land slides, tsunamis, etc., man-made disasters, such fires, power outages, collapsing bridges, buildings, etc., are the most significant and critical kind of catastrophe. Over the years, coal has shown to be very toxic and has resulted in several unintentional fatalities. In light of this, we have created an intelligent system that can be mounted on the helmets of these underground coal miners and that has the ability to continuously monitor and analyse a few key dangerous characteristics. The absence of oxygen, mine erosion, elevated levels of carbon monoxide, and other factors are the reasons of the coal mine-based business. After identifying every problem, we create a smart helmet that uses Internet of Things technology to monitor the mine worker's surroundings and send him regular alerts about things like oxygen and depth levels, accidents, and other concerns. With the use of IOT technology, the worker will be able to anticipate potential hazards and prepare accordingly. Should an accident occur, it will also enable other workers to locate the affected worker.

I. INTRODUCTION

The world's most hazardous places to work are mines, where explosions often occur and thousands of people perish. Furthermore, according to a recent research, 12,000 or so individuals have perished in these kinds of mining catastrophes on average. Because coal is an unsustainable resource that cannot be extensively substituted by humans, there are many coal mine accidents that occur, endangering the lives of the miners who labour there. Sadly, there are also occasional instances in which miners lose their lives underground. These accidents are mostly caused by outdated machinery and electrical devices, which ultimately lead to the improper treatment of toxic gas spills in coal mines, which seriously endangers the workers who operate excavators there. In order to avoid this issue, we built the coalmine prevention system. We tested all of the data gathered by the sensors we used to address the concerns in our study, and we used the Thinger system to complete the analysis. One may choose to control manually or automatically.

II. LITERATURE SURVEY

Yongping Wu and Guo Feng use Bluetooth wireless communication technology to monitor coal mines. Bluetooth technology aims to provide a universal low-power, low-cost wireless air interface and controlling software opening system as a standard of unified worldwide short-range wireless communication. This article explains the history of development, technical specifications, and protocol stack structure of Bluetooth technology. It also suggests Bluetooth host controller interface (HCI) wireless communication solutions to address the intricacy of Bluetooth technology development [2].

Proposed DCS Coal Mine Monitoring System by Zhenzhen Sun The RS485 bus structure, which is based on RS485 Bus, allows for both multipoint and two-way communication. Thus, standard 8-bit microcontrollers may be used to create this kind of monitoring system. Its inexpensive cost and simple circuit configuration are its benefits. Nevertheless, it is challenging to ensure the dependability of the network structure because of the use of the master-slave structure. Additionally, the real-time performance is subpar and the data transmission distance is restricted [3–4].

A wireless sensor network-based autonomous coal mine safety monitoring system was suggested by Jingjiang Song and Yingli Zhu. MSP430F and nRF2401 built this system design monitoring for coal mine safety. The system's sensor groups closely monitor the underground mine's temperature, humidity, and other variables. The microcontroller sends the measured data to the wireless connection module. A cable is used to transmit the gathered data to the long-distance monitoring centre [5]. The issue with this approach is that since the hardware is within the coal mines, it is damaged in the event of a natural disaster or a roof collapse. Therefore, the traditional communication system's longevity and dependability are lacking. The system is exceedingly difficult to install and maintain because of the hostile climate within the mine. Another issue is that loud coal mine operations might prevent miners from receiving the right messages if they are too far away from the system.

III. DESIGN OF HARDWARE

This chapter briefly explains about the Hardware. It discuss the circuit diagram of each module in detail.

ARDUINO UNO

A microcontroller board based on the ATmega328 is called the Arduino Uno (datasheet). It has a 16 MHz ceramic resonator, 6 analogue inputs, 14 digital input/output pins (six of which may be used as PWM outputs), a USB port, a power connector, an ICSP header, and a reset button. It comes with everything required to support the microcontroller; all you need to do is power it with a battery or an AC-to-DC converter or connect it to a computer via a USB connection to get going.The FTDI USB-to-serial driver chip is not used by the Uno, setting it apart from all previous boards. As an alternative, it has the Atmega16U2 (or Atmega8U2 up to version R2) configured as a serial-to-USB converter. The 8U2 HWB line on the Uno board is pulled to ground by a resistor, which facilitates DFU mode entry. The Arduino board now includes the following updates:

• 1.0 pin out: two further new pins, the IOREF, are positioned next to the RESET pin, the SDA and SCL pins that were introduced, and they enable the shields to adjust to the voltage supplied by the board. Shields will eventually work with both the Arduino Due, which runs on 3.3V, and the boards that utilise the AVR, which runs on 5V. The second pin is unconnected and set aside for future uses.

• A more robust RESET circuit.

• The 8U2 is replaced with an ATMega 16U2.

"Uno" is an Italian word for one, and it was chosen to commemorate the impending introduction of Arduino 1.0. Going future, the Arduino reference versions will be the Uno and version 1.0. The Uno is the most recent in a line of USB Arduino boards and the platform's standard model; see the index of Arduino boards for a comparison with earlier iterations.

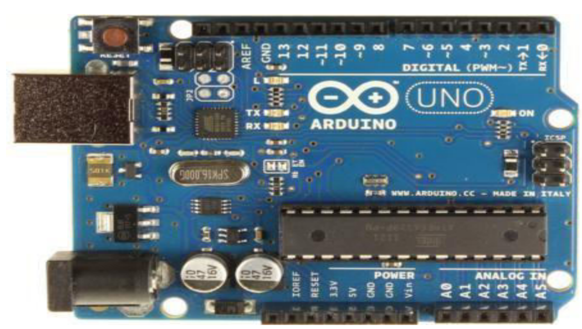


Fig: ARDUINO UNO

POWER SUPPLY:

The power supplies are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. A d.c power supply which maintains the output voltage constant irrespective of a.c mains fluctuations or load variations is known as "Regulated D.C Power Supply".

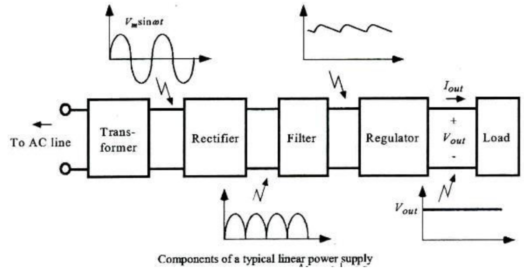


Fig: Block Diagram of Power Supply

LCD DISPLAY

The model shown here is the one that is most often utilised in practice due to its cheap cost and enormous potential. Its HD44780 microcontroller (Hitachi) platform allows it to display messages in two lines of sixteen characters each. All of the alphabets, Greek letters, punctuation, mathematical symbols, etc., are shown. Furthermore, it is possible to show custom symbols created by the user. Some important features are the automatic changing of the message on the display (shift left and right), the presence of the pointer, the lighting, etc.

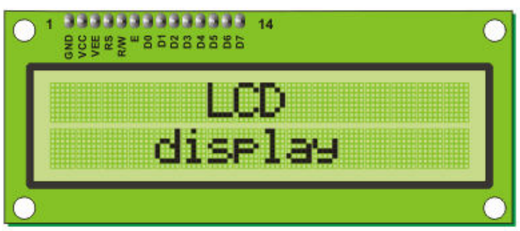
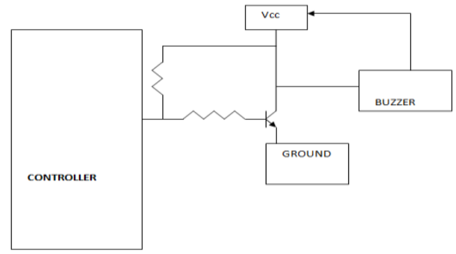


Fig: LCD

BUZZER

Digital systems and microcontroller pins lack sufficient current to drive the circuits like relays, buzzer circuits etc. While these circuits require around 10milli amps to be operated, the microcontroller's pin can provide a maximum of 1-2milli amps current. For this reason, a driver such as a power transistor is placed in between the microcontroller and the buzzer circuit.



IR SENSOR:

IR technology serves a variety of functions in both industry and everyday life. TVs, for instance, employ infrared sensors to decipher signals sent by remote controls. The key advantages of infrared sensors are their low power consumption, simple construction, and practical properties. Infrared transmissions are invisible to the naked eye. The visible and microwave portions of the electromagnetic spectrum include infrared radiation. These waves typically have wavelengths between 0.7 µm and 1000 µm. There are three sections of the infrared spectrum: near-, mid-, and far-infrared. The wavelength ranges for the near-infrared area are 0.75–3µm, the mid-infrared region is 3–6µm, and the far-infrared region's infrared radiation is more than 6µm.

Numerous wireless applications are addressed by infrared technology. The two primary domains are remote controls and sensors. The near infrared area, mid infrared region, and far infrared region comprise the infrared section of the electromagnetic spectrum. These areas' wavelengths along with their uses are given below.

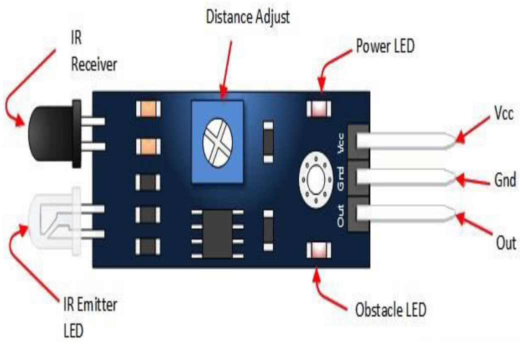
• Near infrared range: 700–1400 nm; infrared sensors; fibre optic

• Mid-infrared spectrum: heat sensing from 1400 to 3000 nm

• Far infrared range: thermal imaging, 3000 nm to 1 mm

Compared to microwaves, infrared light has a wider frequency range than visible light. In the near infrared, photo optics technologies are employed for optical sensing and optical communication because, when used as a signal source, light is less complicated than radiofrequency (RF). For applications that need short range, optical wireless communication uses infrared data transfer.

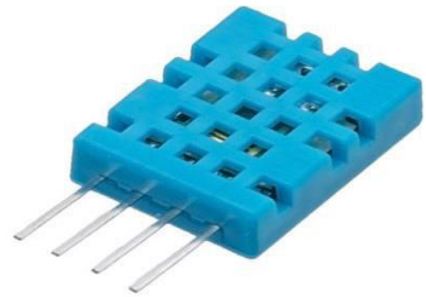
To perceive its surroundings, an infrared sensor produces or detects infrared radiation.



DHT TEMPERATURE & HUMIDITY SENSORS.

Although these sensors are sluggish and relatively basic, they are excellent for amateurs who want to do simple data recording. The capacitive humidity sensor and the thermistor are the two components that make up the DHT sensors. Additionally, there is a very simple chip inside that converts analogue to digital and outputs a digital signal that includes the humidity and temperature. Any microcontroller can easily interpret the digital signal.

The amount of water vapour in the air is measured as humidity. Air humidity has an impact on a number of physical, chemical, and biological processes. Humidity in industrial settings may have an impact on worker health and safety as well as the cost of the goods. So, humidity measurement is crucial in the semiconductor and control system sectors. The quantity of moisture in a gas, which may consist of a combination of water vapour, nitrogen, argon, or pure gas, etc., is determined by measuring its humidity. Based on their measuring units, there are two kinds of humidity sensors. A relative humidity sensor and an absolute humidity sensor are what they are. A digital sensor for temperature and humidity is called DHT11.



MQ3 Alcohol Gas Sensor Module

This module is built using the MQ3 Alcohol Gas Sensor. It is a cheap semiconductor sensor that can identify alcohol gases at concentrations between 0.05 and 10 mg/L. $SnO2$, the sensitive substance utilised in this sensor, has a reduced conductivity in clean air. As the concentration of alcohol gases rises, so does its conductivity. It is very sensitive to alcohol and resists disruptions from petrol, smoke and vapour well. There are analogue and digital outputs available on this module. It is simple to link the MQ3 alcohol sensor module with microcontrollers, Arduino boards, Raspberry Pis, and other devices.

Similar to a standard breathalyser, this alcohol sensor can identify the amount of alcohol in your breath. It responds quickly and with great sensitivity. Based on the amount of alcohol present, the sensor outputs an analogue resistive. One resistor is all that is required for the very basic driving circuit. A basic Global System for Mobile Communications (GSM) system

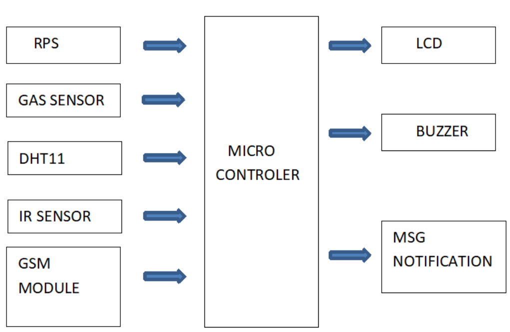
The Global System for Mobile Communications, or GSM, is a cellular network that is connected by mobile devices looking for nearby cells. GSM networks operate within four distinct frequency bands. The majority of GSM networks use the 900 MHz or 1800 MHz bands for operation. Because the 900 and 1800 MHz frequency channels were previously assigned, several American nations utilise the 850 MHz and 1900 MHz frequencies.

Some governments have allocated the more elusive 400 and 450 MHz frequency bands, which were formerly used for first-generation systems.

Using a frequency range of 890–915 MHz for uplink (information sent from the mobile station to the base station) and 935–960 MHz for downlink (information sent in the other way), GSM-900 offers 124 RF channels (numbers 1 through 124) that are spaced 200 kHz apart. 45 MHz is the duplex spacing utilised. The GSM-900 band has been expanded to encompass a wider frequency range in some nations. This "extended GSM," or E-GSM, adds 50 channels (numbers 975 to 1023 and 0) to the original GSM-900 band, using 880–915 MHz (uplink) and 925–960 MHz (downlink). Each radio frequency channel may support up to eight full-rate or sixteen half-rate voice channels using time division multiplexing. A TDMA frame is made up of eight radio timeslots, which provide eight burst periods. In the same timeslot, half rate channels utilise different frames. The frame time is 4.615 milliseconds, and the channel data rate is 270.833 kbit/s.

IV. BLOCK DIAGRAM AND HARDWARE DISCRIPTION

4.1. BLOCK DIAGRAM:



WORKING

The working of a coal mine workers' safety system utilizing Arduino and Wireless Sensor Networks (WSN) integrated with Internet of Things (IoT) technology is designed to enhance the safety and monitoring of miners in hazardous environments. Below is a detailed explanation of how this system operates, the components involved, and its functionality.

1. Components of the System

- **Arduino Microcontroller**: The central processing unit that manages all data collection, processing, and communication tasks.
- **Wireless Sensor Network (WSN)**: Composed of various sensors that monitor environmental conditions (e.g., gas levels, temperature, humidity, and vibration).
- **IoT Module**: Connects the system to the internet, allowing real-time data transmission to remote servers or mobile applications for monitoring and alerts.
- **Power Supply**: Provides the necessary power for the Arduino and sensors.
- **Alerts System**: Includes buzzers, LEDs, and notifications to alert workers and control rooms of any dangerous conditions.

2. Functionality of the System

Data Collection

1. **Sensor Deployment**: Various sensors are deployed throughout the mine to continuously monitor critical parameters such as:
    - **Gas Sensors**: Detect hazardous gases (e.g., methane, carbon monoxide) that could pose a risk to workers.
    - **Temperature and Humidity Sensors**: Monitor environmental conditions that could affect worker safety.

- **Vibration Sensors**: Detect any significant ground movements or structural integrity issues.

2. **Data Acquisition**:
   - The sensors collect data and transmit it wirelessly to the Arduino microcontroller. The data acquisition is continuous to ensure real-time monitoring.

Data Processing and Analysis

3. **Arduino Processing**:
   - The Arduino receives the sensor data and processes it. It checks for thresholds set for safe operation (e.g., maximum allowable gas concentration, temperature limits).
   - If the data exceeds predefined thresholds, the Arduino triggers an alert mechanism.

Alert Mechanism

4. **Alert Generation**:
   - **Local Alerts**: The Arduino activates local alarms, such as buzzers and flashing LEDs, to alert workers in the vicinity of hazardous conditions.
   - **Remote Notifications**: Using an IoT module (e.g., GSM, Wi-Fi), the system sends notifications to a control room or safety personnel via SMS, email, or an app, informing them of the danger and the exact location.

Real-Time Monitoring

5. **Data Transmission**:
   - The processed data, along with alerts, is transmitted to a centralized server or cloud platform. This allows safety managers to monitor the status of all sensors in real-time.
6. **User Interface**:
   - A web or mobile application can be developed to provide a user-friendly interface for monitoring the mine's conditions remotely. This interface can display live data from sensors, alert history, and other relevant information.

3. Operational Workflow

- **Initialization**:
  - Upon powering up, the Arduino initializes all connected sensors and the IoT module, preparing them for operation.
- **Continuous Monitoring**:
  - The system continuously monitors environmental parameters using the sensors.
- **Alert Activation**:
  - If any sensor detects a dangerous condition, the system activates local alarms and sends remote notifications.
- **Data Logging**:
  - All sensor data is logged and can be analyzed later to identify patterns or recurring issues, contributing to overall mine safety improvements.

4. Benefits of the System

- **Enhanced Safety**: Continuous monitoring of hazardous conditions can prevent accidents and injuries.
- **Real-Time Alerts**: Immediate notifications can lead to quicker responses to emergencies.
- **Data Analysis**: Historical data helps in assessing safety measures and making informed decisions.
- **Worker Awareness**: Local alarms ensure that workers are immediately aware of dangerous conditions.

V. CONCLUSION

The IoT-enabled, Arduino WSN-based coal mine workers' safety system greatly improves coal mining operations' safety and monitoring capabilities. This system makes mining safer by using several sensors for real-time data collecting, processing, and alerting. It also makes it possible for safety workers to monitor the area effectively. Integrating IoT in these applications will probably result in even greater gains in worker safety and operational efficiency in hazardous areas as technology continues to progress.

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