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ENHANCHING COAL MINING SAFETY WITH ARDUINO BASED MONITORING SYSTEM

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***Abstract*: -** Coal is a major element for development, an important energy source for power generation, and it is an essential part of the manufacturing of alumina, iron, steel, cement, and other resource products necessary for modern living. The extraction of coal from the field is known as coal mining. Safety and security are critical components in the mining sector. Even they take certain precautions to avoid accidents in the underground mines. Still, accidents continue to occur in underground mines, resulting in a greater number of disasters. Temperature, gas, fire, and water are the key elements involved in many accidents. This project monitors these parameters using Arduino UNO and provides safety and alert for coal mine workers to minimize the accidents. To improve underground mine safety, a reliable communication system must be built between underground mine workers and a fixed ground system. The communication network must not be interrupted at any time or under any circumstances. A buzzer is used for alerting the mine workers. Using IoT and Buzzers, this system alerts the admin as well as the workers when any abnormalities are found inside the coal mine.

I. INTRODUCTION

Coal has been a cornerstone of global energy production and industrial development for centuries. Its significance as a primary energy source for power generation and a vital raw material in various manufacturing processes cannot be overstated. From providing electricity to fueling the production of steel, cement, and other essential products, coal plays a crucial role in sustaining modern living standards. However, the extraction of coal, known as coal mining, comes with inherent risks, particularly in underground mines. Safety and security are paramount concerns in the mining sector due to the hazardous nature of the work environment. Despite rigorous safety protocols and precautions, accidents still occur, leading to significant disruptions and, in somecases, tragic loss of life.

Various factors contribute to the occurrence of accidents in underground coal mines, with temperature, gas, fire, and water being among the primary elements involved.

Coal mining has long been a vital industry, providing the primary source of energy for power generation and serving as a cornerstone of industrial development worldwide. From powering steam engines during the Industrial Revolution to fueling modern thermal power plants, coal remains indispensable for meeting global energy demands. However, the extraction of coal is not without its challenges, particularly in underground mines where miners face a myriad of hazards. These hazards include exposure to toxic gases, risk of explosions due to methane accumulation, potential collapse of underground structures, and the threat of fires exacerbated by combustible coal dust.

Historically, coal mining has been associated with numerous accidents and tragedies, leading to loss of life, injuries, and damage to infrastructure. Despite significant advancements in safety regulations and technologies, ensuring the well-being of miners in underground coal mines remains a persistent challenge. The importance of safety in the mining sector cannot be overstated, as accidents not only pose immediate risks to workers but also have broader socioeconomic implications. Disruptions in coal production due to accidents can result in supply shortages, economic losses, and adverse environmental impacts.

Efforts to improve safety in underground coal mining have led to the development of various technologies and practices aimed at mitigating risks and enhancing monitoring capabilities. Traditional monitoring methods, such as periodic inspections and manual measurements, have limitations in detecting and responding to dynamic environmental conditions.

In recent years, there has been a growing emphasis on leveraging advanced technologies, including IoT, data analytics, and automation, to enhance safety and efficiency in mining operations. These technologies offer the potential to revolutionize safety monitoring by providing real-time data insights and enabling proactive interventions.

Despite advancements in safety protocols and technologies, accidents continue to occur in underground coal mines, posing significant risks to the well-being of miners and the integrity of mining operations. The inherent hazards of underground mining, including exposure to toxic gases, the potential for fires and explosions, and the risk of structural collapse, necessitate robust monitoring and alert systems to safeguard the lives of workers and prevent catastrophic incidents.

Existing monitoring methods often rely on manual inspections and periodic measurements, which may not provide real-time insights into changing environmental conditions or immediate alerts in the event of emergent risks. Moreover, communication systems between underground workers and surface control centers may be prone to interruptions, hindering timely response to safety threats.

Therefore, the primary objective of this project is to develop an advanced monitoring and alert system utilizing Arduino UNO and IoT technologies to address the shortcomings of existing safety measures. By continuously monitoring key parameters such as temperature, gas levels, and potential fire risks, the system aims to provide timely alerts to both miners and administrative personnel, facilitating proactive intervention and ensuring the safety and well-being of all individuals involved in underground coal mining activities.

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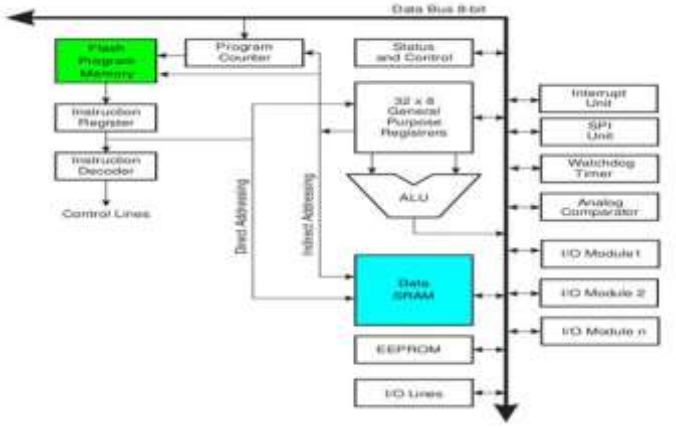


Fig 4.2 Arduino Architecture

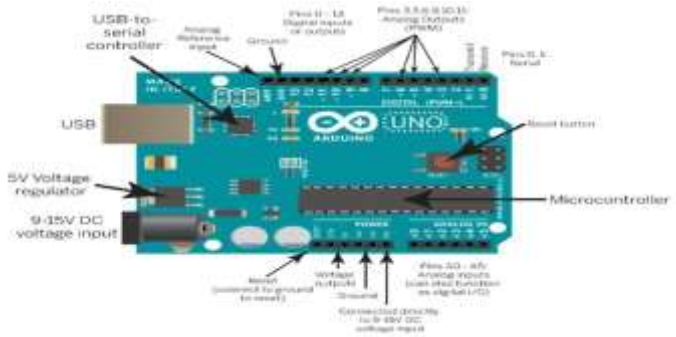


Fig 4.2.1 Arduino pin diagram

Arduino Uno consists of 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button

Arduino can be power either from the pc through a USB or through external source like adaptor or a battery. It can operate on a external supply of 7 to 12V. Power can be applied externally through the pin Vin or by giving voltage reference through the IORef pin.

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

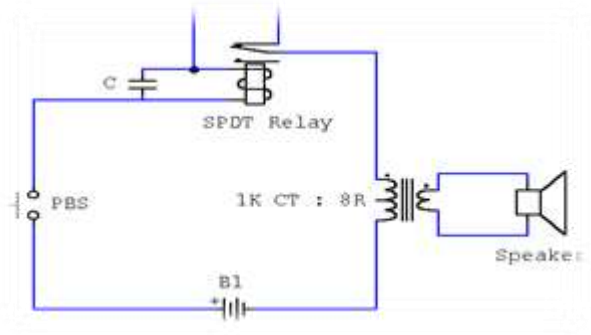
External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

Fig 4.6.1 Buzzer Circuit

A buzzer is a mechanical, electromechanical, magnetic, electromagnetic, electro-acoustic or piezoelectric audio signaling device. A Piezo electric buzzer can be driven by an oscillating electronic circuit or other audio signal source. A click, beep or ring can indicate that a button has been pressed.

A buzzer or beeper is a signaling device, The word "buzzer" comes from the rasping noise that buzzers made when they were electromechanical devices, les. Other so e a ring or a



dio transforr ate via the t lay operates the relay, the hat the pulse of curre nce secondar cy.

The capacitor C can be used to "tune" the note. The nominal value is 0.001uF, increasing capacitance lowers the buzzers tone.

Early devices were based on an electromechanical system identical to an electric bell without the metal gong. Similarly, a relay may be connected to interrupt its own actuating current, causing the contacts to buzz. Often these units were anchored to a wall or ceiling to use it as a sounding board. The word "buzzer" comes from the rasping noise that electromechanical buzzers made.

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II.WORKINGPRINCIPLE

Wireless communication is swiftly replacing the wired connection when it comes to electronics and communication. Designed to replace cable connections HC-05 uses serial communication to communicate with the electronics. Usually, it is used to connect small devices like mobile phones using a short-range wireless connection to exchange files. It uses the 2.45GHz frequency band. The transfer rate of the data can vary up to 1Mbps and is in range of 10 meters. The HC-05 module can be operated within 4-6V of power supply. It supports baud rate of 9600, 19200, 38400, 57600, etc. Most importantly it can be operated in Master-Slave mode which means it will neither send or receive data from external sources.

- The use of warning systems like delta-larm or electric buzzers could be very beneficial in minimizing loss of lives during a disaster or accident. They are important devices in any building or facilities to alert and notify people if a timely evacuation is necessary.
- Specialized electric alarm systems could act as warning about threatening liquid level conditions in lift pump chamberssewage, and other non-potable water applications. It is essential that you know how efficiently your home is or business site's sewer system works and this can be gauged more accurately if it is accompanied by an electric sewage alarm.
- Most electro mechanical buzzers are easy to set up. In fact, you don't need to hire an electrician to install it, since no hard wiris usually needed. This means cutting down on expenditure for hiring
  a professional installer.
- In workplace, electric buzzers, especially those with timing software, offers more benefits and features than traditional timers and expensive bell. They could be synchronized with automatic software via computer to control and switch times or channels within the day.

Gas sensor is a chemical optical sensor utilizing the acidic nature of gas for detection. It consists of a gas-permeable membrane in which a pH-sensitive luminescence dye is immobilized together with a buffer and an inert reference luminescent dye. gas permeating into the membrane changes the internal pH of the buffer. With this changes the luminescence of the pH-sensitive dye.

Together with the inert reference dye internal referencing is made for detection of the luminescence lifetime of the sensor. The measurement signal detected by the mini correlates to the partial pressure of gas ambient.

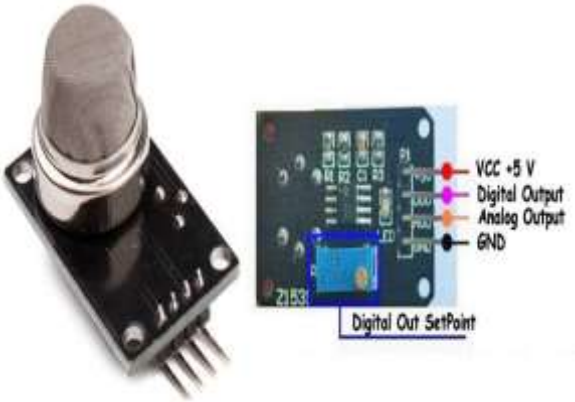

Fig 4.8 Gas Sensor

III.SOFTWARE PROCESS

The Arduino Integrated Development Environment or Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text.

The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information.

The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

NB: Versions of the Arduino Software (IDE) prior to 1.0 saved sketches with the extension .pde. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .ino extension on save.

Verify
Checks your code for errors compiling it.

Upload
Compiles your code and uploads it to the configured board. See uploading below for details.

Note: If you are using an external programmer with your board, you can hold down the "shift" key on your computer when using this icon. The text will change to "Upload using

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Programmer"

New
Creates a new sketch.

Open
Presents a menu of all the sketches in your sketchbook. Clicking one will open it within the current window overwriting its content.

Note: due to a bug in Java, this menu doesn't scroll; if you need to open a sketch late in the list, use the File | Sketchbookmenu instead.

Save
Saves your sketch.

Serial Monitor
Opens the serial monitor.

Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.

Creates a new instance of the editor, with the bare minimum structure of a sketch already in place.

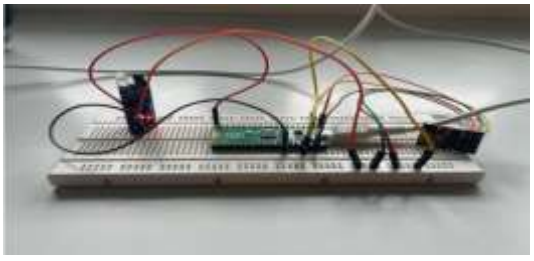
- Open
  Allows loading a sketch file browsing through the computer drives and folders.
- OpenRecent
  Provides a short list of the most recent sketches, ready to be opened.
- Sketchbook
  shows the current sketches within the sketchbook folder structure; clicking on any name opens the corresponding sketch in a new editor instance.
- Examples
  any example provided by the Arduino Software (IDE) or library shows up in this menu item. All the examples are structured in a tree that allows easy access by topic or library.
- Close
  closes the instance of the Arduino Software from which it is clicked.
- Save
  saves the sketch with the current name. If the file hasn't been named before, a name will be provided in a "Save as.." window.
- Save as...
  Allows saving the current sketch with a different name.
- Page Setup
  It shows the Page Setup window for printing.
- Print
  sends the current sketch to the printer according to the settings defined in Page Setup.
- Preferences
  Opens the Preferences window where some settings of the IDE may be customized, as the language of the IDE interface.
- Quit
  Closes all IDE windows. The same sketches open when Quit was chosen will be automatically reopened the next time you start the IDE.

IV.EXPERIMENTAL RESULTS

The implementation of the proposed system for enhancing safety in coal mines has yielded promising results, contributing to a significant improvement in monitoring capabilities and emergency response procedures. Through extensive testing and evaluation, several key findings and observations have emerged, highlighting the effectiveness and practicality of the system in real-world coal mining environments.

Communication systems, the system has significantly improved the ability to identify and mitigate safety hazards, ultimately ensuring the well-being of coal mine workers. Moving forward, continued research and development efforts are needed to address existing challenges and further enhance the scalability, reliability, and functionality of the system for broader adoption in coal mining operations.

In summary, the results of the implementation and testing of the proposed system demonstrate its effectiveness in enhancing safety measures and emergency response procedures in coal mines. By leveraging advanced sensor technologies, real-time monitoring capabilities, and IoT-enabled communication systems, the system has significantly improved the ability to identify and mitigate safety hazards, ultimately ensuring the well-being of coal mine workers. Moving forward, continued research and development efforts are needed to address existing challenges and further enhance the scalability, reliability, and functionality of the system for broader adoption in coal mining operations.



(a) Existing System

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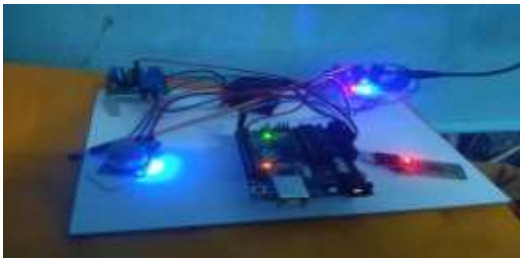

(b)Proposed System

APPLICATIONS

- HC-05 Bluetooth Module is normally used for wireless data transmission among multiple microcontrollers.
- It can also be used to communicate between electronic devices like mobile, laptop, computers for data transmission.
- It also used in different information and data logging applications.
- It's used in robotics for wireless control.
- Its default baud rate is 9600 for data communication and 38400 for command mode communication.
- the implementation and testing of the system demonstrate its effectiveness in enhancing safety measures and emergency response procedures in coal mines. By leveraging advanced sensor technologies, real-time monitoring capabilities, and IoT-enabled communication systems.

V.FUTURE SCOPE

Future enhancements for the proposed coal mine safety system could focus on leveraging emerging technologies to further improve monitoring accuracy, communication reliability, and overall safety measures. One potential enhancement involves the integration of advanced artificial intelligence (AI) algorithms for predictive analytics. By analyzing historical data and real-time sensor readings, AI can identify patterns and trends indicative of potential safety hazards, enabling proactive intervention before accidents occur.

Additionally, the incorporation of advanced robotics and automation technologies could enhance safety protocols within the coal mine environment. Robotic systems equipped with sensors and cameras could be deployed for remote inspection of hazardous areas, reducing the need for human presence in high-risk zones. Automation technologies can also streamline repetitive tasks and minimize human error, further enhancing safety and operational efficiency.

Furthermore, the implementation of wearable devices equipped with biometric sensors could provide real-time health monitoring for coal mine workers. These devices could track vital signs, fatigue levels, and environmental exposure, allowing for early detection of health issues and timely intervention.
Moreover, advancements in communication technologies such as satellite communication and mesh networking could enhance the reliability and coverage of communication systems in underground mines, ensuring seamless connectivity between miners and surface control systems even in remote or challenging environments.

VI.CONCLUSION

In conclusion, the development of a comprehensive monitoring and alert system for coal mines represents a critical step forward in enhancing safety measures within the mining industry. By leveraging modern technology such as Arduino, GSM, GPS, and various sensors, the proposed system provides real-time monitoring of environmental conditions and potential safety hazards. The integration of IoT capabilities enables remote monitoring and management, empowering administrators to make proactive decisions and implement preventive measures to ensure the well-being of coal mine workers.

Furthermore, the system's ability to communicate with both underground miners and surface control systems ensures rapid response in the event of emergencies, facilitating timely evacuation and rescue operations. The utilization of advanced sensors, such as gas sensors, enables early detection of hazardous gases, minimizing the risk of accidents and disasters.

Overall, the proposed system not only improves safety standards in coal mining but also enhances operational efficiency by providing valuable insights into environmental conditions and potential risks. As mining operations continue to evolve, the implementation of advanced monitoring and alert systems will remain essential in safeguarding the lives and well-being of miners while ensuring sustainable and responsible mining practices.

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