An IoT based Safety Helmet for Mining Workers using Node MCU

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Abstract- The risk factor in coal mining is very high when compared to any other industries. They constantly ran across unanticipatedcrises. Mining is necessary for the production of items, amenities, and infrastructure that raise people's standard of living. IoT is used to save lives and lessen injuries. By processing these fundamental resources, we are privileged to enjoy the many advantages that commercially manufactured goods provide. There are many hazards to one's health and safety when working in the soil. In mining, the Internet of Things (IoT) is utilized to better control employee health and reduce injuries.According to this poll, one piece of personal protective equipment (PPE) that can notify the control room and warn the miner of impending danger is a helmet. High gas concentrations in coal mines can make miners feel lightheaded and disoriented. To solve this problem, we here can design a helmet with all the needed components embedded to it, which notifies the workers at the control centre and expedites rescue efforts. Multiple sensors are integrated inside the helmet to monitor vital signs such as temperature, pulse response, and gas levels. To integrate a communication module within the helmet, allow for connectivity within the external devices or emergency services, enabling quick response in case of critical situations. In the proposed design, a framework is created using the open-source ESP8266-NODEMCU software and hardware development environment, which is based on a low-cost System-on-a-Chip (SoC) that is integrated into the helmet. All of these parameters are then examined, and the ESP8266 NODE MCU transfers the data to the Internet of Things cloud. When the sensor's data is recognized and transmitted to the Internet of Things cloud via the microcontroller, alert signals are produced and identified. Thus, the availability of helmets for miners is a critical first step toward modernizing safety procedures in the mining sector through integrating IoT technology into protective measuresin the provision of helmets for miners. Not only does it provide real-time monitoring, it also fosters a safer and more informed working environment.

Keywords- IoT (Internet of Things), Safety helmet, Methane sensor, Heartbeat sensor, Temperature sensor, Personal Protective Equipment (PPE), System-on-a-Chip (SoC), Microcontroller unit (MCU).

I. INTRODUCTION

The coal mining industry is the reason for the growth of the country's economy. Coal plays an exuberant role in generating the electricity throughout the world.In the fiscal year 2023, approximately 1.3 million individuals were employed in India's mining industry.There are 3,37,400 miners in the mining industry.India, the second-biggest coal producer in the world, employs roughly half as many people as the Shanxi province of China. Every year thousands of mining workers die due to circumstances in the mining area where they face lot of problems while working in the mining area. Where some of the difficulties are suffocation, reeling sensation due toSuffocation, a whirling feeling brought on by the dangerous gasses in the mining area, and the temperature are some of the challenges.Keeping all of these parameters in view this project came up with an idea of developing anIoT-enabled safety helmet for miners. Here the project is about using different sensors needed for collecting data in the mining area and sendthe data in real time to the cloud of IoT.Fundamentally here the Sensors which are being used in the project are LPG sensor that is employed to identify hazardous gases in the mining area, which this LPG Sensor is also called as (MQ-2) combustible Gas and smoke Sensor. And also, a Temperature sensor (DHT11), a cheap digital sensor, is used to monitor temperature and humidity. The heart rate sensor is then utilized to determine the heartbeat rateratio between two consecutive heart beats and Methane Sensor (MQ-3) which is made using alcohol gas sensor whichidentifies the methane gas and a buzzer which is used for sending an alarm sound and a LCD display which exhibits the required data, Signage etc. Now, the main component of this project is ESP8266 Node-MCU, where all of the above components are integrated to this Node-MCU. Where from here the data is fetched and is transmitted to the IoT cloud. Where, the blynk software app is used to collect all the data which is given to Node-MCU and right after the data assembling the blynk software sends the information to the worker in the mining area where here the worker can get information of risk and also if the worker clicks on the Buzzer then Node-MCU take the command and sends the Alert to the IoT cloud where immediately the information is passed to the Blynk app where the worker who is in risk can be extricated right away.The worker who is in danger can be immediately rescued using the Blynk app. Blynk was created as an Internet of Things app. It has the ability to remotely control hardware, show sensor data, save data, and visualize. Here the Blynk app is a platform that allows users to effortlessly create IoT (Internet of Things) projects and control them through a mobile app. It provides a drag-and-drop interface to design custom user interfaces for controlling hardware's such as ESP8266, Arduino, Raspberry PI and others, without any requirement of extensive programming knowledge. Users here can remotely monitor and control their devices which areconnected via the Blynk app, which provide features like real-time data visualization, notifications, and integration with numerous sensors and actuators.

II.   RELATED WORK

An essential technological advancement that facilitates data exchange across industries, including smart homes, manufacturing, smart cities, and healthcare, is the Internet of Things (IoT). Researchers have used Internet of Things (IoT) technology, namely ARM Cortex-M, to create an AI-based safety helmet for miners. With a transmitter module within the helmet and a receiver module outside the area, the helmet employs five sensors to monitor mining conditions. When details regarding a potentially hazardous workplace are discovered, the control module, which is outfitted with a receiver air position indicator (API), receives real-time data and issues warning signals.

This IEEE journal paper titled AI-basedsafety helmet for mining workers using IOT technology ARM Cortex-M is the closest match, STM32 technology is used in a mining helmet with five sensors to monitor mining conditions. The receiver module is located outside the region, while the transmitter module is integrated within the helmet. Gestures are transmitted to the control unit using the integrated camera module. The control module receives Bluetooth data and contains an air position indicator for real-time analysis. When information about a hazardous workplace is discovered, warning signals are sent out [1].

Coal mine safety intelligent monitoring based on wireless sensor network where in this Wireless Sensor Network (WSN). This paper addresses the concept and benefits of wireless sensor networks as well as the design foundation for wireless sensor networks in coal mine safety intelligent monitoring systems. Ultimately, a laboratory simulation was used to test the gateway presented in this study [2].

The paper talks about how acoustic position estimate techniques are necessary because of limited vision, and it also addresses the safety of mining workers in underground places. For developed countries, the mining industry—which entails removing subsurface resources like coal, diamonds, gold, and iron—is essential. In an emergency, panic switch buttons and wireless communication methods are utilized. Subterranean mines, on the other hand, are not well investigated and present concerns related to climate change, concentrations of dangerous gases, impediments, and injuries because of their complex structures [3].

Another finding which is a smart and secured helmet for coal mining workers. International Journal for Research in Applied Science and Engineering Technologythis study focuses on designing new mine monitoring/control systems using Zigbee technology, utilizing an embedded system for temperature sensors and a wireless patient health monitoring system with heartbeat sensors. Safety and security are crucial in the mining industry, and continuous monitoring of characteristics like collisions and gas is essential using sensors like temperature, humidity, and gas [4].

This finding here is an IoT based smart helmet used in mining industry international journal of scientific research in engineering and managementfor industrialized nations, the mining sector—which involves the finding and extraction of subterranean resources like coal, diamonds, gold, and iron—is essential. IEEE 802.14.5 protocol is used for wireless communication within the Internet of Things (IoT). In an emergency, panic switch buttons are utilized to offer assistance. Yet, the risks associated with underground mining remain unrecognized, raising the possibility of hazardous gas concentrations rising and unnoticed climate shifts for workers. Miners may encounter difficulties and injuries due to the intricate nature of mines [8-10].

Smart helmet for coal miners.The objective of this project is to connect sensors to make the helmets utilized by coal miners wiser. With a DHT11 sensor for temperature and humidity, a MQ2 gas sensor for gas concentration, and an LDR sensor for resistance control based on light intensity, the main device is an Arduino Uno. An alarm, vibration motor, LED, and LCD display are examples of outputs. DHT11 and gas sensor threshold values are kept at, which causes vibration and sound [11-12]

Methane and carbon monoxide gas accidents in mines are caused by colourless, odourless, and undetectable gases. To control these accidents, sensors and microcontrollers are used to predict outbursts and generate alarm systems. Continuous monitoring is necessary, requiring accurate sensing systems. Semi-conductor gas sensors are effective, but can sometimes cause problems in mining. Continuous monitoring is crucial for safety[20].

After reviewing all the paper thisproject developed by us is to use Internet of Things technologies to build a safety helmet for miners. The central component is the ESP8266 Node- MCU, which integrates many sensors like the DHT11, LCD display, buzzer, LPG, methane, and heart rate. The ESP8266 Node-MCU receives data from these sensors that are gathered in the mining region. The Internet of Things (IoT) is redefined by the Blynk app, a smartphone application that processes and saves the acquired data. Mining employees can use the Blynk app to hit a buzzer that instantly sounds a warning, enabling rescue efforts to begin right away. The IoT is being reshaped by this technology, which offers a smooth platform for remote control and monitoring.

III. PROPOSED SYSTEM

In this project we would redefine industry safety standards by developing an ultra-modern protective helmet with advanced IoT (Internet of Things) technologies, especially made for miners. A wide range of sensors, including gas detectors, temperature and humidity sensors, and others, will be integrated into this state-of-the-art helmet to enable real-time monitoring of critical physiological and environmental variables.These sensors will gather data, which will be evaluated by advanced algorithms that can recognize anomalies that could be signs of danger or emergencies. In addition, a strong communication system will make it easier to transmit this data to a central monitoring station, which will guarantee prompt attention to any safety issues. The integration of aural, and haptic feedback systems will enhance workers' situational awareness and facilitate prompt response in crucial situations by providing instant alerts. A user-friendly monitoring app (Blynk) will also be created, giving managers the ability to keep an eye on employees' safety conditions and take proactive measures to address any threats before they arise. We hope to provide a complete solution that not only satisfies but surpasses the industry's strict safety standards. This project sets new standards for safety in dangerous work conditions anda significant improvement in the safety and health of mine workers. Modern mines often employ a variety of safety procedures, worker education and training programs, and health and safety laws, which greatly changes and raises,which significantly alters and raises the bar for safety in both opencast and underground mining. The removal of high-risk environments can be aided by mine ventilation systems. The use of canaries and other animals are used to alert miners whenturns hazardous in the origin of early methods for monitoring the atmosphere in mining operations. A "safety helmet" is the most basic device that mine workers take with them. As a result, this helmet is chosen as the focal point for the improvisation, keeping the helmet's features intact. Only accurate environmental sensing will be able to address the issues raised.A microcontroller is interfaced with a variety of sensors for this purpose. The structure of industrial helmets is said to include a vacuum between the inner and outer layers, which may be the best location for the electronic components. The issue of data transmission from the helmet to the control room also exists. Due to the variable dimensions of mines, routers cannot be installed inside of them. This might be accomplished by connecting every helmet to a wireless network so that data from the end nodes can be sent to the coordinator via a mesh network.Monitoring the mine's internal conditions is the final task to be completed. Using the idea of IoT might potentially lower the enormous cost required to set up a separate control centre.Mining serves as essential for the development of goods, services, and infrastructure that raise people's standard of living. Because industry combines raw materials to create manufactured items, we as a society are lucky to have access to their many advantages.The temperature, heart rate, and GPS sensors on the helmet allow for real-time monitoring of the miners' well-being. The heart rate sensor tracks the miners' heart rates to identify any unusual activity and notify the safety crew if there are any health concerns. This is particularly crucial in hazardous and physically taxing jobs like mining. The temperature sensor keeps track of both the ambient and the miner's body temperatures. It can identify whether a miner is experiencing heat exhaustion or whether the high temperatures are making the surrounding area dangerous. Overall, by offering real-time monitoring and notifications for potential hazards or health issues, an IoT-based safety helmet for miners can greatly enhance their safety and well-being.So, we here designed a block diagram keeping all of these parameters in mind. The proposed architecture is provided in the fig.1
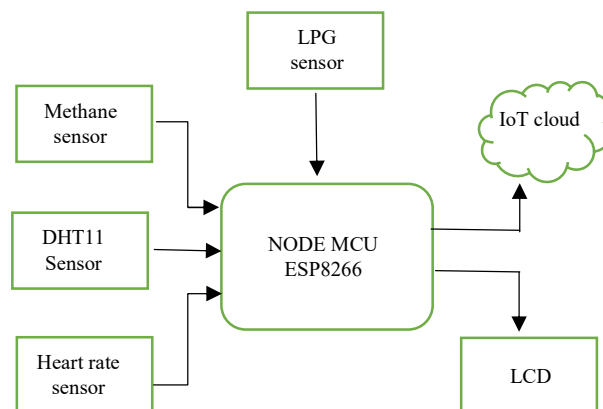

Fig.1 Proposed block diagram of safety helmet for mining worker using IOT

So, now we here use a software called proteus which is one software tool for electronic design automation (EDA) is called Proteus. The main applications for it are PCB (printed circuit board) design, simulation, and schematic capture. Electronic engineers and enthusiasts alike use Proteus to build and test circuits prior to actual implementation. It enables users to efficiently and accurately design, test, and layout PCBs. The program is a useful tool for embedded system development since it has a simulation module that can mimic the behaviour of designs based on microcontrollers. Proteus is a flexible tool for electronics design and prototyping all around.Simulation of microcontrollers is done. The Proteus micro-controller simulations are run by attaching a hex file or a debug file to the schematic's microcontroller section. All electronic devices, both digital and analog attached to it are then co-simulated with it. This makes it possible to utilize it for a wide range of project prototyping, including

user interface design, temperaturecontrol, motorcontrol. It is also useful for general hobbyists and is convenient to use as a trainingor teaching tool because no hardware is needed. By this we here design a schematic circuit using the proteus software app.Now here we also use Blynk app with NodeMCU for safety helmets in mining. With this configuration, we here monitor the environment and conditions inside the mine by integrating sensors like temperature, humidity, and even gas detectors. This can also incorporate features like real-time location tracking and panic buttons that let employees to notify supervisors in the event of an emergency. It's an effective technique to improve safety protocols in dangerous areas, such as mines.One useful way to monitor environmental conditions with IoT technology is by using a Blynk app and a DHT11 sensor incorporated into mining safety helmets. The temperature and humidity can be measured using the DHT11 sensor, which offers useful information to guarantee the comfort and safety of miners. Supervisors may remotely monitor the temperature and humidity levels experienced by workers in real-time by attaching the DHT11 sensor to a NodeMCU board and combining it with the Blynk app.This makes it possible to take preventative action to lessen the hazards brought on by harsh environments, protecting the safety of mining workers.The critical safety precaution for mining workers utilizing IoT technology where here weintegrated a Blynk app with a methane sensor in their safety helmets. Methane gas is a common concern in mining sites, and methane sensors can detect potentially harmful levels of the gas.So, by integrating methane sensor in their helmetsthis makes it possible to respond quickly in the event that dangerous levels are found, allowing for the evacuation of employees or the installation of ventilation techniques to lessen the possibility of explosions or health problems from methane exposure. The safety procedures in mining operations will be greatly improved by this application. Now we integrated an LPG (liquefied petroleum gas) sensor in their safety helmets. Potentially dangerous gas leaks, which can present significant concerns in mining operations, can be detected by LPG sensors. We here can remotely check gas levels in real-time by attaching the LPG sensor to a NodeMCU board and connecting it to the Blynk app. In the event that a gas leak is discovered, this enables prompt action to be taken, such as worker evacuation or equipment shutdown to avoid mishaps or explosions. By putting such a system in place, safety precautions are greatly improved, and mining workers' wellbeing is protected.A heart rate sensor is integrated into safety helmets for miners, important information about the health and welfare of workers in hazardous conditions will be obtained. This makes it possible to identify possible health concerns or emergencies like overdoing it, stress, or heart-related issues. This helps safeguarding the mining workers' physical health and improves safety protocol. The Blynk app has an ability to log sensor data over time. The mine's working conditions can be improved or safety audits and compliance reporting can be conducted using this data.So, by this we may improve safety protocols and guarantee the wellbeing of mining staff by remotely monitoring environmental conditions and worker health in real-time by integrating the Blynk app software into the safety helmet used by workers.

IV. RESULT AND DISCUSSIONS

In accordance to this principle, the helmet functions as a multifunctional equipment to detect potentially hazardous gases in a mining area, such as methane or excessive CO2. To more accurately monitor the standard of life for coalmine miners and estimate the amount of hazardous fumes present, we utilized four sensors. An ESP8266 NODE MCU, incorporated within this helmet, serves as an intermediary in the conveyance of the concentrations of chemicals of all the gases it comprises. Sensor data acquisition is facilitated by the microcontroller's built-in Wi-Fi module. The Blynk app simplifies this process and can be installed easily from the Google Play Store.In today's modernized world, the safety and health of workers should be protected especially when dealing with circumstances where there are several possible risks at work. The mining industry is intrinsically hazardous because toxic gases like CO2 and methane constantly jeopardize both the well-being of coalmine miners and their ability to sustain themselves.

This study introduces a multifunction safety helmet that employs contemporary sensor technology to detect and manage the number of toxic gases, resolving the issue of improving precautions for miners. As part of our research, we are monitoring the quantities of toxic substances using a total of four different sensors. The aforementioned sensors have become crucial since they provide precise data on concentrations of gases that preserve human health while assessing the air quality in the mining zone. It is essential to use this quick reaction system in order reduce the risks of toxic gas inhalation while safeguarding the health and safety of workers. The integration of interface modules and gas sensors with the ESP8266 microcontroller facilitates continuous surveillance and data retrieval. The Blynk program, that enables users to track and interpret gas concentration data remotely, significantly broadens the project's scope. An industrial safety management system might be supplied by our safety helmet's data from sensors, Wi-Fi connectivity, and real-time monitoring operations. The interface between the Blynk App and the microcontroller unit, executed in the Arduino IDE, plays an important role in establishing a seamless communication channel.An application known as an integrated development environment (IDE) gives computer-based developers all the tools they need to create software. Generally, an IDE contains at least source code. editor, debugger, and build tools for automation. Several IDEs, such as Lazarus and Sharp Develop, aren't provided with the necessary compiler or interpreter; other IDEs, as NetBeans and Eclipse, do. It can be hard to determine where an IDE often includes at least source code, editor, debugger, and automated building tools. This helps to meet specific requirements; the code relies on built-in libraries and functions for optimal functionality. Once transposed onto the ESP8266 microcontroller, this code establishes a connection between the microcontroller unit and the cloud. By handling the sensor data, the system not only enhances the safety of mining operations but also contributes to the environmental protection.By generating real-time insights into sensor readings, the Blynk mobile application allows users to take preventive actions in response to potentially dangerous circumstances.In simple terms, The Blynk application's integration with the Arduino development environment and esp8266 microcontroller establishes an infrastructure that assists in reading sensor values and protecting mining workers. This technology not only strengthens operational effectiveness but also indicates a commitment to environmental accountability and safety at coalmine work zones.

V. OUTCOMES OF THE SAFETYHELMET

To precisely measure the concentration of gases in the environment, a variety of gas sensors have been incorporated with the ESP8266, which is the primary microcontroller. This comprehensive sensing system ensures real-time gas level monitoring, providing crucial details to assess worker safety. This data can be accessed remotely according to the interface with a Wi-Fi module, which also makes connecting to the Blynk App easy. Users may immediately obtain gas concentration measurements through the Blynk App interface, which enables them to track and assess the environmental factors affecting the workforce.

FIG: 2Sensors Output displaying in the LCD

Additionally, the microcontroller is configured to obtain gas concentration threshold values that have been predefined. The system initiates a warning process in the event that the concentration being measured surpasses the limits that have been established.The sensors mounted on the helmet are tested for their capabilities within predetermined bounds as well as for particular tasks such as temperature, humidity, and dangerous chemical detection. Furthermore, functioning properly is the buzzer system, which receives its input from sensors.The buzzer begins to sound and the status is shown on the LCD display when the sensor values surpass their designated limits.The buzzer that is attached to the microcontroller produces an audible noise to notify individuals about elevated gas levels instantaneously. As a crucial safety attribute, this audible indicate makes sure workers are apprised of potential hazards right away and can implement precautions that are necessary. A thorough grasp of the work environment is made possible for both on-site and remote users by the incorporation of data collected by sensors, wireless internet access, and continuous surveillance abilities. This revolutionary device delivers an effective solution for proactive gas tracking and cautioning in workplaces, while additionally enhancing security for workers. Here in the project, we used Proteus where Proteus is an all-around versatile tool for electronics designing and development. The way Proteus works its microcontroller simulation is by attaching a file with a hex extension or a debugging file to the schematic's microcontroller area. It then co-simulates with any correlated analog and digital electrical circuits. This makes it possible it to be utilized in a variety of project prototyping, such as motor control, temperature control, and user interface creation. Because no additional equipment is required, it can be utilized readily as a training or instructional device and is also useful for regular enthusiasts. In this case, we use the Proteus software program to construct a schematic circuit. Now integrating all the sensors to the Node MCU we used the proteus softwareto design a circuit diagram.
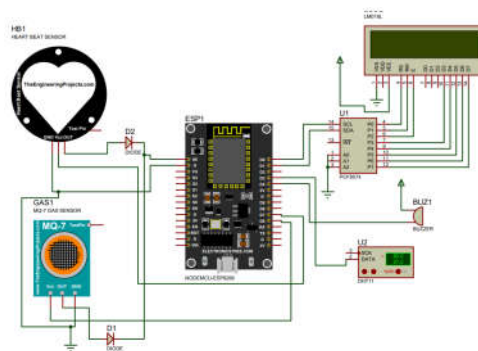

FIG: 3Proteus circuit diagram

Consequently, the integrated sensors' ultimate output, which has been incorporated in the helmet, is shown belowfig:
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FIG: 4Safety helmet completely embedded with sensors

VI. CONCLUSIONS

The implementation of a multifunctional safety helmet, integrated with advanced sensor technologies and the ESP8266 microcontroller, ensures the well-being of coalmine workers. The incorporation of gas sensors for detecting hazardous substances, coupled with real-time monitoring capabilities and remote accessibility through the Blynk App, offers a comprehensive safety solution. Being able to understand the air and check for dangerous gases helps people at the mine, whether they're there or far away, to take quick and smart actions to stay safe. This makes sure that everyone is looking out for potential dangers and doing what they can to keep things secure. The integration of a buzzer alert system further enhances worker safety by providing timely warnings when gas concentrations exceed predefined thresholds. The inclusion of a heartbeat sensor adds an additional layer of monitoring, addressing potential health risks associated with gas exposure.A key aspect is the setup of various gas sensors, which can detect potentially hazardous substances in the mining area. This is essential to minimize any possible hazards caused by gas exposure. Because of the Blynk App'scontinuous monitoring features and remote accessibility, individuals both close and far away may be kept alerted and take immediate action to ensure safety.

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