VISVESVARAYA TECHNOLOGICAL UNIVERSITY

JNANA SANGAMA, BELAGAVI – 590 018

A Project Report on

"Chatura Suraksha Kavacha-The Smart Safety Helmet for Mine Workers"

Submitted in partial fulfillment of the requirements for the VIII semester of Bachelor of Engineering in Computer Science and Engineering

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Certificate

Department of Computer Science and Engineering

This is to certify that Ms. Bhuvaneshwari B S, Mr. Jagadish K Arali, Mr. Ravindragouda B, Mr. Shantveeresh bearing USN 2KA19CS010, 2KA19CS018, 2KA19CS043, 2KA19CS048 respectively has satisfactorily completed the Project Work entitled "Chatura Suraksha Kavacha-The Smart Safety Helmet for Mine Workers" in partial fulfillment for the VIII semester of Bachelor of Engineering in Computer Science and Engineering of Visvesvaraya Technological University Belagavi, during the year 2022-23. Project report has been approved, as it satisfies the academic requirements in respect of project work prescribed for the said degree.

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ABSTRACT

The underground mines all over the world are adversely affected by various hazards including gaseous explosions, landslides, fire hazards, etc. This leads to the significance of safety for the mine workers. The proposed work talks about safety helmet which is used to avoid the accidents which will cause in the work space with a low-cost sensor. The smart helmet has been produced to assist miners operating in the mining industry. Many risky incidents commonly occur in the mining sector, many of which result in life-threatening injuries or death. A miner's helmet is one of the most regularly used safety equipment for mine workers hence it must be loaded with some more advanced features. With the use of different sensors, the smart helmet will be able to identify catastrophic situations such as harmful gases like Carbon-Monoxide (CO), methane (CH4), liquified petroleum gas (LPG), and natural gases. The existence of the helmet on the worker's head is detected by an infrared sensor. Each sensor has a threshold value that, if exceeded, causes the buzzer to activate and the LEDs to illuminate, signaling the miners and supervisors. The ESP32 cam module fitted in the miner's helmet allows the mining officials to monitor the worker continuously. Furthermore, an Emergency Button has been implemented, which, when pressed, sends an emergency signal to the higher authorities outside the mines. A mobile application has also been created to display all of the data supplied wirelessly from the sensors. As a result, the proposed smart helmet protects miners from upcoming accidents.

Keywords: ***Internet of things, Blynk, ESP-8266, ESP32 CAM module, GPS module, DHT11, MQ6 Sensor***

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CHAPTER 1

INTRODUCTION

In the 21st century, the mining industry has become one of the most dominant sectors of the economy because of the increasing need for metals and other geological materials. It also generates various opportunities for many sectors. Coal is the most abundant specimen among the fossil fuels, i.e., the coals, oil shales, oil, and gas deposits of Earth. It is the deposit of organic matter – the remains of dead plants and animals – entrapped in sedimentary rocks at the site of organic matter growth many millennia ago. Coals generally contain 10-30% of inorganic material made up of clay minerals, quartz silt, and sand, thus contributing to metal emission load upon their combustion. By igniting coal, the Sun energy stored in it is being released, thus producing heat and energy needed for industry, and generally, sustaining nations' standards of living. However, the fuel burning emissions are the largest source of anthropogenic greenhouse gases and aerosols [6]. Also, some European and Asian countries have experienced devastating damage to the environment and to the human health owing to many years of intensive coal mining/burning and associated metallurgy in the past [7]. Not with standing, in the current situation of high-energy demand, coal still remains a vibrant industry. According to the World Coal Association (WCA), proven reserves of coal are much greater than those of oil and gas combined, and are sufficient to supply more than 100 years of production at 2015 levels. However, emphasize that a peak in global coal production should be reached in the 2020-2030, and that 'This is much sooner than commonly thought, and if this is correct it would represent a significant challenge for future energy supplies'. Furthermore, the latest WCA reports note that coal still makes up 29% of global primary energy and 41% of global electricity [8].

As a society, we are blessed to appreciate the benefits that this sector manufactures by processing these materials and products that supply us. Considering the number of people engaged in mining directly, the high investment and operational costs of mining activities, the uncertainty of various mining units, and the dangerous nature of mining operations, increasing the safety of these people while working is an unavoidable issue. On the other hand, occupational hazards and the healthcare issues related to the activities of the mine

workers are fundamental concerns of this industry. It is evident that the safety in open pit mines is more than in underground mines due to adequate light and fresh air access. Regarding the complexity of geology, the structure of present non-continuities, and their direct influence on the type of stress distribution, the underground mines are more accident-prone. Unexpected accidents and existing dangers in underground mines could provide a stressful and dangerous workplace for workers and operational facilities that impose considerable life and financial threats. Hazards of working in underground mines require particular attention to all influential factors of safety due to the circumstances emerging from area constraints, environmental pollutants, geology complexities, inadequate light, etc. [6]. The deeper the mines are, the more harmful it might be to conduct tasks. Among all the minerals available, coal is used extensively in electricity production due to its high availability. It can be mined both by surface mining and underground mining. Thus, the safety of underground miners becomes paramount for the concerned authorities. Coal mines involve dangers like falling objects and the presence of dangerous gases like methane (CH_4), liquified petroleum gas (LPG), Carbon Monoxide (CO), Carbon-di-oxide (CO_2), Sulphur-di-oxide (SO_2), and Nitrous oxides (N_2O) which could cause serious cardiovascular complications and cause skin disease by absorbing the harmful particles into the skin. These harmful gases usually released during shipping, loading, drilling, and managing waste from the site or accommodate inside the pit. However, some metals like arsenic, lead and mercury, which are one of the parts of ore causes air pollution which results in serious health issues in downwind area. On the other hand, the workers tend to avoid bringing some safety equipment due to its weight, heat, and bothersome ergonomic. The safety helmets are utilized to protect the worker’s heads against the impacts caused in the mines. Removal of helmets while operating in mines is additionally dangerous. If any bulky object falls on a mineworker’s head even after putting on a helmet, the individual may become injured and could die if immediate treatment is not provided. So, this smart helmet is built in such a way that it will notice all types of dangerous events with the assistance of devices that are mounted on it. Multiple sensors are mounted on the smart helmet that will help to detect any change in environmental parameters and is also capable of tracking the miners' location incessantly. In the proposed safety helmet, there are three salient factors. First is detecting the presence of dangerous gases, the second is helmet removal by the miners, and the third one is the emergency button pressed in any adverse situation. Therefore, it is crucial to have a monitoring and surveillance system to acquire the evaluated data, transmit it to the control

center, and make the most appropriate decision at the earliest possible moment. To enhance security, safety and productivity in underground mines, a reliable communication system must be established between workers, moving in the mine, and a fixed base station. The communication network must not be interrupted at any moment and at any condition. Networks within the mines are a serious downside for the communication of miners. There are two types of communication networks for underground places they are wired and wireless networks. Wired networks have some disadvantages like High installation and commissioning costs, being damaged during accidents, High maintenance costs, Time-consuming installation and repairing, Difficult and time-consuming diagnoses. Regarding the mentioned disadvantages, implementing a wired network does not have any technical and economic justifications. On the other hand, wireless networks do not have the weaknesses of the wired networks. Still, they are also technically and economically defensible, acquiring features such as high speed, high safety, self-diagnosis, remarkable reliability, etc. This project is a continuous, real-time monitoring and surveillance system based on wireless communication to increase safety by monitoring various parameters such as temperature, humidity, dangerous gasses, impact to the head, helmet wearing, and navigation. Moreover, in addition to mentioned parameters, this system can also detect helmet wearing and measure impact to the head.

1.1 MOTIVATION

The motivation for developing a Smart Safety Helmet for mine workers is to improve their safety and well-being in the workplace. Mining is a hazardous industry with numerous risks and hazards that could lead to serious injuries or even fatalities. By incorporating advanced technology into safety helmets, it is possible to provide additional protection and prevent accidents. Another motivation for developing a smart safety helmet is to improve the efficiency and productivity of mining operations. The helmet can provide real-time data and insights that enable mining companies to optimize their processes and improve their output.

1.2 EXISTING MODEL

In Existing Model, Smart Safety Helmet for mine workers has been developed using wireless communication system such as Bluetooth, RF, Zigbee technology. A lot of sensors

are used for underground environment monitoring and automating progression of measurement data through digital wireless communication technique.

Disadvantages:

- Technology such as Bluetooth, RF, Zigbee used in the existing systems have a very short range of communication system.
- The speed of data transmission is slow in the existing system.
- The safety helmet does not have any technology added to it to let miners know about the helmet removal.

1.3 PROPOSED MODEL

In our project, all the information gathered from various integrated sensors is being sent to the Node MCU of the helmet. This Node-MCU sends the data to the Blynk server. An ESP32 camera module is also installed which will send a live video stream to the Blynk server. Now all the data from the Blynk server is shown in the Blynk app. The miners will be notified through Red LED and buzzer. Moreover, it also warns the miner by activating the buzzer in case of any emergency.

Advantages:

- **Long range communication system**- We are using a Wi-Fi technology in the proposed model which have a long range of communication system.
- **Data transmission-**As we are using a Wi-Fi communication system, we have a very good speed of data transmission.
- **Low-power sensors**-In the proposed model we are using a low-power operating sensor.

1.4 PROBLEM STATEMENT

"According to The World Counts reports more people are killed or injured in the mining industry and more than 15,000 miners are killed every year."

How can we help the mine workers to operate in mining industry safely?

1.5 OBJECTIVES

Based on the extensive literature review, the following objectives are set:

- Detecting the presence of Hazardous gases like Carbon-Monoxide, Methane, LPG, and other natural gases.
- To detect the existence of the helmet on the worker's head.
- Emergency button is provided which need to be pressed in any adverse situation.
- To monitor the mine worker's location continuously using ESP32 Cam.

1.6 CHALLENGES

The main challenges in the work are that the mine workers operate in harsh and challenging environments where there are high levels of dust, moisture, and extreme temperatures. The design of the smart helmet must be rugged and durable enough to withstand these environmental factors. The smart helmet must adhere to strict safety standards to ensure the protection of the workers. The helmet must be designed to protect against head injuries, and its sensors must accurately detect any potential hazards.

1.7 SCOPE

ESP32-CAM is a versatile development board that combines Wi-Fi connectivity with a camera module. When integrated into a smart safety helmet for mine workers, it could potentially provide the live video streaming and could be used to track the location of workers within the mine, ensuring that they do not wander into hazardous areas and providing a record of their movements in case of an incident.

CHAPTER 2

LITERATURE SURVEY

A literature survey is a comprehensive summary of previous research on a topic. The literature review surveys scholarly articles, books, and other sources relevant to a particular area of research. The review should enumerate, describe, summarize, objectively evaluate, and clarify this previous research. The purpose of a literature review is to gain an understanding of the existing research and debates relevant to a particular topic or area of study, and to present that knowledge in the form of a written report. Conducting a literature review helps you build your knowledge in your field.

Dr. B. Paulchamy and Dr. C. Natarajan [4] has implemented a wireless surveillance and safety system for mine workers based on Zigbee. This system addresses a cost-effective, flexible solution of underground mine workers' safety. A module of MEMS based sensors are used for underground environment monitoring and automating progression of measurement data through digital wireless communication technique is proposed with high accuracy, smooth control and reliability. A microcontroller is used for collecting data and making decision, based on which the mine worker is informed through alarm as well as voice system. The voice system with both microphone and speaker transforms into digital signal and effectively communicate wirelessly with the ground control centre computer. ZigBee, based on IEEE 802.15.4 standard is used for this short distance transmission between the hardware fitted with the mine worker and the ground control centre. Zigbee is a short distance wireless communication network so it is not possible to intimate to responsible authorities who are at long distance.

Yeanjae Kim and Jieun Baek [2] implement coal mine monitoring using the Bluetooth wireless transmission system. As a standard of unified global short-range wireless communication, Bluetooth technology is to establish a common low-power, low-cost wireless air interface and controlling software opening system. This system describes the development background, technical features and the structure of the protocol stack of

Bluetooth technology, and proposed the solutions of the Bluetooth host controller interface (HCI) wireless communication for the complexity of its development. The main difficulty of this system is that the Bluetooth is short distance wireless technology and use of cabling is difficult. When a natural calamity or a roof fall occurred, the cabling is damage. So, the reliability and long life of conventional communication system is poor. Due to the harsh environment inside the mine, the installation and maintenance of the wired communication is very difficult.

G Pradeepkumar and S Sanjay Rahul [3] has stated that to provide flexible and complete solution for building private LoRa network, design and implementation using hardware and software were done. LoRaWAN is compared with other wireless communication devices such as Bluetooth, Wi-fi, ZigBee and it has huge scope for implementation in smart city applications. The energy consumption of LoRaWAN end device transmitting data have been modelled. The required power of LoRaWAN in class A and C type devices were investigated which have the high efficiency. LoRaWAN is an open standard development to prevent consumption and moderate the network effectively. This new technology can concentrate on network management, optimization of high dense, etc.

Ms. Rakshitha.N and Ms. Vaishnavi.R [5] has chosen the RF technology for the communication inside the mines. The Radio Frequency communication technology uses transmission of radio signals, having the frequency range 30 KHz-300 GHz, inside underground mines The wireless sensor network is provided for the sensing of adverse working environment conditions. Combining both these technologies, a new smart helmet module is developed. This RF based wireless sensor network is reliable with easy installation and fast sensing and locating system. One of the main advantages of this scheme is that it does not need any line-of-sight communication. The RF technology also ensures the localization of the mine workers for their safety in a dangerous working platform. The propagation of the electromagnetic waves through underground mines is influenced by path loss, multipath fading, reflection/refraction, reduced propagation velocity, noise, and realistic waveguide effect.

Suraj C. Godse and Pradeep C. Sawant [1] has implemented an Arduino Based Smart Helmet for Coal Mine Safety. This system addresses a cost-effective, flexible solution

of underground mine workers' safety. A lot of sensors are used for underground environment monitoring with high accuracy, smooth control and reliability. The problem addressed in this system was the improvement of a mining helmet in order to ensure more safety awareness among miners. The safety helmets do not have any technology added to it to let miners know about the helmet removal. If an object falls on a miner's head when he is not wearing his helmet, he can become unconscious or immobile so when a miner removes his helmet he needs to be warned. This system does not store the data which can be used in future for research.

CHAPTER 3

DOMAIN ANALYSIS

In software engineering, domain analysis, or product line analysis, is the process of analyzing related software systems in a domain to find their common and variable parts. It is a model of wider business context for the system. The term was coined in the early 1980s by James Neighbors. Domain analysis is the first phase of domain engineering. It is a key method for realizing systematic software reuse.

3.1 THE INTERNET OF THINGS (IOT)

"The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction."

The Internet of Things (IOT) is the network of everyday objects physical things embedded with electronics, software, sensors, and connectivity enabling data exchange. Basically, a little networked computer is attached to a thing, allowing information exchange to and from that thing. Be it light bulbs, toasters, refrigerators, flower pots, watches, fans, planes, trains, automobiles, or anything else around you, a little networked computer can be combined with it to accept input (esp. object control) or to gather and generate informational output (typically object status or other sensory data). This means computers will be permeating everything around us ubiquitous embedded computing devices, uniquely identifiable, interconnected across the Internet. Because of low-cost, networkable micro-controller modules, the Internet of Things is really starting to take off.

IoT Enablers:

- **RFIDs:** uses radio waves in order to electronically track the tags attached to each physical object.
- **Sensors:** devices that are able to detect changes in an environment (ex: motion detectors).

- **Nanotechnology:** as the name suggests, these are extremely small devices with dimensions usually less than a hundred nanometers.
- **Smart networks:** (ex: mesh topology).

Modern Applications:

- Smart Grids and energy saving
- Smart cities
- Smart homes
- Healthcare
- Earthquake detection
- Radiation detection/hazardous gas detection
- Smartphone detection
- Water flow monitoring

3.2 CLOUD COMPUTING

Cloud computing is the on-demand availability of computer system resources, especially data storage (cloud storage) and computing power, without direct active management by the user. Large clouds often have functions distributed over multiple locations, each location being a data center. Cloud computing relies on sharing of resources to achieve coherence and typically using a "pay-as-you-go" model which can help in reducing capital expenses but may also lead to unexpected operating expenses for unaware users.

Types of Cloud Computing:

Infrastructure as a Service (IaaS) means you're buying access to raw computing hardware over the Net, such as servers or storage. Since you buy what you need and pay-as-you-go, this is often referred to as utility computing. Ordinary web hosting is a simple example of IaaS: you pay a monthly subscription or a per megabyte/gigabyte fee to have a hosting company serve up files for your website from their servers.

Software as a Service (SaaS) means you use a complete application running on someone else's system. Web-based email and Google Documents are perhaps the best-known examples.

Platform as a Service (PaaS) means you develop applications using Web-based tools so they run on systems software and hardware provided by another company. So, for example, you might develop your own ecommerce website but have the whole thing, including the shopping cart, checkout, and payment mechanism running on a merchant's server. App Cloud (from salesforce.com) and the Google App Engine are examples of PaaS.

Applications of Cloud Computing:

- Art Applications
- File Storage Platform
- Image Editing Applications
- Data Storage Applications
- Antivirus Applications
- Entertainment Applications
- URL conversion Applications
- Meeting Applications.
- Presentation Applications
- Social Media Applications
- GPS Application

CHAPTER 4

METHODOLOGY

Methodology is a set of guiding principles and processes used plan, manage, and execute projects. The project management methodology you choose determines how work is prioritized and completed.

Proposed System

In our proposed work, we have used different sensors which perform different tasks. DHT11 is a sensor which measures the temperature and humidity of the working place. MQ6 sensor is a gas sensor which is used to detect the hazardous gases. The temperature, humidity and gas sensor's data are collected by the Node-MCU microprocessor.

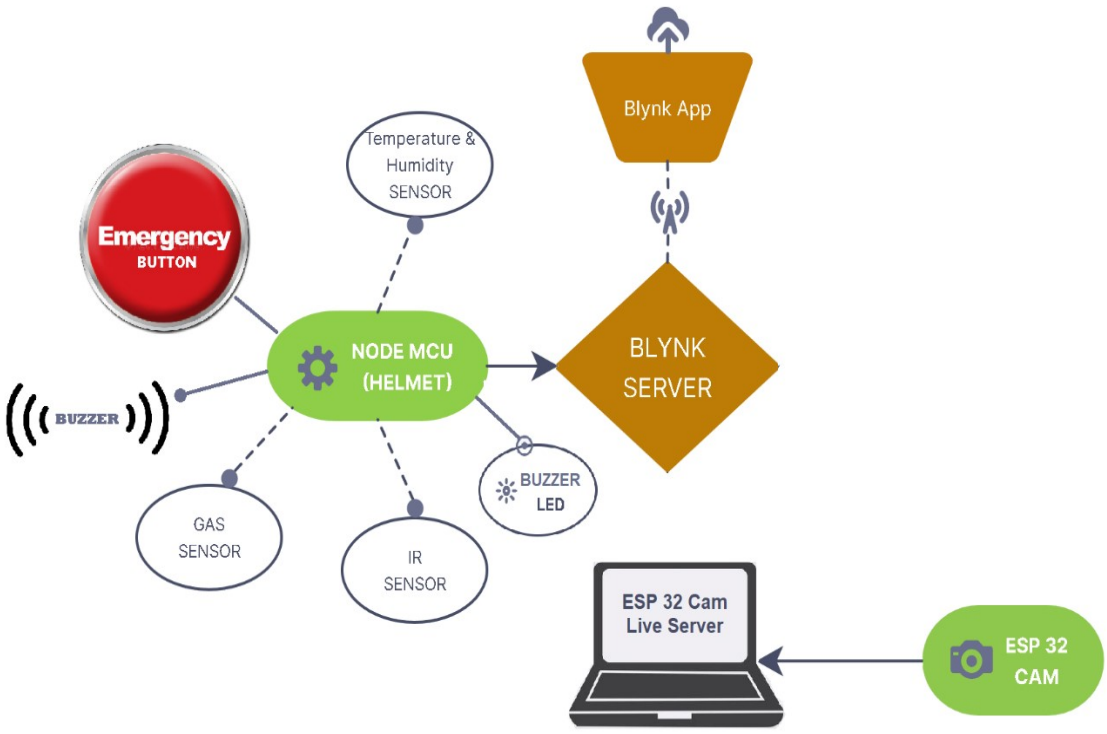


Figure 4.1: Block Diagram of Working Flow of Smart Safety Helmet

Infrared (IR) sensor notifies the existence of the helmet on the worker's head. Using ESP32 CAM the current working condition of the worker can be known. All the data is finally sent to the Blynk server and displayed in the Blynk app. Then the temperature, humidity and gas level will be displayed on the Blynk app.

In case of emergency a distress signal can be sent to the mining authorities using the emergency button. As the miner presses the emergency button a mail is sent to the authorities within 5 seconds which helps the authorities to reach the miner as fast as possible thereby saves the miners life. To avoid the possibility of mail ignorance the mail is continuously sent until the authorities give a suitable response**.**

To continuously monitor the working condition of the worker a live streaming ESP32 cam is embedded on top of the helmet. The streaming is done at 160 MHz clock speed with a pixel count of 2MP. This live video stream will help the mining officials to get a constant update of the situation under the mines, it also helps to know whether the worker is properly working in the assigned area or not, through live streaming if any adverse situation in their surrounding area happens then it can be identified and further it can be intimated to the worker in that particular area and can also use this feed for research and future reference.

CHAPTER 5

REQUIREMENTS SPECIFICATION

In software development, a requirements specification is the result of a series of processes designed to collect and record information that describes how a system or an application should behave. Whether it's a web site, mobile application or any other type of system, you should always write a requirements specification before the implementation phase starts. This is especially important if the user and the developer are of two different parties.

Requirement specifications are divided into two categories. Those are hardware and software requirements. Requirement specification is a description of a software and hardware system to be developed. It lays out functional and non-functional requirements, and may include a set of use cases that describe user interactions that the software must provide.

The Hardware Requirements Specification (SRS) captures the complete Hardware requirements for the system, or a portion of the system. Following is a typical SRS outline for a project using only traditional natural-language style requirements – with no use-case modelling

5.1 HARDWARE REQUIREMENTS

- Micro controller (ESP8266 (Node-MCU))
- IR Sensor
- DHT-11 Sensor
- MQ-6 Gas Sensor
- ESP32 Cam Module

Micro Controller (ESP8266 (Node-MCU)):

Node MCU is an open source IOT platform. It includes firmware which runs on the ESP8266 Wi-Fi SOC from Express if Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the Lau scripting language. It is based on the Lau project, and built on the Espressif Non-OS SDK for ESP8266.

Figure 5.1: Node MCU

Node MCU was created shortly after the ESP8266 came out. On December 30, 2013, Espressif Systems began production of the ESP8266.The ESP8266 is a Wi-Fi SOC integrated with a Tensilica Xtensa LX106 core, widely used in IOT applications. Node MCU started on 13 Oct 2014, when Hong committed the first file of Node MCU -firmware to GitHub.

What is ESP8266?

The Chip: ESP8266 (presently ESP8266EX) is a chip with which manufacturers are making wirelessly networkable micro-controller modules. More specifically, ESP8266 is a system-on-a-chip (SOC) with capabilities for 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2), general-purpose input/output (16 GPIO), Inter-Integrated Circuit (I^2C), analog-to-digital conversion (10-bit ADC), Serial Peripheral Interface (SPI), I^2S interfaces with DMA (sharing pins with GPIO), UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and pulse-width modulation (PWM). It employs a 32-bit RISC CPU based on the Tensilica Xtensa LX106 running at 80 MHz (or overclocked to 160 MHz).

It has a 64 KB boot ROM, 64 KB instruction RAM and 96 KB data RAM. External flash memory can be accessed through SPI.

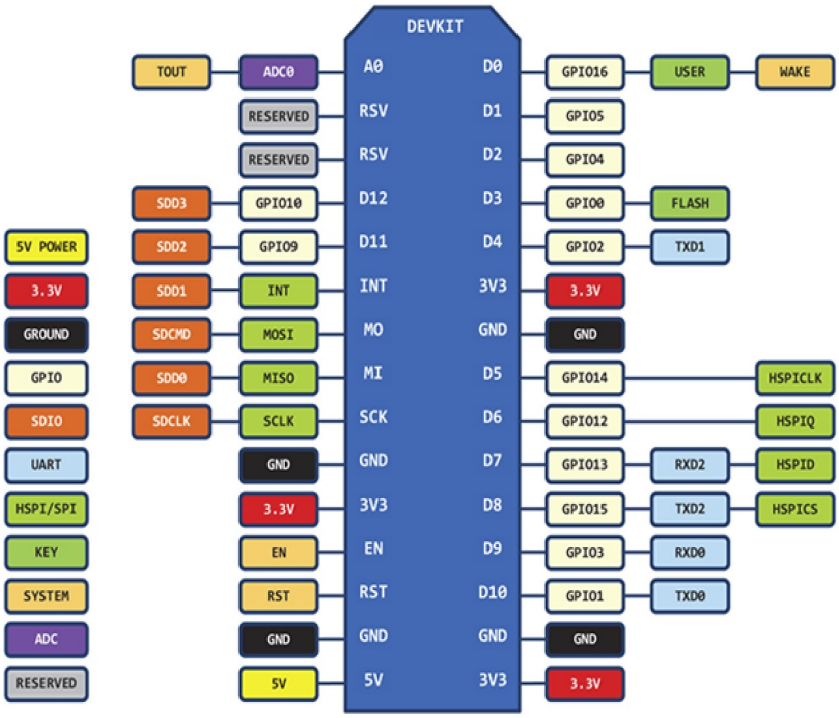


Figure 5.2: Pin Configuration of Node MCU

IR SENSOR:

IR technology is used in daily life and also in industries for different purposes. For example, TVs use an IR sensor to understand the signals which are transmitted from a remote control. The main benefits of IR sensors are low power usage, their simple design & their convenient features. IR signals are not noticeable by the human eye. The IR radiation in the electromagnetic spectrum can be found in the regions of the visible & microwave. Usually, the wavelengths of these waves range from 0.7 µm 5 to 1000 µm. The IR spectrum can be divided into three regions like near-infrared, mid, and far-infrared. The near IR region's wavelength ranges from 0.75 – 3 µm, the mid-infrared region's wavelength ranges from 3 to 6 µm & the far IR region's infrared radiation's wavelength is higher than 6 µm.

What is an IR Sensor/Infrared Sensor?

An infrared sensor is an electronic device that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measure only infrared radiation, rather than emitting it that is called a passive IR sensor. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation.

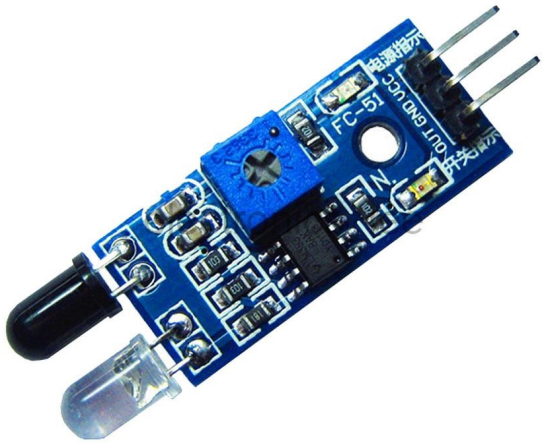


Figure 5.3: Infrared Sensor

Working Principle:

The working principle of an infrared sensor is similar to the object detection sensor. This sensor includes an IR LED & an IR Photodiode, so by combining these two can be formed as a photo-coupler otherwise optocoupler. The physics laws used in this sensor are planks radiation, Stephan Boltzmann & weans displacement.

IR LED is one kind of transmitter that emits IR radiations. This LED looks similar to a standard LED and the radiation which is generated by this is not visible to the human eye. Infrared receivers mainly detect the radiation using an infrared transmitter. These infrared receivers are available in photodiodes form. IR Photodiodes are dissimilar as compared with usual photodiodes because they detect simply IR radiation. Different kinds of infrared receivers mainly exist depending on the voltage, wavelength, package, etc.

Once it is used as the combination of an IR transmitter & receiver, then the receiver's wavelength must equal the transmitter. Here, the transmitter is IR LED whereas the receiver

is IR photodiode. The infrared photodiode is responsive to the infrared light that is generated through an infrared LED. The resistance of photo-diode & the change in output voltage is in proportion to the infrared light obtained. This is the IR sensor's fundamental working principle.

Once the infrared transmitter generates emission, then it arrives at the object & some of the emission will reflect back toward the infrared receiver. The sensor output can be decided by the IR receiver depending on the intensity of the response.

IR Sensor Circuit Diagram: An infrared sensor circuit is one of the basic and popular sensor modules in an electronic device. This sensor is analogous to human's visionary senses, which can be used to detect obstacles and it is one of the common applications in real-time. This circuit comprises the following components

- LM358 IC 2 IR transmitter and receiver pair
- Resistors of the range of kilo-ohms.
- Variable resistors.
- LED (Light Emitting Diode).

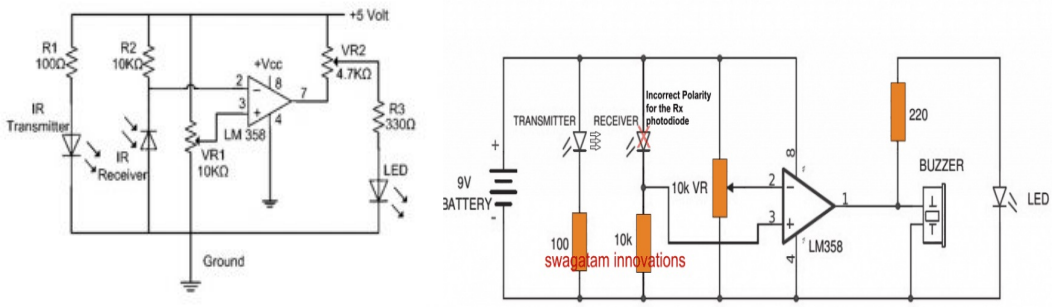


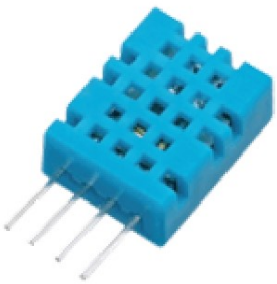
Figure 5.4: IR Sensor Circuit Diagrams

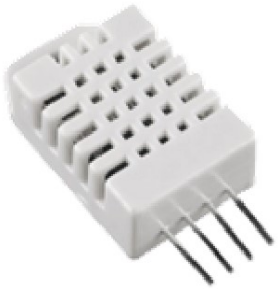
DHT 11 SENSOR:

These sensors are very popular for electronics hobbyists because there are very cheap but still providing great performance. Here are the main specifications and differences between these two sensors:

The DHT22 is the more expensive version which obviously has better specifications. Its temperature measuring range is from -40 to +125 degrees Celsius with +-0.5 degrees accuracy, while the DHT11 temperature range is from 0 to 50 degrees Celsius with +-2

degrees accuracy. Also, the DHT22 sensor has better humidity measuring range, from 0 to 100% with 2-5% accuracy, while the DHT11 humidity range is from 20 to 80% with 5% accuracy.





DHT11 ***DHT22***

0 - 50°C / ± 2°C	*Temperature Range*	-40 - 125 °C / ± 0.5 °C
20 - 80% / ± 5%	*Humidity Range*	0 - 100 % / ± 2-5%
1Hz (one reading every second)	*Sampling Rate*	0.5 Hz (one reading every two seconds)
15.5mm x 12mm x 5.5mm	*Body Size*	15.1mm x 25mm x 7.7mm
3 - 5V	*Operating Voltage*	3 - 5V
2.5mA	*Max Current During Measuring*	2.5mA

Figure 5.5: Comparing DHT11 with DHT22

There are two specifications where the DHT11 is better than the DHT22. That's the sampling rate which for the DHT11 is 1Hz or one reading every second, while the DHT22 sampling rate is 0,5Hz or one reading every two seconds and also the DHT11 has smaller body size. The operating voltage of both sensors is from 3 to 5 volts, while the max current used when measuring is 2.5mA.

DHT11 / DHT22 Working Principle:

Ok now let's see how these sensors actually work. They consist of a humidity sensing component, a NTC temperature sensor (or thermistor) and an IC on the back side of the sensor.

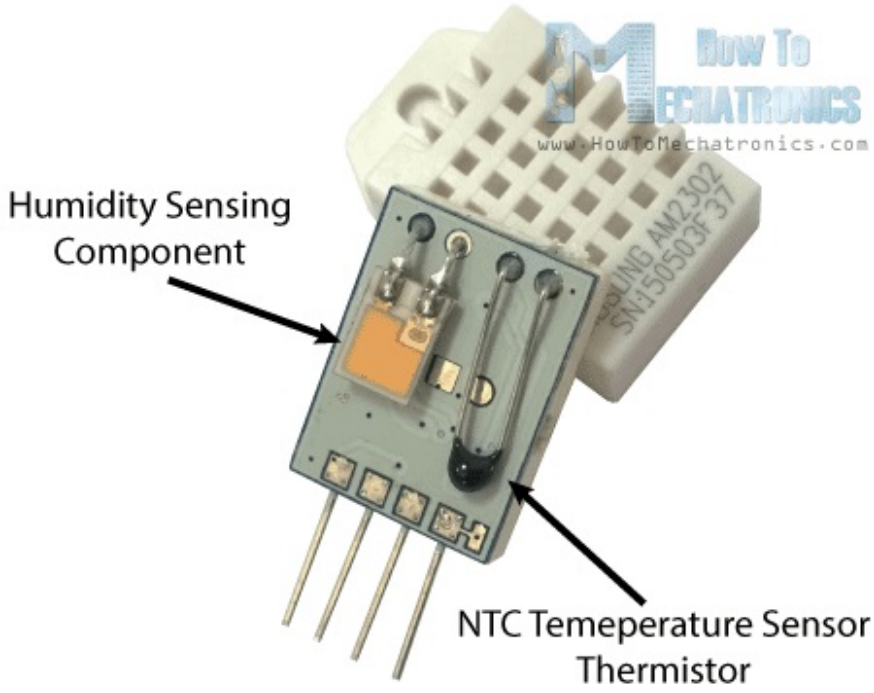


Figure 5.6: DHT 11/DHT 22 Working Components

For measuring humidity, they use the humidity sensing component which has two electrodes with moisture holding substrate between them. So as the humidity changes, the conductivity of the substrate changes or the resistance between these electrodes' changes. This change in resistance is measured and processed by the IC which makes it ready to be read by a microcontroller.

MQ-6 GAS SENSOR:

Where to use MQ-6 Gas sensor?

The MQ-6 Gas sensor can detect or measure gases like LPG and butane. The MQ-6 sensor module comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. When it comes to measuring the gas in ppm the analog pin has to be used, the analog pin also TTL driven and works on 5V and hence can be used with most common microcontrollers.

So, if you are looking for a sensor to detect or measure gasses like LPG, or methane with or without a microcontroller then this sensor might be the right choice for you.

How to use MQ-6 Sensors to Detect gas?

Using a MQ sensor it detects a gas is very easy. You can either use the digital pin or the analog pin to accomplish this. Simply power the module with 5V and you should notice the power LED on the module to glow and when no gas it detected the output LED will remain turned off meaning the digital output pin will be 0V. Remember that these sensors have to be kept on for pre-heating time (mentioned in features above) before you can actually work with it. Now, introduce the sensor to the gas you want to detect and you should see the output LED to go high along with the digital pin, if not use the potentiometer until the output gets high. Now every time your sensor gets introduced to this gas at this particular concentration the digital pin will go high (5V) else will remain low (0V).

You can also use the analog pin to achieve the same thing. Read the analog values (0-5V) using a microcontroller, this value will be directly proportional to the concentration of the gas to which the sensor detects. You can experiment with these values and check how the sensor reacts to different concentration of gas and develop your program accordingly.

How to use MQ-6 sensor to measure PPM?

If you are looking for some accuracy with your readings then measuring the PPM would be the best way to go with it. It can also help you to distinguish one gas from another. So, to measure PPM you can directly use a module. A basic wiring for the sensor from datasheet is shown below.

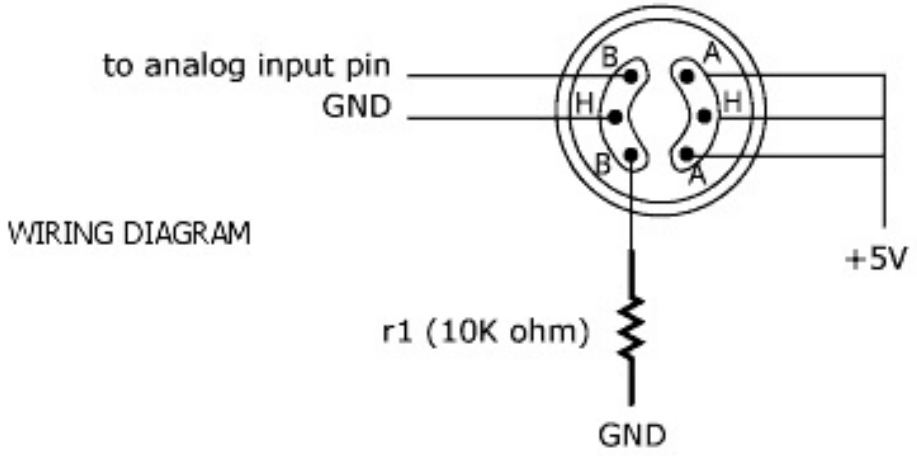


Figure 5.7: Warning Diagram

The procedure to measure PPM using MQ sensor is the same but few constant values will vary based on the type of MQ sensor used. Basically, we need to look into the (Rs/Ro) VS PPM graph given in the **MQ-6 datasheet**, and also shown below.

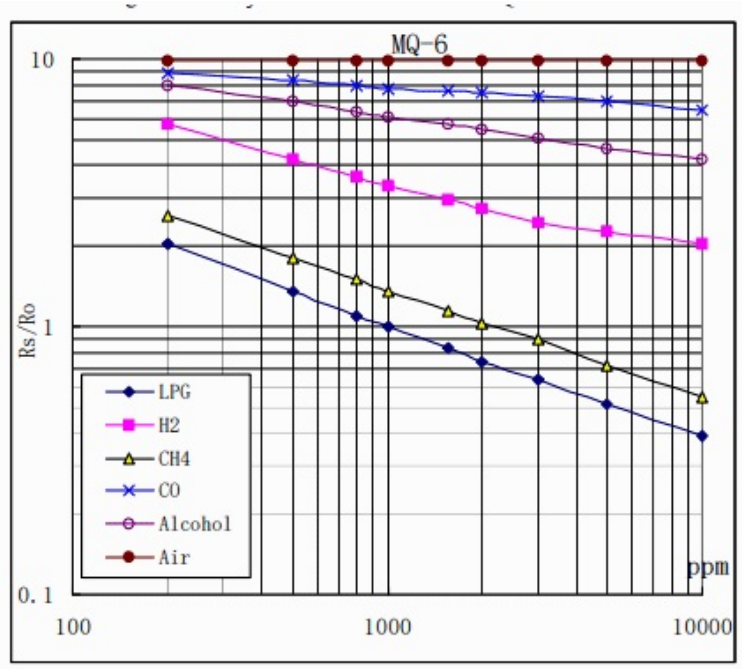


Figure 5.8: (Rs/Ro) VS PPM Graph given in the MQ-6 Datasheet

The value of Ro is the value of resistance in fresh air and the value of Rs is the value of resistance in Gas concentration. First you should calibrate the sensor by finding the values of Ro in fresh air and then use that value to find Rs using the formulae:

Resistance of sensor (R_s): $R_s=(V_c/VRL-1) *RL$

Once we calculate Rs and Ro we can find the ratio and then using the graph shown above we can calculate the equivalent value of PPM for that particular gas.

Applications:

- Detect or measure Gases like LPG, and butane
- Air quality monitor
- Gas leak alarm
- Safety standard maintenance
- Maintaining environment standards in hospitals

2D model of MQ-6 Gas sensor

If you purchased as sensor then you can use the following dimensions to create your own PCB for your application

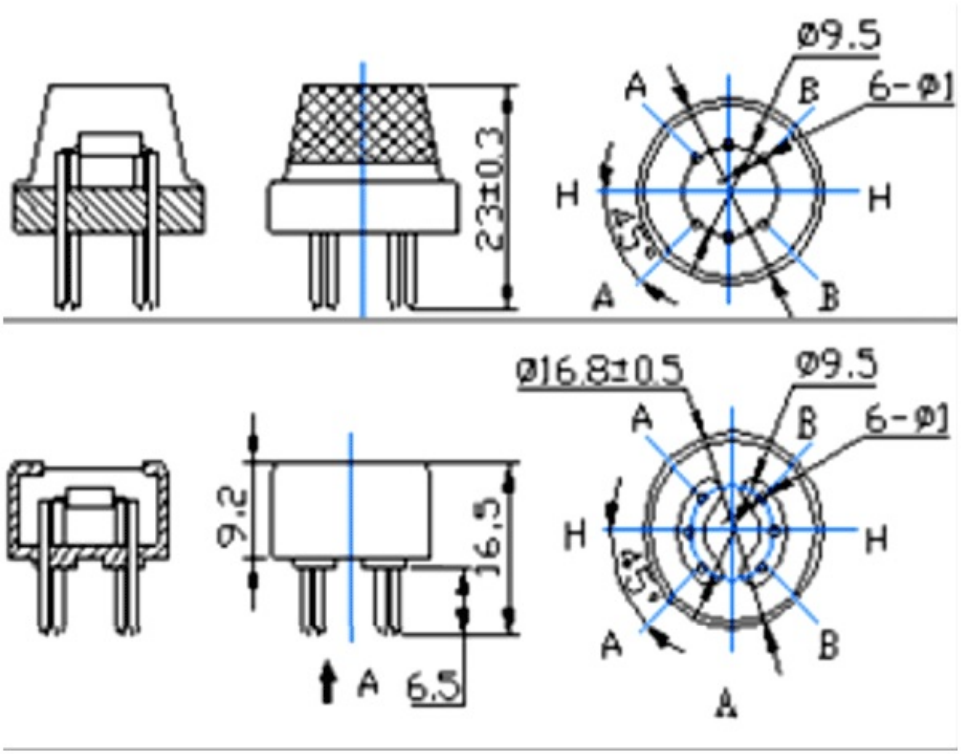


Figure 5.9: 2D Model of MQ-6 Gas Sensor

ESP 32 CAM MODULE

The AI-Thinker ESP32-CAM module comes with an ESP32-S chip, a very small size OV2640 camera and a micro-SD card slot. Micro SD card slot can be used to store images taken from the camera or to store files. This ESP32-CAM module can be widely used in various IoT applications. It can be used as a face detection system in offices, schools and other private areas and can also be used as wireless monitoring, QR wireless identification, and many other IoT applications.

The **ESP32-CAM** module can be programmed with ESP-IDF or with **Arduino IDE**. ESP32-CAM module also has several GPIO pins to connect the external hardware. The ESP32-CAM doesn't have a USB connector, so to program the module you need an FTDI board.

Features:

- The smallest 802.11b/g/n Wi-Fi BT SoC module
- Low power 32-bit CPU, can also serve the application processor
- Up to 160MHz clock speed, summary computing power up to 600 DMIPS
- Built-in 520 KB SRAM, external 4MPSRAM
- Supports UART/SPI/I2C/PWM/ADC/DAC
- Support OV2640 and OV7670 cameras, built-in flash lamp
- Support image Wi-Fi upload
- Support TF card
- Supports multiple sleep modes

Specifications:

- SPI Flash: Default 32Mbit
- RAM: 520KB SRAM+ 4M PSRAM
- Support TF Card: Max. 4G
- Support Interface: UART, SPI, I2C, PWM
- Image Output Format: JPEG, BMP, GRAYSCALE
- IO Port: 9
- Power Supply Range: 5V

How to Program/Upload Code to ESP32-CAM AI-Thinker (Arduino IDE)

The ESP32-CAM AI-Thinker development board can be programmed using Arduino IDE. This guide shows how to program and upload code to the ESP32-CAM (AI-Thinker) development board using Arduino IDE.

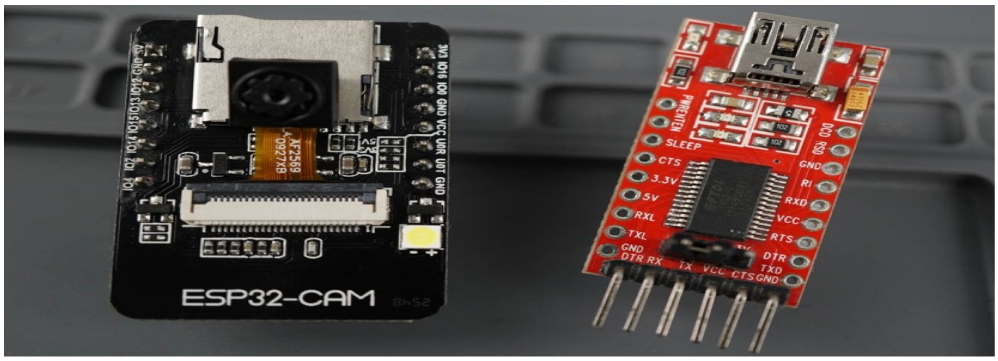


Figure 5.10: ESP-Cam AI-Thinker

The ESP32-CAM AI-Thinker module is an ESP32 development board with an OV2640 camera, microSD card support, on-board flash lamp and several GPIOs to connect peripherals. However, it doesn't have a built-in programmer. You need an FTDI programmer to connect it to your computer and upload code.

- Buy an FTDI Programmer
- Buy an ESP32-CAM AI-Thinker with OV2640 Camera

Install the ESP32 Add-on

To program the ESP32-CAM board with Arduino IDE, you need to have Arduino IDE installed as well as the ESP32 add-on. Follow the next tutorial to install the ESP32 add-on, if you haven't already:

- Installing the ESP32 Board in Arduino IDE

Program ESP32-CAM (Upload Code with Arduino IDE)

To upload code to the ESP32-CAM (AI-Thinker) using Arduino IDE, follow the next exact steps.

Connect the ESP32-CAM board to your computer using an FTDI programmer. Follow the next schematic diagram:

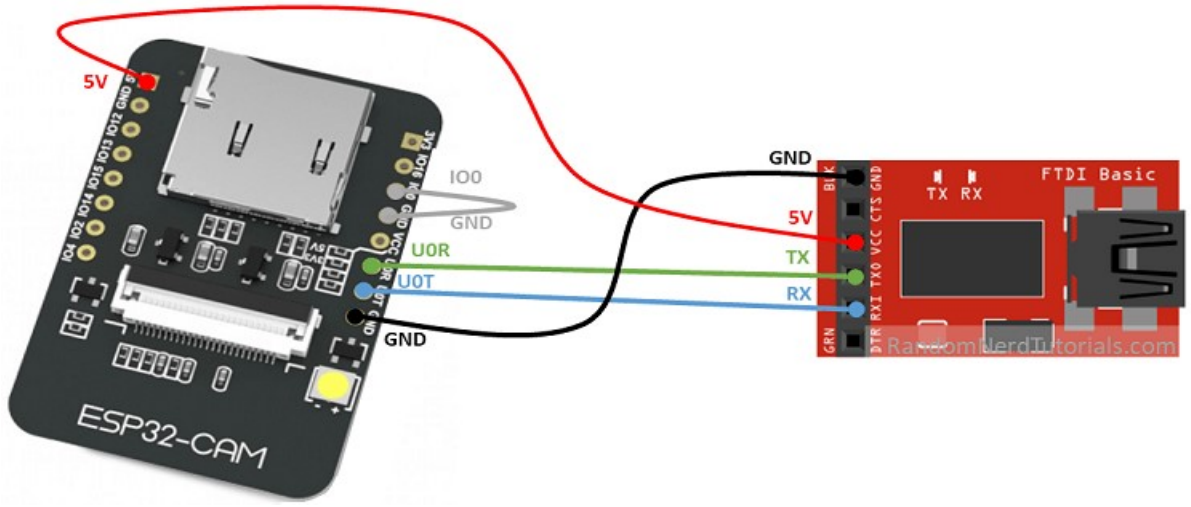


Figure 5.11: Connecting the ESP32-CAM

Note: the order of the FTDI pins on the diagram may not match yours. Make sure you check the silkscreen label next to each pin.

Many FTDI programmers have a jumper that allows you to select 3.3V or 5V. Make sure the jumper is in the right place to select 5V.

To upload code to the ESP32-CAM using Arduino IDE, follow the next steps:

1) Go to **Tools** > **Board** and select **AI-Thinker ESP32-CAM**. You must have the ESP32 add-on installed. Otherwise, this board won't show up on the Boards menu.

2) Go to **Tools** > **Port** and select the COM port the ESP32-CAM is connected to.

3) For demonstration purposes, you can upload a blank sketch to your board:

```
void setup () {
  // put your setup code here, to run once:
}

void loop () {
  // put your main code here, to run repeatedly:
}
```

4) Then, click the **Upload** button in your Arduino IDE.

5) When you start to see some dots on the debugging window, press the ESP32-CAM on-board RST button.

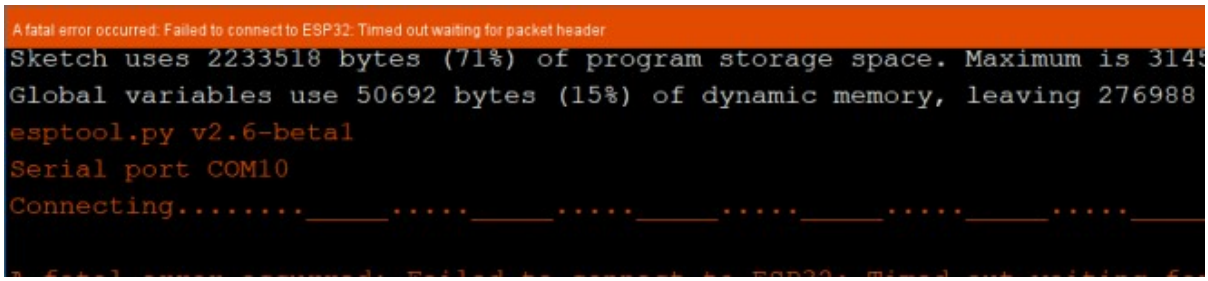
After a few seconds, the code should be successfully uploaded to your board.

6) When you see the "**Done uploading**" message, you need to remove GPIO 0 from GND and press the RST button to run your new code.

Common Errors and How to Fix Them

If you don't follow the previous instructions exactly, you may get the following errors:

Failed to connect to ESP32: Timed out waiting for packet header



This error means that the ESP32-CAM is not in flashing mode or it is not connected properly to the FTDI programmer.

PCB PREPARATION

Printed Circuit Board, popularly known as PCB, PCB is a piece of plastic insulating board, on one side of which a complete layout diagram of an electronic circuit consisting of copper silver conducting paths is printed by a special photo etching process.

Construction:

The steps involved in the manufacturing of PCB are as follows:

- Design and preparation
- Pattern Design
- Resist Application
- Etching
- Clearing and resist remover
- Finishing
- **Design and preparation**: Artwork should be prepared on transparent polystyrene film using block ink or adhesive tapes and pads. In modern technique screen printing method is used for art working of PCB. This is the primary step in fabricating the PCB.
- **Pattern Design:** In industrial work, pattern is usually transformed to the surface of the laminate by means of screen printing or by photographic method.

- **Resist application:** Adhesive tapes and pads which have high chemical resistance and excellent adhesion can be attached to copper clad laminate.

- **Etching:** Etching sol can be prepared using available etchers like ferric Chloride, cupric chloride etc. Ferric chloride is popularly used. Etching can be carried out in a spray etching chambers. Few drops of HCL can be added to FECL3 to spread a etching action. The Etching process may take 30-40 min depending upon the PCB.

- **Clearing and Resist Removal:** After etching, board should be washed under running water and then dried by applying turpentine pads or spirit, the tapes can be cleaned off from PCB, Now printed pattern will be clearly visible.

- **Finishing:** After PCB is cleaned, center of terminals can be center punched and holes can drill over board. The drilling machine can be used to drill the holes. Then terminal points can be lightly tinned. After wards suitable component can be mounted on PCB.

SOLDERING

- The two surfaces to be soldered should be thoroughly cleaned and made free from any dust, grease or oil. Infect, through clearing of the PCB before beginning of the soldering operation and proper tinning of the component leads at the time of soldering that component achieves good result.

- A small quantity of flux may be applied on the surfaces to be soldered. It is the function of the soldering flux to keep away any oxide film. During soldering operation allow the two surfaces to make a metallic contact and alloy with each other. The flux residue should be removed after the soldering is done.

- One of the most common problems in soldering is the application of insufficient heat. The alloying action in soldering cannot be achieved without a uniform distribution of heat b/n the solder and the metal being soldered. If hot solder is applied to a cold metal or a cold solder is applied to a hot metal, there can never be a proper soldering action. Soldering will be proper when the solder alloy is hot enough to remain in a liquid state, as soldering is being done. To achieve a proper wetted soldering joint, heat up the component terminal and slightly and apply solder by alloy right on the

component lead and instead of applying it on the soldering iron tip, melt the solder so that it flows over the joint, avoid putting solder metal and ensure that it is in the liquid state till it has completely flowed over the joint. A perfect soldered joint would give a shiny bead like appearance. Different electronic components used have different soldering temperatures **PIN.**

7805 REGULATED POWER SUPPLY

CIRCUIT DIAGRAM

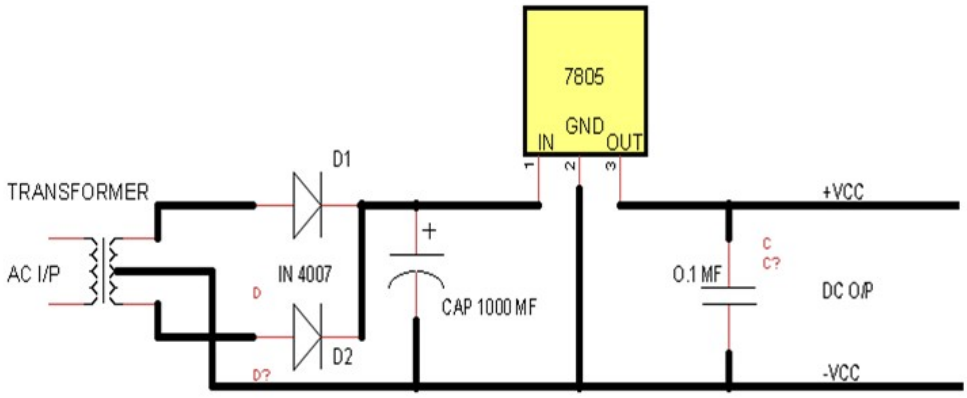


Figure 5.12: Circuit Diagram of Regulated Power Supply

A full-wave rectifier is a device that has two or more diodes arranged so that load current flows in the same direction during each half cycle of the ac supply.

We need to rectify AC power to obtain the full use of both half-cycles of the sine wave, a different rectifier circuit configuration must be used. Such a circuit is called a full-wave rectifier. One kind of full-wave rectifier, called the center-tap design, uses a transformer with a center-tapped secondary winding and two diodes, as in figure below.

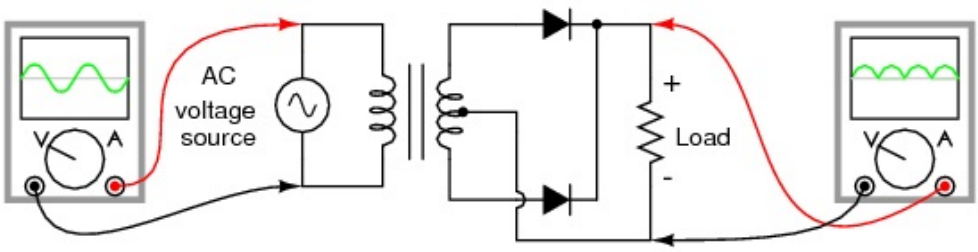


Figure 5.13: Full Wave Rectifier

This circuit's operation is easily understood one half-cycle at a time. Consider the first half-cycle, when the source voltage polarity is positive (+) on top and negative (-) on bottom. At this time, only the top diode is conducting; the bottom diode is blocking current, and the load “sees” the first half of the sine wave, positive on top and negative on bottom. Only the top half of the transformer's secondary winding carries current during this half-cycle as in Figure below.

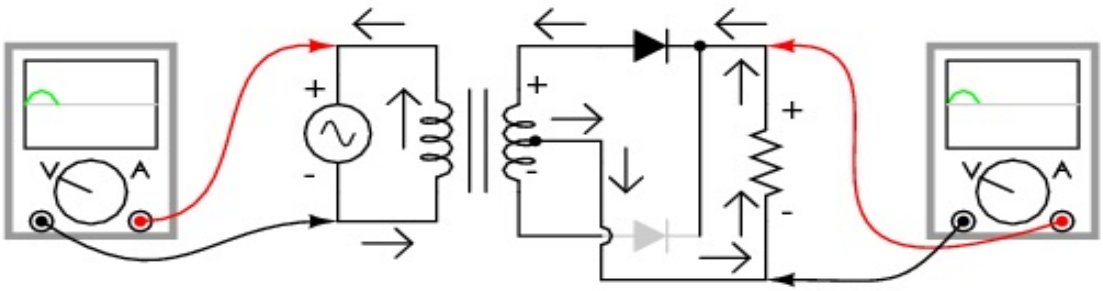


Figure 5.14: Full Wave Rectifier Center Tapped Design

The pulsating DC is connected across a filter capacitor which removes the ripples and smoothens the DC output

Regulator section

A **DC** power supply system, which maintains constant voltage irrespective of fluctuations in the main supply or variation in the load, is known as Regulated Power supply.

The **7805 IC** referred to fixed positive voltage regulator, which provides fixed voltage 5 volts. The **7805** regulator is known as fixed voltage regulator.

Fixed –Voltage regulator design has been greatly simplified by the introduction of 3-terminal regulator ICs such as the 78xx series of positive regulators and the 79xxx series of negative regulators, which incorporate features such as built-in fold back current limiting and thermal protection, etc. These ICs are available with a variety of current and output voltages ratings, as indicated by the ‘xxx’ suffix; current ratings are indicated by the first part of the suffix and the voltage ratings by the last two parts of the suffix. Thus, a 7805 device gives a 5V positive output at a 1mA rating, and a 79L15 device gives a 15V negative output at a 100mA rating. 3-terminal regulators are very easy to use. The regulators ICs typically give

about 60dB of ripple rejection, so 1V of input ripple appears as a mere 1mV of ripple on the regulated output.

A rectified filter and unregulated **DC** voltage is given to pin of **IC** regulator. A bypass capacitor is connected between input and ground to bypass the ripples and oscillations. The output capacitor is connected between output and ground to improve transient response. The unregulated input is applied to the **IC** must be always more than the regulated output.

5.2 SOFTWARE REQUIREMENTS

A software requirements specification (SRS) is a comprehensive description of the intended purpose and environment for software under development. The SRS fully describes what the software will do and how it will be expected to perform.

5.2.1 Operating System

- Windows 7 or Above

5.2.2 BLYNK

What is Blynk?

Imagine a prototyping board on your smartphone where you drag and drop buttons, sliders, displays, graphs and other functional widgets. And in a matter of minutes these widgets can control Arduino and get data from it.

How it works

Blynk works over the Internet. So, the one and only requirement is that your hardware can talk to the Internet. No matter what type of connection you choose - Ethernet, Wi-Fi or maybe this new ESP8266 everyone is talking about – Blynk libraries and example sketches will get you online, connect to Blynk Server and pair up with your smartphone.

Currently, Blynk libraries work with this stuff:

- ❖ USB
- ❖ Ethernet shield
- ❖ WiFi shield

- Arduino with Ethernet
- ESP8266

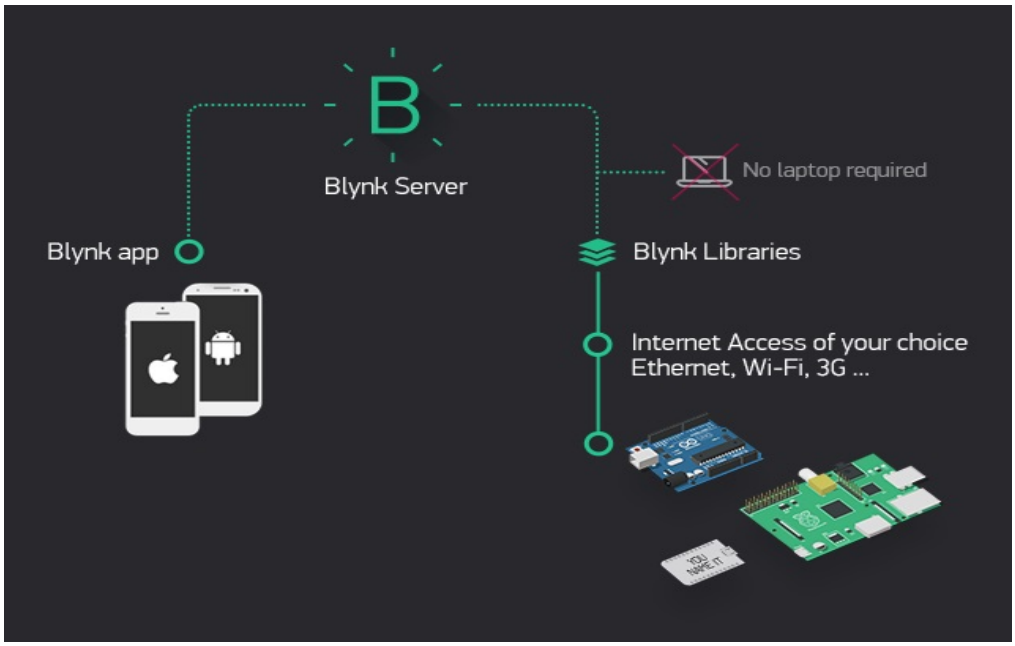


Figure 5.15: Blynk's Architecture

Raspberry Pi (Blynk will communicate with Pi's GPIOs) more Arduino compatible shields and boards (this list will be updated as we test the compatibility) We are excited to extend this list with other awesome internet enabled products. These are our next integrations:

- Electric Imp
- Spark Core
- The AirBoard
- Wicked Wildfire
- TinyDuino
- WunderBar

It handles all the authentication and communication, and also keeps an eye on your board while the smartphone is offline. Blynk server runs on Java and is open-source. You will be able to run it locally if you really need to. Messaging between mobile apps, Blynk Server and Arduino is based on a simple, lightweight and fast binary protocol over TCP/IP sockets.

For new and experienced makers Blynk works out of the box: no new languages to learn, no additional software to install and no long documentation reading.

Super easy setup

When designing Blynk, we really focused on simplifying things so that you could see your first results very quickly. However, if you are into writing more serious code, you'll have the full freedom in your hands.

5.3 Functional Requirements

A functional requirement document defines the functionality of a system or one of its subsystems. It also depends upon the type of software, expected users and the type of system where the software is used.

5.4 Non-Functional Requirement

Non-Functional Requirements are the constraints or the requirements imposed on the system. They specify the quality attribute of the software. Non-Functional Requirements deal with issues like scalability, maintainability, performance, portability, security, reliability, and many more. Non-Functional Requirements address vital issues of quality for software systems. If NFRs not addressed properly, the results can include:

- Users, clients, and developers are unsatisfied.
- Inconsistent software.
- Time and cost overrun to fix the software which was prepared without keeping NFRs in mind.

CHAPTER 6

EXPERIMENTAL RESULTS

Experiment Results means any tangible and intangible outputs of the Experiments that are generated by or on behalf of the Experimenter as well as any rights attached to them.

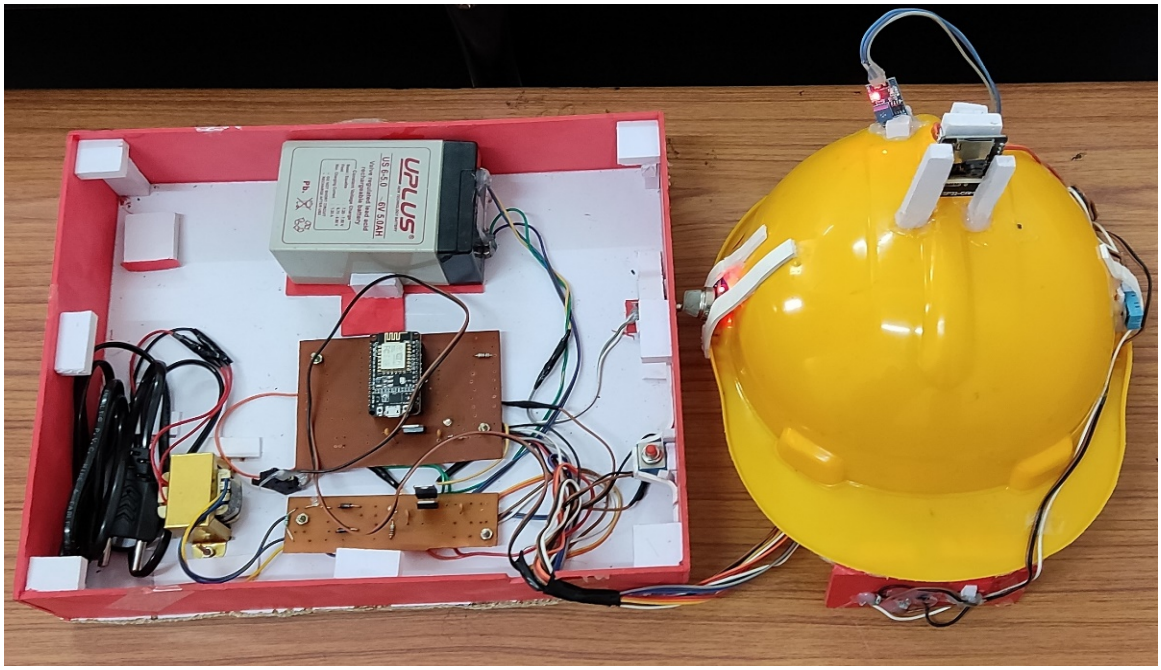


Figure 6.1: Working Model

In this project, the smart safety helmet for mine workers, there are four main objectives. First objective is to detect the presence of Hazardous gases like Carbon-Monoxide, Methane, LPG, and other natural gases, the second objective is about helmet removal by the miners, the third objective is the emergency button pressed in any adverse situation and the last objective is to monitor the miners continuously using ESP32 cam. Therefore, it is crucial to have a monitoring and surveillance system to acquire the evaluated data, transmit it to the control center, and make the most appropriate decision at the earliest possible moment.

i. To Detect Hazardous Gases

Figure 6.2: Detecting Gases

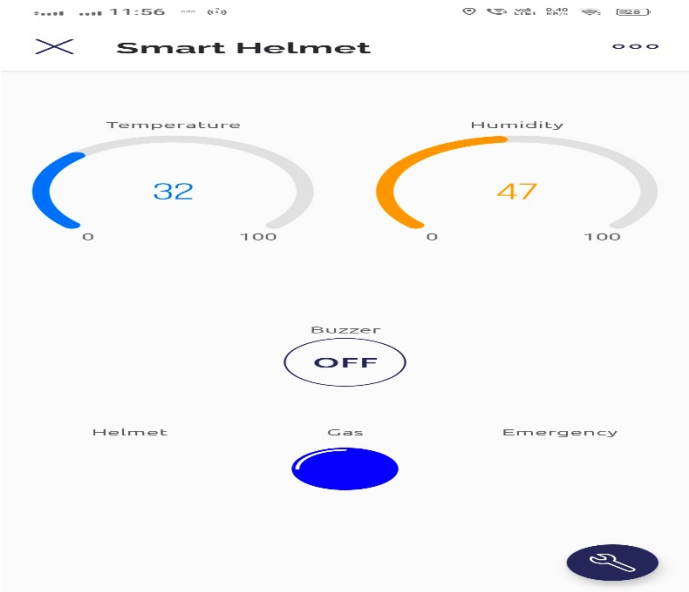


Figure 6.3: Gas Alert in Blynk App

Detecting the presence of Hazardous gases like Carbon-Monoxide, Methane, LPG, and other natural gases is the first objective of our project. Air quality test is done using MQ-

6 gas sensor. As shown in Fig 5.14, as soon the presence of CH4, LPG and natural gases above 55% is detected by the MQ-6 sensor a signal is sent to the higher authorities in the control room. Concurrently, the buzzer and the LED is switched ON to notify the mine worker. The MQ-6 sensor collects data after every 0.2 second interval for better accuracy.

ii. Detection of Helmet Removal

Figure 6.4: Detection of Helmet Removal

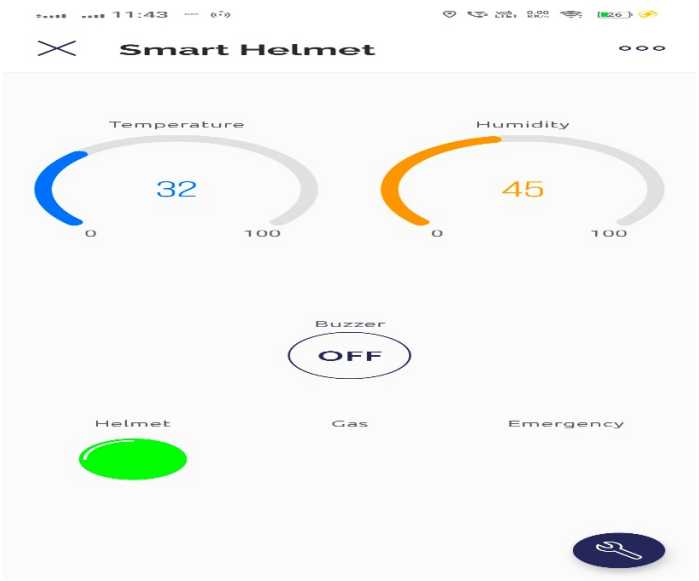


Figure 6.5: Alert About Helmet Removal

Second objective of our project is to detect the existence of the helmet on the worker's head. An IR sensor is used to perform smart helmet removal test, when a miner removes their helmet, it gets detected by the sensor. As soon as the worker removes the helmet it is detected in the blynk server. Red LED along with a buzzer sound prompting to wear the helmet back is activated. The IR sensor checks the condition after every 0.2 second for more accuracy.

iii. Emergency Button For any Adverse Situation

Figure 6.6: Emergency Button Press

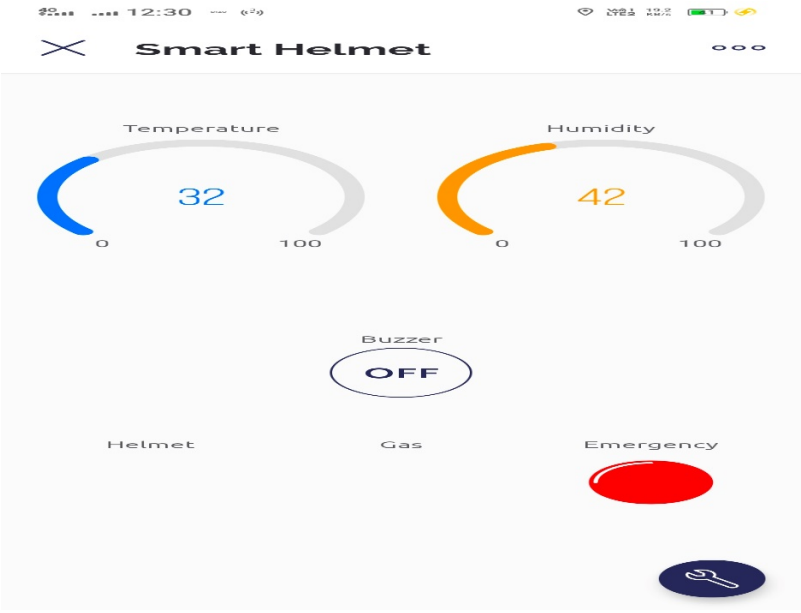


Figure 6.7: Emergency Signal in Blynk App

Third objective of our project is to press the emergency button in any adverse situation. In case of emergency a signal can be sent to the mining authorities using the emergency button. As the miner presses the emergency button a mail is sent to the higher authorities sitting in the control room within 5 seconds which helps the authorities to reach the miner as fast as possible thereby save the miners life. To avoid the possibility of mail ignorance the mail is continuously sent until the authorities give a suitable response.

iv. Monitoring Miners Using ESP32 cam

Figure 6.8: Live Video Streaming Using ESP32 cam

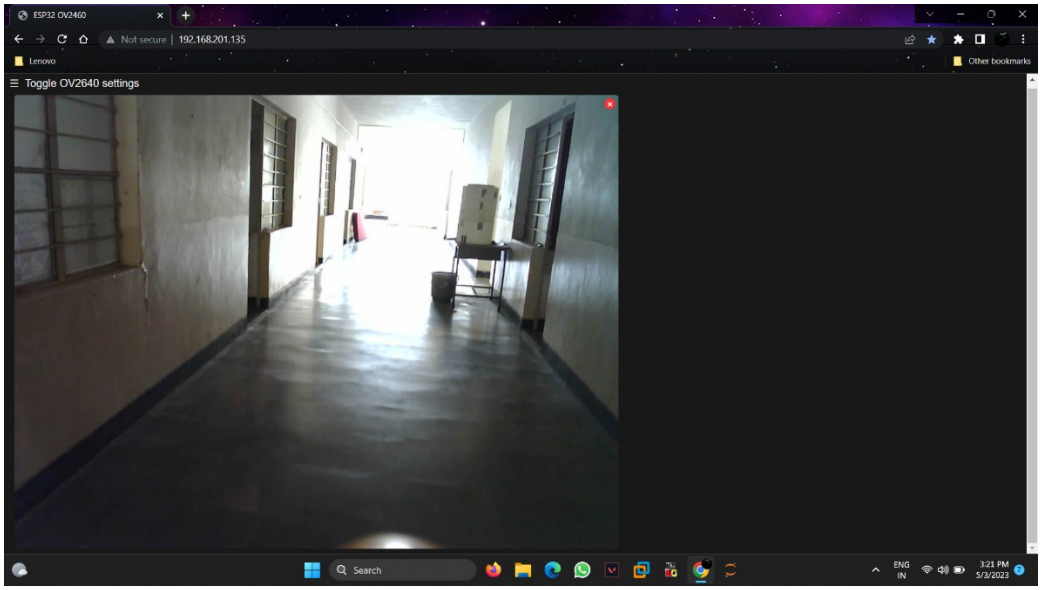


Figure 6.9: Live Video Streaming of Mine Worker

The last objective of our project is to monitor the mine worker's location continuously using ESP32 camera. As shown in above Fig, the ESP32 camera module attached to helmet, will stream live video to the authorities for monitoring. The streaming is done at 160 MHz clock speed with a pixel count of 2MP. This live video stream will help the mining officials to get a constant update of the situation under the mines and can also use this feed for research and future reference.

v. Temperature and Humidity

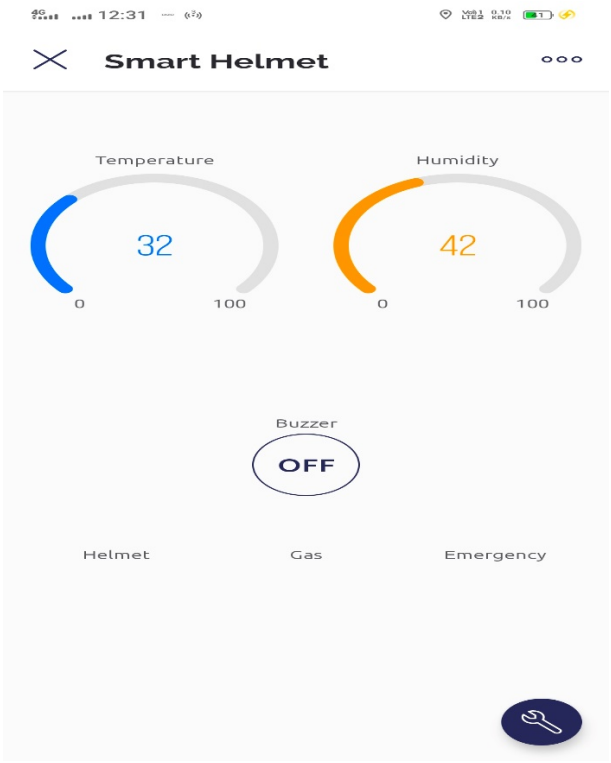


Figure 6.10: Temperature and Humidity Readings in Blynk app

In our project, we also display the temperature and humidity readings in the Blynk app. In order to increase the efficiency of the measurement, a measurement was conducted every 2 seconds with the DHT11 sensor. It measures temperature from 0 to +50 °C with an accuracy of +/-2 °C and relative humidity from 20 to 95% with an accuracy of +/-5% as shown in above Fig. In the proposed model, if the temperature rises above 38°C and if the humidity of the environment exceeds over 86% then the worker is alerted through a red LED and buzzer by the higher authorities in the control room.

CONCLUSION AND FUTURE SCOPE

The mining industry all over the world is adversely affected by various hazards including gaseous explosions, landslides, fire hazards, etc. Many risky incidents commonly occur in the mining sector, many of which result in life-threatening injuries or death. This leads to the significance of safety for the mine workers. A miner's helmet is one of the most regularly used safety equipment for mine workers hence it must be loaded with some more advanced features. A Wi-Fi based smart helmet has been designed for coal miners which is capable of detecting threatening events like the increase in the level of harmful gases inside the mine. This smart helmet is also capable of sending real time temperature and humidity levels to the servers thereby keeping the concerned authorities always updated about the mine conditions. The presence of an emergency button in the smart helmet helps the miners to send signals easily just with a press of a single button that indicates the rescue team that the worker needs to be rescued. The helmet removal notified feature helps the authorities to get informed if any miner tries to remove the helmet. We have provided an ESP32 camera to monitor the mine worker’s location continuously. This low-cost, reliable and efficient prototype has been designed and tested with software and hardware debugging. Placement of each module and sensors has also been done carefully thus resulting in the best working of the product.

FUTURE SCOPE

The proposed model can be upgraded by using a LORA module in addition to the Wi-Fi thereby making the communication process less network dependent. Further an oximeter can also be included to constantly monitor miners’ oxygen level and heart rate. Also, a collision sensor can be installed which can detect any collision or accidents. To detect the increasing water level in mines we can integrate a water level sensor in the miners’ boots, which will warn the miner of increasing water levels.

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