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"Automated Rescue System for Coal Mine Workers"

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ABSTRACT

Coal mining is one of the most hazardous industries, where workers face numerous risks, including exposure to toxic gases, high temperatures, and humidity. This project proposes an "Automated Rescue System for Coal Mine Workers," which utilizes modern technology to enhance safety and reduce fatalities in mines. The system consists of a transmitter and a receiver module.

The transmitter module includes sensors for monitoring temperature, humidity, gas levels, and motion, which are interfaced with an Arduino Nano microcontroller. The collected data is displayed on an LCD screen and transmitted wirelessly using an RF transmitter. In case of abnormal conditions, the system sends alerts to the receiver module.

The receiver module, equipped with an RF receiver and controller, processes incoming data and displays it on an LCD screen. Additionally, a speaker alarm provides audio alerts to notify rescue teams of dangerous conditions. This real-time monitoring and alert system ensure timely interventions, improving worker safety and facilitating effective rescue operations in coal mines.

This project demonstrates a cost-effective and reliablesolution for monitoring environmental hazards and enhancing the safety of coal mine workers.

INTRODUCTION

Coal mining is a vital industry that plays a significant role in powering global economies, but it is also one of the most dangerous workplaces. Miners are constantly exposed to life-threatening conditions such as toxic gas emissions, extreme temperatures, high humidity levels, and the risk of physical injuries due to collapses or equipment failures. Despite advancements in safety protocols, the unpredictable nature of mining environments demands a robust and automated system to monitor hazardous conditions and alert workers and rescue teams in real time.

The "Automated Rescue System for Coal Mine Workers" is designed to address these challenges by providing continuous environmental monitoring and alert mechanisms. The system uses sensors to detect critical parameters such as temperature, humidity, gas concentrations, and motion. These sensors are connected to an Arduino Nano microcontroller, which processes the data and displays it on an LCD screen. Any anomalies detected are transmitted wirelessly to a receiver module through an RF transmitter.The receiver module, stationed at a safe location, receives the transmitted data via an RF receiver.

It displays the information on an LCD screen and triggers a speaker alarm when unsafe conditions are identified. This system ensures real-time communication between the mine and the monitoring station, enabling timely interventions and reducing the risks faced by miners.The proposed system is cost-effective, easy to deploy, and capable of significantly improving the safety standards in coal mining operations.

By automating hazard detection and alert mechanisms, it reduces response times and facilitates better rescue coordination, ultimately saving lives and enhancing the working conditions of coal miners.

Block Diagram:

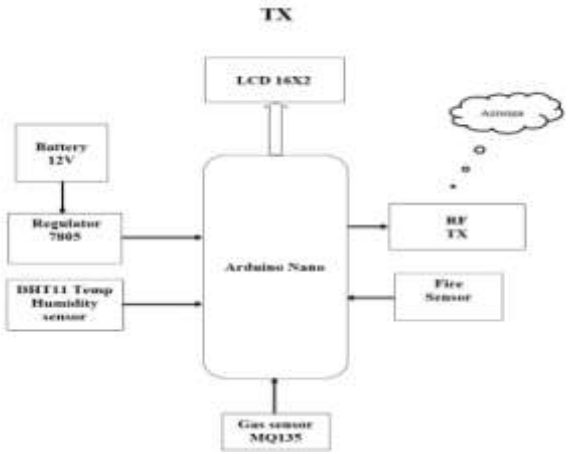


Fig. 1. Block Diagram Automated rescue system for coal mine workersTransmitter side.

Description of Block diagram:

This block diagram represents the transmitter section of an automated rescue system designed to ensure the safety of coal mine workers by continuously monitoring environmental conditions and transmitting alerts in case of hazards.

1. Battery (12V)
- Acts as the primary power source for the entire system.
- Supplies voltage to the regulator circuit.

2. Voltage Regulator (7805)
- Converts 12V DC input from the battery to a stable 5V DC output.
- Powers the Arduino Nano and other 5V components.

3. Arduino Nano
- The central controller of the system.
- Collects data from all sensors, processes it, and controls the output devices.
- Programs can be uploaded to handle sensor thresholds, logic conditions, and communication.

4. Temperature and Humidity Sensor (e.g., DHT11)
- Measures environmental temperature and humidity levels.
- Sends real-time data to the Arduino for monitoring and decision-making.

5. Gas Sensor (e.g., MQ135 or MQ2)
- Detects the presence of hazardous gases such as methane, carbon monoxide, or smoke.
- Critical for early detection of gas leaks or air quality degradation.

6. Fire Sensor (e.g., Flame or IR sensor)
- Detects fire or abnormal heat signatures.
- Helps identify fire outbreaks in early stages to trigger immediate alarms.

7. LCD Display (16x2)
- Displays real-time data like temperature, humidity, gas levels, and fire alerts.
- Useful for quick on-site monitoring and debugging.

8. RF Transmitter (RF TX)
- Sends the processed information wirelessly to the receiver unit located outside the mine.
- Operates on RF communication protocols (like 433 MHz) to cover short-range underground communication.

9. Antenna
- Enhances the range and reliability of the RF transmission.

- Ensures strong signal propagation from underground to the surface.

10. System Function Overview
- The system continuously reads sensor values and displays them on the LCD.

Block Diagram:

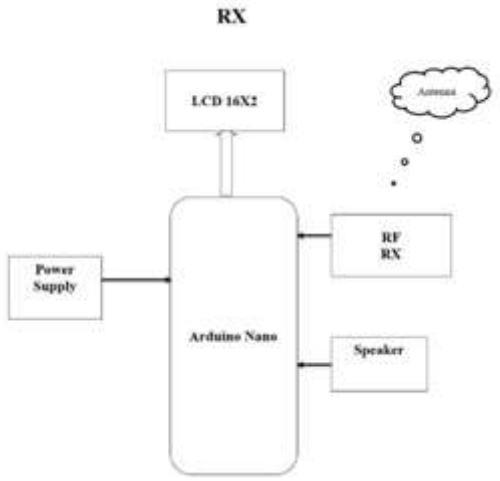


Fig., Block Diagram Automated rescue system for coal mine workers Receiver side.

Description of Block Diagram:
This block diagram represents the **receiver section** of the coal mine worker safety system. It is located at the surface and receives signals from the transmitter (installed underground). The goal is to alert rescue teams about dangerous conditions underground.

1. Power Supply
- Provides the necessary operating voltage (typically 5V regulated) for the receiver system.
- Powers the **Arduino Nano** and other connected components.

2. Arduino Nano
- Acts as the **central processing unit** for the receiver section.
- It receives data from the **RF Receiver module**, processes it, and then provides appropriate outputs.
- Handles logic to determine alert messages and system response.

3. RF Receiver (RF RX)
- Receives data transmitted by the **RF Transmitter** from the underground unit.
- The signal carries sensor readings or alert statuses (e.g., gas leak, fire detected, etc.).
- The data is passed to the Arduino Nano for interpretation.

4. Antenna
- Improves the signal strength and reception reliability of the RF module.
- Ensures stable communication between underground and surface units.

5. LCD Display (16x2)
- Displays received data from the transmitter such as:
  - Gas levels
  - Fire alerts
  - Temperature and humidity conditions

6. Speaker / Voice Message
- The Arduino activates an audio alert through a speaker in case of emergencies.
- This may include **pre-recorded warning messages** (e.g., "Fire Detected", "Gas Leak", "High Temperature") to prompt quick action.
- Ensures that alerts are noticed even without looking at the LCD.

System Function Overview
- The receiver system remains on standby to capture data from the underground transmitter.
- Upon receiving hazard signals, it displays sensor readings and triggers a **voice alert** via the speaker.
- This improves the **response time** in case of emergencies, potentially saving lives.

2.Objectives

- To ensure real-time monitoring of underground environmental conditions
- To detect hazardous situations early and trigger immediate alerts
- To automate the emergency alerting and response system
- To transmit critical data wirelessly to a remote monitoring station
- To assist in locating trapped or affected workers during emergencies
- To provide a user-friendly visual interface for status updates
- To reduce human error and improve decision-making in rescue operations
- To enhance overall safety and minimize casualties in coal mining operations.

AT mega328 Microcontroller:

Microcontroller Architecture

- **Architecture:** 8-bit AVR RISC (Reduced Instruction Set Computing).
- **Operating Voltage:** 1.8V to 5.5V (typically 5V or 3.3V).
- **Package Types:**
  - 28-pin PDIP (Dual In-line Package).
  - 32-pin TQFP (Thin Quad Flat Package).
  - 28-pin MLF (Micro Lead Frame).

➢ **Core Features**

- **CPU:** 8-bit AVR.
- **Clock Speed:** Up to 20 MHz when using an external crystal oscillator.
- **Program Memory (Flash):** 32 KB (of which 0.5 KB is used by the bootloader).
- **SRAM (Static RAM):** 2 KB.
- **EEPROM (Electrically Erasable Programmable Read-Only Memory):** 1 KB.
- **Instruction Set:** RISC architecture, with around 131 instructions that mostly execute in one clock cycle.

➢ **Input/output (I/O)**

- **General Purpose I/O Pins (GPIO):**
  - 23 digital I/O pins.
  - 6 of these can be used as PWM (Pulse Width Modulation) outputs.
- **Analog Inputs:**
  - 6 Analog input pins with a 10-bit ADC (Analog-to-Digital Converter).
- **Timers:**
  - 1x 16-bit Timer/Counter.

- 2x 8-bit Timer/Counters with separate Prescalers and compare modes.

- **Communication Interfaces:**
- **USART (Universal Synchronous and Asynchronous serial Receiver and Transmitter):** 1 (supports both synchronous and asynchronous modes).
- **SPI (Serial Peripheral Interface):** 1.
- **I²C (Two-Wire Interface):**

Regulator LM2596 DC-DC Buck Converter:

The **LM2596** is a **DC-DC buck converter** module, which means it steps down higher DC voltage to a lower voltage. It's based on the **LM2596 switching regulator IC**, designed to provide high-efficiency voltage conversion with minimal heat generation. This module is widely used in projects that require a stable, adjustable DC output.

- Output Voltage: Adjustable, usually between 1.25V to 35V DC (depending on the input voltage).
- Output Current: Up to 3A, but optimal performance is usually achieved around 2A for extended use.
- Efficiency: Can reach up to 92% efficiency, meaning it generates very little heat during operation.
- Switching Frequency: 150 kHz, which ensures minimal power loss and better efficiency compared to linear regulators.
- Load Regulation: 0.5% to 1%, which ensures stable output even under changing load conditions.
- Thermal Shutdown: Protects the module from overheating.

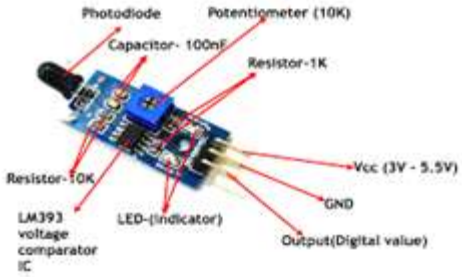
➢ **Pin Layout:**

1. **Input (+)**: Positive terminal for the input voltage (connected to the high voltage source).
2. **Input (-)**: Negative terminal (ground) for the input voltage.
3. **Output (+)**: Positive terminal for the stepped-down output voltage.
4. **Output (-)**: Negative terminal (ground) for the output voltage.
5. **Adjustable Potentiometer**: Used to adjust the output voltage. Rotating the screw clockwise increases the output voltage, while counterclockwise decreases it.

LCD 16*2:

The **16x2 LCD Display** is a popular display unit in embedded systems and electronics projects. It is used to display alphanumeric characters and basic symbols.This display contains two internal byte wise resisters Onefor the commands (RS=0) and second for character to be displayed (RS=1). It also contains a user programmed RAM area (the character RAM) that can be programmed to generate any desired character that can form using a dot matrix. To distinguish between these two data areas, the hex command byte 80H will be used to signify that display RAM address 00H is chosen. Port 1 is used to furnish the command or data byte, and ports 3.2 to 3.4 furnish register select and read/write levels. The display takes varying amounts of time to accomplish the functions. LCD bit 7 is monitored for a logic high (Busy) to ensure the display is not overwritten.

DHT11 Temperature sensor:



The **DHT11** is a popular sensor that measures both temperature and humidity. It's widely used in various applications due to its affordability and ease of use. The sensor communicates through a digital signal, making it simple to interface with microcontrollers like Arduino, ESP32, or Raspberry

Fire Sensor

➢ **General Description:**

Flame sensor is the most sensitive to ordinary light that is why its reaction is generally used as flame alarm purposes. This module can detect flame or wavelength in 760 nm to 1100 nm range of light source. Small plate output interface can and singlechip can be directly connected to the microcomputer IO port. The sensor and flame should keep a certain distance to avoid high temperature damage to the sensor. The shortest test distance is 80 cm, if the flame is bigger, test it with farther distance. The detection angle is 60 degrees so the flame spectrum is especially sensitive. The detection angle is 60 degrees so the flame spectrum is especially sensitive.

➢ **Specifications:**

i. On-board LM393 voltage comparator chip and infrared sensing probe.
ii. Support 5V/3.3V voltage input.
iii. On-board signal output indication, output effective signal is high level, and the same time the indicator light up, output signal can directly connect with microcontroller IO.
iv. Signal detection sensitivity can be adjusted.
v. Reserved a line voltage compare circuit (P3 is leaded out).
vi. PCB size: 30(mm) x15(mm).
vii. • Digital and Analog Output DO digital switch outputs (0 and 1) AO Analog voltage output
viii. Power indicator and digital switch output indicator

➢ **Pin Configuration:**

Interface Description (4-wire)
1) VCC -- 3.3V-5V voltage
2) GND --- GND
3) DO -- board digital output interface (0 and 1)
4) AO -- board Analog output interface

Speaker-Audio message:

ISD1820 is a small Voice Recorder and Playback module that can do the multi-segment recording. The user can achieve a high quality of recording (for 8 to 20secs) for each application with the adjustment of the on-board resistor. This Voice Recorder/Playback module is designed with embedded-Flash memory, which can hold data for up to 100 years and erase/record the life cycle up to 100,000

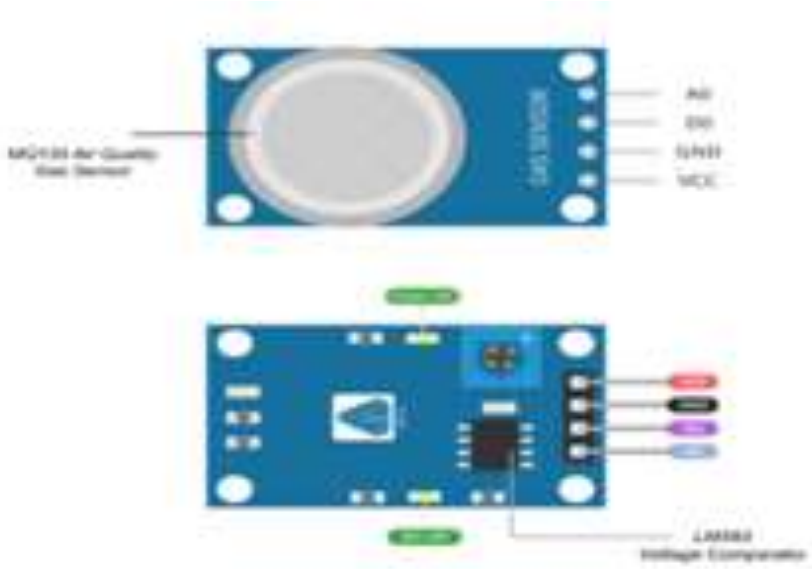
- **Features**
- Operating Voltage: Wide power supply ranges from 2.4V to 5.5V DC

- With the internal audio amplifier, this board can drive 8 Ohm 0.5W speakers directly.
- An on-board microphone.
- Dual operating modes

1. Standalone mode
2. Microcontroller Driven mode

- Push-button interface, playback can be edge or level activated
- Record up to 20 seconds of audio
- Automatic power-down mode (standby mode)
- Dimensions (LxWxH) in cm 8 x 6 x 3

MQ135



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semiconductor sensor and has high sensitivity to ammonia gas, sulphide, benzene series steam, also can monitor smoke and other toxic gases well. It is a Metal Oxide Semiconductor (MOS) type Gas Sensor also known as Chemiresistors as the detection is based upon change of resistance of the sensing material when the Gas comes in contact with the material. Using a simple voltage divider network, concentrations of gas can be detected. This module provides both digital and analog outputs. It can be easily interfaced with Microcontrollers, Arduino Boards, Raspberry Pi etc.

➢ **Features and Specifications:**

- 5V operation
- LEDs for output and power
- Output sensitivity adjustable
- Analog output 0V to 5V
- Digital output 0V or 5V
- Low Cost
- Fast Response
- Stable and Long Life

Both Digital and Analog Output

RESULT

An automated rescue system for coal mine workers is designed to enhance safety and efficiency during emergencies. It uses advanced technologies such as sensors, robotics, and wireless communication to detect hazards like gas leaks, fires, or cave-ins. These systems can automatically alert rescue teams, provide real-time location tracking of trapped workers, and deploy rescue robots or drones to assess and stabilize conditions before human responders arrive. Overall, such systems reduce response time, minimize human risk, and increase the chances of survival for miners during critical situations.

4.**Future Scope :**

- **Safety & Early Warning Systems**

sensors and AI can predict hazardous conditions like gas leaks, fires, and structural failures, providing early alerts to prevent disasters.

- **Integration of Robotics & Drones**

Autonomous robots and drones can navigate dangerous or inaccessible areas to locate trapped miners, deliver supplies, and even assist in rescue operations without risking human rescuers.

- **IoT-Based Real-Time Monitoring**

Wearable devices connected through IoT can continuously track miners' health, location, and environmental conditions, enabling quicker responses during emergencies.

- **AI-Driven Decision Making**

AI algorithms can Analyze Advanced data from sensors to make real-time decisions during crises, optimizing rescue strategies and minimizing response time.

- **Smart Communication Network**

Future systems may include underground communication networks that remain functional even after structural damage, ensuring continuous contact with trappedworkers.

- **Autonomous Rescue Vehicles**

Development of smart vehicles that can automatically detect and reach victims without human control, improving the speed and safety of rescue missions.

- **Data-Driven Safety Protocols**

Continuous data collection and analysis can help develop more effective mining safety protocols and reduce the risk of accidents.

CONCLUSION

The development of an automated rescue system for coal mine workers represents a significant advancement in ensuring miner safety and enhancing emergency response. By integrating modern technologies such as IoT, robotics, AI, and real-time monitoring, these systems can detect hazards early, reduce human involvement in dangerous rescue operations, and save lives. As mining remains one of the most hazardous occupations, investing in such automated

solutions is not only a technological necessity but also a humanitarian priority. With continued innovation and implementation, the future of mine safety can be significantly improved.

REFERENCES

[1.] Kumar, A. Gupta, "IoT-based Safety Monitoring System for Coal Mines," International Journal of Engineering Research & Technology (IJERT), vol. 9, no. 7, 2020.
[2.] B. Singh, R. Sharma, "Automation in Mining: A Technological Revolution," Journal of Mining and Environment, vol. 12, no. 2, S 2021.
[3.] World Health Organization (WHO) – "Occupational Health in Mining," https://www.who.int
[4.] Ministry of Coal, Government of India, "Safety in Coal Mines," https://coal.nic.in
[5.] IEEE Xplore Digital Library, "Smart Rescue Robots in Underground Mining," 2019. https://ieeexplore.ieee.org