SAFETY HELMET FOR MINERS

EVERY LIFE IS PRECIOUS

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Abstract

Mining is a major economic activity involving many countries and many mining accidents take place all across the globe that no one pays attention to because miners are seen as mere laborers, and they get exploited in many ways, major exploitation being their loss of lives. Most mining accident take place that can be prevented but there are no mechanisms to rectify the problems, for example authorities can't track the location of miners when they get trapped underground and die of suffocation. There are many long term issues that miners face and can't be prevented like miners nystagmus, Pneumoconiosis, Black lung disease, etc, but the short term problems that can be prevented are also taken for granted like lack of oxygen, defective lights and unseen obstacles. Some medical emergencies and health related problems can also be prevented before hand. The existing mining systems also have a problem of high discharge rate. So we are designing a miners helmet with some advancements incorporating some ways to tackle the short term problems that can save precious lives. A high tech transmitter receiver system is designed to predict the location of miner. Along with automatic lighting, real time data transmission and reception, oxygen level check, features like color-coded LED based hazardous gas detection (CH4, CO) have also been incorporated. Secondly, both temperature and humidity detection sensors have been mounted. A panic button gives the user freedom to raise alarm for collective safety. An accelerometer has been used to detect the orientation of the user keeping in view encounters resulting in disabling or head injury. Accessories like sonar based removable ferrule is also included to measure distance of obstacle and underground water depth. High temperature inside the mine is used to charge the system battery, so as long as the miner is inside the mine, the system keeps working.

Index Terms – Arduino, Wireless communication, HC 12, Ultrasonic waves, Thermoelectric effect.

INTRODUCTION

According to the International Labour Organisation (ILO), while mining employs around 1% of the global labour force, it generates 8% of fatal accidents. Because of this, people refrain from mining jobs. There were about 92,000 working miners in the United States in 2011, compared with about 52,000 in 2017, the lowest figure since the Energy Information Administration began collecting data in 1978. But mining plays a vital role in the economic development of many countries. Historically this has been the case in many parts of the developed world, and while mineral development is an important factor for economic growth it can also, if done responsibly, be a catalyst for social growth in developing countries. So methods need to be developed that would help to make mining a safe job so that people contribute themselves into it and help in economic progress of the nation. So a system is designed that takes into account the short term problems faced by the miners and tries to overcome them. A transmitter-receiver helmet system is proposed that is divided into two sides. At one end there is a helmet mounted with sensors, headlights, transceiver, thermoelectric module and sound wave reflector. On the other end, there is a static system connected to laptop that consists of transceiver, LEDs, buzzer and sound wave transmitter. Every miner has a dedicated helmet with an identity number. In order to locate the miner, his identity number is written on the serial monitor of the Arduino and transmitted by the sound wave transmitter. Only the helmet with the transmitted identity number will reflect the sound wave and depending on the time the wave takes to come back, the distance and the location of the miner can be calculated. There is a oxygen sensor mounted on the helmet that measures the oxygen content in the mine. The miner as well as the person on the other end is alerted if the oxygen level becomes low. A light sensor is used that detects the light intensity in the mine. If the light intensity is less, headlights are turned ON automatically. An emergency button is dedicated for any medical emergency. If the miner presses it, a message is sent to the other side that includes the identity number and location of the person and buzzer starts to beep to alert people around. To keep the helmet working, a thermoelectric module is used that converts the heat inside the mine into electricity and this electricity is used to charge the battery of the helmet. Different color LEDs are used on the laptop side. In normal conditions, Green LED is ON and in case of emergency Red LED is turned ON. For the implementation of this project, both hardware and software are used.

HARDWARE COMPOSITION

The system uses Arduino Mega, Arduino Nano, LEDs, Light Sensor, AQ-104, HC-12 transceiver, thermoelectric module and self made sound wave transmitter and receiver..

SOFTWARE AND PROGRAMMING USED

Arduino IDE
Embedded C/C++

METHODOLOGY

The project comprises of two sides, Helmet side and Laptop side. The sides are linked together wirelessly by HC12 transceiver modules. Laptop side consists of a laptop, USB TTL Serial device, Arduino Nano, buzzer, LEDs, HC-12 transceiver and a sound wave transmitter. Helmet side consists of Arduino Mega, LDR, AQ Sensor, headlight, thermoelectric module, HC-12 transceiver and a sound wave reflector.

Laptop Side

A laptop is connected to Arduino nano via USB TTL Serial device. This side keeps monitoring all the helmets in the mine. In normal conditions, it receives '0' from all miners and 'Normal' is displayed on the serial monitor of Arduino. In case of any problem, the identity number and the location of the miner is received from the helmet end and displayed on the serial monitor. HC-12 transceiver helps in transmitting and receiving data at both sides. A self made sound wave transmitter is connected at the Laptop end. It is used to locate a miner. A buzzer and two LEDs of different colors are also used. In normal conditions, Green LED glows and in case of any problem, buzzer beeps and RED LED glows.
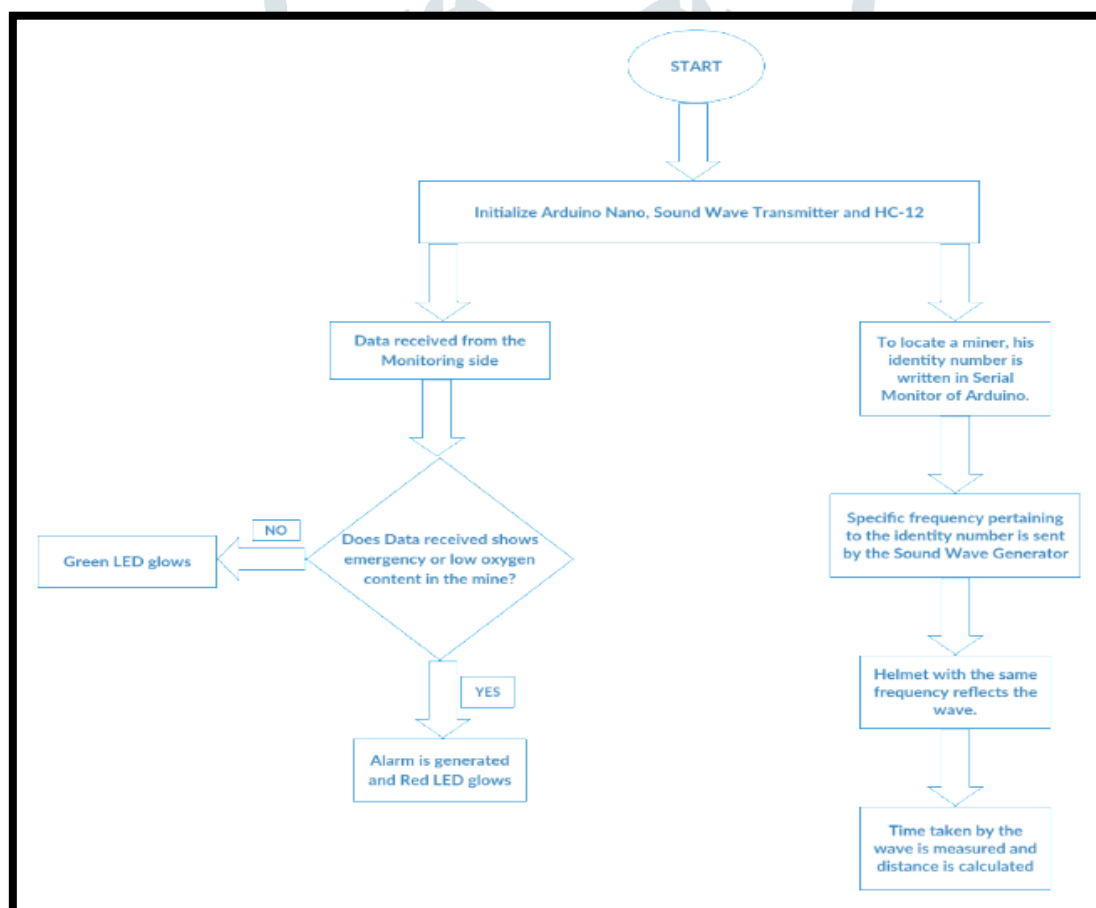

FIGURE I: Flowchart of Monitoring/Laptop Side

I.   Self made Sound Wave transmitter

A high range ultrasonic sensor along with an amplifier circuit is used. In order to locate a miner, his identity number is written on the serial monitor and SENT button is pressed. Arduino receives the identity number and produces a

sound wave of specific frequency through Sound Wave Transmitter. The wave transmits through the mine and is reflected only by the sound wave reflector mounted on the helmet of the miner designed with the same frequency. When the same ultrasonic wave is received at the Laptop end. The time taken by the Ultrasonic sound wave to travel the distance is achieved and after doing some calculations, distance between Laptop side and the miner is calculated. **[1](Sansury, Hendryg. (2019))**

Let the time taken by the wave to travel the complete distance be 'x'.

One way time= x/2.

Speed of sound=330m/sec.

Distance between monitoring side and miner = (x/2 * 330) metres

II.   HC-12 Transceiver

The HC-12 is a half-duplex wireless serial communication module with 100 channels in the 433.4-473.0 MHz range that is capable of transmitting up to 1 km. It has a total of 100 channels with a stepping of 400 KHz between each channel. Transmitting power is from -1dBm (0.79mW) to 20dBm (100mW). Receiving sensitivity is from -117dBm (0.019pW) to -100dBm (10pW). **[2](Zhang, Zhou & Zhang, Andy & Zhang, Mingshao & Esche, Sven. (2019))**
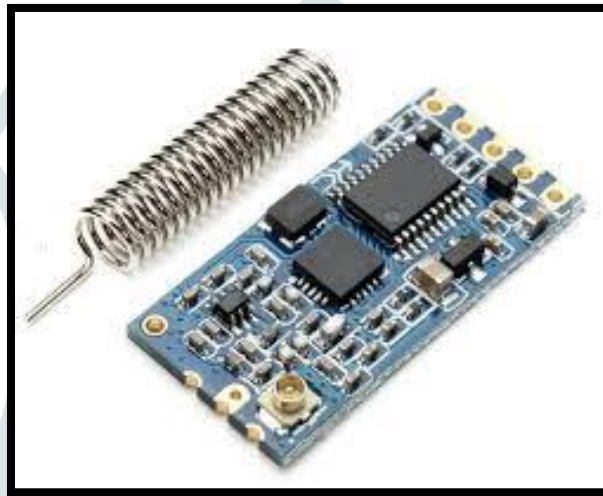

FIGURE II: HC-12 Transceiver

In our system, HC-12 is used at both ends. At Helmet end it is used to transmit data about the surrounding conditions of the miner and at the Laptop side, it is used to receive the same data. The role of HC-12 also comes into play when the miner presses the emergency button and the person on the Laptop end is alerted.
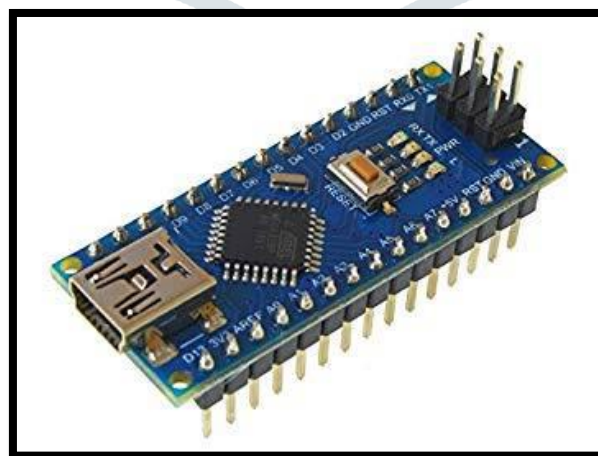
III.   Arduino Nano

FIGURE III: Arduino Nano

Arduino Nano is a microcontroller board designed by Arduino.cc. The microcontroller used in the Arduino Nano is Atmega328, the same one as used in Arduino UNO. It has a wide range of applications and is a major microcontroller board because of its small size and flexibility. On Laptop side, Arduino Nano acts as the brain. When the HC-12

receives surrounding conditions from the Helmet side, it forwards it to Arduino nano which display it on Serial monitor. If the data received pertains to Normal conditions, Arduino glows the Green LED and glows the red LED in case of emergency or undesired conditions. When the location of the miner is needed, Arduino nano commands the Sound Wave Transmitter to generate an ultrasonic wave.

Helmet Side

Helmet side consists of sensors, Sound Wave Reflector, HC-12, buzzer, headlight and Arduino Mega.
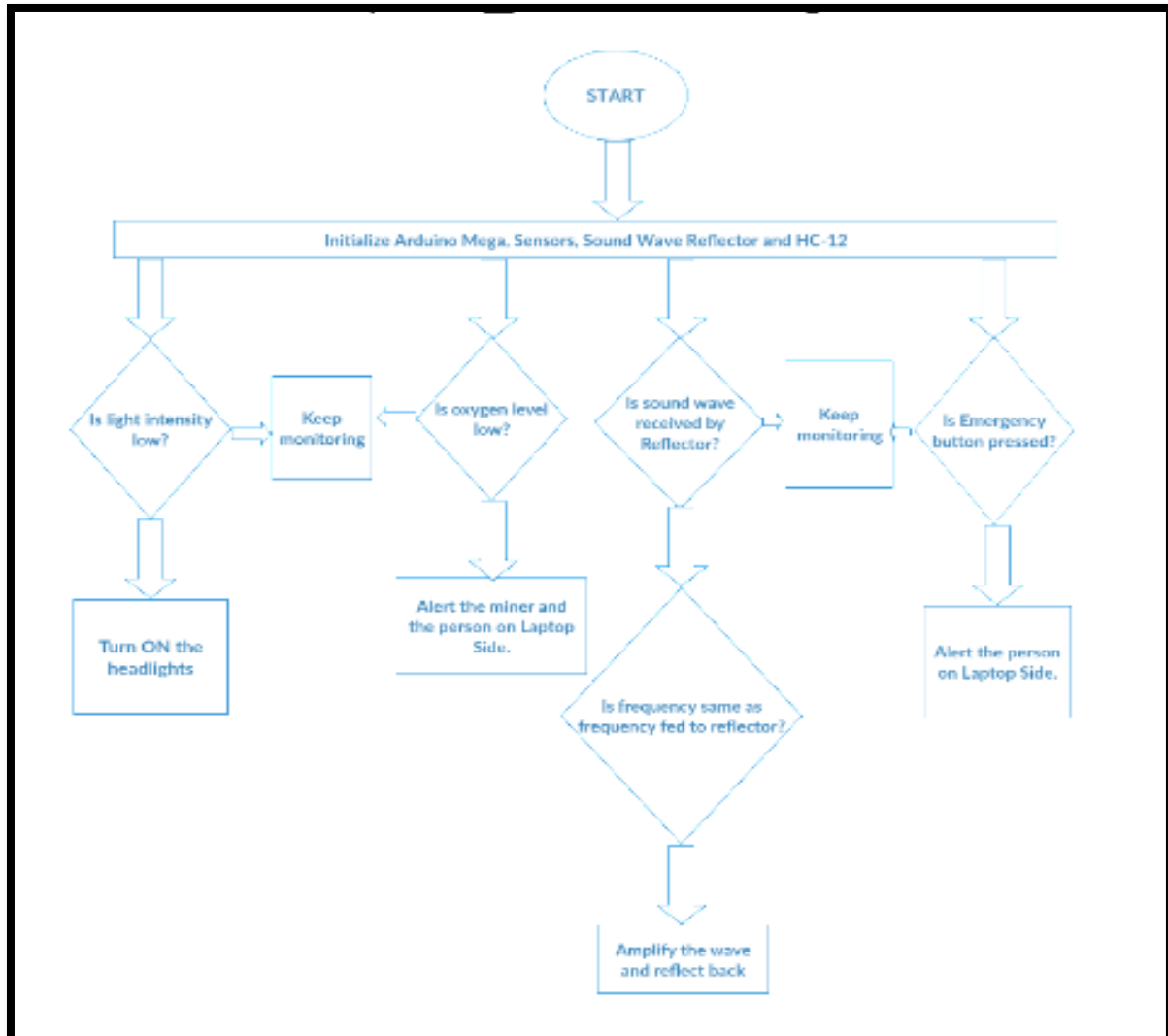

FIGURE IV: Flowchart of Helmet Side

I. AQ-104

For measuring the level of oxygen in the mine, AQ-104 gas sensor is used. If the oxygen level goes below the threshold value, a high signal is sent to Arduino and in response Arduino alerts the miner and sends his info to the Laptop side where appropriate steps may be taken. **[5](X.B. Jiang, ZigBee technology and its applications [J]. Low-voltage apparatus, 2005).**

II.   Arduino Mega

FIGURE V: Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, four UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. In our project, all the sensors, LDR, HC-12 transceiver and headlight is connected to Arduino Mega. Arduino Mega keeps on monitoring the light intensity on the LDR. If it goes below the threshold value, Arduino commands the headlight to turn ON and when the light intensity is good, headlight is turned OFF. Arduino also keeps on monitoring the oxygen level in the mine and in case it goes below the desired value, alarm gets generated and miner is alerted to avoid any difficulty in breathing. In this case Arduino Mega also alerts the person on the Laptop side about the low oxygen content in the mine by sending a specific data with the help of HC-12. Arduino Mega also keeps on monitoring the emergency button state and when the button is pressed, a high signal is passed to digital pin of Arduino. Arduino in response commands the HC-12 to send the alert message data to the Laptop end.

III.   Thermoelectric Module

FIGURE IV: Thermoelectric Module

Thermoelectric generators take a temperature difference and turn it into electrical power. Heating one end of a thermoelectric material causes the electrons to move away from the hot end toward the cold end. When the electrons go from the hot side to the cold side this causes an electrical current. The larger the temperature difference the more electrical current is produced and therefore more power generated. **[3](Sadowski, Emil & Pniewski, Romek. (2018))** This power is used to charge the battery supporting the system. This proves to be very handy and the system becomes independent and self sustaining.

CONCLUSION

The proposed system may turn out to be the backbone for miners. Following conclusions are drawn from it:

1. Miner is alerted when oxygen level gets low so that he doesn't go further down the mine.
2. Location of the miner is easily known by using his identity number and ultrasonic waves.
3. In case of low light intensity, headlights are turned ON.
4. Battery is charged by itself by using the high temperature of the mine.
5. System is compact and cost affective.
6. Emergency button is incorporated to take care of any urgent need or help.

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