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IOT BASED SMART HELMET FOR MINERS

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ABSTRACT:
A safety monitoring helmet is being developed for the miners to help and rescue them at times of emergencies. We have used an integrated sensor module which has various sensors such as gas sensors like MQ2 and MQ135, temperature sensor like LM35, plug and play sensor to examine the ambience of mine. The sensor datum is displayed using OLED (Organic Light Emitting Diode) display We have also designed the location module using NRF24L01 transceiver module which is used to trace the location of the miner. The integrated sensor module and the location module is connected to nodeMCUESP8266 Wi-Fi module which is installed at the mines at regular distances .This enables the miners data to be monitored from the remote base station and the values are continuously checked against the threshold and the local alert is being created with the help of the buzzer and the miner is saved with the help of the location module.

Keyword:- *Arduino UNO Board, NRF24L01 Transceiver module, NODEMCU module, OLED Display.*

I. INTRODUCTION:

Today, safety of miners is a big confront. The mining industry is frequently in the list of hazardous trade. This is due to the miscellaneous harmful events in mines. There are various kinds of mines such as Metal mines like Diamond, Gold, Aluminum, Copper, Bauxite, Mineral wells etc [1]. Among these Coal mines are very dangerous as they release harmful gases in the environment during its extraction process .This makes the miners susceptible to life risks. The difficulties faced by miners working underground are gas explosion, ground collapse, acid mine water drainage, mine gas emissions, spontaneous combustion, landslides etc. A large number of workers (approximately 2.3 million) die each year worldwide, 3, 50,000 because of occupational accidents and approximately 2 million because of occupational diseases [2]. If any disaster occurs in mine no information on the condition of the miner is passed on to the base station. This may decrepitude the lives of miner. So there must be a proper communication between miners and control station [3].

Table 1 Causes of Indian Coalmine accidents

S. No.	Causes	Number of Accidents			Total
		Under Ground	Open Cast	Surface	
1.	Roof/Side fall	372	10	0	382

2.	Winding	16	0	3	19
3.	Haulage	117	2	8	127
4.	Dumper	0	75	25	100
5.	Conveyer	6	4	14	24
6.	Other Transport Mach	5	25	43	73
7.	Other Machinery	17	36	31	84
8.	Explosives	22	8	2	32
9.	Electricity	4	11	23	38
10.	Dust/Gas	9	4	2	15
11.	Fall of person/Object	52	15	37	104
12.	Inundation	7	0	0	7
13.	Miscellaneous	17	20	17	54
14.	Cause Unknown	11	5	5	21
	Total	655	215	210	**1080**

From Table 1, it is clear that the number of accidents is more in underground mines compared to opencast mines and surface mines. Undergrounds coal mines can drive 2,400 feet and even deeper are the Uranium mines [4]. But those depths are extreme; most top (or bottom) out at about 1,000 feet.

Hence, the aim of this research work is to make a smart helmet with additional features to sense surrounding conditions of the miner. Then the sensed data can be transmitted with the help of internet using Think Speak Platform. Using the information the base station will be intimidated about the current situation of the miner. Also it is proposed to use NODEMCU to track the location of the miner in order to rescue the victim [5]. The proposed system has OLED display in the helmet as an add-on feature. It also uses sensors like Gas, Humidity, Temperature and Pulse sensors. A predefined threshold value has to be fixed for the concentration of harmful gases sensed by gas sensors in mines. If the sensed parameters are greater than the predefined value, a local alert has to be created to the miner using buzzer. The location of miner can be tracked with the help of the NRF24L01 Transceiver module [6]. The miner can be rescued if the location is found at times of emergency, so there are so far many technologies incorporated to track the location like GSM, GPS, RFID, Wi-Fi, and Wireless Sensor Networks (WSN).

II. LITERATURE SURVEY:

The existing safety and security management systems are mostly manually triggered and reactive. Since real time data and security parameters are not available, there is minimal scope to take any prior preventive measure to avoid security hazards.

In most of the research works the sensor data collected under the mines are transmitted to the base station via various wired technologies like leaky feeder cable and wireless technologies like Bluetooth and Zigbee modules. The locations of the miners are tracked with the help of RFID, Wireless Sensor Networks (Beacons) and GPS module with GSM for building communication. A real-time monitoring of the mining environment established with the help of Wireless Sensor Networks (WSN) is helpful in monitoring and sensing the environment of interest and is highly economical compared to the conventional sensors. The collected data continuously sent to the base station via Zigbee module. A panic switch is also placed to inform the basestation about the situation of the miner from his side [7].

The IR sensor is used in order to indicate whether the miner is wearing the helmet or not. The collision or impact or vibration detection is a measure employing accelerometer and software to calculate the Head Injury Criteria (HIC), which is the force against what the miner got struck and a threshold for HIC is fixed as 1000. The air quality sensors are used to detect and indicate the quality of the air. All of these data is fed onto a data processing unit to check against threshold value and let into the alerting unit which is operated by using the Zigbee module, which is able to penetrate deep into the walls and harsh environments [8]. The air, humidity and temperature around the miner has been sensed and collected by S3C44B0X microcontroller and then they are transmitted to the Zigbee module CC2420. If the threshold exceeds the siren turns ON and the two way communication is being established using CMX639 voice codec circuit [9].

Zolertia Remote is the wireless module used in the helmet of the miner and phidget thin force sensor (Impact or Vibration sensor) is used to scrutinize the miner. In case of emergency, a distress message is sent with the help of routing protocols like Distance Vector Routing (DVR) and neighbor discovery method. The entire scenario is visualized with the help of Graphical User Interface (GUI) [10]. The temperature, humidity, gas sensors are used to sense the mining environment with the help of Wireless Sensor Networks (WSN) [7]. Also, the two way communication has been established via the Radio Frequency (RF) Transmitter and Receiver module [11]. The IR sensor data used to sense the availability of helmet, LDR sensor to measure the intensity of light and other sensors like temperature, gas and humidity measuring the underground environment. All these data are collected via Rasberrypi module and is envisioned by using ThinkSpeak IoT platform [12]. Each miner has been given a unique tag ID, which helps in collecting the miner data and the sensor data are collected through WSNs [3].

Table 2: Comparison of Existing methods

Ref.	Method/Processor	Sensors	Limitations
[13]	PIC Controller	Gas sensor, Load sensor, vibration sensor, IR sensor and MEMS sensors	Less accuracy
[14]	Microcontroller	Heart beat sensors, Temperature sensors, Tri-axis accelerometer	Detects when person falls down

[15]	Microcontroller	Position sensor, Alcohol sensor, Piezoelectric sensor, RF transmitter, IOT modem, GPS receiver,	High Cost.
[16]	Arduino-uno	Air quality sensors, Infrared sensor, GSM modem, Alerting unit	The helmet should be properly weared.
[17]	Microcontroller	Air Quality Sensor, Helmet Removal Sensor, Collision Sensor, Wireless Transmission	Short distance.
[18]	Bio & Framework Subsystem (BFS)	Multimedia Processing Subsystem (MPS) and Communication Subsystem (CPS).	High power requirement

The smart helmet approach, which detects and reports accidents, was proposed by [10]. This technique makes use of a microcontroller connected to an accelerometer and a GSM module. Cloud infrastructures are used to provide the accident report and notification. According to this method, if an accident occurs or the level of acceleration exceeds the threshold, information is sent to the accident authority server, which then uses the GPS module to send the message to the designated emergency contact. A system of intelligent mining helmets has been setup [11] that can identify three different forms of hazards: hazardous gases, helmet removal, and collisions. Many sensors, including IR sensors, gas sensors, and accelerometers, are used here. Drawbacks of the existing Systems from Table 2:

- The node by node hopping technique used here leads to holdback of data channeling. [2]
- The WSN based safety helmet implemented is having large false positives and has delay in transmission due to node to node hopping [10]
- The furnishing and erection cost is high [1].

III. PROPOSED METHODOLOGY:

This paper intended to develop the smart helmet to sense the density of harmful gases like Methane, CO, LPG by using the air quality sensors like MQ-2 and MQ-135, temperature sensor (LM35), Humidity sensor (DHT11) and pulse sensor. The sensed data are transmitted to the base station using WiFi module. Here, the concentration level of each gas should be taken into an account.

In order to monitor the health condition of miners pulse sensor has been included to monitor the heartbeat of the miners. The sensor data is collected from the mining environment and it is transmitted to the base station via NODEMCU, which is a WIFI module and the WiFi Routers mounted in mines at specific distances (about 50 meters). Additionally, location tracking of the miners has been done with NRF24L01 Transceiver Module. The NRF24L01 Transceiver (Transmitter) module is mounted at the mining environment at a distance of about 40 meters and the places are designated as Node1, Node2 and so on. The NRF24L01 (Receiver) is mounted at the miner's helmet. When the miner is within Node1, the receiver continuously receives the signal transmitted by the Transmitter. The sensor data along with the location is

transmitted to the Wifi module so that the environment can be continuously monitored from a remote base station and necessary actions can be made at times of emergency.

Integrated Sensor module:

From the Fig 1, it is observed that the sensor module consists of MQ2, MQ135, LM35 and Pulse sensors. The MQ2 gas sensors senses dangerous gases like Carbon-monoxide, smoke, Methane and combustible gases Butane, Propane,LPG etc.The MQ135 gas sensor is used to sense gases like,Carbon-dioxide .The LM35 is atemperature sensor which is used to sense the temperature in the mining environment. The pulse sensor is used to check the heartbeat of the miner. The pulse sensor is attached to the ear lobe of the miner and all these sensors are integrated and are connected to the Arduino UNO Board. The integrated sensor data which is collected from the mining environment is transmitted to the remote base station via Wi-Fi Module NODEMCU ESP8266.This is responsible for transmitting the data collected from the mining environment to the remote station.The sensor data is continuously monitored by using ThinkSpeak IoT Platform.

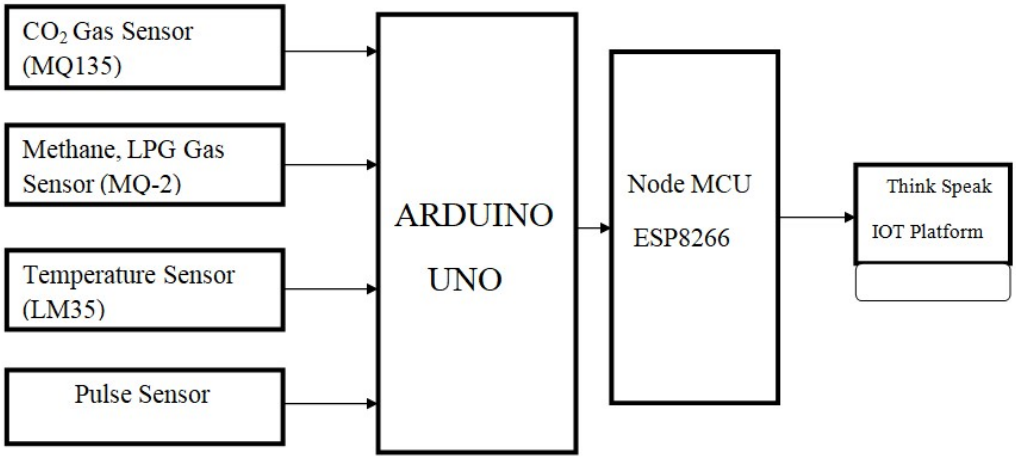

Fig 1. Block Diagram for Integrated Sensor Module

Location module:

A. Transmitter end:

The location module consists of NRF20L01 transceiver. The NRF24L01 transceiver (Transmitter) is fixed in the mining environment at a distance of 40 meters radius. This module is connected to the Arduino UNO Board as shown in Fig 2. As a result module continuously transmits the location data like in range of Node1, Node2 and so on.

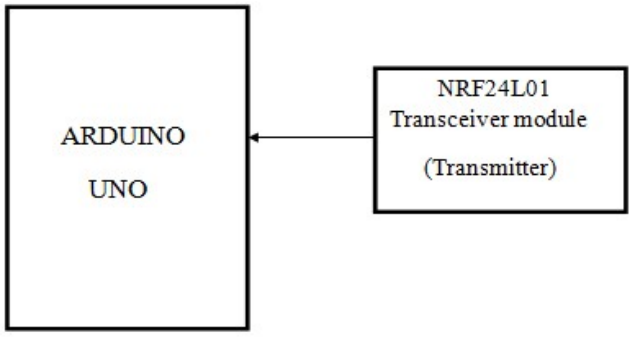

Fig 2. Block Diagram for the transmitter module

B. Receiver end:

The NRF24L01 transceiver (Receiver) module is integrated with the sensor module which is fixed at the helmet of the miner. So the miner can receive the signal which is transmitted by the NRF24L01 Transmitter module, which is fixed in the mining environment if the miner is in vicinity of the transmitter module as shown in Fig 3. It is connected to the WiFi module the remote base station continuously able to track the location of the miner. This facilitates the fast recovery of the miner.

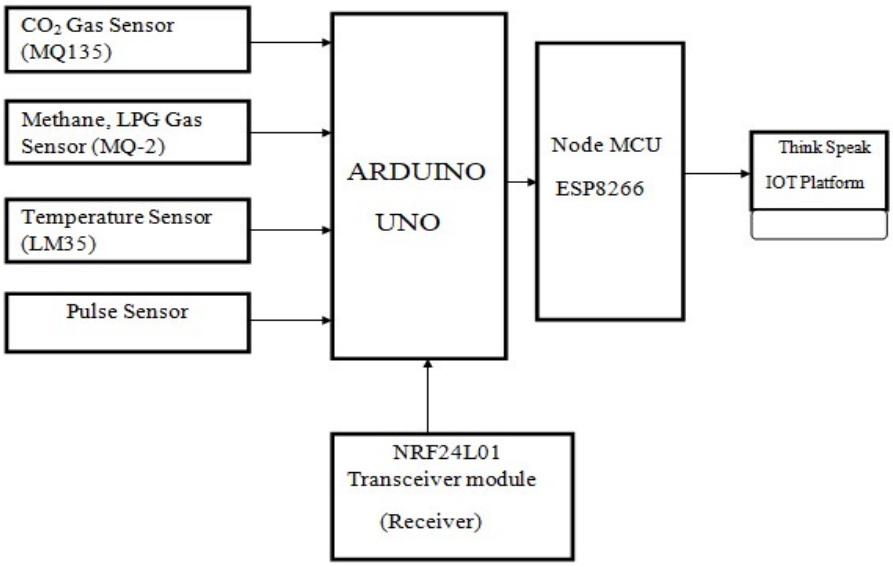

Fig 3. Block Diagram of the Receiver module.

IV. EXPERIMENTAL RESULTS AND DISCUSSION:

The various sensors MQ2, MQ135, LM35 and Pulse sensors are integrated together on the board level and the data are viewed in the serial monitor. The serial monitor shows the concentration of sensed gases in ppm and pulse sensor shows whether the heart beat is present or not, the LM35 senses the ambient temperature and the result is displayed with the help of Organic Light Emitting Diode (OLED). The integrated prototype module and the serial monitor output is as shown in Fig 4 and Fig 5.

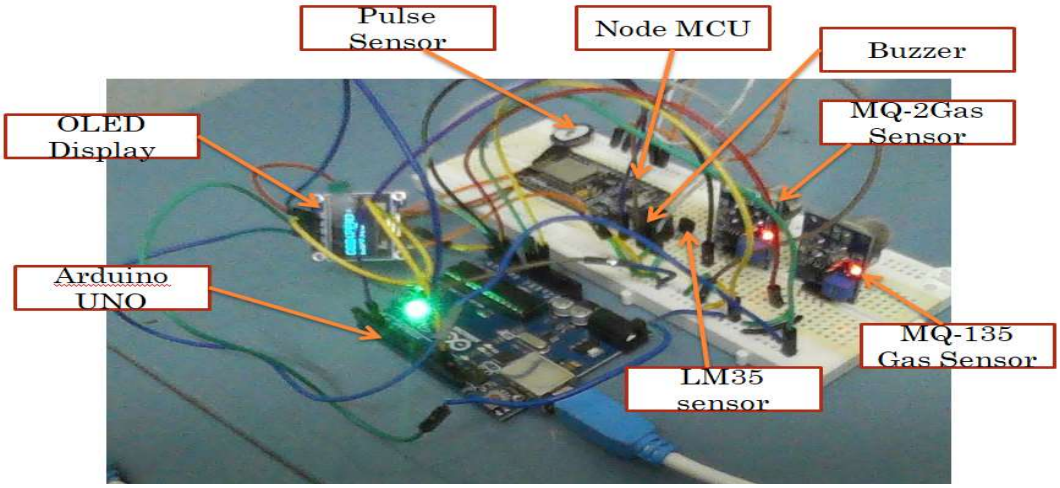

Fig 4. Integrated Sensor Module with NODEMCU

Fig 5.Serial Monitor Output of the Integrated sensor module with NODEMCU

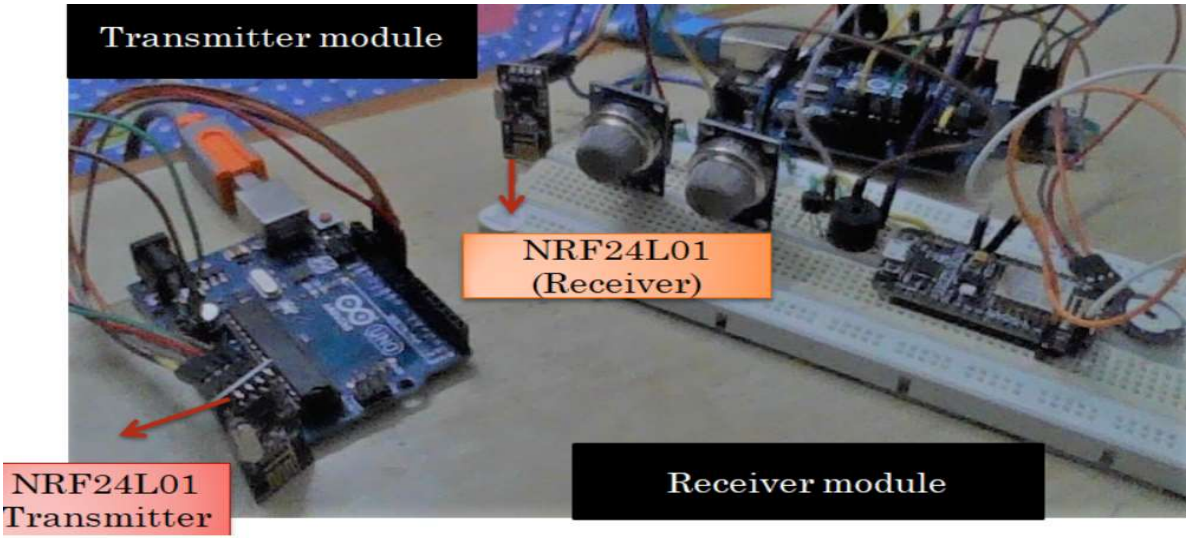

Fig 6. Location module with NRF24L01 Transceiver Module

In the Fig 6, the tracking has been done with NRF24L01 Transceiver Module**.** The NRF24L01 Transceiver module (Transmitter) has installed at the mines at a distance of about 40 meters which are designated as Node1, Node2 and so on. The NRF24L01 Transceiver module (Receiver) module is fixed to the helmet of the miners. So the miner's location has been obtained accurately.

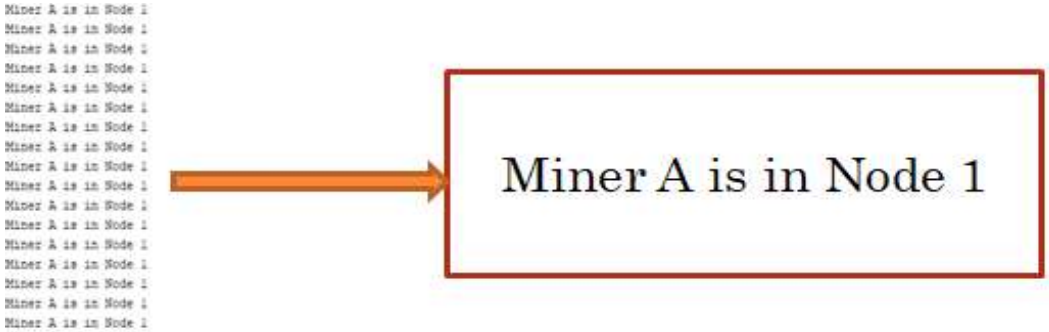

Fig 7. Serial monitor output of the location module (<20 meters).

From the Fig 7, When the miner is in the range of 20 meters the signal is received by the transceiver module (Receiver) which is fixed in the helmet of the miner and is displayed in the serial monitor.

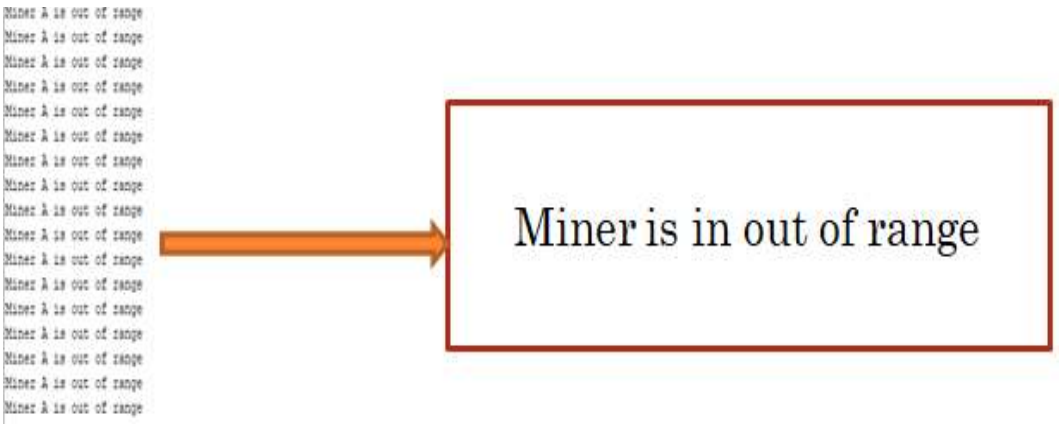

Fig 8. Serial monitor output of the location module (>20 meters).

From the Fig 8, when the miner is beyond the range of 20 meters the signal is not received by the transceiver module (Receiver) which is fixed in the helmet of the miner and the miner out of range message is displayed in the serial monitor.

Fig 9 shows the prototype of the helmet of the miner. The sensors are integrated with Arduino UNO is fixed in the helmet. The location module (receiver) is fixed in the helmet.

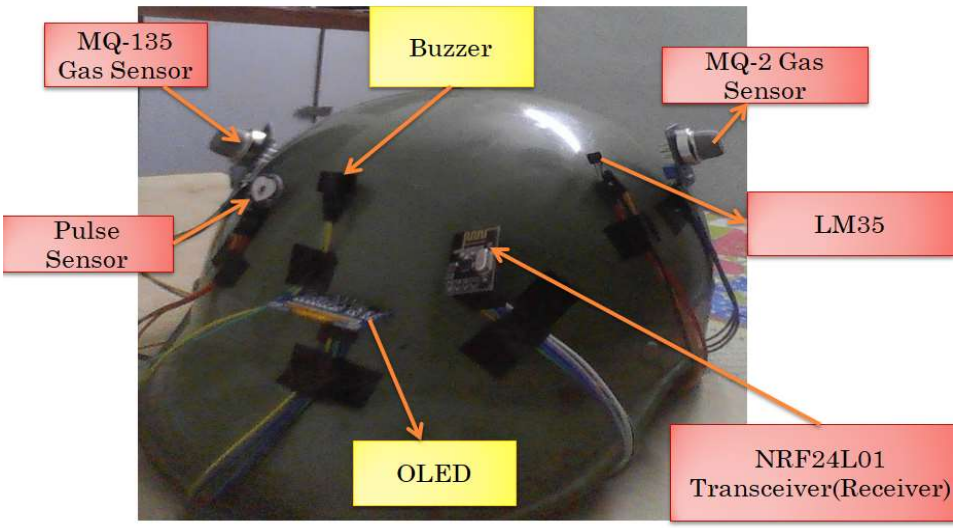

Fig 9. Prototype of the Helmet

ThinkSpeak IoT Platform Output:

A.MQ2 Sensor output:

The concentration of hazardous gases like Carbon-monoxide, Smoke and combustible gases Liquefied Petroleum Gas with the help of MQ-2 gas sensor is shown in Fig 10, 11 & 12 respectively.

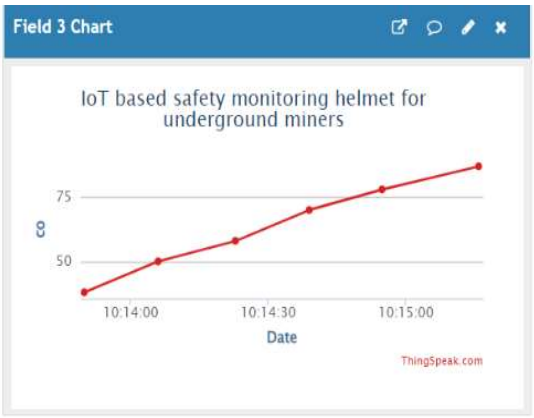

Fig 10. Carbonmonoxide values on ThinkSpeak **Fig 11. Smoke values on ThinkSpeak**

Fig 12. LPG values on ThinkSpeak

***B. MQ135 Sensor Data Output*:**

Below figure shows the Carbon-dioxide gas sensed by MQ135 gas sensor. The safe limit of Carbon-dioxide exposure is 4000 parts per million. The local alert using a buzzer is created when the value exceeds the predefined threshold as shown in Fig 13.

Fig 13.Carbondioxide values on ThinkSpeak

C. Temperature Data Output:

The Fig 14 below shows the temperature sensed by LM35 sensor, the normal environmental temperature is 40℃. If the temperature sensed is beyond the threshold the local alert is produced with the help of buzzer.

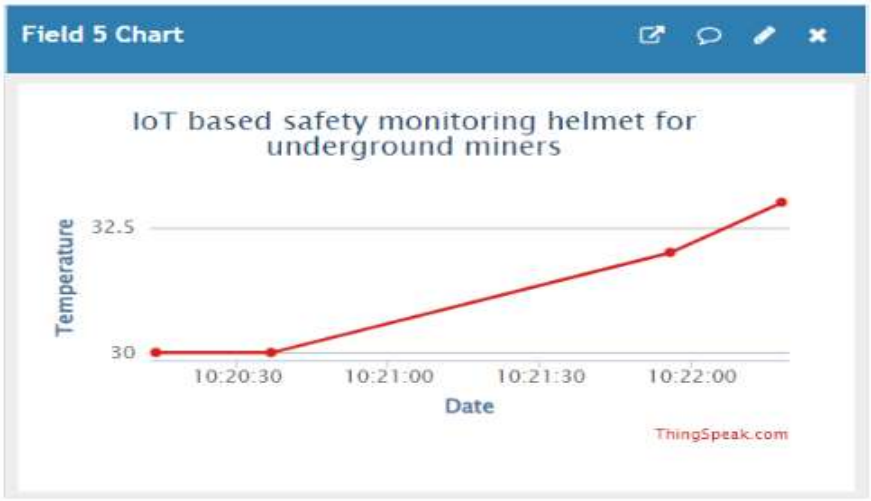

Fig 14. Temperature values on ThinkSpeak.

This is the demonstration of the various concentrations of gasses which is plotted by the ThinkSpeak IoT platform from the integrated sensor module through the NODEMCU ESP8266 Wi-Fi Module. The graph is plotted with Time as X-axis and gas concentration along the Y-axis.

D. Email Notification:

If the temperature and the smoke value of the mining environment increase the threshold level, the Email Notification is generated with the help of IFTTT platform which is integrated with the ThingSpeak IoT Platform. It is triggered with the help of Webhook application from the ThinkSpeak Iot Platform. The email notification for temperature exceeds and smoke level alert is shown in the Fig 15 and Fig 16 respectively.

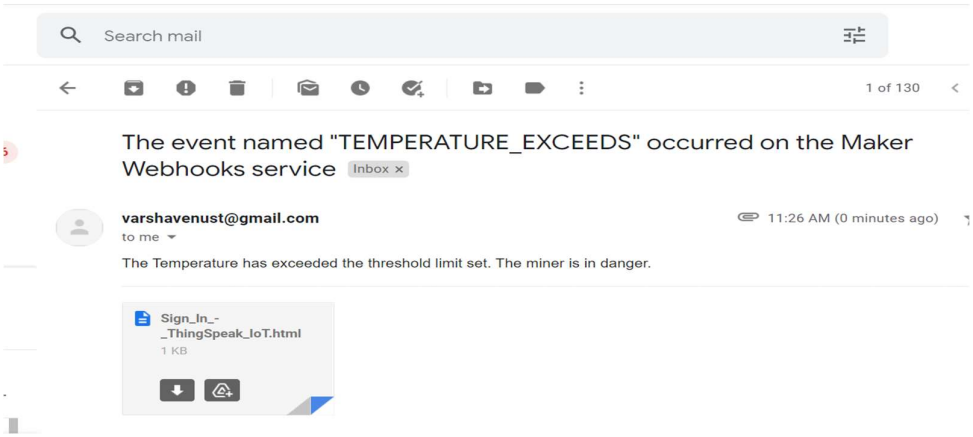

Fig 15. Email Notification for exceeded temperature

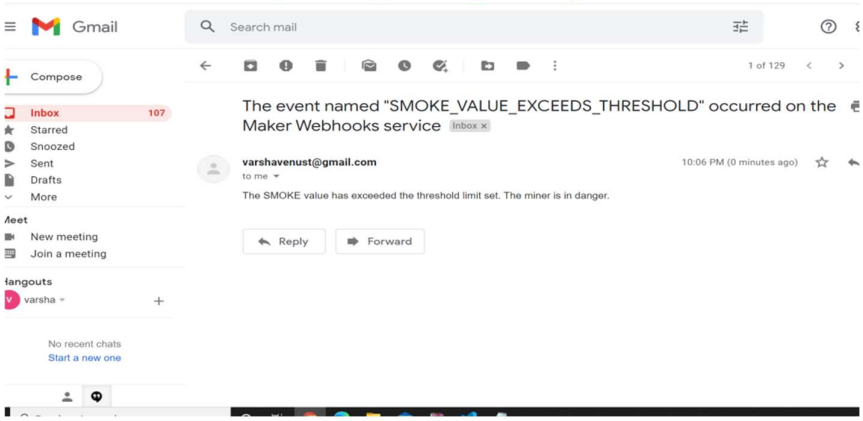

Fig 16. Email Notification for exceeded Smoke level

Thus the environmental and health conditions of miner is monitored through various sensors like gas sensors (MQ-135,MQ-2)to sense gas density, temperature sensor to monitor the ambient temperature and Pulse sensor to monitor the Pulse rate of the miner. A local alert to the miner at adverse conditions is created via buzzer and the Email Notification is send to the designated person about emergency in the base station using WiFi module NODEMCU. The location of the miner is traced at times of emergency with the help of NRF2401 RF transceiver modules with frequency range 2.4 KHz can able to cover the radius of 50 meters and the response time is fast when compared to other technologies.

CONCLUSION AND FUTURE SCOPE

A Safety helmet was developed which is able to detecting the concentration of hazardous gases like CO_2, CH_4, CO, H_2S, Smoke Ammonia and the combustible gases like Butane, Propane, LPG etc , ambient temperature and heart beat of the miner. The location of the miner is tracked with the help of NRF24L01 transceiver module which is based on Radio Frequency protocol .This module has capability to cover the distance of about 40meters radius in the underground. In this project we have created a local alert to the miner to intimate him that he is in danger in the sense to revert his direction through a buzzer when the sensed value exceeds the threshold. Also an alert message is being created to the control station authorities to let them know about the worst condition of the miner along with the details required to rescue the miner. The alert is made in the form of an Email Notification. This is the helmet which could assure the safety

of the miners at times of risk .The project can be improvised further by incorporating more sensors, Collision test using Accelerometer to detect the Head Injury Criteria (HIC) at times of emergency; also we can increase the coverage area by integrating the high frequency antenna in the transceiver module.

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