

IOT-BASED COAL MINE SAFETY MONITORING AND ALERTING SYSTEM

Submitted in partial fulfilment of the requirements for the award of **Bachelor of
Degree in Electronics and Communication Engineering**

By

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ENGINEERING**

SCHOOL OF ELECTRICAL AND ELECTRONICS

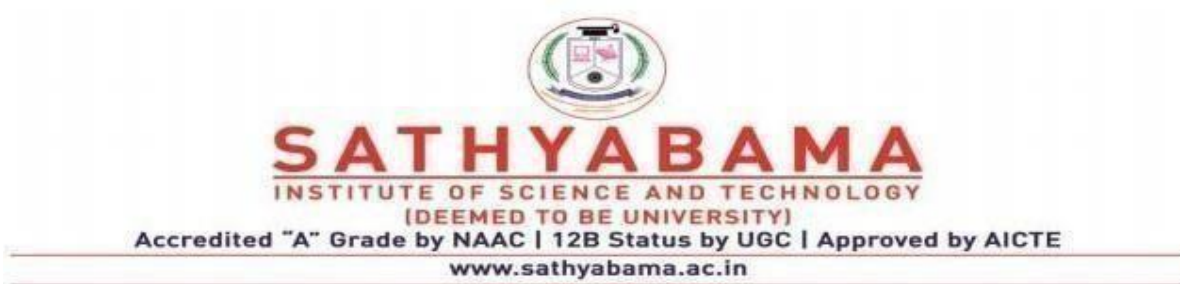
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **VEERANENI SAI (39130505)** and **KARRI TARUN KUMAR (39130540)** who carried out the project entitled "**IOT-BASED COAL MINE SAFETY MONITORING AND ALERTING SYSTEM**" under my / our supervision from January 2023 to April 2023.

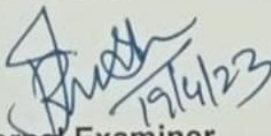
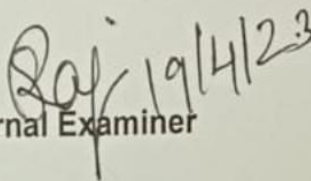
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Submitted for Viva voce Examination held on **19.04.2023**

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DECLARATION

I V E E R A N E N I S A I (39130505) report entitled “**IOT-BASED COAL MINE SAFETY MONITORING AND ALERTING SYSTEM**” done by us under the guidance of **Dr.G.D.ANBARASI JEBASELVI** at **Sathyabama Institute of Science and Technology, Chennai- 600119** is submitted in partial fulfilment the requirements for the award of **Bachelor of Engineering in Electronics and Communication**.

DATE:19.04.2023

PLACE: CHENNAI



SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. We are grateful to them

We convey our thanks to **Dr. N.M. NANDITHA, M.E., Ph.D.**, Dean, School of Electrical and Electronics Engineering and **Dr. T. RAVI, M.E., Ph.D.**, Head of the Department, Dept. of Electronics and Communication Engineering for providing us necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Dr.G.D.ANBARASI JEBASELVI**, for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of our project work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the Department of **Electronics and Communication Engineering** who were helpful in many ways for the completion of the project.

ABSTARCT

Safety is the most important aspect of any industry. Security and safety are absolutely essential in the mining industry. The mining industry follows a few fundamental safety measures to prevent any accidents. Underground mines still have accidents because of rising temperatures, rising water levels, and methane gas leaks. Here, we provide worker safety. He can call security by pressing the panic button when a worker is in danger. A reliable communication system between workers in underground mines and the fixed ground mine system is required to improve safety in underground mines. There must be no interruptions to the communication network at any time or under any circumstance. In this project, a low-cost, early-warning intelligence-based wireless mine supervision system is proposed. IoT allows for monitoring of worker status.

Coal mines are one of the most important and industries in the country, as they are used as fuel in the steel and cement industries to extract iron from the stone and create cement. Every parameter, such as methane gas, high temperature, fire incidents, etc., should be regularly checked in the underground mining business. Due to the complexity of the mining environment and the variety of activities performed in coal mines, it is important to monitor the working environment. To address this issue, there is a system that monitors basic safety measures and regulates many restrictions on coal mines, such as gas leaks, temperature and humidity conditions, and fire sensor. All the sensors are assembled into a single unit and then placed in a coal mine.

The most crucial component of every industry is security. The only factor in the mining business is safety and security. The mining industry takes many safeguards to prevent accidents of any kind, including steel accidents. Temperature increases cause methane gas leaks and an increase in water levels in underground mines. Here, we give workers protection. When the danger can be suppressed by the worker, we alert the panic switch protection. To improve safety between employees in underground mines and 10 between the stationary landmine system, a dependable communication system should be implemented. There should never be a break in the communication network.

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CHAPTER 1

INTRODUCTION:

Mines are the world's most dangerous place to work because in the mines, explosion often happens and thousand people are dying. And a recent report state that in such mine accidents an average of around 12,000 people have died. Coal is a no sustainable origin that cannot be widely replaced by humans, there are several mishaps of coal mines occurring in the mines, and the diggers are putting their lives at risk, by working in the coal mines, even once in a while they end up losing their lives in the coal mines that are an unfortunate part. Mainly such mishaps happen as a direct result of the old equipment and wired devices, resulting in the end, mishandling, spillage of the noxious gases in the coal mines, pose tremendous hazards to the excavators inside the coal mines. So we've designed the coal mine protection system to stay away from this problem. We tackled the issues in our research by testing each of the information collected by the sensors, we use and finishing the analysis using the Thinker system. Controlling can be done automatically or manually.

Objective:

IOT based coal mine safety monitoring and alerting system project is proposed for the purpose of **implementing security and detection of hazards inside a coal mine.**

Aim:

Coal mining companies aim **to create economic value for greater good with a keen eye on the welfare of the communities in their areas of operation.** A shared value approach, underpinned by collaboration, aims to ensure that communities' daily needs are challenges are addressed

CHAPTER-2

LITERATURE SURVEY

Title:1 IOT based Coal Mine Safety Monitoring And Alerting System

Author: Manohara K M, Nayan Chandan D C, Pooja S V, Sonika P, Ravikumar K I

Coal mines are one of the most important and industries in the country, as they are used as fuel in the steel and cement industries to extract iron from the stone and create cement. Every parameter, such as methane gas, high temperature, fire incidents, etc., should be regularly checked in the underground mining business. Due to the complexity of the mining environment and the variety of activities performed in coal mines, it is important to monitor the working environment. To address this issue, there is a system that monitors basic safety measures and regulates many restrictions on coal mines, such as gas leaks, temperature and humidity conditions, and fire sensor. All the sensors are assembled into a single unit and then placed in a coal mine.

Title:2 Coal Mine Safety Monitoring and Alerting System with Smart Helmet

Author: Mangesh Rudrawar, Shivam Sharma, Madhuri Thakur, Vivek Kadam

Traditional monitoring systems in coal mines are difficult to install, hazardous, and difficult to power. Because of the complexity of the mining environment and the wide range of operations performed in coal mines, it is vital to monitor and maintain the parameters in the background to increase the efficiency and safety of mineworkers. As a result, traditional monitoring methods cannot be relied on to ensure coal workers' safety. This research represents a ZigBee-based wireless monitoring system using a smart helmet. The presented wireless monitoring system is capable of detecting and transmitting critical parameters in coal mines such as methane gas, high temperature, humidity, and fire. In an emergency, this monitoring system transmits distress signals. A buzzer will sound if emergency conditions are detected, and the monitored variables will be displayed on the user interface machine. Moreover, the Parameters are wirelessly transmitted to the control room, allowing people to determine the safety situation of the mine. This model is easily reprogrammable. Experiments have demonstrated the system's reliability and stability.

Title:3 : Safety Monitoring System in Coal Mine Using IoT

Author: Sathishkumar N1 , Manoj A M2 , Muniraj K2 , Naveenkumar M2 , Praveen C2

The key abstract is to use IoT to incorporate a coal mine safety monitoring system. The extraction of coal from the field is known as coal mining. Coal is used as a fuel in the steel and cement industry to extract iron from ore and to manufacture cement. Every parameter

in the underground mining industry must be controlled on a regular basis, including methane gas, high temperatures, fire incidents, and so on. The level of safety in coal mines is still poor, resulting in fatalities. A coal mineshaft salvage action is profoundly perilous because of various elements. It is particularly risky for rescuers to enter a coal mineshaft burrow in a debacle without earlier attention to the climate on the grounds that ensuing blasts are probably going to happen at any second. It is along these lines basic to recognize unstable climate data like toxic gases and high temperatures, just as to direct a visual review of excavators caught in a fell passage through the imploded burrow. These information would aid rescuers in devising a strategy and equipping themselves to carry out the rescue operation defensively. This paper proposes a design for coal mines that will reduce the damage caused by a coal mine accident and allow for a more effective rescue operation.

Title:4 INTERNET OF THINGS BASED AN INTELLIGENT HELMET FOR WIRELESS SENSOR NETWORK

Author- G.Ravi Kumar*1 & B. Keerthi Reddy2

The main aim of the paper is to develop a smart helmet for mining industry workers. The problem addressed in this paper was the improvement of a mining helmet in order to ensure more safety awareness between miners. When working with noisy equipment, being aware of one's surroundings can sometimes be challenging. In the mining trade miners tend to get rid of their safety gear because the gear is too significant, heat or uncomfortable to work with. So this system is developed to intimate the authorities in critical conditions. To overcome the above problem, we are developing a smart helmet for mining industry workers. Firstly to identify the worker, each worker will be having different tag. Once the tag is identified, person's data will be sent to the PC through ZIGBEE. In order to check whether the worker has been using the helmet or not, IR sensors are used to check the helmet presence. The surrounding hazardous gases will be detected by the gas sensor present in the helmet. When gas is detected voice notification will be given through speaker. By the use of MEMS sensor, the head injuries occurrence will be identified. All the data related to sensors will be posted into the PC through ZIGBEE transceiver.

Title-5 Smart Helmet for Coal Mines Safety Monitoring and Alerting

Author- S. R. Deokar1 , V. M. Kulkarni2 , J. S. Wakode3

Industrial safety is one of the main aspects of industry specially coal mine industry. Underground mining hazards include suffocation, gas poisoning, object fall, roof collapse and gas explosion. So air quality and hazardous event detection is very important factor in mining industry. This system provides a wireless sensor network for monitoring real time situation of underground mines from base station. It provides real time monitoring of harmful gases like CO, CH₄ and LPG and also temperature. The main reason for death of miners is that, due to any reason miners falls down and loses consciousness also proper treatment is not provided them at that

time. To overcome this problem the system provide emergency alert to the supervisor if person fall down by any reason. Some workers are not aware for safety and they are not wear helmet. A Limit switch was then used to successfully determine whether a miner has removed his helmet or not. The system uses Zigbee technology for transmission of data from underground mine to base station. There is alert switch at mines and base station for emergency purpose.

Title-6 Intelligent safety system for coal miners

Author- Beena M Varghese, Binisha Balan, Neethu Varghese, Reshma Gangadharan, Shaima PK

Disasters are common in coal mine due to the complexity of its natural Environment. These frequent disasters bring huge loss of possession and life. Therefore, the safe production of coal in the mine is inevitable. A cost effective ZigBee-based wireless supervising system for coal mine is presented. An intelligent helmet is used as a mobile safety system with sensor network. The system adopted a ZigBee wireless technology to build wireless sensor networks, realized real-time surveillance with early-warning intelligence on methane, temperature, humidity in mining area to reduce potential safety problems in coal production. PIC16F877A micro-controller is used for controlling all the operations. Sensors, an RF receiver and transmitter for location identification, LCD (Liquid-crystal-display) and a keyboard with alert buttons are used as input/output devices. As a result of this project, we obtained the desired system having a range of communication of 8 meters which give proper results in normal atmospheric conditions.

Title- 7 An Intelligent Helmet for Miners with Air Quality and Destructive Event Detection using Zigbee

Author- Dr. B. Paulchamy, Dr. C. Natarajan, A. Abdul Wahith, P. V. Madhu Sharan, R. Hari Vignesh

An intelligent helmet has been developed to assist the miners working in the mining industry. Harmful events tend to occur in the mining industry that can lead to severe injury or be fatal. LED miner's helmet is the most commonly used helmet because of light weight and low power consumption. However it does not improve the safety of miners apart from providing illumination. Zigbee wireless sensor networks are used to collect sensor data and transmit them. The zigbee based system is cost effective and details are shared with central control unit. This paper presents a study of the mining environment and its hazards and how a zigbee is used for transmission from miner to ground control system in case of hazardous events.

CHAPTER 3

SYSTEM DESIGN:

EXISTING SYSTEM:

In the underground mining area, the methane gas level present in the mine is detected by Electronic Gas Sensor. The climatic conditions in underground mine including temperature and humidity are measured by the Temperature sensor. The vibrations occurring in the mines while mining are detected using the Vibration sensor. This senses the vibration level and occurrence of earthquake can be known easily. With a power supply given, the data which the various sensors collect are fed to the Arduino UNO, the numbers are displayed in the LCD display module. The numbers also check with the maximum level each parameter like gas, pressure, temperature, vibration etc., using the Zigbee module. If the number crosses the predefined level, the buffer buffers and gives alert to the miners. The machine collects data in a coal mine using a sensor network based on (MEMS) Micro Electrical Mechanical Systems. The sensor module is made up of MEMS sensors that range in size from 1 to 100 micrometres.

Disadvantages

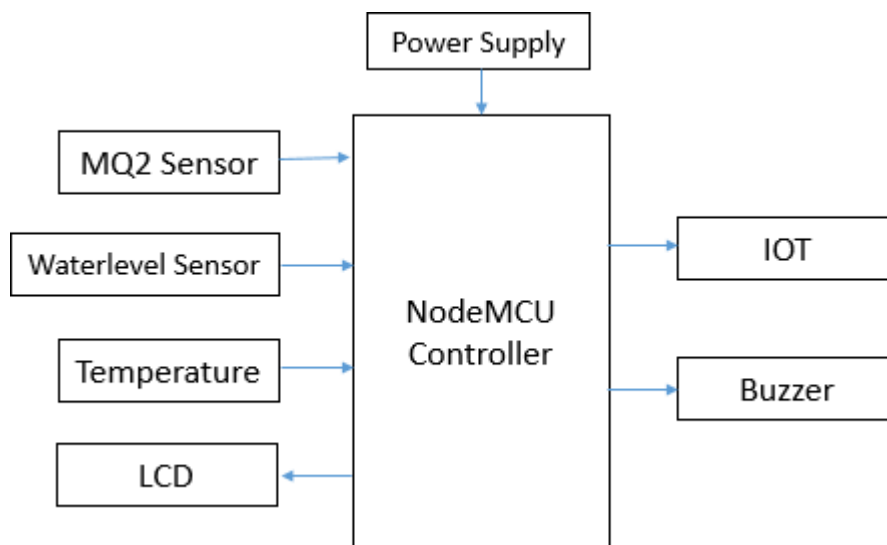
Proposed system:

In this proposed system the coal mine safety systems are fixed with gas sensor modules, temperature sensor, water level sensor and relays. We integrate all the sensors to the controller. First we need to create an account in the ThingSpeak platform. In this system we mainly have monitoring and controlling systems. In monitoring system we monitor all the data from different sensors. Gas sensor detects the gas in the coal mine environment. If the gas level exceeds the normal level then the buzzer gets high so that the mine workers get notified. These sensor values are continuously uploaded to the cloud for analysis and also for further use. The temperature and water level values are also monitored inside the coalmine and send data control unit and stored in IOT.

CHAPTER 4

PROJECT DESIGN:

BLOCK DIAGRAM:



Hardware used:

- NodeMCU Controller
- MQ2 sensor
- Water level Sensor
- Temperature Sensor
- LCD Display
- Buzzer

Software Used:

- Arduino IDE

CHAPTER 5

HARDWARE EXPLANTION:

IOT (Internet of Things):

IoT stands for Internet of Things, which means accessing and controlling daily usable equipments and devices using Internet.

Our IoT tutorial includes all topics of IoT such as introduction, features, advantage and disadvantage, ecosystem, decision framework, architecture, and domains, biometric, security camera and door unlock system, devices, etc.

What is an Internet of Things (IoT)

Let's us look closely at our mobile device which contains GPS Tracking, Mobile Gyroscope, Adaptive brightness, Voice detection, Face detection etc. These components have their own individual features, but what about if these all communicate with each other to provide a better environment? For example, the phone brightness is adjusted based on my GPS location or my direction.

Connecting everyday things embedded with electronics, software, and sensors to internet enabling to collect and exchange data without human interaction called as the Internet of Things (IoT).

The term "Things" in the Internet of Things refers to anything and everything in day to day life which is accessed or connected through the internet.

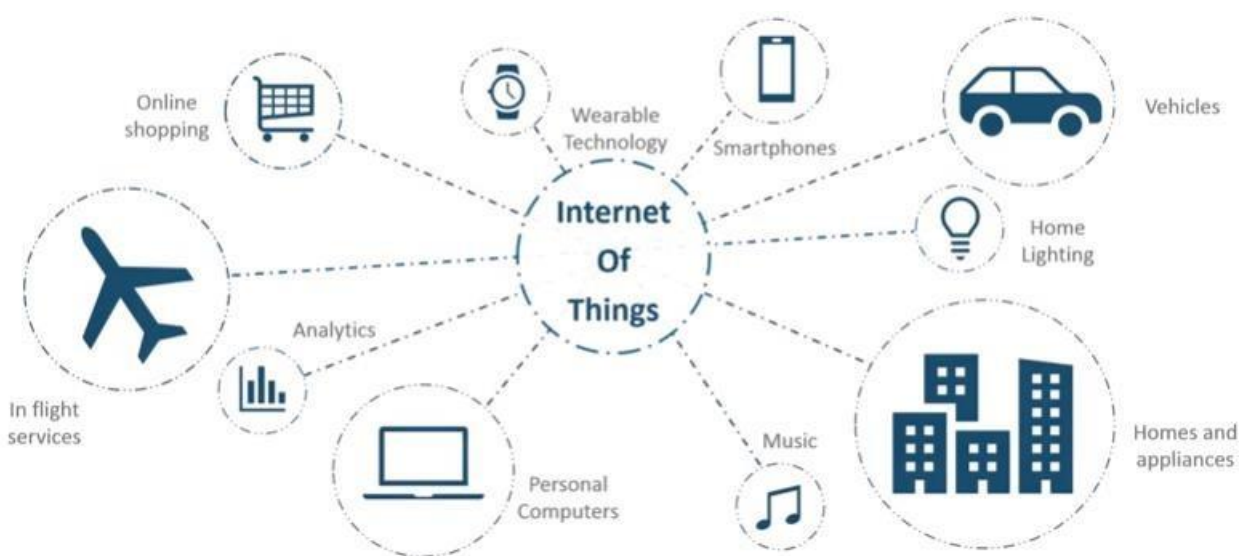


Fig 5.1 Internet Of Things

IoT is an advanced automation and analytics system which deals with artificial intelligence, sensor, networking, electronic, cloud messaging etc. to deliver complete systems for the product or services. The system created by IoT has greater transparency, control, and performance.

As we have a platform such as a cloud that contains all the data through which we connect all the things around us. For example, a house, where we can connect our home appliances such as air conditioner, light, etc. through each other and all these things are managed at the same platform. Since we have a platform, we can connect our car, track its fuel meter, speed level, and also track the location of the car.



If there is a common platform where all these things can connect to each other would be great because based on my preference, I can set the room temperature. For example, if I love the room temperature to be set at 25 or 26-degree Celsius when I reach back home from my office, then according to my car location, my AC would start before 10 minutes I arrive at home. This can be done through the Internet of Things (IoT).

How does Internet of Thing (IoT) Work?

The working of IoT is different for different IoT echo system (architecture). However, the key concept of there working are similar. The entire working process of IoT starts with the device themselves, such as smartphones, digital watches, electronic appliances, which securely communicate with the IoT platform. The platforms collect and analyze the data from all multiple devices and platforms and transfer the most valuable data with applications to devices.

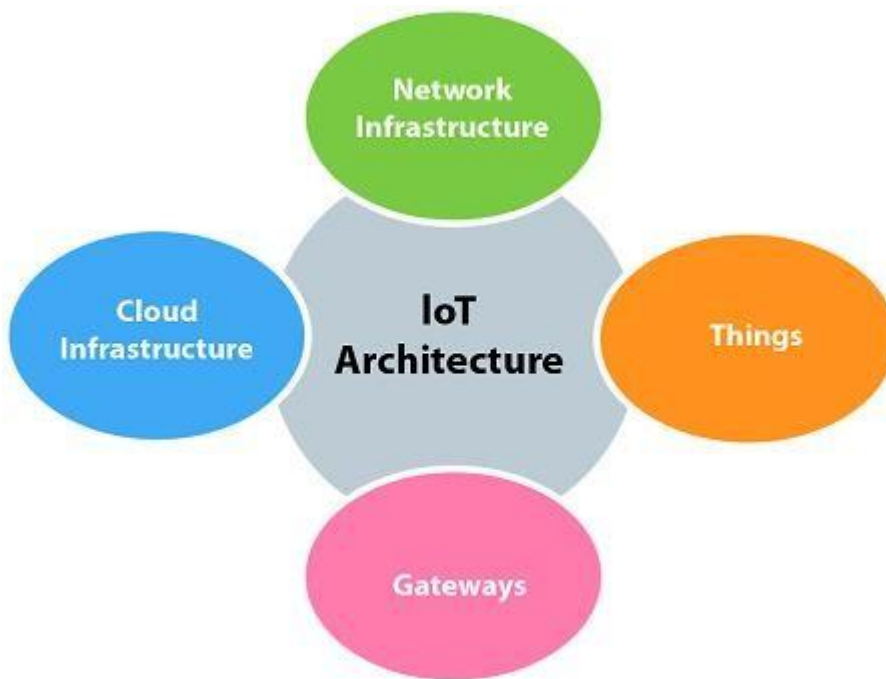


Fig 5.2 IoT Architecture

Features of IOT

The most important features of IoT on which it works are connectivity, analyzing, integrating, active engagement, and many more. Some of them are listed below:

Connectivity: Connectivity refers to establish a proper connection between all the things of IoT to IoT platform it may be server or cloud. After connecting the IoT devices, it needs a high speed messaging between the devices and cloud to enable reliable, secure and bi-directional communication.

Analyzing: After connecting all the relevant things, it comes to real-time analyzing the data collected and use them to build effective business intelligence. If we have a good insight into data gathered from all these things, then we call our system has a smart system.

Integrating: IoT integrating the various models to improve the user experience as well.

Artificial Intelligence: IoT makes things smart and enhances life through the use of data. For example, if we have a coffee machine whose beans have going to end, then the coffee machine itself order the coffee beans of your choice from the retailer.

Sensing: The sensor devices used in IoT technologies detect and measure any change in the environment and report on their status. IoT technology brings passive networks to active networks. Without sensors, there could not hold an effective or true IoT environment.

Active Engagement: IoT makes the connected technology, product, or services to active engagement between each other.

Endpoint Management: It is important to be the endpoint management of all the IoT system otherwise, it makes the complete failure of the system. For example, if a coffee machine itself order the coffee beans when it goes to end but what happens when it orders the beans from a retailer and we are not present at home for a few days, it leads to the failure of the IoT system. So, there must be a need for endpoint management.

NODE MCU

NodeMCU is an open source IoT platform.^{[4][5]} It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.^{[6][7]} The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua- cJSON^[8] and SPIFFS

NodeMCU was created shortly after the ESP8266 came out. On December 30, 2013, Espressif Systems^[6] began production of the ESP8266.^[10] The ESP8266 is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core,^[citation needed] widely used in IoT applications (see related projects). NodeMCU started on 13 Oct 2014, when Hong committed the first file of nodemcu-firmware to GitHub.^[11] Two months later, the project expanded to include an open-hardware platform when developer Huang R committed the gerber file of an ESP8266 board, named devkit v0.9.^[12] Later that month, Tuan PM ported MQTT client library from Contiki to the ESP8266 SoC platform,^[13] and committed to NodeMCU project, then NodeMCU was able to support the MQTT IoT protocol, using Lua to access the MQTT broker. Another important update was made on 30 Jan 2015, when Devsaurus ported the u8glib^[14] to NodeMCU project,^[15] enabling NodeMCU to easily drive LCD, Screen, OLED, even VGA displays.

In summer 2015 the creators abandoned the firmware project and a group of independent contributors took over. By summer 2016 the NodeMCU included more than 40 different modules. Due to resource constraints users need to select the modules relevant for their project and build a firmware tailored to their needs.

ESP8266 Arduino Core[edit]

As Arduino.cc began developing new MCU boards based on non-AVR processors like the ARM/SAM MCU and used in the Arduino Due, they needed to modify the Arduino IDE so that it would be relatively easy to change the IDE to support alternate toolchains to allow Arduino C/C++

to be compiled for these new processors. They did this with the introduction of the Board Manager and the SAM Core. A "core" is the collection of software components required by the Board Manager and the Arduino IDE to compile an Arduino C/C++ source file for the target MCU's machine language. Some ESP8266 enthusiasts developed an Arduino core for the ESP8266 WiFi SoC, popularly called the "ESP8266 Core for the Arduino IDE".^[16] This has become a leading software development platform for the various ESP8266-based modules and development boards, including NodeMCUs.

Introduction

NodeMCU is an open source LUA based firmware developed for ESP8266 wifi chip. By exploring functionality with ESP8266 chip, NodeMCU firmware comes with ESP8266 Development board/kit i.e. NodeMCU Development board.

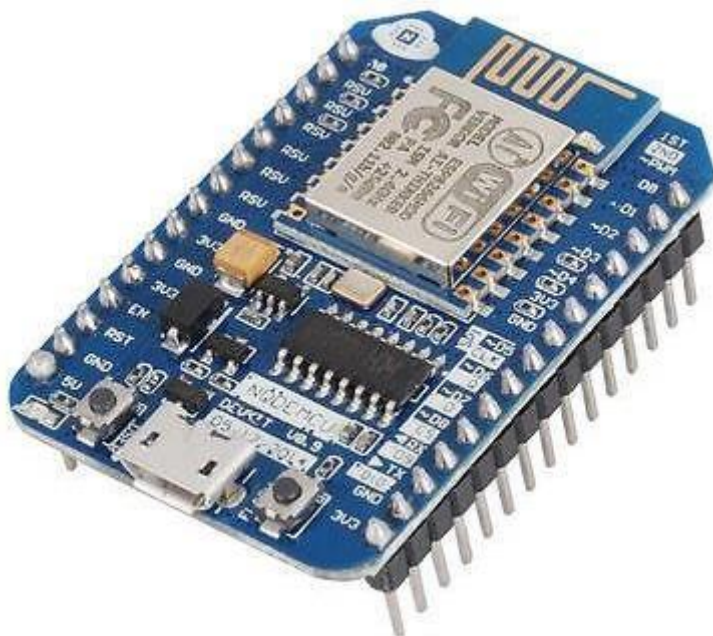


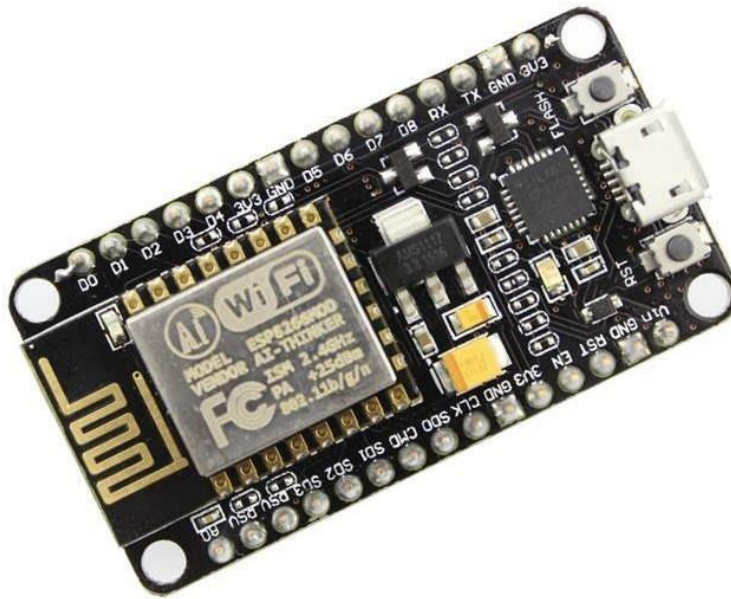
Fig 5.3 NODE MCU

NodeMCU Development Board/kit v0.9 (Version1)

Since NodeMCU is open source platform, their hardware design is open for edit/modify/build.

NodeMCU Dev Kit/board consist of ESP8266 wifi enabled chip. The **ESP8266** is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. For more information about ESP8266, you can refer ESP8266 WiFi Module.

There is Version2 (V2) available for NodeMCU Dev Kit i.e. **NodeMCU Development Board v1.0 (Version2)**, which usually comes in black colored PCB.



NodeMCU Development Board/kit v1.0 (Version2)

For more information about NodeMCU Boards available in market refer [NodeMCU Development Boards](#)

NodeMCU Dev Kit has **Arduino like** Analog (i.e. A0) and Digital (D0-D8) pins on its board.

It supports serial communication protocols i.e. UART, SPI, I2C etc.

Using such serial protocols we can connect it with serial devices like I2C enabled LCD display, Magnetometer HMC5883, MPU-6050 Gyro meter + Accelerometer, RTC chips, GPSmodules, touch screen displays, SD cards etc.

How to start with NodeMCU?

NodeMCU Development board is featured with wifi capability, analog pin, digital pins and serial communication protocols.

To get start with using NodeMCU for IoT applications first we need to know about how to write/download NodeMCU firmware in NodeMCU Development Boards. And before that where this NodeMCU firmware will get as per our requirement.

There is online NodeMCU custom builds available using which we can easily get our custom NodeMCU firmware as per our requirement.

To know more about how to build custom NodeMCU firmware online and download it refer [Getting started with NodeMCU](#)

How to write codes for NodeMCU?

After setting up ESP8266 with Node-MCU firmware, let's see the IDE (Integrated Development Environment) required for development of NodeMCU.

NodeMCU with ESPlorer IDE

Lua scripts are generally used to code the NodeMCU. Lua is an open source, lightweight, embeddable scripting language built on top of C programming language.

For more information about how to write Lua script for NodeMCU refer [Getting started with NodeMCU using ESPlorerIDE](#)

NodeMCU with Arduino IDE

Here is another way of developing NodeMCU with a well-known IDE i.e. Arduino IDE. We can also develop applications on NodeMCU using Arduino development environment. This makes easy for Arduino developers than learning new language and IDE for NodeMCU.

For more information about how to write Arduino sketch for NodeMCU refer [Getting started with NodeMCU using ArduinoIDE](#)

Difference in using ESPlorer and Arduino IDE

Well, there is a programming language difference we can say while developing application for NodeMCU using ESPlorer IDE and Arduino IDE.

We need to code in C\C++ programming language if we are using Arduino IDE for developing NodeMCU applications and Lua language if we are using ESPlorer IDE.

Basically, NodeMCU is Lua Interpreter, so it can understand Lua script easily. When we write Lua scripts for NodeMCU and send/upload it to NodeMCU, then they will get executes sequentially. It will not build binary firmware file of code for NodeMCU to write. It will send Lua script as it is to NodeMCU to get execute.

In Arduino IDE when we write and compile code, ESP8266 toolchain in background creates binary firmware file of code we wrote. And when we upload it to NodeMCU then it will flash

all NodeMCU firmware with newly generated binary firmware code. In fact, it writes the complete firmware.

That's the reason why NodeMCU not accept further Lua scripts/code after it is getting flashed by Arduino IDE. After getting flashed by Arduino sketch/code it will be no more Lua interpreter and we got error if we try to upload Lua scripts. To again start with Lua script, we need to flash it with NodeMCU firmware.

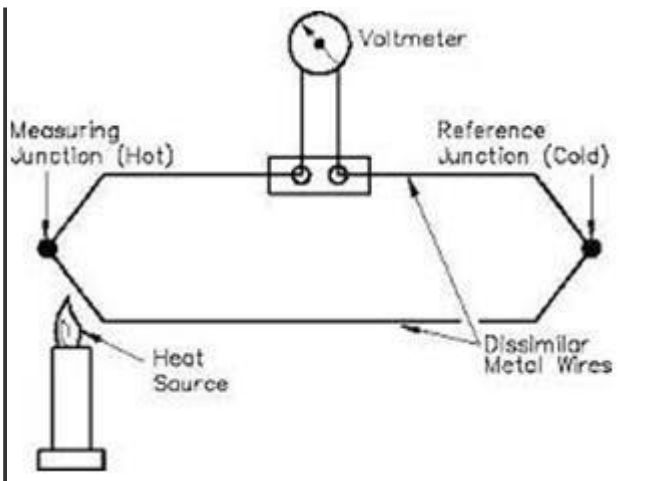
Since Arduino IDE compile and upload/writes complete firmware, it takes more time than ESPlorer IDE.

TEMPERATURE SENSOR

Temperature is the most often-measured environmental quantity. This might be expected since most physical, electronic, chemical, mechanical, and biological systems are affected by temperature. Certain chemical reactions, biological processes, and even electronic circuits perform best within limited temperature ranges. Temperature is one of the most commonly measured variables and it is therefore not surprising that there are many ways of sensing it. Temperature sensing can be done either through direct contact with the heating source, or remotely, without direct contact with the source using radiated energy instead. There are a wide variety of temperature sensors on the market today, including Thermocouples, Resistance Temperature Detectors (RTDs), Thermistors, Infrared, and Semiconductor Sensors.

THERMOCOUPLE:

It is a type of temperature sensor, which is made by joining two dissimilar metals at one end. The joined end is referred to as the HOT JUNCTION. The other end of these dissimilar metals is referred to as the COLD END or COLD JUNCTION. The cold junction is actually formed at the last point of thermocouple material. If there is a difference in temperature between the hot junction and cold junction, a small voltage is created. This voltage is referred to as an EMF (electro-motive force) and can be measured and in turn used to indicate temperature.



Thermocouple

The RTD is a temperature sensing device whose resistance changes with temperature. Typically built from platinum, though devices made from nickel or copper are not uncommon, RTDs can take many different shapes like wire wound, thin film. To measure the resistance across an RTD, apply a constant current, measure the resulting voltage, and determine the RTD resistance. RTDs exhibit fairly linear resistance to temperature curves over their operating regions, and any nonlinearity are highly predictable and repeatable. The PT100 RTD evaluation board uses surface mount RTD to measure temperature. An external 2, 3 or 4-wire PT100 can also be associated with measure temperature in remote areas. The RTDs are biased using a constant current source. So as to reduce self-heat due to power dissipation, the current magnitude is moderately low. The circuit shown in figure is the constant current source uses a reference voltage, one amplifier, and a PNP transistor.

Thermistors:

Similar to the RTD, the thermistor is a temperature sensing device whose resistance changes with temperature. Thermistors, however, are made from semiconductor materials. Resistance is determined in the same manner as the RTD, but thermistors exhibit a highly nonlinear resistance vs. temperature curve. Thus, in the thermistors operating range we can see a large resistance change for a very small temperature change. This makes for a highly sensitive device, ideal for set-point applications.

Semiconductor sensors:

They are classified into different types like Voltage output, Current output, Digital output, Resistance output silicon and Diode temperature sensors. Modern semiconductor temperature sensors offer high accuracy and high linearity over an operating range of about 55°C to $+150^{\circ}\text{C}$. Internal amplifiers can scale the output to convenient values, such as $10\text{mV}/^{\circ}\text{C}$. They are also useful in cold-junction compensation circuits for wide temperature range thermocouples. A brief details about this type of temperature sensor are given below.

SENSOR ICS

There are a wide variety of temperature sensor ICs that are available to simplify the broadest possible range of temperature monitoring challenges. These silicon temperature sensors differ significantly from the above mentioned types in a couple of important ways. The first is operating temperature range. A temperature sensor IC can operate over the nominal IC temperature range of -55°C to $+150^{\circ}\text{C}$. The second major difference is functionality.

A silicon temperature sensor is an integrated circuit, and can therefore include extensive signal processing circuitry within the same package as the sensor. There is no need to add compensation circuits for temperature sensor ICs. Some of these are analogue circuits with either voltage or current output. Others combine analogue-sensing circuits with voltage comparators to provide alert functions. Some other sensor ICs combine analogue-sensing circuitry with digital input/output and control registers, making them an ideal solution for microprocessor-based systems.

Digital output sensor usually contains a temperature sensor, analog-to-digital converter (ADC), a two-wire digital interface and registers for controlling the IC's operation. Temperature is continuously measured and can be read at any time. If desired, the host processor can instruct the sensor to monitor temperature and take an output pin high (or low) if temperature exceeds a programmed limit. Lower threshold temperature can also be programmed and the host can be notified when temperature has dropped below this

threshold. Thus, digital output sensor can be used for reliable temperature monitoring in microprocessor-based systems.

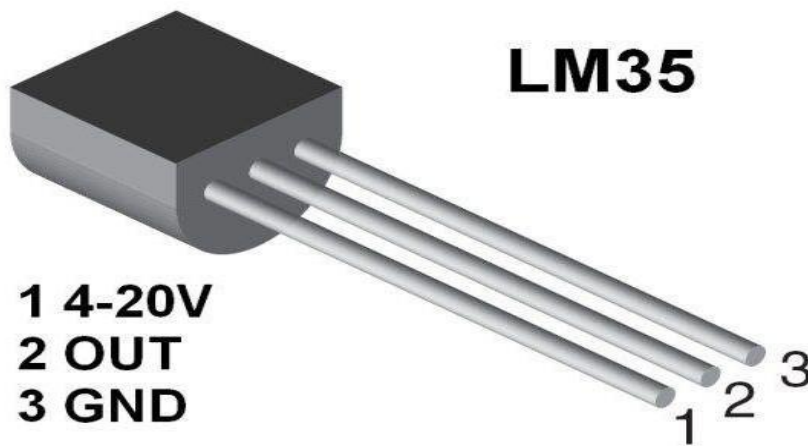


Fig 5.4 Sensor ICS

Above temperature sensor has three terminals and required Maximum of 5.5 V supply. This type of sensor consists of a material that performs the operation according to temperature to vary the resistance. This change of resistance is sensed by circuit and it calculates temperature. When the voltage increases then the temperature also rises. We can see this operation by using a diode.

Temperature sensors directly connected to microprocessor input and thus capable of direct and reliable communication with microprocessors. The sensor unit can communicate effectively with low-cost processors without the need of A/D converters.

An example for a temperature sensor is **LM35**. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius temperature. The LM35 is operates at -55° to $+120^{\circ}\text{C}$. The basic centigrade temperature sensor ($+2^{\circ}\text{C}$ to $+150^{\circ}\text{C}$) is shown in figure below.

Features of LM35 Temperature Sensor:

Calibrated directly in $^{\circ}$ Celsius (Centigrade)

Rated for full -55° to $+150^{\circ}\text{C}$ range

Suitable for remote applications

Low cost due to wafer-level trimming

Operates from 4 to 30 volts

Low self-heating,

$\pm 1/4^{\circ}\text{C}$ of typical nonlinearity

Operation of LM35:

The LM35 can be connected easily in the same way as other integrated circuit temperature sensors. It can be stuck or established to a surface and its temperature will be within around the range of 0.01°C of the surface temperature.

This presumes that the ambient air temperature is just about the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature of the LM35 die would be at an intermediate temperature between the surface temperature and the air temperature.

The temperature sensors have well known applications in environmental and process control and also in test, measurement and communications. A digital temperature is a sensor, which provides 9-bit temperature readings. Digital temperature sensors offer excellent precise accuracy, these are designed to read from 0°C to 70°C and it is possible to achieve $\pm 0.5^{\circ}\text{C}$ accuracy. These sensors completely aligned with digital temperature readings in degree Celsius.

MQ2 Gas Sensor

The MQ2 sensor is one of the most widely used in the MQ sensor series. It is a MOS (Metal Oxide Semiconductor) sensor. Metal oxide sensors are also known as Chemiresistors because sensing is based on the change in resistance of the sensing material when exposed to gasses.



Fig 5.5 MQ2 Gas Sensor

The MQ2 gas sensor operates on 5V DC and consumes approximately 800mW. It can detect LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide concentrations ranging from 200 to 10000 ppm.

What does the concentration of 1 ppm mean?

Parts-per-million, or ppm for short, is the most commonly used unit for measuring gas concentration. ppm is simply the ratio of one gas to another. For example, 500ppm of carbon monoxide means that if you could count a million gas molecules, 500 would be carbon monoxide and the remaining 999500 would be other gasses.

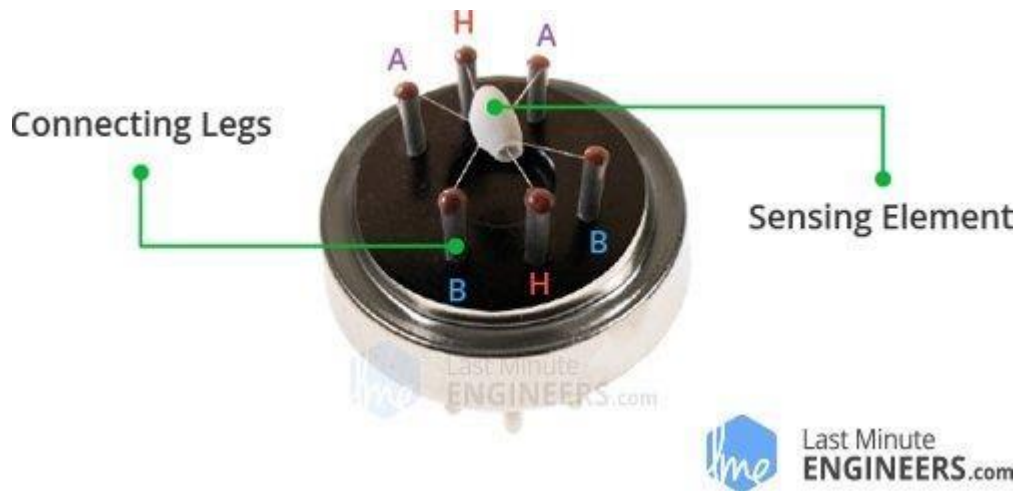
Note that the MQ2 gas sensor detects multiple gases, but cannot identify them! That is normal; most gas sensors operate in this manner. Therefore, it is best suited for measuring changes in a known gas density rather than detecting which one is changing.

Internal structure of MQ2 Gas Sensor

The MQ2 is a heater-driven sensor. It is therefore covered with two layers of fine stainless steel mesh known as an “anti-explosion network”. It ensures that the heater element inside the sensor does not cause an explosion because we are sensing flammable gasses.

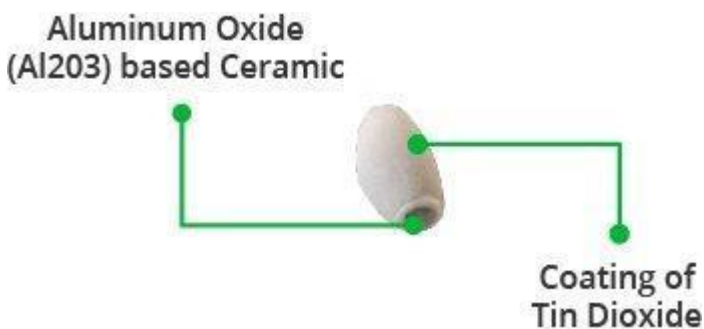


It also protects the sensor and filters out suspended particles, allowing only gaseous elements to pass through the chamber. A copper-plated clamping ring secures the mesh to the rest of the body.

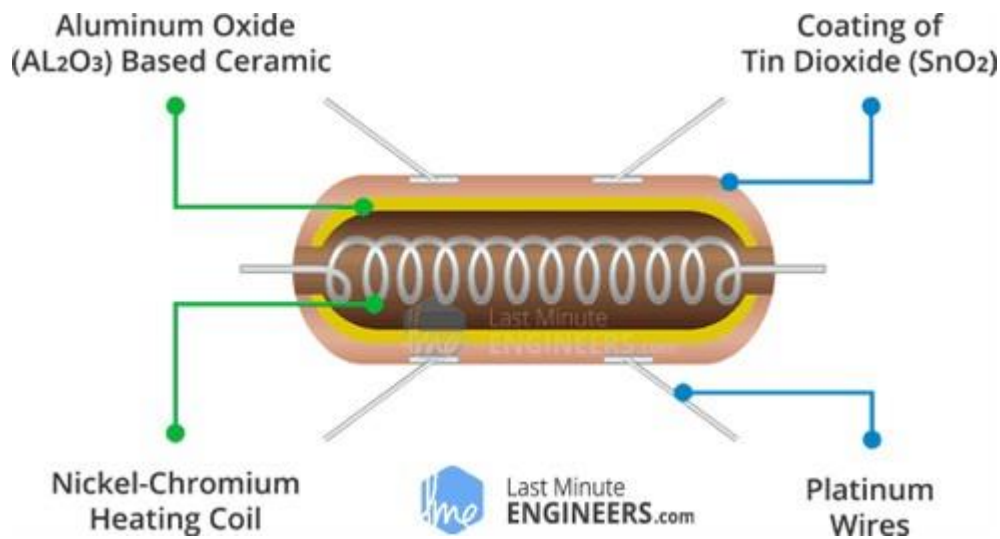


When the outer mesh is removed, the sensor looks like this. The sensing element and six connecting legs that extend beyond the Bakelite base form the star-shaped structure. Two (H) of the six leads are in charge of heating the sensing element and are linked together by a Nickel-Chromium coil (a well-known conductive alloy).

The remaining four signal-carrying leads (A and B) are connected with platinum wires. These wires are connected to the body of the sensing element and convey slight variations in the current flowing through the sensing element.



The tubular sensing element is made of Aluminum Oxide (Al₂O₃) based ceramic with a Tin Dioxide coating (SnO₂). Tin Dioxide is the most important material because it is sensitive to combustible gasses. The ceramic substrate, on the other hand, improves heating efficiency and ensures that the sensor area is continuously heated to the working temperature.



To summarize, the Heating System is composed of a Nickel-Chromium coil and an Aluminum Oxide-based ceramic, while the Sensing System is composed of Platinum wires and a Tin Dioxide coating.

How Does a Gas Sensor Work?

When a SnO_2 semiconductor layer is heated to a high temperature, oxygen is adsorbed on the surface. When the air is clean, electrons from the conduction band of tin dioxide are attracted to oxygen molecules. This creates an electron depletion layer just beneath the surface of the SnO_2 particles, forming a potential barrier. As a result, the SnO_2 film becomes highly resistive and prevents electric current flow.

In the presence of reducing gasses, however, the surface density of adsorbed oxygen decreases as it reacts with the reducing gasses, lowering the potential barrier. As a result, electrons are released into the tin dioxide, allowing current to freely flow through the sensor.

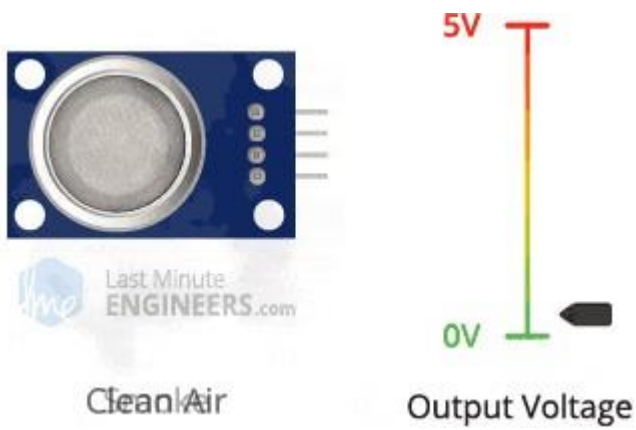


MQ2 Gas Sensor Module Hardware Overview

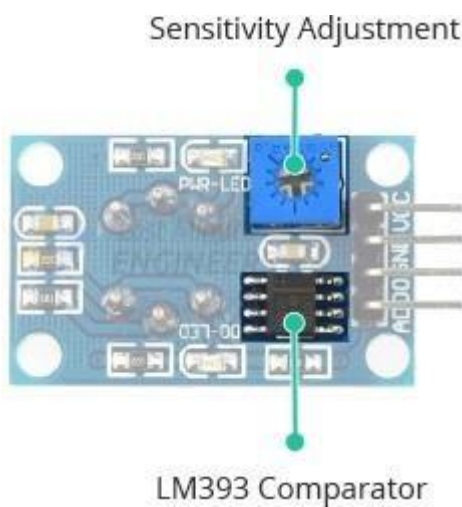
The MQ2 gas sensor is simple to use and has two different outputs. It not only provides a binary indication of the presence of combustible gasses, but also an analog representation of their concentration in air.



The sensor's analog output voltage (at the A0 pin) varies in proportion to the concentration of smoke/gas. The higher the concentration, the higher the output voltage; the lower the concentration, the lower the output voltage. The animation below shows the relationship between gas concentration and output voltage.

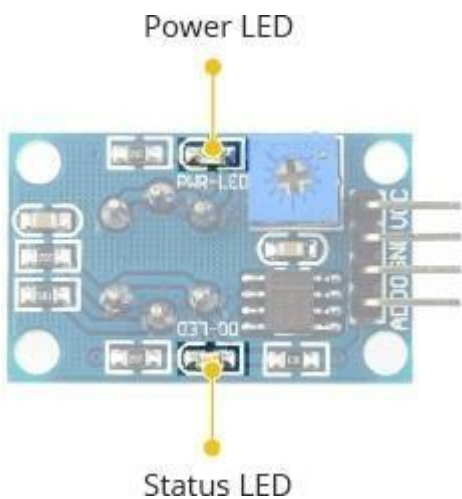


This analog signal is digitized by an LM393 High Precision Comparator and made available at the Digital Output (D0) pin.



The module includes a potentiometer for adjusting the sensitivity of the digital output (D0). You can use it to set a threshold so that when the gas concentration exceeds the threshold value, the module outputs LOW otherwise HIGH.

Rotating the knob clockwise increases sensitivity and counterclockwise decreases it.



In addition, the module has two LEDs. The Power LED illuminates when the module is turned on, and the Status LED illuminates when the gas concentration exceeds the threshold value.

Technical Specifications

Here are the specifications:

Operating voltage	5V
Load resistance	20 K Ω
Heater resistance	33 $\Omega \pm 5\%$
Heating consumption	<800mw
Sensing Resistance	10 K Ω - 60 K Ω
Concentration Range	200 - 10000ppm
Preheat Time	Over 24 hour

MQ2 Gas Sensor Module Pinout

Let's take a look at the pinout now.



VCC supplies power to the module. Connect it to the 5V output of your Arduino.

GND is the ground pin.

D0 indicates the presence of combustible gasses. D0 becomes LOW when the gas concentration exceeds the threshold value (as set by the potentiometer), and HIGH otherwise.

A0 produces an analog output voltage proportional to gas concentration, so a higher concentration results in a higher voltage and a lower concentration results in a lower voltage.

Calibrating the MQ2 Gas Sensor

Because the MQ2 is a heater-driven sensor, the calibration of the sensor may drift if it is left in storage for an extended period of time.

When first used after a long period of storage (a month or more), the sensor must be fully warmed up for 24-48 hours to ensure maximum accuracy.

If the sensor has recently been used, it will only take 5-10 minutes to fully warm up. During the warm-up period, the sensor typically reads high and gradually decreases until it stabilizes

MQ2 Gas Sensor Features & Specifications

- Operating Voltage is +5V
- Analog output voltage: 0V to 5V
- Digital Output Voltage: 0V or 5V (TTL Logic)
- Preheat duration 20 seconds
- Can be used as a Digital or analog sensor
- The Sensitivity of Digital pin can be varied using the potentiometer

Water level sensor:

If you have ever had a water heater explode or ever tried to make submersible electronics, then you know how important it is to detect when water is around.

With this Water Level Sensor, you can do just that!

This sensor can be used to measure the water level, monitor a sump pit, detect rainfall or detect leakage.

Hardware Overview

The sensor has a series of ten exposed copper traces, five of which are power traces and five are sense traces.

These traces are interlaced so that there is one sense trace between every two power traces.

Usually these traces are not connected but are bridged by water when submerged.

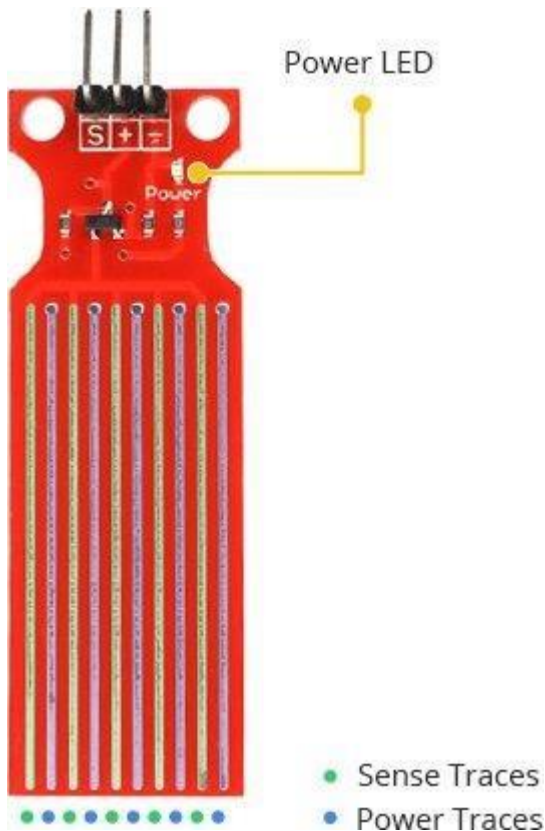


Fig 5.6 Water Level Sensor

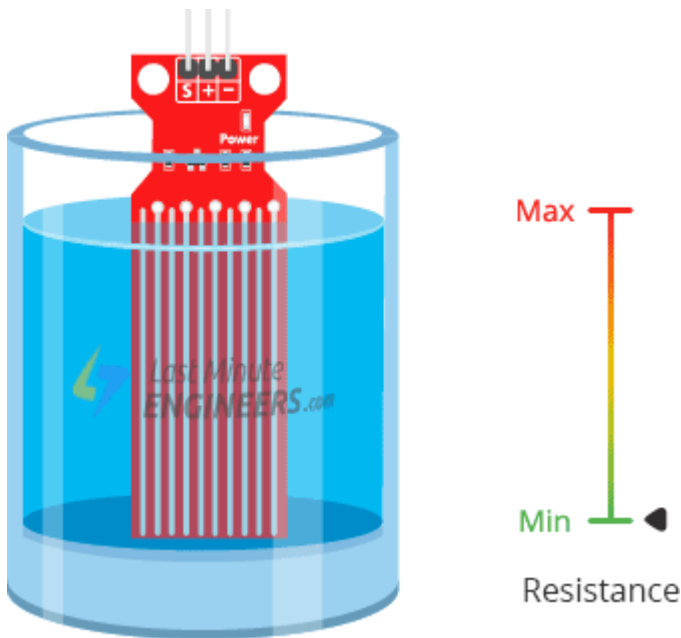
There's a Power LED on the board which will light up when the board is powered.

How Water Level Sensor Works?

The working of the water level sensor is pretty straightforward.

The series of exposed parallel conductors, together acts as a **variable resistor** (just like a potentiometer) whose resistance varies according to the water level.

The change in resistance corresponds to the distance from the top of the sensor to the surface of the water.



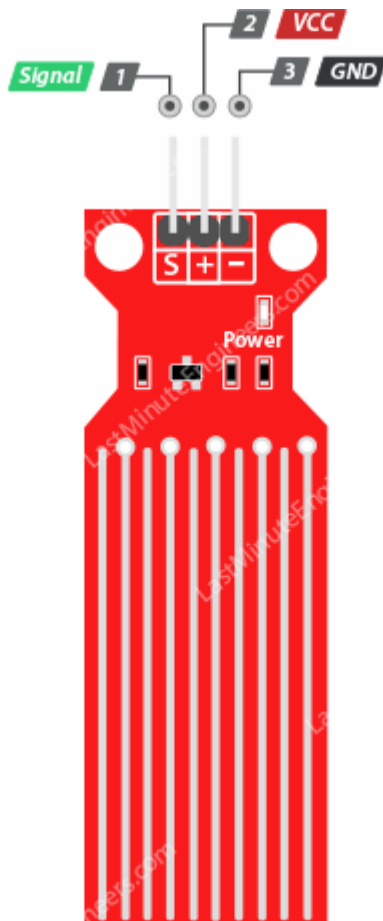
The resistance is inversely proportional to the height of the water:

- The more water the sensor is immersed in, results in better conductivity and will result in a lower resistance.
- The less water the sensor is immersed in, results in poor conductivity and will result in a higher resistance.

The sensor produces an output voltage according to the resistance, which by measuring we can determine the water level.

Water Level Sensor Pinout

The water level sensor is super easy to use and only has 3 pins to connect.



Water Level Sensor Pinout



S (Signal) pin is an analog output that will be connected to one of the analog inputs on your Arduino.

+ (VCC) pin supplies power for the sensor. It is recommended to power the sensor with between 3.3V – 5V. Please note that the analog output will vary depending on what voltage is provided for the sensor.

- (GND) is a ground connection.

Wifi Module

In 2014, an ESP8266 Wi-Fi module was introduced and developed by third-party manufacturers like AI thinkers, which is mainly utilized for IoT-based embedded applications development. It is capable of handling various functions of the Wi-Fi network from another application processor.

It is a SOC (System On-chip) integrated with a TCP/IP protocol stack, which can provide microcontroller access to any type of Wi-Fi network. This article deals with the pin configuration, specifications, circuit diagram, applications, and alternatives of the ESP8266 Wi-Fi module.

What is the ESP8266 Wi-Fi Module?

An ESP8266 Wi-Fi module is a SOC microchip mainly used for the development of end-point IoT (Internet of things) applications. It is referred to as a standalone wireless transceiver, available at a very low price. It is used to enable the internet connection to various applications of embedded systems.

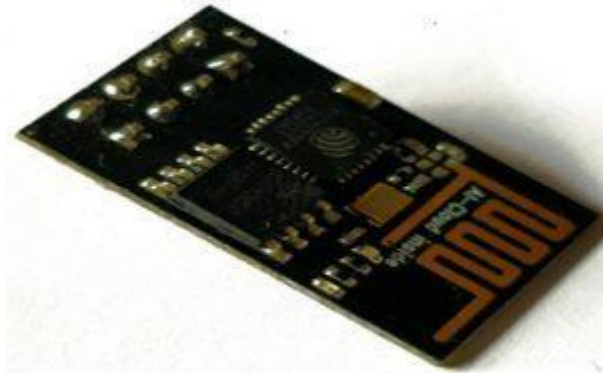


Fig 5.7 ESP8266 Wi-Fi Module

Espressif systems designed the ESP8266 Wi-Fi module to support both the TCP/IP capability and the microcontroller access to any Wi-Fi network. It provides the solutions to meet the requirements of industries of IoT such as cost, power, performance, and design.

It can work as either a slave or a standalone application. If the ESP8266 Wi-Fi runs as a slave to a microcontroller host, then it can be used as a Wi-Fi adaptor to any type of microcontroller using UART or SPI. If the module is used as a standalone application, then it provides the functions of the microcontroller and Wi-Fi network.

The ESP8266 Wi-Fi module is highly integrated with RF balun, power modules, RF transmitter and receiver, analog transmitter and receiver, amplifiers, filters, digital baseband, power modules, external circuitry, and other necessary components. The ESP8266 Wi-Fi module is a microchip shown in the figure below.

A set of AT commands are needed by the microcontroller to communicate with the ESP8266 Wi-Fi module. Hence it is developed with AT commands software to allow the Arduino Wi-Fi functionalities, and also allows loading various software to design the own application on the memory and processor of the module.

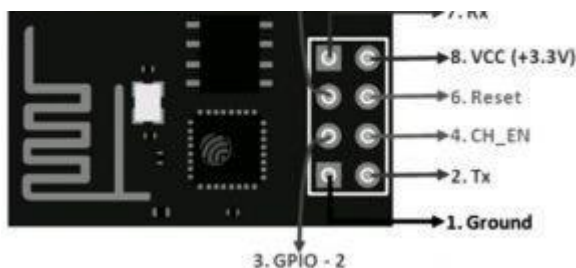
The processor of this module is based on the Tensilica Xtensa Diamond Standard 106 micro and operates easily at 80 MHz. There are different types of ESP modules designed by third-party manufacturers. They are,

- ESP8266-01 designed with 8 pins (GPIO pins -2)
- ESP8266-02 designed with 8 pins (GPIO pins -3)
- ESP8266-03 designed with 14 pins (GPIO pins- 7)
- ESP8266-04 designed with 14 pins (GPIO pins- 7)

The ESP8266 Wi-Fi module comes with a boot ROM of 64 KB, user data RAM of 80 KB, and instruction RAM of 32 KB. It can support 802.11 b/g/n Wi-Fi network at 2.4 GHz along with the features of I2C, SPI, I2C interfacing with DMA, and 10-bit ADC. Interfacing this module with the microcontroller can be done easily through a serial port. An external voltage converter is required only if the operating voltage exceeds 3.6 Volts. It is most widely used in robotics and IoT applications due to its low cost and compact size.

Pin Configuration/Pin Diagram

The **ESP8266 Wi-Fi module pin configuration/pin diagram** is shown in the figure below. The ESP8266-01 Wi-Fi module runs in two modes. They are;



Pin Configuration of ESP8266

Flash Mode: When GPIO-0 and GPIO-1 pins are active high, then the module runs the program, which is uploaded into it.

UART Mode: When the GPIO-0 is active low and GPIO-1 is active high, then the module works in programming mode with the help of either serial communication or Arduino board.

LCD Display

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal.

An LCD consists of two glass panels, with the liquid crystal material sandwiched in between

them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed. Polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle.

One each polariser is pasted outside the two glass panels. These polarisers would rotate the light rays passing through them to a definite angle, in a particular direction.

When the LCD is in the off state, light rays are rotated by the two polarisers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent.

When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarisers, which would result in activating / highlighting the desired characters.

The LCD's are lightweight with only a few millimeters thickness. Since the LCD's consume less power, they are compatible with low power electronic circuits, and can be powered for long durations.

The LCD's don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCD's have long life and a wide operating temperature range.

Changing the display size or the layout size is relatively simple which makes the LCD's more customer friendly.

The LCDs used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

Crystalonics dot-matrix (alphanumeric) liquid crystal displays are available in TN, STN types, with or without backlight. The use of C-MOS LCD controller and driver ICs result in low power consumption. These modules can be interfaced with a 4-bit or 8-bit micro processor /Micro controller.

The built-in controller IC has the following features:

- Correspond to high speed MPU interface (2MHz)
- 80 x 8 bit display RAM (80 Characters max)
- 9,920 bit character generator ROM for a total of 240 character fonts. 208 character fonts (5 x 8 dots) 32 character fonts (5 x 10 dots)
- 64 x 8 bit character generator RAM 8 character generator RAM 8 character fonts (5 x 8 dots) 4 characters fonts (5 x 10 dots)
- Programmable duty cycles
 - 1/8 – for one line of 5 x 8 dots with cursor
 - 1/11 – for one line of 5 x 10 dots with cursor
 - 1/16 – for one line of 5 x 8 dots with cursor
- Wide range of instruction functions display clear, cursor home, display on/off, cursor on/off, display character blink, cursor shift, display shift.

FUNCTIONAL DESCRIPTION OF THE CONTROLLER IC

REGISTERS:

The controller IC has two 8 bit registers, an instruction register (IR) and a data register (DR). The IR stores the instruction codes and address information for display data RAM (DD RAM) and character generator RAM (CG RAM). The IR can be written, but not read by the MPU.

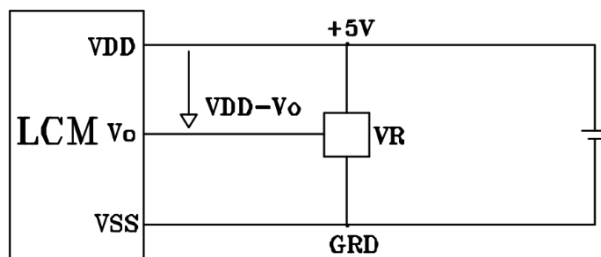
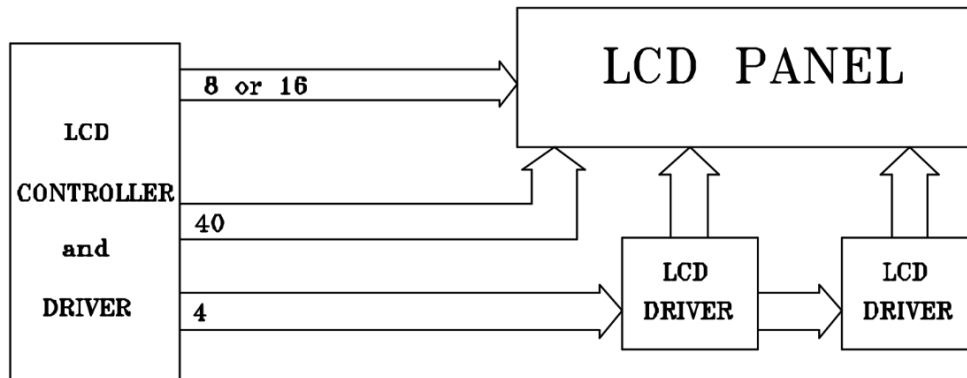
The DR temporally stores data to be written to /read from the DD RAM or CG RAM. The data written to DR by the MPU, is automatically written to the DD RAM or CG RAM as an internal operation.

When an address code is written to IR, the data is automatically transferred from the DD RAM or CG RAM to the DR. data transfer between the MPU is then completed when the MPU reads the DR. likewise, for the next MPU read of the DR, data in DD RAM or CG RAM at the address is sent to the DR automatically. Similarly, for the MPU write of the DR, the next DD RAM or CG RAM address is selected for the write operation.

The dot-matrix liquid crystal display controller and driver LSI displays alphanumeric, Japanese kana characters, and symbols. It can be configured to drive a dot-matrix liquid crystal display under the control of a 4- or 8-bit microprocessor. Since all the functions such as display

RAM, character generator, and liquid crystal driver, required for driving a dot-matrix liquid crystal display are internally provided on one chip, a minimal system can be interfaced with this controller/driver.

Block Diagram



VDD-V₀: LCD DRIVING VOLTAGE

VR: 10K-20K

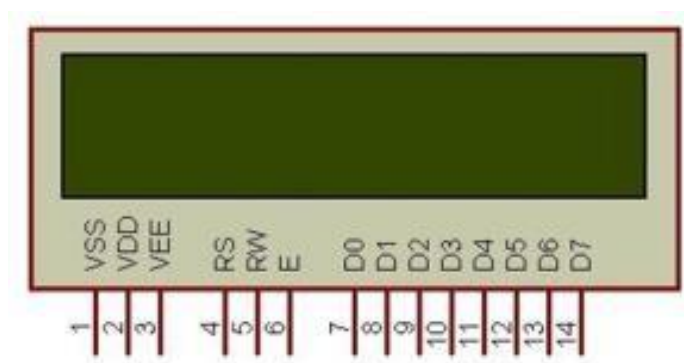


Fig 5.8 LCD Display

Absolute Maximum Ratings

Item	Symbol	Min	Max	Unit
Power Voltage	VDD - VSS	0	7.0	V
Input Voltage	V _{in}	V _{SS}	VDD	
Operating Temperature Range	T _{OP}	0	+50	T
Storage Temperature Range	T _{ST}	-20	+60	

Buzzer

There are many ways to communicate between the user and a product. One of the best ways is audio communication using a buzzer IC. So during the design process, understanding some

technologies with configurations is very helpful. So, this article discusses an overview of an audio signaling device like a beeper or a buzzer and its working with applications.

What is a Buzzer?

An audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical type. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren.



Fig 5.9 Buzzer Pin Configuration

The **pin configuration of the buzzer** is shown below. It includes two pins namely positive and negative. The positive terminal of this is represented with the '+' symbol or a longer terminal. This terminal is powered through 6Volts whereas the negative terminal is represented with the '-' symbol or short terminal and it is connected to the GND terminal.

History

The history of an electromechanical buzzer and piezoelectric is discussed below.

Electromechanical

This buzzer was launched in the year 1831 by an American Scientist namely Joseph Henry but, this was used in doorbells until they were eliminated in 1930 in support of musical bells, which had a smooth tone.

Piezoelectric

These buzzers were invented by manufacturers of Japanese & fixed into a broad range of devices during the period of 1970s – 1980s. So, this development primarily came due to cooperative efforts through the manufacturing companies of Japanese. In the year 1951, they recognized the Application Research Committee of Barium Titanate that allows the corporations to be cooperative competitively & bring about numerous piezoelectric creations.

Specifications

The **specifications of the buzzer** include the following.

- Color is black
- The frequency range is 3,300Hz
- Operating Temperature ranges from - 20° C to +60°C
- Operating voltage ranges from 3V to 24V DC
- The sound pressure level is 85dBA or 10cm
- The supply current is below 15mA

RESULT:

The physical traits of temperature and humidity, light depth value, and gas molecule attention are detected within the mining surroundings and saved on the cloud those outcomes may be plotted at the blink net site or app, and that they may

be stored for later exam. If there any doubt, swift movement can be taken. Blynk is an open-supply net of gadgets utility and API for storing and retrieving data from matters over the net or via a local area community utilizing the HTTP and MQTT protocols. Blynk offers channels for storing statistics retrieved using IOT technologies. Every channel has eight information fields, 3 location fields, and one status field. The data is stored within the blink channel as soon as it is allotted.

The outcomes of the coal mine safety system as seen through the Blynk app are shown in the figures above. In this programme, we can see two units, each with a set of sensors, with only one temperature in the range of 30,40, and so on, while the remaining data are all between 1 and 0. When the value is 1, there is no problem; however, when the value is 0, flames, falls, toxic

fumes, and other hazards are recognised. When the value of the sensors reaches a certain threshold, an alarm message will be delivered to Blynk app users. It will supply the values displayed on the LCD display in each unit before sending the alarm message, as well as the buzzer sound for the alert message.

CONCLUSION:

The Arduino microcontroller is used to create a prototype for a mine safety system in this proposed method. This device is made from each hardware and software program factors. The hardware is made from several sensors, while the software program is made of an Android software that connects to the Arduino board and other hardware additives via the internet of things. The android-based totally programme consists of signals and a database in which readings from sensors are presented and inserted the usage of hardware. The use of the wireless community to growth mine safety is a solution for reaching each protection and development in mining initiatives. This look at objectives to automate the method of mining unit monitoring and handing over updates via cell networks. This gadgets hardware components talk with all the sensors. This project is used to

optimise the utilisation of the mining subject without the intervention of human beings with the aid of using sensors that screen the environment and a microcontroller that switches on/off the buzzer routinely in the event of unstable condition maintaining mining operation these days necessitates ensuring the protection and well-being of employees and property. The employment of arduino, gasoline sensors, Temperature sensors, and humidity sensors inside sensors inside

the improvement of coal mine security for employees maintains to screen mining protection and replace data at the IOT websites.

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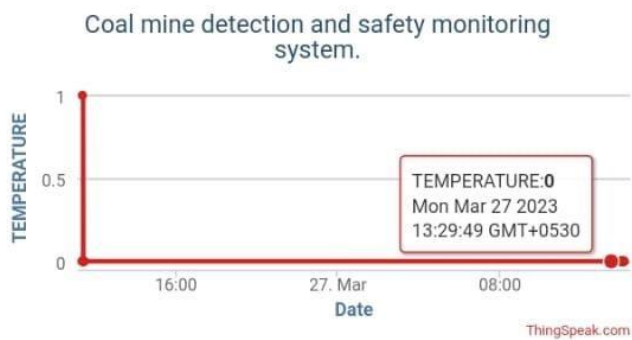
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SCREENSHOTS

Export recent data

Coal mine detection and safety monitoring system. Channel Feed:	JSON X ML CSV
Field 1 Data: GAS	JSON X ML CSV
Field 2 Data: TEMPERATURE	JSON X ML CSV
Field 3 Data: FIRE	JSON X ML CSV

Field 1 Chart



Coal mine detection and safety monitoring system.



Coal mine detection and safety monitoring system.



IOT-BASED COAL MINE SAFETY MONITORING AND ALERTING SYSTEM

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Abstract– Installing and powering conventional coal mine monitoring systems is a challenging task fraught with danger. It is critical to keep and monitor the variables in the foreground to optimize the effectiveness & safety of miners due to the complicated mined environments and the large variety of activities done in coal fields. Therefore, the safety of coal miners cannot be guaranteed by using conventional monitoring techniques. This study illustrates a wireless tracking system based on a wise headgear and ZigBee technology. The shown wirelessly surveillance system is sensitive enough to identify and communicate dangerous conditions in coal mines, including the presence of methane gas, high temperatures, high humidity, and fire. This tracking device sends out distress alerts as necessary. In the situation of an emergency, a buzzer will ring, and data on the tracked parameters will be shown on the computer serving as the interface. The Variables are also wirelessly communicated to the command center, where they are used to assess the mine's security. This paradigm can be simply re-coded. The

dependability and steadiness of the mechanism have been empirically proven.

Keywords–: – Smart helmet, ZigBee, IOT, Monitoring system, Coal mine safety.

I. INTRODUCTION

The goal of this initiative was to make coal mines safer for employees. Workplace hazards in the coal mining sector include exposure to noxious gases, cave-ins, and fires. Employees are at risk since the present techniques for monitoring and warning on these threats are typically rudimentary and ineffective. This project uses IoT technologies to create a real-time alerting & surveillance system to solve this problem. The technology is based on a high-tech helmet that can detect and record data from a wide range of environmental factors. These sensors provide to a centralized monitor information system about the surroundings and the status of the person wearing them.

This information is analysed in real time by the centralized monitoring system to determine hazards in the coal mine. For instance, if the system detects excessive concentrations of dangerous gases, a warning may be sent to the employees and the appropriate authorities. The smart helmet may also be outfitted with Gps data, two-way communications, and flashing illumination to further enhance the wearer's safety.

A mining mishap is any mishap that takes place in the course of extracting metals or minerals from the earth. Several hundred thousand of miners are killed annually in the line of duty [1]. Most of these deaths that occur in mines that are underground. Coal mining is more riskier than igneous and sedimentary rocks because of the plain, often ineffective rock layers, the existence of CH₄ gas, and the existence of coal particles.

Inadequate safety measures are mostly to blame for the majority of fatalities in today's world, especially in less developed countries and rural parts of more developed ones [2]. For this reason, it is crucial to keep records of any factors that might lead to an accident. A gadget to monitor potentially life-threatening conditions in a mine site is shown in this work in progress. In this system, surveillance is carried out using sensors & Zigbee.

A safety feature with a personal button is also a feature of this system. When a sensor's reading goes beyond a predetermined threshold, a signal is sent to the appropriate application. The control room receives the alert and acts accordingly. Large numbers of lives might be lost if underground mines catastrophes are not

effectively managed. Workplace hazards, such as toxic gases and unsafe temperatures, are tracked by a system of sensors. The data is then transmitted to experts for further review and action. In retrospect, it is clear that the coal industry plays a major role in the country's fast economic and social growth. Numerous studies have been conducted by academics from all over the globe to increase the level of security. The energy found in coal mines is crucial to the development of civilization.

As a result of mining failures, security might be improved. A chain reaction of malfunctions or errors in industry is usually what leads to an incident. Many viable options exist. Mine-related initiatives, including the installation of safety lighting, may have a major effect. Both legislative action and the development of an underground coal mine tracking system are now underway. Multi-dimensional statistical analysis was used to look at the trend of coal mine accidents in China over the last decade and determine what role humans had in these tragedies. Large coal mine mishaps and fatalities were steadily declining, but random events still accounted for the vast majority of coal mine fatalities. Ninety-four point nine percent of the origins of these occurrences were attributed to human factors [3]. Intentional infringement, incompetence, and defective design contributed for 35.43%, 56.12%, and 4.54%, respectively.

To investigate potential irregularities inside a coal pillar, a technology that uses a spherical, penetration synthesized pulses radar was used. Direct matrices invert was used to create a velocity image of the pillar's interior. Low-velocity substance's location and existence were indicated

by the reconstructed image. The tomogram's limited substance matched a clay seam in the centers [4].

While technology may help in certain ways, for many people it won't be enough to overcome the obstacles they face. Coal mining has serious risks, therefore it's crucial that miners get the training they need to be safe [5]. Optic fibre detectors have already been created and put into use as a result of this study's findings to ensure the safe tracking of roofing strength and toxic gases in coal mines. The FOS-based mining hazard warning system is unparalleled because of its built-in reliability, scalability (to several locations), and ability to monitor multiple parameters simultaneously. They might be used to develop expert systems for anticipating and eliminating mining risks [6]. Unfortunately, fatal accidents often occur in deep mines. The creation of risk-free mining methods is essential. Innovative mining techniques may help with this issue. The driverless electric locomotives [7] is a crucial part of the smart mine infrastructure.

The remaining parts of the paper are structured as follows: The technique behind the current plan is covered in Part 2. Third part provides a high-level overview of the system. The functionality of the tracking apparatus and the intelligent helmet is described in Part 4. Part 5 details the review and evaluation of the output results, while the last section discusses the project's findings and its potential future expansion.

II. LITERATURE SURVEY

Both Abid[3] & MustafaAbro, they unveiled a wearable IoT suit. As its name implies, it is

designed to protect the lives of those who risk theirs every day by working in mines. This model is constructed in such a manner that it can detect the presence of hazardous chemicals, the miner's pulse rate, the subterranean atmosphere, and the precise position of the miner via GPS. Typically, a Wi-Fi secured connection will be used to provide these settings to a technology that changes on the go via the network. [4]

Synonymous expression The undergraduates in this conceptual and detailed a gadget that can locate a coal miner to within a few feet. Workers' lives may be saved in the event of an emergency because to the pinpoint accuracy with which their position can be determined. The technology relies on radio-frequency identification tags to keep tabs on and pinpoint their whereabouts. This precise location may aid in rescue efforts as early as an occurrence is reported. Coal mining operations have been given a huge boost in efficiency because to the robotics developed by DKock. It was designed with South African miners in mind. Together, they investigated the problem of CID. Specifically, they used vibration analysis and the study of naturally occurring gamma rays to achieve their goal. A ZigBee-based safety system was proposed by Gaidhaane. [6] for use by miners. Gas levels are also monitored, which is important since deadly gases are the leading cause of mortality in mines. When the value exceeds the set limit, ZigBee sends a signal by sounding an alarm and activating a series of LEDs. An IoT-based wireless communication system was proposed by ChengQiang[7]; it would allow coal miners to monitor environmental conditions such as moisture, CH₄, or warmth. The miner is alerted by a verbal transmission from the worker tracking on

the floor channel.

Authors GuoFeng, YongpingWu, & many others. This technology, invented by the investigators, is effective for reducing dangers associated with mining for coal, gold, and other precious metals. If you need to pinpoint the precise position of the coal miner, this method is your best bet. This gadget makes tracking simple and expedites the arrival of necessary assistance in an emergency. This method has a number of drawbacks, the most significant being that Beta is a short-range wifi module and that wire is difficult to use.

Specifically, AlSuwaidi and Zemerll(2009)[8]. They proposed a method that uses GPS to solve a variety of problems. Any missing coal workers may be readily located with the use of GPS thanks to this app's precise location search capabilities. User technology is used to facilitate communication between users and the system. The client's mobile telephone is given the ability to enroll & log in, with the user's passwords and privileges being securely stored in the server's data. Coworkers led by PranjaliHazarik[8] This coal miner-specific helmet was built for use in environments with potentially harmful gases including formaldehyde, particulate matter, and others that are encountered during underground mining extraction. This helmet is equipped with sensors to detect the aforementioned hazardous chemicals, and data is sent instantly to the control booth through a ZigBee-connected wifi router.

III. METHODOLOGY

When it comes to monitoring and detecting factors in a mine site, the Arduino is the tool of choice.

Sensors for heat, moisture, infrared flame, and gases all offer real-time measurements. Each of these senses are linked to a computer and a transmitter. The information is transmitted to the mcu, while Zigbee WPAN IEEE 802.15.3 is used for communications between gate as well as the designated node. As was previously explained, the XBee technology is used to transmit the data to the command centre. When anything goes wrong, the system sends out an alarm message that is also presented on an Arduino-connected Lcd just at coalfield's entry.

In the event that any of the aforementioned sensors report an unexpected value, Arduino will be used to create and operate a beep to alert the user. A microprocessor and a button are all that's needed to power a wise helmet's computations. The mcu includes a ZigBee transmitter. For the benefit of all coalfield employees, this precautionary action has been implemented. A crisis settings allow a worker to alert the control room of a crisis, allowing for prompt hospital treatment to be provided in the event of illness or injury.

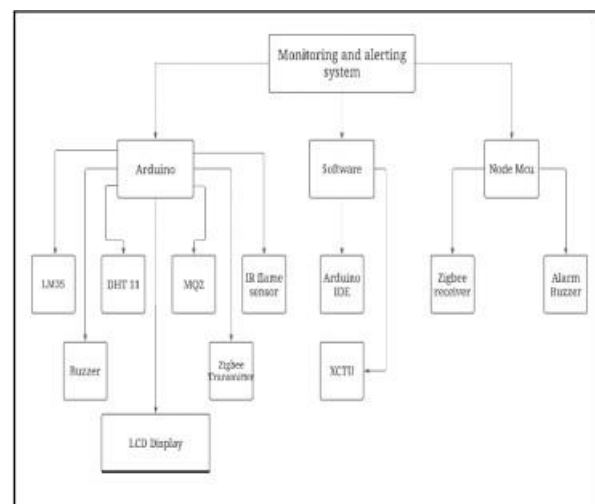


Fig. 1: Block Diagram Of Coal Mine Safety And Monitoring System.

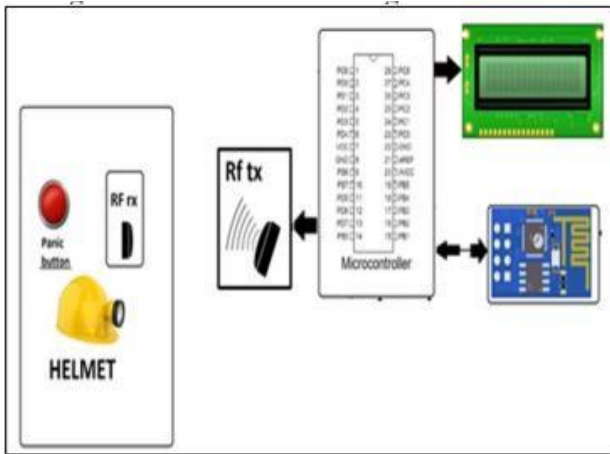


Fig. 2: Block Diagram of Smart Helmet

A. Sensor Technical Details -

The concept is meant to detect disease or fire and monitor parameters such as the temperature, volatiles like No₂, Carbon dioxide, & moisture. In Table 1 we can see the sensors & their settings that were used in the prototype. The Analog output

sensor is used to take readings of temperature since it is both compact and precise, to be within 3°F or [8]. With just a Micro controller sensor module, we can detect gas concentrations to within 85%, and with a DHT11 sensor, we can measure humidity to within 5% RH. An infrared flame sensors, also used for fire detection, was included in the prototype because of its superior sensitivity and precision compared to other kinds of flame sensors. These sensors endure a long time, are resistant to the coalfield's extreme temperatures and humidity, and don't break the bank.

Zigbee is a solution based on rules, making it ideal for low-cost and low-power M2M as well as IoT networking. ZigBee uses a cellular communication architecture to get rid of hub devices and create a self-healing architecture, allowing for far lower transmission rates than a Wifi. Mixed versions from

various vendors are possible because to this, however it has been updated and refined. Zigbee is a widely used protocol because of its low power requirements and moderate bit rate [9].

Table 1: Specification table for selected sensors

Sr no.	Parameters	DHT11 Humidity sensor	MQ2 Gas sensor	LM35 Temperature sensor	IR Flame sensor	ZigBee Module
1	Sensing variable/Uses	Humidity	Gas concentration	Temperature	Fire	Transceiver
2	Operating Voltage	3.5V to 5.5V	5V	+4V to 30V	3.3V to 5V	2.1V to 3.6V
3	Operating Current	0.3 mA	800 mW	60 micro-A	15 mA	45 mA
4	Output Voltage	5.5 V	0 to 10 V	10 mV	Digital output (0 or 1)	-
5	Operating Temperature Range	0 to 50 degrees Celsius	-20 to 70 degree Celsius	-55 to 150 degrees Celsius	-25 to 85 degrees Celsius	-40 to 85 degree Celsius
6	Output/sensing Range	20% - 90%	300 to 10000 ppm	-55 to 150 degrees Celsius	760 to 1100 nm	4000 ft

B. Flow Chart -

The process flow of the surveillance system is shown in Fig. 3. The first step is to provide electricity to the experimental circuitry. The readings of the sensor we've connected to the Microcontroller UNO will need to be monitored from now on. When you've analysed the data and determined when abnormal conditions exist in the environment, you may assign a threshold value to each sensor.

A siren would ring, the measurements will be presented on an Lcd with an alarm text, & information will be sent via Zigbee network to the command center if the sensor is larger than the set threshold level. Whereas if sensor is below the set predefined threshold, the Beep would not activate, but the data will still be displayed on the LCD and sent to the command centre. At this point, the process stops moving forward.

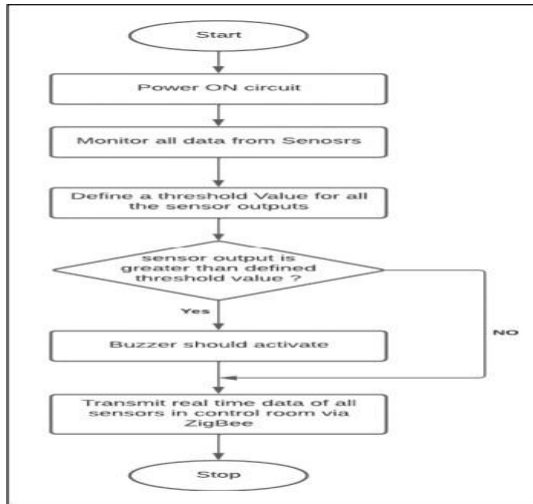


Fig. 3: Flow Chart For Controller Programming

IV. WORKING

The Circuit receives data from the Esp8266, which then uploads it to the web. The circuit receives its voltage from a direct current (DC) power source. This is a schematic of the monitor & alert platform designed into the helmet. It will consist of an Arduino ide, Wlan nodes, and many sensors like the DTH11 sensing element as well as the Infrared fire detector. We want to employ monitors that track heat, gas levels, and smoke detectors to keep mine workers safe. In addition, it will include a cable that links to an LCD screen at the coal mine works gate. In addition, the Zigbee chip will send the information captured by the sensor to the control booth, where it will be processed and used to perform the necessary steps as quickly as possible. The schematic circuit layout is seen in Fig. 4.

Other preventative measure, the "smart headgear," will have a ZigBee receiver, a pushbutton, as well as an alarm. Any employee who feels unwell or needs treatment may hit the pushbutton to sound the alarm and transmit a ZigBee signal to the command centre.

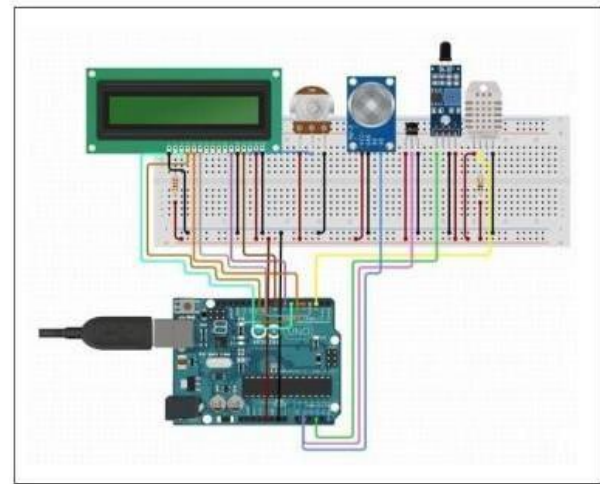


Fig. 4: Circuit Diagram of Coal Mine-Side Monitoring System.

V. RESULTS & DISCUSSIONS

IoT ideas & devices are utilised to build a compact, efficient, yet low-cost prototype. Throughout in this validation process, LM35 detectors were able to accurately detect the heat, and the results were good. Additionally, the DTH11 detector was employed to keep a close eye on humidity levels. Upon detecting elevated gas levels, the Mq2 detector effectively triggered the display's alert system. The infrared gas sensor might potentially identify burning and issue warning to the user. The Zigbee System was created for data transmission after extensive testing over a variety of locations & ranges. Uwb was the most action and achieve protocol, and it worked perfectly. Figure 5 depicts the coal mine prototype, while Figure 6 depicts the command center working model. However, the bike helmet was functioning normally and showing a signal of assistance.

The helmet carries messages to the command centre when an incident arises. Figure 8 depicts the smart helmet's integrated drive & ZigBee chip. Coal miners become lightheaded when co2 or CH4 levels increase in the mine. They may press the buzzer on their headgear in this situation to notify the central management staff and speed up the recover.

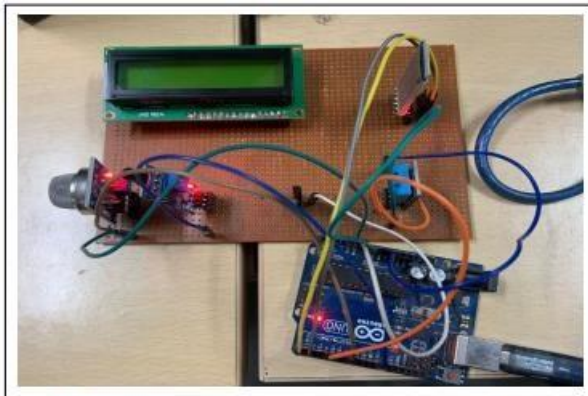


Fig. 5: Prototype Of Monitoring System in Coal Mine



Fig. 6: Prototype Of Monitoring System in Control Room.

Table 2 & Table 3 display the findings of the analysis performed on the surveillance program's data, while fig 7 displays the results visually. While Table 2 details the surveillance system's outputs when everything is under management, contrasts the instruments' readings to their predetermined limits, and displays the hardware changes & their present status. Table 3 details the equipment modifications and evacuation outputs that are going to implemented in case of a manufacturing fault.

The experimental tracking program's real measurements are shown in Fig.7. The values from each sensor are uploaded to the user experience of the Arduino every five secs. Cautions such as "high gas sensor," "near the building," "moisture," & "elevated heat" are shown whenever the critical value is exceeded.

Table 2 : Result analysis of monitoring system

Sr no.	Parameter	Threshold value set	Sensor reading	Hardware changes	remark
1	Temperature (degree Celsius)	25	21.09	Buzzer off	Safe condition
2	Gas (PPM)	600	518.2	Buzzer off	Safe condition
3	Humidity(%RH)	45	33	Buzzer off	Safe condition
4	IR flame sensor (digital output)	0	0	Buzzer off	Safe condition

Table 3 : Result analysis of monitoring system

Sr no.	Parameter	Threshold value set	Sensor reading	Hardware changes	remark
1	Temperature (degree Celsius)	25	31.05	Buzzer on	unsafe condition
2	Gas (PPM)	600	694.1	Buzzer on	unsafe condition
3	Humidity(%RH)	45	48.3	Buzzer on	unsafe condition
4	IR flame sensor (digital output)	1	1	Buzzer on	unsafe condition

```

temperature: 21.09 °C
gas density: 561.00
Humidity = 33.5
* Close Fire *
temperature: 21.14 °C
gas density: 561.00
Humidity = 33.5
* Close Fire *
temperature: 21.19 °C
gas density: 563.00
Humidity = 33.5
* Close Fire *
temperature: 21.14 °C
gas density: 561.00
Humidity = 33.5

```

Fig. 7: Result of Monitoring System

In Figure 8, we see the winning solution for the wise headgear concept. The helmet carries messages to the command centre when an emergency occurs. The helmet has a Zigbee protocol as well as a pushbutton to activate it. Whenever the concentration of co2 or gases in an active mining increases, prospectors begin to feel lightheaded or Indeed any sensation of disquiet in wellbeing or damage in the bloodstream, those who can press the button on one's headgear, that also notifies the employees in the command center as well as significantly lowers the time it requires for people to be saved due to rapid intervention.



Figure 8: Prototype of Smart Helmet

The ZigBee data is analyzed in Table 4. The only two potential outcomes from pressing a button are 0 and 1. The outcome would be 1 if the pushing button is pushed, activating the device, and 0 otherwise, with the buzzer in its off state.

Table 4: result analysis of smart helmet

Sr.no	Sensor reading	Hardware changes	remark
1	0	Buzzer OFF	Safe condition
2	1	Buzzer ON	emergency

VI.CONCLUSION

In this work, we will discuss the Zigbee-based tracking network. Coal tragedies may be avoided with the help of the suggested method, which monitors the subterranean features of a mine. ZigBee is a low-power, low-size communication network that may easily be adapted to new situations. As an added bonus, the suggested solution eliminates the drawbacks of traditional powerline networking entirely. Therefore, this is an improvement above the standard method of ensuring workers rights in mining towns. In addition, a distress beacon sent via the smart helmet might be helpful in extreme weather or even when emergency treatment is required. The security of several sectors may benefit from this technology. There is a low barrier to entry for additional improvement and customization in light of future developments.

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